



**iView X<sup>TM</sup>**  
**System Manual**

**Version 2.4**

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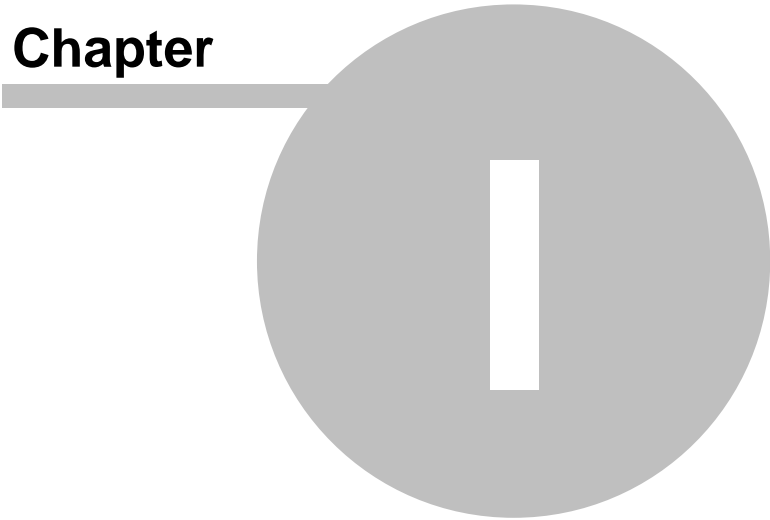
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# Introduction

**Chapter**



# 1 Introduction

The iView X™ system is designed for eye tracking studies in a number of fields ranging from psychology/neuroscience to human factors, to usability and marketing. Interfaces are available for remote and head-mounted eye tracking as well as more complex applications like fMRI and EEG.

All required components for efficient high-quality eye movement and scene video recordings are combined into a high-performance PC Workstation, which can be a stationary or a mobile computer. Real-time image processing, calibration, auxiliary device I/O, stimulus-software interface, as well as data and video recording are all combined into one easy-to-use MS Windows™ application.

Document version: IVX-2.4-0912

## 1.1 How to read this document

This manual is designed to serve both as online help and as printed system documentation of iView X™.

Latest software versions covered in this document:

iView X™ - Version 2.4.31

You can use this manual in one of these ways:

- . Read through the chapters pertaining to particular functions to get background information before using the program.
- . Consult the manual as a reference document to find out particular information. You can find a topic either by consulting the table of contents (at the front of the manual), or the index (at the end).

All the information in this manual can also be accessed through the program. Press **F1** to get help on the menu-item or the element that is currently selected. See also [Help](#)<sup>[364]</sup>.

It is probably not necessary to read all the chapters consecutively as every chapter tries to be complete in itself. Therefore some phrases may recur. You may jump through the chapters to look for the topics that interest you. Several links inside the text and the index should help you find your way through this book.



You can find specific help topics using the help's *Table of Contents*, *Index* or *Find* (full text search in online help).

Last updated: 12/7/2009

## 1.2 Safety Notes

Under specified conditions of use all iView X™ camera devices comply with the EN-60825-1 standard.  
Detailed calculations and ratings are available for customers on request.

The IR sources should be switched off when not in use. This will improve the product life-time.



### **WARNING:**

- Proper use of this device depends on careful reading of this manual and all additional instructions and labels.
- Before connecting or disconnecting components or additional devices switch off the system.
- Switch off the system before cleaning.
- The system must not be used in humid environments as it is not protected against moisture.
- The system must not be used in presence of explosive or flammable gases.
- In case your iView X system or a component of the system is damaged, do not use the system until the system or its component has been repaired by a certified distributor or SensoMotoric Instruments GmbH.
- Do not repair the system by yourself. Electrical shock hazard.

## Photosensitive Epilepsy

Some people may have epileptic seizures triggered by light flashes or patterns. This may occur while presented successive pictures or video material, even if they have never had a seizure before.

Supervise your test persons during experiments. Stop immediately and consult a doctor if a test person has the following or similar symptoms:

- Involuntary movements
- Disorientation
- Convulsions
- Loss of awareness
- Altered vision

## Experiment Responsibility

Make sure the presented visual stimuli do not harm or injure your test persons. SensoMotoric Instruments GmbH is in no way responsible for the experiments you develop, execute, and analyze. Do not offend against your test person's cultural background, age, psychological condition, or similar.

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BeGaze is a trademark of SensoMotoric Instruments GmbH

iView X is a trademark of SensoMotoric Instruments GmbH

Experiment Center is a trademark of SensoMotoric Instruments GmbH

SensoMotoric Instruments is a trademark of SensoMotoric Instruments GmbH.

Microsoft, Windows are registered trademarks of Microsoft Corporation.

See also:

[License Agreement and Warranty](#) 

## 1.5 About SMI

SensoMotoric Instruments (SMI) is a world leader in dedicated computer vision applications, developing and marketing eye & gaze tracking systems and OEM solutions for a wide range of applications.

Founded in 1991 as a spin-off from academic research, SMI was the first company to offer a commercial, vision-based 3D eye tracking solution. We now have over 17 years of experience in developing application-specific solutions in close collaboration with our clients.

We serve our customers around the globe from our offices in Teltow, near Berlin, Germany and Boston, USA, backed by a network of trusted local partners in many countries.

Our products combine a maximum of performance and usability with the highest possible quality, resulting in high-value solutions for our customers. Our major fields of expertise are:

- Eye & gaze tracking systems in research and industry
- High speed image processing, and
- Eye tracking and registration solutions in ophthalmology.

More than 4,000 of our systems installed worldwide are testimony to our continuing success in providing innovative products and outstanding services to the market. While SMI has won several awards, the largest reward for us each year is our trusted business relationships with academia and industry.

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Please also visit our home page:

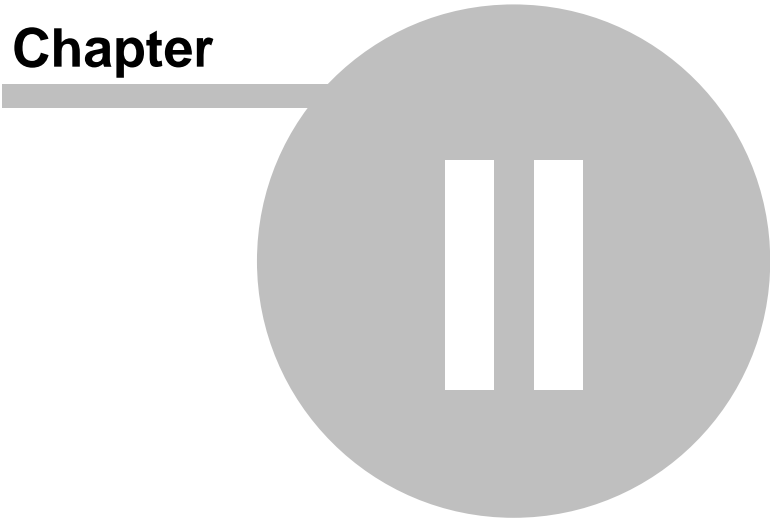
<http://www.smivision.com>

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# General Overview

**Chapter**



## 2 General Overview

This chapter gives a general overview of the iView X™ system.

### 2.1 Basic Remarks on Eye Tracking

This chapter gives a general overview of what eye tracking is about. It will outline some of its basic concepts and most important terms. It covers, what of the eye can be tracked, what kind of eye movements exist, which methods have been or are still in use to measure eye movements, the relevance of head movements and why calibration is important.

We recommend reading this chapter to all first-time users of eye trackers.

#### 2.1.1 What is Eye Tracking?

Eye tracking is the science of measuring the movement of the eyes, usually in response to visual, auditory, cognitive, or vestibular stimulus. Researchers study eye movements both as physiological responses to stimuli and as an indication of cognition. There are quite a few different fields that use eye tracking, ranging from neurological to psychological to advertising.

#### 2.1.2 Types of Eye Tracking

Some researchers who study eye movements are interested in the physiological movements of the eyes in response to a stimulus, but not necessarily where the test person is looking in space. The movement of the eyes as an absolute measure is called orbital eye tracking. The orbital position of the eye refers only to the deflection of the pupil itself. This type of eye tracking is common in vestibular and neurological-visual research. In the iView X™ system, this data type is called "Pupil Data".

Most researchers who study eye movements are interested in gaze position. The gaze position is the point in the test person's field of view where the eye is actually looking. Gaze data can be reported as a vector

in space, or as an actual position in the stimulus. This kind of data is common when a test person's eye position relative to stimulus is studied, such as in reading, usability, cognitive neuroscience, and advertising research. Eye tracking systems that determine gaze position do so by applying complicated mathematical algorithms to the measured orbital pupil position. Therefore, all gaze-tracking systems must be calibrated (see below). The iView X™ gaze data is called "Mapped Screen Coordinates" and is usually reported in terms of computer screen or scene video pixels.

Torsional data is a special kind of eye tracking that tracks the eye in three dimensions, horizontal deflection, vertical deflection, and rotation around a center axis parallel with the line of sight. Torsional eye tracking is most often applied to vestibular or binocular vision research. SMI has a system that measures torsional data, called the 3D VOG Video-Oculography®.

### 2.1.3 Common Types of Eye Movements

#### Fixations

Fixations are very low-velocity eye movements that correspond to the test person staring at a particular point. Fixations contain very small randomly drifting eye movements and quick adjustments to keep the target centered. A fixation is detected by applying a maximum-movement threshold amount for a minimum amount of time.

#### Pursuit

Pursuit movements occur when the eyes follow a moving target in the environment in order to fix that target on the retina. Normally the eyes smoothly track a moving object, but in some cases the eyes will perform 'catch-up saccades', rapid eye movements intended to reacquire the target. Pursuit movements are involuntary and are affected by a number of environmental and pathological variables.

#### Saccades

Saccades are rapid eye movements the eye makes while jumping from point to point in the stimulus. They can be triggered by displaying fixation targets at defined times within the stimulus. Saccades are also studied as

movements between points while reading or studying an image. Saccades are usually detected according to velocity and acceleration thresholds.

### **Gaze Path**

Gaze path is path the eye takes while studying a stimulus image. Gaze path can be thought of as the chronological ordering of fixations and saccades, or more generally the pattern the eye takes while studying the image.

## **2.1.4 Eye Tracking Methods**

### **Electrical Oculography (EOG)**

Because there are differences between the polarity of the eye from back to front, original eye tracking systems tracked electrical field changes as the eyes moved. These systems are limited in accuracy and extremely susceptible to noise.

### **Coil Systems**

A coil eye tracking system tracks eye movements by observing a magnetic coil inserted into the eye surgically or as part of a contact lens. The head must be fixed via bite bar or a separate coil must be used for head position analysis. The method is susceptible to noise and the coils can be fragile. This type of eye tracking experiment is invasive and potentially dangerous, therefore it is mostly used for animal studies.

### **Dual Purkinje Systems**

These systems track multiple reflections of light on the front and back surfaces of the cornea. By geometrically calculating the orientation of these reflections, the eye position can be determined. An algorithm converts this eye position to gaze position. Dual Purkinje Systems are usually very accurate but they require the complete immobilization of the head through the use of an uncomfortable bite-bar.

## Bright Pupil Systems

Shining IR light directly into the eye, coaxial with an IR sensitive camera, produces a glowing effect in the cornea. By tracking the movement of this bright reflection, bright pupil systems track orbital eye movements. Using a calibrated algorithm, the system can translate these eye movements to gaze position. Bright pupil systems require some external head-tracking method or the head must be immobilized.

## Dark Pupil Systems

The eye is illuminated by IR light at an angle from an IR sensitive camera. The eye and face reflects this illumination but the pupil will absorb most IR light and appear as a high contrast dark ellipse. Sophisticated image-analysis software determines where the center of the pupil is located and this is mapped to gaze position via an eye-tracking algorithm. Dark pupil systems are versatile and easier to set up though they also require some kind of head movement compensation.

### 2.1.5 Head Movements

In order for eye tracking systems to determine gaze position, they must have a method for separating head-movements from eye movements. If a test person fixates on a target and makes a 15-degree head rotation to the left, a system observing only the eye will see a 15-degree eye rotation to the right. This is accurate, since the eyes did in fact deflect in a direction and magnitude opposite to the head in order to maintain the fixation.

However, many eye tracking systems render eye movements in terms of a gaze point in the stimulus, such as a target displayed on a computer screen. In order for the system to accurately determine fixation on that target, any detected eye movements must be adjusted to eliminate head movements.

The most accurate way to do this is to immobilize the head using a bite bar (even a chin rest will allow enough head movement to alter gaze position results). However, this is invasive, uncomfortable, and could have a profound impact on test person behavior in some kinds of experiments.

Alternatively, the head position can be determined and subtracted for eye data via magnetic tracking systems. The iView Head Tracking systems uses a 6D head tracker to determine the direction of the head at all times during the experiment. This is valuable in complex experiments where the test person is surrounded by their environment.

A different solution is the use of methods that compensate for head movement without calculating it as a variable. A system that compensates for head movements will automatically remove these from the determination of gaze position.

The iView RED and fMRI systems use this method by tracking the cornea reflex (CR) in relation to the static camera. The CR location in the eye changes with head position relative to the camera and it is used along with pupil location to determine the gaze point in the stimulus.

### **2.1.6 Calibration**

The calibration process varies considerably between different types of eye tracking systems. Electrical and coil-based systems must be calibrated in order to define the ratio between voltage changes and pupil movements. Video-based systems can often record relative eye movements without calibration. However, all systems that determine mapped gaze position must be calibrated in order to relate orbital pupil position to a point in the test person's view.

Calibration of a video-based eye tracking system involves instructing the test person to look at specific points while the system observes the pupil position at that point. The system will then develop the necessary algorithm to translate pupil position to gaze position to all points in the area defined by the calibration.

### **2.1.7 Further Reading**

For a more comprehensive discussion of eye tracking methods, the following books can be recommended:

*Methods & Designs: Survey of Eye Movement Recording Methods,*

Laurence Young and David Sheena  
Behavior Research Methods & Instrumentation 1975 Volume 7(5),  
397-429

*Eye Tracking Methodology, Theory and Practice*  
Andrew T. Duchowski  
Springer, London, 2003

## 2.2 How iView X works

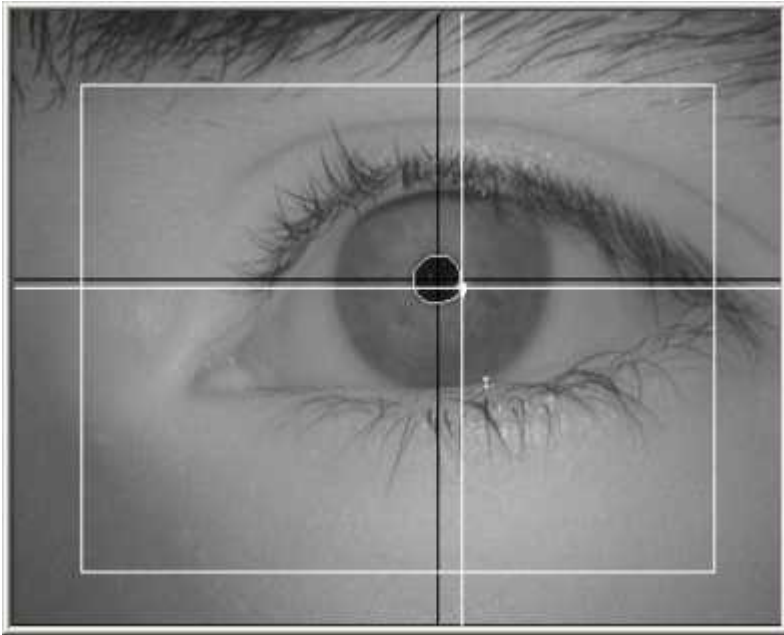
This chapter gives an overview of how iView X™ works, its general system layout and its various camera systems.

### 2.2.1 Eye Tracking Method

The iView X™ system is a dark pupil eye tracking system that uses infrared illumination and computer-based image processing. Images of the eye are analysed in real-time by detecting the pupil, calculating the centre, and eliminating artifacts. Once a calibration is performed, the pupil location is translated into gaze data.

#### Corneal Reflex

In most applications, one or several corneal reflexes are tracked by the iView X™ system in order to compensate for changes in position of the camera relative to the head. In the iView X™ HED system this compensates errors caused by slippage of the eye tracking helmet. In RED systems small movements of the head are compensated.



A Typical Eye Image with two crosshairs,  
one for the pupil and one for the corneal reflex.

## 2.2.2 General System Layout

Your iView X™ system consists of the following components:

### Eye Tracking Camera System

There are several types of eye tracking interfaces available for use with iView X™. These range from remote cameras, to head-mounted, to fMRI compatible interfaces. Some configurations are better suited for certain experiments than others. In most cases, it is possible to reconfigure an iView X™ system for use with another interface. For an overview see [here](#)<sup>23</sup>.



## iView X™ workstation

The iView X™ workstation is the eye tracking computer system that runs the iView X™ software and contains the hardware components that allow the system to capture eye movements. The iView X™ workstation controls all camera equipment and processes all eye and scene video signals from the experiment. Data and video files are collected there and additional data out is provided on the various [IO interfaces](#)<sup>4291</sup> of the iView X™ workstation.

A researcher uses the iView X™ workstation to setup an experiment, control the eye tracking camera system, and to trigger events, such as calibration, drift correction, start and stop recording.

## Stimulus Presentation

The form of stimulus presentation varies according to the type of experiment and the eye tracking interface used. Some experiments may not use coordinated stimulus at all (driving, locomotion, etc.). Other experiments use a second computer for stimulus presentation via monitor, projector, or fMRI interface.

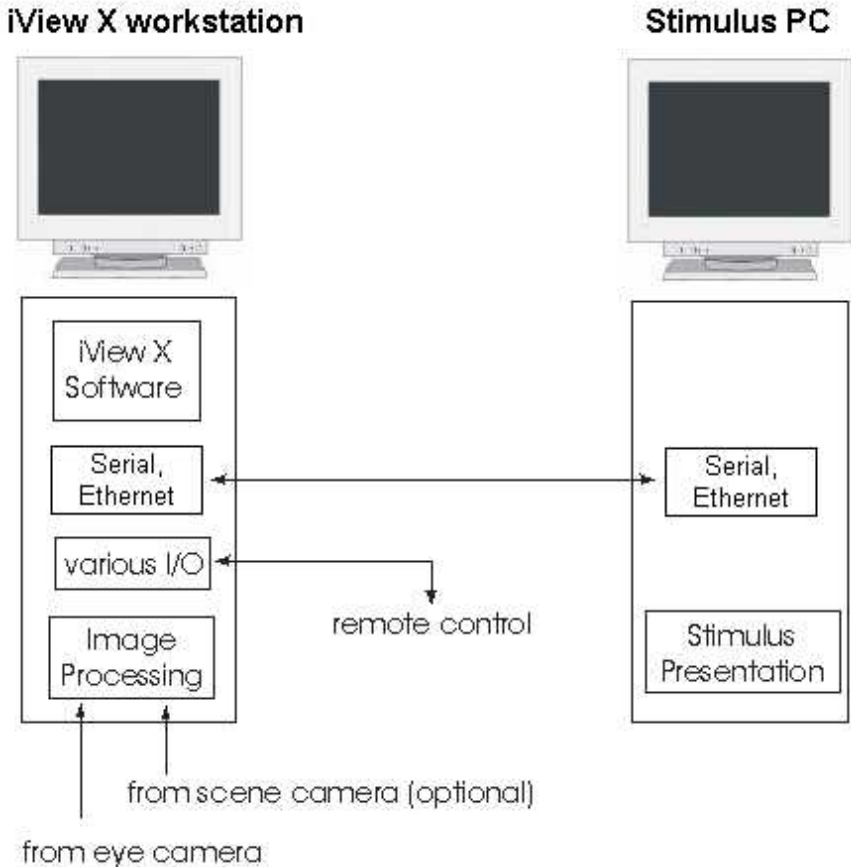
The optional Stimulus PC is the computer that is used to generate stimulus for the test person. When the stimulus is presented on a computer monitor or fMRI projector, this is the computer that the test person watches during the experiment.

The Stimulus PC can run third party stimulus presentation software or programs written by the researcher. Stimulus events presented on the Stimulus PC can be synchronized with data collection on the iView X™ workstation by trigger signals from the Stimulus PC LPT or COM port to the iView X™ workstation's IO ports.

## Remote Control

There are several options for remote control of the eye tracking computer and these will be covered in more detail in the chapter on [I/O Interfaces](#) [429]. Synchronization triggers are used to coordinate the presentation of stimulus with eye movements in the data file. Time-stamped messages can be inserted into the data file by the Stimulus PC. The researcher also can incorporate commands into the stimulus program that tell the eye tracker when to begin recording, when to perform drift correction, etc. The iView X™ workstation can output gaze information and object hits and these can trigger stimulus events on the Stimulus PC.

Using these optional communication schemes along with any of the common stimulus programs available today, the researcher can design an eye tracking experiment that is completely controlled by software running on the Stimulus PC that allows complete interaction between the test person and the stimulus.





**Simplified system overview:**

## 2.2.3 Eye Tracking Camera Systems

Two main families of the camera systems are the Headmounted Eyetracking Devices (HED) and the Remote Eyetracking Devices (RED). The systems can be extended with magnetic head-tracking (MHT). Special camera types are used for high precision measurements

(hi-speed) and measurements in magnetic fields (MRI).

The following iView X™ camera systems are available:

<b>iView X™ Camera System</b>	<b>Fields of application</b>	<b>Output data</b>
<a href="#">HED 4</a> 	driving, industrial, hand-eye coordination, locomotion and gait studies, human factors, ergonomics, consumer behavior, sports, behavioral research	scene video with gaze cursor, gaze position relative to head position, pupil size
<a href="#">HED-MHT</a> 	driving, industrial, hand-eye coordination, locomotion and gait studies, human factors, ergonomics, simulators, virtual reality	scene video with gaze cursor, gaze position in real world (gaze vector in space and intersection point with defined planes in 3D coordinates), pupil size
<a href="#">RED</a> 	gaze research on computer monitor, television or poster, psychology, usability, marketing research	gaze position on screen, projection screen or magazine (gaze position coordinates in units of the calibration area), pupil size
<a href="#">Hi-Speed</a> 	reading research, neurology, physiology, vision / ophthalmology research, psycho-linguistics,	gaze position on screen (gaze position coordinates in units of the calibration area), pupil size

psychology

[MRI](#) <sup>[182]</sup>

fMRI research,  
neurology,  
psychophysiology,  
brain mapping

gaze position on  
projection screen or  
stimulus goggles (gaze  
position coordinates in  
units of the calibration  
area), pupil size

The list of applications is not exhaustive but reflects only typical fields.

## 2.2.4 System Output

The iView X™ system has several output options, the use of which will depend on the scope of your experiment. Any of these data formats can be used concurrently.

### Data File

The system produces a binary **iView Data File (IDF)**, which is used as a basis for further analysis. The IDF file can be loaded into the *IDF Converter* and the *Event Generator*, which exports various kinds of data, such as pupil size and position, gaze position, detected saccades and fixations, etc. See [iView Data File](#) <sup>[260]</sup> for more information.

The IDF file can be also directly loaded into the SMI Behavioural & Gaze Analysis program **BeGaze™\***.

### Digital Output

The system outputs digital data through a digital IO card. The data include pupil position, mapped gaze data, or object hits. The digital communication can be used to trigger gaze-contingent changes in the stimulus display or to alert of a loss of fixation, a useful feature in fMRI studies.

## Analog Output

With an optional analog card, eye data can be translated to analog signals for incorporation into other research equipment.

## Video Data

iView provides the capability to add gaze cursor directly onto a PAL or NTSC video signal from a scene camera or scan converter. The output video can be captured as a video file on the computer or recorded on a standard VCR.

*\* BeGaze™ might not be part of your system. Contact [SMI](#)<sup>[11]</sup> for more information.*

## 2.2.5 Experimental Workflow

A typical eye tracking experiment consists of the following steps:

### Eye Camera Setup

The eye camera setup strongly depends on the used [Eye Tracking Camera System](#)<sup>[23]</sup> and will be outlined separately for each camera system.

### Calibration

A good calibration is crucial for the accuracy and the reliability of the results. How to calibrate will be covered separately for each camera system. For more detailed information see section on [System Calibration](#)<sup>[24]</sup>.

### Recording and Saving Data

Recording and saving the data will be performed by the iView X™ application software installed on the iView X™ workstation.

## Analysis of the Results

Depending on the [System Output](#) <sup>[25]</sup> there are various tools on the market available that help the researcher to automatically analyse the data. The IDF file can be directly analyzed by the analysis program SMI BeGaze™\*.

\* *BeGaze™ might not be part of your system. Contact [SMI](#) <sup>[11]</sup> for more information.*

## 2.3 Getting Started

This chapter outlines what to do when starting iView X™ for the first time, and how to run your first experiment.

### 2.3.1 Software Installation

If you obtained a new iView X™ workstation from SMI, the software is already installed and fully operational. You may then skip this section.

If, however, you have to install the iView X™ software on another PC you simply have to insert the installation CD into the CD ROM drive and follow the instructions of the installer.

If, for one reason, you have to reinstall the software, follow the instructions under [De-Installation and Update](#) <sup>[33]</sup>.

When the application runs for the first time you have to follow the [licensing procedure](#) <sup>[27]</sup>.

#### 2.3.1.1 Licensing Process

iView X™ is only licensed for installation on one computer with a specified set of components. When you first run the application, a reference code will be displayed in the initial dialog box. You must report this reference code to [SMI via phone or email](#) <sup>[11]</sup>. SMI will issue a Licence Key, which must be entered into the empty space of the initial dialog box for

activating the software.

The reference key consists of six four-number blocks. The Licence key consists of ten four-number blocks.

**Example: licensing by email**

iView X™ pops up a licensing dialog containing the reference code:

1234-1234-1234-1234-1234-1234

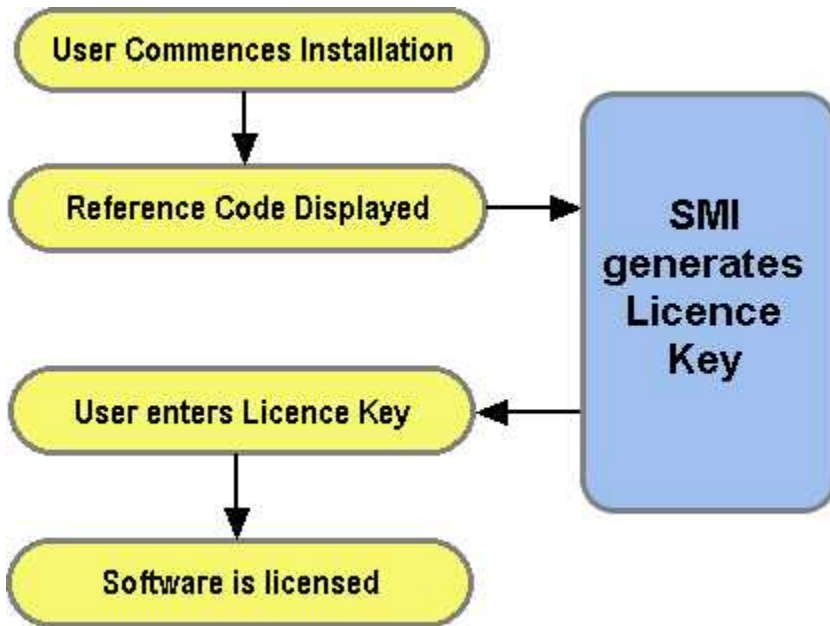
Mark the line and copy it to clipboard (Alt+C). Paste it (Alt+V) into your email. Send the email to SMI. SMI will send you an email with the licence key:

1234-5678-1234-5678-1234-5678-1234-5678-1234-5678

Copy and paste it in the licensing dialog into the empty space and click OK. The dialog disappears and the iView X™ program is opened. iView X™ is licensed and will not display the dialog again during the validity period, as long as you do not copy the software, or change hardware settings of your computer.



Overview of licensing process:



## Transfer Licence

If you have to transfer the licence to another computer, first [terminate the licence](#) on the old computer. Send the termination code together with the Reference Code of the new computer to SMI. SMI will then issue a new Licence Key.

## Add/Remove components

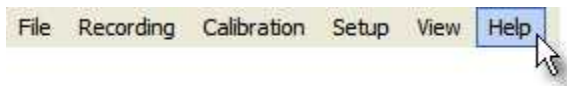
Every change of functionality requires a different Licence Key. Click on [Help](#) to view a list of currently licensed components on your computer. If you want to add or remove some of the components, please contact [SMI](#) for more information. If you obtain other components, SMI will ask you to [terminate the licence](#). Send the termination code to SMI. SMI will then issue a new Licence Key for the desired components.

### 2.3.1.1.1 Terminate Licence

In the following cases you need to terminate the licence:

- you need to transfer the licence to another computer
- you add or remove components to or from iView X

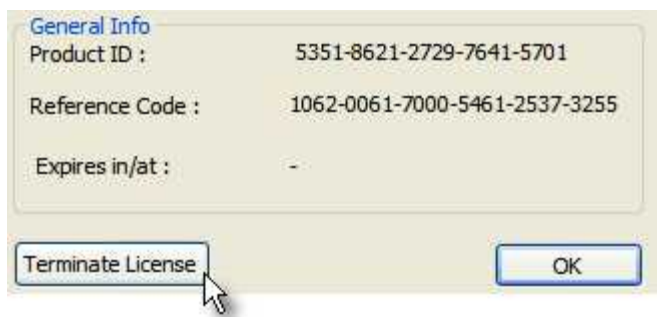
To terminate the licence go to the *Help Menu* :



and click on *License Information*:



A dialog box opens with an overview which components are [licensed](#)<sup>366</sup>.  
At the bottom of the overview find the *Terminate License* button:



Click on it. The current licence will be terminated. If you exit iView X you need a new Licence Key for activation.

iView X has generated a termination code and saved it to the file *TerminationCode.txt* in the iView X installation directory. Send this file to SMI to obtain a new licence.

Back to [Licensing Process](#) .

### 2.3.1.1.2 Time-limited Licence

If you have been issued a licence with a time-limitation, iView X asks you for a new Licence Key after the time limit has been expired. Contact SMI to issue a new Licence Key. Sending in the Reference Code is not necessary.

Back to [Licensing Process](#) .

### 2.3.1.1.3 Reusable Licence

If you have been issued with a 'Reusable' Licence Key it is important that you make a note of the number. In the event that the iView X installation folder has been corrupted or deleted, it is possible, after reinstallation of iView X to reuse the same Licence Key again on the same computer, *provided the hard disk has not been reformatted or the operating system reinstalled.*

Back to [Licensing Process](#) .

### 2.3.1.2 De-Installation and Update

If you update iView X™, follow the steps:

1. De-install iView X™ as usual under Windows. The usual procedure is to go to Start - Settings - Control Panel - Add/Remove Components. There you find all software components listed that are installed on your computer. Select iView X™ and click on *Remove*.
2. Install the new iView X™ version by putting the installation CD into the CD ROM drive. After installation you need to reboot the system.
3. After updating to the new version you have to tell the system again, of which components your iView X™ system consists. Therefore, you can consult the [System User Guide](#)<sup>51</sup>.

Licensing will not be affected through the update process.

### 2.3.2 Starting the Software



Start iView X™ by double-clicking on the iView X™ icon.



*It is recommended not to run other applications on the iView X™ workstation parallel to the iView X™ software. Other applications may interfere with its realtime behaviour.*

### 2.3.3 Quick Start Guide


This chapter covers how to set up, calibrate and run a typical experiment. Major procedures are described here without going much into detail. This should enable you to run your first experiment. More details can be found in other parts of the manual.

Quick guides exist for the following systems:

[HED 4](#)<sup>34</sup>  
[RED](#)<sup>43</sup>


[Hi-Speed](#) 

### 2.3.3.1 HED 4

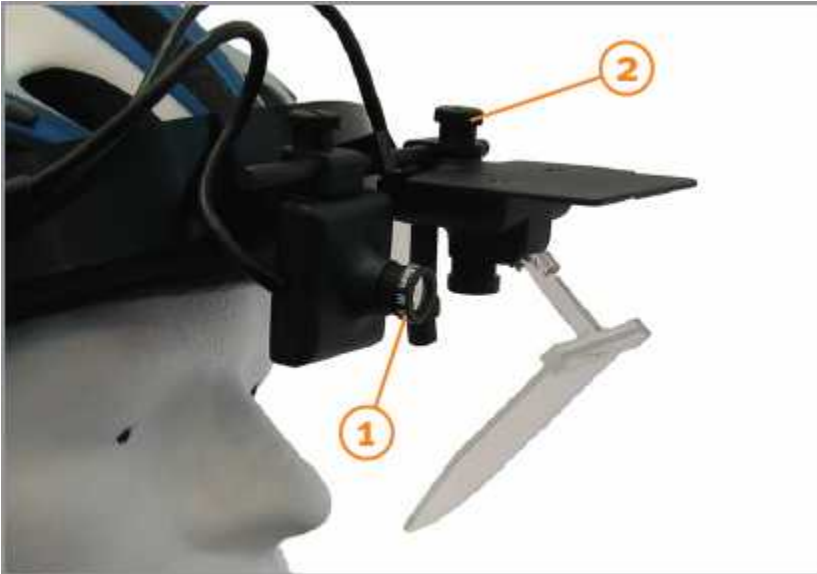
The following steps will roughly guide you through an experiment with an HED 4 system. For more information consult the chapter on [iView X HED 4](#) .

#### 2.3.3.1.1 Experiment Preparation

This quick guide describes the necessary steps to execute your first iView X™ HED experiment.

Start the program iView X HED by clicking on the iView X icon  on the desktop.

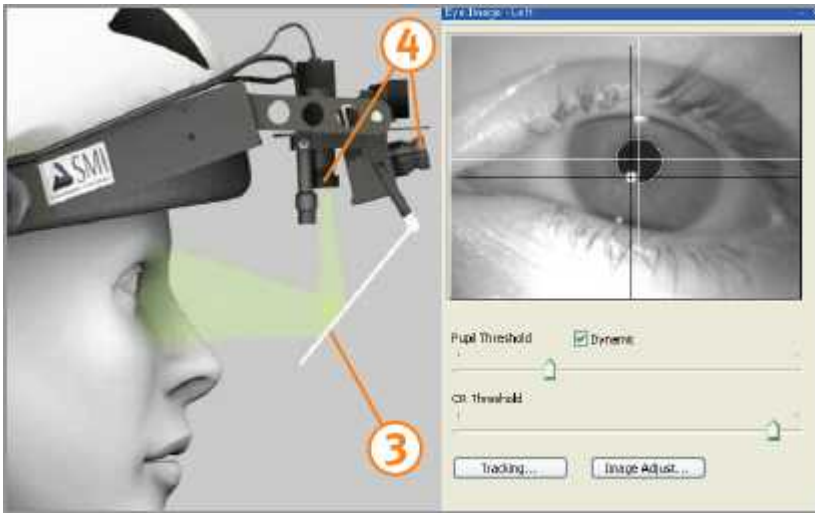
### 2.3.3.1.2 Step 1 - Camera Adjustments



- 1 **Scene camera adjustment:** Please verify that the wide-angle lens (3.6mm, +/-33°) is used on the scene camera. The wide-angle lens captures the widest visual field viewed by the subject.

**Hint:** Depending on the experimental goals, other lenses may be used. For example, in near field studies where the visual field of the subject is smaller and more focused, like reading or looking at an object in your hand, the 8mm lens may be more appropriate.

- 2 **Eye camera adjustment:** Loosen the screw that holds the eye camera and mirror. Turn the unit slightly upwards to avoid touching the test person with the mirror. Then place the cap on the test person's head. Adjust the cap/helmet so it is snug enough to avoid slipping during the experiment.

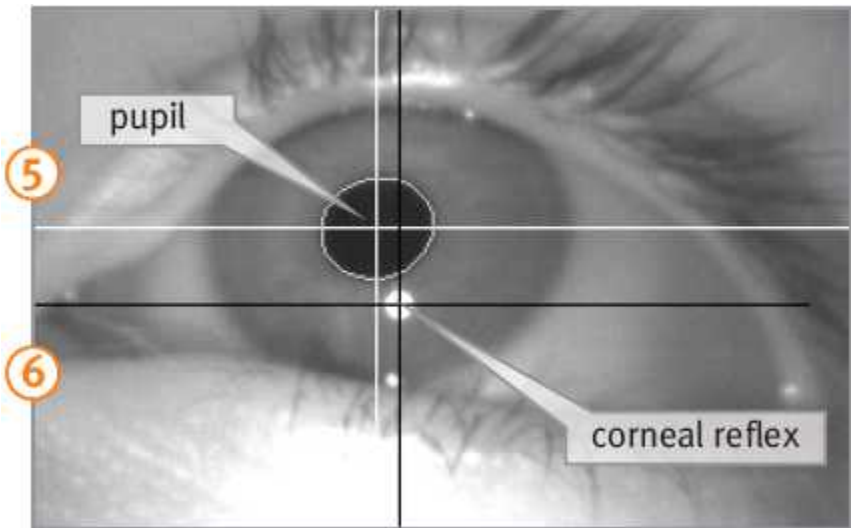


- 3 Adjust the mirror while watching the eye control window in iView X™ . The mirror is in the correct position if the test person's eye is centered. Fasten the mirror. The mirror should not touch the subject's face!

Hint: Minimize the distance between scene camera and eye camera if possible.

- 4 You can bring the video images into focus by rotating the focus ring on the scene camera and eye camera, respectively.



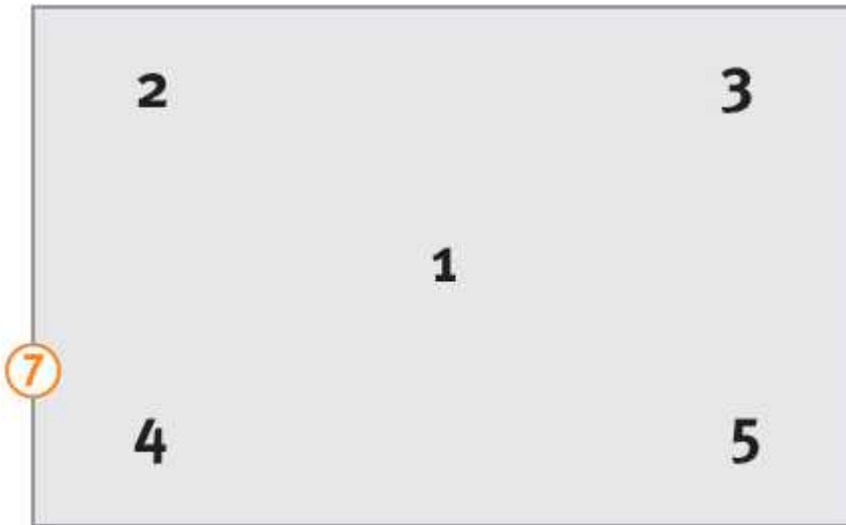


- 5 The white crosshair marks the center of the pupil and the black crosshair marks the center of the corneal reflex.
- 6 To ensure that conditions are adequate for tracking, ask the subject to look up and down, and to the right and left and verify that the crosshairs are following the pupil and the corneal reflex.

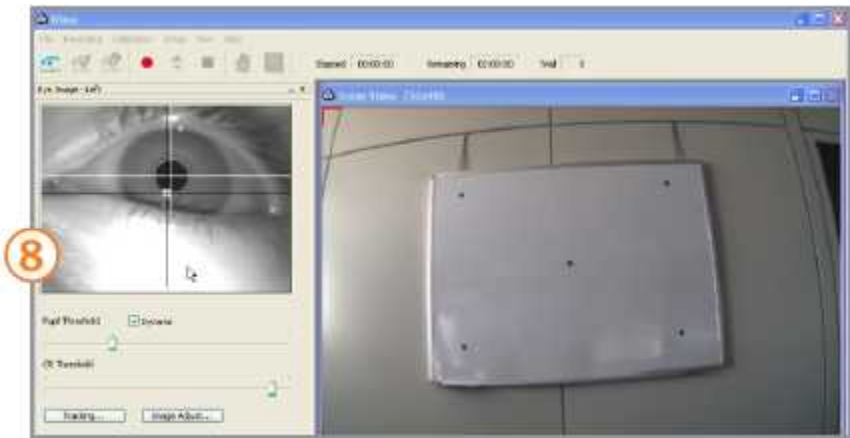


If the eye tracker is not tracking the pupil or CR properly, consult the chapter [Advanced Eye Image Adjustment](#)<sup>370</sup>.

### 2.3.3.1.3 Step 2 - Prepare for Calibration



- 7 Use a calibration plane with five distinctive targets in front of the subject on a flat panel. Calibration targets must be arranged according to this pattern. Instead of the numbers there should be distinctive targets, like dots or crosses.
- The panel can be a wall, whiteboard, paper, monitor, cupboard; any surface with a flat plane.
  - Targets can be stickers, corners of a window, magnets or anything else that is small and unique enough to allow the subject to focus on it.



- 8 The test person should sit or stand comfortably and look straight ahead at the calibration panel without moving the head. The calibration panel must be centered in the scene video window as shown in the picture.

Hint: For best accuracy the distance between the subject and the calibration plane should be approximately the same distance as objects observed during experimentation.


#### 2.3.3.1.4 Step 3 - Execute Calibration

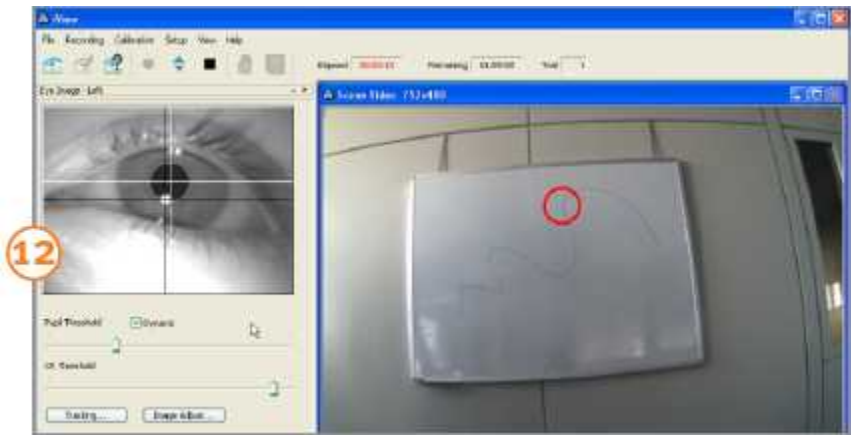
- 9 Click on the start calibration button  (or F5) to begin calibration.



- 10 Please advise the subject to look at center target point without moving their head. Left-click with the mouse on the calibration target to align the cross/diamond in the iView X™ scene video with the center (first) point on the calibration panel. The diamond shaped frame that surrounds the cross indicates a stable fixation.



- 11 Now press the calibration point accept button  (or space bar). After the calibration point has been accepted from iView X™, the cross will move the second calibration point position in the upper left corner.




12 Please repeat the procedure in the same way with all the remaining calibration points that will appear in turn. When the calibration is complete, the scene video will display a realtime gaze cursor indicating the subject's gaze position.

#### 2.3.3.1.5 Step 4 - Study/Experiment Execution

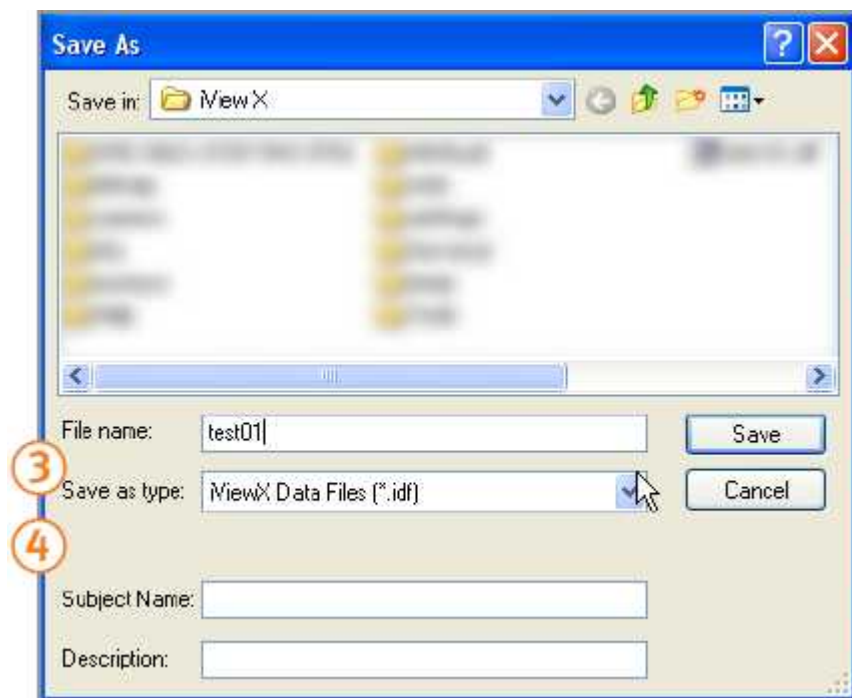
Upon completion of a successful calibration you are ready to start your study/experiment.


#### Record Video

1 Click on the *start recording button*  to start the live video recording with gaze cursor overlay.

2 Click on the *stop recording button*  to stop the recording.

## Save Data



3 Click on the *save button*  to open the save video and data dialog and enter a filename.

4 Optionally, fill in *Subject Name* and *Description*. Click on *Save* to save the data.

### 2.3.3.1.6 Step 5 - Analysis

The result after recording is an AVI video file containing the scene video with a real-time gaze cursor overlay indicating the subject's gaze position. You can playback this video with any video player software (e.g. Windows Media player). Please note that the xVid MPEG4 codec has to be installed on your PC.

### 2.3.3.2 RED

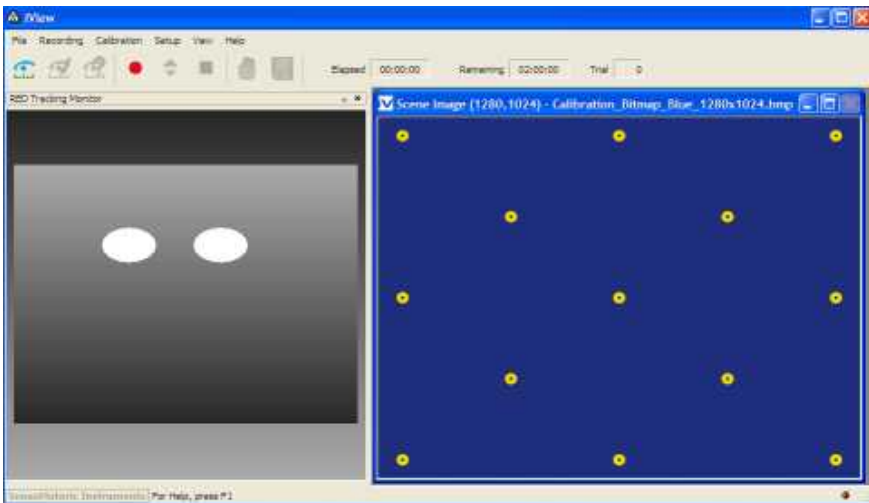
The following steps will roughly guide you through an experiment with an RED system. For more information consult the chapter on [iView X RED](#) <sup>[101]</sup>.

#### 2.3.3.2.1 Experiment Preparation

1. Check that iView X™ workstation is properly connected to the [ET module](#) <sup>[105]</sup> and is running.



2. Start iView X™ by clicking on the icon



3. Check Calibration Settings under Setup-Calibration. The following options are recommended:
  - enable *Accept Points Automatically*.
  - enable *Wait for Valid Data*.
4. It is recommended to enable *Average Binocular Data* under Setup-Tracking-Input Filter.

5. Start SMI Experiment Center™ or a stimulus program capable of running an automatic calibration
6. Check that the Ethernet Settings are properly set:
  - in iView X™ under Setup - Hardware - Communication
  - in SMI Experiment Center™ under Extras - Global Settings

For details about these settings, consult in the manual [Network Connection to Stimulus PC](#)<sup>[394]</sup>.

7. In the stimulus program choose *Calibration Background Color* and *Target Color* so, that it is similar to the stimulus presentation (what you want to look at during recording).

#### 2.3.3.2.2 Test Person Placement

1. Place a test person in a comfortable position in front of and centered to the Stimulus PC monitor.
2. If the eyes are tracked by the system, two white eye dots are visible in the RED Tracking Monitor.
3. If tracking is lost the white dots have disappeared from the RED Tracking Monitor.
4. Arrows indicate the optimum position of the test person in front of the monitor:
  - . If the test person sits too far away from the screen an arrow indicates that he or she should move closer:



- . If the test person sits too close to the screen an arrow indicates that he or she should increase the distance to the screen:



Other arrows direct the test person to center his or her head in front of the monitor. The test person sits correctly if all arrows have vanished. A correct test person to monitor distance should be



between 60 and 80 cm.

### 2.3.3.2.3 Run Experiment

Start an experiment with *SMI Experiment Center™*. For more information see the *SMI Experiment Center™* manual.

The result of the measurement is an [.idf file](#)<sup>[260]</sup> recorded and stored on the iView X PC. The resulting file can be loaded into *SMI BeGaze™* analysis software for visualization and further analysis.



### 2.3.3.3 Hi-Speed

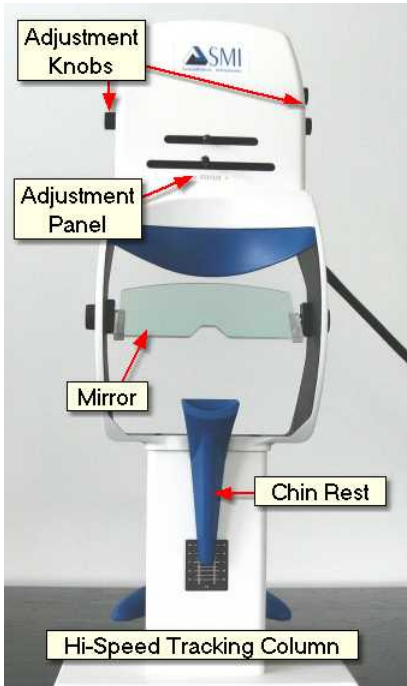
The following steps will roughly guide you through an experiment with a Hi-Speed system. For more information consult the chapter on [iView X Hi-Speed](#)<sup>[129]</sup>.

#### 2.3.3.3.1 Experiment Preparation

The following steps describe how to run a simple monocular iView X™ Hi-Speed experiment. It is assumed that

- the iView X™ workstation and the Stimulus PC are properly connected, powered and running. The *Eyetracking Column* has to be switched on prior to starting iView X™ software.
- the stimulus PC is properly connected to the iView X™ workstation and is running *SMI Experiment Center™* or a stimulus program capable of running an automatic calibration
- calibration settings are set properly in the iView X™ application

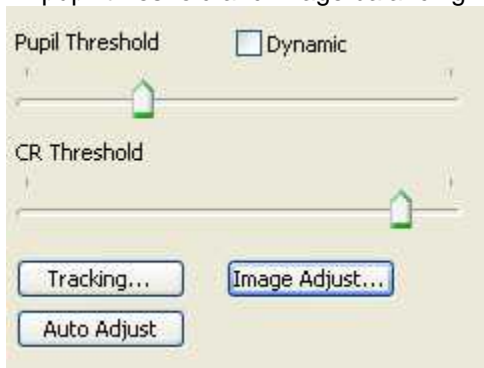
### 2.3.3.3.2 Eye Camera Setup



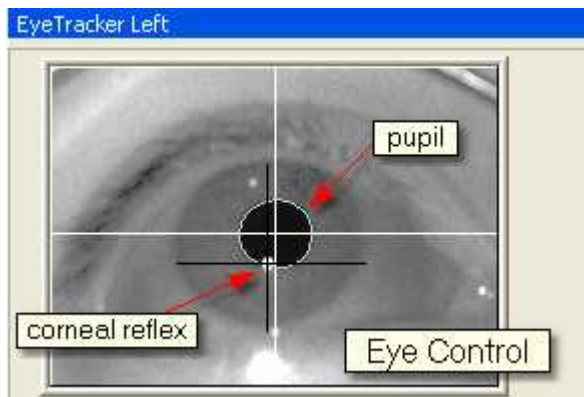
Click in the Eye Control window to activate the eye tracker. The User message in the System Log should read "Grab started". Then follow the steps:

1. Place the test person in front of the tracking column. Make sure that test person is comfortably seated and that the mirror does not touch any parts of the face or the eyes. The forehead should rest on the head rest.
2. Vertically move the chin rest until the eyes and the markers at both sides of the column are on the same height.
3. Move camera horizontally until the eye is horizontally centered in the eye image control.

- Adjust the vertical position of camera (camera tilt), until the eye is vertically centered in the eye image control.
- Adjust the tilt of the mirror to remove possible reflections from the eye image, after which the vertical position/tilt of the camera probably needs to be readjusted.
- Adjust the focus until the corneal reflection is as small as possible. This assures optimal focus on the eyeball.
- Let the test person look at a center target of the stimulus display. Click on the *Auto Adjust* button to automatically adjust the image regarding pupil threshold and image balancing.



- The white cross-hair should be centered on the pupil and the black cross-hair on the corneal reflex (CR). If not, you can adjust them by moving the sliders.



9. Ask the test person to look at the four corners of the screen. Setup is complete if both crosshairs follow the pupil and cornea reflex during these eye movements.

If the image seems to be blurred, is too dark or too bright, click on the [Image Adjust](#)<sup>[348]</sup> button to adjust brightness and contrast, where you can also click on *Auto Balance* to let the eye tracker self-adjust its brightness and contrast.



If the eye tracker is not tracking the pupil or CR properly, consult the chapter [Advanced Eye Image Adjustment](#).<sup>[370]</sup>

### 2.3.3.3.3 Run Experiment

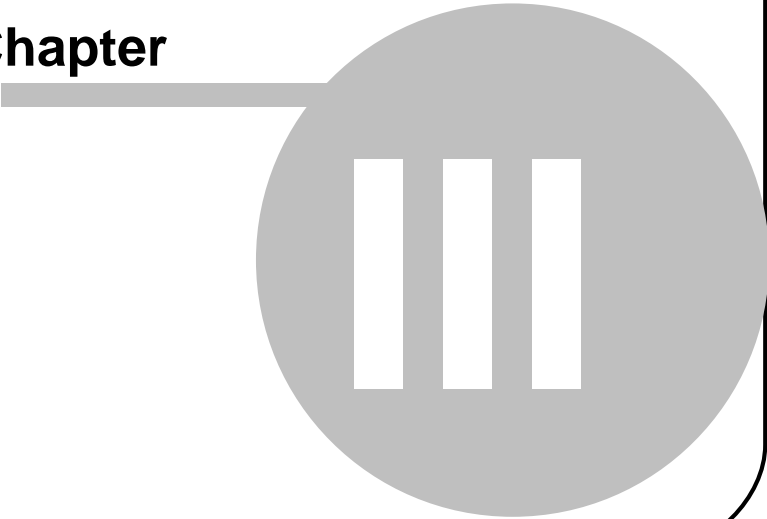
Start an experiment with *SMI Experiment Center*<sup>TM</sup>. For more information see the *SMI Experiment Center*<sup>TM</sup> manual.

The result of the measurement is an [.idf file](#)<sup>[260]</sup> recorded and stored on the iView X PC. The resulting file can be loaded into *SMI BeGaze*<sup>TM</sup> analysis software for visualization and further analysis.



# System User Guide

**Chapter**



## 3 System User Guide

This chapter describes all available iView X™ eye tracking interfaces and their uses.

### 3.1 iView X HED 4



The iView X™ HED 4 system is a headband, cap or helmet, on which a camera assembly is mounted. Typical applications include driving, industrial, hand-eye coordination, locomotion and gait studies, human factors, ergonomics, consumer behavior, sports and behavioral research.

Gaze data is usually recorded in terms of the scene camera pixel resolution. The HED also outputs the head-mounted scene video with

gaze position indicated by a gaze cursor.

The cornea reflex is tracked to provide slip compensation, which compensates for movement of the camera assembly on the head.

The test person can freely move during the experiment and the gaze point is detected in a 3-D-space. This feature makes iView HED suitable for most applications.

The output is a video with a gaze cursor displayed on it. Numerical data is given in coordinates of the scene video.

### 3.1.1 Features and Benefits

The iView X HED 4 system is a fully mobile, lightweight head-mounted eye tracking system for tracking gaze position in real life environments. It excels in minimal setup and accurate recording, is easy to use and extremely versatile.

#### Technology

- Non-invasive, video-based eye tracking
- Monocular, pupil-CR, dark-pupil tracking

#### Performance

- Sampling rate                                    50 Hz (default)  
    200 Hz (optional)
- Tracking resolution                            < 0.01° (typ.)
- Gaze position accuracy                        0.5° - 1° (typ.)

#### System

- Operating system                                Windows XP
- Workstation                                        Tablet PC or laptop
- Mobility Package                                 Extra batteries, external charger,



12V car adaptor

## Headset

- Lightweight, comfortable, quick & easy to adjust
- Bike helmet, baseball cap, headphones, flight helmet, and headband mount available
- Interface weight 79g
- Cable length 5m and 2m (set of cables)

## Auxiliary Devices / Communication

- Digital scene video recording in broadcast quality (MPEG-4)
- Audio channel recording
- Open platform communication interface (UDP)
- Compatible with SMI BeGaze™ Analysis Software.
- Compatible with 3rd-party video analysis packages (e.g. The Observer™ from Noldus)

## System Options

- High-speed eye tracking option (200Hz)
- 6D head tracking option for numerical recording of gaze position in complex environments (e.g. simulators, CAVE)

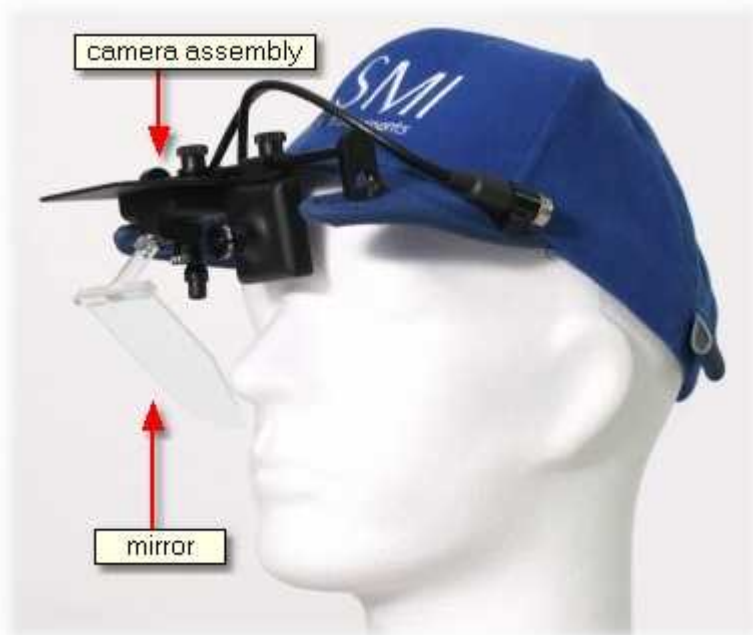
## Approvals

- CE, EMC, Eye Safety

### 3.1.2 Hardware Components

In the HED 4 system the video signals are not analogue but digitized and send to the iView X™ workstation via USB port. See [HED 4 Camera](#) <sup>[54]</sup> for details.

#### 3.1.2.1 HED 4 Camera



The HED is a camera assembly, that depending on the specific application can be mounted on a cap, helmet or headband. It consists of an eye camera, a mirror which directs the eye image to the eye camera and a scene camera, that is directed towards the scene in front of the test person.

The scene camera is provided with three different [lenses](#) <sup>[55]</sup>.

## Connection

Both cameras are connected to two USB ports of the iView X™ workstation.

After having connected the plugs, the iView X™ software must be told the current configuration in the [Setup Hardware](#) <sup>[290]</sup> dialog.

### 3.1.2.2 HED 4 Scene Camera Lenses

The HED 4 is provided with three scene camera lenses, which fit for various experimental setups:

focal length	aperture angle
3.6 mm	$\pm 33^\circ$
6 mm	$\pm 22^\circ$
8 mm	$\pm 15^\circ$

The aperture angles reach from  $\pm 33^\circ$  for experiments that need a wide angle survey to  $\pm 15^\circ$  for limited surveys on panels or similar. For best accuracy it is recommended to use the lens that fits best to your experiment.

## 3.1.3 User Guide

The following guide describes the steps how to set up, calibrate and run an iView X™ HED 4 experiment, after the system has been [wired](#) <sup>[54]</sup> properly.

### 3.1.3.1 Initialization of Software

Turn on the iView X™ workstation.

Start iView X™ by double-clicking on the iView X™ icon.



Next, iView X™ must be initialized to run with this configuration. Therefore, the iView X™ program must be told, which hardware components we use. Usually, it will be done only once on installation, but just in case, the software must be reinitialized, check the following:

From the [Setup](#)<sup>[290]</sup> menu go to [Hardware](#)<sup>[290]</sup>.

- Set *Eye Tracker Device* to HED 4.
- Click on [Advanced](#)<sup>[290]</sup>.
- Under *Eye* choose, if left or right eye should be tracked and recorded.
- Click on *OK* to close the *Advanced* dialog.
- Click on *OK* to close the *Setup Hardware* dialog.

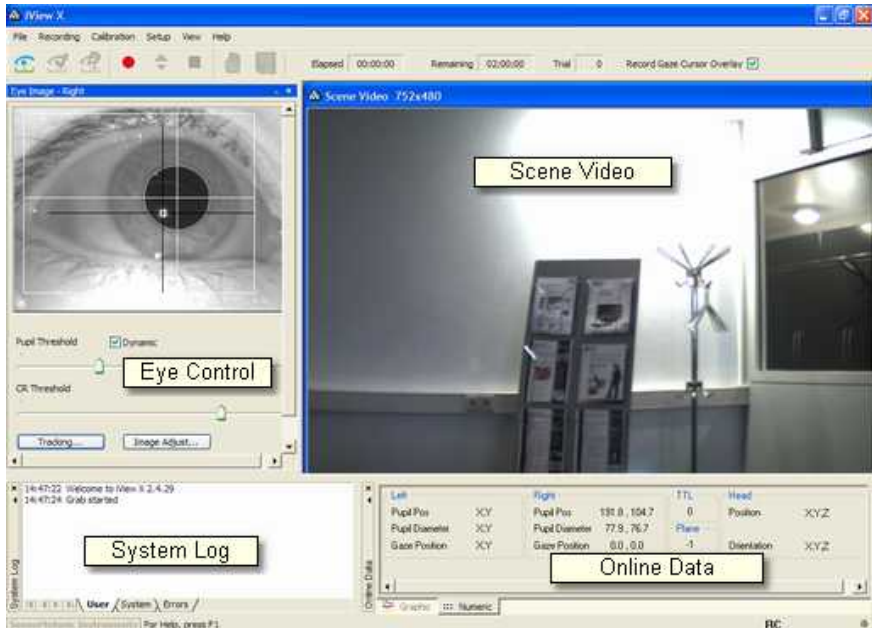
Activate eye camera by clicking on the [Eye Control](#)<sup>[343]</sup>.

Arrange docking windows.

- Go to the [View](#)<sup>[337]</sup> menu and set a check mark to the following windows:



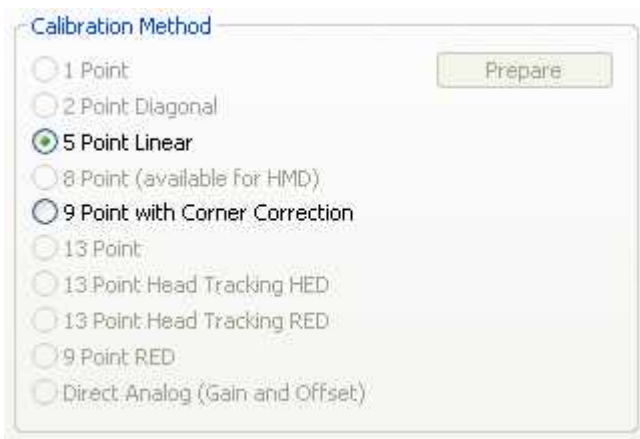
- Align all windows around the Scene Image Window as suggested below:



A typical iView X™ window arrangement (HED systems)

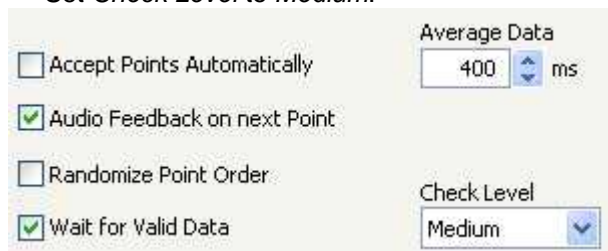
From the menu go to [Setup](#)<sup>[290]</sup> - [Calibration](#)<sup>[313]</sup>.

- Set Calibration Method to 5 Point Linear, which is quick and accurate enough for HED.



*Calibration Settings for HED systems (upper part)*

- Uncheck *Accept Points Automatically*, because we will do a manual calibration.
- Check *Audio Feedback on next point*.
- Uncheck *Randomize Point Order*. As we do a manual calibration we have to know the calibration point order.
- Check *Wait for Valid Data*.
- Set *Check Level* to *Medium*.



*Calibration Settings for HED systems (lower part)*

- Click on OK to close the window.

From the [Setup](#)<sup>[290]</sup> menu go to [Output](#)<sup>[324]</sup>.

- Go to the [Gaze Cursor Properties](#)<sup>[327]</sup> tab.
- If needed, enlarge the sizes of all cursors (left, right and calibration cursor) so that the targets can be comfortably look at. Adjust color to

the scene. The cursors will be overlaid on the scene video during recording, so choose a color that can be easily distinguished from the scene.

- Go to the [Gaze Cursor Filter](#)<sup>[326]</sup> tab.
- Set *Method* to *Manual*.
- Set *Filter Depth* to 100 ms and *Saccade Length* to 20 pixel.
- Click on OK to close the window.

### 3.1.3.2 Adjust Camera and Eye Video

Loosen the screw that holds the IR mirror and turn the mirror slightly upwards, so it will not touch the test person, then put the cap on the test person's head.

Adjust the cap so it is snug enough to avoid slipping during the experiment.

Turn the mirror downwards and adjust it while watching the Eye Control: The mirror is in the correct position if the test person's eye is centered. Fasten the mirror. The mirror should not touch the test person's face.

Rotate the focus ring on the eye camera to focus the eye image. Use the cornea reflex as indicator: The eye image is sharpest if the cornea reflex is smallest.

Check the *Dynamic* check box, so the eyetracker tries to adjust the pupil threshold automatically.

If necessary, click on [Image Adjust](#)<sup>[347]</sup> to change the brightness of the eye video.

Ask the test person to look up and down, and to the right and left. The setup is complete if both crosshairs follow the pupil and the corneal reflex during likely eye movements and positions.

If the eye tracker has difficulties to track the pupil or CR, see more in chapter [Advanced Eye Image Adjustment](#)<sup>[370]</sup>.

### 3.1.3.3 Adjust Scene Video

Adjust the scene video so that it covers the field of view of the test person. You can loose the screw that holds the scene camera. The camera can then be tilted and moved. Control the field of view by watching the scene video. If the field of view is appropriate, fasten the camera.

If you right-click on the scene video, a [context menu](#)<sup>[60]</sup> pops up.

#### 3.1.3.3.1 Context Menu: HED scene video

If you right-click on the [HED](#)<sup>[51]</sup> scene video, the following context menu pops up:

##### **Reset to Original Size**

Sets the scene video window to its original size, if it has been resized previously.

##### **Adjust Scene Cursor**

Is enabled only for [HED-MHT](#)<sup>[68]</sup> systems. Starts a [Scene HT calibration](#)<sup>[322]</sup>.

##### **Copy Scene**

Copies contents of scene video window to clipboard.

##### **Use Hardware Gamma**

Hardware Gamma can be used to increase the picture quality under extreme light conditions (very dark or very bright light conditions). You can also switch ON/OFF this feature in realtime by using the shortcut Ctrl+H.

##### **Gaze-following gain control**

Enable this option if you measure under extreme light changing conditions, like car driving in bright sunlight, where inside and outside need to be observed.

See also [HED settings](#)<sup>[299]</sup>.



### 3.1.3.4 Calibration

As the accuracy of the measurement strongly depends on the previously performed [calibration](#) <sup>[18]</sup> of the system, we should spend some thoughts on it.

First you have to select the proper [calibration distance](#) <sup>[61]</sup>.

Then you have the choice between two calibration methods:

- [with calibration panel](#) <sup>[62]</sup>
- [without calibration panel](#) <sup>[63]</sup>, instead using a laser pointer.

#### 3.1.3.4.1 Select Calibration Distance

For a calibration the test person has to fixate points at known positions on a calibration plane. For best accuracy the distance of the calibration plane should be exactly the distance of the observed objects. The bigger the deviation between the calibration plane distance and the distance of the observed objects, the bigger is the parallax error. In an actual measurement, however, the distance of the observed objects vary. Therefore, you have to decide, if the measurement is more focussed on the near field (< 1 m) or the far field (> 1 m).

Examples:

	measurement examples:	distance between test person and calibration plane
near field (< 1 m)	<ul style="list-style-type: none"> <li>- observing monitor/keyboard/mouse while working in an office</li> <li>- reading a newspaper</li> <li>- observing the panels in a driver/pilot cockpit</li> <li>- handling of terminals (like cashpoints)</li> </ul>	exact or average distance of the observed panels
far field (> 1 m)	<ul style="list-style-type: none"> <li>- observing the street scene outside of the driver's cockpit</li> <li>- going through a supermarket</li> </ul>	exact or average distance of the observed objects, or, if not possible, at least 2 m.

both	- going through a supermarket (far field observation) and choosing articles from a shelf (near field observation)	no optimum distance, divide the experiment into two measurement series
------	---	--

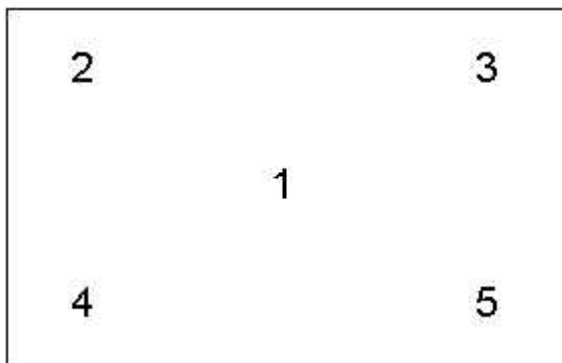
If you calibrate in the near field and observe a scene in a far field, or if you calibrate in the far field and observe a near field, you will get a noticeable parallax error.

If you need both, you have to perform two measurement series, each of them optimized for each field.

#### 3.1.3.4.2 With Calibration Panel

Place a calibration panel with the proper [distance](#) <sup>61</sup> in front of the test person.

The calibration panel should have five calibration points in the following arrangement:




Instead of the numbers there should be distinctive targets, like dots or crosses, without the corresponding numbers. Trials with labelled targets have shown that test persons first look at the numbers, then at the crosses, which would spoil the calibration process. Therefore the test person must be guided by voice output or by the operator to fixate the respective targets.

The actual calibration points should resemble this pattern roughly in geometry. The exact distances between the points are not important.


While the test person sits or stands comfortably without moving its head and looking at the calibration panel, the calibration pattern should cover most of the visual field of the test person. Watch the scene video to adjust the calibration panel properly.



Click on *Start Calibration* . The first centered point appears in the scene view.

[Move](#) <sup>[252]</sup> the point, so that it matches the first point on the calibration panel. Tell the test person to look at the first point.



Click on *Accept Calibration Point*  or hit F6 to accept the point and proceed to the next point. The next point appears in the scene view. Move the point to match with the second point of the calibration panel.

Repeat with all calibration points.

Check the *Error* tab in the *System Log* window for potential problems during the calibration.

If the *User* message in the *System Log* is "Calibration finished successfully", the scene video shows you live gaze data as a cursor overlay.

After having calibrated all points you can check its accuracy by asking the test person to look at a specific point.

#### 3.1.3.4.3 Without Calibration Panel

Make sure the calibration points have default positions. To make sure, go to [Setup Calibration](#) <sup>[313]</sup>, click on *Reset Calibration Points* and then on *OK*.

Place the test person comfortably facing any flat plane, wall or similar, which serves as the calibration plane.

If the test person wears a wide angle scene camera, the default calibration points in the corners are probably too far outside. In this case you can select from the [Calibration](#) <sup>[287]</sup> menu *Edit Points* and [move](#) <sup>[252]</sup> the

corner calibration points nearer to the center. Otherwise the default positions need not be changed. The test person should be able to look at all the calibration points without moving its head.



Click on *Start Calibration*. A calibration cursor will appear in the centre of the scene video. Use the laser pointer to shine a light on the scene at the location of the calibration cursor. Get the user to look at this point, while he should avoid moving its head.

The target on the iView X™ workstation will indicate a fixation according to the following:



Stable Fixation



No Fixation  
or Lost Pupil



Click on *Accept Calibration Point* or hit F6 to accept the point and proceed to the next point.  
Repeat with all calibration points.

Check the *Error* tab in the *System Log* window for potential problems during the calibration.

If the *User* message in the *System Log* is "Calibration finished successfully", the scene video shows you live gaze data as a cursor overlay.


After having calibrated all points you can check its accuracy by asking the test person to look at a specific point.

### 3.1.3.5 Record and Save



1. Click on *Start Recording* to start the measurement.

2. Click on *Stop Recording*  to end the measurement.

3. Click on the *Save* button  to open the save data dialog.
4. Enter a file name.
  5. Optionally, fill in *Subject Name* and *Description*.
  6. Click on *Save* to save the data.

As a result of the measurement two files will be created:

- a video file with an overlay gaze cursor
- an [IDF](#)<sup>[260]</sup> data file, which contains the numerical gaze data given in coordinates of the scene video.

Normally, sound is recorded as well, if a microphone is connected and activated. See [Audio Recording](#)<sup>[372]</sup> for more details.

### 3.1.4 Safety Notes

Switch off all components before connecting or disconnecting cables.

When setting up the system, make sure that all connectors and switches are easily accessible.

Periodically check the technical safety of the device, e.g., check for damage to the housing etc.

Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).

In case your iView X system or a component of the system is damaged, switch off the whole system and unplug it from the power source. Do not use the system until the system or its component has been repaired by a certified distributor or the manufacturer (SMI).

Only use original components (cables, power supply etc.) from SMI.

In case a component needs to be replaced, only replace it with original components from SMI.

Do not repair the system by yourself. Electrical shock hazard.

No part of the product may be modified or rebuilt.

Any usage other than described in this manual is not permitted, can damage the device and eventually lead to associated risks such as short-circuit, fire, electric shock, etc.

We do not assume liability for resultant damages to property or personal injury if the product has been abused in any way or damaged by improper use or failure to observe these operating instructions. In addition, any unauthorized modifications or repairs of the device will render the warranty null and void!

### **LED illumination**

To avoid unnecessary IR radiation for the eyes, switch off the system when not in use.

The HED camera system uses invisible LED radiation Class 1.

The used wavelength is 880 nm.

### **Electromagnetic compliance**

**WARNING:** This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications.

### **Electrostatic sensitivity**

**WARNING:** All internal electronics are sensitive to high voltage or electrostatic discharge. The system can be destroyed if carelessly handled, so extreme care should be taken during set up and operation.

## **Operating Temperature**

The system is designed to operate satisfactorily in an environment where the ambient temperature is between 10 °C and 50 °C, and that there is no water condensation present.

## **Storage Temperature**

Do not store the equipment in an area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## **Packaging for shipment**

When shipping, use the shipping cartons in which the units were originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## **Disposal**

Dispose the device according to legal regulations.

## **3.1.5 Maintenance**

Switch off the system before cleaning.

Use a clean lint-free, antistatic, slightly moistened cloth to clean the device. Do not use abrasives, detergents or solvents.

Make sure that the camera modules do not come into contact with liquids during cleaning.

## 3.2 iView X HED-MHT



The iView Head Tracking HED (HED-MHT) system is an extension of the [HED](#). It uses the same head-mounted interface but adds a 6D Magnetic Head-Tracker. The system tracks both eye movements and head position in space. Objects in the environment are identified so gaze vector intersection can be calculated. The HED-MHT is used for complex environments when gaze intersection with several defined planes is necessary. This may include simulators or complex industrial experiments. iView HED-MHT data consists of gaze vector in space and intersection point with defined planes (usually in millimeters).

The iView HED-MHT system combines the advantages of the RED and the HED: During the experiment the test person can freely move in a certain perimeter, limited only by the radius of the magnetic transmitter. The output of the system is numerical gaze position data on various planes in a 3-D field, which can be processed automatically by other programs. Additionally, head position, head rotation and eye position are provided.



See also:

[Features and Benefits of the HED system](#) <sup>52</sup>

### 3.2.1 Hardware Components

The iView X™ HED-MHT system can be used with the following components for head tracking:

- . [Polhemus Fastrak System](#) <sup>69</sup>



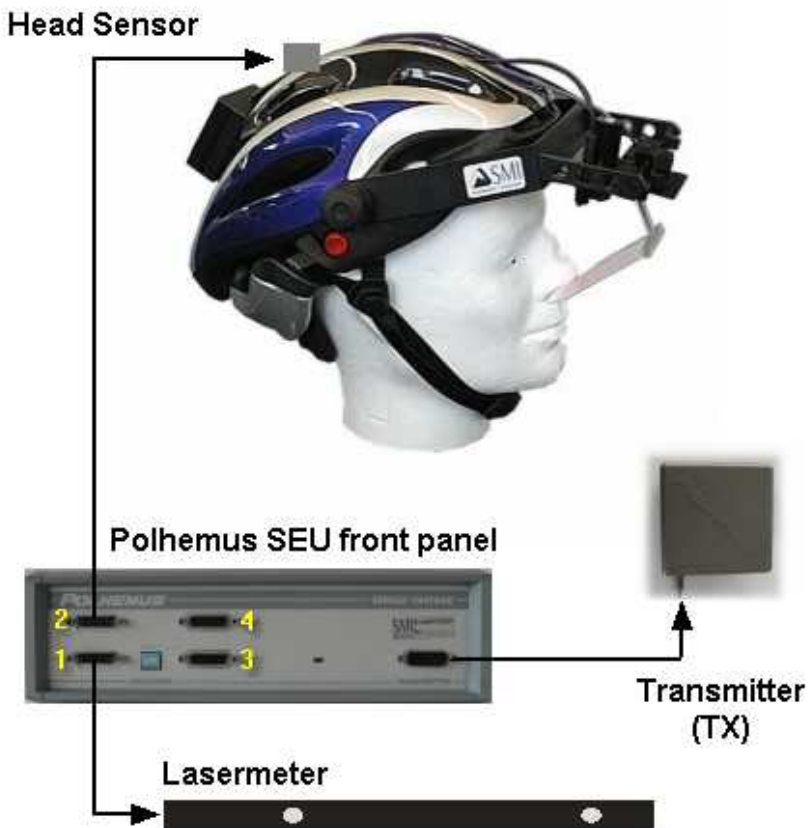
*For safety reasons switch off all components before connecting or disconnecting cables!*

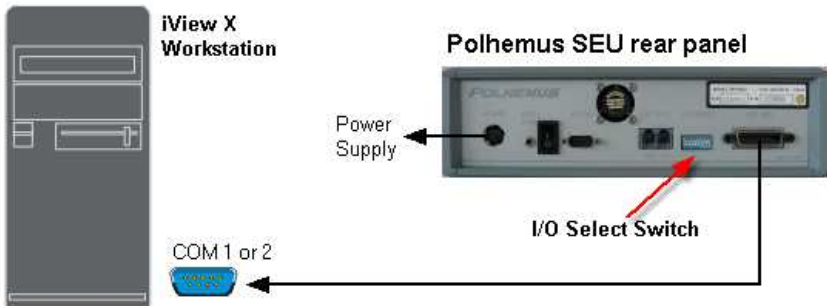
#### 3.2.1.1 HED-MHT with Polhemus Fastrak System

The iView HED-MHT is an add-on to the [HED 4](#) <sup>51</sup>. It adds a Polhemus FASTRAK motion tracking system.

Additional required hardware components:

- Polhemus System Electronics Unit (SEU)
- Transmitter cube (TX)
- Passive receiver (head sensor) mounted on the helmet of the HED
- Lasermeter, with laser pointer and *Stylus* receiver integrated
- Serial connection cable





### Cabling scheme:

- The lasermeter is plugged into port 1 of the SEU.
- The head sensor is plugged into port 2 of the SEU.
- The transmitter cube is connected with the designated plug at the front side of the SEU.
- The RS-232 connector of the SEU is connected with a free COM port of the iView X™ workstation.
- Identify the I/O Select Switch located on the rear panel of the SEU. Set the switches to the following positions:



*I/O Select Switch Settings*

<u>Switch</u>	<u>Position</u>
1	UP
2	UP
3	UP
4	DOWN
5	UP
6	DOWN

7	DOWN
8	UP

- Finally connect the power input connector with the power supply.

### 3.2.2 User Guide

The following sections describe how to setup, calibrate and run an [HED-MHT](#)<sup>[68]</sup> experiment.

Check the connection between the head tracker and the iView X™ workstation according to the wiring overview in section

[HED-MHT with Polhemus Fastrak System](#)<sup>[69]</sup>.

Check, if the iView X™ software is licensed to use Head Tracking HED, see

[Licensing](#)<sup>[73]</sup>

Some thought should be given to the measurement environment and its survey. Follow the steps, that are described in the following sections

[The Measurement Model](#)<sup>[73]</sup>

[The Transmitter](#)<sup>[74]</sup>

[Plane Definition](#)<sup>[76]</sup>

[Plane Properties](#)<sup>[77]</sup>

[Surveying a single plane](#)<sup>[79]</sup>

[Points on a Plane](#)<sup>[82]</sup>

[Objects on a Plane](#)<sup>[83]</sup>

[Calibration Plane](#)<sup>[84]</sup>

iView X has to be prepared to use Head Tracking HED, see

[Adding Head Tracking HED to iView X](#)<sup>[87]</sup>

A step-by-step software initialization procedure is provided in

[Initialization of Software](#)<sup>[87]</sup>

After the measurement environment is set up properly you can work with the test persons, which is described in

[Operating Procedure](#) <sup>[91]</sup>

Only if you need to disassemble the Lasermeter you should read

[Lasermeter Calibration](#) <sup>[94]</sup>

### 3.2.2.1 Licensing

#### Licensing

iView X™ has to be licensed to use head tracking. Click on [Help](#) <sup>[364]</sup> [License](#) <sup>[366]</sup> to see if head tracking is currently licensed on your computer. If not, contact your vendor. If you purchased the head tracking component, you have to add the component to the License Key. To do so, you have to terminate the old license and ask SMI to issue a new License Key. See also [SMI Software License](#) <sup>[27]</sup> for more information on the licensing process.

### 3.2.2.2 The Measurement Model

iView HED-MHT detects gaze points on various theoretically infinite planes in a 3-D field. The location of the planes must be surveyed before the actual experiments can be performed. In reality, though, there are no planes, so you have to design a measurement model, which fits your environment best.



iView X™ handles up to 16 limited flat panels that we furthermore call "planes". On each plane you can define up to 16 areas of interest, furthermore called [objects on a plane](#)<sup>83)</sup>, that will be dealt with later. One plane will be the [Calibration Plane](#)<sup>84)</sup>, that leaves you 15 free selectable planes for your model. Thus, the next step will be:

- Divide your environment into not more than 15 even planes + 1 calibration plane.

If you can integrate the calibration plane in your environment, you will have up to 16 planes for your model, but the calibration plane need not be integrated.

The planes need not be necessarily right-angled. They can also be parallelograms. If you choose them right-angled, however, it will be easier later to check the accuracy of the survey.

### 3.2.2.3 The Transmitter

The transmitter (TX) contains electromagnetic coils enclosed in a cube that emit the magnetic fields. The transmitter is the headtracker's reference frame for all measurements.

Two types of transmitters can be used with the system:

**TX2**

The 2-inch (5 cm) transmitter is best suited for experiments where only small head movements are expected.

Working range is 10 to 80 cm.

**TX4**

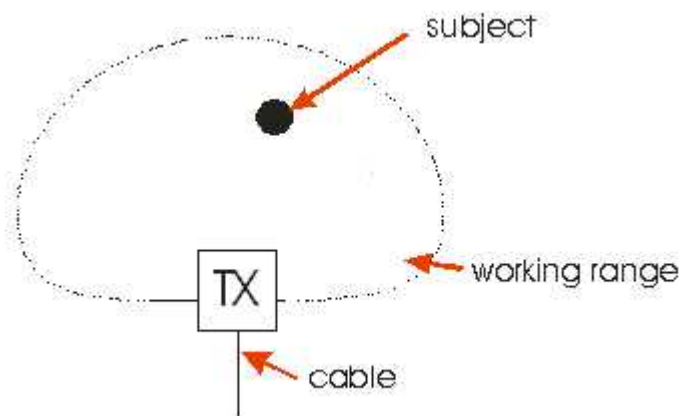
The 4-inch (10 cm) transmitter is used whenever a wider working range is needed. Please note that this transmitter requires a larger minimum distance to the sensor.

Working range is 30 to 120 cm.

Both the TX2 and the TX4 use the same mounting hole pattern so they are easily interchangeable.

In iView Head Tracking experiments the test person can move freely within the working range of the transmitter: However, the working range is a hemisphere rather than a sphere. If the test person moves to the wrong side of the cube the data becomes invalid. The 'forbidden' hemisphere is the side, at which the cable leaves the cube.

- The test person can freely move in a hemisphere at the opposite site of the cube's cable exit.



Considering this the next step of your preparations will be to find a proper place for the transmitter. The space between the transmitter cube and the test person's head should contain as little metal parts as possible. Typically the transmitter cube can stand on a (wooden) tripod near the test person's head. The cube can also be mounted at the ceiling, with the cable exit towards the ceiling.

The center point of the transmitter is the origin of the [Measurement Model](#) [73]. Therefore it must be installed on a fixed ground and may not move. So the next step will be:

- Find a suitable place for the transmitter (TX) inside of your measurement model. It must be mounted on a solid ground.

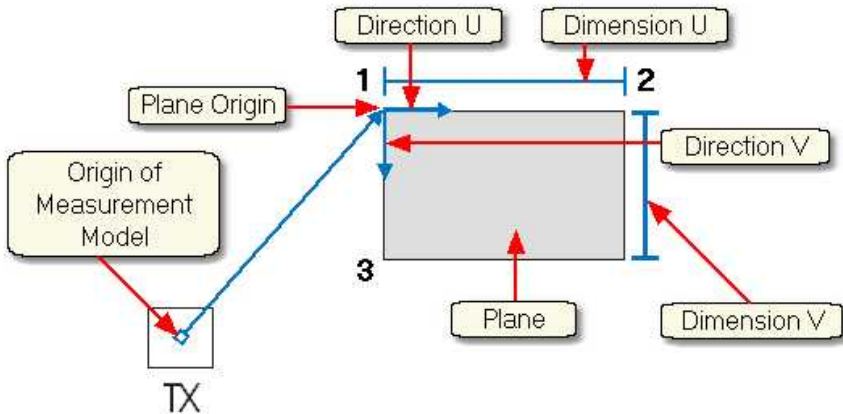
### 3.2.2.4 Plane Definition

A plane is defined through three points in space. In the [Surveyor](#) [405] a plane is defined as follows:

- **Plane Origin** in  $(x,y,z)$  coordinates based on the origin of the measurement model
- **Direction U** as a normalized  $(x,y,z)$  vector plus a **Dimension** of U (*first direction*)



- **Direction V** as a normalized (x,y,z) vector plus a **Dimension of V** (*second direction*)



The origin of the measurement model lies in the center point of the [Transmitter](#) <sup>74)</sup> (TX) cube.

The vector resultant of a normalized vector has the dimension of 1. Therefore each component has necessarily a dimension < 1. To define a position of a point in a 3-D environment, the normalized vector must be multiplied with a dimension value. Thus, the room coordinates of, for example, the second point is given by the multiplication of the **Direction U** vector (x,y,z) with the **Dimension U** value.

Direction U is also called **First Direction**, Direction V is called the **Second Direction**, respectively.

These definitions are important to understand the [survey of a single plane](#) <sup>79)</sup> with the Surveyor.

### 3.2.2.5 Plane Properties

Each plane has a number and a description.

It can be assigned the following properties:

**Calibration Plane:** If checked the plane is used for Calibration. See [Calibration Plane](#) <sup>[84]</sup> for details.

**Monitor Plane:** If checked, the plane is a monitor, on which an overlay cursor can be displayed. See also [Scene HT Calibration](#) <sup>[322]</sup> for details.

### ***Fill Style***

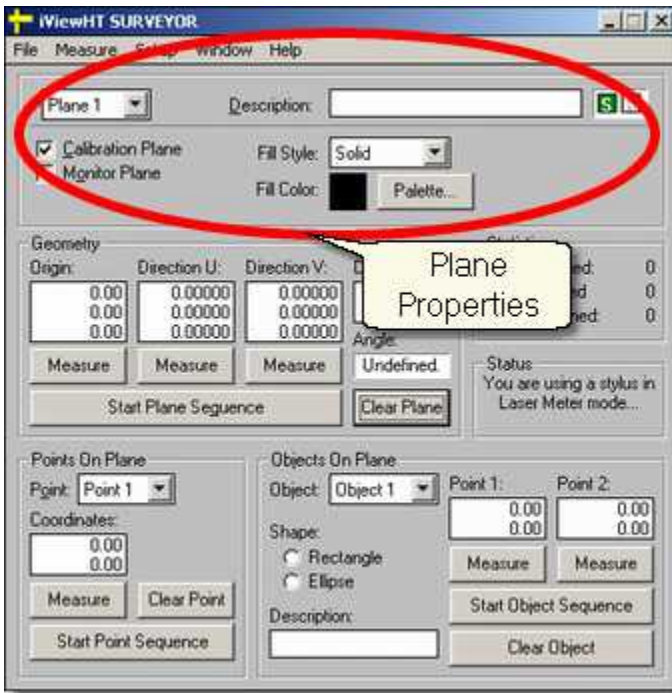
**Solid:** If it is solid you can assign a colour to the plane.

**Bitmap:** If it is a bitmap you can enter the path of the bitmap, that will be displayed in the plane.

**Transparent:** If it is transparent, the plane is only used for calibration, but later during the experiment the plane will not be visible. See [Calibration Plane](#) <sup>[84]</sup> for details.

**Virtual:** This property can not be used and is for internal use, only.

In the [Surveyor](#) <sup>[405]</sup> you can set the plane properties in the box at the top of the Surveyor user interface:



### 3.2.2.6 Surveying a single plane

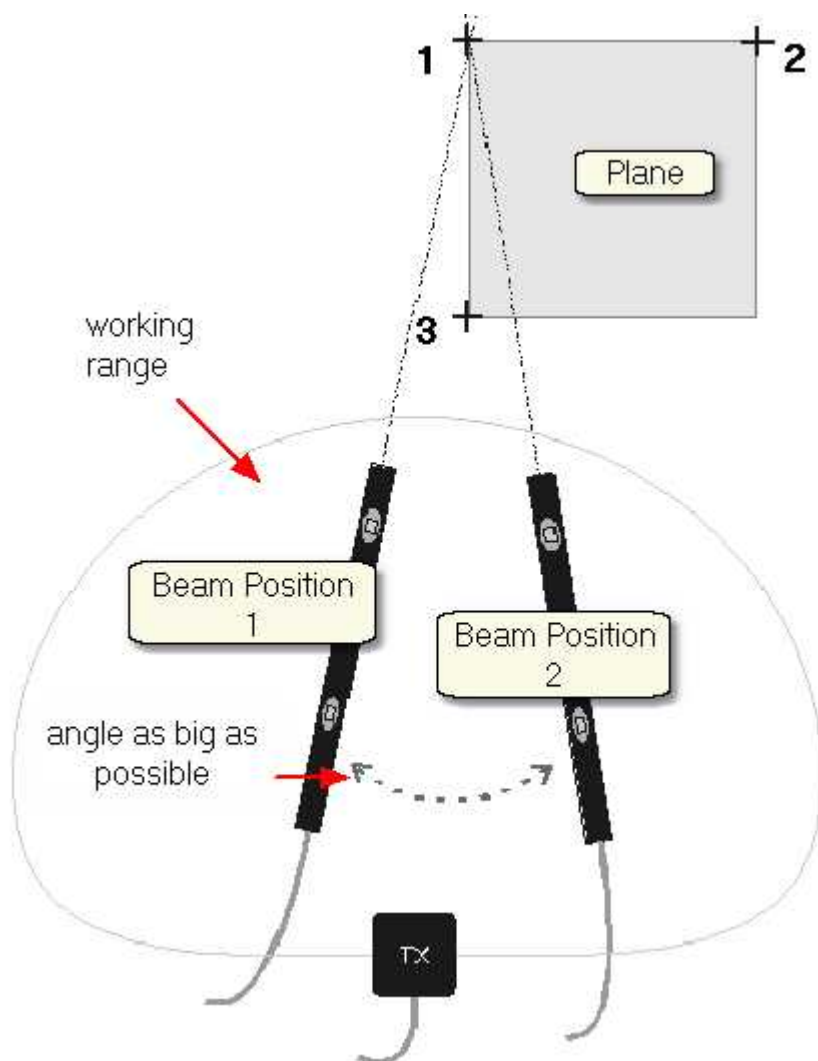
The [Measurement Model](#)<sup>[73]</sup> will be completely surveyed in Cartesian coordinates in millimeter units. The origin of the coordinate system lies in the center point of the [Transmitter](#)<sup>[74]</sup> (TX) cube.



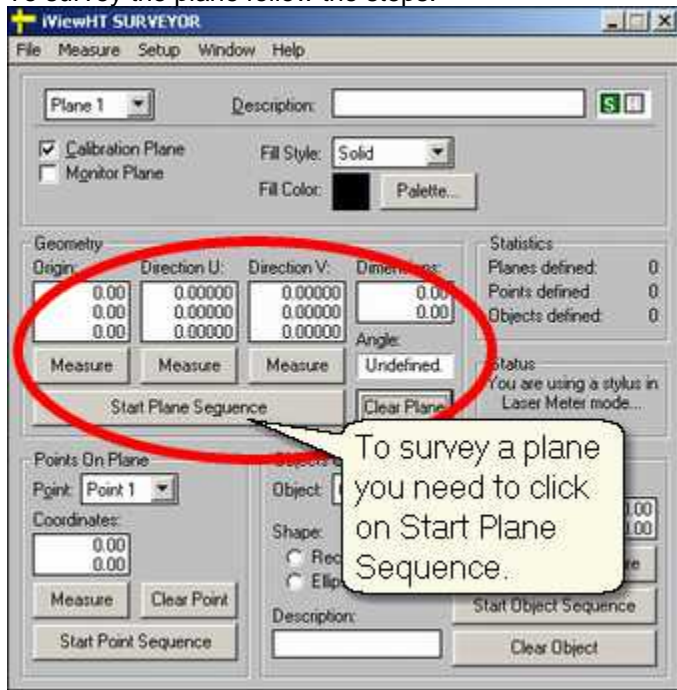
If the transmitter is moved, all planes of the measurement environment must be surveyed again.

For each point two shots of a the [Lasermeter](#)<sup>[94]</sup> is necessary to detect the point. The Surveyor calculates the intersection of the two laser beams. For best results the angle and distance between the two beams should be as big as possible, at least > 15 degrees. At the same time the lasermeter should be in the working range of the transmitter cube not too

far from the transmitter:




To survey the plane follow the steps:



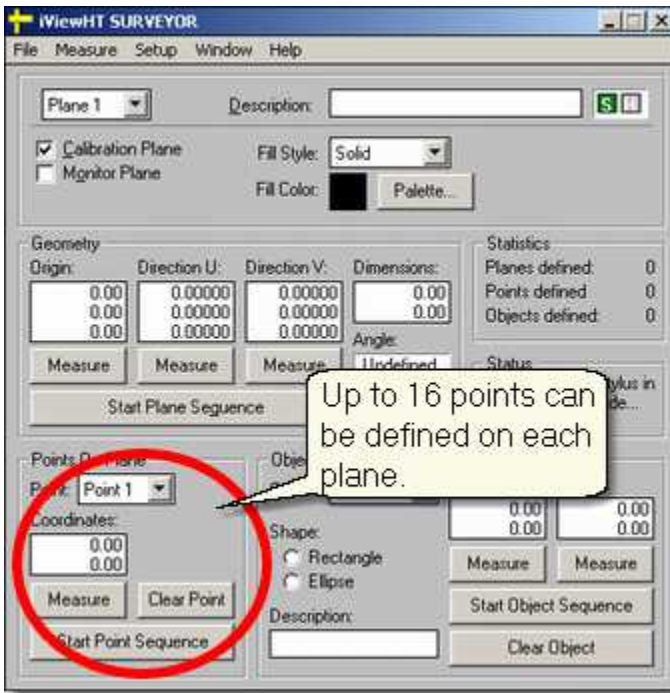
1. Start the [Surveyor](#)<sup>[405]</sup>. Make sure that you know how a [Plane](#)<sup>[76]</sup> is defined in the Surveyor.
2. Choose the [Plane Properties](#)<sup>[77]</sup>. Start with Plane 1.
3. Press **Start Plane Sequence** in the **Geometry** box. The program will guide you through the measurement.
4. The program will ask you for plane *origin first shot*.
5. Aim with the lasermeter from the first beam position at the first point to be acquired. Press the trigger on the *Stylus* receiver and hold the lasermeter still until the Surveyor confirms the measurement.
6. The program will ask you for plane *origin second shot*.
7. Acquire data as in step 5, but from the second beam position.
8. The program will ask you for *direction U first shot*.
9. Aim with the lasermeter from the first beam position at the second

- point to be acquired. Press the trigger on the *Stylus* receiver and hold the lasermeter still until the Surveyor confirms the measurement.
10. The program will ask you for *direction U second shot*.
  11. Acquire data as in step 9, but from the second beam position.
  12. The program will ask you for *direction V first shot* and finally for *direction V second shot*. Acquire the data for the third point in the same way.
  13. Check the accuracy: The data of the surveyed planes are displayed in the **Geometry** box. If your model consists of right-angled planes the displayed **Angle** should be 90 degrees. A deviation of 0.5 degrees would be tolerable.
  14. Proceed to the next plane and acquire the plane position as described in the previous steps.

### 3.2.2.7 Points on a Plane

After [surveying a plane](#)  up to 16 points can be additionally defined. For each point you only need one shot of the lasermeter. The Surveyor will calculate the intersection point of the beam with the plane.

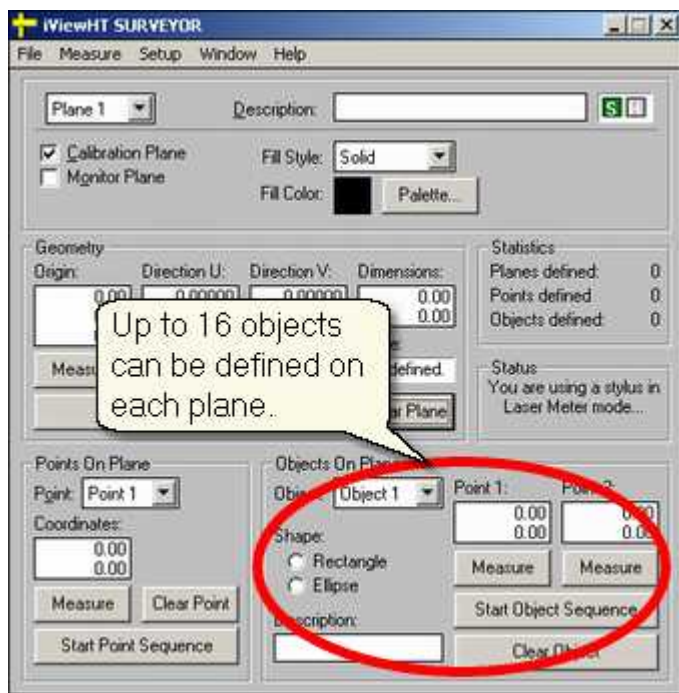
Click on **Start Point Sequence** to measure the points:



For the [Calibration Plane](#) <sup>84</sup> we need to acquire the 13 calibration points on the plane.

### 3.2.2.8 Objects on a Plane

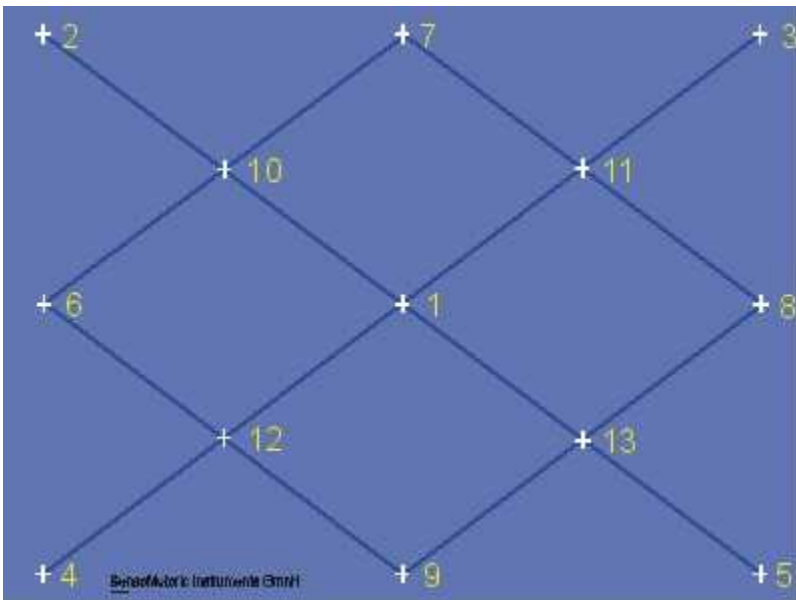
After [surveying a plane](#) <sup>79</sup> up to 16 rectangular or elliptic objects can be additionally defined. For each object you need two shots of the lasermeter.



### 3.2.2.9 Calibration Plane

One of the 16 planes of the [Measurement Model](#)<sup>73</sup> must be the calibration plane. There are 13 points defined on the calibration plane. The targets must be arranged in a certain pattern (see figure). During calibration the test person has to fixate the targets in the correct order.





*13-point calibration pattern*

During a calibration the presented 13-point calibration plane should only show the targets, not the corresponding numbers. Trials with labelled targets have shown that test persons first look at the numbers, then at the crosses, which would spoil the calibration process. Therefore the test person must be guided by voice output or by the operator to fixate the respective targets.

It is advisable but not necessary to keep the head still during calibration. Since iView HED-MHT uses a 3D model for the test person's eye and head as well as for all the planes, head movement is taken into consideration and has absolutely no negative effect on calibration and measurement results. However, keeping the head still forces the test person to move the eyes rather than turning the head during calibration which results in a wider calibrated viewing angle and, thus, a better accuracy.

For best resolution it is recommended to achieve an eye movement angle of approximately  $\pm 20$  degrees horizontal and  $\pm 15$  degrees vertical during

calibration. This should determine the optimum size and position of the calibration plane.

### The transparent calibration plane

In some applications the calibration plane can be part of the [Measurement Model](#)<sup>[73]</sup>, e.g. in reading research applications. In other applications, in which this is not possible, the Calibration Plane can be transparent.

A transparent plane is only visible during the calibration process. Place the calibration plane with the 13 targets somewhere in front of the test person's view. This plane will be one of the 16 planes that can be measured with the [Surveyor](#)<sup>[405]</sup>. You have to tell the Surveyor that the plane is transparent by setting the Fill Style respectively:



Survey the plane as described in the [Surveying a single plane](#)<sup>[79]</sup> section. Calibrate the test person as described in the [HED-MHT Standard](#)<sup>[91]</sup> section. After calibration remove the calibration plane. When you start the experiment, the system is calibrated, but the calibration plane is no longer visible. The gaze points are calculated on all the other planes.

### Surveying the calibration plane

1. Survey the plane as described in [Surveying a single plane](#)<sup>[79]</sup>.
2. To acquire the 13 calibration points press *Start Point Sequence* in the [Points on a Plane](#)<sup>[82]</sup> box.
3. To measure a point on the plane only one shot of the lasermeter is needed. If asked for the shot aim with the lasermeter at the first calibration target of the plane. Press the trigger on the Stylus

- receiver and hold the lasermeter still until the Surveyor confirms the measurement.
4. Repeat with all the other targets.
  5. If you have finished measuring the 13th target cancel the point sequence, as we only need 13 points.

### 3.2.2.10 Adding Head Tracking HED to iView X

#### Initialization of Software

For a step-by-step software initialization see section [Initialization of Software](#) <sup>[87]</sup>.

#### Setup Hardware

You have to tell iView X™, that you have connected the head tracker. Go to [Setup Hardware](#) <sup>[290]</sup> and select under **Head Tracker** the *Polhemus* system. Go to the [Advanced](#) <sup>[298]</sup> tab and configure the system accordingly.

#### Setup Calibration

After you have at least surveyed a single plane (see [User Guide](#) <sup>[72]</sup>), go to [Setup](#) <sup>[290]</sup> [Calibration](#) <sup>[313]</sup> and select *13 Point Head Tracking HED* as Calibration Method. Enter the paths for planes.ini and iview.ini which have been created by the [Surveyor](#) <sup>[405]</sup>.

#### Setup Scene Overlays

If you need a scene video with parallax-free gaze cursor overlay you have to configure the scene overlay behaviour in [Setup](#) <sup>[290]</sup> [Calibration](#) <sup>[313]</sup> [Scene HT Calibration](#) <sup>[322]</sup>.

### 3.2.2.11 Initialization of Software

Turn on the iView X™ workstation.



Start iView X™ by double-clicking on the iView X™ icon.

Next, iView X™ must be initialized to run with this configuration. Therefore, the iView X™ program must be told, which hardware components we use. Usually, it will be done only once on installation, but just in case, the software must be reinitialized, check the following:

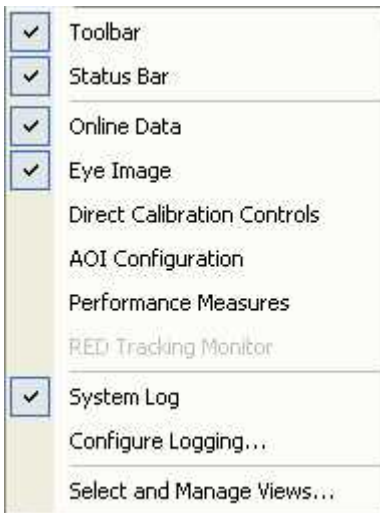
From the [Setup](#)<sup>[290]</sup> menu go to [Hardware](#)<sup>[290]</sup>.

- Set *Eye Tracker Device* to HED 4.
- Click on *Advanced*.
- On the [Eye Tracking](#)<sup>[299]</sup> tab choose, if left or right eye will be tracked and recorded.
- Click on *OK* to close the *Advanced* dialog.
- Click on *OK* to close the *Setup Hardware* dialog.

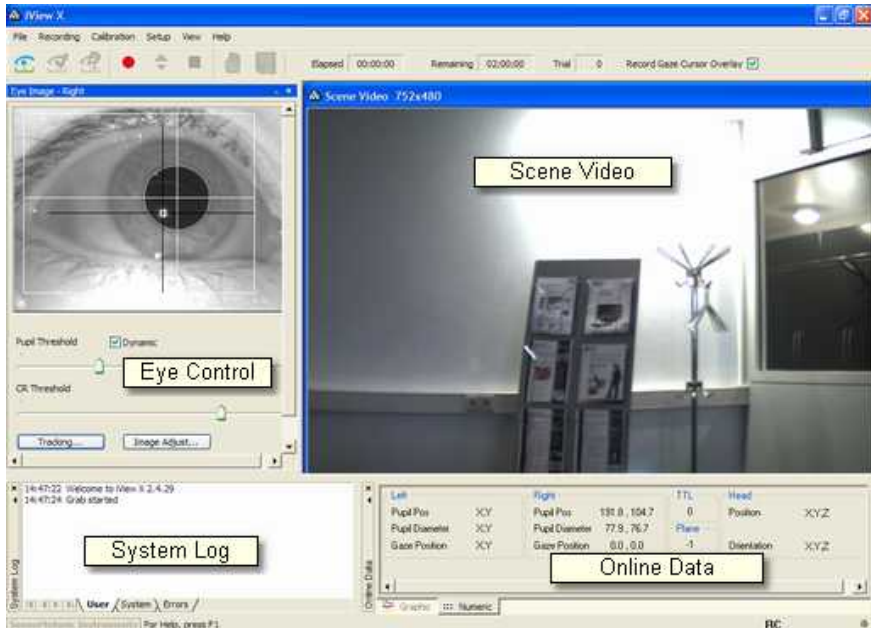
Activate eye camera by clicking on the [Eye Control](#)<sup>[343]</sup>.

Arrange docking windows.

- Go to the [View](#)<sup>[337]</sup> menu and set a check mark to the following windows:



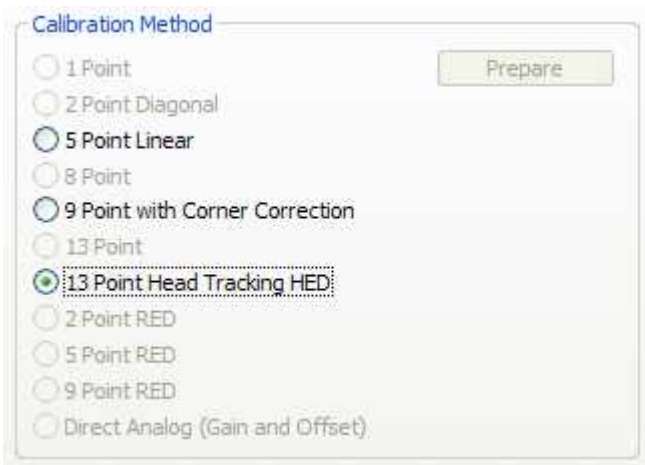
- Align all windows around the Scene Image Window as suggested below:



A typical iView X™ window arrangement (HED systems)

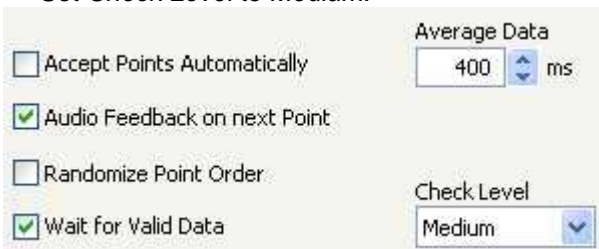
From the menu go to [Setup](#)<sup>[290]</sup> - [Calibration](#)<sup>[313]</sup>.

- Set Calibration Method to 13 Point Head Tracking HED.



*Calibration Settings for HED-MHT (upper part)*

- Uncheck *Accept Points Automatically*, because we will do a manual calibration.
- Check *Audio Feedback* on next point.
- Uncheck *Randomize Point Order*. As we do a manual calibration we have to know the calibration point order.
- Check *Wait for Valid Data*.
- Set *Check Level* to *Medium*.



*Calibration Settings for HED systems (lower part)*

- Click on OK to close the window.

From the [Setup](#)<sup>[290]</sup> menu go to [Output](#)<sup>[324]</sup>.

- Go to the [Gaze Cursor Properties](#)<sup>[327]</sup> tab.
- If needed, enlarge the sizes of all cursors (left, right and calibration

cursor) so that the targets can be comfortably look at. Adjust color to the scene. The cursors will be overlaid on the scene video during recording, so choose a color that can be easily distinguished from the scene.

- Go to the [Gaze Cursor Filter](#)<sup>[326]</sup> tab.
- Set *Method* to *Manual*.
- Set *Filter Depth* to 100 ms and *Saccade Length* to 20 pixel.
- Click on OK to close the window.

### 3.2.2.12 Operating Procedure

If your measurement environment is setup properly, you can work with your test persons. The following steps describe the typical steps to be done with each test person to perform the experiment.

[Helmet and Eye Video Setup](#)<sup>[91]</sup>  
[Helmet Sensor Alignment](#)<sup>[92]</sup>  
[Calibration](#)<sup>[93]</sup>  
[Record Data](#)<sup>[94]</sup>

#### 3.2.2.12.1 Helmet and Eye Video Setup

##### Helmet adjustment

Turn the wheels on both side of the helmet to loose the camera bracket.

Turn the bracket slightly upwards, so the helmet can be easier put on.

Place the helmet on the test person's head, thereby avoid touching the IR mirror.

Adjust the helmet size, so it is snug enough to avoid slipping during the experiment.

Turn back the bracket downwards, until the eye is visible in the eye control. Tighten the bracket wheels.

##### Eye camera adjustment.

Loosen the wheel in front of the bracket, so the eye camera and mirror assembly can be moved from left to right. It also can be tilted.

Adjust the eye camera, so that the pupil is centered in the eye control window. Thereby, the IR mirror should not touch the test person's face. If there are distorting reflections in the eye image, as coming from glasses, the IR mirror can be tilted, until the reflections leave the eye image. Then fasten the wheel again.

Rotate the focus ring at the eye camera to focus the eye image.  
Use the cornea reflex as indicator: The eye image is sharpest if the cornea reflex is smallest.

If the eye tracker has difficulties to track the pupil or CR go to the [advanced options](#) <sup>[370]</sup>.

Check *Dynamic Threshold*.

If you right-click on the scene video, a [context menu](#) <sup>[60]</sup> pops up.

### 3.2.2.12.2 Helmet Sensor Alignment

After the helmet is mounted on the test person's head, the system needs the following offset values:

[Eye Offset](#) <sup>[92]</sup>

[Scene Camera Offset](#) <sup>[93]</sup> (only for scene video recording)

#### Eye Offset

The system needs to know the position of the measured eye relative to the head sensor. Follow the steps:

1. Close iView X.
2. Start [Surveyor](#) <sup>[405]</sup>.
3. Go to **Setup | Eye Offset**.
4. Click on **Measure**.
5. Ask the test person to close his eyes.
6. Put the cap on the lasermeter's aperture.





7. Hold the lasermeter at the eye of the test person. **Do not trigger the laser pointer.**
8. Press the trigger on the *Stylus* receiver and hold the lasermeter still until the Surveyor confirms the measurement.
9. Proceed to *Scene Camera Offset* or close the Surveyor and launch iView X again.

### Scene Camera Offset



If you do not need a scene video you may skip the alignment of the *Scene Camera Offset* and directly proceed to the next step.

If you need a parallax-free scene video the system needs to know the position of the scene camera relative to the head sensor.

1. Go to **Setup | Camera Offset**.
2. Click on **Measure**.
3. Ask the test person to close his eyes.
4. Put the cover on the lasermeter's aperture. Hold the lasermeter at the scene camera. **Do not trigger the laser pointer.**
5. Press the trigger on the *Stylus* receiver and hold the lasermeter still until the Surveyor confirms the measurement.
6. Close the Surveyor and launch iView X again.

#### 3.2.2.12.3 Calibration

1. Check that the test person is properly seated in front of the [Calibration Plane](#)<sup>[84]</sup>.
2. Load a bitmap of the calibration plane: Go to the [File menu](#)<sup>[283]</sup>, click on [Open Scene Image](#)<sup>[284]</sup> and select the bitmap with the calibration plane.
3. Activate the calibration sequence by hitting the *start calibration*




button

4. Guide the test person to the calibration process. As the calibration pattern is fixed you have to tell the test person at which target he should look next.

5. Check the [User](#) tab in the [System Log](#) window for the result of the calibration. If the calibration is successful, the [Online Data](#) window will begin showing live GAZE data.
6. Start HE Visual to check the accuracy of the measurement.
7. In case a scene video with an overlaid gaze cursor is used, settings and calibration for the gaze cursor can be found under [Setup](#), [Calibration](#), [Scene HT Calibration](#). Note, that the gaze cursor must be calibrated to get a meaningful scene overlay.

### 3.2.2.12.4 Record Data

1. Click on the *start recording* button  to start recording.
2. Occasionally it is beneficial to run a drift correction. This is a one-point calibration that corrects for any drift that may have entered the system. Choose in the [Calibration menu](#) [Drift Correction](#).
3. Use the laser pointer to display the point to the test person the same way the center point is calibrated during the calibration routine.
4. When the test person has fixated, press the F6 key to accept the drift correction point. The system is now corrected for drift.
5. If at any time the HED IR mirror, the scene camera, or eye camera are moved, the system must be recalibrated. Drift correction will only correct linear changes such as the slipping of the helmet.
6. Alternatively, ask the test person to look at a certain point. You see if there is an offset in the scene video. You can manually shift the gaze to the fixation point by using Shift+Ctrl+Cursor keys.

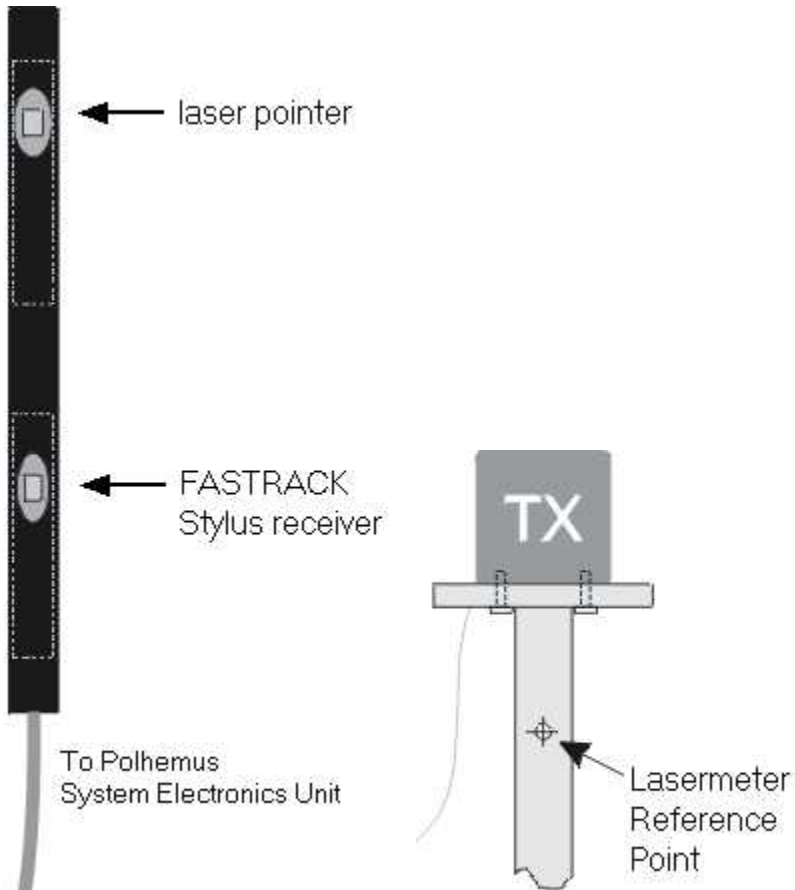
### 3.2.2.13 Lasermeter Calibration



The iView HED-MHT system will be delivered with an already calibrated lasermeter. The following section is only of importance if you need to disassemble the lasermeter.

The Lasermeter consists of a tube in which a laser pointer and a *FASTRAK Stylus* receiver is integrated. With the lasermeter all measurements for the environment survey are performed. For the accuracy of the measurement it is crucial to calibrate the lasermeter

before first use and after disassembling.



The tripod delivered with the system has a marked reference point with coordinates printed on the transmitter (TX) mounting.

If the transmitter is disassembled from the tripod and needs to be mounted again, the reference point must be remeasured, see [Reference](#)

## [Point Measurement](#)

Try to perform the calibration in a preferably metal free area and avoid the presence of other magnetic fields.

### The Calibration Process


With a known reference point two values are necessary to calibrate the lasermeter: the *Offset* and the *Direction*.

*Offset*: The offset is the distance between the *Stylus* receiver and the laser pointer.

*Direction*: The direction describes the angular deviation between receiver and laser pointer.

To perform the calibration follow the steps:

*Offset Measurement:*

1. Start the [Surveyor](#) .
2. Select **Setup | Laser Meter**
3. Click on **Measure** under the **Beam Offset** column.
4. Hold the lasermeter's end at the reference point.
5. Press the trigger on the *Stylus* receiver and hold the lasermeter still until the Surveyor confirms the measurement.

*Direction Measurement:*

6. Click on **Measure** under the **Beam Direction** column.
7. Hold the lasermeter parallel to the ground and aim with the laserpointer at the reference point at a distance of approximately 30 to 40 cm.
8. Press the trigger on the *Stylus* receiver and hold the lasermeter still until the Surveyor confirms the measurement.
9. Click on OK to accept the measurement.

## Reference Point Measurement

In case you need to change the TX mounting, a new reference point must be set:

1. Choose a new reference point. The reference point should be within the working range of the transmitter. If you use the tripod with its marked reference point, the transmitter should be mounted on the tripod so that the cable exit lies on the opposite side of the reference point.
2. Select **Setup | Preferences** from the [Surveyor](#)<sup>405</sup>.
3. Click on **Measure** in the **LaserMeter** box.
4. Disassemble the lasermeter and hold the nose of the *Stylus* receiver at the new reference point.
5. Press the trigger on the *Stylus* receiver and hold the lasermeter still until the Surveyor confirms the measurement.
6. Click on OK to accept the measurement.
7. Reassemble the lasermeter and proceed with offset and direction measurement of the lasermeter's [calibration process](#)<sup>96</sup>.

### 3.2.3 Safety Notes

Switch off all components before connecting or disconnecting cables.

When setting up the system, make sure that all connectors and switches are easily accessible.

Periodically check the technical safety of the device, e.g., check for damage to the housing etc.

Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).

In case your iView X system or a component of the system is damaged, switch off the whole system and unplug it from the power source. Do not use the system until the system or its component has been repaired by a certified distributor or the manufacturer (SMI).

Only use original components (cables, power supply etc.) from SMI.

In case a component needs to be replaced, only replace it with original components from SMI.

Do not repair the system by yourself. Electrical shock hazard.

No part of the product may be modified or rebuilt.

Any usage other than described in this manual is not permitted, can damage the device and eventually lead to associated risks such as short-circuit, fire, electric shock, etc.

We do not assume liability for resultant damages to property or personal injury if the product has been abused in any way or damaged by improper use or failure to observe these operating instructions. In addition, any unauthorized modifications or repairs of the device will render the warranty null and void!

### **Additional Power Supply Safety Notes**

Only use connecting cables provided by the manufacturer (SMI). Make sure the conductive earth wire is not broken, disconnected, removed or interrupted as this can pose a serious threat to life in the event of malfunction.

The device must only be operated in dry, indoor spaces.

Take precautions to make sure that the insulation of the entire product, the safety sockets, connected cables and mains cables are neither damaged nor destroyed.

Always use fuses of the specified type and rating. It is impermissible to use repaired fuses!

Never operate the device without supervision while loads are connected.

Ensure to protect connected loads from the effects of operational disturbance as well as overvoltages.

Do not use the power supply as a direct or indirect charging device.

The device shall not be subjected to heavy mechanical stress.

The device must not be exposed to extreme temperatures, direct sunlight, intense vibration or moisture. Position the device on a level and sturdy surface.

The device generates operational heat. Never insert any objects, block cooler opening of the device, or hinder ventilation in any form or manner.

The device is predominantly cooled by convection.

Never put a naked flame or any containers with liquids on or near the apparatus.

Caution! Capacitors within the device may retain their charge even if the device is disconnected from all power sources.

Never turn on the device immediately after it has been brought from a cool into a warmer environment. Condensing water might destroy your device. Leave the device in OFF position and wait until it has reached ambient temperature.

Before operating the device, make sure that your hands, shoes, clothing, the floor as well as the device itself are dry.

During thunderstorm, unplug the device's power plug from the mains outlet in order to avoid damages due to excess voltage.

In industrial facilities, the safety regulations laid down by the professional trade association for electrical equipment and facilities must be observed.

In schools, training facilities, DIY and hobby workshops, the usage of electrical devices is to be supervised by trained personnel.

If there is reason to believe that safe operation is no longer possible, the device is to be put out of operation and secured against unintended operation. Safe operation is no longer possible if:

- the device has sustained visible damages,
- the device no longer works,
- and the device was stored under unfavorable conditions for a long period of time,
- the device was subject to considerable transport stress.

This device is not a toy and should be kept out of reach of children!

Should you have any questions that are not answered in this operating manual, please contact our technical customer service, or other experts.

## **LED illumination**

To avoid unnecessary IR radiation for the eyes, switch off the system when not in use.

The HED camera system uses invisible LED radiation Class 1.

The used wavelength is 880 nm.

## **Electromagnetic compliance**

**WARNING:** This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications.

## **Electrostatic sensitivity**

**WARNING:** All internal electronics are sensitive to high voltage or electrostatic discharge. The system can be destroyed if carelessly handled, so extreme care should be taken during set up and operation.

## **Operating Temperature**

The system is designed to operate satisfactorily in an environment where the ambient temperature is between 10 °C and 50 °C, and that there is no water condensation present.

## **Storage Temperature**

Do not store the equipment in an area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## **Packaging for shipment**

When shipping, use the shipping cartons in which the units were originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## **Disposal**

Dispose the device according to legal regulations.

### **3.2.4 Maintenance**

Switch off the system before cleaning.

Use a clean lint-free, antistatic, slightly moistened cloth to clean the



device. Do not use abrasives, detergents or solvents.

Make sure that the camera modules do not come into contact with liquids during cleaning.

### 3.3 iView X RED



The **Remote Eyetracking Device (RED)** is developed for absolutely contact-free measurement of eye movements with automatic head-movement compensation. The camera views the eye without touching the test person. The RED configuration is most often used when there is a confined stimulus area such as a computer monitor, poster or beamer projection. Eye movements are defined in units appropriate to the stimulus.

The system compensates for head movements by tracking the corneal reflex.

With the iView RED system the researcher obtains numerical gaze data in units of the calibration area, which can be automatically post-processed by other programs, e.g. for statistical analysis.

The working range is limited to one flat panel with a strictly limited dimension. The test person cannot move freely and must sit or stand still during the experiment. Only small head movements are compensated.

### 3.3.1 Features and Benefits

The iView X RED system is an actual remote, non-invasive eye tracking system for gaze position tracking on a TFT monitor, projection screen, or magazine. It excels in a very easy setup and usage, full automatic tracking and accurate recordings.

#### Technology

- Non-invasive, video-based eye tracking
- Binocular, multiple feature and pupil-CR, dark-pupil tracking

#### Performance

- Sampling rate 50/60 Hz for RED 4 (FireWire)  
60/120 Hz for RED (USB) and 250 Hz for RED 250 (USB)
- Tracking resolution < 0.01° (typ.)
- Gaze position accuracy < 0.5° (typ.)
- Operating distance subject - camera 60 - 80 cm
- Head tracking range 40 x 40 cm at 70 cm distance
- Viewing angle approx. ± 30° hor. / 22.5° vert.

## System

- Operating system Windows XP
- Workstation Desktop / Notebook

## Interface

- Contact-free, remote-controlled infrared eye camera with automatic eye and head tracker
- Flexible three-in-one setup for screen, projector and print media, comes with mounts for monitor, stand-alone and magazines

## Auxiliary Devices / Communication

- Audio channel recording
- Open communication interface via Ethernet (UDP)
- Easy integration with third-party stimulus and analysis packages such as Presentation®, E-Prime®, Superlab™, MATLAB®, SPSS®, Excel™ and others

## System Options

- SMI Experiment Suite 360° (incl. BeGaze™ & Experiment Center™)
- Application Programming Interface (API)
- Flightcase

## Approvals

- CE, EMC, Eye Safety
- Degree of Protection: IP 20 for RED (USB) and RED 250 (USB)

### 3.3.2 Hardware Components

The RED camera system is available in three versions:

#### [RED 4 \(FireWire\)](#)<sup>[105]</sup>

It consists of the following components:

- . an eye tracking module ([ET module](#)<sup>[105]</sup>) with a FireWire connection to the computer
- . an Illumination Controller ([e-box](#)<sup>[105]</sup>)

Sampling rates can be selected between 50 and 60 Hz.

#### [RED \(USB\)](#)<sup>[110]</sup>

The eyetracking module uses an USB connection to the computer.

Sampling rates can be selected between 60 and 120 Hz.

#### [RED 250 \(USB\)](#)<sup>[110]</sup>

The eyetracking module uses an USB connection to the computer.

Sampling rates can be selected between 60, 120 and 250 Hz.



*For safety reasons switch off all components before connecting or disconnecting cables!*

### 3.3.2.1 RED 4 (FireWire): ET Module



#### *RED ET module*

The RED 4 (FireWire) eye tracking module (ET module) observes the test persons eyes. It uses infrared LEDs to illuminate the eyes. Please also consider the [Safety Notes](#)<sup>[125]</sup>.

#### **Connectors at the rear side of the camera unit:**

*Power* must be connected with the *Power* connector of the e-box.  
*Trigger* must be connected with the *Trigger* connector of the e-box.  
*Video* must be connected with the Firewire connector of the iView X workstation.

#### **3.3.2.1.1 Illumination Controller (E-Box)**

The illumination controller (e-box) is used to control the RED 4 (FireWire) camera and its illumination. Please also consider the [Safety Notes](#)<sup>[125]</sup>.

### 3.3.2.1.1.1 Explanation of Symbols



This equipment is CE compliant and meets the requirements of the current European and national guidelines.

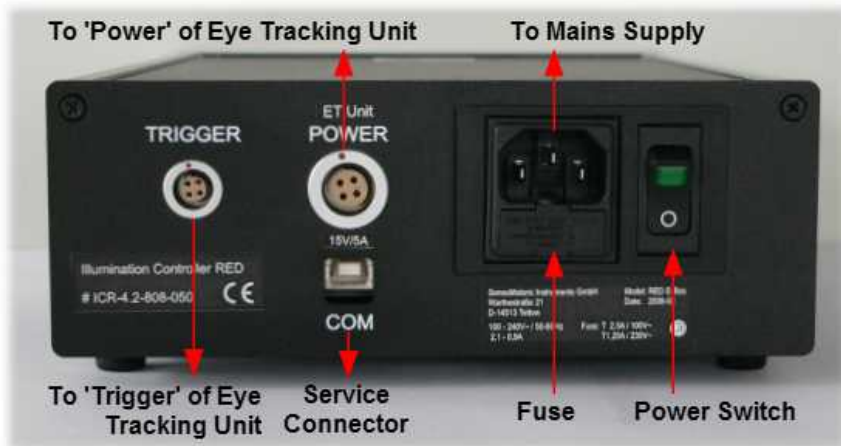


Instructions should be read carefully.



Earth symbol.

### 3.3.2.1.1.2 Connectors and Switches



### Connectors of the Illumination Controller (E-Box):

**Power** must be connected with the *Power* connector of the eye tracking unit.

**Trigger** must be connected with the *Trigger* connector of the eye tracking unit.

The *power supply plug* must be connected with the mains supply. The E-Box is designed in compliance with the protection class 1. It is only approved for connection to sockets with protective grounding and an alternating current of 100-240V~ 50/60Hz commonly used domestically.

### Power Switch

To switch on the e-box the power switch must be pushed upwards (the green indicator light then comes on).

To switch off the e-box the power switch must be pushed downwards to the '0' position (green indicator light off).

### Fuses

The fuses box contains the fuse and a spare fuse. Depending on the region in which the e-box is used it contains

100V: T 2.5 A/250V AC or

230V: T 1.25A /250V AC.



*Do not replace the fuses by yourself.*

*Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).*

See also [Safety Notes](#)<sup>[125]</sup> and [Maintenance](#)<sup>[128]</sup>.

### COM

The com interface is a communication interface only used by the manufacturer.

### 3.3.2.1.1.3 Technical Data

The following specifications are at nominal input voltages at 25°C unless otherwise specified.

**INPUT VOLTAGE:**

Nominal 100-120V AC, 220-240V AC, range: 85-265V AC (0 to 100% load, -10 to 60°C); DC range: 120 -370V DC

The power supply may shut down if operated below the input voltage range or if the input voltage increases slowly at start up (> 1 second)]. To reset the power supply, wait one minute and reapply input power.

**INPUT SOURCE FREQUENCY:**

Nominal 50/60 Hz; Range 47-66 Hz. (Above 66Hz to 440 Hz the leakage current exceeds the VDE safety specification limit.)

**INPUT CURRENT:** (maximum load at 25°C with nominal output voltage): 2.0A typ., 2.7A max. (100 V AC input, 100% load); 0.8A typ., 1.5.A max. (240 V AC input, 100% load)

**INPUT PROTECTION AND SOFT START:** A thermistor circuit reduces start-up surge. Units are protected against shorts by an input fuse. Fuse value 5A, 250V.

**OUTPUT VOLTAGE:** 15V +/- 0.75V

**POWER CONSUMPTION (max.):** 150 W

**OPERATING TEMPERATURE:** -10 to 60°C (start up -20 to -10°C).

**STORAGE TEMPERATURE:** -30°C to + 75°C.

**COOLING:** Natural convection

**ORIENTATION:** Horizontal or vertical

**HUMIDITY:** 10% to 90% relative humidity, operating and storage, noncondensing, wet bulb temperature < or = 35°C

**WITHSTAND VOLTAGE**

(at 5 to 35°C ambient, 45 to 85% relative humidity, cutout current 10 mA):

Between input and output terminals, 3000V AC for 1 minute.

Between input terminals and ground, 2000V AC for 1 minute.

Between output terminals and ground, 500V AC for 1 minute.

**INSULATION RESISTANCE:** Between input and output, input and ground,

output and ground 100 megohms minimum (500V DC, 5 to 35°C ambient, 45 to 85% relative humidity)

**VIBRATION:** Three axes, one hour each, sweep time 10 min.;



nonoperating

5-10 Hz., 10 mm amplitude

10-200 Hz., 2G (19.6m/s<sup>2</sup>) acceleration

**SHOCK:** Three axes, 60G (588m/s<sup>2</sup>), 11 ms ±5 msec pulse duration, three shocks each axis, nonoperating, 1/2 sine pulse

**SAFETY:** All units designed to meet UL 60950-1.c, and TÜV Rheinland EN60950-1 (ambient temp. 50°C max.). JBW 150W units are CE marked per the Low Voltage Directive (LVD), EN60950.

**EMC - EMISSIONS:**

Conducted Noise 0.15MHz to 30MHz: FCC Class B, VCCI-B, EN55011-B, EN55022-B.

Input Harmonics (on AC Mains) 0 to 2KHZ: EN 61000-3-2.

**EMC - IMMUNITY:** Designed to meet EN 50082-2.

ESD: EN 61000-4-2 Level 4, Normal operation.

Radiated Field Noise: EN 61000-4-3 Level 3, Normal operation.

Electrical Fast Transient/Burst (EFT): EN 61000-4-4 Level 3, Normal operation.

Surge: EN 61000-4-5 Level 4, no damage.

Conducted Noise: EN 61000-4-6 Level 3, Normal operation.

Power Frequency Magnetic Field: EN 61000-4-8 Level 4, Normal operation.

Interruptions and voltage dips, short variations: EN 61000-4-11, Normal operation.

**FUSES:**

T 2.5 A / 100 V AC

T 1.25 A / 230 V AC

**PROTECTION CLASS: 1**

**DIMENSIONS (L x W x H in mm):** 270 x 180 x 70

**WEIGHT:** 1.6 kg

### 3.3.2.2 RED (USB) / RED 250 (USB): ET module



#### *RED ET module*

The RED eye tracking module (ET module) observes the test persons eyes. It uses infrared LEDs to illuminate the eyes. Please also consider the [Safety Notes](#) <sup>[125]</sup>.

#### **Connectors at the rear side of the camera unit:**

*Power* must be connected with a 19 V [power supply](#) <sup>[110]</sup>.

*USB* must be connected to a free USB port of the iView X workstation.



Make sure to connect the ET module directly with an USB port of the PC, not with an USB hub.

#### **3.3.2.2.1 Power Supply**

The RED (USB) / RED 250 (USB) ET module is connected to a 19 V power supply. See also [Safety Notes](#) <sup>[125]</sup> and [Technical Data](#) <sup>[117]</sup>.

### 3.3.2.2.1.1 Technical Data



**Operating Temperature** : 0 ~ 50° C

**Dimension** : 119 x 54 x 36 mm

**Approvals / Marks** : c-UL, TÜV, CE, CB, PSE (15~30V models)

#### FEATURES

Universal range 90~264V AC / 47~63Hz / Power On LED

Overload, Over Voltage & Short Circuit protection

#### OUTPUT

**Model**: SYS1183-6019

**Voltage**: 19V

**min. Load**: 0A

**max. Load**: 3.15A

**Tolerance**: ±5%

**Ripple & N.:** 1%  
**Efficiency:** 70% min.  
**Max. Power:** 60W

## INPUT

**Voltage** 90 ~ 264V AC  
**Frequency** 47 ~ 63Hz  
**Current** 1.6A @ AC low line input and DC output full load  
**Leakage Current** < 0.25mA  
**Surge Current** 60A max. @ 230V AC and 25°C

## PROTECTION

**Overload OCP** 150% ~ 200%, Fold back  
**Over Voltage OVP** 110% ~ 140%, Voltage limiting  
**Short Circuit** Yes, Output to Ground, Auto recovery when fault has been removed  
Short Current & Over Current can not exceed 8A max. after 1minute at nominal line input  
**No Load Operation** Yes , to protect the power supply and system from damage

## OTHERS

**Holdup time** 10ms @ AC nominal Input and Output full load  
**Power On LED** Yes  
**Cooling** Free air convection  
**Withstand Voltage** HI-POT B / I/P-O/P (FG): 3KVAC / 10mA / 1 minute  
**Power Consumption** max. 1W @ AC nominal Input and Output min. load  
**Input Fuse** 250V AC / 1.6A

## ENVIRONMENT

**Temperature** Operating: 0 ~ 50°C / Storage: -20 ~ 70°C  
**Humidity** Operating: 8% ~ 90% RH / Storage: 5% ~ 95% RH

## CONNECTION

**Input** IEC320-C8

**Output** Plug: standard: 5.5 x 2.1 x 9.5mm (spring loaded center) / Cable: 180cm ( 6ft. )

**MTBF** > 35K hours

**SAFETY** TÜV EN60905 / CE / CB / PSE (15~30V models only)

## EMC

**EMI** Meets : EN55022 Class B / EN50081-1 / EN50082-1

**EMS** EN60555-2,3

**WEIGHT** N.W.: 0.33 kg

### 3.3.3 User Guide

The following guide describes the steps how to set up, calibrate and run an iView X RED experiment, after the system has been [wired](#)<sup>[105]</sup> properly.

The RED can be used in 3 different modes of operation:

- . [monitor integrated](#)<sup>[113]</sup>
- . [stand alone](#)<sup>[123]</sup>
- .. [used with a document stand](#)<sup>[122]</sup>

#### 3.3.3.1 RED Monitor Integrated

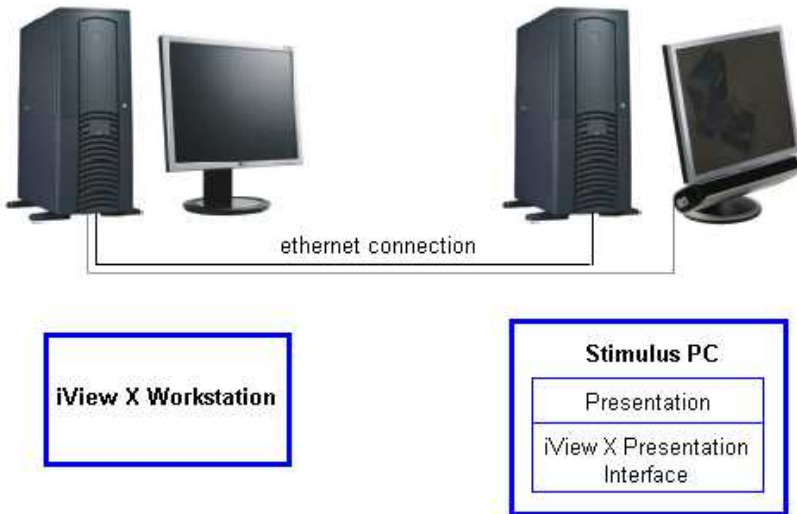
In the *Monitor Integrated* operation mode, the [ET module](#)<sup>[105]</sup> is fixed at the adapter plate, which is located behind the monitor, with a screw. The RED is placed right underneath the monitor in a specified position. Both monitor and ET module work as a unit, thus, the height of the monitor cannot be changed.

The monitor is used as stimulus screen.

The following steps describe how to set up and run a typical iView RED experiment. In this experiment the iView X workstation is connected via ethernet connection to a Stimulus PC.

On the **Stimulus PC** the following components must be installed:

- Presentation stimulus software, available at [www.neuro-bs.com](http://www.neuro-bs.com).
- iViewX Presentation Interface



If your Stimulus PC is a Laptop, connect the RED monitor with the Laptop, then press Fn+F10 to direct the monitor output to the RED monitor.

### 3.3.3.1.1 Initialization of Software

Turn on the iView X workstation.

Start iView X by double-clicking on the iView X icon.



Next, iView X must be initialized to run with this configuration. Therefore, the iView X program must be told, which hardware components we use. Usually, it will be done only once on installation, but just in case, the software must be reinitialized, check the following:

From the [Setup](#)<sup>[290]</sup> menu go to [Hardware](#)<sup>[290]</sup>.

- Depending on the version you have, set *Eye Tracking Device* to one of the following devices:  
RED 4 (FireWire) - RED (USB) - RED 250 (USB).
- Click on *Advanced* and choose the tracking mode or sample rate.

[Establish an ethernet connection](#)<sup>[394]</sup> between the stimulus PC and the iView X workstation.

- Click on *OK* to close the *Setup Hardware* dialog.

From the menu go to [Setup](#)<sup>[290]</sup> - [Calibration](#)<sup>[313]</sup>.

- Set *Calibration Method* to *9 Point RED*.
- Check *Accept Points Automatically*.
- Check *Audio Feedback* on next point.
- Check *Wait for Valid Data*.
- Set *Check Level* to *Medium*.

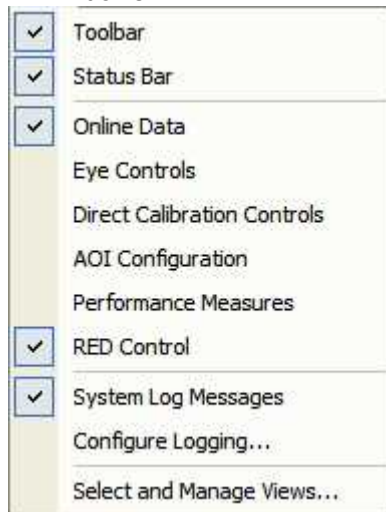
<input checked="" type="checkbox"/>	Accept Points Automatically	Average Data
		400 ms
<input checked="" type="checkbox"/>	Audio Feedback on next Point	
<input type="checkbox"/>	Randomize Point Order	Check Level
<input checked="" type="checkbox"/>	Wait for Valid Data	Medium

*Calibration Settings for RED systems (lower part)*

- Go to the [RED Operation Mode](#)<sup>[319]</sup> tab.
- Set *Operation Mode* to *Monitor Integrated*.
- Set *Stimulus Screen Resolution* to the size of the bitmaps that will be presented. (Typical sizes are 1024x768 or 1280x1024.)  
The values will be stored in the iView data file. Later analysis tools may use these values.
- Click on *OK* to close the window.

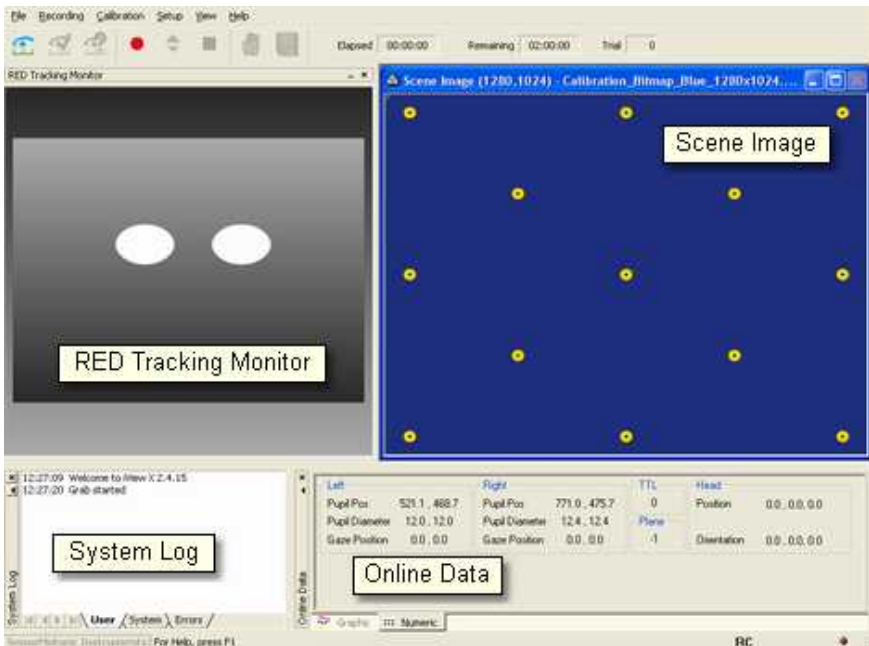
Arrange docking windows.

- Go to the [View](#) <sup>337</sup> menu and set a check mark to the following windows:



- Align all windows around the Scene Image Window as suggested below:





A possible iView X RED window arrangement

From the menu go to [Setup](#)<sup>[290]</sup> - [Output Gaze Cursor Properties](#)<sup>[327]</sup>.

- If needed, enlarge the sizes of all cursors (left, right and calibration cursor) so that the targets can be comfortably look at.
- Click on OK to close the window.

The Scene Image has [context menu](#)<sup>[117]</sup>.

### 3.3.3.1.1 Context Menu: RED Scene Image

If you right-click on the RED scene image, a context menu pops up.

#### Open Scene Image

Opens a file selection box, in which you can select a scene image.

#### Stretch View

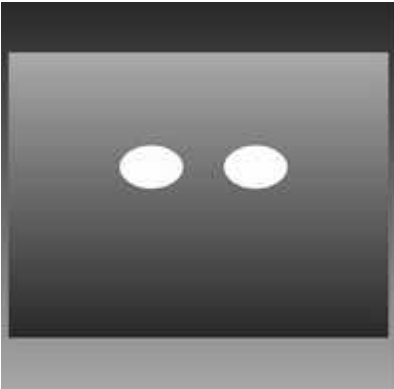
Stretches the scene image so it best fits into the iView X workspace.

**Copy Scene**

Copies contents of scene image window to clipboard.

**Show AOIs**

Shows or hides any drawn [AOIs](#) .

**3.3.3.1.2 Test Person Placement**

*RED Tracking Monitor*

1. Place a test person in a comfortable position in front of and centered to the Stimulus PC monitor.
2. If the eyes are tracked by the system, two white eye dots are visible in the RED Tracking Monitor.
3. If tracking is lost the white dots have disappeared from the RED Tracking Monitor.
4. Arrows indicate the optimum position of the test person in front of the monitor:
  - . If the test person sits too far away from the screen an arrow indicates that he or she should move closer:



- . If the test person sits too close to the screen an arrow indicates that he or she should increase the distance to the screen:



Other arrows direct the test person to center his or her head in front of the monitor. The test person sits correctly if all arrows have vanished. A correct test person to monitor distance should be between 60 and 80 cm.

### 3.3.3.1.3 Run Experiment

Now you are ready to run an experiment.

#### Using Presentation

It is a good idea to use one of the example experiments from the *iView X Presentation Interface* as a starting point for your own experiment.

On the *Stimulus PC* go to the folder, where the *Presentation Interface* is installed. Go to the subfolder *Experiments*. There you find various experiment examples. Go to a subfolder and double-click on the .exp file. *Presentation* opens.

Go to the *Settings* tab, click on *Video*. Under *Display Device Adapter* select your monitor.

Go to the *Main* tab and click on *Run* to start the experiment.

The example experiments demonstrate remotely controlled calibration and recording, while presenting a stimulus.

#### Using SMI Experiment Center™

Start an experiment with *SMI Experiment Center™*. For more information see the *SMI Experiment Center™* manual.

## Calibration

The above stimulus programs are capable of automated calibration. Make sure to carefully select the type, size, and colour of the calibration targets. Background and cursor colours should be similar to the stimulus background and foreground colours.

If calibration starts, proceed as follows:


1. A calibration point will be displayed for the test person.
2. During the calibration process the test person should look at the presented targets without moving its head. When the test person has fixated, press <space> to accept the point.
3. If calibration is set to *Auto Accept Points*, the system will automatically advance through the calibration points. The test person should view each one as it is presented. Verify that the test person complies with the calibration and does not look away from points too early.
4. If the calibration was completed successfully, the *User* message in the *System Log* will display "Calibration finished successfully" and the scene image will show a cursor indicating the test person's gaze position.
5. Check the [Error](#)<sup>[362]</sup> tab in the [System Log](#)<sup>[360]</sup> window for potential problems during the calibration. If the calibration is successful, the [Online Data](#)<sup>[340]</sup> window will begin showing live gaze data.



## Automated Recording

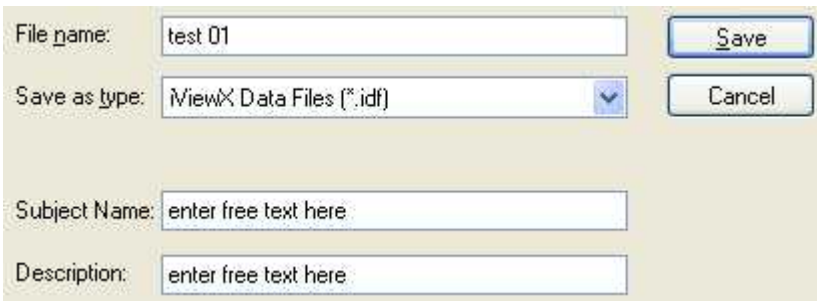
The above stimulus programs automatically start and stop a recording during the stimulus presentation and save the recorded data.

## Manual Recording

If you choose to manually start recording proceed as follows:

1. Perform a calibration using a suitable [calibration process](#)<sup>[245]</sup>.
2. Click on the *start recording* button  to start recording.
3. Begin the stimulus presentation software on the Stimulus PC.

4. Click on the *stop recording* button  to stop recording.
5. Click on the *save* button  to open the save data dialog.
6. Enter a file name.
7. Optionally, fill in *Subject Name* and *Description*.
8. Click on *Save* to save the data as a file of type *.IDF*.



File name:

Save as type:

Subject Name:

Description:

Save Cancel

## Remote Recording


*Start*, *stop* recording, *save* and many more functions can also be controlled by the [Remote Command Language](#)<sup>[438]</sup>.

## Analysis

The result of the measurement is an [.idf file](#)<sup>[260]</sup> recorded and stored on the iView X PC. The resulting file can be loaded into *SMI BeGaze™* analysis software for visualization and further analysis.

To export the IDF data into an ASCII text format, load the IDF file into the IDF Converter program and choose options for export. (The IDF Converter is part of the *iTools* package on the iView X CD.) The resulting text file can be loaded and analyzed with Excel™, Matlab™ or other spreadsheet programs. (Note: Consider keeping IDF files as a data archive).

### 3.3.3.2 RED Document Stand

1. Fixate the RED at the adapter plate behind the monitor with the screw.
2. Plug the power, video and trigger cable in.
3. Put the E-Box on.
4. Start iView X.
5. Go to Setup-Hardware and choose "RED" as Device Selection.
6. Press OK.
7. Go to the Setup Calibration [RED Operation Mode](#)  tab and select "document stand" as operation mode.
8. Enter the size of your document.
  - a. The document cannot be bigger than A3 format.
9. The software will give you the advice which calibration panel you have to use.
10. Press OK.
11. Place the document stand on the Monitor.
  - a. The Document Stand is parallel to monitor.
  - b. The Document Stand is centered to the monitor.
12. Place the document on the document stand.
  - a. The document is parallel to document stand.
  - b. The document is centred to the document stand.
  - c. The document has to be planar.
13. Place the Calibration panel on the document.
  - a. The calibration panel is parallel to the document stand.
  - b. The calibration panel has to be centered to the document.
14. Start Calibration by pressing F5 and follow the instructions.
15. Remove the Calibration panel and start your Experiment.

### 3.3.3.3 RED Stand Alone

1. Remove the RED from the monitor and mount it at the Stand Alone foot.
2. Plug the power, video and trigger cable in.
3. Switch on the E-Box.
4. Switch on your beamer or monitor and position it.
  - a. The screen has to be planar.
  - b. The screen has to be at right angle with the floor.
  - c. The screen bottom line has to parallel to the floor.
5. Switch on your computer and connect it to the beamer or monitor.
6. Start iView X.
7. Go to Setup-Hardware and choose "RED" as Device Selection.
8. Press OK.
9. Go to the Setup Calibration [RED Operation Mode](#)<sup>[319]</sup> tab and select "stand alone".
10. Click in *Profile Selection* on *New* to create a new profile and enter a name. If you select from the list an already existing profile, continue with point 11.
  - a. A dialog for [Stand Alone Geometric Setup](#)<sup>[320]</sup> opens. Here you have to enter the geometric dimensions of your setup. You can let iView X suggest values according to the test person's placement. Therefore check *Use Placement Suggestion*. Select the distance between floor and the test person's eyes. The options are:
    - i. 80-110 cm: for test persons sitting comfortably on a coach or similar.
    - ii. 110-140 cm: usual height for test persons setting at a desk.
    - iii. 140-180 cm: for test persons who are standing during the

experiment.

- b. Measure screen height, width and distance bottom line of screen to floor and enter the values.
  - c. Click on "Suggest RED Placement". The output of the software is a suggestion for
    - the distance RED to screen
    - the distance floor to RED
    - the RED inclination angle.
  - d. Place your RED according to the suggestions.
    - i. RED is in the horizontal middle of the screen.
    - ii. The screen bottom line has to be parallel to the RED.
  - e. Measure your chosen distance RED to screen and enter it.
  - f. Adjust and measure angle of the RED according to the suggestions and enter it.
  - g. Adjust and measure the distance RED to floor according to the suggestions and enter it.
  - h. Press OK.
11. To review if the profile fits, place an average test person in front of the RED and check if the eyes are in the middle of the tracking monitor, if this is not the case, correct the distance RED to floor and the RED inclination angle and correct the parameters in the profile.
12. [Move calibration points](#)<sup>[124]</sup>.
13. Test your experiment once and check if there is a stable tracking over the whole screen.

#### **3.3.3.3.1 Move Calibration Points**

In an experimental setup the test person is looking at a sideboard. To choose proper calibration target positions do the following:



1. Make a decision about the stimulus area.
2. Insert some calibration markers.
3. Take a photo of the stimulus.
4. Cut it to the stimulus area dimensions.
5. In iView X in your RED stand alone profile click on the [Points tab](#)<sup>[320]</sup>.
6. Load the photo.
7. Move calibration points to the labelled positions.

### 3.3.4 Safety Notes

Switch off all components before connecting or disconnecting cables.

When setting up the system, make sure that all connectors and switches are easily accessible.

Periodically check the technical safety of the device, e.g., check for damage to the housing etc.

Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).

In case your iView X system or a component of the system is damaged, switch off the whole system and unplug it from the power source. Do not use the system until the system or its component has been repaired by a certified distributor or the manufacturer (SMI).

Only use original components (cables, power supply etc.) from SMI.

In case a component needs to be replaced, only replace it with original components from SMI.

Do not repair the system by yourself. Electrical shock hazard.

No part of the product may be modified or rebuilt.

Any usage other than described in this manual is not permitted, can damage the device and eventually lead to associated risks such as short-

circuit, fire, electric shock, etc.

We do not assume liability for resultant damages to property or personal injury if the product has been abused in any way or damaged by improper use or failure to observe these operating instructions. In addition, any unauthorized modifications or repairs of the device will render the warranty null and void!

### **Additional Power Supply and E-Box Safety Notes**

Only use connecting cables provided by the manufacturer (SMI).

Make sure the conductive earth wire is not broken, disconnected, removed or interrupted as this can pose a serious threat to life in the event of malfunction.

The device must only be operated in dry, indoor spaces.

Take precautions to make sure that the insulation of the entire product, the safety sockets, connected cables and mains cables are neither damaged nor destroyed.

Always use fuses of the specified type and rating. It is impermissible to use repaired fuses!

Never operate the device without supervision while loads are connected.

Ensure to protect connected loads from the effects of operational disturbance as well as overvoltages.

Do not use the power supply as a direct or indirect charging device.

The device shall not be subjected to heavy mechanical stress.

The device must not be exposed to extreme temperatures, direct sunlight, intense vibration or moisture. Position the device on a level and sturdy surface.

The device generates operational heat. Never insert any objects, block cooler opening of the device, or hinder ventilation in any form or manner.

The device is predominantly cooled by convection.

Never put a naked flame or any containers with liquids on or near the apparatus.

Caution! Capacitors within the device may retain their charge even if the device is disconnected from all power sources.

Never turn on the device immediately after it has been brought from a cool into a warmer environment. Condensing water might destroy your device. Leave the device in OFF position and wait until it has reached ambient temperature.

Before operating the device, make sure that your hands, shoes, clothing, the floor as well as the device itself are dry.

During thunderstorm, unplug the device's power plug from the mains outlet in order to avoid damages due to excess voltage.

In industrial facilities, the safety regulations laid down by the professional trade association for electrical equipment and facilities must be observed. In schools, training facilities, DIY and hobby workshops, the usage of electrical devices is to be supervised by trained personnel.

If there is reason to believe that safe operation is no longer possible, the device is to be put out of operation and secured against unintended operation. Safe operation is no longer possible if:

- the device has sustained visible damages,
- the device no longer works,
- and the device was stored under unfavorable conditions for a long period of time,
- the device was subject to considerable transport stress.

This device is not a toy and should be kept out of reach of children!

Should you have any questions that are not answered in this operating manual, please contact our technical customer service, or other experts.

### **LED illumination**

To avoid unnecessary IR radiation for the eyes, switch off the system when not in use.

The ET module uses invisible LED radiation Class 1.

The used wavelength is 870 nm.

Invisible LED radiation Class 1M may leak when camera housing is opened. Do not view directly with optical instruments when device is opened.

### **Electromagnetic compliance**

**WARNING:** This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications.

### **Electrostatic sensitivity**

WARNING: All internal electronics are sensitive to high voltage or electrostatic discharge. The system can be destroyed if carelessly handled, so extreme care should be taken during set up and operation.

### **Operating Temperature**

The system is designed to operate satisfactorily in an environment where the ambient temperature is between 10 °C and 50 °C, and that there is no water condensation present.

### **Storage Temperature**

Do not store the equipment in an area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

### **Packaging for shipment**

When shipping, use the shipping cartons in which the units were originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

### **Disposal**

Dispose the device according to legal regulations.

## **3.3.5 Maintenance**

### **Cleaning**

Switch off the e-box, disconnect all connection cables before cleaning. The e-box is maintenance-free besides replacing fuses if needed. Use a clean lint-free antistatic slightly moistened cloth to clean the device. Do not use abrasives, detergents or solvents.

Make sure that the camera modules do not come into contact with liquids during cleaning.

## 3.4 iView X Hi-Speed



### iView X Hi-Speed

The iView Hi-Speed system is an easy-to-use high speed eyetracker, which is available with the sampling rates: 240/350 Hz (version until 2005) and 500/1250 Hz (version since 2006). The camera and its IR illumination reside inside a stand-alone Tracking Column with an integrated ergonomic chin/forehead rest. The chin rest and forehead rest stabilizes the test person's head in front of the camera, thus, lacking the need for time-consuming camera adjustment or straining helmet/headband. The system is comfortable for the test person and stays accurate even over long time recordings.

### 3.4.1 Features and Benefits

The iView X Hi-Speed system is a 1250 Hz hyper-accurate eye tracking system for scientific applications in research fields such as neurology, psychology, and reading where ultimate data quality is required. The Hi-Speed 1250 is a desktop system for lab use.

#### Technology

- Non-invasive, video-based eye tracking
- Monocular and binocular dark-pupil tracking, pupil/pupil-CR

#### Performance

- Sampling rate 1250 Hz / 500 Hz monocular  
500 Hz binocular
- Tracking resolution < 0.01° (typ.)
- Gaze position accuracy 0.25° - 0.5° (typ.)
- Processing latency < 0.5 ms
- System latency < 2 ms (typ.)
- Viewing angle ± 30° hor. / 30° (up), 45° (down)  
vert.

#### System

- Operating system Windows XP
- Workstation Desktop / Tower PC

#### Interface

- Genuine SMI ergonomic design with Integrated camera adjustments
- Height-adjustable chin rest (removable for SpeakAloud™ option)
- Easy-to-clean parts

- Head accessible for simultaneous use of recording and stimulation devices (e.g. EEG electrodes, magnetic coils)
- SpeakAloud™ option for out-loud reading with removed chin rest
- BiteBar™ option for superior head fixation

### Auxiliary Devices / Communication

- Audio channel recording
- Open communication interface via Ethernet (UDP)
- Easy integration with third-party stimulus and analysis packages such as Presentation®, E-Prime®, Superlab™, MATLAB®, SPSS®, Excel™ and others
- Analog-Out, Digital IO Interface

### System Options

- SMI Experiment Suite 360° (incl. BeGaze™ & Experiment Center™)
- Application Programming Interface (API)

### Approvals

- CE, EMC, Eye Safety

## 3.4.2 Hardware Components and Wiring

The iView X Hi-Speed system mainly consists of an iView X workstation and a [Hi-Speed Tracking Column](#)<sup>[132]</sup>, that can be connected to a stimulus PC.

For a wiring overview see [Hi-Speed with Stimulus PC](#)<sup>[141]</sup>.

For a wiring overview for the use with non-human primates see [Hi-Speed Primate with Stimulus PC](#)<sup>[161]</sup>.



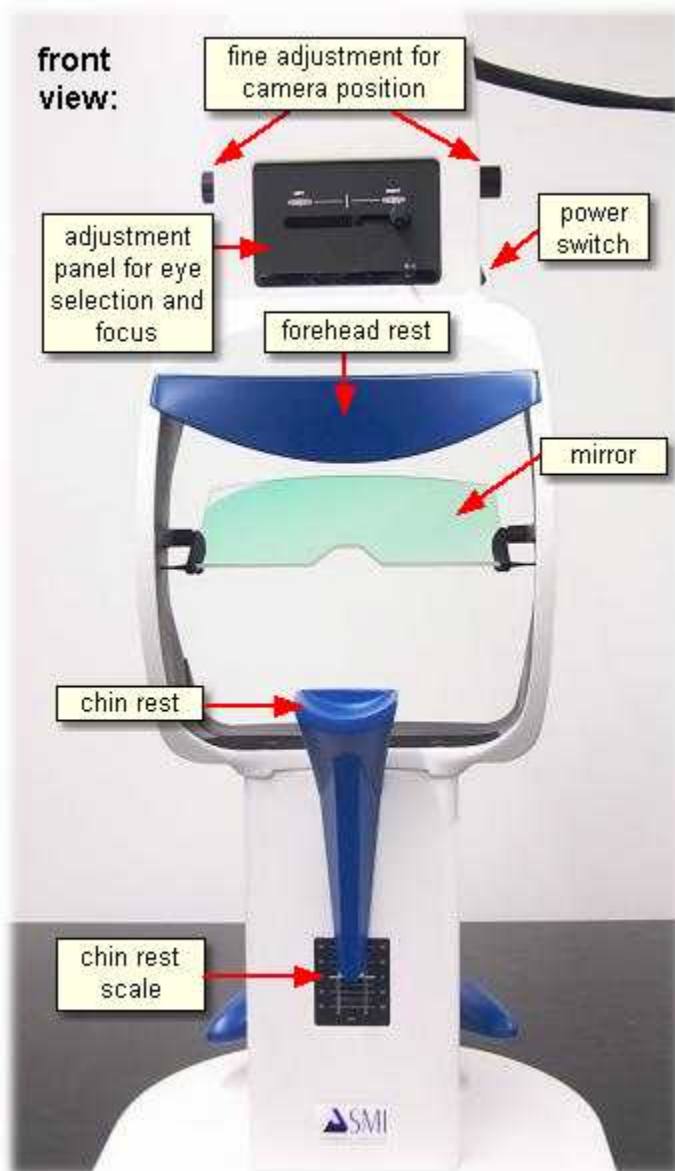
*For safety reasons switch off all components before connecting or disconnecting cables!*

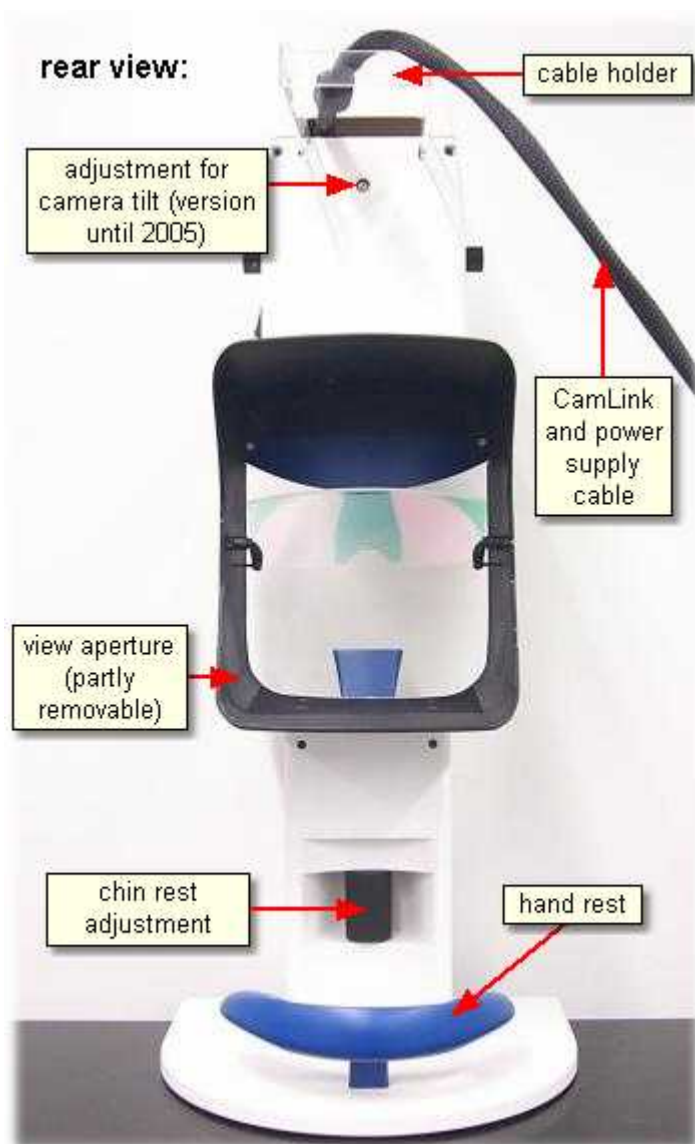
### **3.4.2.1 Hi-Speed Tracking Column**

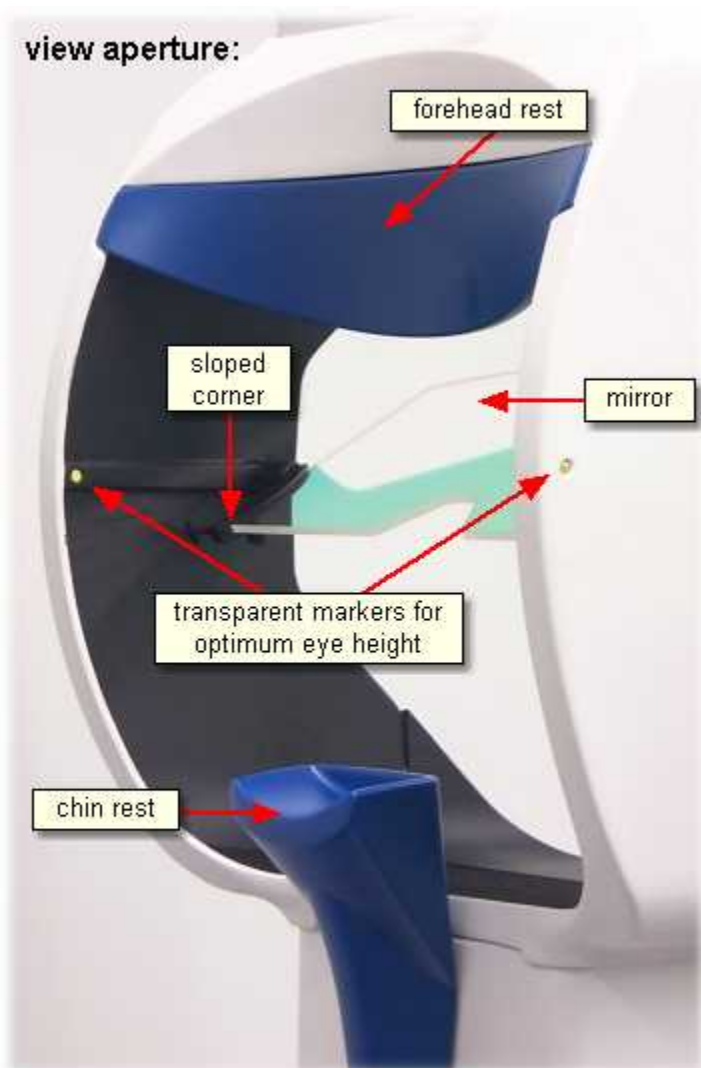
The Hi-Speed Tracking Column is an integrated module which consists of a built-in high speed camera and a comfortable fixture that keeps the test person's head still in front of the camera.

Parts that are in direct connection with the test person have a blue colour:









### 3.4.2.1.1 Operational Controls

**Power Switch:** Located at the right side of the [Tracking Column](#)<sup>[132]</sup>. The Tracking Column should be switched off if not in use.

**Horizontal:** Knob at both sides of the Tracking Column, labelled *HORIZONTAL* (version dependent). Turn the knob to adjust the position of the camera horizontally. If [binocular](#)<sup>[389]</sup> mode is used, the camera has to be set to a central position.

**Vertical:** At one side of the Tracking Column is a knob, labelled *VERTICAL* (version dependent), with which the tilt of the camera can be changed, and therewith the position of the eye relative to the camera will be adjusted vertically.

**Eye Selection:** At the front of the Tracking Column the upper slider is used to select the eye. If monocular eye tracking is used, the slider should be set to left position. If [binocular](#)<sup>[389]</sup> eye tracking is used, move the slider to the right.

**Focus:** At the front of the Tracking Column the lower slider is used to focus the camera. Carefully move the focus lever from left to right to focus.

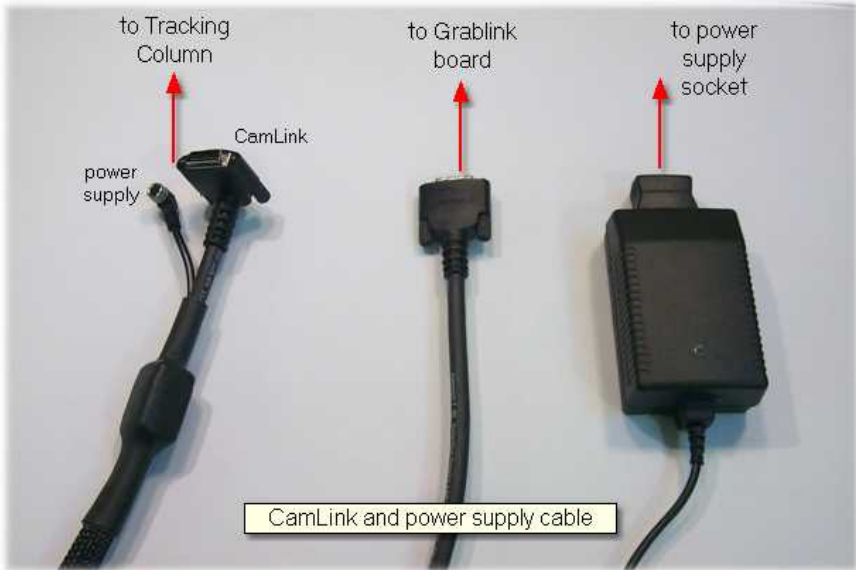
**Mirror tilt:** The mirror can be tilted (version dependent). As a standard setting the mirror should be set to the most upright or steepest position. To adjust the system for people wearing glasses tilt the mirror until possible reflections on the glasses do not disturb the tracking.

**Chin rest adjustment:** The chin rest height can be adjusted with the wheel at the rear side of the Tracking Column. A scale at the front side should help to restore defined positions.

See more details and a version dependent description in [Tracking Column Adjustment](#)<sup>[157]</sup>.

### 3.4.2.1.2 Cables and Connectors

The [Tracking Column](#) <sup>[132]</sup> is connected with the iView X workstation via a CamLink and power supply cable, which has the following three ends:



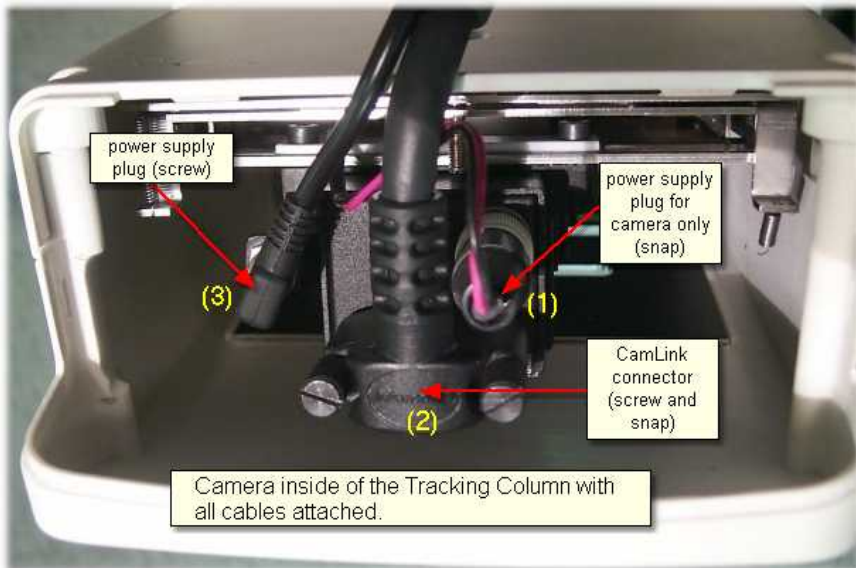
To assemble the system proceed as follows:

1. Make sure that the power switch at the side of the Tracking Column is in off position.
2. At the top of the Tracking Column is a cover, that can be easily removed. To have a better access you can place the Tracking Column onto the floor before removing the cover. Press slightly at both ends of the cover to pull it off.
3. The camera power supply plug should be already connected **(1)** (version dependent). If not, gently plug it in. Avoid tearing at the thin cables.
4. Connect the small power supply plug of the *CamLink and power supply cable* **(3)** (version dependent).

5. Plug in the CamLink connector **(2)** and additionally fasten it with the screws.
6. At the other end of the *CamLink and power supply cable* connect the CamLink connector with the *Grablink* board at the back of the PC.
7. Connect the power supply.

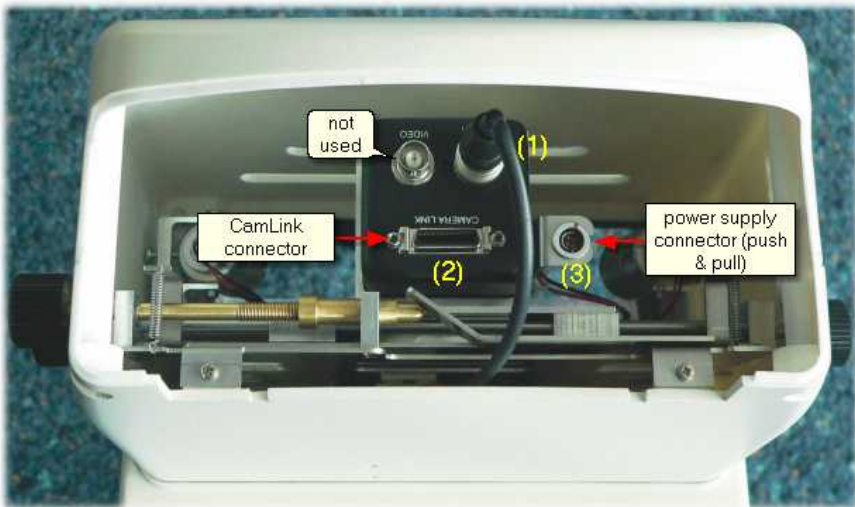
### Version until 2005:

To attach the cable the CamLink connector is to be pushed and screwed, the power supply connector is screwed into the socket.



### Version since 2006:

To attach the cable the CamLink connector is to be pushed and screwed, the power supply connector only needs to be pushed into the socket.



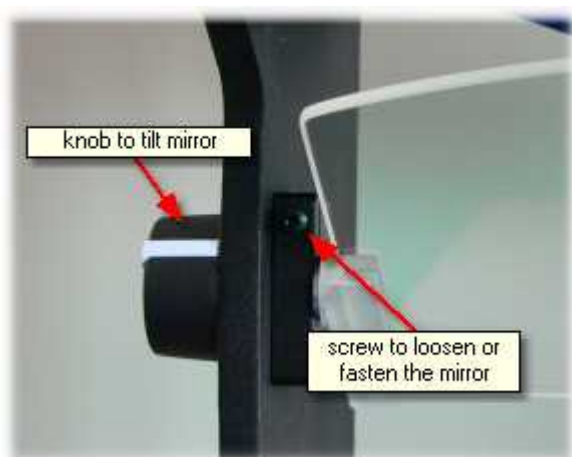
### 3.4.2.1.3 Mirror

The mirror is coated on one side. Infrared light is reflected and visible light is transmitted. Its task is to redirect the infrared illuminated eye image to the high speed camera, which is situated in the upper part of the Tracking Column.

#### Mirror adjustment

As a standard setting the mirror should be set to the most upright or steepest position. To adjust the system for people wearing glasses tilt the mirror until possible reflections on the glasses do not disturb the tracking. To center the eye image vertically afterwards use the adjustment knob labelled *VERTICAL*.

With the screws on each side of the mirror holder you can loosen or fasten the mirror.



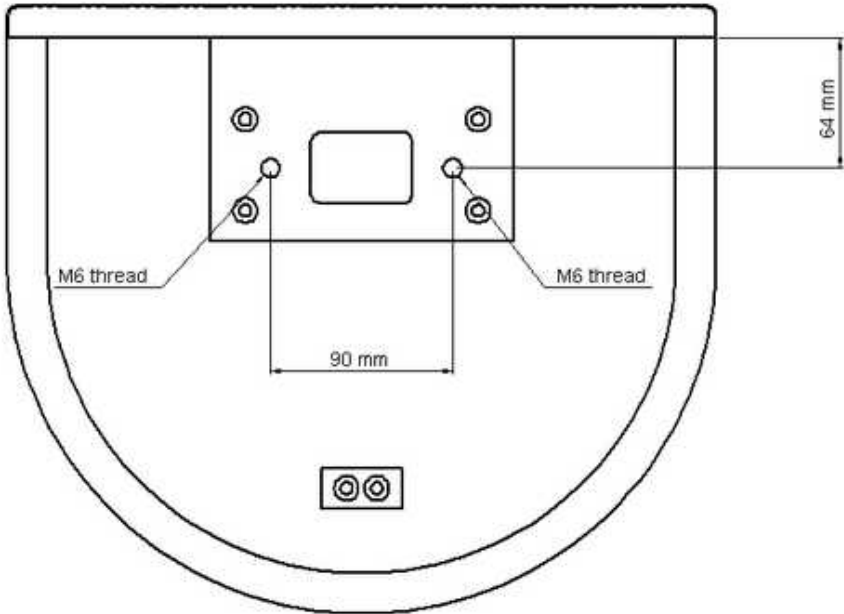
## Assembling

If the mirror is to be dismantled, carefully loose the two plastic screws at the mirror holding and gently pull out the mirror, thereby avoid to touch the surface. The mirror has a sloped side at one corner. When the mirror is reassembled, the sloped side should be in the lower left corner of the aperture (looking from the test person's side).

### 3.4.2.1.4 Foot End

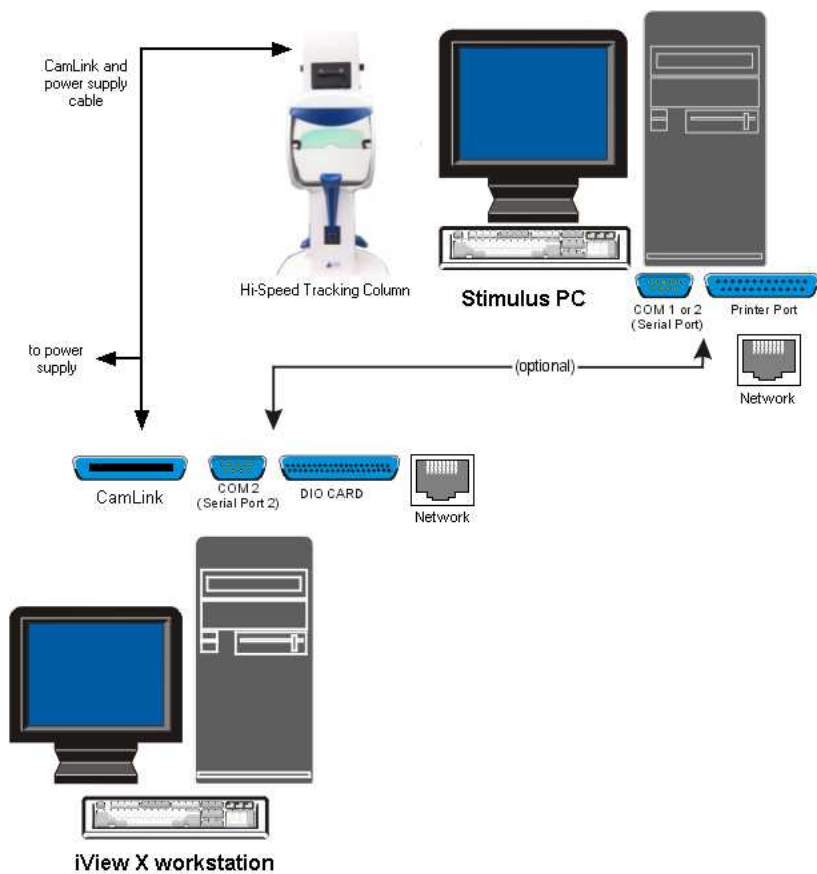
A rubber mat and an angle bracket at the foot end provides a fixed stand. Additionally, the base plate contains mounting threads (M6) to firmly mount the device on a dedicated table.



**Location of the mounting threads (M6) in the base plate:****3.4.2.2 Hi-Speed Wiring with Stimulus PC**

Required hardware components:

- iView X workstation and monitor
- Stimulus PC and monitor for stimulus presentation
- local network or crosspatch cable for direct connection
- [Hi-Speed Tracking Column](#) <sup>[132]</sup>
- [CamLink and power supply cable](#) <sup>[137]</sup>
- [Grablink board](#) <sup>[418]</sup> installed in the iView X workstation, which provides a CamLink interface



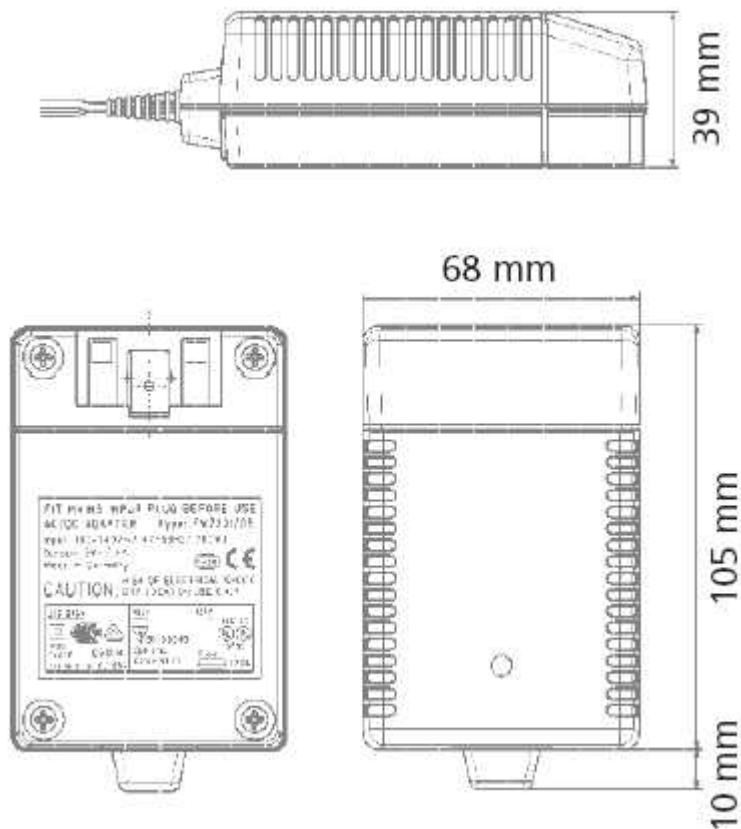
### Cabling Scheme:

- The *Hi-Speed Tracking Column* is connected with the iView X workstation via a *CamLink and power supply cable*, which has three ends:
  - one end goes to the head part of the Tracking Column (see [Cables and Connectors](#)<sup>[137]</sup> for assembling)
  - one end is connected with the CamLink plug at the iView X workstation
  - one end is connected with the power supply
- The iView X workstation and the Stimulus PC are connected via an ethernet connection.

#### 3.4.2.3 Power Supply

The Hi-Speed Tracking Column is connected to a 12 V power supply. See also [Safety Notes](#)<sup>[157]</sup> and [Technical Data](#)<sup>[144]</sup>.

### 3.4.2.3.1 Technical Data



## Characteristics

Universal input 100 - 240 V AC  
Interchangeable primary adapters  
Constant voltage, current limited  
Green LED indicating power on  
Low leakage current < 10  $\mu$ A

Low standby power  $\leq 0.5$  Watt

## Technical data

**Input voltage** 100 V AC - 240 V AC

**Input current** 0.7 A

**Frequency** 50 - 60 Hz

**Efficiency** 80% typ. at full load

**EMC norm** Conforms to FCC, CISPR 22, EN 55022, class B, IEC 61000-4-3, IEC 61000\_4\_6

**Output voltage tolerance**  $\pm 10\%$

## Environmental specification

**Operating temp.** 0 °C to 40 °C at maximum load

**Storage temp.** -40 °C to 70 °C

**Humidity** 5% to 95% non condensing

**Input Transient Susceptibility** Complies with IEC 61000 requirements

## Safety specification

**Standards** Fulfills Class II SELV for the following applications:

IEC 60601-1, UL 2601, VDE, CE label, fulfills medical application class B /BF /CF

## Reliability specification

**MTBF calculation** 200,000 hours at maximum load levels and an ambient temperature of 25 °C (in correspondence with MIL-HDBK-217)

## Mechanical specification

**Weight** 278 g

**Plug connector** AC input: FRIWO exchangeable mains plug system: EURO, UK, USA /Japan, Australia, ROW

## World exclusive

**Medical** 100 - 240 V input voltage  
**power supplies** without earthing, leakage current < 10 µA

## Output data

**Voltage** 12 V  
**Current** 2500 mA  
**Ripple volt.** 100 mV pp

### 3.4.3 User Guide

The following guide describes the steps how to set up, calibrate and run an iView X Hi-Speed experiment, after the system has been [wired](#)<sup>[14]</sup> properly.

#### 3.4.3.1 Experimental Setup

In an experimental setup of iView Hi-Speed a [Hi-Speed Tracking Column](#)<sup>[13]</sup> is placed in front of the test person.

#### The Test Person Chair

A chair should be selected that minimizes the amount of upper body movements made by the test person. Ideally, one lacking wheels and pivots is best.

#### Computer Placement

The area around the stimulus computer screen should be relatively free of distractions. A typical eye tracking setup places the stimulus and iView X monitors in a position where both are visible to the researcher, but only the stimulus monitor is visible to the test person.

#### Tracking Column Placement

The Tracking Column should be placed between the test person and the monitor on the edge of a table. The Tracking Column has a fixed stand

without further assembling.

## Optimum Operating Temperature

It is recommended to switch on the Hi-Speed Tracking Column about 20 minutes before performing any measurements, in order to allow the camera to reach its optimum operating temperature.

## Stimulus Monitor Placement

The iView X Hi-Speed system can be used with most stimulus screens. Please consider the following suggestions when planning your physical setup:

Place the stimulus screen at a distance, so that the viewing angle does not exceed  $\pm 20$  degrees horizontally and  $\pm 15$  degrees vertically, when the test person looks at the edges of the screen.

Place the stimulus screen at a height, so that the test person looks at the center of the screen when looking straight ahead.

### 3.4.3.2 Initialization of Software

Turn on the iView X workstation.



Start iView X by double-clicking on the iView X icon.

Next, iView X must be initialized to run with this configuration. Therefore, the iView X program must be told, which hardware components we use. Usually, it will be done only once on installation, but just in case, the software must be reinitialized, check the following:

## Licensing

First, iView X must be licensed to use high speed. Click on [Help](#)<sup>364</sup> [License Information](#)<sup>366</sup> to see if high speed is currently licensed on your computer. If not, contact your vendor. If you purchased the high speed component, you have to add the component to the License Key. To do so, you have to terminate the old license and ask SMI to issue a new License Key. See also [SMI Software License](#)<sup>27</sup> for more information on the

licensing process.

## Hardware Setup

From the [Setup](#) <sup>[290]</sup> menu go to [Hardware](#) <sup>[290]</sup>.

- Set *Eye Tracking Device* to *Hi-Speed*.

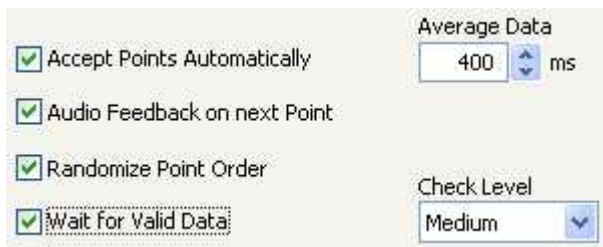
If needed, [establish an ethernet connection](#) <sup>[394]</sup> between the stimulus PC and the iView X workstation.

- Click on *OK* to close the *Setup Hardware* dialog.

## Calibration Setup

From the menu go to [Setup](#) <sup>[290]</sup> - [Calibration](#) <sup>[313]</sup>.

- Set *Calibration Method* to *13 Point* for highest accuracy.
- Check *Accept Points Automatically* so the system will accept each calibration point after the test person fixates.
- Check *Audio Feedback* on next point.
- Check *Randomize Point Order*. Calibration points will be displayed in a random order to keep the test person from anticipating and looking ahead.
- Check *Wait for Valid Data*. The system will only proceed with each calibration point after a valid fixation is detected.
- Set *Check Level* to *Medium*. The stronger this is, the more strict the system will be in accepting calibration points and overall geometry.



*Calibration Settings for Hi-Speed systems (lower part)*

- Go to the *Geometry* tab.
- Set *Stimulus Screen Resolution* to a size that matches the resolution of the Stimulus PC. This will definite the resolution of the output data



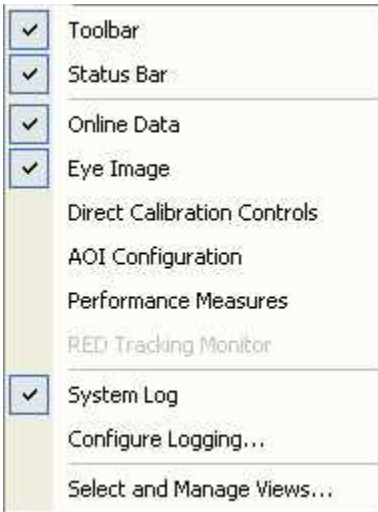
file. (Typical sizes are 1024x768 or 1280x1024.)

- Enter *Stimulus Physical Dimension*, which is the dimension of the stimulus screen and the Monitor-Head-Distance. Both values will be stored in the iView file. Later analysis tools may use these values.
- Click on *OK* to close the window.

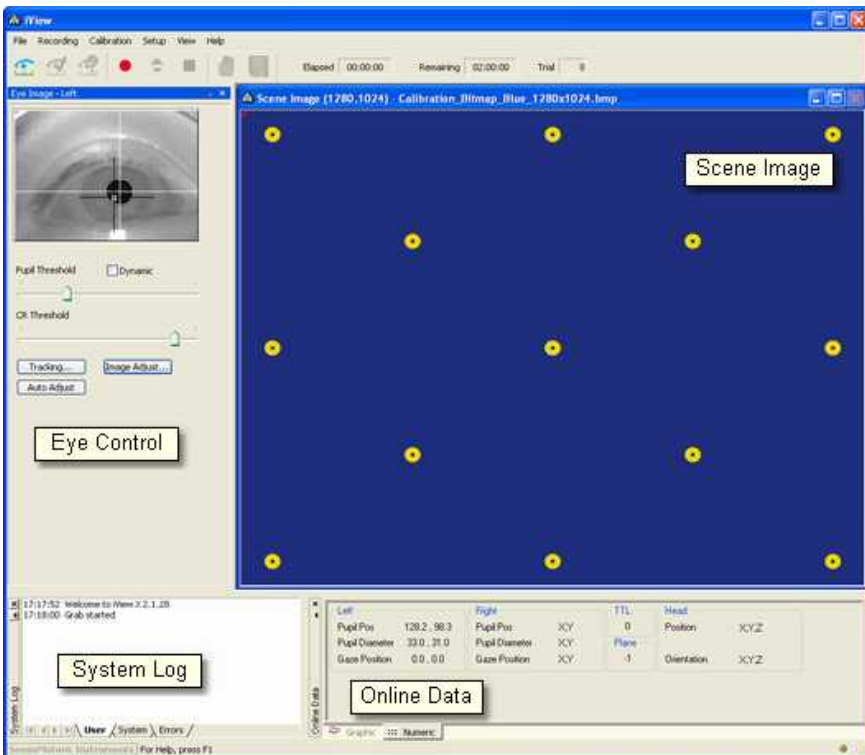
## Docking Windows

Arrange docking windows.

- Go to the [View](#) <sup>[337]</sup> menu and set a check mark to the following windows:



- Align all windows around the Scene Image Window as suggested below:



*A possible iView X Hi-Speed window arrangement*

## Overlay Options

From the menu go to [Setup](#)<sup>[290]</sup> - [Output Gaze Cursor Properties](#)<sup>[327]</sup>.

- If needed, enlarge the sizes of all cursors (left, right and calibration cursor) so that the targets can be comfortably look at.
- Click on OK to close the window.

### 3.4.3.2.1 Context Menu: Hi-Speed Scene Image

If you right-click on the scene image, a context menu pops up.

#### Open Scene Image

Opens a file selection box, in which you can select a scene image.

### Stretch View

Stretches the scene image so it best fits into the iView X workspace.

### Copy Scene

Copies contents of scene image window to clipboard.

### Show AOIs

Shows or hides any drawn [AOIs](#)<sup>[37]</sup>.

### 3.4.3.3 Tracking Column Adjustment

The [Hi-Speed Tracking Column](#)<sup>[132]</sup> can be put on a table without any assembling. To optimize the test person's comfort a height adjustable table is recommended.

### Test Person Placement

The test person sits in front of the Tracking Column and the monitor is placed behind the rear side. The test person should be relaxed and sitting in a comfortable position for using the chin rest.

### Chin rest adjustment and optimum eye height

Have the test person rest his or her head in the chin-rest. The chin rest height can be adjusted with the wheel at the rear side of the Tracking Column. A scale at the front side should help to restore defined positions. Ideally the test person will be comfortably seated with his or her back straight, the forehead resting against the blue forehead rest, with no unnecessary tilt in the face and head.

The optimum eye height is indicated by vitreous or transparent markers at either side of the aperture. The chin rest height should be adjusted until the eyes and the vitreous/transparent markers build a horizontal line.

### Adjust Eye Video

Adjust the Tracking Column in a way that the eye is to be seen in the [eye control](#)<sup>[342]</sup> display as follows:

1. Click in the Eye Control window to activate the eye tracker. The User

message in the System Log should read "Grab started".

2. Turn the upper slider on the adjustment panel to the left to select *monocular*, or to the right for *binocular* tracking.
3. Turn the knob labelled HORIZONTAL, until the eye to be tracked is horizontally centered in the eye camera video.
4. Move the lower slider on the adjustment panel to focus the eye. The focus is best if the corneal reflection is smallest.

For more details on the Tracking Column controls and how to adjust the eye video see

[Adjustment Panel](#) <sup>[153]</sup>

5. As a standard setting the mirror should be set to the most upright or steepest position. To adjust the system for people wearing glasses tilt the mirror, until the reflections on the glasses disappear.
6. Let the test person look at a center target of the stimulus display. Click on the *Auto Adjust* button to automatically adjust the image regarding pupil threshold and image balancing.
7. Click on [Image Adjust](#) <sup>[348]</sup>, then click on *Auto Balance* to let the eye tracker self-adjust brightness and contrast.

The white cross-hair should be centered on the pupil. The black cross-hair should be centered on the corneal reflex (CR).



If the eye tracker is not tracking the pupil or CR properly, consult the chapter [Advanced Eye Image Adjustment](#). <sup>[370]</sup>

8. Ask the test person to look at the four corners of the screen. Setup is complete if both crosshairs follow the pupil and cornea reflex during these eye movements.

### 3.4.3.3.1 Adjustment Panel

#### Horizontal and vertical camera adjustment

The camera can be adjusted horizontally and vertically.

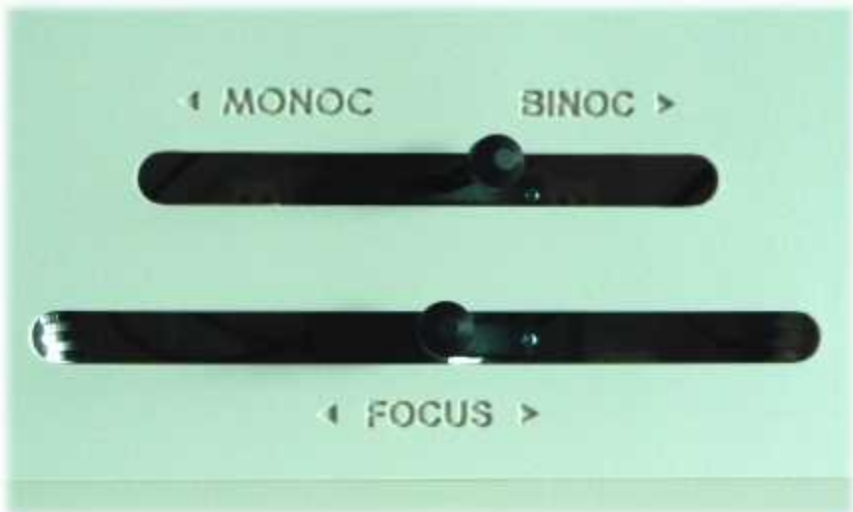
##### *Horizontal*

With a knob at each side of the column, labelled *HORIZONTAL*, the position of the camera can be adjusted horizontally. If [binocular](#)<sup>389)</sup> mode is used, the camera has to be set to a central position.

##### *Vertical*

At one side of the Tracking Column is a knob, labelled *VERTICAL*, with which the tilt of the camera can be changed, and therewith the position of the eye relative to the camera will be adjusted vertically.

#### Adjustment Panel for Focus and Eye Selection



##### *Focus*

Moving the focus lever on the adjustment panel from left to right will focus the camera.

### *Eye Selection*

If monocular eye tracking is used, the upper slider should be set to left position. If [binocular](#) <sup>[389]</sup> eye tracking is used, move the upper slider to the right.

### **Switching between left eye, right eye and binocular**

If you switch eye tracking between left eye, right eye or binocular, make sure, that you set the [assignment of the eye](#) <sup>[296]</sup> accordingly. After this, the control elements of the column should be set as follows:

#### *Left eye*

Set the MONOC/BINOC slider to *left* position. Turn the HORIZONTAL knob until the left eye is visible in the [eye control](#) <sup>[343]</sup>.

#### *Right eye*

Set the MONOC/BINOC slider to *left* position. Turn the HORIZONTAL knob until the right eye is visible in the [eye control](#) <sup>[343]</sup>.

#### *Binocular*

Set the MONOC/BINOC slider to *right* position. Turn the HORIZONTAL knob to move the camera to a *central* position until both eyes are visible in the [eye control](#) <sup>[345]</sup>.

### **3.4.3.4 Run Experiment**

Now you are ready to run an experiment.

### **Using Presentation**

It is a good idea to use one of the example experiments from the *iView X Presentation Interface* as a starting point for your own experiment.

On the *Stimulus PC* go to the folder, where the *Presentation Interface* is installed. Go to the subfolder *Experiments*. There you find various experiment examples. Go to a subfolder and double-click on the .exp file. Presentation opens.

Go to the *Settings* tab, click on *Video*. Under *Display Device Adapter* select your monitor.

Go to the *Main* tab and click on *Run* to start the experiment.

The example experiments demonstrate remotely controlled calibration and recording, while presenting a stimulus.

### Using SMI Experiment Center™

Start an experiment with *SMI Experiment Center*™. For more information see the *SMI Experiment Center*™ manual.

### Calibration

The above stimulus programs are capable of automated calibration. Make sure to carefully select the type, size, and colour of the calibration targets. Background and cursor colours should be similar to the stimulus back- and foreground colours.

If calibration starts, proceed as follows:




1. A calibration point will be displayed for the test person.
2. During the calibration process the test person should look at the presented targets without moving its head. When the test person has fixated, press <space> to accept the point.
3. If calibration is set to *Auto Accept Points*, the system will automatically advance through the calibration points. The test person should view each one as it is presented. Verify that the test person complies with the calibration and does not look away from points too early.
4. If the calibration was completed successfully, the *User* message in the *System Log* will display "Calibration finished successfully" and the scene image will show a cursor indicating the test person's gaze position.
5. Check the [Error](#)<sup>[362]</sup> tab in the [System Log](#)<sup>[360]</sup> window for potential problems during the calibration. If the calibration is successful, the [Online Data](#)<sup>[340]</sup> window will begin showing live gaze data.

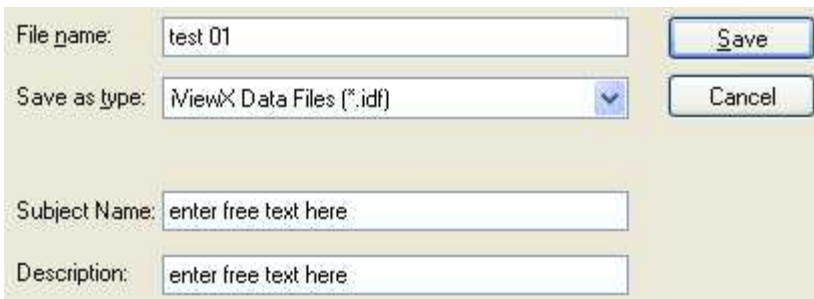
## Automated Recording

The above stimulus programs automatically start and stop a recording during the stimulus presentation and save the recorded data.

## Manual Recording

If you choose to manually start recording proceed as follows:

1. Perform a calibration using a suitable [calibration process](#) <sup>[245]</sup>.
2. Click on the *start recording* button  to start recording.
3. Begin the stimulus presentation software on the Stimulus PC.
4. Click on the *stop recording* button  to stop recording.
5. Click on the *save* button  to open the save data dialog.
6. Enter a file name.
7. Optionally, fill in *Subject Name* and *Description*.
8. Click on *Save* to save the data as a file of type *.IDF*.



The screenshot shows a save dialog box with the following fields and buttons:

- File name:** A text input field containing "test 01".
- Save as type:** A dropdown menu showing "ViewX Data Files (\*.idf)".
- Subject Name:** A text input field containing "enter free text here".
- Description:** A text input field containing "enter free text here".
- Buttons:** "Save" and "Cancel" buttons are located on the right side of the dialog.

## Remote Recording

*Start*, *stop* recording, *save* and many more functions can also be controlled by the [Remote Command Language](#) <sup>[438]</sup>.



## Analysis

The result of the measurement is an [.idf file](#) recorded and stored on the iView X PC. The resulting file can be loaded into *SMI BeGaze™* analysis software for visualization and further analysis.

To export the IDF data into an ASCII text format, load the IDF file into the IDF Converter program and choose options for export. (The IDF Converter is part of the *iTools* package on the iView X CD.) The resulting text file can be loaded and analyzed with Excel™, Matlab™ or other spreadsheet programs. (Note: Consider keeping IDF files as a data archive).

### 3.4.4 Safety Notes

Switch off all components before connecting or disconnecting cables.

When setting up the system, make sure that all connectors and switches are easily accessible.

Periodically check the technical safety of the device, e.g., check for damage to the housing etc.

Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).

In case your iView X system or a component of the system is damaged, switch off the whole system and unplug it from the power source. Do not use the system until the system or its component has been repaired by a certified distributor or the manufacturer (SMI).

Only use original components (cables, power supply etc.) from SMI.

In case a component needs to be replaced, only replace it with original components from SMI.

Do not repair the system by yourself. Electrical shock hazard.

No part of the product may be modified or rebuilt.

Any usage other than described in this manual is not permitted, can damage the device and eventually lead to associated risks such as short-circuit, fire, electric shock, etc.

We do not assume liability for resultant damages to property or personal injury if the product has been abused in any way or damaged by improper use or failure to observe these operating instructions. In addition, any unauthorized modifications or repairs of the device will render the warranty null and void!

### **Additional Power Supply Safety Notes**

Only use connecting cables provided by the manufacturer (SMI). Make sure the conductive earth wire is not broken, disconnected, removed or interrupted as this can pose a serious threat to life in the event of malfunction.

The device must only be operated in dry, indoor spaces.

Take precautions to make sure that the insulation of the entire product, the safety sockets, connected cables and mains cables are neither damaged nor destroyed.

Always use fuses of the specified type and rating. It is impermissible to use repaired fuses!

Never operate the device without supervision while loads are connected.

Ensure to protect connected loads from the effects of operational disturbance as well as overvoltages.

Do not use the power supply as a direct or indirect charging device.

The device shall not be subjected to heavy mechanical stress.

The device must not be exposed to extreme temperatures, direct sunlight, intense vibration or moisture. Position the device on a level and sturdy surface.

The device generates operational heat. Never insert any objects, block cooler opening of the device, or hinder ventilation in any form or manner. The device is predominantly cooled by convection.

Never put a naked flame or any containers with liquids on or near the apparatus.

Caution! Capacitors within the device may retain their charge even if the device is disconnected from all power sources.

Never turn on the device immediately after it has been brought from a cool into a warmer environment. Condensing water might destroy your device. Leave the device in OFF position and wait until it has reached ambient temperature.

Before operating the device, make sure that your hands, shoes, clothing, the floor as well as the device itself are dry.

During thunderstorm, unplug the device's power plug from the mains outlet in order to avoid damages due to excess voltage.

In industrial facilities, the safety regulations laid down by the professional trade association for electrical equipment and facilities must be observed. In schools, training facilities, DIY and hobby workshops, the usage of electrical devices is to be supervised by trained personnel.

If there is reason to believe that safe operation is no longer possible, the device is to be put out of operation and secured against unintended operation. Safe operation is no longer possible if:

- the device has sustained visible damages,
- the device no longer works,
- and the device was stored under unfavorable conditions for a long period of time,
- the device was subject to considerable transport stress.

This device is not a toy and should be kept out of reach of children!

Should you have any questions that are not answered in this operating manual, please contact our technical customer service, or other experts.

### **LED illumination**

To avoid unnecessary IR radiation for the eyes, switch off the system when not in use.

The Hi-Speed camera system uses invisible LED radiation Class 1.

The used wavelength is 910 nm.

### **Electromagnetic compliance**

**WARNING:** This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications.

### **Electrostatic sensitivity**

WARNING: All internal electronics are sensitive to high voltage or electrostatic discharge. The system can be destroyed if carelessly handled, so extreme care should be taken during set up and operation.

### **Operating Temperature**

The system is designed to operate satisfactorily in an environment where the ambient temperature is between 10 °C and 50 °C, and that there is no water condensation present.

### **Storage Temperature**

Do not store the equipment in an area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

### **Packaging for shipment**

When shipping, use the shipping cartons in which the units were originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

### **Disposal**

Dispose the device according to legal regulations.

## **3.4.5 Maintenance**

Switch off the system and the [Tracking Column](#) <sup>132</sup> before cleaning.

The test person will be in direct contact with the forehead rest, chin rest and hand rest of the Tracking Column (blue parts). Therefore, these parts should be cleaned regularly. Use a soft cloth lightly moistened or pads dampened with disinfectant fluids on isopropanol base. Do not use spirit for cleaning.

The camera lenses and the infrared mirror should be carefully cleaned by

using a soft cloth or special lens paper. Avoid touching the glass surface of the lenses with your hands.

Use a clean lint-free, antistatic, slightly moistened cloth to clean all other parts. Do not use abrasives, detergents or solvents.

Make sure that the camera modules do not come into contact with liquids during cleaning.

## 3.5 iView X Hi-Speed Primate



The iView Hi-Speed Primate system offers a solution for eye tracking on non-human primates. The system is easy to set up and involves as little extra training of the subject as possible.

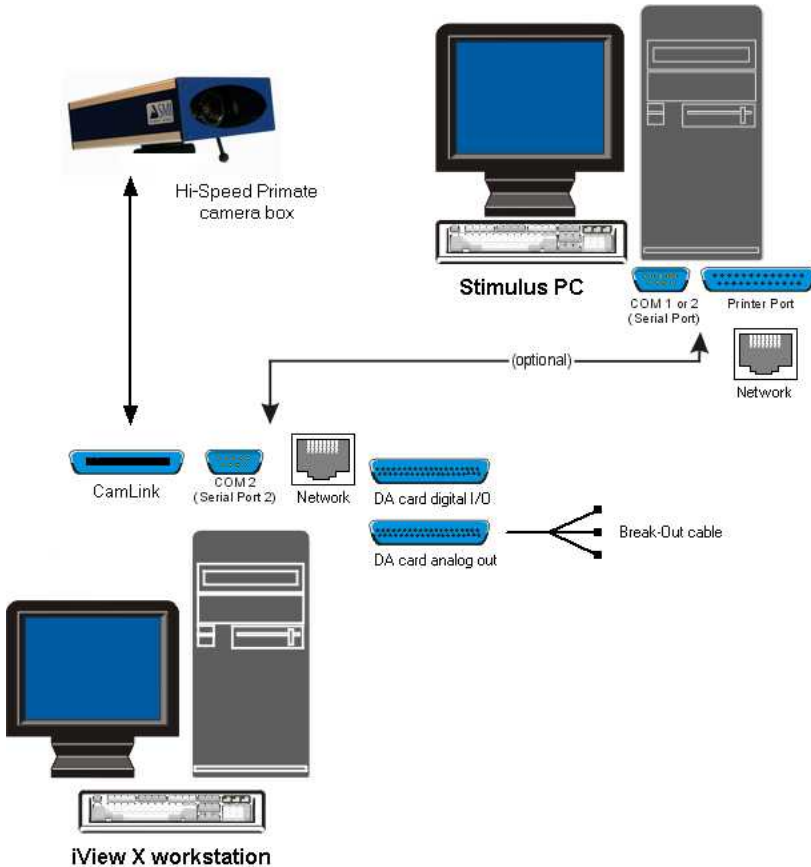
While being completely non-invasive through its video-based eye tracking method the iView Hi-Speed Primate system provides direct analog calibration and a robust, precise analog voltage output similar to scleral search coil (SSC) systems.

### 3.5.1 Hardware Components and Wiring

Required hardware components:

- iView X workstation and monitor
- Stimulus PC and monitor for stimulus presentation
- local network or crosspatch cable for direct connection

- [Hi-Speed Primate camera](#)<sup>[163]</sup> box with CamLink cable
- [Grablink board](#)<sup>[418]</sup> installed in the iView X workstation



*For safety reasons switch off all components before connecting or disconnecting cables!*

### 3.5.1.1 Primate Camera

The Hi-Speed Primate camera system consists of

- a [Hi-Speed Primate camera box](#)<sup>[163]</sup> with a CamLink cable (see [wiring](#)<sup>[165]</sup>)
- and a 12 V [power supply](#)<sup>[167]</sup>

Additional required components for the iView X workstation:

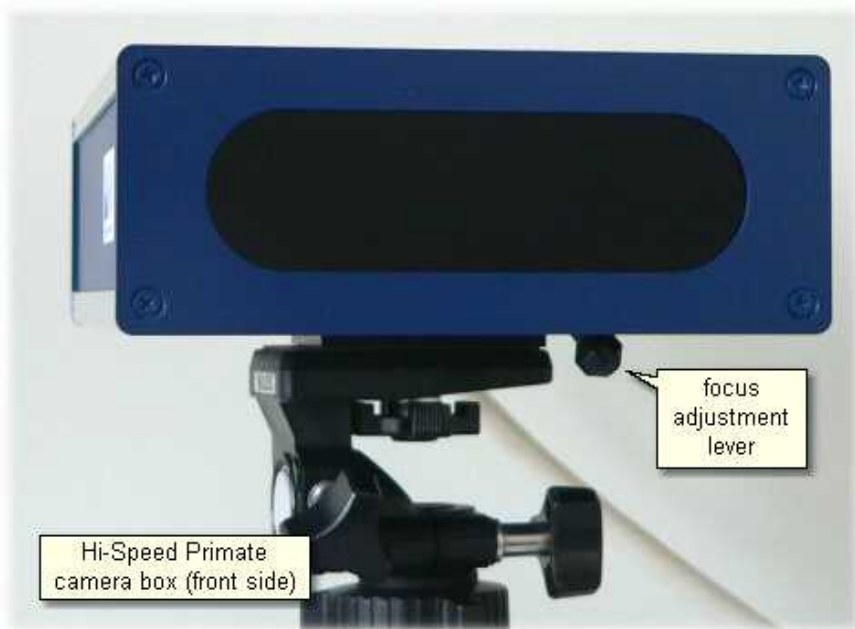
- a [Grablink board](#)<sup>[418]</sup>
- a [DA card digital IO/analog out](#)<sup>[425]</sup> with a break-out cable for [direct analog calibration](#)<sup>[244]</sup>.

#### 3.5.1.1.1 Camera Box

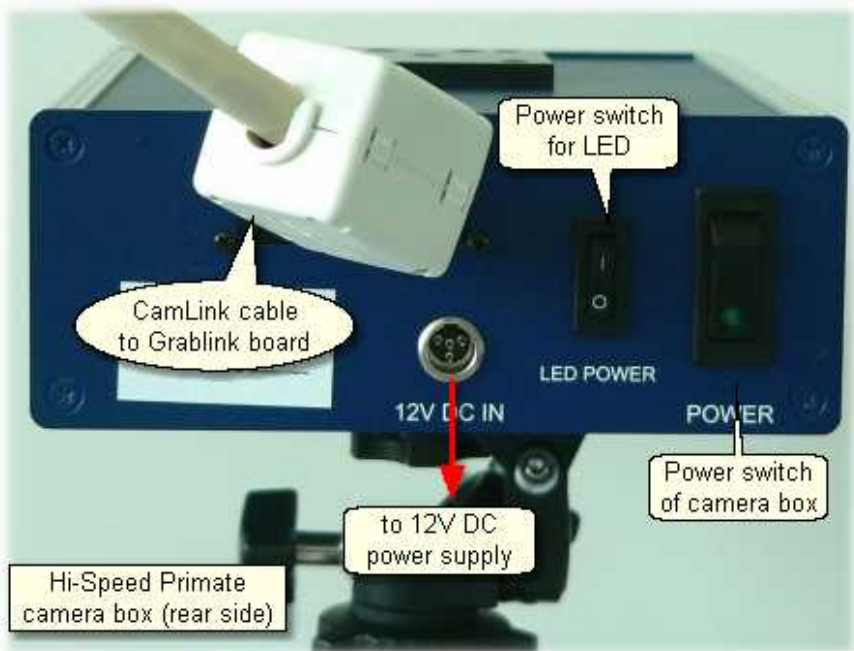
The camera inside the box is a Hi-Speed binocular camera with two illumination LEDs.

The focus can be adjusted with the focus adjustment lever beneath the camera.

The camera box has mounting threads at both sides. The thread in the middle is a standard tripod thread (1/4-20 UNC-2B). The other threads are M6 threads.







At the rear side of the camera box you can find:

- Power switch of camera box
- LED power switch, switches only illumination LEDs
- 12 DC IN connector
- CamLink cable

### 3.5.1.1.2 Wiring

Before connecting the system make sure that the power switch at the rear side of the camera box is in OFF position.

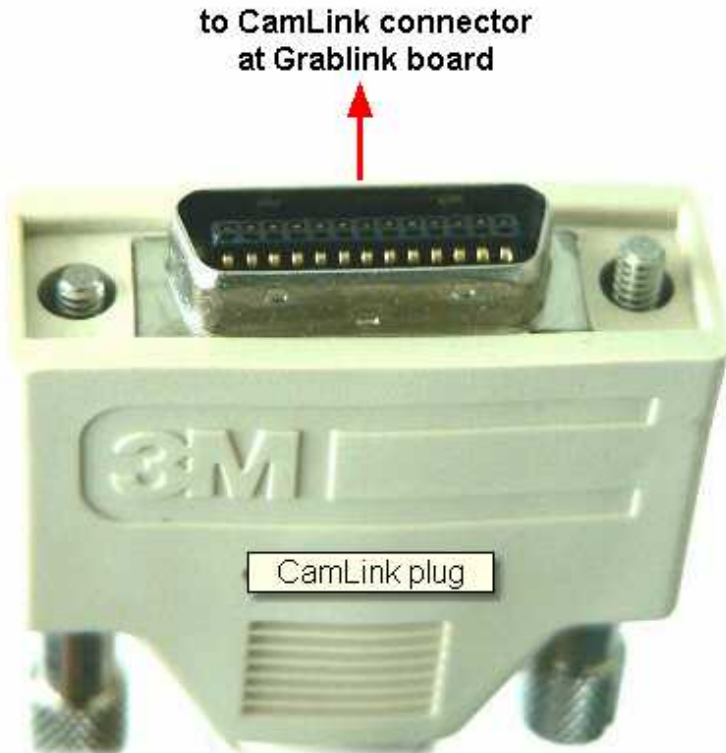
Connect 12 V power supply with the 12 DC IN connector.

Connect the other end of the CamLink cable with the CamLink interface plug ([Grablink](#)<sup>418</sup> board) at the iView X workstation.

to 12 V DC IN of  
the camera box



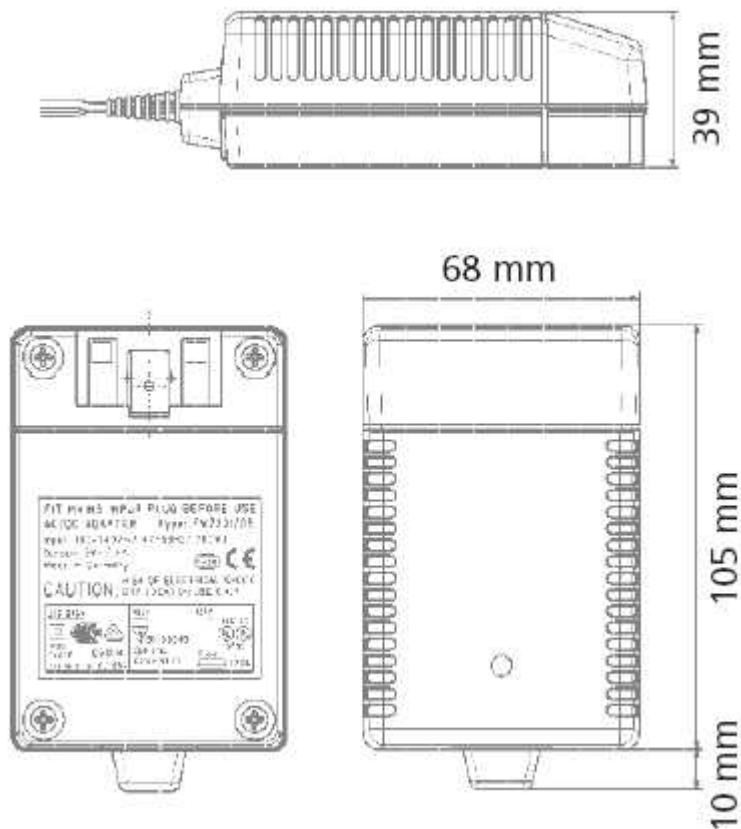
12V DC power plug



### 3.5.1.2 Power Supply

The Hi-Speed Primate system is connected to a 12 V power supply. See also [Safety Notes](#)<sup>[176]</sup> and [Technical Data](#)<sup>[168]</sup>.

### 3.5.1.2.1 Technical Data



## Characteristics

Universal input 100 - 240 V AC  
Interchangeable primary adapters  
Constant voltage, current limited  
Green LED indicating power on  
Low leakage current < 10  $\mu$ A

Low standby power  $\leq 0.5$  Watt

## Technical data

**Input voltage** 100 V AC - 240 V AC

**Input current** 0.7 A

**Frequency** 50 - 60 Hz

**Efficiency** 80% typ. at full load

**EMC norm** Conforms to FCC, CISPR 22, EN 55022, class B, IEC 61000-4-3, IEC 61000\_4\_6

**Output voltage tolerance**  $\pm 10\%$

## Environmental specification

**Operating temp.** 0 °C to 40 °C at maximum load

**Storage temp.** -40 °C to 70 °C

**Humidity** 5% to 95% non condensing

**Input Transient Susceptibility** Complies with IEC 61000 requirements

## Safety specification

**Standards** Fulfills Class II SELV for the following applications: IEC 60601-1, UL 2601, VDE, CE label, fulfills medical application class B /BF /CF

## Reliability specification

**MTBF calculation** 200,000 hours at maximum load levels and an ambient temperature of 25 °C (in correspondence with MIL-HDBK-217)

## Mechanical specification

**Weight** 278 g

**Plug connector** AC input: FRIWO exchangeable mains plug system: EURO, UK, USA /Japan, Australia, ROW

## World exclusive

**Medical** 100 - 240 V input voltage

**power supplies** without earthing, leakage current < 10 µA

## Output data

**Voltage** 12 V

**Current** 2500 mA

**Ripple volt.** 100 mV pp

### 3.5.2 User Guide

The following guide describes the steps how to set up, calibrate and run an iView X Hi-Speed Primate experiment, after the system has been [wired](#)<sup>[16†]</sup> properly.

#### 3.5.2.1 Initialization of Software

Turn on the iView X workstation.



Start iView X by double-clicking on the iView X icon.

Next, iView X must be initialized to run with this configuration. Therefore, the iView X program must be told, which hardware components we use. Usually, it will be done only once on installation, but just in case, the software must be reinitialized, check the following:

From the [Setup](#)<sup>[290†]</sup> menu go to [Hardware](#)<sup>[290†]</sup>.

- Set *Eye Tracking Device* to *Hi-Speed Primate*.
- Click on *Advanced*.
- Select the *Tracking Mode*.
- Select the [Corneal Reflex](#)<sup>[293†]</sup> tab.
- If head movements are possible, CR tracking can offer compensation. Then you can choose the number of reflexes and which to use: left or right CR or average of both.
- Click on *OK* to close the *Advanced* dialog.

- Click on *OK* to close the *Setup Hardware* dialog.

Activate eye camera by clicking on the [Eye Control](#)<sup>[345]</sup>.

Arrange docking windows (if needed). Therefore you can go to the [View](#)<sup>[337]</sup> menu to check/uncheck views.

From the menu go to [Setup](#)<sup>[290]</sup> - [Calibration](#)<sup>[313]</sup>.

- Select 'Direct Analog (Gain & Offset)'.

*Note: This calibration method is only visible if iView X has been configured with the [Analog Out option](#)<sup>[437]</sup>.*

- Click on *OK* to close the window.

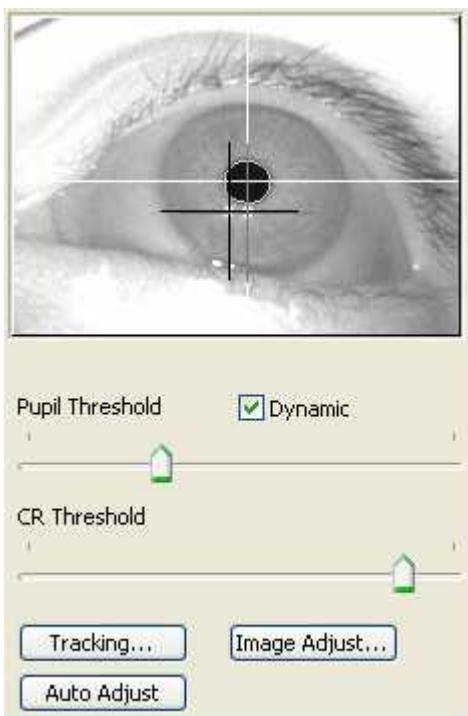
From the menu go to [Setup](#)<sup>[290]</sup> - [Output Gaze Cursor Properties](#)<sup>[327]</sup>.

- If needed, enlarge the sizes of all cursors (left, right and calibration cursor) so that the targets can be comfortably look at.
- Click on *OK* to close the window.

### 3.5.2.2 Adjust Eye Video

Place the subject in a comfortable position in front of the Stimulus PC monitor.

On the iView X PC look at the [Eye Control](#)<sup>[342]</sup>.



### *Eye image for monocular tracking with two CRs*

Depending on if you selected monocular or binocular tracking you will see one of the following

- [Eye Control for Monocular Eye Tracking](#)<sup>[343]</sup>
- [Eye Control for Binocular Eye Tracking](#)<sup>[345]</sup>

### **Focus Adjustment**

Adjust the focus with the focus adjustment lever at the bottom side of the camera.



## Thresholds

Here the detection thresholds for pupil and corneal reflex (CR), if available, can be set.

Move the pupil slider until a white cross-hair is visible in the eye control. The center of the cross-hair should be the center of the pupil.

In case CRs are used, move the CR threshold slider until the black cross-hairs are visible in the eye control. The centers of the cross-hairs should be centered on the corneal reflexes near the center of the pupil.

*Dynamic Threshold:* If checked, the eyetracker automatically adapts the pupil threshold to slightly changing environments like small movements of the head, changing of light etc.

## Image Adjust

Here you can adjust [brightness and contrast](#)<sup>[348]</sup> of the eye image.

## Auto Adjust

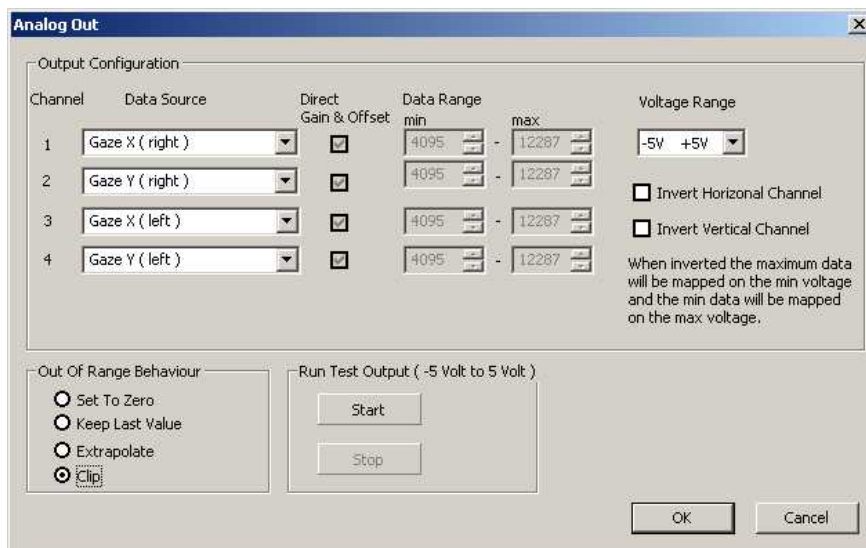
If you click on the *Auto Adjust* button the image is adjusted regarding pupil threshold and [image balancing](#)<sup>[348]</sup>

## Tracking

If the eye tracker has difficulties to track the pupil or CR, you can change the [tracking parameters](#)<sup>[349]</sup>. See also chapter [Advanced Eye Image Adjustment](#)<sup>[370]</sup>.

### 3.5.2.3 Calibration

In the [Setup Hardware](#)<sup>[290]</sup> [Communication](#)<sup>[292]</sup> dialog click on [Config](#)<sup>[307]</sup> in the **TTL IO/Analog Out** section. In the **Analog Out** window, select channel definitions for each of the four output channels. The direct calibration method requires 'Gaze' output. 'Data Range' cannot be adjusted.



If running in monocular mode, only select the data sources that correspond to the selected eye.

*Note: Assign each data source only once to one channel, even if you are not using all four channels. Example: 'Gaze X (Right)' should only appear once in the data source list.*

The voltage range for output can be adjusted via 'voltage range'. Horizontal and vertical output channels can be inverted via check boxes on the right (default origin is upper left corner; X voltage increases when subject looks to the right, Y voltage increases when subject looks down).

To test the output connection, click the 'start' button under 'Run Test Output' to generate a  $-5$ ,  $+5$  square wave.

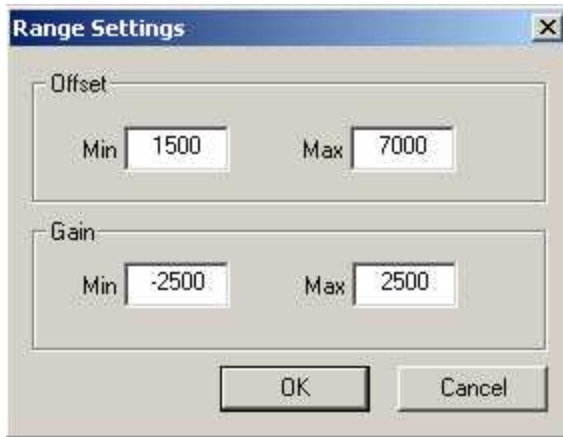
For purposes of these directions, we assume the following channel mapping:

Channel 1	-	Gaze X (right eye)
Channel 2	-	Gaze Y (right eye)
Channel 3	-	Gaze X (left eye)

Channel 4 - Gaze Y (left eye)

## Data Range Setup

On the [Calibration Configuration](#) <sup>356</sup> window, select the 'Ranges' button. This window selects the gain and offset range that can be adjusted during the calibration process.



Offset and Gain ranges should be set to give maximum sensitivity in the next several steps, while allowing enough working range to deal with each subject.

If range is set too narrow, the gain and offset sliders will not allow enough of a change to get desired output.

If range is set too wide, the sliders will be too sensitive to fine-tune output.

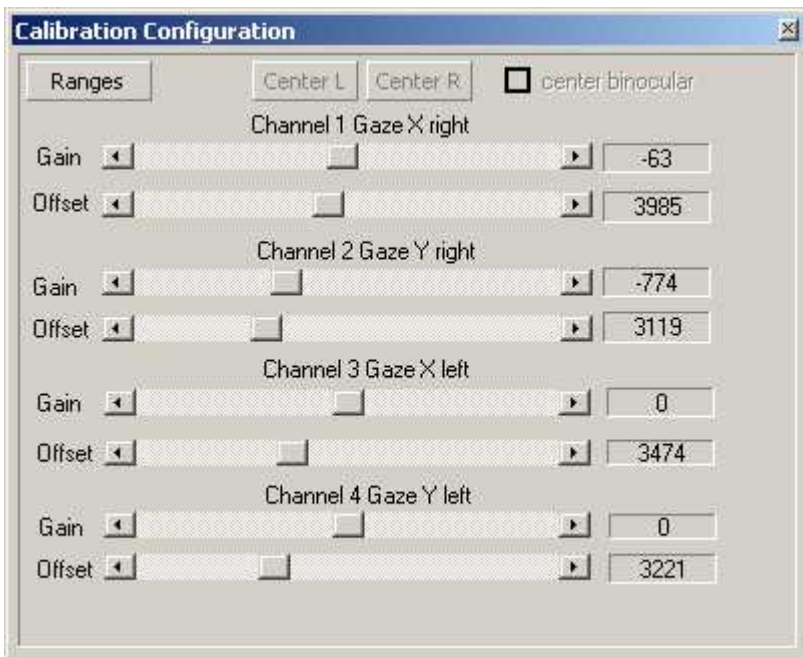
*Note: Some experimentation is required to determine a good working range for each particular system. The values listed above are a good starting point for a 350 Hz system operating in monocular mode.*

Once a good range is selected, it should work for all subjects for this particular system configuration.

## Subject Calibration

The [Calibration Configuration](#) <sup>[356]</sup> window is used to set offset and gain for the eye movement channels.

*Note: Output voltage will remain at minimum (-5,-5 in this example) until any one of the Offset sliders is moved for the first time. At that point you will see live gaze output on your oscilloscope.*



The following steps will calibrate a subject:

1. Have the subject look at the center of the screen. Adjust the channel 1 OFFSET slider until the output for that channel is horizontally centered on the scope. This will define the center of the horizontal output range when the subject is looking at the center of the screen.
2. Adjust the channel 2 OFFSET slider until the output signal is

centered vertically. This will define the center of the vertical output range when the subject is looking at the center of the screen. The output signal should now be displayed in the center, while the subject is looking at the center.

3. With the output centered, click the "Center R" button to define the center of the screen for the first two channels. All gain values will now be applied to this defined center.
4. Repeat this process for Channels 3 and 4 to center the other eye. When complete, click the "Center L" button.
5. Have the subject look at a point in the corner of the useful part of the stimulus. This can be accomplished with a static target in the corner or a moving target that oscillates in and out of a corner.
6. Adjust the GAIN sliders for Channels 1 and 2 so that the expected output range is visible when the subject looks at points at the edge of the screen. If adjusted properly, the output should be centered when the subject looks at the center, and at the maximum expected value for Channel 1 when the subject looks at the far right or left and Channel 2 at the far top and bottom.
7. Repeat the gain process for Channels 3 and 4.

If necessary, gain can be adjusted at any time during the test. If Offset is changed, remember to click the "Center L" and "Center R" buttons in order to reset the center of the screen.

### 3.5.2.4 Run Experiment

After the [calibration process](#)<sup>[173]</sup> analog out voltages that correspond to the pupil and gaze positions are immediately available.

In case additionally gaze and pupil positions need to be recorded to a file,

use the *Start Recording*  and *Stop Recording*  buttons to create an [IDF](#)<sup>[260]</sup> data file.

### 3.5.3 Safety Notes

Switch off all components before connecting or disconnecting cables.

When setting up the system, make sure that all connectors and switches are easily accessible.

Periodically check the technical safety of the device, e.g., check for damage to the housing etc.

Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).

In case your iView X system or a component of the system is damaged, switch off the whole system and unplug it from the power source. Do not use the system until the system or its component has been repaired by a certified distributor or the manufacturer (SMI).

Only use original components (cables, power supply etc.) from SMI.

In case a component needs to be replaced, only replace it with original components from SMI.

Do not repair the system by yourself. Electrical shock hazard.

No part of the product may be modified or rebuilt.

Any usage other than described in this manual is not permitted, can damage the device and eventually lead to associated risks such as short-circuit, fire, electric shock, etc.

We do not assume liability for resultant damages to property or personal injury if the product has been abused in any way or damaged by improper use or failure to observe these operating instructions. In addition, any unauthorized modifications or repairs of the device will render the warranty null and void!

## Additional Power Supply Safety Notes

Only use connecting cables provided by the manufacturer (SMI). Make sure the conductive earth wire is not broken, disconnected, removed or interrupted as this can pose a serious threat to life in the event of malfunction.

The device must only be operated in dry, indoor spaces.

Take precautions to make sure that the insulation of the entire product, the safety sockets, connected cables and mains cables are neither damaged nor destroyed.

Always use fuses of the specified type and rating. It is impermissible to use repaired fuses!

Never operate the device without supervision while loads are connected.

Ensure to protect connected loads from the effects of operational disturbance as well as overvoltages.

Do not use the power supply as a direct or indirect charging device.

The device shall not be subjected to heavy mechanical stress.

The device must not be exposed to extreme temperatures, direct sunlight, intense vibration or moisture. Position the device on a level and sturdy surface.

The device generates operational heat. Never insert any objects, block cooler opening of the device, or hinder ventilation in any form or manner.

The device is predominantly cooled by convection.

Never put a naked flame or any containers with liquids on or near the apparatus.

Caution! Capacitors within the device may retain their charge even if the device is disconnected from all power sources.

Never turn on the device immediately after it has been brought from a cool into a warmer environment. Condensing water might destroy your device. Leave the device in OFF position and wait until it has reached ambient temperature.

Before operating the device, make sure that your hands, shoes, clothing, the floor as well as the device itself are dry.

During thunderstorm, unplug the device's power plug from the mains outlet in order to avoid damages due to excess voltage.

In industrial facilities, the safety regulations laid down by the professional trade association for electrical equipment and facilities must be observed.

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operation. Safe operation is no longer possible if:

- the device has sustained visible damages,
- the device no longer works,
- and the device was stored under unfavorable conditions for a long period of time,
- the device was subject to considerable transport stress.

This device is not a toy and should be kept out of reach of children!

Should you have any questions that are not answered in this operating manual, please contact our technical customer service, or other experts.

### **LED illumination**

To avoid unnecessary IR radiation for the eyes, switch off the system when not in use.

The Hi-Speed camera system uses invisible LED radiation Class 1.

The used wavelength is 910 nm.

### **Electromagnetic compliance**

**WARNING:** This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications.

### **Electrostatic sensitivity**

**WARNING:** All internal electronics are sensitive to high voltage or electrostatic discharge. The system can be destroyed if carelessly handled, so extreme care should be taken during set up and operation.

### **Operating Temperature**

The system is designed to operate satisfactorily in an environment where the ambient temperature is between 10 °C and 50 °C, and that there is no water condensation present.



## Storage Temperature

Do not store the equipment in an area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## Packaging for shipment

When shipping, use the shipping cartons in which the units were originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## Disposal

Dispose the device according to legal regulations.

## 3.5.4 Maintenance

Switch off the system before cleaning.

To clean the device use a soft cloth lightly moistened or pads dampened with disinfectant fluids on isopropanol base. Do not use spirit for cleaning. Do not use abrasives, detergents or solvents.

## 3.6 iView X MRI



### iView X MRI

iView X MRI is an eyetracking system designed for the use with magnetic resonance imaging (MRI).

#### MRI-LR (Long Range)

The LR system consists of a long-range, tripod-mounted camera that is placed in the magnet room. A mirror box is mounted on the coil to reflect stimulus to the test person and the eye image to the camera. The eye is illuminated via an IR light source in the mirror box. The captured eye video is converted to fiber optic and sent to the control room where it is processed by an iView X eye tracking system.

See also [MRI-LR: Features](#) <sup>183</sup>.

## MRI-SV (Silent Vision)

The SV system is used in conjunction with the Avotec Silent Vision™ system. Avotec is a separate company that manufactures auditory and visual stimulus equipment for MRI and fMRI testing. SMI provides an eye tracking system for use in conjunction with Avotec's fiber-optic based visual presentation device.

The eye image is captured and transmitted via a fiber optic add-on to the display device. The image is transferred to a projector and converted to a video signal. This signal is processed by an iView X eye tracking system in the control room.

The iView X compensates for small head movements by tracking and averaging two cornea reflex points that reflect the IR illumination provided by the Silent Vision goggles.

In a Silent Vision setup, display and eye capture components of the system are provided and supported by Avotec™. Only the eye tracking computer itself is an SMI component. See [www.avotec.org](http://www.avotec.org) for more information.

See also [MRI Silent Vision: Features](#)<sup>[184]</sup>.

### 3.6.1 MRI-LR: Features

#### Technology

- Recording unit only

#### Performance

- Sampling rate 50 / 60 Hz
- Gaze position accuracy typ. 3°
- Viewing angle ± 15-20° hor. / ± 10-15° vert. (typ.)

**System**

- Operating system Windows XP
- Dedicated workstation

**Interface**

- Power Supply (control room) 110 - 230 V AC

**Approvals**

- CE, EMC, Eye Safety

**3.6.2 MRI Silent Vision: Features****Technology**

- Non-invasive, video-based eye tracking
- Monocular; Pupil/Pupil-CR; dark-pupil

**Performance**

- Sampling rate 50 / 60 Hz
- Tracking resolution < 0.1° (typ.)
- Gaze position accuracy 0.5° - 1° (typ.)
- Viewing angle ± 15° hor. / ± 10° vert. (typ.)

**System**

- Operating system Windows XP
- Dedicated workstation

## Interface

- Dimensions

Eye Camera (HxWxD)	80 x 500 x 120 mm
Mirror Box	customized to head coil
- Power Supply (magnet room) 110 - 230 V AC
  - Optional: Rechargeable battery
- Various scanners and head coils are supported. (Contact SMI for more information.)

## Approvals

- CE, EMC, Eye Safety

### 3.6.3 General Considerations

The setup of the iView X system depends on the interface and type of stimulus used.

Some general suggestions are as follows:

#### Light changes

Because it tends to be dark in the magnet, special care must be taken to avoid changes in brightness of the stimulus during the test. A large change in pupil size can cause inaccuracies, particularly between the calibration screen and the test. If brightness changes are inevitable, consider re-centering or recalibrating often.

## Eye image

A large, focused eye image will help tracking accuracy and spatial resolution. When using the MRI-SV (Silent Vision) system, the eye image will be optimized if the test person has a clear view of the stimulus. In the MRI-LR setup, zooming in close on the eye and carefully focusing will improve results.

## Calibration points

If the test person has trouble seeing calibration points near the edge of the screen, accuracy will be seriously reduced. In this case, consider locating calibration points in more central locations than usual. The calibration points should not be much farther from the center than the stimulus data itself. However, do not draw the points in too far, as this will increase noise in the eye movement data.

## Maximize stimulus display size

The accuracy of any eye tracker can be expressed as an angle but this is not affected by the size of the stimulus display. Therefore, results will generally improve if the display size is larger. For example, if a system is accurate to within 0.8 degrees, this "uncertainty" in gaze position will represent a much larger portion of a 10-degree wide stimulus than a 20-degree wide one.

## Data mirroring

Horizontal and vertical mirroring can be set to compensate for the mirroring of the eye. Some experimentation might be required to determine the correct configuration. If you receive "subject looked in wrong horizontal/vertical direction" errors during calibration even if the test person is looking in the correct direction, it is likely that mirroring is set incorrectly for your device.

## 3.6.4 MRI-LR

iView X MRI-LR is a device to measure eye movements and pupil diameter of test persons in a magnetic resonance imaging (MRI) scanner. It can also be used to monitor eye movement.

See also [Safety Notes](#)<sup>[210]</sup> and [Maintenance](#)<sup>[214]</sup>.

Video images are recorded by a highly sensitive, high resolution infrared camera, which resides inside of the camera box. The eye of the test person is illuminated with infrared light by a special LED. The camera is directed at the eye of the test person through a mirror in the mirror-box and records the reflection of the IR light. The image information is sent through an optical fiber cable to the iView X workstation.

An additional mirror is located inside of the mirror-box, on which the test person may see an optional stimulus presentation.

### 3.6.4.1 Modes of Operation

The MRI-LR system consists of a mirror-box mounted on a head coil, a camera box on a camera mount and an eye control monitor.

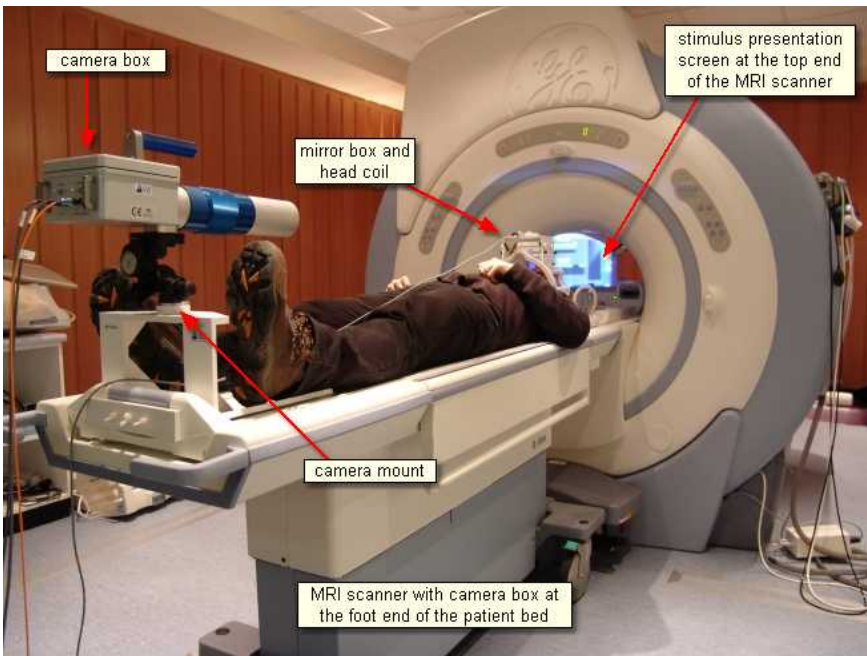
Two modes of operation are possible:

#### **A) camera box at the foot end of the MRI scanner bed**

If the stimulus presentation screen is located at the top end of the scanner bed, the camera box should be mounted at the foot end. In this case the camera box will be mounted on a custom-built table platform, or in some cases on a tripod at the patient bed.

#### **B) camera box at the top end of the MRI scanner bed**

If the stimulus presentation screen is located at the foot end of the MRI scanner bed, the camera box will be mounted on a wheeled tripod and placed at the head of the scanner.



### 3.6.4.2 System Installation

Install the MRI components by following the steps:

- [Mount the Mirror-Box](#)<sup>[188]</sup> on the head coil.
- [Mount and Connect the Illumination Unit](#)<sup>[190]</sup> to the head coil.
- [Setup and connect the Camera Box](#)<sup>[192]</sup>.
- [Setup and connect the Eye Control Monitor](#)<sup>[192]</sup>.
- [Adjust the Camera](#)<sup>[193]</sup> to the test person's eye.

#### 3.6.4.2.1 Mounting the Mirror-Box

Two opposing mirrors are installed inside the mirror box. One is a transparent, IR reflecting mirror for the eye tracker, the other is a silvered mirror for stimulus presentation.

To mount the mirror box on the head coil, loose the four knurled screws



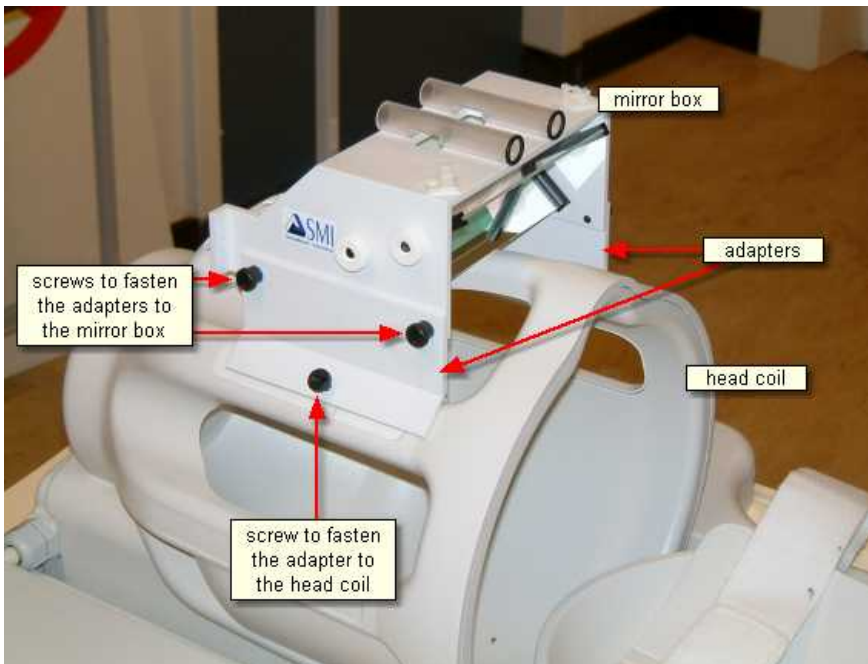
that connects the upper part of the mirror box with the two adapters at each side. With the loosened adapters the mirror box can be easily placed on the head coil.

Note the correct alignment of the mirror box according to labels. The reflecting side of the silvered mirror should be directed towards the stimulus presentation screen.

Fasten the upper four knurled screws.

Move the mirror box until its aperture roughly lies above the assumed test person's eyes.

Fasten the mirror box with the two lower knurled screws.

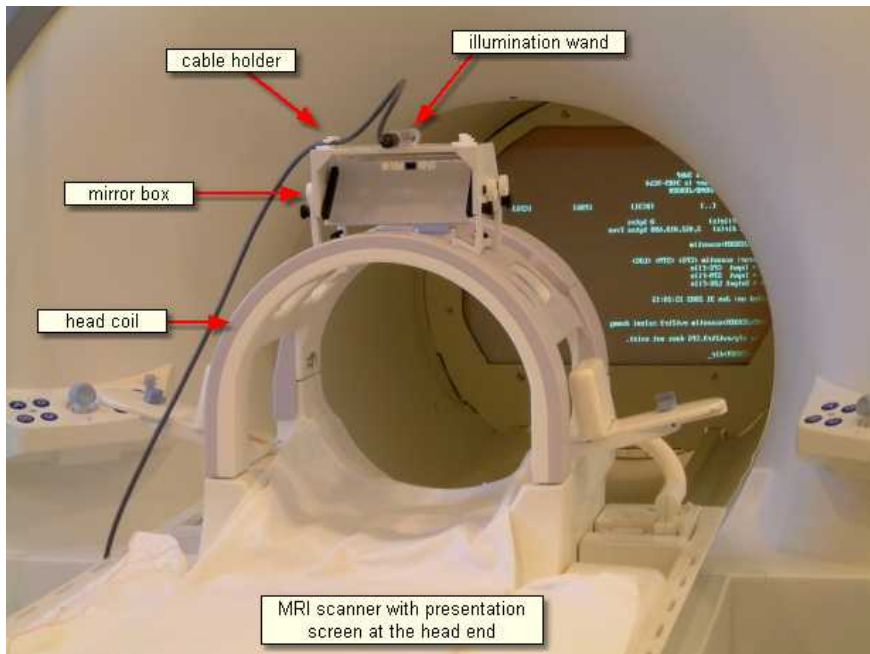


### 3.6.4.2.2 Mounting and Connecting the Illumination Unit

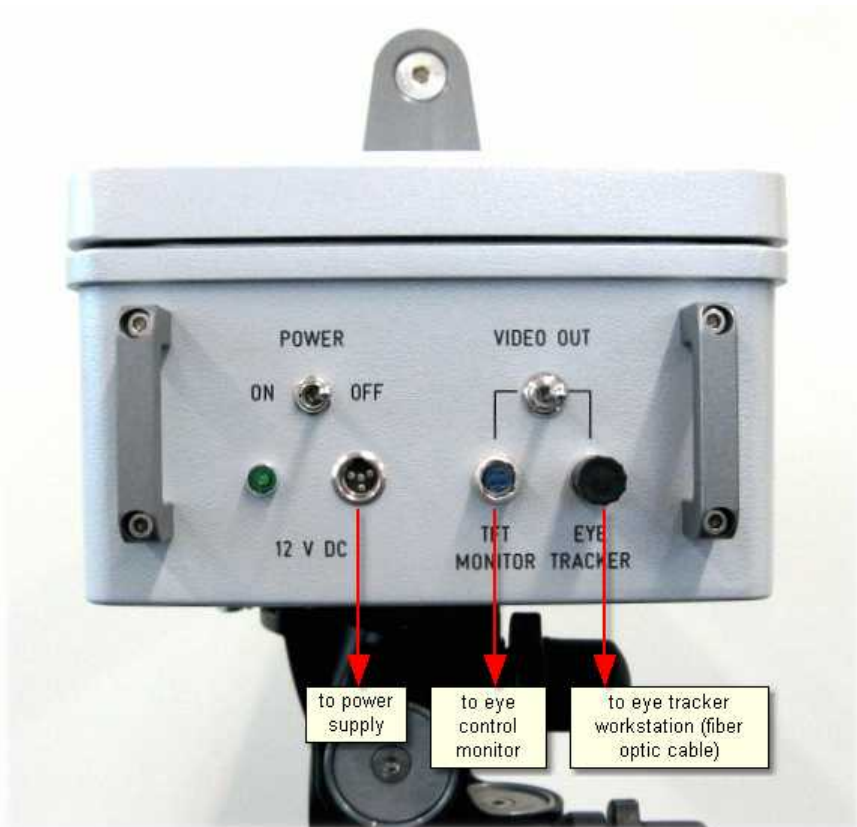
Insert the wand containing the illumination LED into the designated holder of the mirror-box. If the mirror box has two holders, place the wand in the holder above the eye to be tracked.

The light emitting aperture of the wand should be directed downwards. The illumination unit can be adjusted later by using the eye control monitor.

Plug the illumination power supply into an outlet. Contact your safety inspector of the MRI scanner for potential further precautions. See also [Safety Notes](#) <sup>[210]</sup>.



### 3.6.4.2.3 Connectors and Switches



#### Connectors of the MRI Camera Box:

**Power** must be connected with the [power supply](#) <sup>203</sup>.

**Video Out Eye Tracker** must be connected with the eye tracker workstation.

**TFT Monitor** must be connected with eth eye control monitor

## Power Switch

The camera box can be switched on/off.

See also [Safety Notes](#) <sup>[210]</sup> and [Maintenance](#) <sup>[214]</sup>.

### 3.6.4.2.4 Setup and Connecting the Camera Box



Always keep the camera box away from the scanner!  
Never bring the camera box into the bore!

See also [Additional Safety Notes](#) <sup>[210]</sup>.

If the camera box stands at the head of the MRI scanner bed, place it behind the magnet. Once in place, deploy the small non-slip feet by pressing on the grey levers.

Insert the plug of the power supply for the camera box into the connector labelled 'Power' at the rear side of the camera box. Connect the other end of the power supply with a power supply socket in the MRI operating room.

Connect the fiber optic cable with the connector labelled *EYE TRACKER* at the rear side of the camera box. The other end of the cable goes to the control room and must be connected with the fiber optic receiver on the iView X workstation.

Conduct all cables along the axis of the MRI scanner, if possible.

### 3.6.4.2.5 Setup and Connecting the Eye Control Monitor



Always keep the eye control monitor away from the scanner!  
Never bring the eye control monitor into the bore!

See also [Additional Safety Notes](#) <sup>[210]</sup>.

Put the eye control monitor with its tripod at an appropriate place, so that

the image is visible from a position near the camera box. Note that the eye control monitor should maintain a distance of at least one meter from the MRI scanner, or the screen image may be distorted by the magnetic field.

Connect the monitor to the camera box.

Set the switch labelled *VIDEO OUT* at the rear side of the camera box to the *MONITOR* position.

Make sure that the monitor is switched on. An image should now be seen on the display.

#### 3.6.4.2.6 Camera Adjustment

Use the pan, tilt and height controls on the camera mount to aim the camera at the mirror in the mirror box.

Place the test person on the MRI scanner bed with his or her head in the head coil. Place the eye control monitor at a position so that it is visible from a position near the head coil.

Move the mirror-box until the center between both mirrors lies more or less above the bridge of the test person's nose. To do that, you need to loose and fasten the lower knurled screws, see also [Mounting the Mirror Box](#)<sup>188</sup>.

Adjust the transparent eye mirror until the test person's eye is vertically centered on the visual display.

Use the adjustment controls on the camera mount to center the eye on the eye control screen.

Rotate the illumination wand until the eye image on the display is evenly illuminated. The wand can be stabilized with nylon screws, if necessary.

The focal length can be changed by moving the zoom ring of the camera along the axis. The focus can be changed by turning the zoom ring. Use the camera zoom to magnify the eye image, until the eye is as large as possible without leaving the camera view at different eye positions.

Tilt the silvered mirror, until the projector image is visible to the test person.

For front-projection systems, the eye control monitor can now be moved back to the camera side of the magnet.

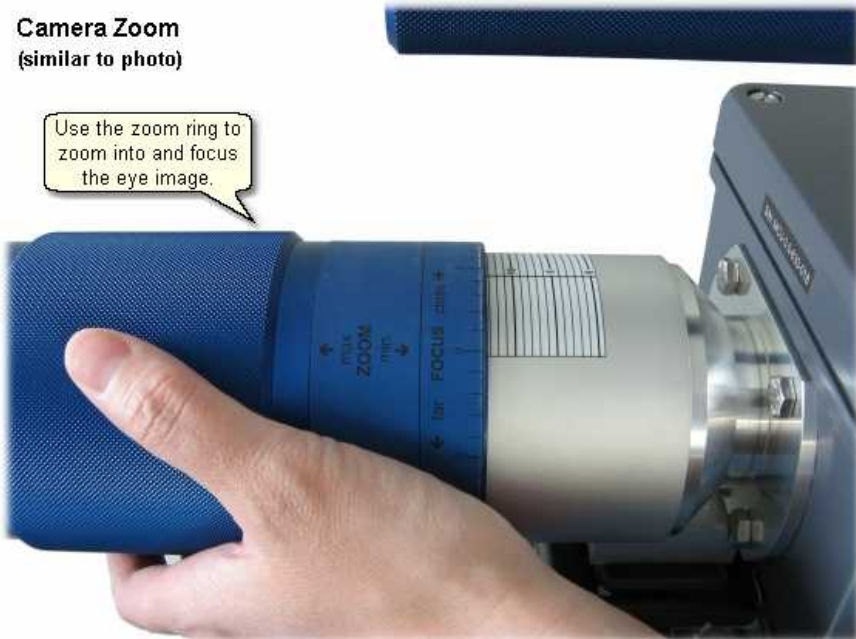
Move the test person into the MRI scanner.

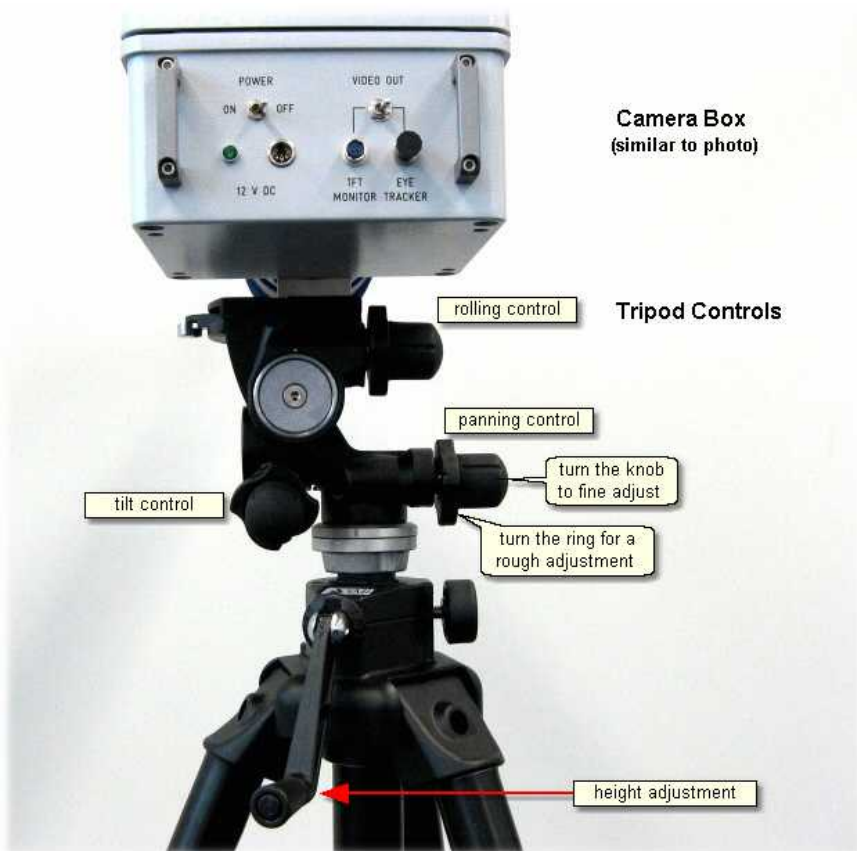
Once satisfied with the eye image, set the switch labelled *MONITOR* to the *EYE TRACKER* position.

Make sure that the eye control monitor is switched off. If it is a small monitor (without own power supply) it will be switched off automatically. Additionally, you might remove the eye control monitor from the magnet room.

#### Camera Zoom (similar to photo)

Use the zoom ring to zoom into and focus the eye image.





### 3.6.4.3 Operating Procedure

The following steps describe how to set up and run a typical iView MRI experiment, after the MRI system has been properly [installed](#)<sup>188</sup>.

### 3.6.4.3.1 Initialization of Software

Turn on the iView X workstation.



Start iView X by double-clicking on the iView X icon.

Next, iView X must be initialized to run with this configuration. Therefore, the iView X program must be told, which hardware components we use. Usually, it will be done only once on installation, but just in case, the software must be reinitialized, check the following:

From the [Setup](#) <sup>[290]</sup> menu go to [Hardware](#) <sup>[290]</sup>.

- Set *Eye Tracking Device* to *MRI-LR*.
- Click on the *Advanced* button.
- Choose, if left or right eye will be tracked and recorded.
- Set in *Video Input*, which connection the eye camera uses. Set here, if the eye camera is PAL or NTSC.
- Click on *OK* to close the *Advanced* dialog.

[Establish an ethernet connection](#) <sup>[394]</sup> between the stimulus PC and the iView X workstation.

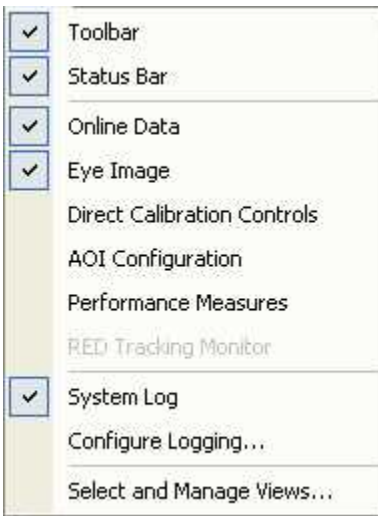
- Click on *OK* to close the *Setup Hardware* dialog.

Activate eye camera by clicking on the [Eye Control](#) <sup>[343]</sup>.

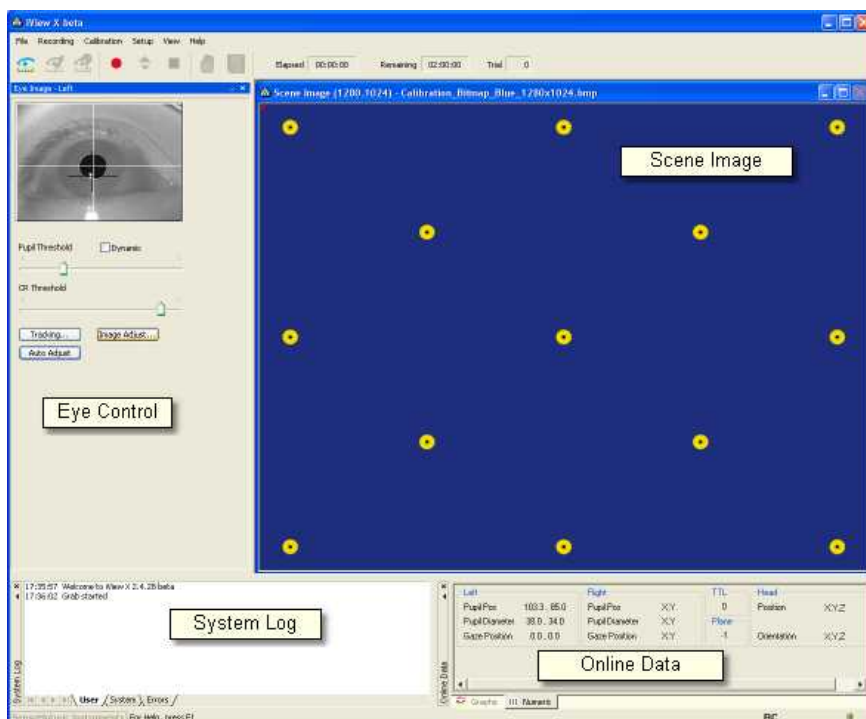
Arrange docking windows.

- Go to the [View](#) <sup>[337]</sup> menu and set a check mark to the following windows:





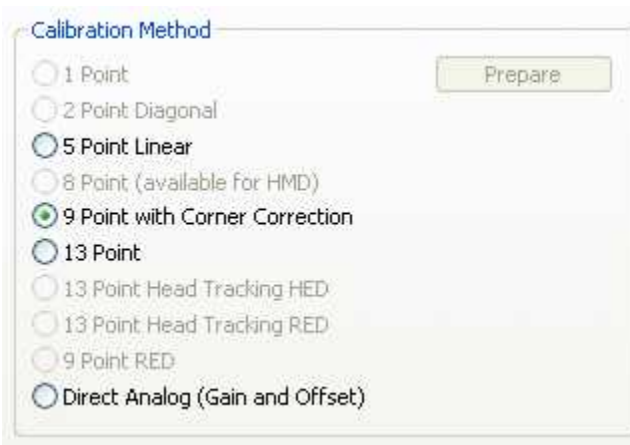
- Align all windows around the Scene Image Window as suggested below:



A typical iView X window arrangement

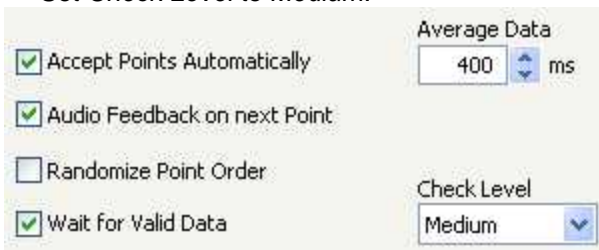
From the menu go to [Setup](#)<sup>[290]</sup> - [Calibration](#)<sup>[313]</sup>.

- Set Calibration Method to 9 Point with corner correction.



#### Calibration Settings for MRI systems (upper part)

- Check *Accept Points Automatically*.
- Check *Audio Feedback* on next point.
- Check *Wait for Valid Data*.
- Set *Check Level* to *Medium*.



#### Calibration Settings for MRI systems (lower part)

- Go to the *Geometry* tab.
- Set *Stimulus Screen Resolution* to the size of the bitmaps, that will be presented. (Typical sizes are 1024x768 or 1280x1024.)
- Enter *Stimulus Physical Dimension*, which is the dimension of the stimulus screen and the Monitor-Head-Distance. Both values will be stored in the iView file. Later analysis tools may use these values.
- Click on *OK* to close the window.

From the menu go to [Setup](#)<sup>[290]</sup> - [Output Gaze Cursor Properties](#)<sup>[327]</sup>.

- If needed, enlarge the sizes of all cursors (left, right and calibration cursor) so that the targets can be comfortably look at.
- Click on OK to close the window.

### 3.6.4.3.2 Adjust Eye Video

If everything was [installed](#)<sup>[188]</sup> correctly you should see a proper eye video image in the [Eye Control](#)<sup>[343]</sup>.

### 3.6.4.3.3 Run Experiment

Now you are ready to run an experiment.

#### Using Presentation

It is a good idea to use one of the example experiments from the *iView X Presentation Interface* as a starting point for your own experiment.

On the *Stimulus PC* go to the folder, where the *Presentation Interface* is installed. Go to the subfolder *Experiments*. There you find various experiment examples. Go to a subfolder and double-click on the .exp file. Presentation opens.

Go to the *Settings* tab, click on *Video*. Under *Display Device Adapter* select your monitor.

Go to the *Main* tab and click on *Run* to start the experiment.

The example experiments demonstrate remotely controlled calibration and recording, while presenting a stimulus.

#### Using SMI Experiment Center™

Start an experiment with *SMI Experiment Center*™. For more information see the *SMI Experiment Center*™ manual.

## Calibration

The above stimulus programs are capable of automated calibration. Make sure to carefully select the type, size, and colour of the calibration targets. Background and cursor colours should be similar to the stimulus back- and foreground colours.

If calibration starts, proceed as follows:


1. A calibration point will be displayed for the test person.
2. During the calibration process the test person should look at the presented targets without moving its head. When the test person has fixated, press <space> to accept the point.
3. If calibration is set to *Auto Accept Points*, the system will automatically advance through the calibration points. The test person should view each one as it is presented. Verify that the test person complies with the calibration and does not look away from points too early.
4. If the calibration was completed successfully, the *User* message in the *System Log* will display "Calibration finished successfully" and the scene image will show a cursor indicating the test person's gaze position.
5. Check the [Error](#)<sup>[362]</sup> tab in the [System Log](#)<sup>[360]</sup> window for potential problems during the calibration. If the calibration is successful, the [Online Data](#)<sup>[340]</sup> window will begin showing live gaze data.



## Automated Recording


The above stimulus programs automatically start and stop a recording during the stimulus presentation and save the recorded data.

## Manual Recording

If you choose to manually start recording proceed as follows:

1. Perform a calibration using a suitable [calibration process](#)<sup>[245]</sup>.
2. Click on the *start recording* button  to start recording.
3. Begin the stimulus presentation software on the Stimulus PC.

4. Click on the *stop recording* button  to stop recording.
5. Click on the *save* button  to open the save data dialog.
6. Enter a file name.
7. Optionally, fill in *Subject Name* and *Description*.
8. Click on *Save* to save the data as a file of type *.IDF*.



File name:

Save as type:

Subject Name:

Description:

## Remote Recording

*Start*, *stop recording*, *save* and many more functions can also be controlled by the [Remote Command Language](#)<sup>[438]</sup>.

## Analysis

The result of the measurement is an [.idf file](#)<sup>[260]</sup> recorded and stored on the iView X PC. The resulting file can be loaded into *SMI BeGaze™* analysis software for visualization and further analysis.

To export the IDF data into an ASCII text format, load the IDF file into the IDF Converter program and choose options for export. (The IDF Converter is part of the *iTools* package on the iView X CD.) The resulting text file can be loaded and analyzed with Excel™, Matlab™ or other spreadsheet programs. (Note: Consider keeping IDF files as a data archive).



## Characteristics

Universal input 100 - 240 V AC  
Interchangeable primary adapters  
Constant voltage, current limited  
Green LED indicating power on  
Low leakage current < 10  $\mu$ A  
Low standby power  $\leq$  0.5 Watt

## Technical data

**Input voltage** 100 V AC - 240 V AC

**Input current** 0.4 A

**Frequency** 50 - 60 Hz

**Efficiency** 80% typ. at full load

**EMC norm** Conforms to FCC, CISPR 22, EN 55022, class B, IEC 61000-4-3; IEC 61000-4-6

**Output voltage tolerance**  $\pm$  10%

## Environmental specification

**Operating temp.** 0 °C to 40 °C at maximum load

**Storage temp.** -40 °C to 70 °C

**Humidity** 5% to 95% non condensing

**Input Transient Susceptibility** Complies with IEC 61000 requirements

## Safety specification

**Standards** Fulfills Class II SELV for the following applications: IEC 60601-1, UL 2601, VDE, CE label, fulfills medical application class B /BF /CF

## Reliability specification

**MTBF calculation** 200,000 hours at maximum load levels and an ambient temperature of 25 °C (in correspondence with MIL-HDBK-217)



## Mechanical specification

**Weight** 130 g

**Plug connector** AC input: FRIWO exchangeable mains plug system:  
EURO, UK, USA /Japan, Australia, ROW

## World exclusive

**Medical** 100 - 240 V input voltage

**power supplies** without earthing, leakage current < 10 µA

## Output data

**Voltage** 12 V

**Current** 1250 mA

**Ripple volt.** 120 mV pp

### 3.6.5 MRI Silent Vision

The following steps describe how to set up and run a typical iView Silent Vision Experiment.

#### 3.6.5.1 Experiment Setup

1. Turn on all Avotec equipment so that a video signal is received by the Real Eye box in the control room. A video signal should be visible on the small LCD screen on this box.
2. Turn illumination on the box up until it is at least  $\frac{3}{4}$  from the highest level.
3. On the iView X workstation, double-click on the iView X icon to start the iView X application.
4. Setup the test person according to instructions provided by Avotec™. Usually, if the test person has a good view of the screen, their eye will be easily tracked by the system. The eye should now be visible on the Real Eye box in the control room.

### 3.6.5.2 Software Setup

1. Click in the Eye Control window over the eye image to activate the eye tracker. The Eye Tracker must be enabled to perform all eye tracking functions.
2. Check DYNAMIC THRESHOLD. This will allow the system to automatically adjust pupil threshold level based on eye image brightness and contrast.
3. On the eye tracker, Click on the *Tracking* button.
4. Under the AOI tab, manipulate the Y-MIN, Y-MAX, X-MIN, and X-MAX controls to frame the eye in the white box in the camera view. This defines the working range of the eye tracker and will allow you to mask out regions of the video image that might look like pupil or CR to the system. The box should be large enough that all likely eye movements keep the pupil entirely within the box.
5. Close the *Tracking* dialog box by clicking OK.
6. Choose [Setup Hardware](#)<sup>[290]</sup> and click on *Advanced*.
7. Click on the CORNEAL REFLEX tab. Verify that the Reflex Number is set to 2 and Reflex Usage is set to AVERAGE.
8. Click OK to exit the *Advanced* dialog.
9. Move the CR Threshold slider so that the two CR cross-hairs are visible in the video image along with the pupil cross-hair.

### 3.6.5.3 Calibration Setup

1. Set your calibration options by selecting the [Setup Calibration](#)<sup>[313]</sup> from the menu.
2. Choose a calibration of 800X600, which is the set resolution of the Avotec display.
3. Choose the 9-point calibration. The 9-point will give better accuracy in the corners.
4. Check ACCEPT POINTS AUTOMATICALLY so the system will accept each calibration point after the test person fixates.
5. Check WAIT FOR VALID DATA. The system will only proceed with each calibration point after a valid fixation is detected.
6. Check RANDOMIZE POINT ORDER. Calibration points will be displayed in a random order to keep the test person from anticipating and looking ahead.
7. Set the CALIBRATION CHECK LEVEL to MEDIUM. The stronger this is, the more strict the system will be in accepting calibration

- points and overall geometry.
8. Click OK to exit the calibration setup window.

### 3.6.5.4 Ethernet Connection to Stimulus PC

If you wish the stimulus program to interact with the iView X program, the stimulus PC and the iView X PC must be properly connected. See [Network Connection to Stimulus PC](#)<sup>[394]</sup>.

### 3.6.5.5 Run Experiment

Now you are ready to run an experiment.

#### Using Presentation

It is a good idea to use one of the example experiments from the *iView X Presentation Interface* as a starting point for your own experiment.

On the *Stimulus PC* go to the folder, where the *Presentation Interface* is installed. Go to the subfolder *Experiments*. There you find various experiment examples. Go to a subfolder and double-click on the .exp file. *Presentation* opens.

Go to the *Settings* tab, click on *Video*. Under *Display Device Adapter* select your monitor.

Go to the *Main* tab and click on *Run* to start the experiment.

The example experiments demonstrate remotely controlled calibration and recording, while presenting a stimulus.

#### Using SMI Experiment Center™

Start an experiment with *SMI Experiment Center*™. For more information see the *SMI Experiment Center*™ manual.

## Calibration

The above stimulus program is capable of automated calibration. If calibration starts, proceed as follows:

1. A calibration point will be displayed for the test person.
2. During the calibration process the test person should look at the presented targets without moving its head. When the test person has fixated, press <space> to accept the point.
3. If calibration is set to *Auto Accept Points*, the system will automatically advance through the calibration points. The test person should view each one as it is presented. Verify that the test person complies with the calibration and does not look away from points too early.
4. If the calibration was completed successfully, the *User* message in the *System Log* will display "Calibration finished successfully" and the scene image will show a cursor indicating the test person's gaze position.
5. Check the [Error](#)<sup>[362]</sup> tab in the [System Log](#)<sup>[360]</sup> window for potential problems during the calibration. If the calibration is successful, the [Online Data](#)<sup>[340]</sup> window will begin showing live gaze data.

If you receive permanent "subject looked in wrong horizontal/vertical direction" errors, it is likely that data mirroring is set incorrectly. If this is the case, go to [Setup](#)<sup>[290]</sup> [Hardware](#)<sup>[290]</sup>. The **Eye Camera** should be set to *Custom Camera*. Click on the [Advanced](#)<sup>[294]</sup> button. In this dialog you can change data mirroring accordingly. In most cases the left-right values are reversed, meaning that the data must be mirrored on the *vertical* axis.




## Automated Recording

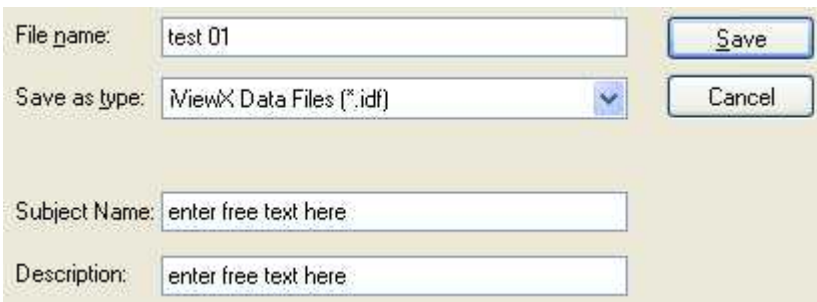
The above stimulus program automatically starts and stops a recording during the stimulus presentation and saves the recorded data.

## Manual Recording

If you choose to manually start recording proceed as follows:

1. Perform a calibration using a suitable [calibration process](#)<sup>[245]</sup>.

2. Click on the *start recording* button  to start recording.
3. Begin the stimulus presentation software on the Stimulus PC.
4. Click on the *stop recording* button  to stop recording.
5. Click on the *save* button  to open the save data dialog.
6. Enter a file name.
7. Optionally, fill in *Subject Name* and *Description*.
8. Click on *Save* to save the data as a file of type *.IDF*.



File name: test 01

Save as type: iViewX Data Files (\*.idf)

Subject Name: enter free text here

Description: enter free text here

Save

Cancel

## Remote Recording

*Start*, *stop* recording, *save* and many more functions can also be controlled by the [Remote Command Language](#)<sup>[438]</sup>.

## Analysis

The result of the measurement is an [.idf file](#)<sup>[260]</sup> recorded and stored on the iView X PC. The resulting file can be loaded into *SMI BeGaze™* analysis software for visualization and further analysis.

To export the IDF data into an ASCII text format, load the IDF file into the IDF Converter program and choose options for export. (The IDF Converter is part of the *iTools* package on the iView X CD.) The resulting text file can be loaded and analyzed with Excel™, Matlab™ or other spreadsheet programs. (Note: Consider keeping IDF files as a data archive).

### 3.6.6 Safety Notes

Switch off all components before connecting or disconnecting cables.

When setting up the system, make sure that all connectors and switches are easily accessible.

Periodically check the technical safety of the device, e.g., check for damage to the housing etc.

Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).

In case your iView X system or a component of the system is damaged, switch off the whole system and unplug it from the power source. Do not use the system until the system or its component has been repaired by a certified distributor or the manufacturer (SMI).

Only use original components (cables, power supply etc.) from SMI.

In case a component needs to be replaced, only replace it with original components from SMI.

Do not repair the system by yourself. Electrical shock hazard.

No part of the product may be modified or rebuilt.

Any usage other than described in this manual is not permitted, can damage the device and eventually lead to associated risks such as short-circuit, fire, electric shock, etc.

We do not assume liability for resultant damages to property or personal injury if the product has been abused in any way or damaged by improper use or failure to observe these operating instructions. In addition, any unauthorized modifications or repairs of the device will render the warranty null and void!

## **Additional Mirror Box Safety Notes**

The mirror-box does not contain metallic parts.

## **Additional Tripod, Camera Box and Eye Control Monitor Safety Notes**

The tripod and the camera box are designed with as few ferromagnetic parts as possible. However, some small magnetic parts are required for full functionality. Therefore, the tripod with the dolly and the camera box should not be disassembled inside of the magnetic room under any circumstances.

The eye control monitor contains some ferromagnetic parts. If the eye control monitor is too close to the magnet it can be attracted. Place the eye control monitor at least in a distance of one meter from the axis of the magnet. An activated eye control monitor will create noise during recording. Therefore, the eye control monitor should be turned off after the setup phase. If it is a small monitor (without own power supply) it will be automatically switched off, when the *VIDEO OUT* switch is set to *EYE TRACKER*. Additionally, you might remove the eye control monitor from the magnet room.

Always keep the camera box and eye control monitor away from the scanner!

Never bring the camera box or eye control monitor into the bore!

Always keep maximum distance between camera box/eye control monitor and scanner when bringing the camera box/eye control monitor into the scanner room and fixing the units to the camera table or tripod!

Never put the camera box/eye control monitor at any place within the scanner room without fastening the units!

Always use the provided camera table or tripod to fasten the camera box/eye control monitor!

Always use the provided straps to fix the camera table to the scanner bed before mounting the camera box!

Never have subjects in the scanner while moving the camera box/eye control monitor into or out of the scanner room!

Only have subjects in the scanner while the camera box/eye control monitor is properly fixed to the camera table or the tripod!

Always fix the eye control monitor to the provided tripod before moving it into the scanner room!

Put the eye control monitor in a position which allows for easy reading during eye camera adjustment, and ensures maximum distance to the scanner at the same time!

If you don't follow all the rules you may damage the camera box, eye control monitor or the scanner, or jeopardize the subject's safety.

### **Additional Power Supply Safety Notes**

The power supply of the infrared LED contains an iron core and is therefore magnetic. Do not place or carry the power supply unit too close to the magnet. It might be attracted by the magnet and damage the system. It is recommended to fasten the power supply unit on the floor or wall. Do not set up the system while a test person is lying inside of the MRI scanner.

Only use connecting cables provided by the manufacturer (SMI). Make sure the conductive earth wire is not broken, disconnected, removed or interrupted as this can pose a serious threat to life in the event of malfunction.

The device must only be operated in dry, indoor spaces.

Take precautions to make sure that the insulation of the entire product, the safety sockets, connected cables and mains cables are neither damaged nor destroyed.

Always use fuses of the specified type and rating. It is impermissible to use repaired fuses!

Never operate the device without supervision while loads are connected.

Ensure to protect connected loads from the effects of operational disturbance as well as overvoltages.

Do not use the power supply as a direct or indirect charging device.

The device shall not be subjected to heavy mechanical stress.

The device must not be exposed to extreme temperatures, direct sunlight, intense vibration or moisture. Position the device on a level and sturdy surface.

The device generates operational heat. Never insert any objects, block cooler opening of the device, or hinder ventilation in any form or manner.

The device is predominantly cooled by convection.

Never put a naked flame or any containers with liquids on or near the apparatus.

Caution! Capacitors within the device may retain their charge even if the device is disconnected from all power sources.



Never turn on the device immediately after it has been brought from a cool into a warmer environment. Condensing water might destroy your device. Leave the device in OFF position and wait until it has reached ambient temperature.

Before operating the device, make sure that your hands, shoes, clothing, the floor as well as the device itself are dry.

During thunderstorm, unplug the device's power plug from the mains outlet in order to avoid damages due to excess voltage.

In industrial facilities, the safety regulations laid down by the professional trade association for electrical equipment and facilities must be observed. In schools, training facilities, DIY and hobby workshops, the usage of electrical devices is to be supervised by trained personnel.

If there is reason to believe that safe operation is no longer possible, the device is to be put out of operation and secured against unintended operation. Safe operation is no longer possible if:

- the device has sustained visible damages,
- the device no longer works,
- and the device was stored under unfavorable conditions for a long period of time,
- the device was subject to considerable transport stress.

This device is not a toy and should be kept out of reach of children!

Should you have any questions that are not answered in this operating manual, please contact our technical customer service, or other experts.

### **Electromagnetic compliance**

**WARNING:** This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications.

### **Electrostatic sensitivity**

**WARNING:** All internal electronics are sensitive to high voltage or electrostatic discharge. The system can be destroyed if carelessly handled, so extreme care should be taken during set up and operation.

## Operating Temperature

The system is designed to operate satisfactorily in an environment where the ambient temperature is between 10 °C and 50 °C, and that there is no water condensation present.

## Storage Temperature

Do not store the equipment in an area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## Packaging for shipment

When shipping, use the shipping cartons in which the units were originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

## Disposal

Dispose the device according to legal regulations.

## 3.6.7 Maintenance

Switch off the system before cleaning.

Use a clean lint-free, antistatic, slightly moistened cloth to clean the device. Do not use abrasives, detergents or solvents.

To clean the mirrors in the mirror-box, use a soft cloth or lens cleaning paper, lightly moistened with alcohol.

Make sure that the camera modules do not come into contact with liquids during cleaning.

### 3.7 iView X MRI-LR High Speed



The iView X MRI-LR High Speed is a high speed eyetracker designed for the use with magnetic resonance imaging (MRI).

It consists of a long-range (LR), tripod-mounted camera that is placed in the magnet room. A mirror box is mounted on the coil to reflect stimulus to the test person and the eye image to the camera. The eye is illuminated via an IR light source in the mirror box. The captured eye video is converted to fiber optic and sent to the control room where it is processed by an iView X eye tracking system.

### 3.7.1 MRI-LR High Speed: Features

#### Technology

- Recording unit only

#### Performance

- Sampling rate 60 / 250 / 500 Hz

#### System

- Operating system Windows XP
- Dedicated workstation

#### Interface

- Power Supply (control room) 110 - 230 V AC

#### Approvals

- CE, EMC, Eye Safety

### 3.7.2 General Considerations

The setup of the iView X system depends on the interface and type of stimulus used.

Some general suggestions are as follows:

## Light changes

Because it tends to be dark in the magnet, special care must be taken to avoid changes in brightness of the stimulus during the test. A large change in pupil size can cause inaccuracies, particularly between the calibration screen and the test. If brightness changes are inevitable, consider re-centering or recalibrating often.

## Eye image

A large, focused eye image will help tracking accuracy and spatial resolution. In the MRI-LR setup, carefully focusing will improve results.

## Calibration points

If the test person has trouble seeing calibration points near the edge of the screen, accuracy will be seriously reduced. In this case, consider locating calibration points in more central locations than usual. The calibration points should not be much farther from the center than the stimulus data itself. However, do not draw the points in too far, as this will increase noise in the eye movement data.

## Maximize stimulus display size

The accuracy of any eye tracker can be expressed as an angle but this is not affected by the size of the stimulus display. Therefore, results will generally improve if the display size is larger. For example, if a system is accurate to within 0.8 degrees, this "uncertainty" in gaze position will represent a much larger portion of a 10-degree wide stimulus than a 20-degree wide one.

## Data mirroring

Horizontal and vertical mirroring can be set to compensate for the mirroring of the eye. By default the data is vertically mirrored. If you receive "subject looked in wrong horizontal/vertical direction" errors during calibration even if the test person is looking in the correct direction, it is likely that mirroring is set incorrectly for your device.

### 3.7.3 MRI-LR High Speed

iView X MRI-LR is a device to measure eye movements and pupil diameter of test persons in a magnetic resonance imaging (MRI) scanner. It can also be used to monitor eye movement.

See also [Safety Notes](#) <sup>[234]</sup> and [Maintenance](#) <sup>[238]</sup>.

Video images are recorded by a highly sensitive, high resolution infrared camera, which resides inside of the camera box. The eye of the test person is illuminated with infrared light by a special LED. The camera is directed at the eye of the test person through a mirror in the mirror-box and records the reflection of the IR light. The image information is sent through an optical fiber cable to the iView X workstation.

An additional mirror is located inside of the mirror-box, on which the test person may see an optional stimulus presentation.

#### 3.7.3.1 Modes of Operation

The MRI-LR system consists of a mirror-box mounted on a head coil and a camera box on a camera mount.

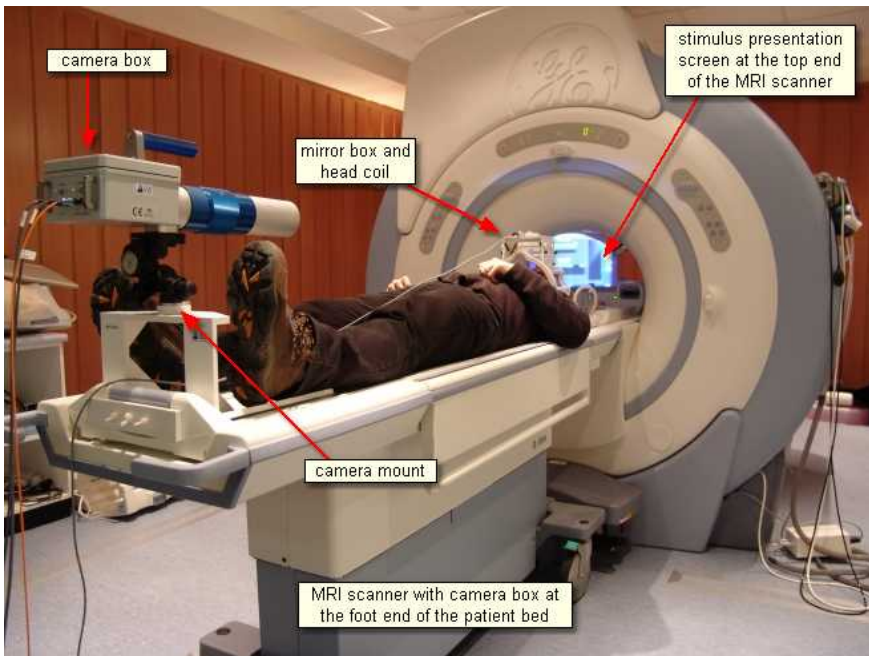
Two modes of operation are possible:

##### **A) camera box at the foot end of the MRI scanner bed**

If the stimulus presentation screen is located at the top end of the scanner bed, the camera box should be mounted at the foot end. In this case the camera box will be mounted on a custom-built table platform, or in some cases on a tripod at the patient bed.

##### **B) camera box at the top end of the MRI scanner bed**

If the stimulus presentation screen is located at the foot end of the MRI scanner bed, the camera box will be mounted on a wheeled tripod and placed at the head of the scanner.



### 3.7.3.2 System Installation

Install the MRI components by following the steps:

- [Mount the Mirror-Box](#) <sup>[219]</sup> on the head coil.
- [Mount and Connect the Illumination Unit](#) <sup>[221]</sup> to the head coil.
- [Setup and connect the Camera Box](#) <sup>[223]</sup>.
- [Adjust the Camera](#) <sup>[223]</sup> to the test person's eye.

#### 3.7.3.2.1 Mounting the Mirror-Box

Two opposing mirrors are installed inside the mirror box. One is a transparent, IR reflecting mirror for the eye tracker, the other is a silvered mirror for stimulus presentation.

To mount the mirror box on the head coil, loose the four knurled screws that connects the upper part of the mirror box with the two adapters at

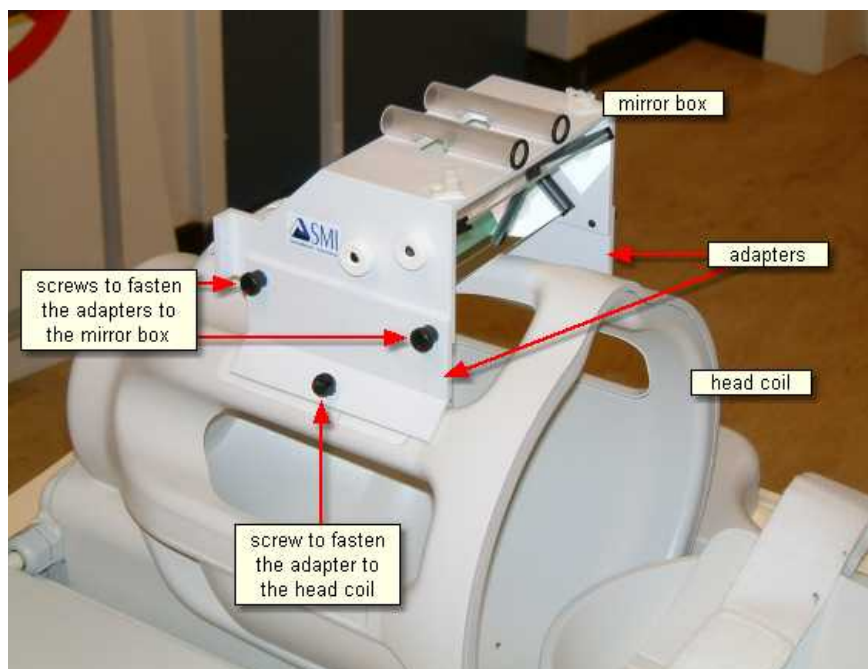
each side. With the loosened adapters the mirror box can be easily placed on the head coil.

Note the correct alignment of the mirror box according to labels. The reflecting side of the silvered mirror should be directed towards the stimulus presentation screen.

Fasten the upper four knurled screws.

Move the mirror box until its aperture roughly lies above the assumed test person's eyes.

Fasten the mirror box with the two lower knurled screws.



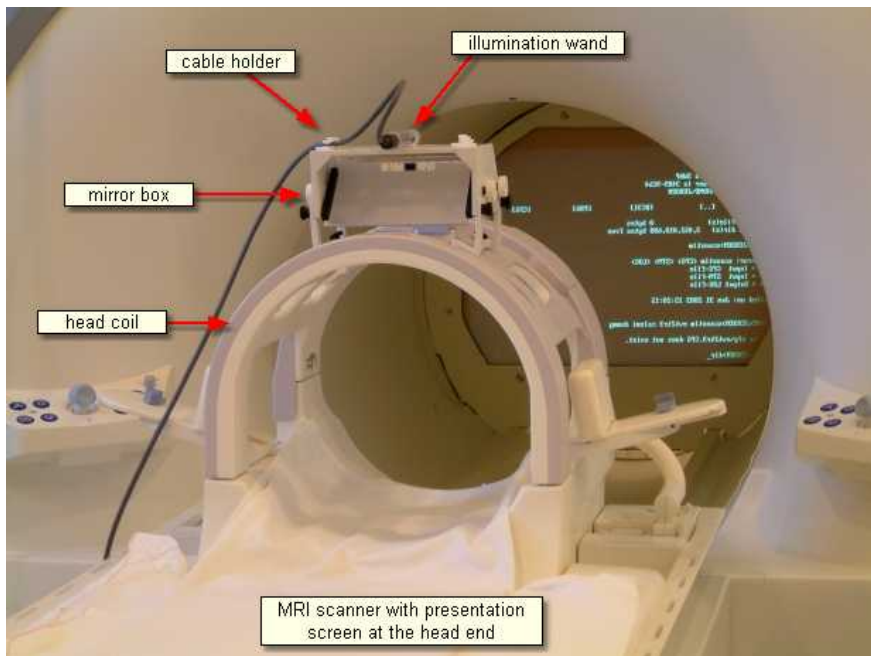


### 3.7.3.2.2 Mounting and Connecting the Illumination Unit

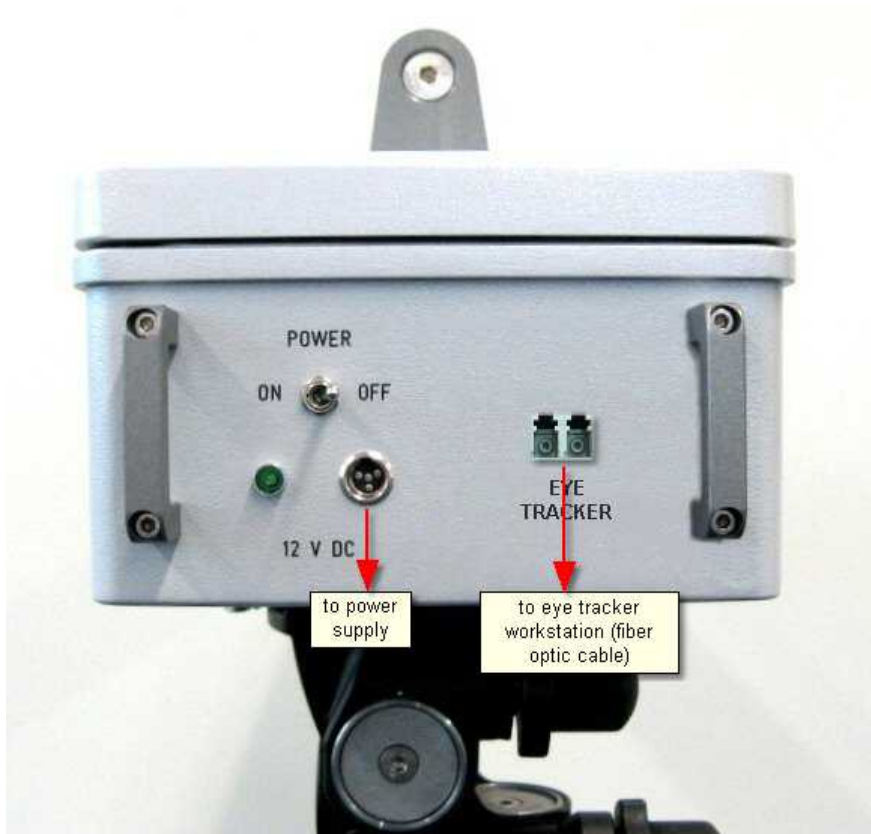
Insert the wand containing the illumination LED into the designated holder of the mirror-box. If the mirror box has two holders, place the wand in the holder above the eye to be tracked.

The light emitting aperture of the wand should be directed downwards. The illumination unit can be adjusted later when adjusting the eye video.

Plug the illumination power supply into an outlet. Contact your safety inspector of the MRI scanner for potential further precautions. See also [Safety Notes](#) <sup>[234]</sup>.



### 3.7.3.2.3 Connectors and Switches



#### Connectors of the MRI Camera Box:

**Power** must be connected with the [power supply](#)<sup>[232]</sup>.

**Eye Tracker** must be connected with the eye tracker workstation.

#### Power Switch

The camera box can be switched on/off.

See also [Safety Notes](#) <sup>[234]</sup> and [Maintenance](#) <sup>[238]</sup>.

#### 3.7.3.2.4 Setup and Connecting the Camera Box



Always keep the camera box away from the scanner!  
Never bring the camera box into the bore!

See also [Additional Safety Notes](#) <sup>[234]</sup>.

If the camera box stands at the head of the MRI scanner bed, place it behind the magnet. Once in place, deploy the small non-slip feet by pressing on the grey levers.

Insert the plug of the power supply for the camera box into the connector labelled 'Power' at the rear side of the camera box. Connect the other end of the power supply with a power supply socket in the MRI operating room.

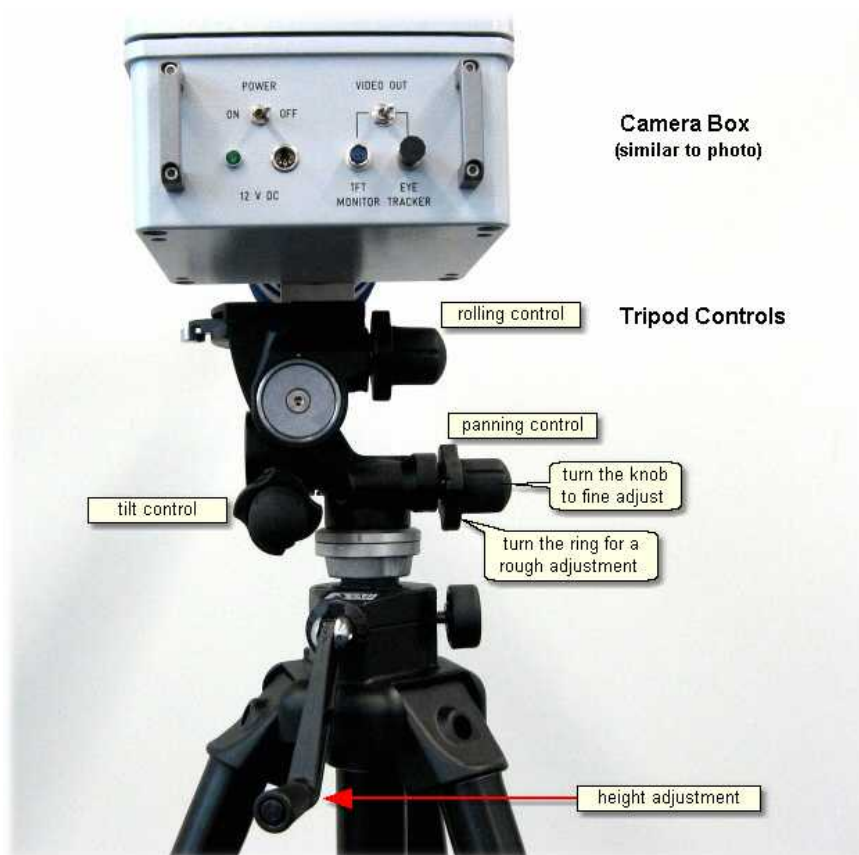
Connect the fiber optic cable with the connector labelled *EYE TRACKER* at the rear side of the camera box. The other end of the cable goes to the control room and must be connected with the fiber optic receiver on the iView X workstation.

Conduct all cables along the axis of the MRI scanner, if possible.

#### 3.7.3.2.5 Camera Adjustment

In iView X go to the [View](#) <sup>[337]</sup> menu and select '[Eye Image \(Full Frame\)](#)' <sup>[359]</sup>. A large video image of the camera is displayed in a new window on the monitor. Place the monitor in the control room in a way that you can see it from the magnet room through the window. Or better, if you have two monitors move the eye image window to the monitor facing the magnet room. Go to the magnet room.

Use the pan, tilt and height controls on the camera mount to aim the camera at the mirror in the mirror box.



Place the test person on the MRI scanner bed with his or her head in the head coil.

Move the mirror-box until the center between both mirrors lies more or less above the bridge of the test person's nose. To do that, you need to loose and fasten the lower knurled screws, see also [Mounting the Mirror Box](#)<sup>[219]</sup>.

Adjust the transparent eye mirror until the test person's eye is vertically centered on the monitor display.

Use the adjustment controls on the camera mount to center the eye on the display.

Rotate the illumination wand until the eye image on the display is evenly illuminated. The wand can be stabilized with nylon screws, if necessary.

Tilt the silvered mirror, until the projector image is visible to the test person.

Move the test person into the MRI scanner.

### 3.7.3.3 Operating Procedure

The following steps describe how to set up and run a typical iView MRI experiment, after the MRI system has been properly [installed](#)<sup>[219]</sup>.

#### 3.7.3.3.1 Initialization of Software

Turn on the iView X workstation.



Start iView X by double-clicking on the iView X icon.

Next, iView X must be initialized to run with this configuration. Therefore, the iView X program must be told, which hardware components we use. Usually, it will be done only once on installation, but just in case, the software must be reinitialized, check the following:

From the [Setup](#)<sup>[290]</sup> menu go to [Hardware](#)<sup>[290]</sup>.

- Set *Eye Tracking Device* to *MRI-LR High Speed*.
- Click on the *Advanced* button.
- Choose, if left or right eye will be tracked and recorded.
- Set *Tracking Mode*: Choose between 60 Hz, 250 Hz or 500 Hz.
- Click on *OK* to close the *Advanced* dialog.

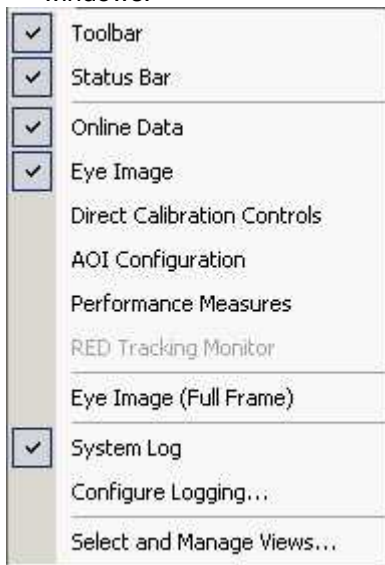
[Establish an ethernet connection](#)<sup>[394]</sup> between the stimulus PC and the iView X workstation.

- Click on *OK* to close the *Setup Hardware* dialog.

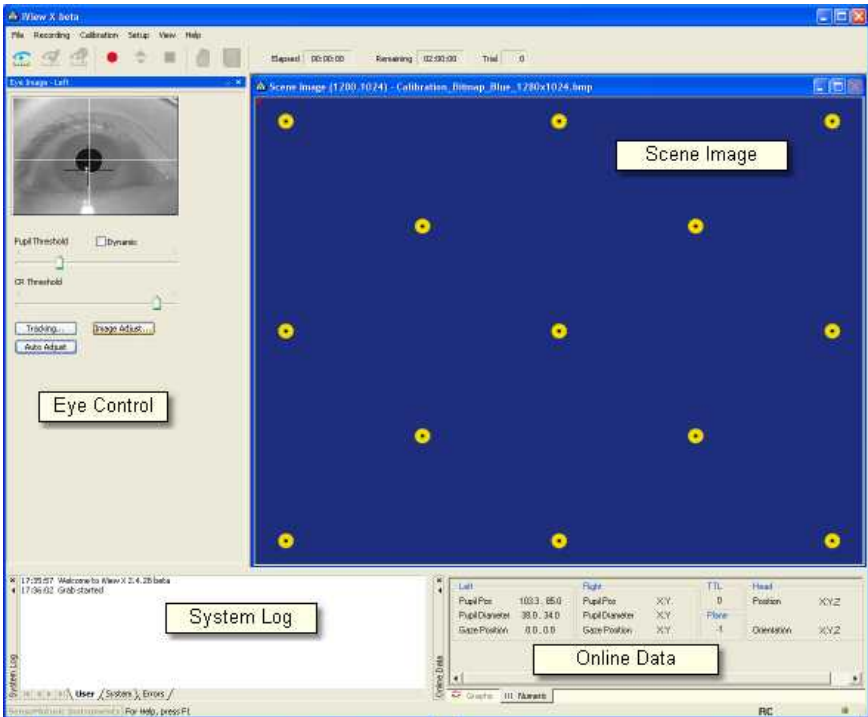
Activate eye camera by clicking on the [Eye Control](#)<sup>343</sup>.

Arrange docking windows.

- Go to the [View](#)<sup>337</sup> menu and set a check mark to the following windows:



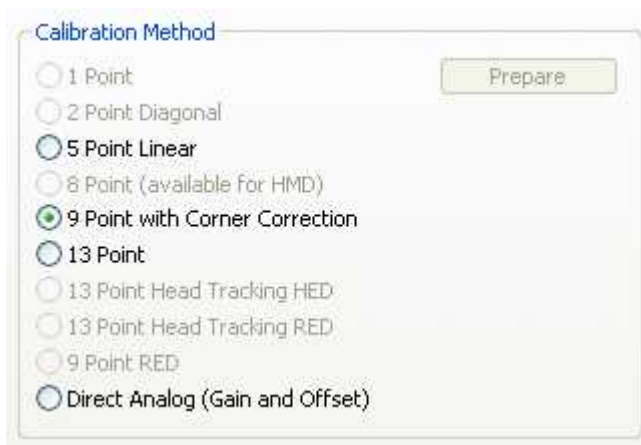
- Align all windows around the Scene Image Window as suggested below:



A typical iView X window arrangement

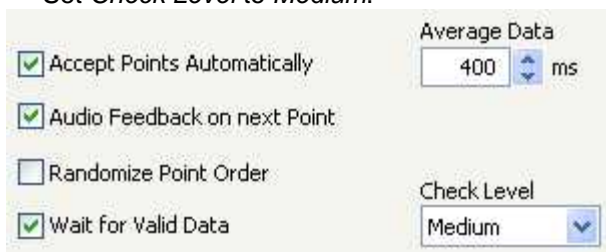
From the menu go to [Setup](#)<sup>[290]</sup> - [Calibration](#)<sup>[313]</sup>.

- Set Calibration Method to 9 Point with corner correction.



Calibration Settings for MRI systems (upper part)

- Check *Accept Points Automatically*.
- Check *Audio Feedback* on next point.
- Check *Wait for Valid Data*.
- Set *Check Level* to *Medium*.



Calibration Settings for MRI systems (lower part)

- Go to the *Geometry* tab.
- Set *Stimulus Screen Resolution* to the size of the bitmaps, that will be presented. (Typical sizes are 1024x768 or 1280x1024.)
- Enter *Stimulus Physical Dimension*, which is the dimension of the stimulus screen and the Monitor-Head-Distance. Both values will be stored in the iView file. Later analysis tools may use these values.
- Click on *OK* to close the window.

From the menu go to [Setup](#)<sup>[290]</sup> - [Output Gaze Cursor Properties](#)<sup>[327]</sup>.



- If needed, enlarge the sizes of all cursors (left, right and calibration cursor) so that the targets can be comfortably look at.
- Click on OK to close the window.

### 3.7.3.3.2 Adjust Eye Video

If everything was [installed](#)<sup>[188]</sup> correctly you should see a proper eye video image in the [Eye Control](#)<sup>[343]</sup>.

### 3.7.3.3.3 Run Experiment

Now you are ready to run an experiment.

#### Using Presentation

It is a good idea to use one of the example experiments from the *iView X Presentation Interface* as a starting point for your own experiment.

On the *Stimulus PC* go to the folder, where the *Presentation Interface* is installed. Go to the subfolder *Experiments*. There you find various experiment examples. Go to a subfolder and double-click on the .exp file. Presentation opens.

Go to the *Settings* tab, click on *Video*. Under *Display Device Adapter* select your monitor.

Go to the *Main* tab and click on *Run* to start the experiment.

The example experiments demonstrate remotely controlled calibration and recording, while presenting a stimulus.

#### Using SMI Experiment Center™

Start an experiment with *SMI Experiment Center*™. For more information see the *SMI Experiment Center*™ manual.

## Calibration

The above stimulus programs are capable of automated calibration. Make sure to carefully select the type, size, and colour of the calibration targets. Background and cursor colours should be similar to the stimulus background and foreground colours.

If calibration starts, proceed as follows:


1. A calibration point will be displayed for the test person.
2. During the calibration process the test person should look at the presented targets without moving its head. When the test person has fixated, press <space> to accept the point.
3. If calibration is set to *Auto Accept Points*, the system will automatically advance through the calibration points. The test person should view each one as it is presented. Verify that the test person complies with the calibration and does not look away from points too early.
4. If the calibration was completed successfully, the *User* message in the *System Log* will display "Calibration finished successfully" and the scene image will show a cursor indicating the test person's gaze position.
5. Check the [Error](#)<sup>[362]</sup> tab in the [System Log](#)<sup>[360]</sup> window for potential problems during the calibration. If the calibration is successful, the [Online Data](#)<sup>[340]</sup> window will begin showing live gaze data.



## Automated Recording

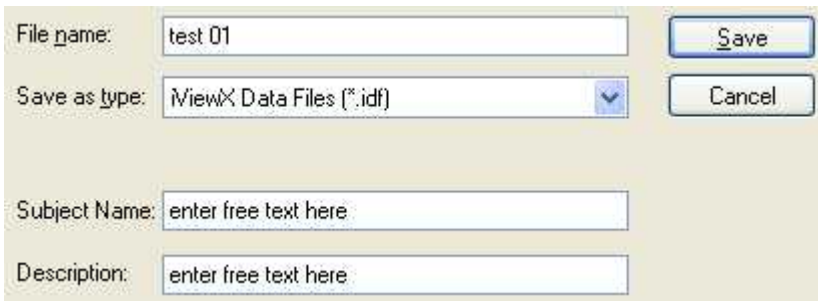
The above stimulus programs automatically start and stop a recording during the stimulus presentation and save the recorded data.

## Manual Recording

If you choose to manually start recording proceed as follows:

1. Perform a calibration using a suitable [calibration process](#)<sup>[245]</sup>.
2. Click on the *start recording* button  to start recording.
3. Begin the stimulus presentation software on the Stimulus PC.

4. Click on the *stop recording* button  to stop recording.
5. Click on the *save* button  to open the save data dialog.
6. Enter a file name.
7. Optionally, fill in *Subject Name* and *Description*.
8. Click on *Save* to save the data as a file of type *.IDF*.



File name: test 01

Save as type: iViewX Data Files (\*.idf)

Subject Name: enter free text here

Description: enter free text here

Save Cancel

## Remote Recording

*Start*, *stop* recording, *save* and many more functions can also be controlled by the [Remote Command Language](#)<sup>[438]</sup>.

## Analysis

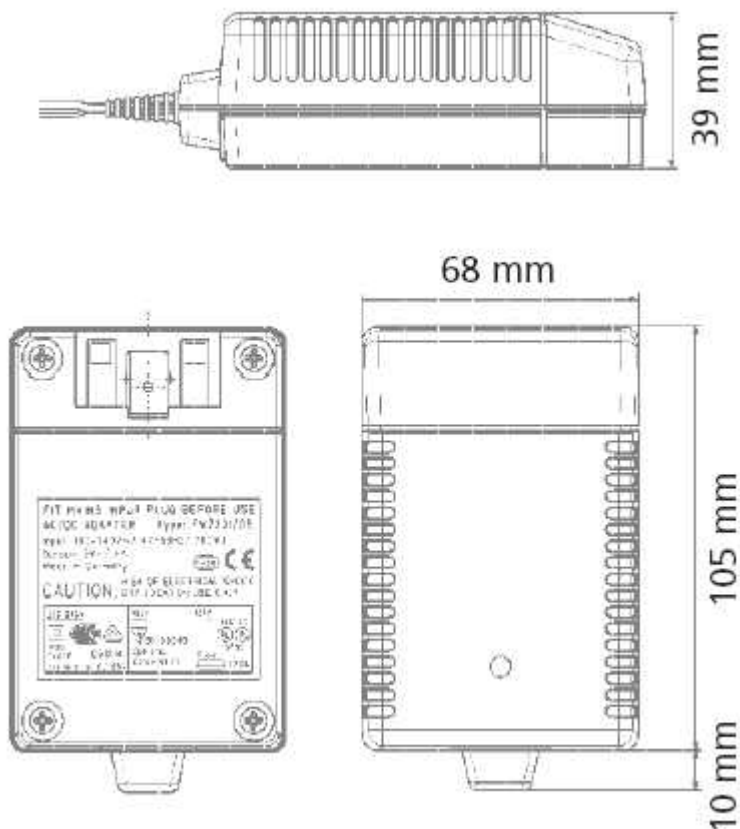
The result of the measurement is an [.idf file](#)<sup>[260]</sup> recorded and stored on the iView X PC. The resulting file can be loaded into *SMI BeGaze™* analysis software for visualization and further analysis.

To export the IDF data into an ASCII text format, load the IDF file into the IDF Converter program and choose options for export. (The IDF Converter is part of the *iTools* package on the iView X CD.) The resulting text file can be loaded and analyzed with Excel™, Matlab™ or other spreadsheet programs. (Note: Consider keeping IDF files as a data archive).

### 3.7.3.4 Power Supply

The MRI Camera Box is connected to a 12 V power supply. See also [Safety Notes](#) <sup>[234]</sup> and [Technical Data](#) <sup>[232]</sup>.

#### 3.7.3.4.1 Technical Data



## Characteristics

Universal input 100 - 240 V AC  
Interchangeable primary adapters  
Constant voltage, current limited  
Green LED indicating power on  
Low leakage current < 10  $\mu$ A  
Low standby power  $\leq$  0.5 Watt

## Technical data

**Input voltage** 100 V AC - 240 V AC  
**Input current** 0.7 A  
**Frequency** 50 - 60 Hz  
**Efficiency** 80% typ. at full load  
**EMC norm** Conforms to FCC, CISPR 22, EN 55022, class B, IEC 61000-4-3, IEC 61000-4-6  
**Output voltage tolerance**  $\pm$  10%

## Environmental specification

**Operating temp.** 0 °C to 40 °C at maximum load  
**Storage temp.** -40 °C to 70 °C  
**Humidity** 5% to 95% non condensing  
**Input Transient Susceptibility** Complies with IEC 61000 requirements

## Safety specification

**Standards** Fulfills Class II SELV for the following applications:  
IEC 60601-1, UL 2601, VDE, CE label, fulfills medical application class B /BF /CF

## Reliability specification

**MTBF calculation** 200,000 hours at maximum load levels and an ambient temperature of 25 °C (in correspondence with MIL-HDBK-217)

## Mechanical specification

**Weight** 278 g

**Plug connector** AC input: FRIWO exchangeable mains plug system:  
EURO, UK, USA /Japan, Australia, ROW

## World exclusive

**Medical** 100 - 240 V input voltage  
**power supplies** without earthing, leakage current < 10  $\mu$ A

## Output data

**Voltage** 12 V

**Current** 2500 mA

**Ripple volt.** 100 mV pp

### 3.7.4 Safety Notes

Switch off all components before connecting or disconnecting cables.

When setting up the system, make sure that all connectors and switches are easily accessible.

Periodically check the technical safety of the device, e.g., check for damage to the housing etc.

Servicing, adjustment or repair works may only be carried out by a certified distributor or SensoMotoric Instruments GmbH (SMI).

In case your iView X system or a component of the system is damaged, switch off the whole system and unplug it from the power source. Do not use the system until the system or its component has been repaired by a certified distributor or the manufacturer (SMI).

Only use original components (cables, power supply etc.) from SMI.

In case a component needs to be replaced, only replace it with original

components from SMI.

Do not repair the system by yourself. Electrical shock hazard.

No part of the product may be modified or rebuilt.

Any usage other than described in this manual is not permitted, can damage the device and eventually lead to associated risks such as short-circuit, fire, electric shock, etc.

We do not assume liability for resultant damages to property or personal injury if the product has been abused in any way or damaged by improper use or failure to observe these operating instructions. In addition, any unauthorized modifications or repairs of the device will render the warranty null and void!

### **Additional Mirror Box Safety Notes**

The mirror-box does not contain metallic parts.

### **Additional Tripod and Camera Box Safety Notes**

The tripod and the camera box are designed with as few ferromagnetic parts as possible. However, some small magnetic parts are required for full functionality. Therefore, the tripod with the dolly and the camera box should not be disassembled inside of the magnetic room under any circumstances.

Always keep the camera box away from the scanner!

Never bring the camera box into the bore!

Always keep maximum distance between camera box and scanner when bringing the camera box into the scanner room and fixing the unit to the camera table or tripod!

Never put the camera box at any place within the scanner room without fastening the unit!

Always use the provided camera table or tripod to fasten the camera box!

Always use the provided straps to fix the camera table to the scanner bed before mounting the camera box!

Never have subjects in the scanner while moving the camera box into or out of the scanner room!

Only have subjects in the scanner while the camera box is properly fixed

to the camera table or the tripod!

If you don't follow all the rules you may damage the camera box or the scanner, or jeopardize the subject's safety.

### **Additional Power Supply Safety Notes**

The power supply of the infrared LED contains an iron core and is therefore magnetic. Do not place or carry the power supply unit too close to the magnet. It might be attracted by the magnet and damage the system. It is recommended to fasten the power supply unit on the floor or wall. Do not set up the system while a test person is lying inside of the MRI scanner.

Only use connecting cables provided by the manufacturer (SMI). Make sure the conductive earth wire is not broken, disconnected, removed or interrupted as this can pose a serious threat to life in the event of malfunction.

The device must only be operated in dry, indoor spaces.

Take precautions to make sure that the insulation of the entire product, the safety sockets, connected cables and mains cables are neither damaged nor destroyed.

Always use fuses of the specified type and rating. It is impermissible to use repaired fuses!

Never operate the device without supervision while loads are connected. Ensure to protect connected loads from the effects of operational disturbance as well as overvoltages.

Do not use the power supply as a direct or indirect charging device.

The device shall not be subjected to heavy mechanical stress.

The device must not be exposed to extreme temperatures, direct sunlight, intense vibration or moisture. Position the device on a level and sturdy surface.

The device generates operational heat. Never insert any objects, block cooler opening of the device, or hinder ventilation in any form or manner. The device is predominantly cooled by convection.

Never put a naked flame or any containers with liquids on or near the apparatus.

Caution! Capacitors within the device may retain their charge even if the device is disconnected from all power sources.

Never turn on the device immediately after it has been brought from a cool into a warmer environment. Condensing water might destroy your



device. Leave the device in OFF position and wait until it has reached ambient temperature.

Before operating the device, make sure that your hands, shoes, clothing, the floor as well as the device itself are dry.

During thunderstorm, unplug the device's power plug from the mains outlet in order to avoid damages due to excess voltage.

In industrial facilities, the safety regulations laid down by the professional trade association for electrical equipment and facilities must be observed.

In schools, training facilities, DIY and hobby workshops, the usage of electrical devices is to be supervised by trained personnel.

If there is reason to believe that safe operation is no longer possible, the device is to be put out of operation and secured against unintended operation. Safe operation is no longer possible if:

- the device has sustained visible damages,
- the device no longer works,
- and the device was stored under unfavorable conditions for a long period of time,
- the device was subject to considerable transport stress.

This device is not a toy and should be kept out of reach of children!

Should you have any questions that are not answered in this operating manual, please contact our technical customer service, or other experts.

### **Electromagnetic compliance**

**WARNING:** This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications.

### **Electrostatic sensitivity**

**WARNING:** All internal electronics are sensitive to high voltage or electrostatic discharge. The system can be destroyed if carelessly handled, so extreme care should be taken during set up and operation.

### **Operating Temperature**

The system is designed to operate satisfactorily in an environment where the ambient temperature is between 10 °C and 50 °C, and that there is no water condensation present.

### **Storage Temperature**

Do not store the equipment in an area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

### **Packaging for shipment**

When shipping, use the shipping cartons in which the units were originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -10 °C or exceed 80 °C. Do not allow moisture to condense on the system.

### **Disposal**

Dispose the device according to legal regulations.

## **3.7.5 Maintenance**

Switch off the system before cleaning.

Use a clean lint-free, antistatic, slightly moistened cloth to clean the device. Do not use abrasives, detergents or solvents.

To clean the mirrors in the mirror-box, use a soft cloth or lens cleaning paper, lightly moistened with alcohol.

Make sure that the camera modules do not come into contact with liquids during cleaning.

# **System Calibration**

**Chapter**



**IV**

## 4 System Calibration

Calibration is called the process, in which the iView X system establishes the relationship between the position of the eye in the camera view and a gaze point in space, the so-called point of regard (POR). The calibration also establishes the plane in space where eye movements are rendered. Since this relationship strongly depends on the overall system setup and also varies between test persons, a reference measurement called calibration must be performed before each experimental run.

### 4.1 Basic Terms

#### General Calibration Process

During calibration, the test person is presented with a number of targets in known locations. These targets must be fixated on by the test person and the position of the eye is noted by the system. Using these reference points, the system creates a mapping function that relates all eye positions to points in the [calibration area](#)<sup>[240]</sup>.

The accuracy of gaze data is directly related to the success of the calibration.

After a successful calibration process the system is ready for measurement.

#### Calibration Area

The Calibration Area is the area on which the eyetracker is calibrated. If the area should match the screen it could have a typical size of 800x600, 1024x768, 1280x1024 etc. in pixels. See the display settings in the system's control panel for more details. The area could be any other area in arbitrary units.

#### Light Changes

Light levels should be approximately the same between calibration and

the experiment. The auto-threshold and auto-iris features of the eye tracker will quickly adjust for light changes. However, because of pupil dilation, some inaccuracy will be seen if the brightness level changes drastically during a test.

Some tips regarding the light conditions:

- . if an experiment is taking place outside, the test person should be calibrated outside
- . if the experiment consists mainly of reading black text on a white background, the calibration process should be also showing black targets on a white background

## Distance

Calibration points should be presented on a plane at an equal depth to whatever the test person will be viewing during the test. There will be a certain amount of parallax error if the calibration plane is close to the test person (within a meter) but gaze position is recorded far away, and vice versa. Care should be taken to select a calibration plane in a place logical to the experiment goals.

## Different calibration processes

The process of calibrating the test person depends on the interface used and the data type desired. For remote-type experiments that use a defined area such as a computer monitor for calibration, points can be displayed dynamically (e.g. by using the program SMI Experiment Center) or statically (using a bitmap, points drawn on a wall, etc..). Head mounted experiments are calibrated in a similar fashion with points identified that correspond to locations in the scene video, typically by using a laser pointer.

In all cases, calibration defines the area of gaze tracking and gives the system a base line for calculations of head movement compensation. The system has adjustable criteria for a successful calibration and procedural variables that can be changed to optimise success.

The method of calibration will slightly vary between different interfaces and different test persons. In most eye tracking experiments, gaze accuracy is important and so the calibration options are set to minimize the chance of error.

However, in some cases, a shorter calibration is required. This is particularly true with test persons who are unable to calibrate well such as those with vision or ocular motor problems. A shorter calibration with less points would be the most comfortable for these test persons, with whom accuracy is generally compromised anyway.

### Manual and automatic calibration

During manual calibration the operator examines the test persons's eye image and confirms the fixation of each calibration point by pressing a key. When calibrating in automatic mode the system checks the test person's eye movement and accepts the calibration points automatically.

### Related topics

- [Calibration Basics](#) <sup>[18]</sup>
- [Calibration Methods](#) <sup>[242]</sup>
- [Calibration Processes](#) <sup>[245]</sup>
- [Setup Calibration](#) <sup>[313]</sup>

## 4.2 Calibration Methods

In general it can be said that more calibration points result in a higher accuracy, at the same time increasing the preparation time prior to the actual measurement.

The following calibration methods are possible:

- [1 Point](#) <sup>[243]</sup>
- [2 Point Diagonal](#) <sup>[243]</sup>
- [5 Point Linear](#) <sup>[244]</sup>
- 8 Point, for HMD users only
- [9 Point with Corner Correction](#) <sup>[244]</sup>
- [13 Point](#) <sup>[244]</sup>
- [13 Point Head Tracking HED](#) <sup>[244]</sup>
- 2 Point RED
- 5 Point RED
- 9 Point RED

[Direct Analog \(Gain & Offset\)](#)<sup>[244]</sup>

See also:

[Setup Calibration](#)<sup>[313]</sup>

### 4.2.1 1 Point

The 1-point calibration uses a novel way to calibrate the system. The 1-point calibration needs a 5-point system calibration as a preparation, which has to be performed once for a given geometric setup. This system calibration is persistent, including system re-starts. After the preparation succeeding test persons only need to calibrate with 1 point.

#### Accuracy

The deviation of measured fixations after a 1-point calibration is approximately 1° worse than measured with 9-point calibration.

#### Limitations

The 1-point calibration might produce varying results with persons wearing glasses. Currently, there is no test data available for persons wearing contact lenses.

#### Licensing

iView X must be licensed to use this feature. Click on [Help](#)<sup>[364]</sup> [License](#)<sup>[366]</sup> to see if this feature is currently licensed on your computer. If not, contact your vendor. If you purchased this feature, you have to add the component to the License Key. To do so, you have to terminate the old license and ask SMI to issue a new License Key. See also [SMI Software License](#)<sup>[27]</sup> for more information on the licensing process.

### 4.2.2 2 Point Diagonal

2 point diagonal calibration has only a very limited accuracy. This can be used, if a quick calibration is needed, and only a rough detection (left or right half plane hit) is sufficient.

### 4.2.3 5 Point Linear

A five-point calibration is best suited for applications where the eye camera is located without big offsets of the middle of the line of sight. Naturally this is the case for the HED, therefore for a HED this method is quick and accurate enough. For other systems (RED) it is useful if mapped gaze accuracy is not critical. The overall accuracy is a little bit lower than with the nine point calibration method.

### 4.2.4 9 Point with Corner Correction

The nine-point calibration uses an additional corner-correction algorithm. In normal applications this will give a sufficient high accuracy.

### 4.2.5 13 Point

The 13 point calibration adds additional fixation points for best accuracy. This is recommended for [High Speed](#)<sup>[129]</sup> systems.

### 4.2.6 13 Point Head Tracking HED

This 13-point calibration is used for [Head Tracking HED](#)<sup>[68]</sup>. See also its [User Guide](#)<sup>[72]</sup> and [Calibration Plane](#)<sup>[84]</sup> for details.

### 4.2.7 Direct Analog (Gain & Offset)

This option is available only if iView X has been configured with the [Analog Out option](#)<sup>[437]</sup>.

The analog gain/offset calibration method is provided for compatibility with analog data collection systems such as those used with scleral search coil based (SSC) eye tracking systems.

This method is useful if the subject population is not entirely cooperative (ie non-human primates) or has limited ability to fixate or see targets.



This calibration method allows the manual setting of output voltage offset and gain for each channel of eye movement data.

### Calibration Process

On start calibration a window will be opened to set gain and offset of the voltage output. To calibrate the system let the subject gaze at two predefined points. When the subject looks at the first point, set the gain value, when the subjects looks at the second point, set the offset value.

Alternatively open the [Direct Calibration Controls](#)<sup>[356]</sup> window from the [View](#)<sup>[337]</sup> menu and change the values during the measurement.

For an example see [Analog Gain/Offset Calibration](#)<sup>[253]</sup>.

See also: [Hi-Speed Primate System](#)<sup>[167]</sup>

## 4.3 Calibration Processes

Depending on the application there are several ways to calibrate the system. This section outlines some of the various calibration processes.

### 4.3.1 General Remarks

#### General Calibration Process

1. To start a calibration run a stimulus program capable of an

automated calibration or click on the *start calibration* button of the [Toolbar](#)<sup>[338]</sup> (hotkey: [<F5>](#)<sup>[367]</sup>).




2. Instruct the test person to look at the calibration point. The target in the iView X™ application window will indicate a stable fixation according to the following:



Stable Fixation

No Fixation  
or Lost Pupil

- When the test person has fixated, press <F6> or <space> or the  *accept point* button to accept the point.
- If calibration is set to *Auto Accept Points*, the system will automatically advance through the calibration points. The test person should view each one as it is presented. Verify that the test person complies with the calibration and does not look away from points too early.
- Check the *Error* tab in the *System Log* window for potential problems during the calibration. If the calibration was completed successfully, the *User* message in the *System Log* will display "Calibration finished successfully" and the scene image will show a cursor indicating the test person's gaze position.
- To verify the accuracy of the calibration, ask the test person to look at defined points within the stimulus while monitoring the gaze cursor on the scene view, or run the Validation routine.

## Colours and light changes

Environmental conditions during calibration should match those of the experiment. This is true of test person posture and both ambient and experimental light levels. Strong light level changes should be avoided between calibration and data recording.

Special care should be taken to match calibration colours with those displayed during the experiment. The fore- and background colours of the calibration targets should be chosen similar to the colours of the experiment.

This is because light level changes in the stimulus have a profound effect on the pupil size. If the pupil size remarkably changes between calibration and the experiment, it will introduce error to gaze position measurements and the resulting gaze position data may not be reliable.

## Moving Calibration Points

During calibration it is possible to reposition the calibration points manually. See [Moving Calibration Points](#)<sup>[252]</sup> for more details.

## Calibration Area

Gaze position will be most correctly determined in the area covered by the calibration points. Gaze position outside of the [calibration area](#)<sup>[240]</sup> will be approximated but it is not nearly as accurate.

However, in some situations it is beneficial to shrink the size of the calibration field to match the useful area of the stimulus. For HED applications using a wide-angle scene camera, it is not practical to use calibration points that are at extreme eye angles, especially if the test person is not likely to look at such an angle during the test without moving his or her head. The same is true of fMRI studies where the stimulus is concentrated near the center of the screen. In these cases, the calibration points can be repositioned to a more central location.

## Head Movements

In all calibration methods, the test person should be encouraged not to make head movements.

### 4.3.2 Computer Screen Using SMI Experiment Center

SMI Experiment CenterThe SMI Experiment Center™ application is a Windows™ program that runs on the stimulus PC. It requires an ethernet connection between the two computers. The application, once activated and enabled, will present calibration points to the test person as they appear. This is usually the easiest way to calibrate, especially for RED, Hi-Speed and fMRI systems.

See the SMI Experiment Center™ manual for more details.

### 4.3.3 Computer Screen Using WinCAL

The [WinCAL](#) <sup>[405]</sup> application is a Windows™ program that runs on the stimulus PC. It requires a serial link or ethernet connection between the stimulus PC and the iView X workstation. The application, once activated and enabled, will present calibration points to the test person as they appear.

During the calibration process WinCAL can either:

- *use iView points*: If you [move](#) <sup>[252]</sup> the calibration points in iView, WinCAL immediately adopts the new positions. This will be used in most cases.
- *use default calibration points*: WinCAL ignores position changes in iView and displays the points at default locations. This must be selected if WinCAL is used with the HED.

If WinCAL is left active during the test, it will maximize its window to display drift correction or calibration points whenever told to by the iView system. It will minimize after a successful completion, returning the Stimulus PC to the stimulus software.

See the WinCAL manual for more details.

### 4.3.4 Computer Screen With Static Targets

It may be necessary to calibrate using static targets on the computer screen. This is the case when the Stimulus PC does not run MS Windows or when a serial link or ethernet is unavailable.

One method of calibrating in this case is to display a static bitmap of calibration points to the test person. The test person must be told which calibration point is active by the operator, who watches the procedure on the iView computer.

The typical geometry used for calibration is this: one point is in the exact center, the other eight points at each 5% of the total image size from the closest border.

For example, if a calibration bitmap is displayed at 800X600 resolution, the upper left point would be located at 40X30, the center point at 400X300, and the lower right point at 760X570.

If using a different geometry for calibration points, the iView calibration must be adjusted to take into account the new target locations. The easiest way to do this is to load the calibration bitmap into the iView as a scene image. Go to the [File](#) <sup>[283]</sup> and choose [Open Scene Image](#) <sup>[284]</sup>. Browse to the appropriate calibration image. Now [move the calibration points](#) <sup>[252]</sup> to match those displayed in the bitmap.

### 4.3.5 HED Calibration

In HED systems the eye is calibrated to the scene video, not necessarily to a fixed area in the test person's view.

There are a few methods of calibrating the HED. One way is to mark points on the wall or some other flat surface. The operator can drag calibration points to match these points as they appear in the scene video. The size of the calibration field should approximate the likely eye movements of the test person at any single head position. Points that are especially peripheral will probably involve head movement during the test.

Another way to calibrate the HED system is to use a laser pointer. The test person stands facing a wall or flat surface. The operator watches the scene video on the screen. Once calibration is started, the operator uses the laser pointer to display to the test person where the calibration point falls in their field of view. This is accomplished by lining the laser point up with the calibration point while looking at the scene video. The operator hits F6 to accept the calibration point and then moves on to the next, until all points are completed. It is easiest to do this with ACCEPT POINTS AUTOMATICALLY turned off.

Because of potential parallax errors, the HED should be calibrated at a distance that approximates whatever the test person will view during the test. If the calibration plane is very close to the test person, there will be a parallax error in the gaze data when the test person looks at points far away, and vice versa. If the experiment involves eye tracking at a number of different distances, a medium-distance calibration area should be

selected.

See also: [HED Calibration](#) <sup>[61]</sup>.

### 4.3.6 HED Calibration and WinCAL

If HED is used together with WinCAL, make sure that WinCAL uses its *default calibration points*. With HED, [moving the calibration points](#) <sup>[252]</sup> is used to map the gaze position to the scene video. Therefore, new calibration positions may not be adopted by WinCAL.

### 4.3.7 Using Remote Commands

It is possible to create an automated calibration routine using the Remote Control Command Language. Your stimulus presentation software must be able to send and receive information on the serial port or using ethernet. For more information see also the section on [I/O Interfaces](#) <sup>[429]</sup>.

## 4.4 Drift Correction

Drift correction is a one-point correction that realigns the calibration field to adjust for any linear drift that may have entered the system. To start a drift correction choose from the [Calibration](#) <sup>[287]</sup> menu [Drift Correction](#) <sup>[289]</sup>. A single fixation point is displayed to the test person and accepted when

the operator hits F6 or clicks on the *accept point* button .

Fixation points can be triggered manually by the operator, or automatically via remote control (see section [I/O Interfaces](#) <sup>[429]</sup> for more details).

Typically, drift correction is done between trials during a test. As with calibration, the fixation target in drift correction should be a similar color and background color as the actual test. This will avoid large changes in pupil size. This is particularly important in the fMRI environment.

The linear adjustment performed by a drift correction requires a steady

fixation by the test person. If your test person is incapable of fixating well (because of macular degeneration or spontaneous nystagmus, for example) the routine will not likely be useful.

Drift correction will not be effective against non-linear disturbances. In these cases, it is better to recalibrate.

## 4.5 Validation

A validation is a process to check the accuracy of the eye tracking system. If validation is started, fixation targets are presented at known locations, as in a calibration process. The test person has to fixate the targets, and the system compares the measured gaze points with the position of the targets and calculates the deviation.

### Setup Validation

Before starting the validation process, check under [Setup](#)<sup>[290]</sup> Calibration in the [Geometry](#)<sup>[317]</sup> tab, that the values for *Stimulus Physical Dimension* and *Monitor-Head Distance* are set correctly.

### The Validation Process

Start Validation by pressing <F8> or click on the *start validation* button



. The test person should look at the first target. Press <space> to accept the first point. If [Auto Accept](#)<sup>[288]</sup> is checked, the system automatically proceeds to the following targets.

### The Output

iView X draws a small red cross at the measured gaze point. The system calculates the deviation to the known calibration target and writes three values for each calibration target in the [User](#)<sup>[360]</sup> tab of the [System Log](#)<sup>[360]</sup>: the x-component, the y-component and the vector resultant of the deviation. Finally, the system calculates the average value for the three resulting columns. Thus, the very last value gives you an idea of the system's average measurement accuracy. Pressing <space> clears the bitmap view/scene video. All units are given in pixel or, for HT systems, in mm.

See also: [ET\\_VLS](#)<sup>[468]</sup>.

## 4.6 Moving Calibration Points

It is possible to manually change the calibration points either by moving them during calibration, or prior to the calibration process.

### Moving the calibration points during calibration

1. Start a calibration.
2. Let the test person gaze at the desired calibration point.
3. Move the calibration point with the mouse by drag and drop until it matches the test person's gaze.
4. Continue with the calibration process.

### Moving the calibration prior to a calibration

1. Choose from the [Calibration](#)<sup>[287]</sup> menu [Edit Points](#)<sup>[289]</sup> to make all calibration points visible in the scene view.
2. Step through the calibration points by hitting the <space> bar until the point you wish to change is highlighted.
3. Move the calibration point with the mouse by drag and drop to the desired position.
4. Hit the <space> bar to proceed to the next point.
5. With another click [Edit Points](#)<sup>[289]</sup> the calibration points will hide again.

### Reset calibration points to their default positions

1. Go to the [Setup](#)<sup>[290]</sup> [Calibration](#)<sup>[313]</sup> dialog box.
2. Click on the [Reset Points](#) button.

By default the distance between the outer calibration points and the border of the [calibration area](#)<sup>[240]</sup> is five per cent of the respective horizontal or vertical dimension. The inner points are equally distributed.



## 4.7 Special Calibration Processes

Some calibration methods are possible that are used for special applications:

[Pupil Only Calibration \(no CR\)](#) <sup>[253]</sup>  
[Analog Gain/Offset Calibration](#) <sup>[253]</sup>

### 4.7.1 Pupil Only Calibration

It is possible to only calibrate the pupil without cornea reflection (CR). This option should be used with caution as the cornea reflex is crucial to compensate for [head movements](#) <sup>[17]</sup>.

To perform a calibration without the cornea reflex go to [Setup Hardware](#) <sup>[290]</sup> Hardware and click on [Advanced](#) <sup>[293]</sup>. Set the number of tracked CRs to 0.

### 4.7.2 Analog Gain/Offset Calibration

There are several ways to accomplishing [Direct Analog](#) <sup>[244]</sup> (Gain/Offset) calibration, depending on the scope of the experiment. We present here the most common.

#### Preparation

It is assumed that the eye camera is setup on the test person with adequate tracking of the pupil and (if used) cornea reflex. Each analog output channel should be properly connected to the input channels of the data collection device.

These directions will work with a number of SMI systems, including: iView X Hi-Speed, iView X Hi-Speed Primate, iView X RED, iView X MEG, MRI-LR/SV.

## Direct Calibration Setup

Under the [Setup](#) <sup>[290]</sup> menu, choose [Calibration](#) <sup>[313]</sup>. From the 'Setup Calibration' window, select 'Direct Analog (Gain & Offset)' and choose 'ok'.

## Analog Output Setup

In the [Setup Hardware](#) <sup>[290]</sup> [Communication](#) <sup>[292]</sup> dialog click on [Config](#) <sup>[307]</sup> in the **TTL IO/Analog Out** section. In the **Analog Out** window, select channel definitions for each of the four output channels. The direct calibration method requires 'Gaze' output. 'Data Range' cannot be adjusted.

**Analog Out**

Output Configuration

Channel	Data Source	Direct Gain & Offset	Data Range min	Data Range max	Voltage Range
1	Gaze X ( right )	<input checked="" type="checkbox"/>	4095	12287	-5V +5V
2	Gaze Y ( right )	<input checked="" type="checkbox"/>	4095	12287	
3	Gaze X ( left )	<input checked="" type="checkbox"/>	4095	12287	
4	Gaze Y ( left )	<input checked="" type="checkbox"/>	4095	12287	

Invert Horizontal Channel  
 Invert Vertical Channel

When inverted the maximum data will be mapped on the min voltage and the min data will be mapped on the max voltage.

Out Of Range Behaviour

Set To Zero  
 Keep Last Value  
 Extrapolate  
 Clip

Run Test Output ( -5 Volt to 5 Volt )

Start

Stop

OK Cancel

If running in monocular mode, only select the data sources that correspond to the selected eye.

*Note: Assign each data source only once to one channel, even if you are not using all four channels. Example: 'Gaze X (Right)' should only appear once in the data source list.*

The voltage range for output can be adjusted via 'voltage range'. Horizontal and vertical output channels can be inverted via check boxes on the right (default origin is upper left corner; X voltage increases when test person looks to the right, Y voltage increases when test person looks down).

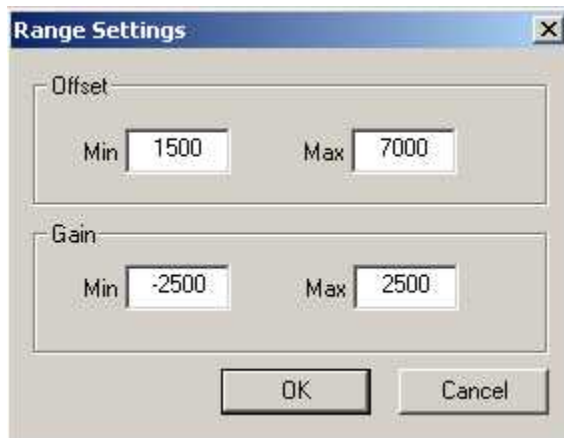
To test the output connection, click the 'start' button under 'Run Test Output' to generate a  $-5$ ,  $+5$  square wave.

For purposes of these directions, we assume the following channel mapping:

Channel 1	-	Gaze X (right eye)
Channel 2	-	Gaze Y (right eye)
Channel 3	-	Gaze X (left eye)
Channel 4	-	Gaze Y (left eye)

### Data Range Setup

On the [Calibration Configuration](#) <sup>356</sup> window, select the 'Ranges' button. This window selects the gain and offset range that can be adjusted during the calibration process.



Offset and Gain ranges should be set to give maximum sensitivity in the

next several steps, while allowing enough working range to deal with each test person.


If range is set too narrow, the gain and offset sliders will not allow enough of a change to get desired output.

If range is set too wide, the sliders will be too sensitive to fine-tune output.

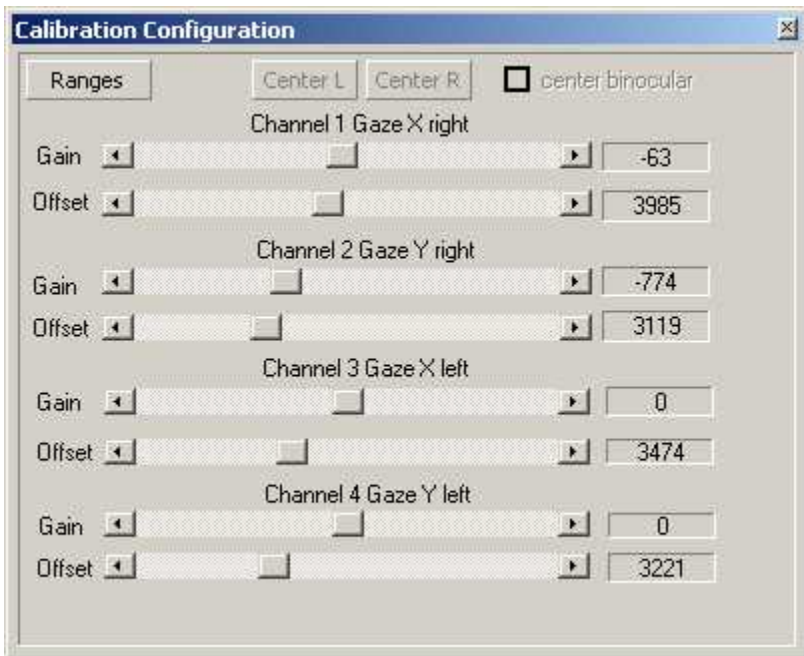
*Note: Some experimentation is required to determine a good working range for each particular system. The values listed above are a good starting point for a 350 Hz system operating in monocular mode.*

Once a good range is selected, it should work for all test persons for this particular system configuration.

### **Subject Calibration**

The [Calibration Configuration](#)  window is used to set offset and gain for the eye movement channels.

*Note: Output voltage will remain at minimum (-5,-5 in this example) until any one of the Offset sliders is moved for the first time. At that point you will see live gaze output on your oscilloscope.*



The following steps will calibrate a test person:

1. Have the test person look at the center of the screen. Adjust the channel 1 OFFSET slider until the output for that channel is horizontally centered on the scope. This will define the center of the horizontal output range when the test person is looking at the center of the screen.
2. Adjust the channel 2 OFFSET slider until the output signal is centered vertically. This will define the center of the vertical output range when the test person is looking at the center of the screen. The output signal should now be displayed in the center, while the test person is looking at the center.
3. With the output centered, click the "Center R" button to define the center of the screen for the first two channels. All gain values will now be applied to this defined center.

4. Repeat this process for Channels 3 and 4 to center the other eye. When complete, click the "Center L" button.
5. Have the test person look at a point in the corner of the useful part of the stimulus. This can be accomplished with a static target in the corner or a moving target that oscillates in and out of a corner.
6. Adjust the GAIN sliders for Channels 1 and 2 so that the expected output range is visible when the test person looks at points at the edge of the screen. If adjusted properly, the output should be centered when the test person looks at the center, and at the maximum expected value for Channel 1 when the test person looks at the far right or left and Channel 2 at the far top and bottom.
7. Repeat the gain process for Channels 3 and 4.

If necessary, gain can be adjusted at any time during the test. If Offset is changed, remember to click the "Center L" and "Center R" buttons in order to reset the center of the screen.

Some experimentation with this process might be necessary to find the easiest method for your particular setup and subject population. Contact your SMI representative for more information.

# **iView Data File (IDF)**

**Chapter**



**V**

## 5 iView Data File (IDF)

One of the [system outputs](#)<sup>[25]</sup> is a binary iView **Data File (IDF)**, which is used as a basis for further analysis. This file contains, among others, information on pupil and gaze data, which is needed to extract saccades, fixations and AOI hits.

See also:

[IDF Utilities](#)<sup>[260]</sup>

[ASCII File Format](#)<sup>[274]</sup>

### 5.1 IDF Utilities

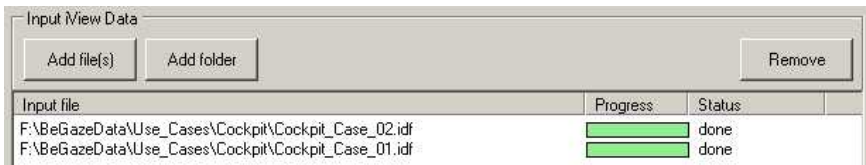
iView X comes together with two IDF utilities:

[IDF Converter](#)<sup>[260]</sup>: converts the binary IDF file to ASCII readable text.

[Event Detector](#)<sup>[264]</sup>: detects saccades, fixations and blinks.

#### 5.1.1 IDF Converter

The IDF Converter is a tool to convert iView **Data Files (IDF)** into ASCII readable text. The lines and columns are separated by a tab, which enables you to easily load the data into other analysis or table calculating programs.



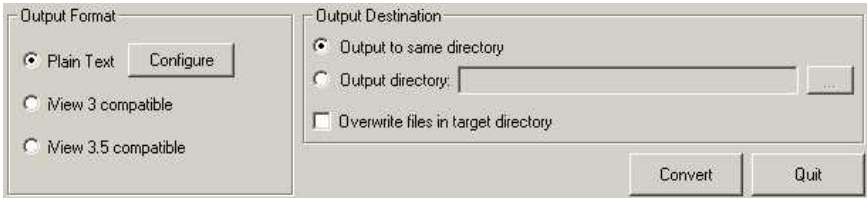
#### Input View Data

Several files can be loaded into a list, that will be processed consecutively.



**Add file(s):** Load files to the list

**Add folder:** Add complete folders to a list



### Output Format:

Plain Text	iView X Plain Text format gives you options, to <a href="#">configure</a> <sup>[262]</sup> your output.
iView 3 compatible	Only for iView 3 users, if you still use iView 3 analysis tools.
iView 3.5 compatible	Only for iView 3 users, if you still use iView 3 analysis tools with head tracking.

For an overview of the iView X file format see section on [Export File Format](#)<sup>[274]</sup>.

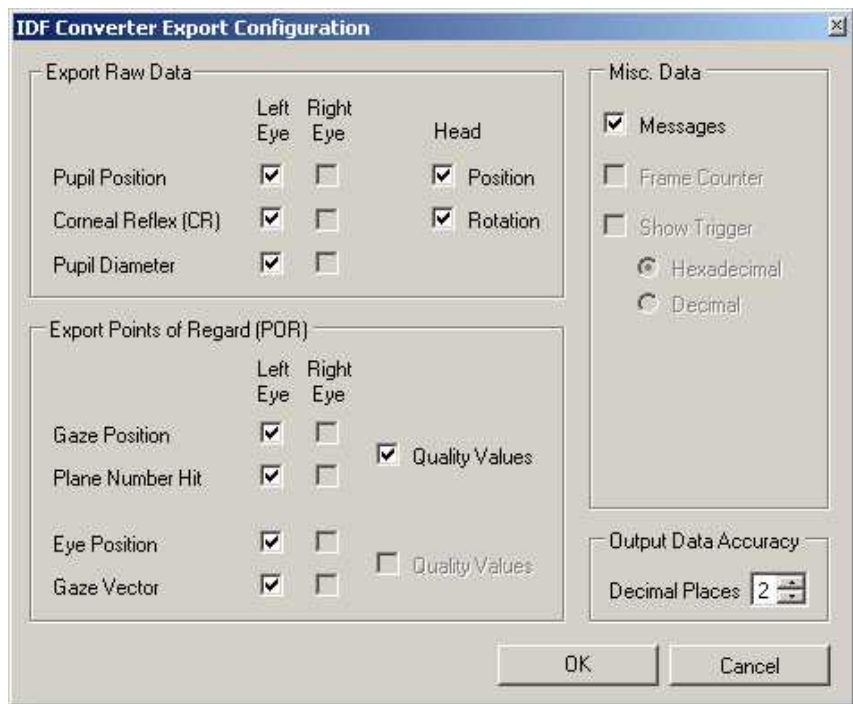
### Output Files

You can choose a directory, where the output files will be saved. All files have the same names as the input files, but will have '\_Samples' added to their original filenames. The extension will be '.txt'

Press **Convert** to start the conversion.

Press **Quit** to close the dialog box.

### 5.1.1.1 IDF Converter Export Configuration



Choose here which items you wish to be exported. Note that only available items can be checked. In the example above our system is monocular, left eye is tracked, and headtracking installed. The not available data is greyed.

## Eye Data

**Raw Data** means unprocessed data. **Pupil Position**, position of all **C**ornea **R**eflexes and **D**iameter will be given in video coordinates or video pixels, respectively.

**Point of Regard** is data mapped to the [calibration area](#)<sup>240</sup>.

**Gaze Position** is the point inside the calibration area at which the test person actually looked, given in the coordinates of the calibration area.

**Plane Number Hit** gives you the number of the plane at which the test person looked in a 3-D-environment. This item is active only, if a headtracker is installed.

**Quality Values** are some additional information for each sample. Currently two types of information will be exported: Timing and Latency. *Timing* is set to 1 if sample was delayed and could not be processed in real time. *Latency* is the time in microseconds iView X needed to process a sample.

## Head Data

Head data exports respective x,y,z coordinates relative to the head tracker's origin (the position of the transmitter cube) for **Head Position**, **Head Rotation** and **Eye Position**.

**Gaze Vector** is normalized given in x,y,z coordinates.

## Misc. Data

If you check **Trigger Signals**, a column will be added with the status of the IO port for each sample.

If you check **Messages**, additional messages will be exported.

If you check **Frame Counter**, the frame counter will be exported as a string.

## Others

**Time and Trial number** will always be exported. The timestamp is given in absolute time in microseconds since the system has been started.

**Load** enables you to load a previous saved export configuration file.

**Save** asks you to save the current settings to an export configuration file.

## File Format

For an overview of the output file format see section on [Export File Format](#) <sup>[274]</sup>.

Back to [IDF Converter](#) <sup>[260]</sup>.

### 5.1.2 Event Detector

The Event Detector is a tool which detects events in the IDF data file. The output is ASCII readable text. The lines and columns are separated by a tab, which enables you to easily load the data into other analysis or table calculating programs.



#### Input View Data

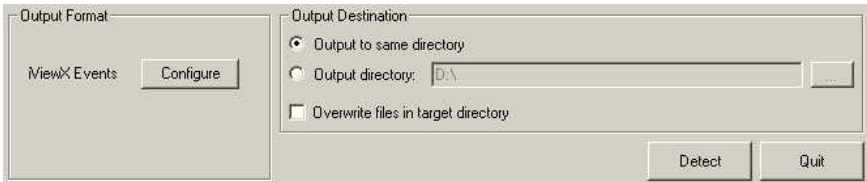
Several files can be loaded into a list, that will be processed consecutively.

**Add file(s):** Load files to the list

**Add folder:** Add complete folders to a list

**Planes file for headtracking data:** If some of the files contain headtracking data, a planes.ini file is required. If it is not loaded, the

status will display an error.



### Output Format:

iView X Events	Export events, such as fixations, saccades and blinks. Click on <a href="#">configure</a> <sup>265</sup> to configure your output.
----------------	--

### Output Files

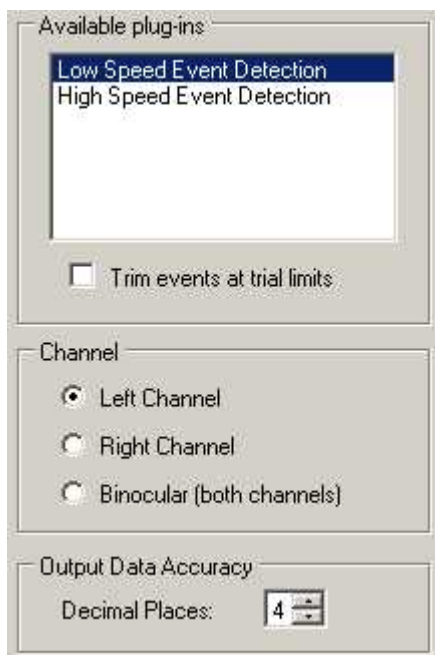
You can choose a directory, where the output files will be saved. All files have the same names as the input files, but will have '\_Events' added to their original filenames. The extension will be '.txt'

Press **Detect** to start the conversion.

Press **Quit** to close the dialog box.

### 5.1.2.1 Event Detector Configuration

**Available plug-ins:** Depending on the sample rate the [built-in detector](#)<sup>269</sup> selects the detection method automatically.



**Channel:** Select, if you want to export left, right or binocular data.

**Detection Parameters:** The detection parameters depend on the selected plug-ins. To fully understand the meaning of the parameters it might be necessary to have a look at how the [Built-In Detector works](#)<sup>[269]</sup>.

**Filter Size for both detection methods:** The Filter Size will be automatically set and need not be changed in normal applications.

### Low Speed Event Detection

Detection Parameters

Min. Duration  ms

Max. Dispersion  °

Low Pass Filter Size

Differential Filter Size

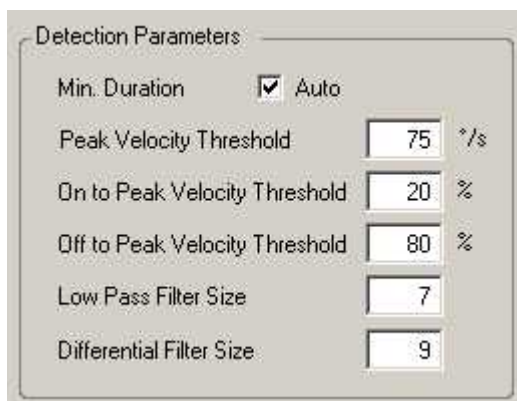
For Low Speed Event Detection the following parameters are displayed and can be changed:

**Min Duration:** minimum fixation duration in [ms]

**Max Dispersion:** maximum dispersion value. The unit depends on the experiment type:

	Unit
standard data	pixels
data with head tracking	degree

### High Speed Event Detection



Detection Parameters

Min. Duration	<input checked="" type="checkbox"/> Auto
Peak Velocity Threshold	<input type="text" value="75"/> °/s
On to Peak Velocity Threshold	<input type="text" value="20"/> %
Off to Peak Velocity Threshold	<input type="text" value="80"/> %
Low Pass Filter Size	<input type="text" value="7"/>
Differential Filter Size	<input type="text" value="9"/>

For High Speed Event Detection the following parameters are displayed and can be changed:

**Min. Duration:** minimum saccade duration in [ms]

**Automatic Min. Duration:** Currently, the *Auto* option is available only for systems with a sample rate between 240 and 350 Hz. If clicked, the minimum duration varies and is automatically set dependent on the peak threshold.

**Peak Velocity Threshold:** in [°/s]. Velocities above the threshold are regarded as belonging to a saccade.

**Peak Velocity Window:** The single peak value has to lie in this window. Start and end is given in % of the saccade length.

**Geometry:** The Built-In Detector needs the physical dimension of the stimulus area and the distance between head and monitor to calculate angular velocities and accelerations.



Geometry

Stimulus Screen Resolution

1280x1024

Horizontal 1280 pix Vertical 1024 pix

Stimulus Physical Dimension

Horizontal 340 mm Vertical 270 mm

Monitor-Head Distance

500 mm

### 5.1.2.2 Built-In Event Detector

The built-in detector detects saccades, fixations and blinks from a gaze data stream. A saccade is defined as a rapid change in gaze location, and a fixation is regarded as being bordered by two saccades. A blink can be considered a special case of a fixation, where eye data is not present.

In general, there are two approaches for the built-in detector: Either it can first look for fixations and the other events are derived from them, or it can first look for saccades, followed by the computation of the other events.

Which event the detector searches first, we call *primary event*. If the primary event is *fixation*, the detector uses a *dispersion* based algorithm. If the primary event is *saccade*, a *velocity* based algorithm is used.

For low speed eye trackers < 200 Hz, choosing fixations as primary event achieves the best results, whereas primary looking for saccades is sensible for high speed eye trackers.

Depending on the sample rate the built-in detector selects the detection

method:

sample rate	detection method	primary event	algorithm based on
< 200 Hz	<a href="#">low speed event detection</a> <sup>[270]</sup>	fixation	dispersion
200 Hz and above	<a href="#">high speed event detection</a> <sup>[271]</sup>	saccade	velocity

### 5.1.2.2.1 Low Speed Event Detection

In the Low Speed Event Detection method, *Fixation* is selected as primary event. The [Built-In Detector](#) <sup>[269]</sup> will first search for fixation events, using a dispersion based algorithm, after which saccade events are computed and derived from the primary fixation events.

### Blink Detection

A blink can be regarded as a special case of a fixation, where the horizontal and vertical gaze position equals 0. If this is the case, we create a blink event. However, the duration of the blink event is expanded in order to include the transition period between valid gaze data and the blink.

### Fixation Detection

The *Minimum Fixation Duration* defines the minimum time window in which the gaze data is analyzed. Fixations smaller than the time window will not be caught.

The algorithm identifies fixations as groups of consecutive points within a particular dispersion, or maximum separation. It uses a moving window that spans consecutive data points checking for potential fixations. The moving window begins at the start of the protocol and initially spans a minimum number of points, determined by the given *Minimum Fixation Duration* and sampling frequency.

The algorithm then checks the dispersion of the points in the window by

summing the differences between the points' maximum and minimum x and y values; in other words, dispersion  $D = [\max(x) - \min(x)] + [\max(y) - \min(y)]$ . If the dispersion is above the *Maximum Dispersion Value*, the window does not represent a fixation, and the window moves one point to the right. If the dispersion is below the *Maximum Dispersion Value*, the window represents a fixation. In this case, the window is expanded to the right until the window's dispersion is above threshold. The final window is registered as a fixation at the centroid of the window points with the given onset time and duration.

### Saccade Detection

At the end a saccade event is created between the newly and the previously created blink or fixation.

### Parameters

**Min Duration:** minimum fixation duration in [ms]

**Max Dispersion:** maximum dispersion value. The unit depends on the experiment type:

	Unit
standard data	pixels
data with head tracking	degree

### Further Reading:

Dario D. Salvucci & Joseph H. Goldberg:

[Identifying Fixations and Saccades in Eye-Tracking Protocols](#)

In: Proceedings of the Eye Tracking Research and Applications Symposium (pp. 71-78). New York, 2000

#### 5.1.2.2.2 High Speed Event Detection

In the High Speed Event Detection method, *Saccade* is selected as primary event. The [Built-In Detector](#)<sup>[269]</sup> will first search for saccade events, using a velocity based algorithm. Blinks and fixations are

computed and derived from the primary saccade events.

## Saccade Detection

From the gaze stream all velocities are calculated. From all velocities the peaks are detected. A peak is defined as the peak value of velocities above the *Peak Threshold* [%/s]. The peak could indicate a saccade, but as we are not sure, yet, we call it saccade-like event. To detect the start of the saccade-like event, we search for the first velocity to the left which is lower than the fixation velocity threshold. To detect the end of the saccade-like event, we search for the first velocity to the right which is lower than the fixation velocity threshold. The fixation velocity threshold is an internal value calculated from the first peakless velocities of the velocity stream. We assume the saccade-like event a real saccade, if

1. the distance between start and end exceeds the *Minimum Saccade Duration* [ms] and
2. the single peak value lies inside of the [Peak Velocity Window](#)<sup>[273]</sup>.

## Blink Detection

However, the saccade we have found could still be an artefact as a result of a start or end of a blink. If so, we discard the saccade event and assign the artificial saccade to a blink. To determine, if this is the case we evaluate the pupil diameter during the saccade period. If the speed of the pupil diameter change exceeds an internal threshold value, the saccade is assumed artificial and part of the blink.

## Fixation Detection

Finally, we create a fixation event between the newly and the previously created blink or saccade.

## Parameters

**Min. Duration:** minimum saccade duration in [ms]

**Automatic Min. Duration:** Currently, the *Auto* option is available only for systems with a sample rate between 240 and 350 Hz. If clicked, the minimum duration varies and is automatically set dependent on the peak

threshold.

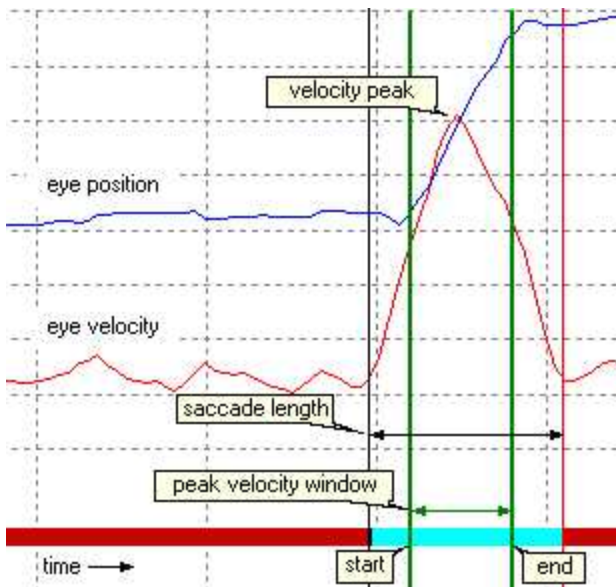
**Peak Threshold:** peak velocity threshold in [°/s]

**Peak Velocity Window:** The velocity curve must resemble a certain pattern to be regarded as the velocity of a saccade. In a typical saccade the velocity of the eye movement increases, reaches a peak and decreases. At first, the detector assumes this kind of movement to be a saccade. The time between start and end of movement is called saccade length. Then the detector searches, if the velocity peak lies within a certain time window inside of the saccade. If the peak lies outside, the assumed saccade is discarded. The start and end of the time window is given in % of the saccade length.

*Default values:*

**On to peak velocity threshold:** Start is 20% of saccade length

**Off to peak velocity threshold:** End is 80% of saccade length



## 5.2 ASCII File Format

The recorded data can be exported to ASCII readable text by converting the generated IDF file with the [IDF Converter](#)<sup>[260]</sup>. The resulting text file can be imported into MatLab™, Microsoft Excel™, or a wide variety of third party analysis software packages available.

You can choose between iView 3 and iView X format. The following will only describe the iView X format.

The output file consists of two parts:

- the [Header](#)<sup>[274]</sup> and
- the [Data Section](#)<sup>[277]</sup>.

Within the data section, messages have a specific [Message Output Format](#)<sup>[279]</sup>.

### 5.2.1 Header

The IDF header is subdivided into groups with a group title in squared brackets. The entries mean the following:

#### [iView X]

<i>Converted from</i>	The original data file.
<i>Date</i>	Date of conversion.
<i>Version</i>	Name and version of the converter.
<i>IDF Version</i>	Version number of iView X data file.
<i>Sample Rate</i>	Sample rate of the data in Hz.
<i>Separator Type</i>	Unknown
<i>Trial Count</i>	Number of trials in experiment
<i>Uses Plane File</i>	Status if a <a href="#">plane file</a> <sup>[317]</sup> was used
<i>Number of Samples</i>	Number of samples.
<i>Reversed</i>	Indicates if x data is reversed (vertical mirrored) or y data is reversed (horizontal mirrored).

#### Example:

```
## [iView]
## Converted from: D:\test\hs2.idf
```

```
## Date:      07.05.2009 09:56:14
## Version:   IDF Converter 3.0.11
## IDF Version: 9
## Sample Rate: 1250
## Separator Type: Unknown
## Trial Count: 1
## Uses Plane File: False
## Number of Samples: 29006
## Reversed: none
```

## [Run]

*Subject* User information.  
*Description* Description of the experiment.

### Example:

```
## [Run]
## Subject:  hs2
## Description: Test #1
```

## [Calibration]

*Calibration Type* Calibration type, number of calibration targets.  
*Calibration Area* Size of calibration area.  
*Calibration Point* Calibration point position.

### Example:

```
## [Calibration]
## Calibration Type:      9-point
## Calibration Area:      1280 1024
## Calibration Point 0: Position(640;512)
## Calibration Point 1: Position(64;51)
## Calibration Point 2: Position(1216;51)
## Calibration Point 3: Position(64;972)
## Calibration Point 4: Position(1216;972)
## Calibration Point 5: Position(64;512)
## Calibration Point 6: Position(640;51)
## Calibration Point 7: Position(1216;512)
## Calibration Point 8: Position(640;972)
```

## [Geometry]

*Stimulus Dimension* Size of stimulus area, if available.





LEFT:	left eye data
RIGHT:	right eye data
RAW:	unmapped raw pupil positions
DIAMETER:	pupil diameter information
CR:	positions of corneal reflexes
POR:	mapped gaze data or point of regard (POR)
QUALITY:	quality values
PLANE:	plane number hits, only available with headtracking
HEADPOSITION:	head position, only available with headtracking
HEADROTATION:	head rotation, only available with headtracking
EYEPOSITION:	position of the eye in an 3D-environment, only available with headtracking
GAZEVECTOR:	gaze vector, only available with headtracking
TRIGGER:	trigger data
MSG:	messages
FRAMECOUNTER:	frame counter

**Example:**

```
## Format: LEFT, RAW, DIAMETER, CR, POR, QUALITY
```

Back to [ASCII File Format](#)<sup>[274]</sup>.

## 5.2.2 Data Section

The IDF data section consists of an equal number of tab-delimited columns, that can be easily imported into a spread sheet program. Number and type of the columns depend on the [export settings](#)<sup>[262]</sup>. Each column has a column title, which mean the following:

<i>Time</i>	time counter in microseconds
<i>Type</i>	indicates if the row describes a sample (SMP) or a message (MSG)
<i>Trial</i>	trial number
<i>L Raw X</i>	raw data position, left eye, x direction, in pixels
<i>L Raw Y</i>	raw data position, left eye, y direction, in pixels
<i>R Raw X</i>	raw data position, right eye, x direction, in pixels
<i>R Raw Y</i>	raw data position, right eye, y direction, in pixels
<i>L Dia X</i>	pupil diameter, left eye, x direction, in pixels <sup>1</sup> <sup>[279]</sup>

<i>L Dia Y</i>	pupil diameter, left eye, y direction, in pixels <sup>1</sup> <sub>[279]</sub>
<i>L Dia</i>	pupil diameter <sup>3</sup> <sub>[279]</sub> , left eye, based on pupil area, in pixels <sup>1</sup> <sub>[279]</sub>
<i>L Area</i>	pupil area <sup>3</sup> <sub>[279]</sub> , left eye, in square pixels <sup>2</sup> <sub>[279]</sub>
<i>L Mapped Diameter</i>	pupil diameter, left eye, in millimeters (only available for <a href="#">RED</a> <sup>[10f]</sup> systems)
<i>R Dia X</i>	pupil diameter, right eye, x direction, in pixels <sup>1</sup> <sub>[279]</sub>
<i>R Dia Y</i>	pupil diameter, right eye, y direction, in pixels <sup>1</sup> <sub>[279]</sub>
<i>R Dia</i>	pupil diameter <sup>3</sup> <sub>[279]</sub> , right eye, based on pupil area, in pixels <sup>1</sup> <sub>[279]</sub>
<i>R Area</i>	pupil area <sup>3</sup> <sub>[279]</sub> , right eye, in square pixels <sup>2</sup> <sub>[279]</sub>
<i>R Mapped Diameter</i>	pupil diameter, right eye, in millimeters (only available for <a href="#">RED</a> <sup>[10f]</sup> systems)
<i>L CR&lt;n&gt; X</i>	cornea reflex position of left eye, with <n> being the number of the CR, x direction, in pixels
<i>L CR&lt;n&gt; Y</i>	cornea reflex position of left eye, with <n> being the number of the CR, y direction, in pixels
<i>R CR&lt;n&gt; X</i>	cornea reflex position of right eye, with <n> being the number of the CR, x direction, in pixels
<i>R CR&lt;n&gt; Y</i>	cornea reflex position of right eye, with <n> being the number of the CR, y direction, in pixels
<i>L POR X</i>	point of regard (gaze data), left eye, x direction, in pixels <sup>4</sup> <sub>[279]</sub>
<i>L POR Y</i>	point of regard (gaze data), left eye, y direction, in pixels <sup>4</sup> <sub>[279]</sub>
<i>R POR X</i>	point of regard (gaze data), right eye, x direction, in pixels <sup>4</sup> <sub>[279]</sub>
<i>R POR Y</i>	point of regard (gaze data), right eye, y direction, in pixels <sup>4</sup> <sub>[279]</sub>
<i>Timing</i>	indicates timing violation. If delayed, value is 1, else 0.
<i>Latency</i>	latency in microseconds
<i>L Validity</i>	general quality value left eye <sup>5</sup> <sub>[279]</sub>
<i>R Validity</i>	general quality value right eye <sup>5</sup> <sub>[279]</sub>
<i>Pupil Confidence</i>	indicates validity of pupil diameter values
<i>L Plane</i>	plane number hit for left eye

<i>R Plane</i>	plane number hit for right eye
<i>H POS X</i>	head position, x direction, in millimeters
<i>H POS Y</i>	head position, y direction, in millimeters
<i>H POS Z</i>	head position, z direction, in millimeters
<i>H ROT X</i>	head rotation, x direction, in millimeters
<i>H ROT Y</i>	head rotation, y direction, in millimeters
<i>H ROT Z</i>	head rotation, z direction, in millimeters
<i>EPOS X</i>	eye position in a 3D-environment, x direction, in millimeters
<i>EPOS Y</i>	eye position, y direction, in millimeters
<i>EPOS Z</i>	eye position, z direction, in millimeters
<i>GVEC X</i>	normalized gaze vector, x direction
<i>GVEC Y</i>	normalized gaze vector, y direction
<i>GVEC Z</i>	normalized gaze vector, z direction
<i>Trigger</i>	trigger status
<i>Frame</i>	frame counter
<i>Aux1</i>	auxiliary data

Units, if available, are added to the column title.

- 1 Pupil diameters can also be given in millimeters. See also [Pupil Diameter](#)<sup>[31†]</sup>.
- 2 Pupil area can also be given in square millimeters. See also [Pupil Diameter](#)<sup>[31†]</sup>.
- 3 Pupil diameters can be given as circle diameter and area size. In this case these columns replace the columns for pupil diameters in x and y directions. See also [Pupil Diameter](#)<sup>[31†]</sup> to choose the option.
- 4 In a [HED-MHT](#)<sup>[68†]</sup> system the point of regard (gaze data) is given in millimeters.
- 5 Not supported by all devices.

Back to [ASCII File Format](#)<sup>[274†]</sup>.

## 5.2.3 Message Output Format

A message in the IDF file will be exported as follows:

```
<Timestamp> MSG <TrialNumber> <any text>
```

in which <any text> stands for any user defined message.

Example:

```
28437864110 MSG 1 any text
```

The following ways can be used to generate a message:

- use the remote command [ET REM](#)<sup>[460]</sup>
- invoke a message through [TTL Input](#)<sup>[304]</sup>.

See also [Messaging with BeGaze](#)<sup>[392]</sup>™.

Back to [ASCII File Format](#)<sup>[274]</sup>.

# **Application User Interface**

**Chapter**

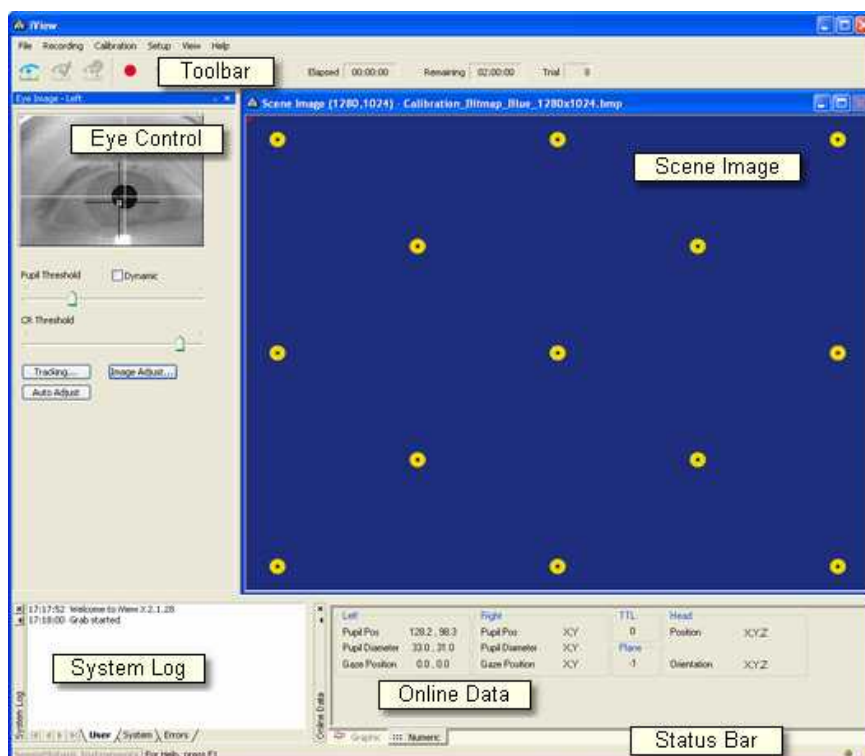


**VI**

## 6 Application User Interface



This section gives a detailed description of the iView X windows and controls.

### 6.1 The Workspace



On start up of iView X a workspace will be opened, which consists of various windows.

Show or hide the windows in the [View Menu](#)<sup>[337]</sup>. Each window of the workspace is dockable, meaning that you can drag and drop the windows to other positions inside the workspace. It will dock automatically to neighbouring windows.

Click on  to expand and on  to hide the window.

Save the view configuration under [View Configuration](#)<sup>[363]</sup> in the [View Menu](#)<sup>[337]</sup>.

## 6.2 Menu Commands

The menu commands on top of the iView X workspace consists of the following entries:

- [File](#)<sup>[283]</sup>: functions to load and save files
- [Recording](#)<sup>[286]</sup>: recording commands (start, stop...)
- [Calibration](#)<sup>[287]</sup>: calibration commands (start of calibration sequence...)
- [Setup](#)<sup>[290]</sup>: system setup functions
- [View](#)<sup>[337]</sup>: shows/hides various view inside of the iView X workspace
- [Help](#)<sup>[364]</sup>: help and licence information

### 6.2.1 File



The file menu consists of the following entries:

- [Open Scene Image...](#)<sup>[284]</sup>
- [Open AOI...](#)<sup>[284]</sup>
- [Open Calibration...](#)<sup>[284]</sup>
- [Save AOI...](#)<sup>[285]</sup>
- [Save Calibration...](#)<sup>[285]</sup>
- [Save Data...](#)<sup>[285]</sup>
- [Clear Recording Buffer](#)<sup>[286]</sup>

[Exit](#) <sup>[286]</sup>

### 6.2.1.1 Open Scene Image...



Opens a scene image (bitmap) into the viewer.

Related Topics:


[How to draw an AOI on a stimulus image](#) <sup>[371]</sup>

Back to [File Menu](#) <sup>[283]</sup>.

### 6.2.1.2 Open AOI...



Opens an Areas of Interest ([AOI](#) <sup>[371]</sup>) definition file.

Alternatively, you can click on the  icon of the [AOI Configuration](#) <sup>[357]</sup> docking window.

Related Topics:

[What are AOIs?](#) <sup>[371]</sup>

[How to draw an AOI on a stimulus image](#) <sup>[371]</sup>

Back to [File Menu](#) <sup>[283]</sup>.

### 6.2.1.3 Open Calibration...



Loads calibration coefficients from a file, which is previously saved under




[Save As Calibration File](#) <sup>[285]</sup>.

Back to [File Menu](#) <sup>[283]</sup>.

#### 6.2.1.4 Save AOI...



Saves Areas of Interest ([AOI](#) <sup>[371]</sup>) to file.

Alternatively, you can click on the save button  of the [AOI Configuration](#) <sup>[357]</sup> docking window.

Back to [File Menu](#) <sup>[283]</sup>.

#### 6.2.1.5 Save Calibration...



Saves the current calibration coefficients to a file. You have to perform a valid [calibration](#) <sup>[242]</sup> before you can save the coefficients.

This is useful if you measure the same test person several times under the same conditions.

Back to [File Menu](#) <sup>[283]</sup>.

#### 6.2.1.6 Save Data...



Saves recorded data to a file.

Back to [File Menu](#) <sup>[283]</sup>.

### 6.2.1.7 Clear Recording Buffer



Clears data buffer and initializes a new recording session.

Back to [File Menu](#) <sup>283</sup>.

### 6.2.1.8 Exit



Exits iView X.

Back to [File Menu](#) <sup>283</sup>.

## 6.2.2 Recording




The recording menu consists of the following entries:

[Start](#) <sup>286</sup>  
[Stop](#) <sup>287</sup>  
[Increment Trial No.](#) <sup>287</sup>

### 6.2.2.1 Start




Starts data recording. On start the [trial number](#) <sup>287</sup> will be automatically

incremented. Same as clicking on the *start recording* button  of the [Toolbar](#) <sup>[338]</sup>.

Back to [Recording Menu](#) <sup>[286]</sup>.

### 6.2.2.2 Stop



Stops data recording. Same as clicking on the *stop recording* button  of the [Toolbar](#) <sup>[338]</sup>.

Back to [Recording Menu](#) <sup>[286]</sup>.

### 6.2.2.3 Increment Trial No.

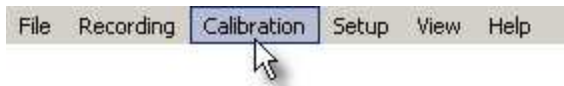


An experiment can be divided into single trials. Every start of a recording increments the trial number. The trial number can also be manually incremented by using this command.

Same as clicking on the *increment trial* button  of the [Toolbar](#) <sup>[338]</sup>.

Back to [Recording Menu](#) <sup>[286]</sup>.

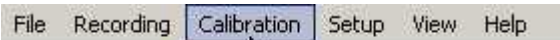
## 6.2.3 Calibration



The calibration menu consists of the following entries:

[Start](#) <sup>[288]</sup>  
[Stop](#) <sup>[288]</sup>  
[Auto Accept](#) <sup>[288]</sup>  
[Drift Correction](#) <sup>[289]</sup>  
[Validation](#) <sup>[289]</sup>  
[Edit Points](#) <sup>[289]</sup>

### 6.2.3.1 Start

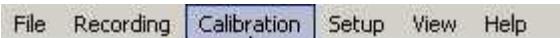


Starts calibration. Either accept points manually or let the system automatically accept points by checking [Auto Accept](#) <sup>[288]</sup> in the [Calibration Menu](#) <sup>[287]</sup>.

See also [Setup Calibration](#) <sup>[313]</sup>.

Back to [Calibration Menu](#) <sup>[287]</sup>.

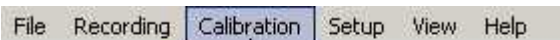
### 6.2.3.2 Stop



Aborts calibration process.

Back to [Calibration Menu](#) <sup>[287]</sup>.

### 6.2.3.3 Auto Accept



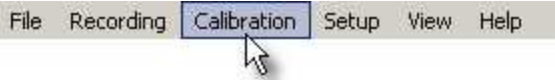
If checked, calibration proceeds automatically after the eyetracker has recognized a fixation. Same as checking **Accept Points Automatically** in

the [Setup Calibration](#)<sup>[313]</sup> dialog box.

Note that the first target - usually in the centre of the calibration area - must be manually accepted.

Back to [Calibration Menu](#)<sup>[287]</sup>.

#### 6.2.3.4 Drift Correction



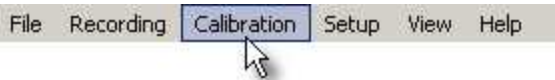
Starts drift correction.

Related topics:

[Drift Correction](#)<sup>[250]</sup>

Back to [Calibration Menu](#)<sup>[287]</sup>.

#### 6.2.3.5 Validation



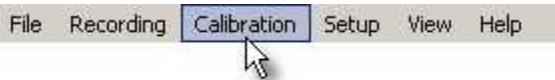
Starts validation.

Related topics:

[Validation](#)<sup>[251]</sup>

Back to [Calibration Menu](#)<sup>[287]</sup>.

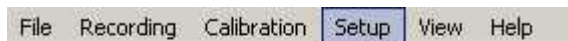
#### 6.2.3.6 Edit Points



Displays the calibration point in the scene view, so it can be [moved](#)<sup>[252]</sup> to other locations.

Back to [Calibration Menu](#) <sup>[287]</sup>.

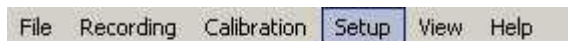
## 6.2.4 Setup



The setup menu consists of the following entries:

- [Hardware...](#) <sup>[290]</sup>
- [Tracking...](#) <sup>[309]</sup>
- [Stimulus...](#) <sup>[313]</sup>
- [Calibration...](#) <sup>[313]</sup>
- [Output...](#) <sup>[324]</sup>
- [Recording Notes...](#) <sup>[334]</sup>
- [Message Log...](#) <sup>[363]</sup>
- [Save Setup...](#) <sup>[337]</sup>

### 6.2.4.1 Hardware



In the tab **Tracking Device** you select the eye tracking components of your iView X system. In the [Communication](#) <sup>[292]</sup> tab you select the I/O devices.

The following gives an overview of all components available. If you click on the **Advanced** button you will get more configuration options.

#### Eye Tracking Device

- |   |   |
|---|---|
| <a href="#">Hi-Speed</a> <sup>[129]</sup>         | <a href="#">Advanced</a> <sup>[296]</sup> |
| <a href="#">Hi-Speed Primate</a> <sup>[161]</sup> |   |
| <a href="#">HED 4</a> <sup>[51]</sup>             | <a href="#">Advanced</a> <sup>[299]</sup> |
| <a href="#">RED 4 (FireWire)</a> <sup>[101]</sup> | <a href="#">Advanced</a> <sup>[296]</sup> |
| <a href="#">RED 250 (USB)</a> <sup>[101]</sup>    | <a href="#">Advanced</a> <sup>[297]</sup> |
| <a href="#">RED (USB)</a> <sup>[101]</sup>        | <a href="#">Advanced</a> <sup>[297]</sup> |

[MRI-LR](#) <sup>[182]</sup>

[MRI-SV](#) <sup>[182]</sup>

MRI-NNL

Custom

## Video Grabber

[Falcon](#) <sup>[417]</sup>

[Advanced](#) <sup>[295]</sup>

[Grablink](#) <sup>[418]</sup>

USB Eye Cam

Mouse

[Advanced](#) <sup>[297]</sup>

## Head Tracker

[Polhemus](#) <sup>[69]</sup>

[Advanced](#) <sup>[298]</sup>

## Stimulus Capture

Bitmap

USB Scene Cam

## Scene Video Compression

[Vidac](#) <sup>[419]</sup>

[Advanced](#) <sup>[301]</sup>

### 6.2.4.1.1 Communication

Remote Interface 1: Ethernet  Accept Remote Commands  Stream Data

Remote Interface 2: RS232  Accept Remote Commands  Stream Data

TTL IO/Analog Out: Pio DIO  Accept Trigger  Activate Output  Send Trigger

#### Remote Interface 1 and 2

Select input device to remotely control iView X.

RS232 [Configure](#)<sup>[301]</sup>  
 Ethernet [Configure](#)<sup>[302]</sup>



Two ethernet connections can be selected if the used [ports](#)<sup>[303]</sup> are different, e.g. '4444' for Remote 1 and '5555' for Remote 2. This is useful if iView X communicates with both an external calibration tool and a different stimulus presentation software at the same time.

**Accept Remote Commands:** if checked, iView X accepts commands. With this feature enabled iView X can be remotely controlled.

**Stream Data:** if checked, iView X sends eye data to external devices.



## TTL IO/Analog Out

Choose the I/O interface to send and accept trigger signals.

Lpt IO	I/O via LPT port
Pio DIO	I/O using Digital IO card
Pio DA	I/O using Analog Out board

**Accept Trigger:** if checked, iView X accepts TTL trigger signals and interprets them. Assign a command to a trigger signal in the [Config](#)<sup>[304]</sup> dialog.

**Send Trigger:** if checked, a TTL signal is sent to a parallel output card every time, when gaze data enters an [area of interest](#)<sup>[371]</sup> (AOI). The signal is HIGH if gaze position is inside of the AOI, and LOW if it is outside. See also: [TTL Output](#)<sup>[305]</sup>.

**Activate Output:** if checked, iView X sends data over the analog output channels. How to use this feature is described in [Analog Out Option](#)<sup>[437]</sup>.

The communication status is indicated as text symbols in the [Status Bar](#)<sup>[339]</sup>

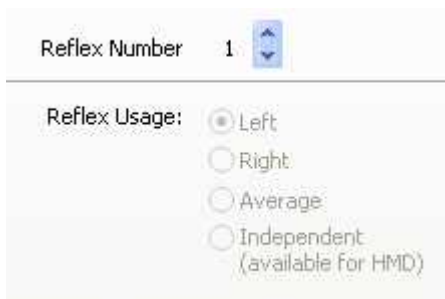
Related topic:

[I/O Interfaces](#)<sup>[429]</sup>.

Back to [Setup Hardware](#)<sup>[290]</sup>.

### 6.2.4.1.2 Corneal Reflex





Reflex Number 1

Reflex Usage:

- Left
- Right
- Average
- Independent  
(available for HMD)

Specify here, how many corneal reflexes should be tracked. In normal cases it is only 1. If two are specified, you can also tell the system, which reflexes should be used, only the left, the right or the average between left and right.

If *Reflex Number* is 0, the system performs a [pupil only calibration](#) <sup>[253]</sup>.

*Independent* usage is only available for HMD users.

Back to [Setup Menu](#) <sup>[290]</sup>.

### 6.2.4.1.3 Data Mirroring



Vertical Data Mirroring

Horizontal Data Mirroring

Video Mirroring

Select here if the measured data should be flipped:

**Vertical:** left-right data is reversed, data is flipped on the vertical axis.

**Horizontal:** up-down data is reversed, data is flipped on the horizontal axis.

#### 6.2.4.1.4 Eye Image

Eye Tracking  Left Eye  
 Right Eye

---

Video Input  Composite 1  
 Composite 2  
 S - Video

---

Video Format  PAL  
 NTSC

---

Video Output Display Rate 1/ 4

Set configuration of the eyetracker frame grabber [Falcon Board](#)<sup>417)</sup> here.

#### Eye Tracking

Select if you want to track left or right eye. This will be noted in the data file.

#### Video Input

Select which connection to the eye camera is used.

#### Video Format

Select video mode (PAL or NTSC) of the camera.

#### Video Output

Set with which display rate the eye video should be displayed in the [Eye Control](#)<sup>342)</sup> window. Selecting 1/1 will display every frame, selecting 1/10 only every 10th frame. Default is 1/4. If your system has workload problems you might try to decrease this value.

### 6.2.4.1.5 Hi-Speed Configuration

Tracking Mode: 500Hz Lens monocular

Eye Tracking:  Left Eye    Set lever on tracking column to MONOC.  
 Right Eye  
 Binocular

Camera: 0

#### Tracking Mode

Depending on the Hi-Speed model and the licence option you may select between:

- 500 Hz monocular
- 500 Hz [binocular](#) <sup>[389]</sup>
- 1250 Hz monocular

#### Eye Tracking

Select if you want to track left, right eye or both eyes (binocular). Your selection will be noted in the data file.

### 6.2.4.1.6 RED 4 (FireWire) Configuration

Tracking Mode:  50 Hz  
 60 Hz

#### Tracking Mode

Select sample rate of tracking. Currently 50 Hz or 60 Hz are available.

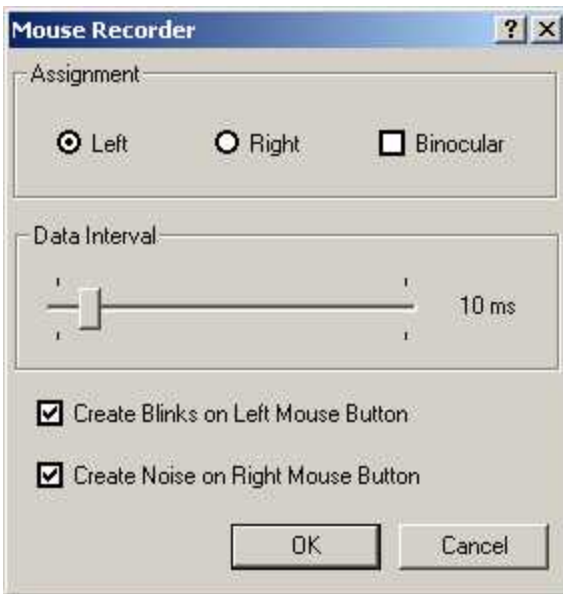
### 6.2.4.1.7 RED (USB) / RED 250 (USB) Configuration

Tracking Mode	<input checked="" type="radio"/> 60 Hz
	<input type="radio"/> 120 Hz
	<input type="radio"/> 250 Hz

#### Tracking Mode

Select sample rate of tracking. For RED (USB) only 60 / 120 Hz are available. For RED 250 (USB) all three modes 60 / 120 / 250 Hz are available.

### 6.2.4.1.8 Mouse Configuration



Set configuration of mouse output if you run iView in [Mouse Mode](#)<sup>394</sup>.

## Assignment

Select if left eye data, right eye data or both eye data should be produced.

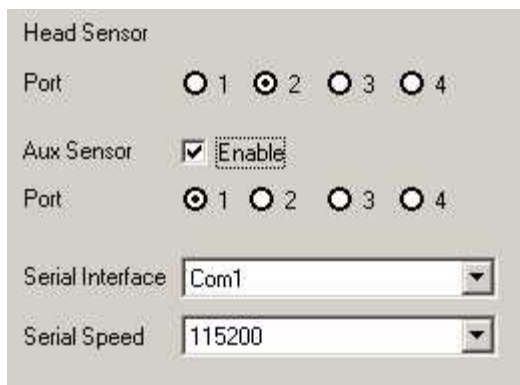
## Data Interval

Select the interval at which a new data sample is produced dependent on the recent position of the mouse. An interval of 10 ms means, that each 10 ms a data sample is produced, which corresponds to a sampling rate of 100 Hz.

## Blinks and Noise

Select here if you want to create blinks with left mouse button and/or noise with right mouse button.

### 6.2.4.1.9 Polhemus Configuration



Head Sensor

Port  1  2  3  4

Aux Sensor  Enable

Port  1  2  3  4

Serial Interface

Serial Speed

Set configuration of the Polhemus 3space FASTRAK head tracking system here.

### Head Sensor Port

Specify at which port the head sensor is connected to the FASTRAK System Electronics Unit.  
The default value is Port 2.

## Aux Sensor Port

Optionally, an additional sensor can be connected. The six coordinates of the auxiliary sensor is saved as a string in the AUX column of the [IDF file](#) <sup>260</sup>.

## Serial Interface and Serial Speed

Select the COM port of the iView X system at which the Polhemus system is connected, and its connection speed.

## Related topics

[iView X HED-MHT](#) <sup>68</sup>

### 6.2.4.1.10 HED Settings

Tracking Mode	<input checked="" type="radio"/> 50 Hz
	<input type="radio"/> 200 Hz
Recorded Scene Video Size	<input checked="" type="radio"/> Full
	<input type="radio"/> Half
Audio recording	<input checked="" type="checkbox"/> Enable
Eye	<input checked="" type="radio"/> Left Eye
	<input type="radio"/> Right Eye
Gaze following gain control	<input type="checkbox"/> Enable
Use Hardware Gamma	<input type="checkbox"/> Enable

## Tracking Mode

Shows sample rate of eye tracking.

## Recorded Scene Video Size

The scene video can be displayed in full size (752x480 pixel) or half size (376x240 pixel). For 200 Hz systems only half size is available.

## Audio recording

Enable [audio recording](#)<sup>[372]</sup> by checking the box.

## Eye

Select if you want to track left or right eye. Your selection will be noted in the data file.

## Gaze-following gain control

For gain control an area of 40x40 pixel around the current gaze point is used.

Enable this option if you measure under extreme light changing conditions, like car driving in bright sunlight, where inside and outside need to be observed. You can also switch ON/OFF this feature in realtime by using the context menu of the Scene Video.

The drawback of this feature is that the overall video seems to flicker.

The default setting is OFF.

## Use Hardware Gamma

Hardware Gamma can be used to increase the picture quality under extreme light conditions (very dark or very bright light conditions). You can also switch ON/OFF this feature in realtime by using the shortcut Ctrl+H or using the context menu of the Scene Video.

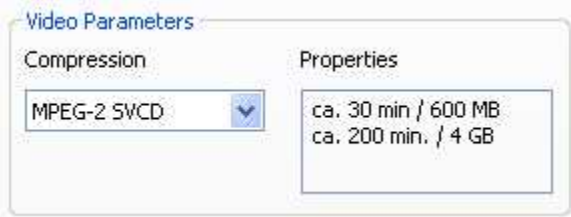
The drawback of this feature is that the sensor is used at its limits and



you might see the sensor noise (“blue stripes”) in the video.

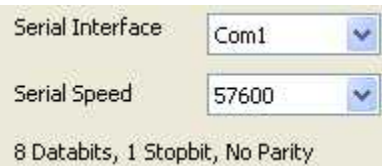
The default setting is OFF.

#### 6.2.4.1.11 Scene Video Compression



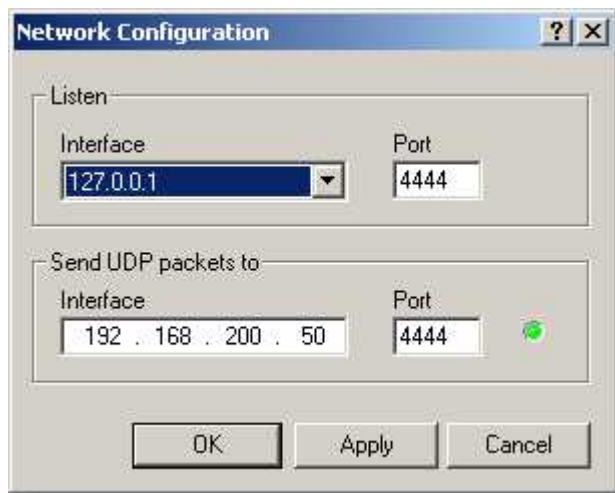
Set the video compression type here.

#### 6.2.4.1.12 RS232 Configuration




Select the serial interface and speed.

### 6.2.4.1.13 Network Configuration



Network connection is established using UDP rather than TCP internet protocol (IP).




#### Listen

Select IP address of the iView X computer and its [port](#)<sup>[303]</sup>. Click on the drop down button  to see a list of choices. If your computer has been already assigned an own address, it will be listed here together with a default address (127.0.0.1). If in doubt ask your network administrator.

#### Send UDP packets to

Select IP address of remote computer and its [port](#)<sup>[303]</sup>. The status light indicates the accessibility of the remote computer:



-  System is accessible.
-  System is not accessible.
-  Undefined status.

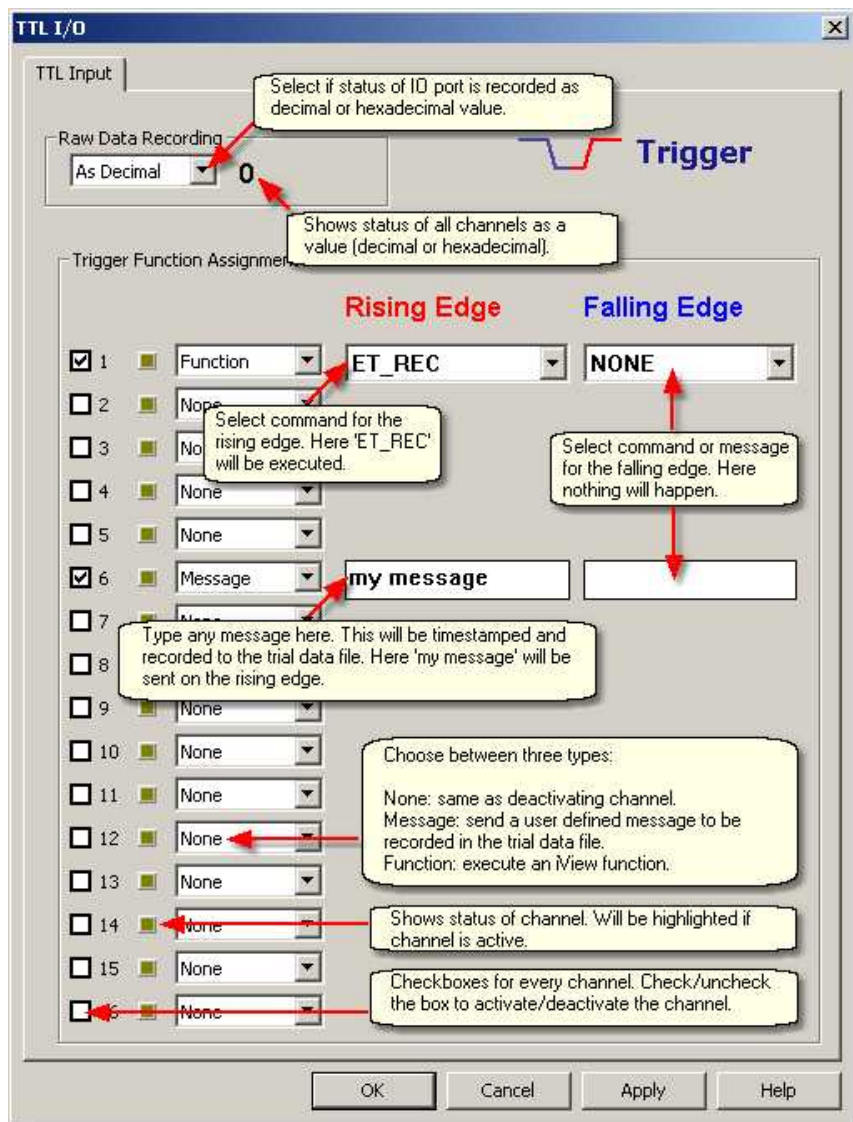
## Port

Port should be an unused port between 1024 and 65535.  
Ports between 0 and 1023 are reserved.

See also:

[Network Connection to Stimulus PC](#)<sup>394</sup>

## 6.2.4.1.14 TTL Input



It is possible to send TTL [trigger signals](#)<sup>[430]</sup> to iView X to remotely control the system. In this dialog you can assign a command to the trigger signal.

The command will be executed, if **Accept Trigger** is checked in the [Communication](#)<sup>[292]</sup> dialog.

Each channel can be activated/deactivated separately by using the check boxes.

A status light reports, if the channel is active.

For each channel choose between three types:

**None:** If *None* is selected the effect is the same as deactivating channel.

**Message:** If *Message* is selected you can type any user defined message to be recorded in the data file.

**Function:** If *Function* is selected you can select from a drop down list [iView functions](#)<sup>[438]</sup> to be executed.

In the example above the following is set:

On the rising edge of channel 1 the function 'ET\_REC' is executed.

On the rising edge of channel 6 the message 'my message' is timestamped and recorded to the data file.

On the falling edges nothing happens. The other channels are deactivated.

If the message is exported from the data file to a text file it has a specific [Message Output Format](#)<sup>[279]</sup>.

For an overview of all commands see [Remote Command Reference](#)<sup>[438]</sup>, Note, that not all commands may be available for TTL triggering.

#### 6.2.4.1.15 TTL Output

If the gaze data is inside of an area of interest ([AOI](#)<sup>[371]</sup>), a corresponding output channel is given a high TTL signal:

**AOI number**

1

**Output Channel**

1

...  
16...  
16

By this means up to 16 AOIs can be signalled.

The channels are available if an IO card is installed and if **Send Trigger** is checked in the [Communication](#)<sup>[292]</sup> dialog.

To choose the IO card go to [Setup-Hardware](#)<sup>[290]</sup> and select a card under **TTL & Analog IO**.

For more information see also the topic [I/O Interfaces](#)<sup>[429]</sup>.

### 6.2.4.1.16 Analog Out

Ch.	Data Source	Direct Gain & Offset	Data Range	
			min	max
1	Gaze X ( left )	<input type="checkbox"/>	0	1200
2	Gaze Y ( left )	<input type="checkbox"/>	0	1000
3	Gaze X ( right )	<input type="checkbox"/>	0	1200
4	Gaze Y ( right )	<input type="checkbox"/>	0	1000

Out Of Range Behaviour

Set To Zero  
 Keep Last Value  
 Extrapolate  
 Clip

Voltage Range: -5V +5V

Invert Horizontal Channel     Invert Vertical Channel

Run Test Output ( -5 Volt to 5 Volt )

In this dialog box you can configure four channels for the analog out signal. Each channel can be assigned to a *Data Source*. The specified *Data Ranges* will be transformed to the *Voltage Range* of the analog out signal. If a data source is selected that contains no data, the output will be the minimum value of the voltage range.

#### Data Source and Data Range

The following data sources can be selected for left and right eye independently:

Data Source	Data Range
Gaze X	X value of gaze data or point of regard. Typical

	values would be the size of the calibration area, e.g. if the calibration area is a monitor screen with 1024x768 pixels resolution, a good value for the range would be X=0..1024.
Gaze Y	Y value of gaze data or point of regard. Typical values would be the size of the calibration area, e.g. if the calibration area is a monitor screen with 1024x768 pixels resolution, a good value for the range would be Y=0..768.
Pupil X	X value of raw pupil data in video coordinates. A typical value would be X=0..384 for PAL cameras and X=0..320 for NTSC cameras.
Pupil Y	Y value of raw pupil data in video coordinates. A typical value would be Y=0..288 for PAL cameras and Y=0..240 for NTSC cameras.
Pupil X - CR X	X value of Pupil minus CR. Distance between Pupil and CR. Typical values would be -video resolution...+video resolution.
Pupil Y - CR Y	Y value of Pupil minus CR. Distance between Pupil and CR. Typical values would be -video resolution...+video resolution.
Diameter (horizontal)	Horizontal Diameter of the pupil. Typical values would be X=0..384 for PAL cameras and X=0..320 for NTSC cameras.

### Direct Gain & Offset

If [Direct Analog](#)<sup>[244]</sup> calibration is selected in the [Calibration](#)<sup>[313]</sup> setup menu, these check-boxes are checked and *Data Range* cannot be adjusted.

### Voltage Range

The maximum voltage range of the [Analog Out Board](#)<sup>[425]</sup> is -10..10 V. Choose a voltage range that fits to the type of device you want to connect to the analog out signal.



### Data Inversion

Data Inversion means that the maximum data value will be mapped on the minimum voltage value and the minimum data value on the maximum voltage value.

### Invert Horizontal Channel

If checked, all X values and the diameter will be inverted.

### Invert Vertical Channel

If checked, all Y values will be inverted.

### Out of range behaviour

Choose between various types of analog output behaviour if the data goes out of specified voltage range.

**Set to zero:** The signal will be set to 0V.

**Keep last value:** The value of the last data sample within the range will be hold.

**Extrapolate:** The signal will exceed the specified voltage range.

**Use this with caution only! Exceeding voltage limits could damage connected hardware!**

**Clip:** The signal will be clipped. The output signal will be hold at maximum or minimum voltage value.

### Run Test Output

If you click on *Start*, each channel will output a sawtooth voltage signal ranging from -5V to +5V.

### Related topics:

[Analog Out Option](#) <sup>[437]</sup>

## 6.2.4.2 Tracking...

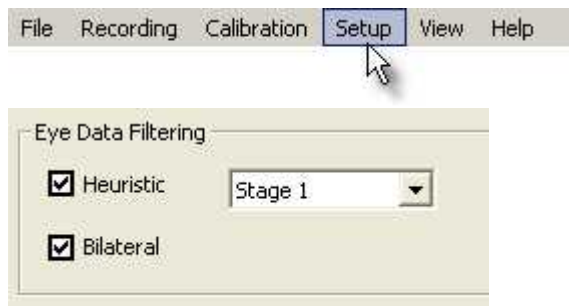
Dependent on the current configuration the following tabs will appear:

[Input Filter Eye](#) <sup>[310]</sup>

[Pupil Diameter](#) <sup>[311]</sup>

[Input Filter Head](#) <sup>[312]</sup>

### 6.2.4.2.1 Input Filter Eye



The *Input Filter Eye* filters all incoming eye data. Two different filters can be cascaded:

**Heuristic Filter:** Removes noise by cleaning the data from peaks. *Stage 1* removes impulse noise of 1 sample. A latency of 1 sample is added to the data. *Stage 2* removes ramp noise of 2 samples. A latency of 2 samples is added to the data.

**Bilateral Filter:** A two-dimensional filter, which filters on time and on value. The filter preserves the edges of large changes in the signal while averaging small changes caused by noise. This filter should be used with RED or Hi-Speed systems. No latency is added to the data.

If the filters are cascaded, heuristic filtering comes first, followed by bilateral filter.

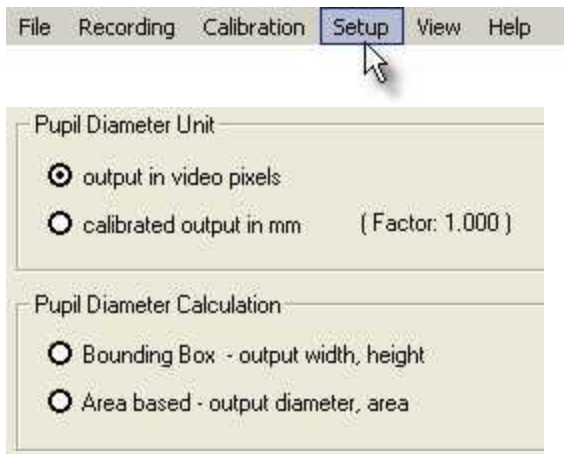
**System presets:** Depending on the system setup, iView X suggests its filter.

## Binocular Data



If the system is binocular you can average left and right eye data. If checked, only one gaze cursor will be displayed and the values for left and right eye data will be identical.

### 6.2.4.2.2 Pupil Diameter



Here you select the pupil diameter unit and the way the diameter is calculated.

#### Pupil Diameter Unit

Choose if the unit is video pixels [px] or millimeters [mm]. If [mm] is chosen, the conversion factor will be given in brackets. To adapt the conversion factor, a [pupil calibration](#)<sup>[32]</sup> must be performed.

#### Pupil Diameter Calculation

Choose between two calculation methods:

**Bounding Box:** a squared bounding box will be layed around the pupil.  
The pupil diameter will be given as x and y values of the bounding box.

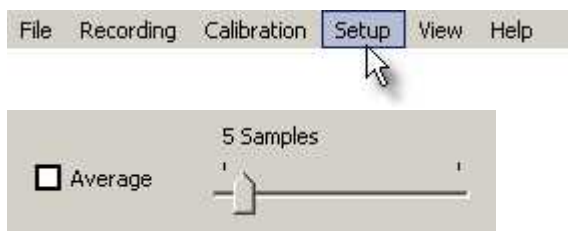
**Area based:** The area will be measured. The area will be assumed a circle, from which the diameter is calculated. The pupil diameter will be given as diameter of circle and area size.

### Output of diameter values

The diameter will be given as a two dimensional value. The output and the units change depending on the chosen settings:

	output in pixels	output in mm
<b>Bounding Box</b>	x [px] y [px]	x [mm] y [mm]
<b>Area based</b>	diameter [px] area [px <sup>2</sup> ]	diameter [mm] area [mm <sup>2</sup> ]

#### 6.2.4.2.3 Input Filter Head



To reduce noise, head tracking data can be averaged. Select here, if you want to average data and how many samples should be averaged. If averaging is enabled the default value is 5.

### 6.2.4.3 Stimulus...



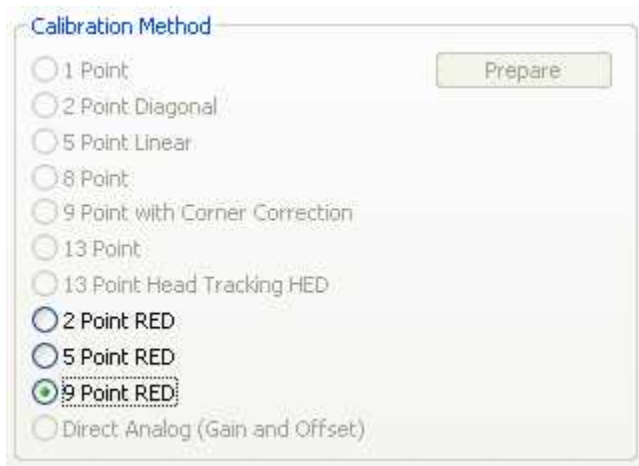
The default path for stimulus images can be set here.

### 6.2.4.4 Calibration



Here you select Calibration Method, [Geometry](#)<sup>[317]</sup>, [Pupil Diameter Calibration](#)<sup>[321]</sup> and [Scene HT Calibration](#)<sup>[322]</sup>.

In case a RED is connected, you can also select the [RED Operation Mode](#)<sup>[319]</sup>.



*Calibration Method tab if a RED is connected*

### Calibration Method

Choose between

[1 Point](#)<sup>[243]</sup>

[2 Point Diagonal](#)<sup>[243]</sup>

[5 Point Linear](#) <sup>[244]</sup>

8 Point, for HMD users only

[9 Point with Corner Correction](#) <sup>[244]</sup>

[13 Point](#) <sup>[244]</sup>

[13 Point Head Tracking HED](#) <sup>[244]</sup>

2 Point RED

5 Point RED

9 Point RED

[Direct Analog \(Gain & Offset\)](#) <sup>[244]</sup>

## 1 Point Calibration

[1-point calibration](#) <sup>[243]</sup> needs a preparation procedure that has to be performed once for a given geometric setup. The preparation is a 5-point calibration. Click on *Prepare* to perform the 5-point calibration. After the preparation succeeding test persons only need to calibrate with 1 point.

The screenshot shows a dialog box titled "Calibration Point Recording". It contains several options and settings:


- Accept Points Automatically
- Audio Feedback on next Point
- Randomize Point Order
- Wait for Valid Data
- Average Data: 400 ms (with up/down arrows)
- Check Level: Medium (with a dropdown arrow)
- Reset Calibration Points (button)

### Accept Points Automatically

If checked, calibration proceeds automatically after the eyetracker has recognized a fixation. This is not true for the first point, which must always be manually accepted by the operator. For most test persons, the automatic calibration is a fast and accurate method.

In some cases it may be easiest to manually accept each point, particularly if the test person is incapable of holding a fixation for long. If

unchecked, the operator must manually accept all points with F6 or the

accept point button .

Same as [Auto Accept](#) <sup>[288]</sup>.

### **Average data for \_\_\_ms**

Minimum time for a fixation. The eye must gaze at the calibration target at least for this time to be recognized as a fixation.

A longer period will minimize the chance that the test person glanced in the wrong place briefly. It will also average more points for a more representative sample of the fixation location. However, if set too high, test persons may have difficulty fixating for the time required.

If *Accept Points Automatically* is not checked and the operator manually accepts calibration points, the fixation data is still averaged for the time specified here.

### **Audio feedback on next point**

If checked the computer gives an audio feedback, when it displays the next calibration target.

### **Randomize Point Order**

If checked the calibration targets are displayed in randomized order. This will hopefully prevent the test person from anticipating the next calibration point and looking for it before a fixation has been recorded for the present point. If an individual test person has trouble waiting for each point even with "Randomize Point Order" checked, try manually triggering calibration points (turn "Accept Points Automatically" off).

If not checked, the system will show calibration points in the same order every time.

### **Wait for Valid Data**

If checked, calibration proceeds only if the system recognizes a fixation

on the current calibration target.

If not checked, calibration proceeds even if some fixations could not be recognized. These calibration points will be repeatedly presented until for every calibration point a valid fixation has been detected.

### Check Level

Specifies the tolerance level, with which the fixations are accepted. It does not necessarily translate directly to an increase in accuracy – a test person who calibrates well will calibrate the same at any check level. However, it does control how likely the iView will be at spotting a bad calibration. In general, it is best to use the highest check level that is practical for your application.

Check Level can be set to the following:

**Strong:** The eye should be very stable during fixation. The maximum amount of checking will be done. This will give the least potential problems during calibration but many test persons will have difficulty fixating well enough for this check level. It is often not practical for low-light applications such as fMRI.

**Medium:** A medium amount of checking will be done. This is probably the most useful check level for most experiments.

**Weak:** Less checking is done. This is often used to compensate for difficult conditions (poor IR lighting) or difficult test persons (people who can not fixate well).

**None:** No check level is performed at all. The system will accept any fixation information as a valid calibration. Use with caution.

### Reset Calibration Points

By default the distance between the outer calibration points and the border of the [calibration area](#)<sup>[240]</sup> is five per cent of the respective horizontal or vertical dimension. The inner points are equally distributed. Click on the *Reset Calibration Points* button to set the points to its default positions. This is useful if the calibration points have been previously



changed by [Moving calibration points](#)<sup>[252]</sup> and you wish to restore them.

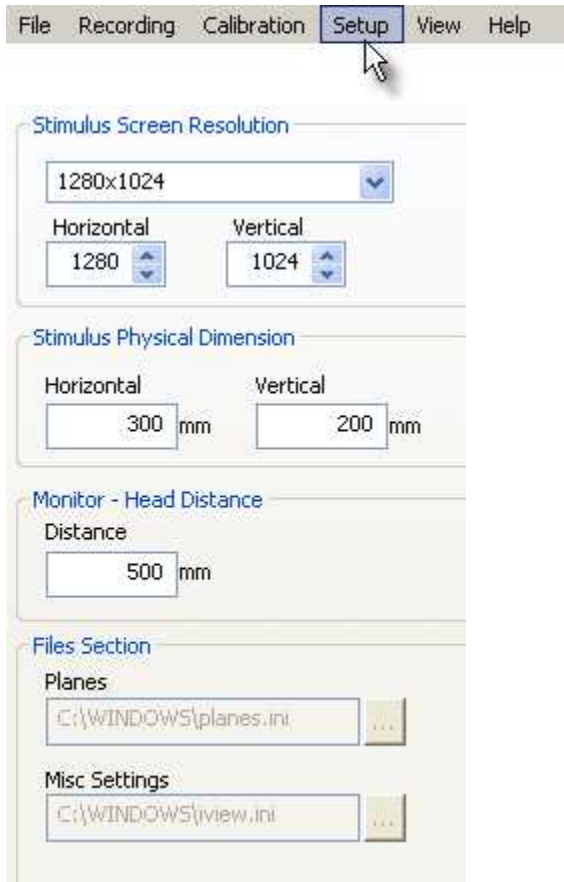
### Related topics:

[Calibration Methods](#)<sup>[242]</sup>

[Calibration Processes](#)<sup>[245]</sup>

Back to [Setup Menu](#)<sup>[290]</sup>.

#### 6.2.4.4.1 Geometry



## Stimulus Screen Resolution

Select size of the two-dimensional [calibration area](#)<sup>[240]</sup> or enter your self-defined values. This is the plane on which the eyetracker will be calibrated. iView X needs these values to map the eye position data to the point of regard, which is the point at which the eye is looking on the plane.

## Stimulus Physical Dimension and Monitor-Head Distance

Enter *Stimulus Physical Dimension*, which is the dimension of the stimulus screen and the Monitor-Head-Distance. Both values will be stored in the iView data file. Later analysis tools may use these values.

## Planes and Misc Settings

Only available if *13 Point Head Tracking HED* is selected. Specify here the paths in which *planes.ini* and *iview.ini* from the [Surveyor](#)<sup>[405]</sup> are located.

Back to [Setup Calibration](#)<sup>[313]</sup>.

#### 6.2.4.4.2 RED Operation Mode

**Operation Mode**

Monitor Integrated    19"    Edit

---

Document Stand

Document Format Preset: A4 (portrait)

Physical Document Dimension (mm): Width 210, Height 297

Use Calibration Pattern: A4 (portrait)

---

Stand Alone    Profile: [ ]

New    Edit    Delete

---

**Stimulus Screen Resolution**

Preset Resolution: 1280x1024

Pixel Dimensions: Horizontal 1280, Vertical 1024

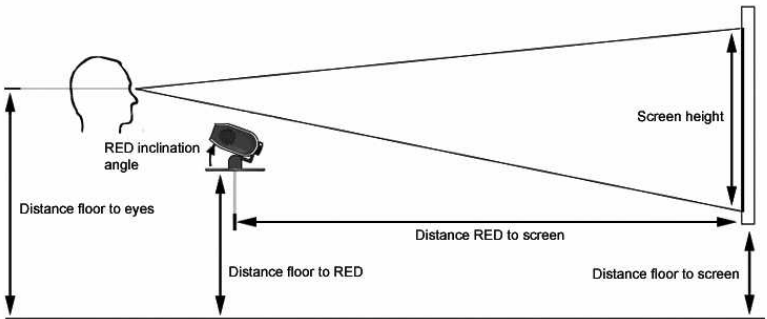
The RED system offers several operation modes. See [RED User Guide](#) <sup>[113]</sup> for details.

If you select *Monitor Integrated* and click on *Edit* you can [change the calibration point positions](#) <sup>[320]</sup>.

If you select *Stand Alone*, you will have more options in the [RED - Stand Alone Geometric Setup](#) <sup>[320]</sup>.

Back to [Setup Calibration](#) <sup>313</sup>.

### 6.2.4.4.2.1 RED - Stand Alone Geometric Setup



The diagram illustrates the geometric setup for the RED stand alone system. It shows a person's eye at a certain distance from the floor, a RED device mounted on a stand at a certain height and distance from the floor, and a screen at a certain distance from the RED device and a certain height. The diagram labels the following dimensions:

- Distance floor to eyes
- RED inclination angle
- Distance floor to RED
- Distance RED to screen
- Distance floor to screen
- Screen height

Below the diagram is a control panel with four sections:

- 1) Experiment Setup**
  - Use Placement Suggestion
  - Distance floor to eyes:
    - 80cm - 110cm
    - 110cm - 140cm
    - 140cm - 180cm
- 2) Setup Stimulus Screen**
  - Screen Width (cm):
  - Screen Height (cm):
  - Distance floor to screen (cm):
- 3) Suggest Placement**
  - Have iViewX suggest a RED placement based on the information given in 1) and 2)
  -
- 4) Position RED**
  - Distance floor to RED (cm):
  - Distance RED to screen (cm):
  - RED inclination angle (deg):

Here you have to enter the geometric dimensions of your setup for the [RED stand alone system](#) <sup>123</sup>.

If you click on the *Points* tab you can [change the calibration point positions](#) <sup>320</sup>.

### 6.2.4.4.2.2 RED Calibration Points

Here you can change the calibration point positions. To change the positions drag & drop the targets.

### Load Image

Opens a file selection box, with which you can choose an image. The image will be set to the background of the calibration targets.

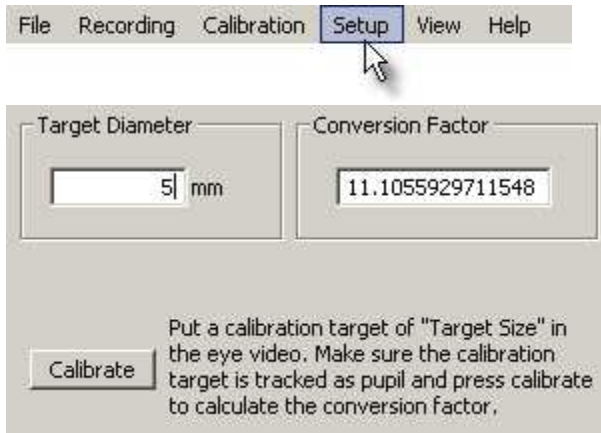
### Clear Image

Removes image from the view.

### Reset Points

Resets calibration point positions to factory settings.

#### 6.2.4.4.3 Pupil Diameter Calibration



By default, pupil diameter is given in video pixels. If you need millimeters as output, the pupil diameter must be calibrated. To activate calibration go to [Setup](#) <sup>[290]</sup> [Tracking Pupil Diameter](#) <sup>[311]</sup> and choose the option *calibrated output in mm*. Then go back to this tab and proceed as follows:

1. Prepare a black circle that can be assumed a pupil, measure the diameter with a ruler and enter the value in [mm] under *Target Diameter*.
2. Hold the black circle in front of the eye camera at the distance, where the eye should be, so that the circle is tracked as a pupil.
3. Click on *Calibrate*. The system calculates a *Conversion Factor* that will be used in subsequent recordings to convert diameter pixel units into millimeters.

*Note:* Pupil Diameter Calibration is not available for [RED](#) <sup>[101]</sup> systems. RED systems already calculate pupil diameter in mm and write the values

into the [IDF file](#) <sup>277</sup> in the column *L/R mapped diameter*.

Back to [Setup Calibration](#) <sup>313</sup>.

#### 6.2.4.4.4 Scene HT Calibration

Configure additional overlay settings for [HED-MHT \(Head Tracking\)](#) <sup>68</sup>:

Scene video calibration

Monitor Plane  
 Scene Camera

Scene Camera

Center Point  
Point 1

Offcenter Point  
Point 2  Enable Debug

Off-Plane Distance  
500 mm  Map to calibration point  
0

Monitor Plane

Scene Bitmaps  Draw Points

Calibration Plane      Monitor Plane      Calibration & Monitor Plane

- [-] Plane1
  - [-] Dimension
    - Width 286.4 mm
    - Height 195.9 mm
  - [+] Filename
  - [+] Transparent
  - [+] Points
  - [+] Plane2

Cursor overlay can be done either on *Monitor Plane* display or on *Scene Camera* display. It is not possible to activate both at the same time.

#### Monitor Plane

This function takes effect only if the scene video is used.

**Calibrate:** If you choose Monitor Plane, *Calibrate* in the Monitor Plane section can be selected. If you press the *Calibrate* button or <Ctrl>+<F5>, two targets will appear on the iView X control screen. Drag both targets until the two points are visible in the upper left and lower right corners of the monitor screen. After this the Monitor Plane display is calibrated. A cursor will be displayed at gaze position on the monitor screen if the test person looks at it.

## Scene Camera

This function takes effect only if the scene video is used.

**Calibrate:** If you choose *Scene Camera*, *Calibrate* in the Scene Camera section can be selected. If you press the *Calibrate* button or <Ctrl>+<F5>, two targets will appear on the iView X control screen. Make sure that the scene camera is directed to the [13-point](#) <sup>[244]</sup> calibration plane, so that the calibration plane will be visible on the iView X control screen. Select *Center Point* and *Offcenter Point*.

**Center Point and Offcenter Point:** Choose the two calibration targets of the calibration plane to which the scene video overlay should be mapped. Usually it would be point 1 for the *Center Point* and point 2 for the *Offcenter Point*. (Note that the thirteen points are arranged in a fixed pattern, see also [13-point Calibration](#) <sup>[244]</sup>.) On the iView X control screen you see two dots, red and green, that should be mapped to the selected *Center Point* and *Offcenter Point*. Ask the test person to move his head until the center dot (red) matches the *Center Point*. Drag the second dot (green) on the screen until it maps the *Offcenter Point*. After this the Scene Camera display is calibrated. A cursor will be displayed at gaze position on the scene video.

**Enable Debug and Map to Calibration Point:** The accuracy of the calibration can be visualized by checking the *Enable Debug* checkbox. Then an overlay target will appear on the screen which should exactly map to one of the thirteen calibration points, which is selected in the *Map to Calibration Point* field.

**Off-Plane Distance:** If no plane is hit by the gaze, an *Off-Plane Distance* can be set, which will be used to calculate the point of regard. To choose a proper value here will minimize parallaxic errors for the gaze data outside or between the planes.

## Scene Bitmaps

This function takes effect only if the scene video is not used.

**Draw Points:** Each defined plane can be attached to a bitmap. If a point of regard falls on a specific plane its attached bitmap will be displayed in the bitmap view. The accuracy of the calibration can be visualized by checking the *Draw Points* checkbox. Then all previous measured points on each bitmap will be displayed.

## Plane Parameters

In the field below all plane parameters are listed as given in `planes.ini` which comes from the [Surveyor](#)<sup>[405]</sup>. The plane which is the Calibration Plane is marked **red**. The plane which is the Monitor Plane is marked **blue**. If a plane is both Calibration and Monitor Plane it is marked **green**.

Related topics:

[Adding Head Tracking Functionality to iView X](#)<sup>[87]</sup>

Back to [Setup Calibration](#)<sup>[313]</sup>.

### 6.2.4.5 Output...



The following output options can be configured:

[Recording Options](#)<sup>[325]</sup>

[Gaze Cursor Filter](#)<sup>[326]</sup>

[Gaze Cursor Properties](#)<sup>[327]</sup>

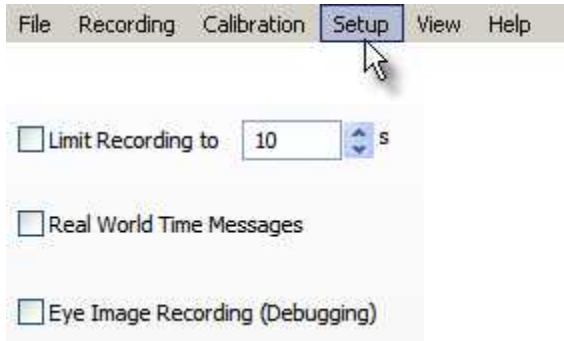
[Scene Video](#)<sup>[329]</sup>

[Overlay Selection](#)<sup>[332]</sup>



[Overlay Options](#) <sup>3337</sup>

### 6.2.4.5.1 Recording Options



Set your options for data recording here.

#### Limit Recording To

If you check the box the recording stops automatically after a given time in seconds.



Currently recording time is limited to 2 h.

#### Real World Time Messages

If you check the box, messages containing the real world time in UTC format will be added to the data file. The message will be inserted after a recording is started and before a recording is stopped.

The time stamped message contains the current number of seconds and milliseconds since 01-01-1970 00:00:00 GMT.

*Format:*

<timestamp> MSG <trial number> # UTC: <seconds> <milliseconds>

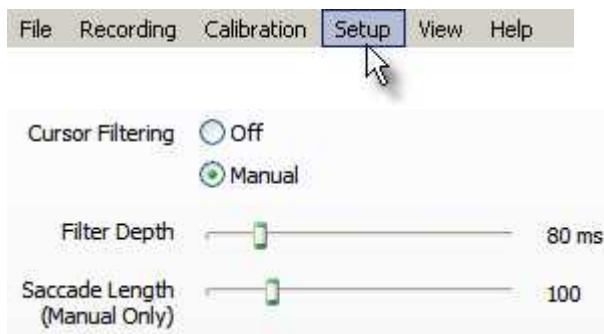
*Example:*

2298022189 MSG 2 # UTC: 1218638861 968

## Eye Image Recording (Debugging)

If you check the box, [eye image recording for quality evaluation](#)<sup>389</sup> will be enabled. Eye images will be recorded during calibration.

### 6.2.4.5.2 Gaze Cursor Filter



The *Gaze Cursor Filter* filters data needed to display the cursor. **This filter affects cursor display only** and does not influence recorded gaze data.

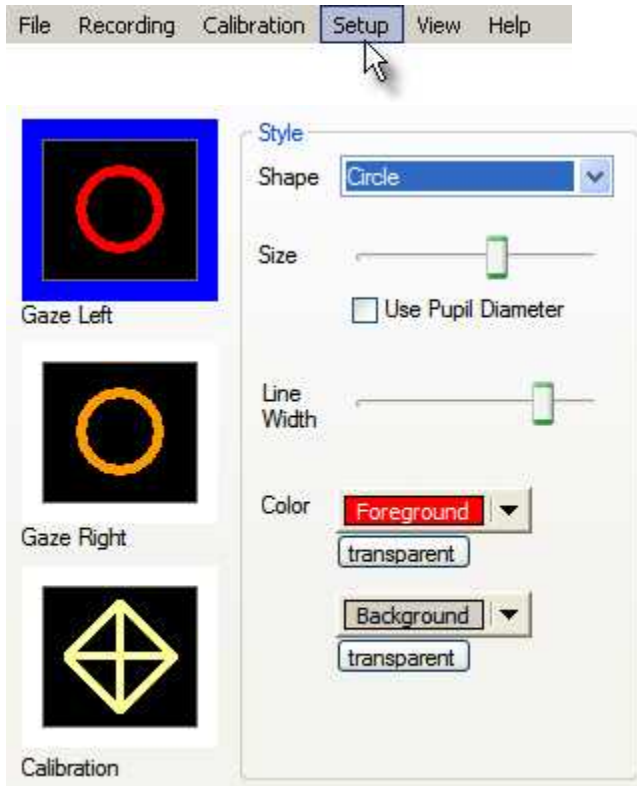
### Cursor Filtering

*Manual:* Filter depth and saccade length can be set manually.

**Filter Depth:** The *Overlay Output Filter* reduces noise by averaging the data over a period of time. The time can be set from 0 ms to 500 ms.

**Saccade Length:** If saccades are detected the *Gaze Cursor Filter* will be switched off. The jump of the cursor will be clearly visible and not be smoothed. The minimum saccade length, which must be exceeded to switch off the *Output Filter*, can be set from 0 to 500 pixels.

### 6.2.4.5.3 Gaze Cursor Properties



Specify size and shape of the overlay cursor. The cursors can be configured for left eye, right eye and the calibration target, independently.

First select the cursor type to be changed, then select the style.

For each cursor the following can be specified:

**Shape:** one of *Circle*, *Square* or *Crosshair*. For *Calibration Cursor* the shape is preselected and cannot be changed..

**Size:** Diameter of the whole cursor overlay.

**Use Pupil Diameter:** If checked, size of cursor overlay changes with pupil diameter.

**Line Width:** width of the line.

**Color Foreground:** Foreground color of the overlay. Color of the line.

**Color Background:** Background color of the overlay. Color the area inside the line.

**Transparent:** If clicked, this part of the overlay is invisible, i.e. has the same color as the underlying scene video or image.

#### 6.2.4.5.4 Scene Video

Configure shape and size of the scene video cursors:

Installed Hardware

**CurVid X - ( 768 x 576 )**

Standard Overlays

Shape:


Size:

Border:

Color:

Size = Pupil Diameter

Left Eye  Right Eye



Additional Overlays

Frame Counter   Reset Counter on

Clock

Trial Description

Logo

Timestamp

Setnumber

TTL Status  Bit Width

Working Area

Offset: 0,0 Gain: 1.0,1.0

## Installed Hardware

Shows you resolution of installed overlay card.

## Standard Overlays

Specifies shape and size of the cursor overlay for each cursor.

To specify shape and size of the various overlay cursors first select the cursor, whose shape you wish to modify. Choose between cursor for left eye (*Gaze Cursor Left*) cursor for right eye (*Gaze Cursor Right*) and the target displayed during calibration (*Calibration Cursor*). For each cursor the following can be specified:

**Shape:** one of *Circle*, *Square* or *Crosshair*. For *Calibration Cursor* only *Crosshair* can be selected.

**Size:** Diameter of the whole cursor overlay.

**Border:** Thickness of the margin.

**Color Fore:** Foreground color of the overlay. Color of the area inside the margin.

**Color Back:** Background color of the overlay. Color of the margin.

**Hollow:** For *Color Fore* and *Color Back* *hollow* can be chosen. The respective part of the overlay is then transparent, i.e. has the same color as the underlying scene video or image.

**Size = Pupil Diameter:** If checked for left, right or both eyes, size of cursor overlay changes with pupil diameter.

## Additional Overlays

Choose here type and position of additional overlays, such as frame counter, time counter etc.

## Working Area

Under [Setup](#) <sup>[290]</sup> [Calibration](#) <sup>[313]</sup> you set the size of the [calibration area](#) <sup>[240]</sup> in units. The calibration area can differ from the area you see in the scene video view, which is the case if the video comes from a scan converter. Here you can adjust the working area of the gaze cursor overlay. The working area will be mapped to the calibration area. The current used *Offset* and *Gain* values are displayed.

**Adjust:** Click on *Adjust* to define the working area of the gaze cursor overlay. In the upper left corner of the *Scene Video view* you will find a **red** cursor, in the lower right corner a **green** cursor. These two cursors define the bounding rectangle of the working area. Drag and drop the **red** cursor to the upper left corner of the desired working area and the **green** cursor to the lower right corner. If you use a scan converter, the working area usually is the visible area excluding the black margins. After you have finished adjusting you can press the <Esc> key. If you start calibration, you will see the working area in the *Scene Video view* as a rectangle.

**Reset:** Click on *Reset* to set *Offset* to 0,0 and *Gain* to 1.0,1.0. The working area equals the calibration area and no mapping will be done.

### 6.2.4.5.5 Overlay Selection



The overlay behaviour can be set here. The following types of overlays can be selected:

**Time:** shows date and time

**Logo:** shows a user defined logo

**Description:** shows a description of current run

**Stamp:** shows timestamp

**TTL:** shows TTL signals

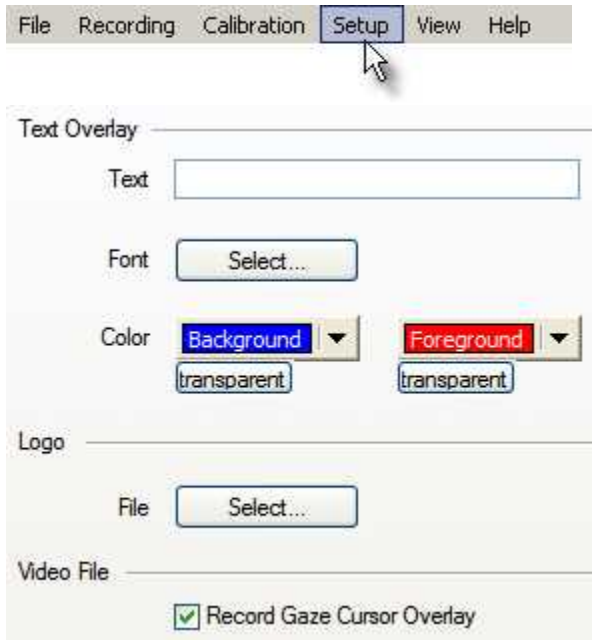
**Trial No.:** shows current trial number

**Border Distance:** move the slider to adjust the margin width between text and the boundary of the image.

More configuration options see [Overlay Options](#) <sup>333</sup>.



### 6.2.4.5.6 Overlay Options



In this dialog the appearance of the overlays is configured. The overlay selection is configured [here](#)<sup>332</sup>.

**Text:** arbitrary text that can be displayed in the video.

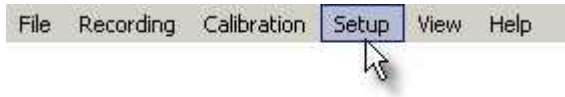
**Font and Color:** select font and color. If *transparent* is clicked, this part of the overlay is invisible, i.e. has the same color as the underlying scene video or image.

**Logo:** select an arbitrary bitmap that will be displayed in the video. Note, that the transparency color is RGB (255, 128, 255), meaning that pixels with this RGB value are transparent and have the same color as the underlying scene video.

**Video File:** It can be selected if gaze cursor should be overlaid on the recorded video, or not. By default, the gaze cursor will be recorded. This

option can also be selected in the [Toolbar](#)<sup>338</sup>.

#### 6.2.4.6 Recording Notes...



During a recording it is possible to write a user defined message into the iView Data File (IDF).

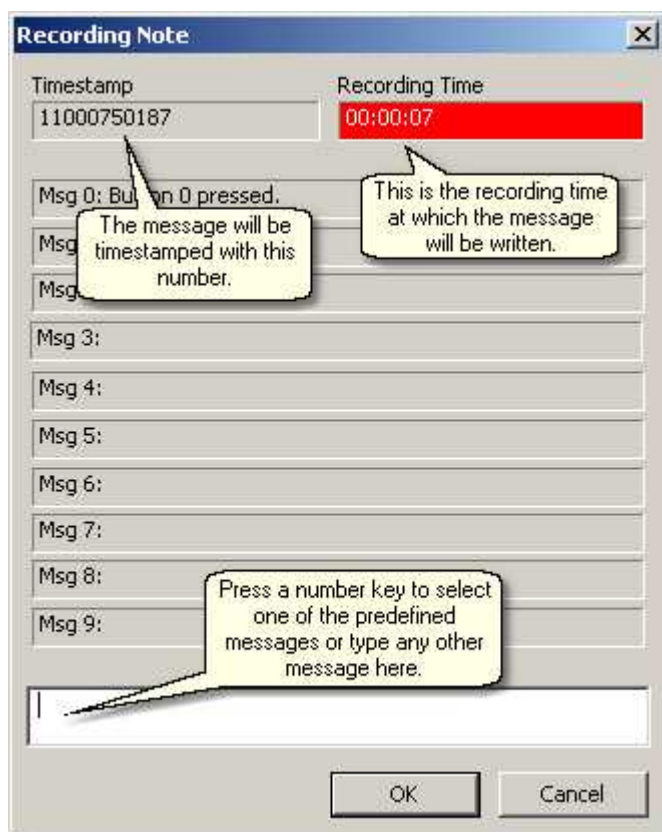
#### Configuration Dialog

In this dialog ten shortcuts can be given to arbitrary messages:

Key	Description	<input checked="" type="checkbox"/> Enable Recording Notes
0	Enter arbitrary message here. This can be several lines long.	Check 'Enable' to activate recording notes capability.
1	Key 1 pressed.	
2	Key 2 pressed.	Type any text here that should appear in the data file.
3		
4		This is the shortcut number to the message.
5		
6		
7		
8		
9		

### Working with Recording Notes

1. Start a recording.
2. Press **<Ctrl> + <Enter>** to catch the timestamp, at which the message should appear. A dialog will be displayed:



3. Select a predefined message (i.e. press one of the number keys) or type any other message.
4. Press <OK> to write the message to the data file at the given timestamp.

### 6.2.4.7 Save Setup...



The current configuration can be saved in a file by using this command. A file selection dialog will pop-up, asking for a name of the file. The file has the extension .ivs.

See also [loading a setup file](#) <sup>[392]</sup>.

This is useful when you want to run iView X as a [background task](#) <sup>[389]</sup>.

### 6.2.5 View



Shows/hides various views inside of the [workspace](#) <sup>[282]</sup>. The respective view is visible if a tick is displayed next to it. The windows are free dockable windows, so you can drag and drop them to various places of the workspace window.

The following windows can be displayed:









- [Toolbar](#) <sup>[338]</sup>
- [Status Bar](#) <sup>[339]</sup>
- [Online Data](#) <sup>[340]</sup>
- [Eye Image](#) <sup>[342]</sup>
- [Direct Calibration Controls](#) <sup>[356]</sup>
- [AOI Configuration](#) <sup>[357]</sup>
- [Performance Measures](#) <sup>[358]</sup>
- [RED Tracking Monitor](#) <sup>[359]</sup>
- [Eye Image \(Full Frame\)](#) <sup>[359]</sup>
- [System Log](#) <sup>[360]</sup>
- [Configure Logging...](#) <sup>[363]</sup>
- [Select and Manage Views...](#) <sup>[363]</sup>

### 6.2.5.1 Toolbar

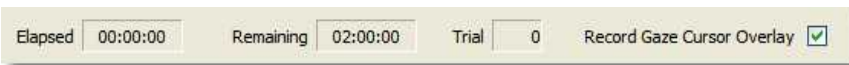


The toolbar is at the top of the [workspace](#)<sup>[282]</sup>. It gives you short-cuts to important features.

Here is an overview of the buttons and its meanings:

-  Starts/stops calibration. This option is available after eye data has been grabbed.
-  Accepts target fixation. Available only during calibration.
-  Starts validation.
-  Starts recording.
-  Increments trial number
-  Stops recording.
-  Clears recording buffer.
-  Saves recording to file.

The right half of the toolbar shows the following:



**Elapsed:** Time that has elapsed since recording has been started.

**Remaining:** Usually recording time is limited to 2 hours. The limit can be changed under [Setup - Output - Recording Options](#)<sup>[325]</sup>. This display shows, how much time is left before the recording time limit will be reached.

**Trial:** Current trial number.

**Record Gaze Cursor Overlay:** Only available for [HED systems](#)<sup>[51]</sup>. If checked, gaze cursor overlays will be recorded together with the scene video. This option can also be selected under [Setup - Output - Overlay Options](#)<sup>[333]</sup>.

Back to [View Menu](#)<sup>[337]</sup>.

### 6.2.5.2 Status Bar







The status bar is at the bottom of the [workspace](#)<sup>[282]</sup>.



#### Timing Status

A light at the far right of the status bar indicates the timing status:

light status	system idle	eyetracker	real time violation
 or 	yes	no	no
	no	enabled	no
	no	enabled	yes

A bright red light indicates timing problems. Try to switch off background tasks of the system (such as screensavers etc.) to improve performance. Note that activating video recording will likely result in loss of real time capability.

#### Communication Status

A two letter text symbol indicates the [Communication](#)<sup>[292]</sup> status:

text symbol	communication status
DS	data streaming enabled
RC	remote commands enabled
TO	trigger output enabled
TI	trigger input enabled
AO	analog output enabled

Back to [View Menu](#) <sup>337</sup>.

### 6.2.5.3 Online Data

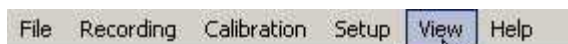


The window displays online data in two modes:

[graphical](#) <sup>340</sup>  
[numerical](#) <sup>341</sup>

Back to [View Menu](#) <sup>337</sup>.

#### 6.2.5.3.1 Online Data Graphic



Displays incoming data. On the x-axis is a time window of the last 10 sec.



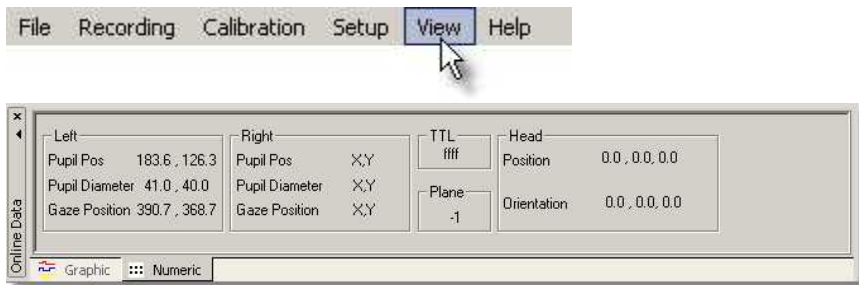
On the y-axis are the values for pupil gaze, diameter or TTL trigger signal.

### Graph orientation

The (0,0)-point is in the upper left corner of the [calibration area](#)<sup>[240]</sup>. This means that a gaze movement downwards is visualized in the graph as a movement upwards of the y data. A gaze movement to the right is visualized as a movement upwards of the x data.

Back to [View Menu](#)<sup>[337]</sup>.

#### 6.2.5.3.2 Online Data Numeric



### Left and Right

The Gaze Position of the eye is presented in units of the calibrated area, Pupil Pos and Pupil Diameter are in pixels of the eye camera video.

### TTL

In the TTL field the status of all channels of the parallel port is displayed.

### Plane

The number in the *Plane* field means the following:

- 1        no plane is hit by the gaze
- 0        no Head Tracking installed
- 1..n     number of plane that is currently hit by the gaze

## Head

This field only contains valid values if a Head Tracker is installed. It contains x, y and z head position in units of the measured area and x, y, z angles of the heads rotation.

Back to [View Menu](#)<sup>[337]</sup>.

### 6.2.5.4 Eye Image Control



The contents of the eye image control varies slightly depending on the used camera system. In general three main variants are possible:

[Eye Control for Monocular Eye Tracking](#)<sup>[343]</sup>

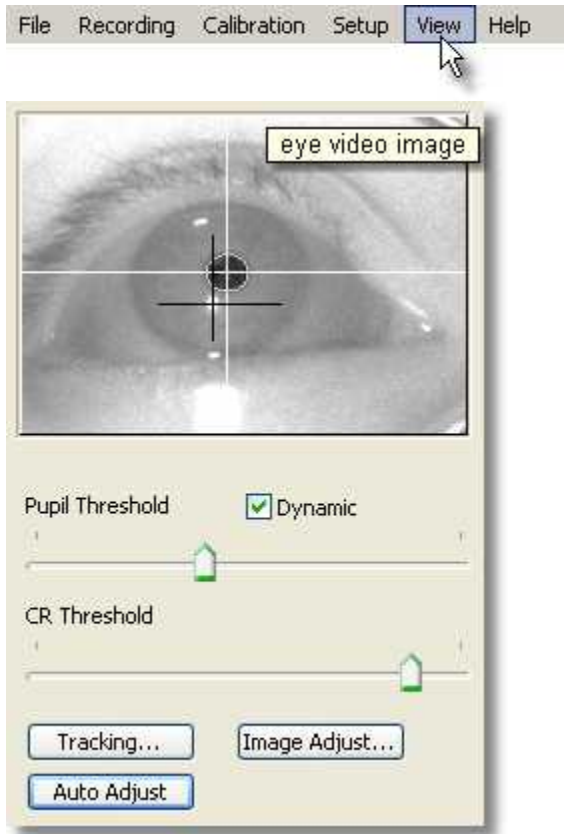
[Eye Control for Binocular Eye Tracking](#)<sup>[345]</sup>

[Mouse Control](#)<sup>[347]</sup>

*Note:* [RED](#)<sup>[101]</sup> systems do not have a configurable Eye Image Control.

Back to [View Menu](#)<sup>[337]</sup>

#### 6.2.5.4.1 Eye Control for Monocular Eye Tracking



#### Eye Video Image

Shows camera image of the eye camera. If the image is not shown, click on the window to enable eye tracking. In the picture above the camera is properly aligned. The two cross-hairs indicate that the pupil is detected as well as the corneal reflex.

(Note that in this example the test person wears glasses, so also a big reflection of the infrared light is to be seen, which illuminates the eye. As

this reflection is too far away from the pupil, it does not effect the quality of the measurement.)

## Thresholds

Here the detection thresholds for pupil and corneal reflex (CR) can be set.

Move the pupil slider until a white cross-hair is visible in the eye control. The center of the cross-hair should be the center of the pupil.

Move the reflex slider until a black cross-hair is visible in the eye control. The center of the cross-hair should be the center of a bright dot near the center of the pupil.

*Dynamic Threshold:* If checked, the eyetracker automatically adapts the pupil threshold to slightly changing environments like small movements of the head, changing of light etc.

## Tracking

If the eye tracker has difficulties to track the pupil or CR, you can change the [tracking parameters](#)<sup>[349]</sup>. See also chapter [Advanced Eye Image Adjustment](#)<sup>[370]</sup>.

## Image Adjust

Here you can adjust [brightness and contrast](#)<sup>[348]</sup> of the eye image (may differ depending on used eyetracker).

## Auto Adjust

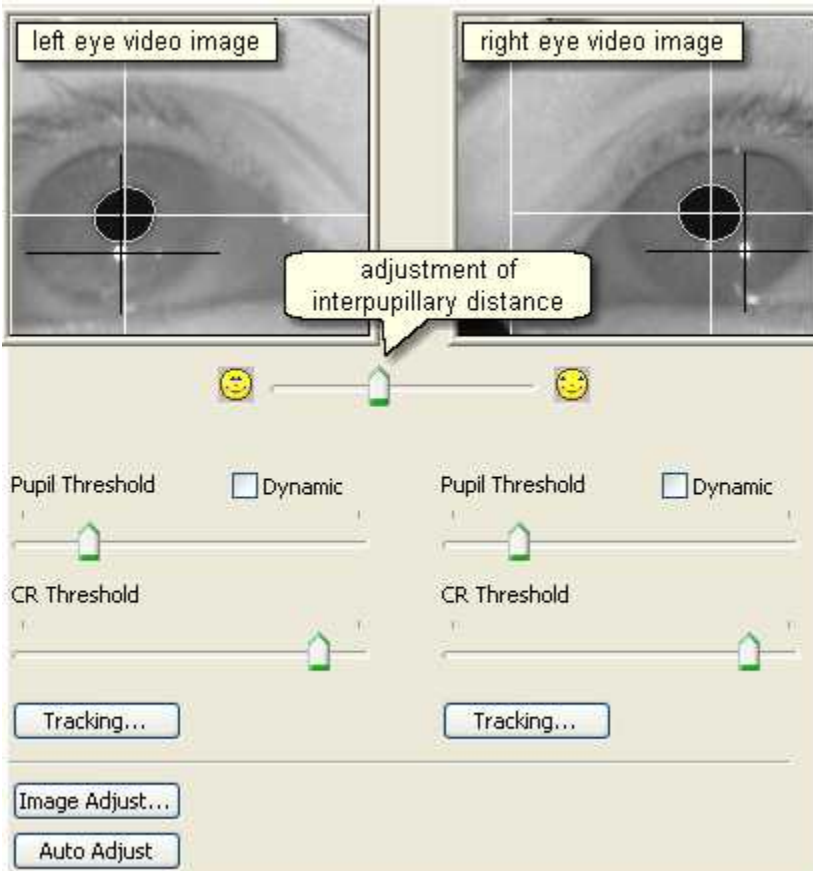
If you click on the *Auto Adjust* button the image is adjusted regarding pupil threshold and [image balancing](#)<sup>[348]</sup> (currently this is available only for [Hi-Speed](#)<sup>[129]</sup> and [Hi-Speed Primate](#)<sup>[161]</sup> systems).

Back to [Eye Control](#)<sup>[342]</sup>.

### 6.2.5.4.2 Eye Control for Binocular Eye Tracking

File Recording Calibration Setup **View** Help

In [binocular mode](#)<sup>389</sup> the eye camera video shows images of both left and right eye:



With the slider directly below the video images the interpupillary distance can be adjusted.

## Thresholds

Here the detection thresholds for pupil and corneal reflex (CR) can be set separately for each eye.

Move the pupil slider until a white cross-hair is visible in the eye control. The center of the cross-hair should be the center of the pupil.

Move the reflex slider until a black cross-hair is visible in the eye control. The center of the cross-hair should be the center of a bright dot near the center of the pupil.

*Dynamic Threshold:* If checked, the eyetracker automatically adapts the pupil threshold to slightly changing environments like small movements of the head, changing of light etc.

## Tracking

If the eye tracker has difficulties to track the pupil or CR, you can change the [tracking parameters](#)<sup>[349]</sup>. See also chapter [Advanced Eye Image Adjustment](#)<sup>[370]</sup>.

## Image Adjust

Here you can adjust [brightness and contrast](#)<sup>[348]</sup> of the eye image.

## Auto Adjust

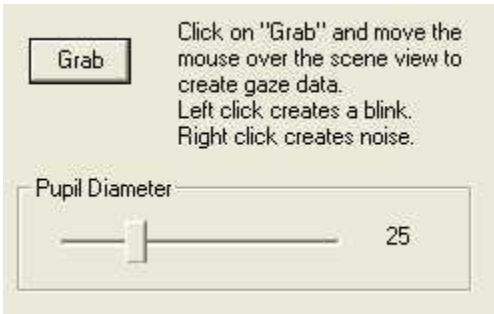
If you click on the *Auto Adjust* button the image is adjusted regarding pupil threshold and [image balancing](#)<sup>[348]</sup> (currently this is available only for [Hi-Speed](#)<sup>[129]</sup> and [Hi-Speed Primate](#)<sup>[161]</sup> systems).

Back to [Eye Control](#)<sup>[342]</sup>.

### 6.2.5.4.3 Mouse Control



In [Mouse Mode](#)<sup>[394]</sup> the eye tracker control is replaced by a mouse control:

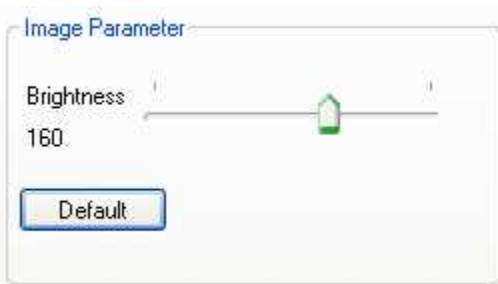


Click on *Grab* to start creating data contingent on mouse movements.

With the slider you can set the *pupil diameter*.

Back to [Eye Control](#)<sup>[342]</sup>.

### 6.2.5.4.4 Image Adjust



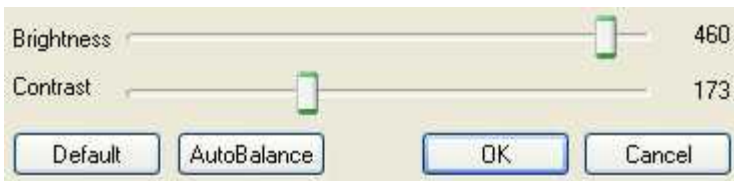
Move the slider to adjust the brightness of the eye video. If you click on *Default*, the value returns to factory settings.

#### 6.2.5.4.5 Image Adjust MRI



Contrast and brightness can be manually adjusted here. If you turn Auto Gain Control (AGC) on, contrast and brightness will be adjusted automatically. Only change anything here if you know what you are doing. It is recommended to use the default values, which are set if you click on the *Default* button.

#### 6.2.5.4.6 Image Adjust Hi-Speed



#### Brightness and Contrast

After the test person has been comfortably seated in front of the camera and the eye is properly visible in the eye control window, you can adjust brightness and contrast of the eye video by moving the sliders.

#### Default

Click on *Default* to reload the default values.

#### Auto Balance

In case the left and the right half of the image differ in brightness and contrast, click on *Auto Balance* to eliminate this effect.



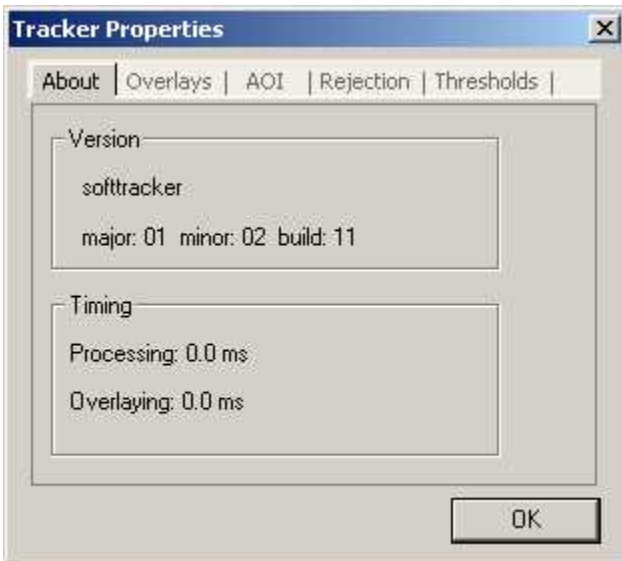
### 6.2.5.4.7 Tracking

If it is difficult to track the pupil or the cornea reflex (CR), it may be necessary to adjust the tracking parameters of the eye tracker. See more in chapter [Advanced Eye Image Adjustment](#)<sup>[370]</sup>.

Choose between the following:

[About](#)<sup>[349]</sup>  
[Overlays](#)<sup>[350]</sup>  
[AOI](#)<sup>[351]</sup>  
[Rejection](#)<sup>[352]</sup>  
[Linecut](#)<sup>[353]</sup>  
[Thresholds](#)<sup>[355]</sup>

#### 6.2.5.4.7.1 About



Information about this eyetracker.

Back to [Tracking Parameters](#) <sup>349</sup>.

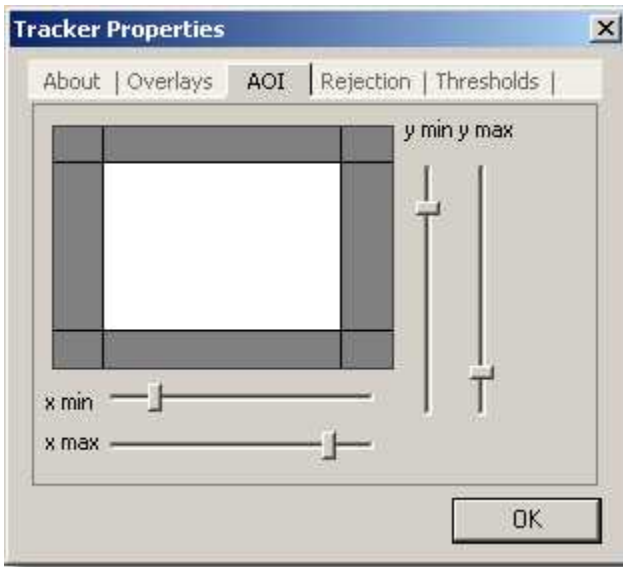
#### 6.2.5.4.7.2 Overlays



Switch on or off the various overlays.

Back to [Tracking Parameters](#) <sup>349</sup>.

### 6.2.5.4.7.3 AOI



Configure the area of interest (AOI) of the eye camera. Increase or decrease the area by using the sliders. This is the area in which the eyetracker tries to find the pupil and the corneal reflex.

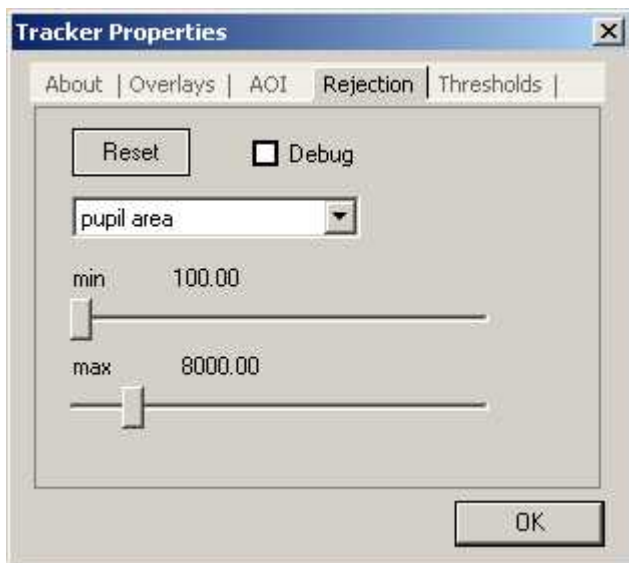
For all sliders it is possible to use the cursor keys to fine adjust.

If the AOI is visible in the [Eye Control](#) <sup>[342]</sup> camera video you can change its size with the mouse. (Which overlays are shown in the camera video can be set in the [Overlays](#) <sup>[350]</sup> tab.)

Do not mix up this camera AOI with the gaze data [AOI](#) <sup>[371]</sup>.

Back to [Tracking Parameters](#) <sup>[349]</sup>.

#### 6.2.5.4.7.4 Rejection



Configure various rejection parameters here. If you check the **Debug** box you see in the [eye control window](#)<sup>[342]</sup>, which parameter is responsible for rejecting the pupil. If it is difficult to detect the pupil change the according parameter.

Under normal trial conditions the default values need not be changed. The default values adapt themselves depending on the eye tracking system used. Click on **Reset** to load the default values.

For all sliders it is possible to use the cursor keys to fine adjust.

#### Rejection parameters

The eyetracker uses the rejection parameters to detect the pupil. The values of the various parameters must lie within the minimum and maximum range to be considered a valid (non-rejecting) pupil parameter.

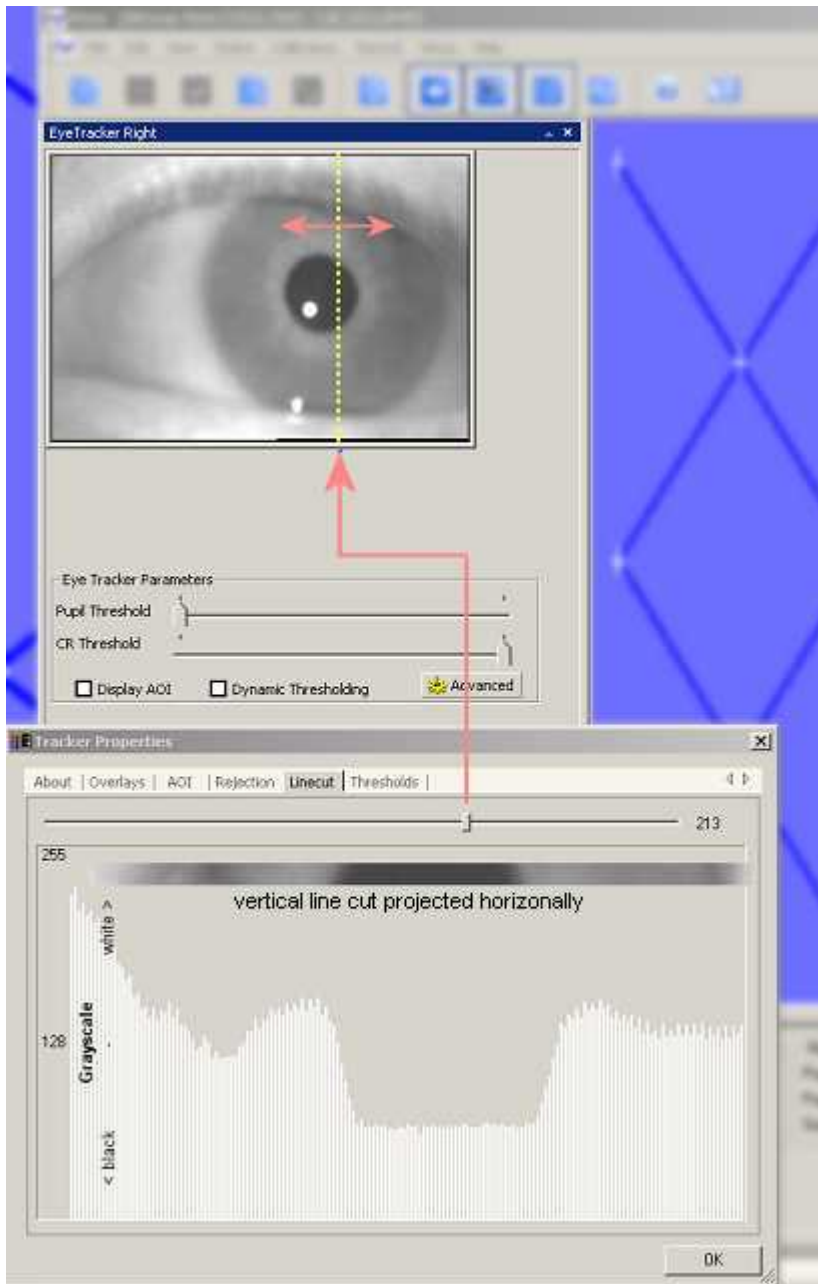
<b>Parameter</b>	<b>Description</b>
<i>pupil area</i>	pupil area in pixel
<i>pupil density</i>	ratio between pupil area and area of bounding box. 1 means that the pupil area equals the bounding box.
<i>pupil perimeter</i>	pupil perimeter in pixel.
<i>reflex perimeter</i>	perimeter of corneal reflex (CR) in pixel
<i>reflex pupil distance</i>	distance between CR and pupil center in pixel.

Back to [Tracking Parameters](#)<sup>[349]</sup>.

#### **6.2.5.4.7.5 Linecut**

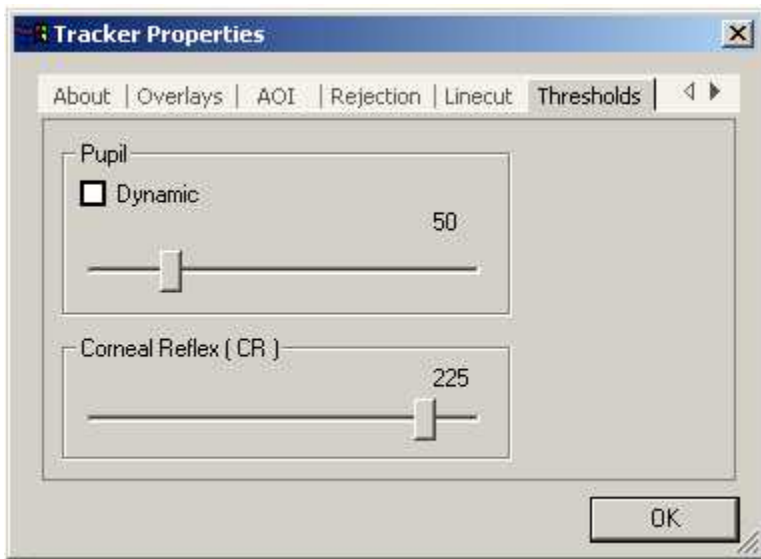
The Linecut diagram shows on the x-axis a vertical line cut through the eye image. On the y-axis the greyscale value of each point in the line is shown. The greyscale value is higher, the brighter the point, and lower, the darker the point.

The location of the cut can be moved horizontally.



Back to [Tracking Parameters](#)<sup>[349]</sup>.

#### 6.2.5.4.7.6 Thresholds



Set pupil and reflex detection thresholds here. Before you change settings use the controls in the [Eye Control](#)<sup>[342]</sup> window first to properly align the camera to the pupil.

#### Pupil

Move the pupil slider until a white cross-hair is visible in the eye control. The center of the cross-hair should be the center of the pupil. Once a correct threshold is found you can click on *Dynamic* to let the eyetracker automatically adapt the threshold to slightly changing environments like small movements of the head, changing of light etc.

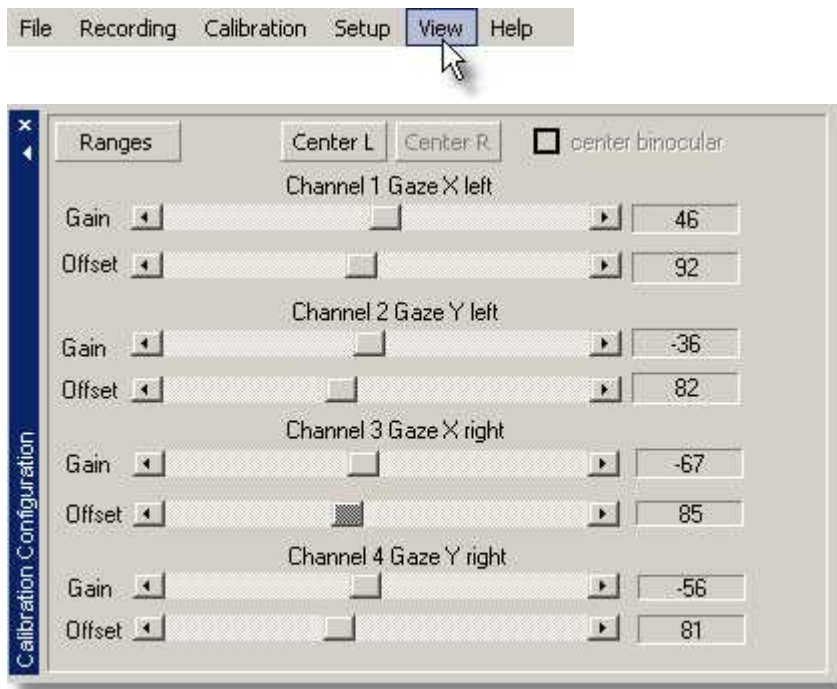
#### Corneal Reflex

Move the reflex slider until a black cross-hair is visible in the eye control. The center of the cross-hair should be the center of a bright dot near the center of the pupil.

For all sliders it is possible to use the cursor keys to fine adjust.

Back to [Tracking Parameters](#)<sup>[349]</sup>.

### 6.2.5.5 Direct Calibration Controls



If [Direct Analog](#)<sup>[244]</sup> calibration is used, gain and offset of the analog channels for gaze movement can be set here.

**Ranges:** Opens a window, in which you can set the ranges for gain and offset that can be adjusted during the calibration process.

**Center L:** If clicked, center of the screen is defined with the given channel settings for the left eye.

**Center R:** If clicked, center of the screen is defined with the given

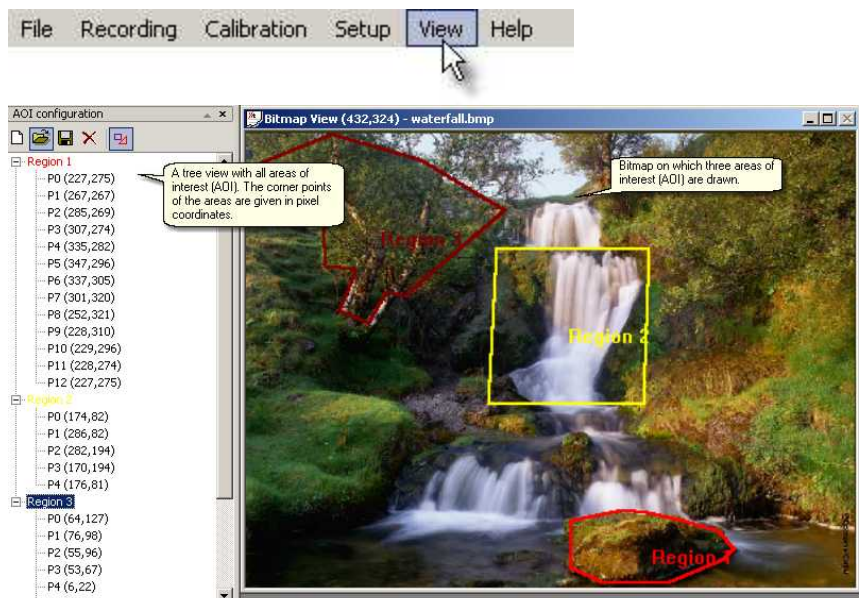


channel settings for the right eye.

See also [Analog Gain/Offset Calibration](#) <sup>[253]</sup>.

Back to [View Menu](#) <sup>[337]</sup>.

### 6.2.5.6 AOI Configuration



The [Area of Interest \(AOI\)](#) <sup>[371]</sup> configuration window displays in a tree view, which areas are drawn on the stimulus image. The corner points of the AOI are given in pixel coordinates.

On top of the AOI configuration window are 5 icons:



deletes all visible AOIs and creates a new AOI definition set



[opens an AOI file](#) <sup>[284]</sup>



[saves AOIs to file](#) <sup>[285]</sup>



deletes current in the tree view selected AOI



shows/hides AOIs

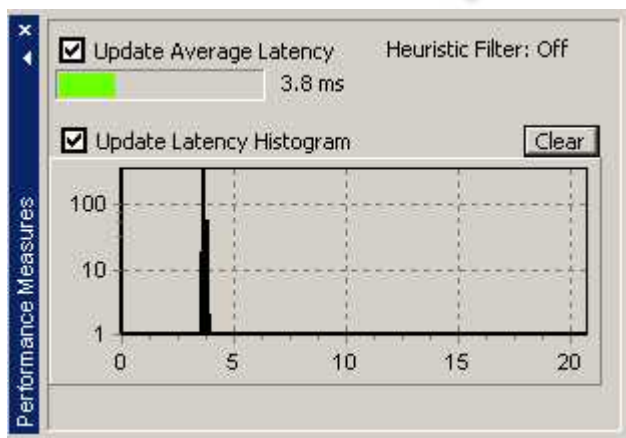
Related topics:

[Open a stimulus image](#) <sup>[284]</sup>

[How to draw an AOI on a stimulus image](#) <sup>[37]</sup>

Back to [View Menu](#) <sup>[337]</sup>.

### 6.2.5.7 Performance Measures



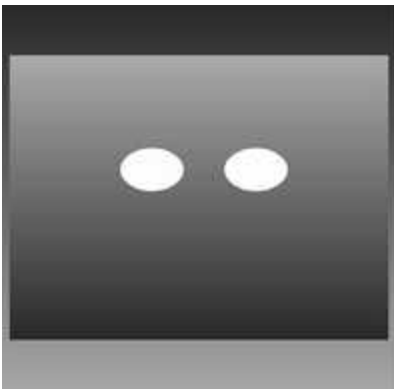
Indicates workload of the system. The bar at the top shows the average latency of a sample from the time it is grabbed at the eyecamera until it is ready to display on the iView X workstation. In this case it is 3.8 ms. The graph below shows the same as histogram. On the x-axis is the latency in ms. The maximum time is the refresh time of the camera system, in this

case 20 ms, which corresponds to 50 Hz. The y-axis is the number of hits. If the latency is bigger than a refresh time the value for maximum time (here 20) will be incremented.

Heuristic filtering influences the latency. See [Setup Output](#)<sup>[324]</sup> [Input Filter Eye](#)<sup>[310]</sup> for more information.

Back to [View Menu](#)<sup>[337]</sup>.

### 6.2.5.8 RED Tracking Monitor



The RED Tracking Monitor gives a symbolized visualization of the tracked eyes and the [test person's placement](#)<sup>[118]</sup>. If no test person is sitting in front of the RED camera system, the control only shows a blank page.

Back to [View Menu](#)<sup>[337]</sup>.

### 6.2.5.9 Eye Image (Full Frame)

Only available for [MRI-LR High Speed](#)<sup>[215]</sup> systems.

The eye image is displayed as full frame in a new window. This is useful if you have to watch the eye image on the monitor from a distance.

See also [MRI-LR Camera Adjustment](#)<sup>[223]</sup>.

Back to [View Menu](#)<sup>[337]</sup>.

### 6.2.5.10 System Log

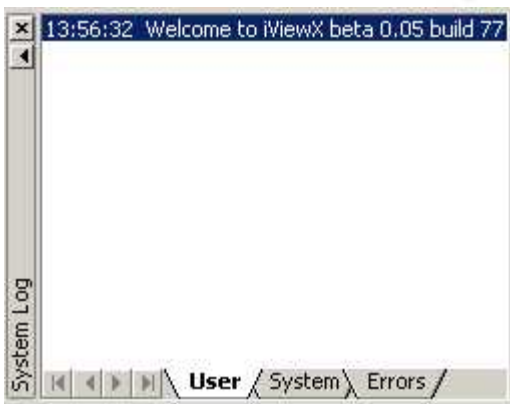


This window displays messages, which fall into three categories:

[System](#)<sup>[361]</sup>  
[Error](#)<sup>[362]</sup>  
[User](#)<sup>[360]</sup>

Back to [View Menu](#)<sup>[337]</sup>.

#### 6.2.5.10.1 User



Displays user messages, e.g. calibration started, data recording started etc.

Choose from the menu [Setup Message Log](#)<sup>[363]</sup> to customize which messages should be displayed.

Back to [System Log](#)<sup>[360]</sup>.

### 6.2.5.10.2 System



Displays system messages like, e.g., which CPU speed is detected, how many disk space is available etc.

Choose from the menu [Setup Message Log](#)<sup>[363]</sup> to customize which messages should be displayed.

Back to [System Log](#)<sup>[360]</sup>.

### 6.2.5.10.3 Error

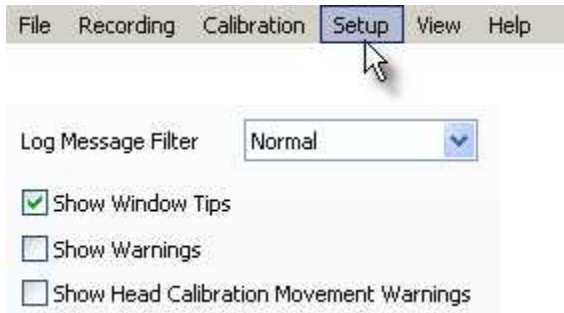


Displays error messages. In this example no eyetracker can be found, i.e. there is no eyetracker installed.

Choose from the menu [Setup Message Log](#)<sup>[363]</sup> to customize which messages should be displayed.

Back to [System Log](#)<sup>[360]</sup>.

### 6.2.5.11 Configure Logging...



#### Log Message Filter

Choose between three severity levels, which decide, how many messages you will see in the [System Log](#)<sup>[360]</sup> window.

#### Window Tips

Check this box if you want to see tips.

#### Warnings

Check this if you want to see [warnings](#)<sup>[368]</sup>.

### 6.2.5.12 Select and Manage Views



As every window in the [workspace](#)<sup>[282]</sup> is dockable you can create your

own arrangement of windows that you want to see. Here you can save up to four view configurations. The default configuration, which cannot be overwritten, is the configuration on start-up of iView X.

Back to [View Menu](#) <sup>337</sup>.

## 6.2.6 Help



iView X is capable of context sensitive help. This means that every window and every dialog has its own help. In general there are three equal ways to get help on a topic:

### Help button

In many dialog boxes you find a help button in the lower right corner:



Click on it to get help for this dialog.

### Question mark button

In many other dialog boxes you find a question mark button in the upper right corner:





Click on it, then click on an area inside of the dialog box. You get help on this item.

### Pressing <F1>

You can also press the F1-key on your keyboard.

### Evoking Help

If you evoke help by one of the methods above, the respective chapter of the [online help book](#) <sup>[365]</sup> will be opened.

#### 6.2.6.1 Help Topics



Opens the *Online Help* book.



iViewX.chm

You can also doubleclick on the file iViewX.chm.

Back to [Help Menu](#) <sup>[364]</sup>.

### 6.2.6.2 Tutorials



Not available in this version.

Back to [Help Menu](#)<sup>[364]</sup>.

### 6.2.6.3 System Info



Shows you which modules are currently loaded.

Back to [Help Menu](#)<sup>[364]</sup>.

### 6.2.6.4 License



Shows you which components are licensed, the product ID, the reference code and the expiration date.

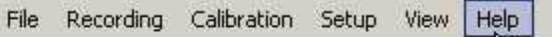
If you click on [Terminate License](#)<sup>[31]</sup> a termination code will be generated and saved to a file. If you then exit iView X you need a new License Key for activation.

Related topics:

[Software License](#)<sup>[27]</sup>

Back to [Help Menu](#)<sup>[364]</sup>.

### 6.2.6.5 About iView



Shows you, who is responsible for the concept, development and implementation of this program.

Back to [Help Menu](#)<sup>[364]</sup>.

### 6.2.6.6 Tip of the day



Shows you tips of the day.

Back to [Help Menu](#)<sup>[364]</sup>.

## 6.3 iView X Hotkeys

Key	Description
F1	Displays help menu.
F3	Starts/stops recording.
F5	Starts <a href="#">calibration</a> <sup>[242]</sup> .
F6	Accepts target fixation.
F7	Starts drift correction.
F8	Starts validation.
<space>	Accepts target fixation.
Ctrl + Shift + Cursor Up/Down/Right/Left	Shifts gaze manually to fixation point.
Ctrl + <enter>	Pops up <a href="#">Recording Notes</a> <sup>[334]</sup>
Ctrl + F5	starts <a href="#">scene cursor calibration</a> <sup>[322]</sup> in head

	tracking mode
Ctrl + Shift + F3	Starts <a href="#">video recording of eye image</a> <sup>[390]</sup> .

*save* and *recall* work on positional, zoom and focus parameters of the camera. Same as pressing on the **Save** and **Recall** buttons on the [Eye Camera Alignment](#) <sup>[342]</sup> window. Parameters are saved at program end.

## 6.4 Warnings and Error Messages

This chapter explains some warnings and error messages that might occur, and describes, what the user should do in these cases.

### 6.4.1 Missing DLL: clser\*.dll

If settings files are deleted, iView X might display a message that the DLL clser\*.dll cannot be found. iView X asks the user to specify the directory. The DLL can be found in

```
<install directory>\Euresys\MultiCam\WinWDM
```

<install directory> is the directory where the Euresys driver is installed. In most cases it is C:\Program Files.

### 6.4.2 Cannot connect to RED

If a message appears: "Cannot connect to RED", try one or more of the following:

- . Check that the Illumination Controller RED (e-box) is switched on.
- . Close iView X, unplug and replug the firewire connection, then restart iView X.
- . Reset the camera by switching off and on the e-box.
- . Check that no other program uses the camera (e.g. the Smartview program).

# More System Functions

**Chapter**



**VII**

## 7 More System Functions

This chapter describes advanced functions and features of the iView X system, sorted in alphabetical order.

### 7.1 Advanced Eye Image Adjustment

If it is difficult to track the pupil or the cornea reflex (CR), it may be necessary to adjust the [tracking parameters](#) <sup>[349]</sup> of the eye tracker.

Click on the *Tracking* button in the [eye control](#) <sup>[342]</sup>.

#### Improve CR tracking

If the CR cross-hair jumps, try to reduce the maximum distance between pupil and CR. Therefore, go to the [Rejection](#) <sup>[352]</sup> tab and decrease the *reflex pupil distance*.

#### Improve pupil tracking

If the pupil cross-hair jumps, go to the [Rejection](#) <sup>[352]</sup> tab and try to increase the pupil density, so more objects with a lower density will be rejected.

#### Generally reduce false positives

If there are false positives tracked around the pupil that cannot be get rid of otherwise, try to reduce the area of interest, in which the tracker tries to find the pupil and the CR. Therefore, go to the [AOI](#) <sup>[351]</sup> tab and reduce the area size by using the sliders.

Always check the results by observing the cross-hairs in the eye image.

## 7.2 Area of Interest (AOI)

The Area of Interest (AOI) feature allows you to create objects within the scene view for real-time I/O signal generation. The eyetracker performs an online analysis and detects, whether the gaze data enters or leaves an AOI. This is useful if you wish to setup gaze-contingent changes in the stimulus display or trigger some other research device by the test person's gaze position.

The status of the AOI is sent as an TTL signal to a corresponding output channel. See also: [TTL Output](#)<sup>[305]</sup>.

If you do not know how to draw an AOI see [How to draw an AOI on a stimulus image](#)<sup>[371]</sup>.

If you like to interact with iView X, e.g. if you need an interactive display, see also the section on [I/O Interfaces](#)<sup>[429]</sup>.

More on loading and saving AOIs see:

[Save AOI](#)<sup>[285]</sup>  
[Open AOI](#)<sup>[284]</sup>

You can show and hide AOIs by right-clicking on the scene view and check *Show AOIs*.

There is an extra [AOI Configuration](#)<sup>[357]</sup> window in the [View](#)<sup>[337]</sup> menu, which helps you to edit AOIs.

Note that this has nothing to do with the [AOI of the eye image](#)<sup>[351]</sup>.

### 7.2.1 How to draw an AOI on a stimulus image

1. A scene image must be loaded into the scene window. Go to the [File](#)<sup>[283]</sup> menu, choose [Open Scene Image](#)<sup>[284]</sup> and browse to the appropriate BMP file. Typically this will match or approximate the image the test person is looking at.
2. On the iView X workstation, the mouse cursor will change to a pen when hovering over the scene bitmap. This pen will draw an AOI around the area you wish to identify.

3. To see more options you can activate the AOI Configuration view (from the View menu click on 'AOI Configuration')
4. Select if you want to draw a polygon, rectangle or ellipse.
5. Double-click left within the scene image to mark the starting point of the AOI.
6. If 'polygon' is selected, single-click left to create a another corner of the polygon.
7. Double click left the mouse button to mark the last corner point. The corner points of the polygon will be automatically connected. Finally you will be prompted for a name and color of the AOI.

To change the size of the AOI

**Note:** Areas of interest can only be drawn on a stimulus image, not on the scene video.

Related topics:

[What are AOIs?](#) <sup>[37]</sup>

[AOI Configuration](#) <sup>[35]</sup>

## 7.3 Audio Recording

Audio signals coming from a microphone can be recorded together with the video signal. The audio signal is multiplexed with the video stream. As part of the video recording the audio recording will be started and stopped together with the video recording.

### Enabling Audio Recording

To enable Audio Recording go to [Setup-Hardware](#) <sup>[29]</sup> and click on [Advanced](#) <sup>[29]</sup>. If the system supports Audio Recording you will find an audio recording check box that needs to be checked.

### Connecting

Before you work with iView X Audio Recording, make sure you have a microphone and speaker connected to your iView X workstation and that they are working properly.



## Testing

To check that everything is working we recommend to try to record a voice with the *Sound Recorder*. You will find this tool in Windows under *Start - Programs - Accessories - Entertainment - Sound Recorder*.

## Recording

Record your video data as usual with iView X. The sound will be automatically recorded together with the video. If you play back the video you should hear sound, too.

## More Help

See the [Audio FAQs section](#)<sup>[373]</sup> and the [Audio Setup Guide for WinXP](#)<sup>[375]</sup> for more help.

### 7.3.1 Audio FAQs section

Topics:

- [How do I test Sound Recording?](#)<sup>[373]</sup>
- [I tested with Sound Recorder, but I do not hear anything](#)<sup>[374]</sup>
- [I have recorded a video, but I do not hear anything](#)<sup>[374]</sup>
- [I hear a lot of background 'hiss'](#)<sup>[375]</sup>
- [Where do I find the Audio Device Properties of my System?](#)<sup>[375]</sup>

Back to [Audio Recording](#)<sup>[372]</sup>.

#### 7.3.1.1 How do I test Sound Recording?

To check that everything is working we recommend to try to record a voice with the *Sound Recorder*.

The Sound Recorder is a tool that comes together with your Windows operating system. Usually, it can be found under *Start - Programs - Accessories - Entertainment - Sound Recorder*.

Follow the steps:

Click on the Windows *Start* button.  
Continue to the *Programs* section of the Start menu.  
Continue to the *Accessories* section of the Programs menu.  
Continue to the *Entertainment* section of the Accessories menu.  
Click on the *Sound Recorder* item.  
The Sound Recorder panel will appear.  
Try to record your speech through the microphone you use.  
Play it back.

If you can't hear your recording, go to the *Sounds and Audio* section of the Control Panel and play with the microphone settings until the recording test works for you. See also the [Audio Setup Guide for WinXP](#) <sup>[375]</sup>.

Back to [Audio Recording](#) <sup>[372]</sup>.

### **7.3.1.2 I tested with Sound Recorder, but I do not hear anything**

Make sure you have a microphone and speaker connected to your iView X workstation.

If you cannot hear anything, check and adjust the audio device properties of your iView X workstation. Make sure that output sound is not muted.

You can find more info in the [Audio Setup Guide for WinXP](#) <sup>[375]</sup>.

Back to [Audio Recording](#) <sup>[372]</sup>.

### **7.3.1.3 I have recorded a video, but I do not hear anything**

Check if the video contains any audio data. Right-click on the video file, which opens the video file properties. In the 'Fileinfo' tab you should find a 'Bitrate' and an 'Audioformat' additionally to the 'Length' of your video. If not, no audio was recorded.

If, however, you find the audio information, and do not hear anything, check and adjust the audio device properties of your iView X workstation. Make sure that output sound is not muted. You can find more info in the

[Audio Setup Guide for WinXP](#) <sup>[375]</sup>.

Back to [Audio Recording](#) <sup>[372]</sup>.

### 7.3.1.4 I hear a lot of background 'hiss'

Obviously, background noise is amplified too much. To reduce this effect, you can play with the microphone settings until the recording test works for you, as follows:

Open the [sound and audio device properties](#) <sup>[375]</sup>.

Go to the Audio tab, click the microphone volume button and reduce the Mic-in volume to an acceptable level (about 10-20% of the scale). Set the output volume to about 50-70%.

Back to [Audio Recording](#) <sup>[372]</sup>.

### 7.3.1.5 Where do I find the Audio Device Properties of my System?

The audio device properties can be found at slightly different places, dependent on the Windows version.

In Win XP you will find it under: *Start - Control Panel - Sounds and Audio Devices - Volume, Audio and Voice* tab

Back to [Audio Recording](#) <sup>[372]</sup>.

## 7.3.2 Audio Setup Guide for WinXP



Please note that the following set of instructions may be different for some users due to their audio software/hardware manufacturer, the installed OS version and the chosen windows style.

## How to get to the Audio Settings

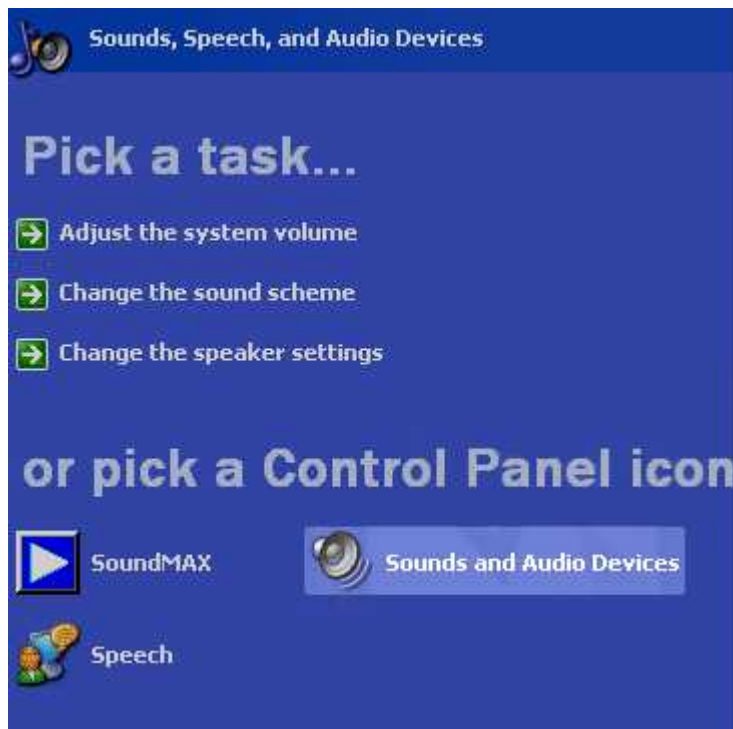
Click on the *Start* button and continue to the *Control Panel* section of the Start menu:



The *Control Panel* window will appear. In the Control Panel window find *Sounds, Speech, and Audio Devices* section, and click on it.



The *Sounds, Speech, and Audio Devices* window will appear  
In the *Sounds, Speech, and Audio Devices* window find the *Sounds and Audio Devices* section, and click on it.



The *Sounds and Audio Devices* panel will appear.  
Find the *Audio* section tab (top line of buttons), click on it.  
The *Audio Settings* section will open.

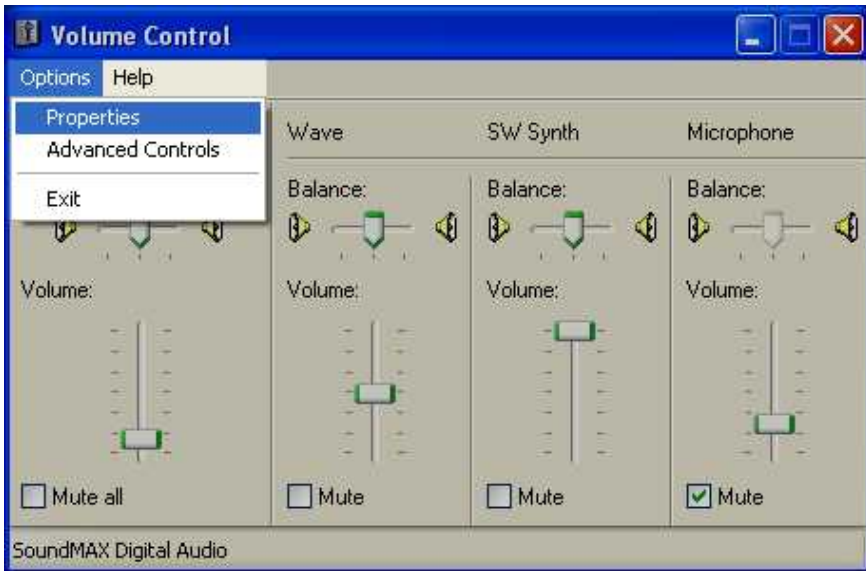
### How to change Playback Options

The following describes to setup the system, so you can hear anything.

In the *Sound Playback* section from the drop down menu, select the device that the iView X workstation uses. Click on the *Volume* button below the drop down menu.



The *Volume Control* panel will appear.  
Find the *Options* menu button, click on it.  
Click on the *Properties* section.

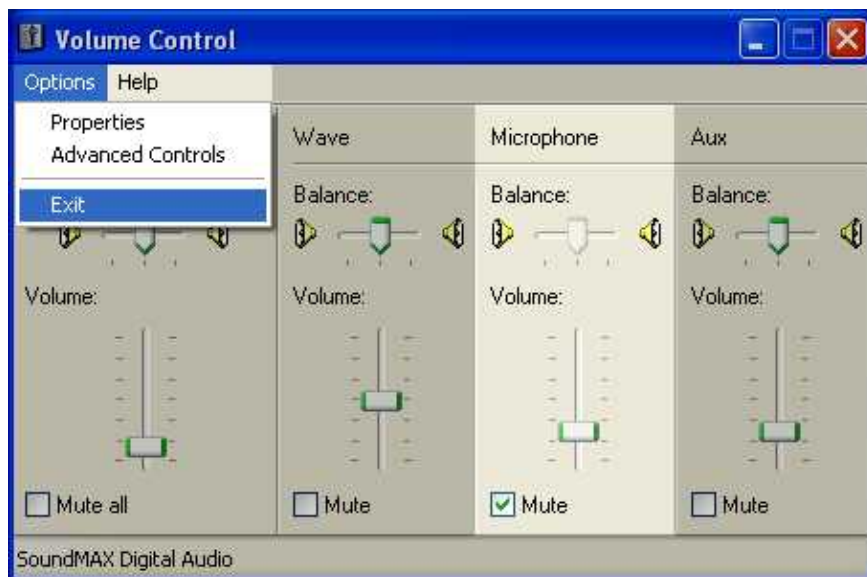




The *Properties* panel will appear.  
Find the *Show the following volume controls:* section.  
Select all by checking all the unchecked boxes.  
Click the OK button.



Make sure that *Microphone* volume controllers for playback are muted in the *Volume Control* panel (not available on all systems). All the other volume controllers should be unmuted. Open the *Options* menu, click on *Exit* section.



## How to Change Recording Options

The following describes to setup the system, so you can record anything by using the connected microphone.

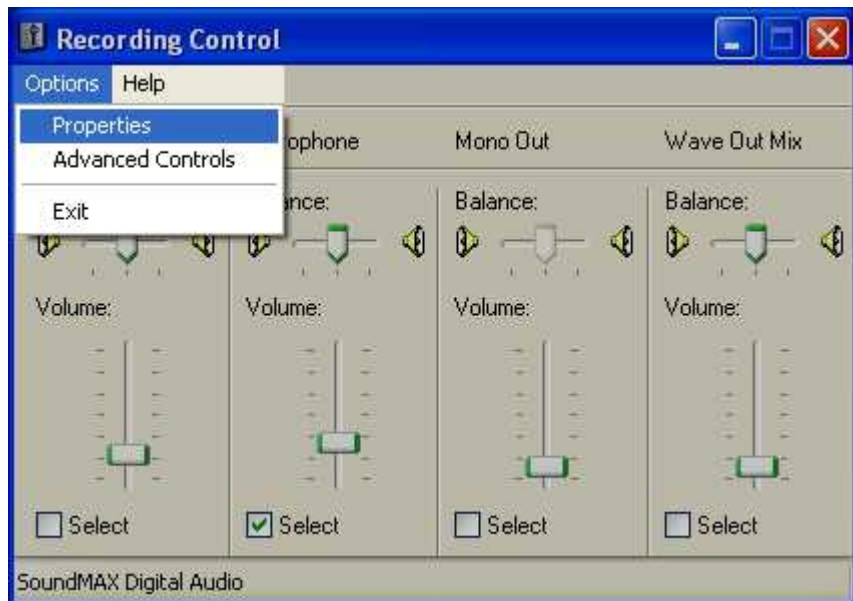
Find the *Sound Recording* section of the *Sounds and Audio Devices* panel.

In the *Sound Recording* section from the drop down menu, select the device that the iView X workstation uses.

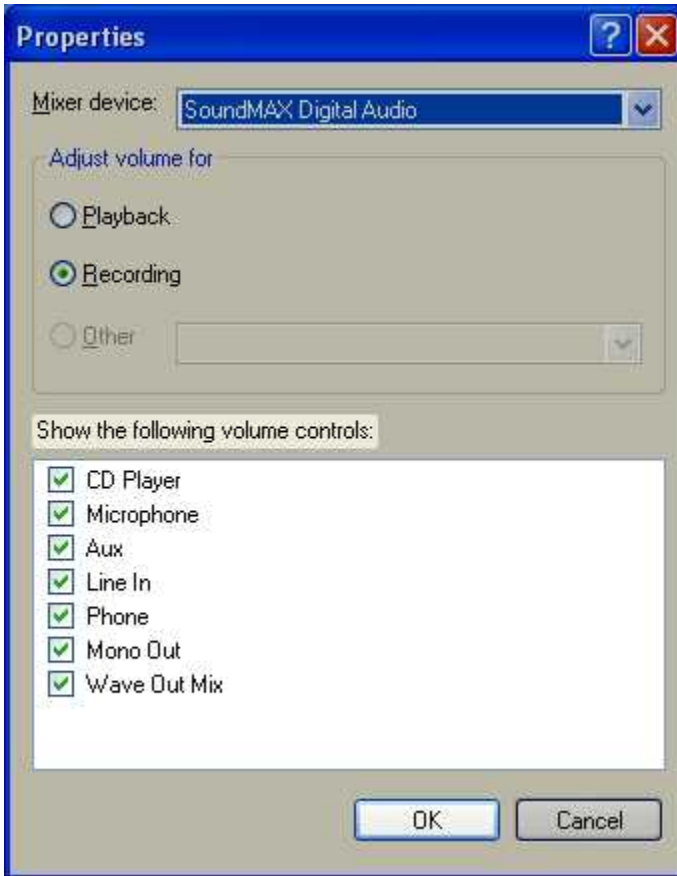
Click on the *Volume* button.



The *Recording Control* panel will appear.  
Click on the *Properties* section of the *Options* menu.



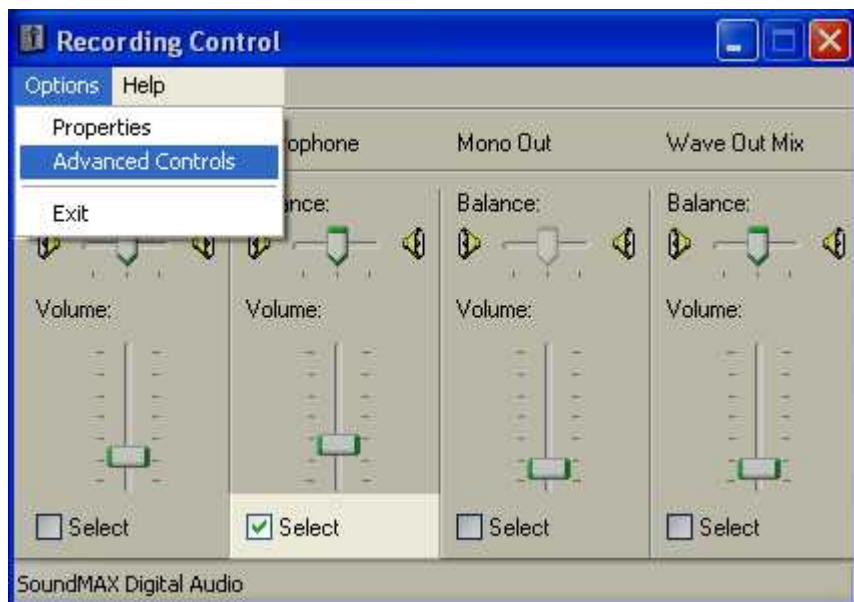
The *Properties* panel will appear.  
Find the *Show the following volume controls:* section.  
Select all by checking the unchecked boxes.  
Click the OK button.



Make sure that *Microphone* volume controllers is checked in the *Recording Control* panel.

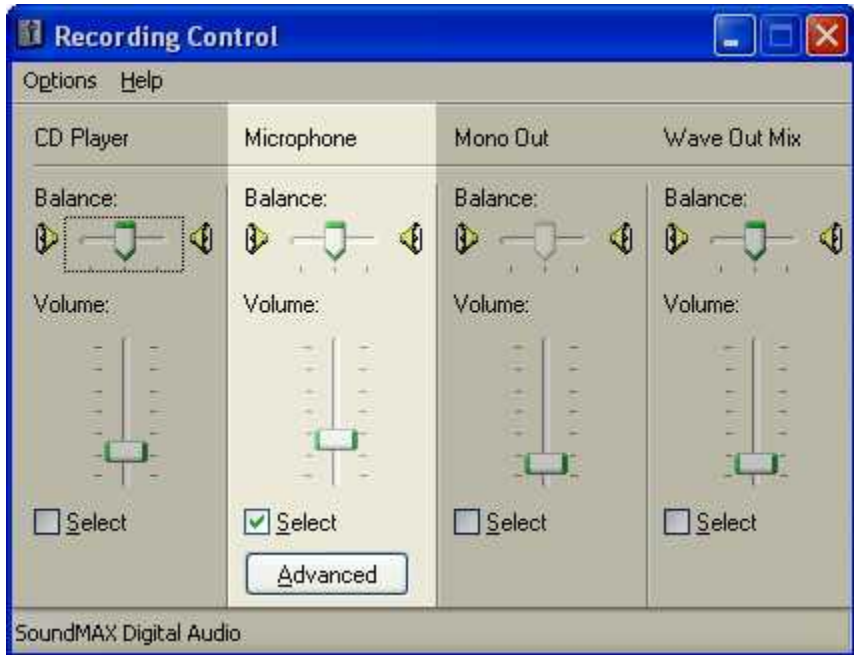
Find the *Options* menu, click on it.

Make sure that the *Advanced Controls* section is checked, if not check it.



Find the *Advanced* button under the *Microphone* volume controller, click on it.

The *Advanced Controls for Microphone* panel will appear.



Find the *Other Controls* section.

Normally, *Microphone Boost* should be unchecked. If sound quality is not satisfying, you might try to check it again.

Click the *Close* button.



In the *Recording Control* panel find the *Options* menu button, click on it, click on *Exit* section.

Now you can [test the Sound Recording](#) <sup>373</sup> capabilities.

Back to [Audio Recording](#) <sup>372</sup>.



## 7.4 Background Operation Mode

iView X can be started with command line parameters as a background task. Therefore you need a predefined setup file.

See [save a configuration](#) <sup>[337]</sup> to get a setup file.

iView X will run as a background process with the following command:

```
<path>\iviewx.exe -b <name>.ivs
```

where

<path> : path to the iView X program  
<b : tells iView X to operate as a background process  
<name>: name of configuration file

The iView X icon will appear in the tray status bar of windows. Right clicking the icon allows you to bring up the maximized iView X window.

## 7.5 Binocular mode

Binocular mode is an option for [Hi-Speed](#) <sup>[129]</sup> systems with an appropriate [configuration](#) <sup>[296]</sup>. In binocular mode all diagrams and exports will show data for both eyes.

## 7.6 Eye Image Recording for Quality Evaluation

Eye images can be recorded during a [RED](#) <sup>[107]</sup> calibration.

### Enabling

To enable this feature go to the [Setup](#) <sup>[290]</sup> menu, click on [Output](#) <sup>[324]</sup> and choose the [Recording Options](#) <sup>[325]</sup> tab. Check the *Eye Image Recording*

(*Debugging*) checkbox.

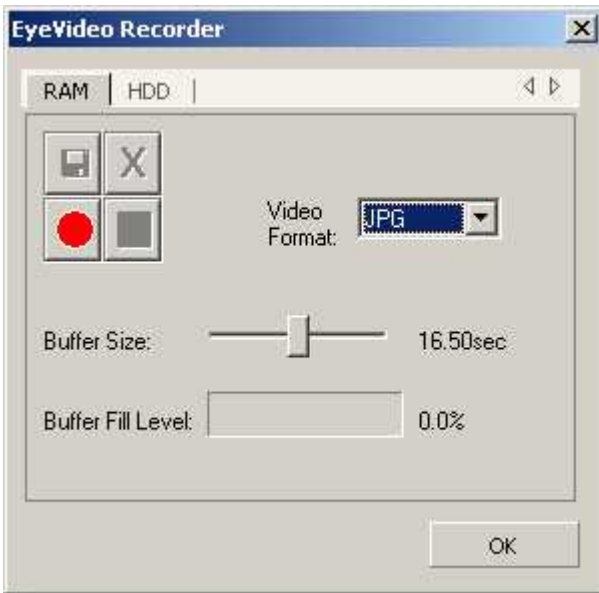
### Remote Command

This feature can also be enabled with the [ET\\_EQE](#)<sup>[448]</sup> command.

### Storing

If this feature is enabled, eye images will be saved in the *eyeImages* subfolder in the installation directory of iView X.

## 7.7 Eye Video Recorder



To start the eye video recorder you have to press **Ctrl+Shift+F3**.

With the eye video recorder you can record the eye video image, which is displayed in the [Eye Control](#)<sup>[342]</sup>.

### RAM or HDD

The data can be either recorded into RAM or directly to HDD. For hi-speed data with a sample rate of 500 Hz or higher it is recommended to record the data first into RAM, and in a second step save the RAM contents to hard disk.

### The recording buttons



Start recording, either to RAM or to HDD.



Stops recording.



Saves the recorded data to hard disk. Not available if directly recorded to HDD



Deletes recorded data from the RAM. Not available if directly recorded to HDD.

### Video Format

The following recording formats are available:

<i>JPG</i>	Single pictures are taken and saved in <i>.jpg</i> format.
<i>BMP</i>	Single pictures are taken and saved in <i>.bmp</i> format.
<i>XVID</i> <i>HUFFYUV</i> <i>ALPARY</i>	A live video is recorded with the codec specified. The video can only be played if the appropriate decoder is installed on the PC.
<i>XMP4</i>	A live video is recorded. The codec is an optimized SMI video codec, which is compatible with Xvid and DivX.

### Buffer Size

Limit the recording by adjusting the slider. The recording will stop automatically, if the maximum recording time is reached. Only available if

recording to RAM is used.

### Buffer Fill Level

Shows fill level of RAM buffer. Only available if recording to RAM is used.

### Storing

The resulting files are saved in the *eyeImages* subfolder in the installation directory of iView X.

## 7.8 Loading a setup file

iView X can be started with a setup file as a command line parameter. To do so first start iView X in normal mode, configure everything as needed, then [save a configuration](#) <sup>[337]</sup>. The configuration will be saved in a file with the extension *.ivs*.

To start iView X with the saved setup use the following command:

```
<path>\iviewx.exe <name>.ivs
```

where

<path> : path to the iView X program  
<name>: name of configuration file

## 7.9 Messaging with BeGaze

BeGaze™ is a behavioural and gaze analysis software for eye tracking data.

### Separation into Trials

When BeGaze loads IDF files, it separates the data stream into single trials. As a trial separator BeGaze uses certain image messages. If the IDF file does not contain image messages, BeGaze uses the [trial number](#) <sup>[287]</sup>.

## Image Messages

The image message must have a specific format to be interpreted by BeGaze as a *Data trial Separator*.

The image message should be the filename or the full path name of the image, including extension. The following file formats are supported: **bmp, jpg, jpeg, png**. Make sure the filename or path name contains one of the supported extensions.

When sending the following to iView X:

```
ET_REM "<image name>"
```

iView X generates the following message in the data file:

```
<Timestamp> MSG <TrialNumber> Scene Image: <image name>
```

where <Timestamp> is the time when the command was sent.

*Example:*

```
ET_REM "C:\images\my image.bmp"
```

*Result:*

```
28437864110 MSG 1 Scene Image: C:\images\my image.bmp
```

The generated message line will be used by BeGaze to generate a trial separation.

## Use with Presentation™

When using Presentation just use the `send_string("<image name>")` command. The Presentation to iView X interface adds "ET\_REM" to the string automatically.

For more information on BeGaze refer to the BeGaze manual.

See also [Message Output Format](#)<sup>279</sup>.

## 7.10 Mouse mode

In mouse mode eye movements are simulated by mouse movements. This option is useful in the experimenter's preparation phase, where measurements on real test persons are not yet needed. In mouse mode calibration is not possible and the camera view is disabled.

In mouse mode you can simulate

- data of left eye, right eye or both eyes,
- blinks
- noise
- various sampling rates

and set a pupil diameter.

To switch to mouse mode do the following:

1. Go to [Setup](#)<sup>[290]</sup> [Hardware](#)<sup>[290]</sup>.
2. Select under **Eye Tracker** *Custom*.
3. Select under **Video Grabber** *Mouse*.
4. Click on the [Advanced](#)<sup>[297]</sup> button to configure mouse data output.

After you have accepted all entries with OK and left the dialogs, the [eye tracker control](#)<sup>[342]</sup> is replaced by a [mouse control](#)<sup>[347]</sup>.

## 7.11 Network Connection to Stimulus PC

If you wish a stimulus program to interact with the iView X program, the stimulus PC and the iView X PC must be properly connected. The following describes how to establish a network connection.

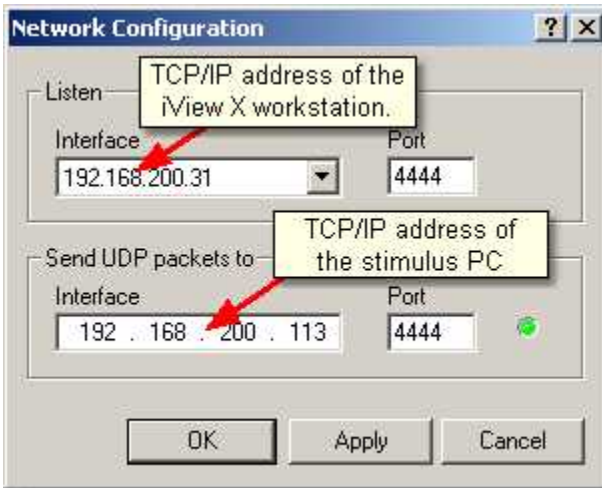
On the **iView X workstation** select from the [Setup](#)<sup>[290]</sup> menu [Hardware](#)<sup>[290]</sup> [Communication](#)<sup>[292]</sup>.

Set *Remote* to Ethernet.


Check *Accept Remote Commands*.

Click on the *Configure* button next to Ethernet. A *Network Configuration*

dialog appears:



### *Network Configuration of the iView X workstation*

In the *Listen* field select IP address of the iView X computer and its [port](#) <sup>[303]</sup>. Click on the drop down button  to see a list of choices. One entry is 127.0.0.1, which is the default address. The other entry should be the IP-address of the iView X workstation, which you should select.

If the iView X workstation succeeds in connecting to the stimulus PC, the LED next to the Send address will turn to green. Close iView X network configuration and the Setup Hardware dialog each with clicking on OK.

## **SMI Experiment Center**

If you use Experiment Center on the stimulus PC, proceed with [Using SMI Experiment Center](#) <sup>[396]</sup>.

## **Presentation Interface**

If you use Presentation on the stimulus PC, proceed with [Using Presentation Interface](#) <sup>[396]</sup>.

### 7.11.1 Using SMI Experiment Center

On the **Stimulus PC** SMI Experiment Center must be installed.

In the SMI Experiment Center program open the *Global Settings* dialog or click on the *network connection* button. At the top of the dialog find the *Connection Settings*:



*Network Configuration of Experiment Center on the Stimulus PC*

The IP address of the Stimulus PC is already given in the *Experiment Center (IP Address)* field. Choose also a [port](#)<sup>[303]</sup>.

In the *iView X System (IP Address)* field enter the *Listen* address of the iView X workstation.

In the *Send* address field of the iView X workstation enter the *Experiment Center (IP Address)*.

Also the respective ports should match.

Close the *Global Settings* dialog by clicking on *OK*.

SMI Experiment Center should show a *connected* status.

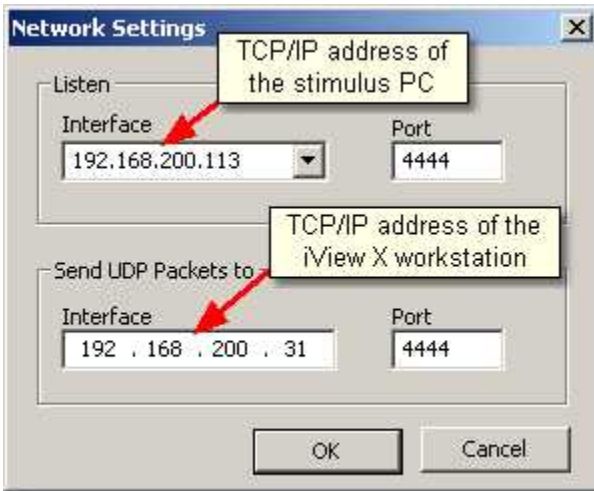
### 7.11.2 Using Presentation Interface

On the **Stimulus PC** the *iView X Presentation Interface Configurator* must be installed. The program can be found on the iView X CD.


Click on *Start* of the taskbar, go to *All Programs - SMI - iTools* and select



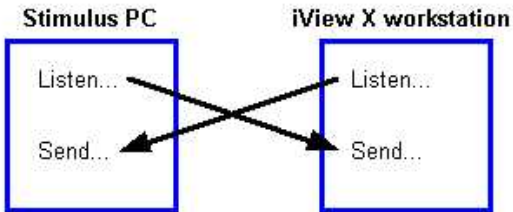
*Presentation Interface - Network Configuration.* A dialog box opens. Click on *Setup Network Configuration.* A *Network Settings* dialog appears:



#### *Network Configuration of the Stimulus PC*

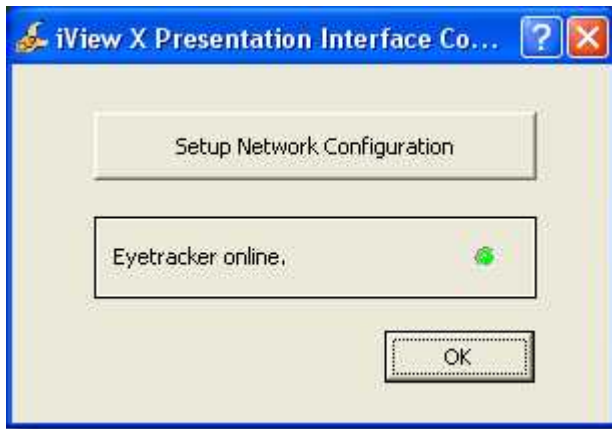
In the *Listen* field select IP address of the stimulus PC and its [port](#)<sup>[303]</sup>. Click on the drop down button  to see a list of choices. One entry is 127.0.0.1, which is the default address. The other entry should be the IP-address of the stimulus PC, which you should select.

Enter under *Send* address of the stimulus PC the value of the *Listen* address of the iView X workstation and under *Send* address of the iView X workstation the *Listen* address of the Stimulus PC. Also the respective ports should match.



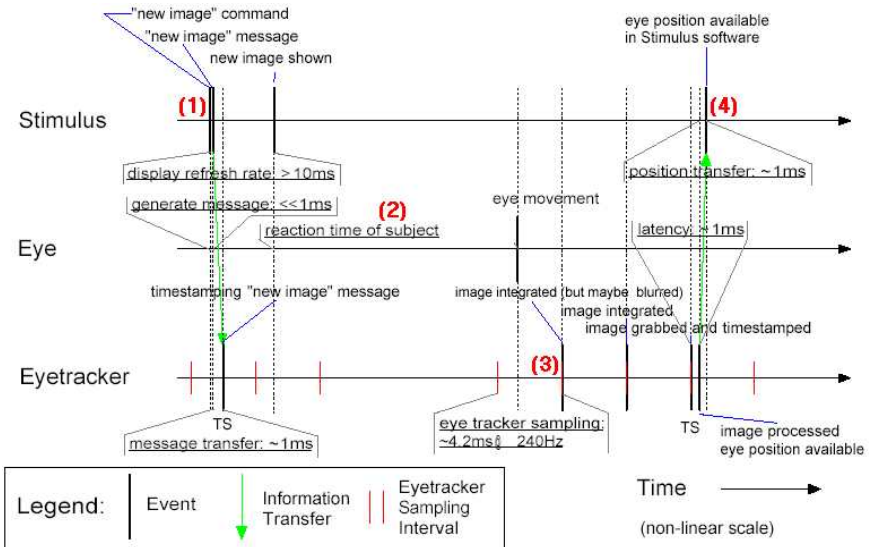
If the iView X Presentation Network Configurator succeeds in connecting to the iView X workstation, the LED next to the Send address will turn to green. Click on OK to close the Network Settings dialog.

If the eyetracker is started on the iView X workstation (camera gets images and is running) a message appears: "Eyetracker online."



This indicates that a successful connection has been established.

## 7.12 Timing of Stimulus and Eyetracker Events



iView X can be notified by stimulus presentation programs on which image is currently presented. The time of the notification will be stored in the iView data file. What happens between a stimulus change notification and an eye tracker event and how much time will pass? The above figure will give an overview.

(1) The stimulus presentation software sends a command to the eyetracker, when a new image is displayed. The eyetracker receives the command and timestamps it within the display refresh rate (typically 10-17 ms for 60-100 Hz).

(2) The test person needs a reaction time, before the eye starts to move. The reaction time may vary and will depend on the type of experiment.

(3) When the eye starts to move the image is grabbed and processed by the eyetracker within 2-3 samples.

(4) After the processing period the eyetracker provides eye position information, which is immediately available to the stimulus software.

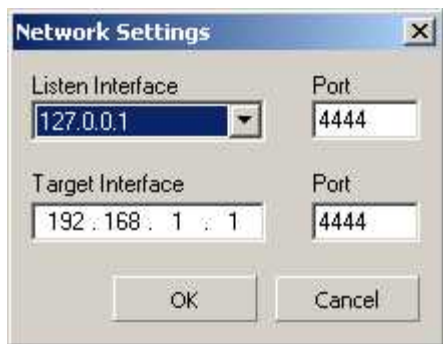
## 7.13 Tools


This chapter gives an overview of optional tools that may accompany iView X. Note, that **IDF utilities** are covered in a separate [chapter](#)<sup>[260]</sup>.

### 7.13.1 iRemote

iRemote is a useful tool to test the ethernet connection. See section [I/O Interfaces](#)<sup>[429]</sup> for details on how to use ethernet connection with iView X.

On first start up the following window will be presented:



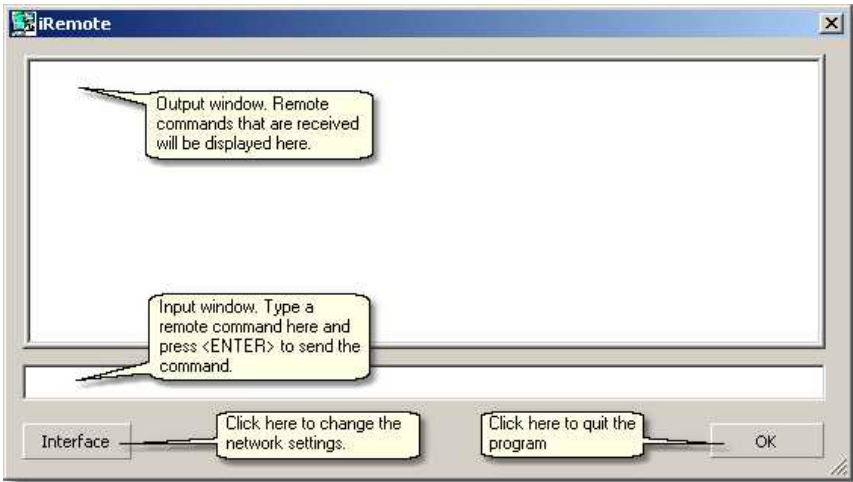
**Listening Interface:** Set the address of the computer on which this program is running. If you do not know the address, click on the drop down button  to see a list of choices. If your computer has been already assigned an own address, it will be listed here together with a default address (127.0.0.1). If in doubt ask your network administrator.

**Target Interface:** Set the address of the iView X workstation.

**Port:** In both cases port should be an unused port between 1024 and 65535.

Ports between 0 and 1023 are reserved.

This is the main window:



## 7.13.2 Remote Video

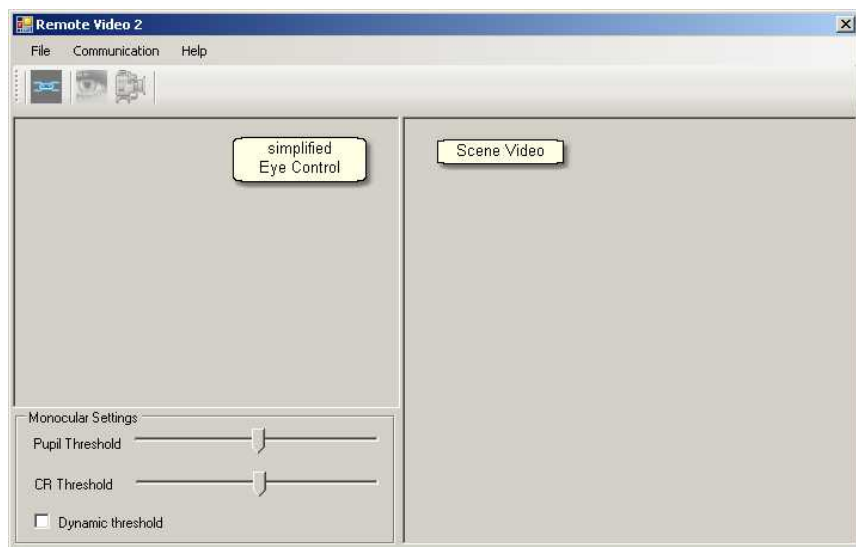
The eye and scene video of iView X can be transferred over network to a remote client PC. On the client PC the *Remote Video* tool is to be installed, with which you can see the eye and scene video.

The remote client PC is normally used to display a stimulus. The *Remote Video* tool enables you to setup the iView X eye and scene video while sitting in front of the stimulus PC.

The iView X workstation and the stimulus PC has to be connected over network.

### Main Window

If you start Remote Video on the client PC you get the following main window:



The main window consists of a simplified eye control, similar to the [iView X Eye Control](#)<sup>[342]</sup>, and a scene video window.

## Toolbar

The three buttons at the top mean the following:



opens network configuration dialog



starts eye video transfer




starts scene video transfer

## First Steps



To adjust eye and scene video do the following:

1. Setup your iView X system and the cameras, so the eye camera is directed at the test person's eye and the scene camera observes the scene in the test person's view of vision. iView X should be up and running on the iView X workstation.

2. Start Remote Video on the remote PC.

3. Click on the network configuration button . Setup [network connection](#) <sup>[404]</sup> of the remote PC.

4. Setup [network connection](#) <sup>[302]</sup> of iView X.

5. Click on the *start eye video* button  and the *start scene video* button  to start data transfer.

6. Setup [pupil and CR threshold](#) <sup>[404]</sup> while observing the eye video.

## Pupil and CR Threshold


Detection thresholds for pupil and corneal reflex (CR) can be set as follows:

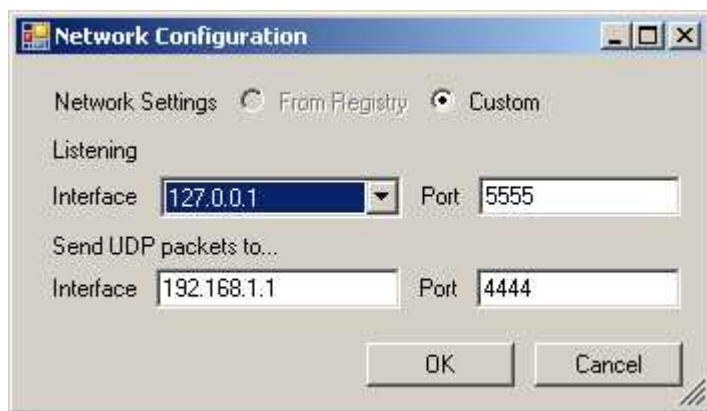
Move the pupil slider until a white cross-hair is visible in the eye control. The center of the cross-hair should be the center of the pupil.

Move the reflex slider until a black cross-hair is visible in the eye control. The center of the cross-hair should be the center of a bright dot near the center of the pupil.


*Dynamic Threshold:* If checked, the eyetracker automatically adapts the pupil threshold to slightly changing environments like small movements of the head, changing of light etc.

## Network Configuration

If you click on the network configuration button , you get the following dialog:





**Listening Interface:** Set the address of the computer on which this program is running. If you do not know the address, click on the drop down button  to see a list of choices. If your computer has been already assigned an own address, it will be listed here together with a default address (127.0.0.1). If in doubt ask your network administrator.

**Send UDP packets to Interface:** Set the address of the iView X workstation.

**Port:** In both cases port should be an unused port between 1024 and 65535.

Ports between 0 and 1023 are reserved.

### 7.13.3 WinCAL

WinCAL is a program to visualize calibration targets. It can be used to calibrate the iView X eyetracker. Typically, it will be installed on a different stimulus PC and be remotely controlled by the iView X eyetracker workstation.

See also [Calibration Processes](#) <sup>[245]</sup>.

For more details, please refer to the *WinCAL Documentation*.

### 7.13.4 Surveyor

The *Surveyor* software tool controls devices to measure the position and attitude of planes in a 3-dimensional space. It is used to survey the measurement model in [HED-MHT Experiments](#) <sup>[68]</sup>. Saves data to *planes.ini* and *iview.ini*.

## 7.14 WLAN connection

A stimulus PC and an iView X™ workstation can be connected over wireless local area network (WLAN).

The following describes how to setup a direct ad-hoc WLAN connection between two computers. WLAN over a wireless access point will not be covered here.



Once a WLAN connection is established, you can setup a TCP/IP connection between a program on the stimulus PC and iView X™ in the same way as you would do with an ethernet (cable-based, not-wireless) network.

### 7.14.1 Ad-hoc WLAN Setup Guide for WinXP



Please note that the following set of instructions may be different for some users due to their OS version and the chosen windows style.

#### Steps for both PCs

1. **Activate WLAN in BIOS:** If the WLAN device is built in, make sure it is enabled in the BIOS. (If you are not sure about it, ask your IT-Specialist, how to do it.)
2. **Switch on WLAN:** The WLAN device has a switch. In built-in systems there should be a switch at the computer case, which you have to set to the ON position. If it is on and if your PC (or laptop/tablet) has a small control display, there should appear a sign next to the battery status, indicating that WLAN is activated.

#### Steps for the first PC

Choose one PC as the first. It does not matter, which.

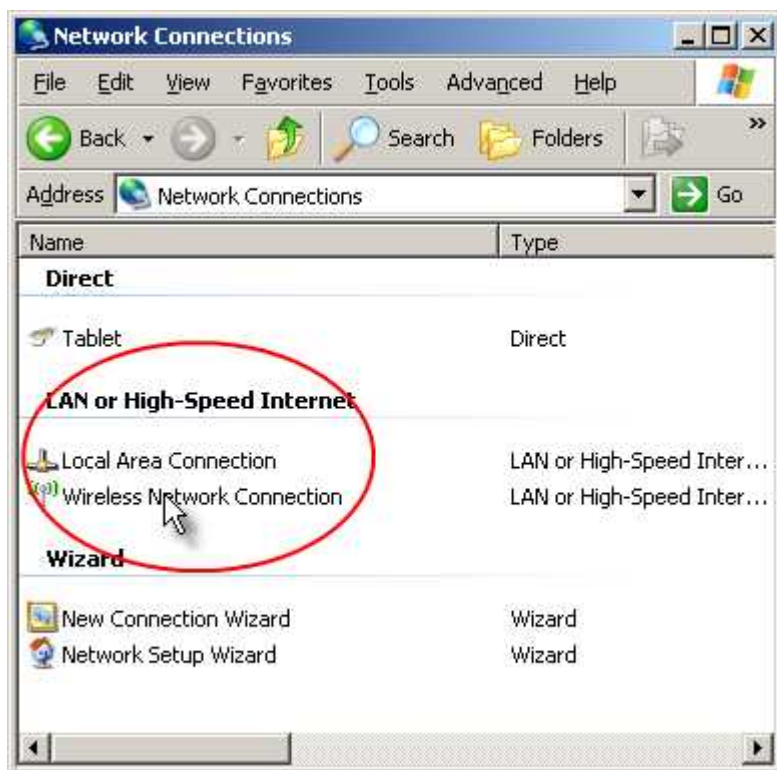
- Click on the *Start* button and continue to the *Control Panel* section of the Start menu:



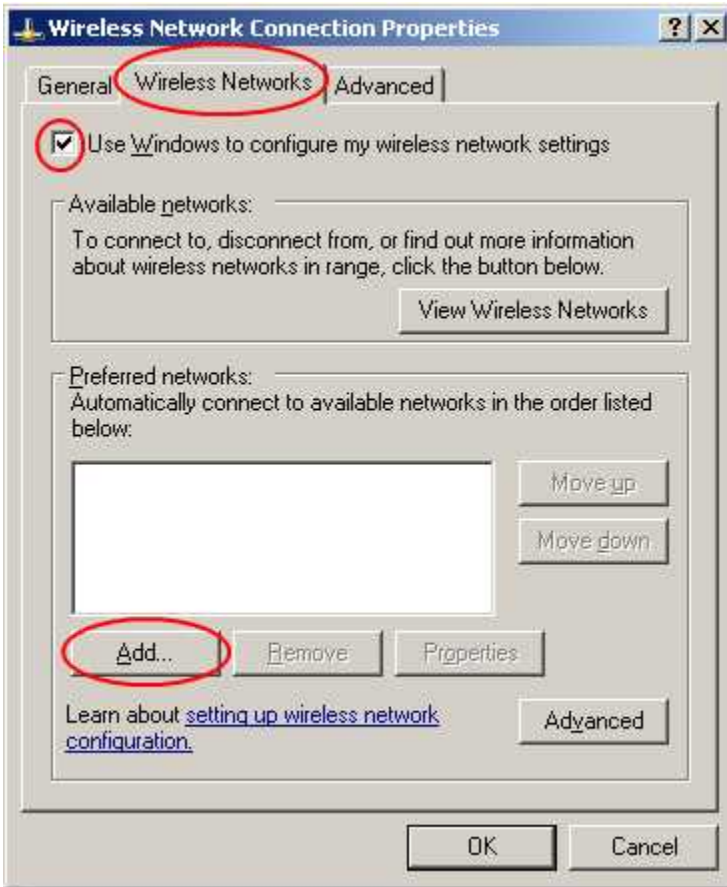
The *Control Panel* window will appear. In the Control Panel window find *Network Connections* and click on it.



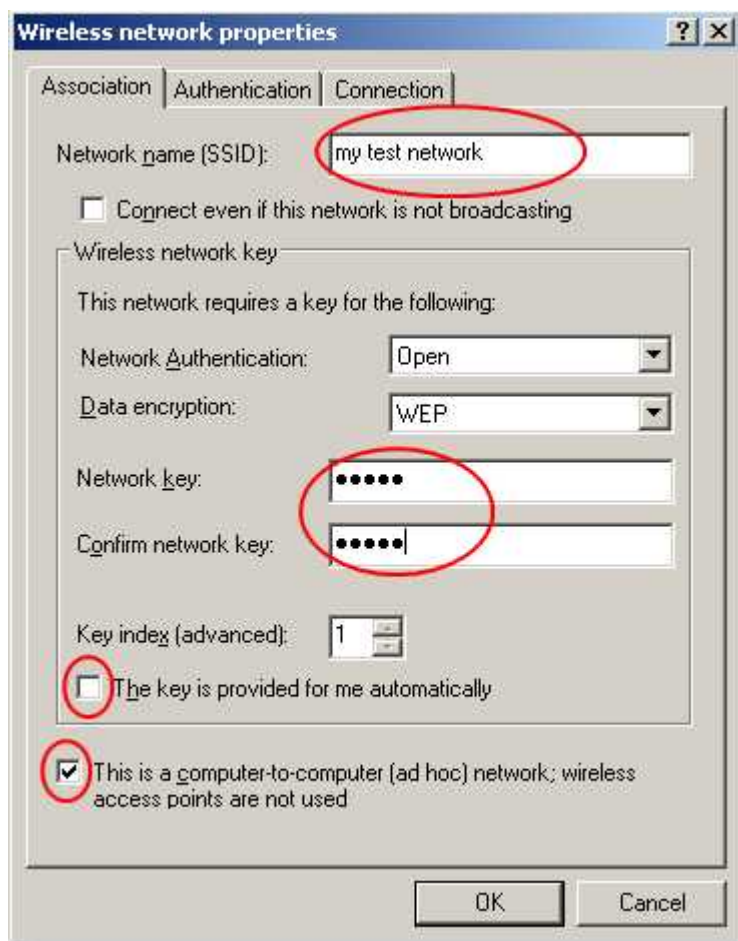
4. Right-click on *Wireless Network Connection*, go to *Properties*.



5. Go to the *Wireless Networks* tab.
6. Check *Use Windows to configure my wireless network settings*.
7. Click on *Add*.

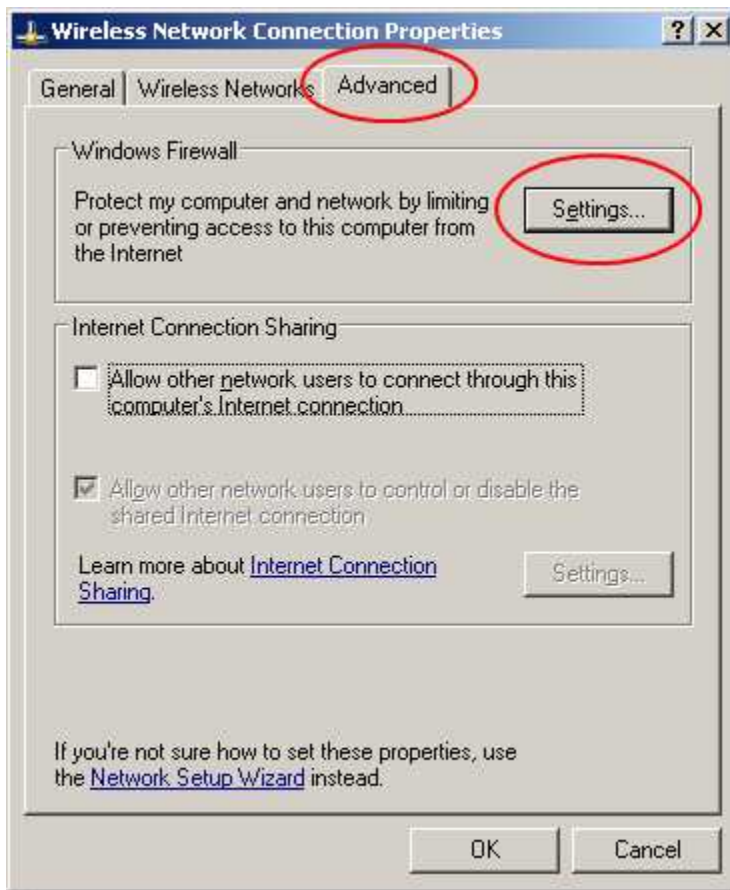


8. Write a network name.
9. Uncheck *The key is provided for me automatically*.
10. Write a network key, which you have to remember.
11. Check *This is a computer-to-Computer (ad hoc) network*.

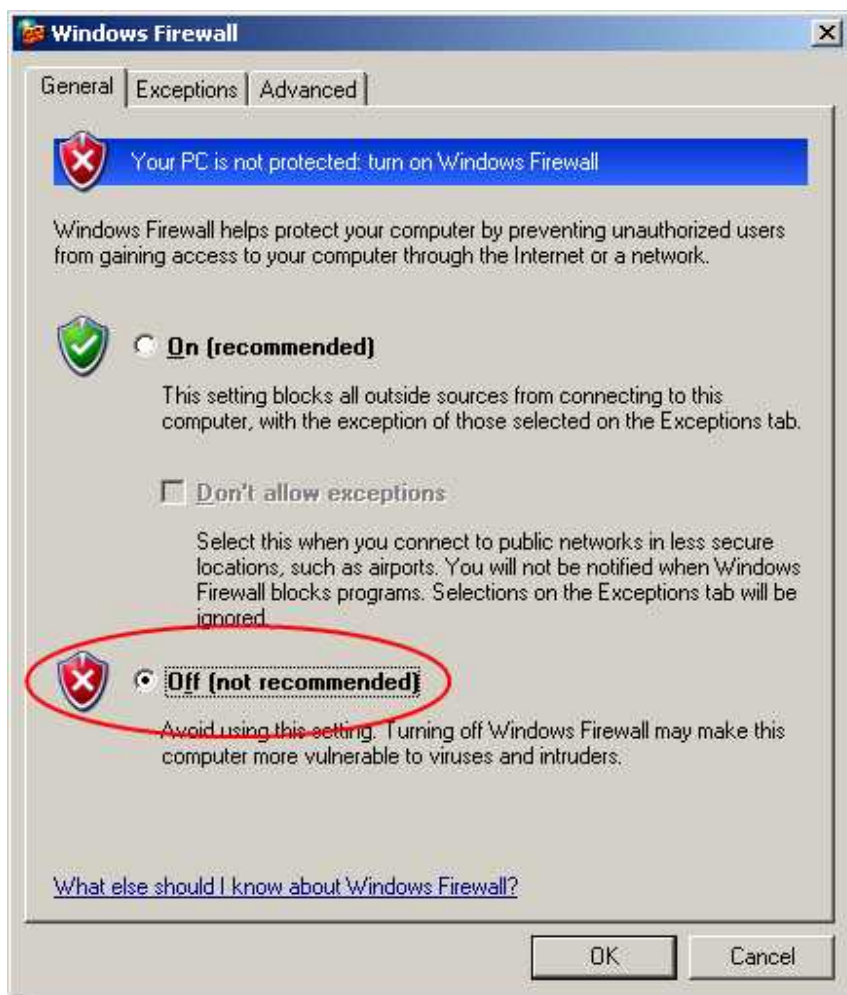


12. Click on OK.

13. Go to the *Advanced* tab.
14. Click on *Settings*.



15. Set firewall to *OFF*.

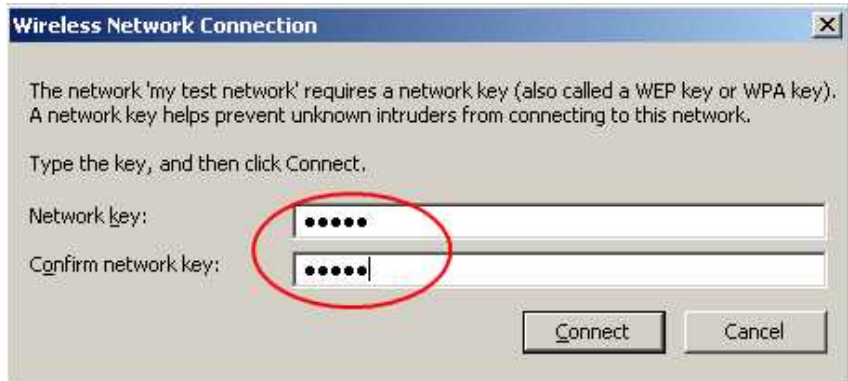


16. Accept all changes with *OK* and close all windows, so you see the window *Network Connections* again.

17. Left-click on *Wireless Network Connections*.

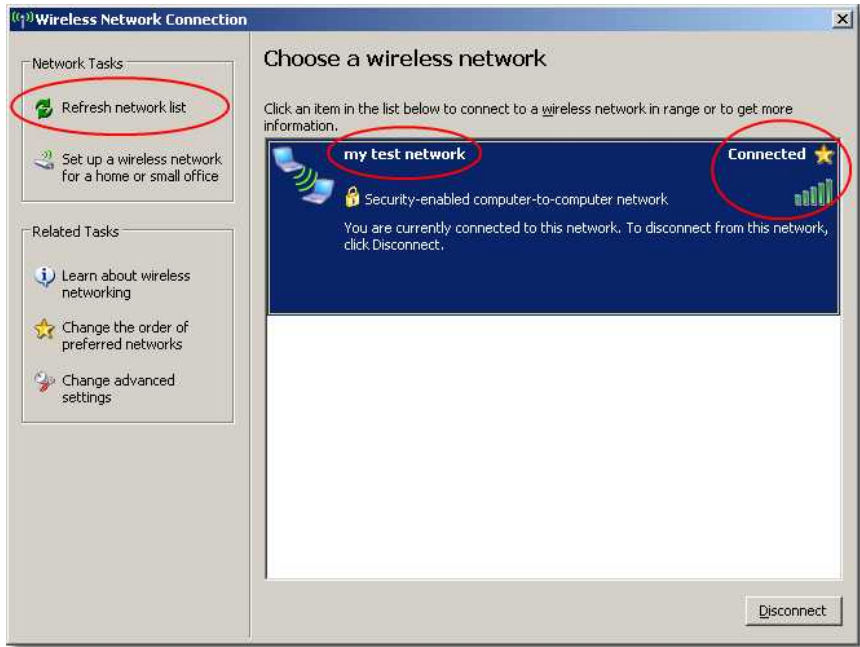


18. Click on *Refresh network list*.
19. Wait a while until your network with the name from step 8 is seen.
20. Double-click on it.
21. Enter the network key from step 10.



22. Click on connect.

23. Wait a while, at least a couple of minutes, until status is *Connected*.



## Steps for the second PC

24. Open *Control Panel* and click on *Network Connections*.



25. Left-click on *Wireless Network Connection*.



26. Repeat steps 18. - 23.

27. Both PCs show the *Connected* status.

Now both PCs are connected via the network you have just created.

Both computers have created IP addresses automatically. When connecting iView X with a remote application, make sure to select these automatically created IP addresses.

# System Interfaces

**Chapter**



## 8 System Interfaces

This chapter gives an overview of all currently used system interfaces.

The section [PC Boards](#)<sup>[417]</sup> deals with all boards and its connectors that can be used with the iView X system.

The section [I/O interfaces](#)<sup>[429]</sup> covers all possibilities for iView X interaction with other devices.

The [remote command](#)<sup>[438]</sup> interface is a set of commands, with which iView X can be remotely controlled by other computers.

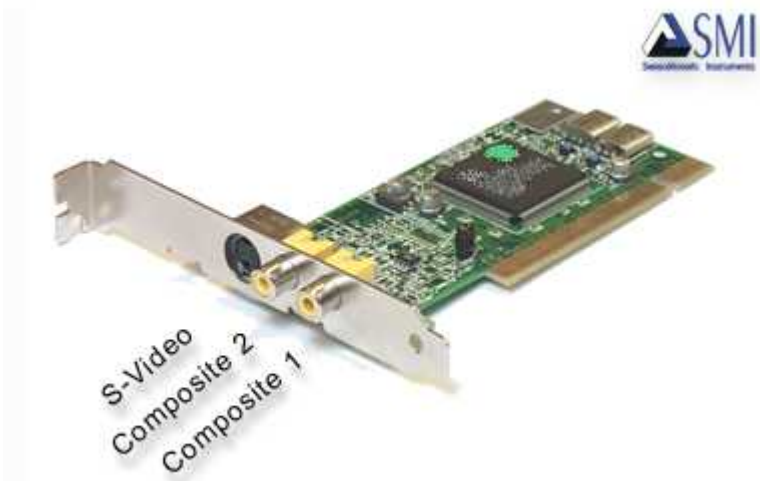
### 8.1 PC Boards

Dependent on the used eye tracking system various PC boards may be integrated into the iView X workstation. This chapter gives an overview of the boards with its various connections.

#### 8.1.1 Falcon Board



*For safety reasons do not connect or disconnect any components while the iView X computer is turned on!*



The Falcon board is the eyetracker frame grabber card. The video out connectors of the [MRI](#)<sup>[182]</sup> camera should be connected to one of the three connectors on the Falcon board.

After having connected everything, you have to tell the iView X system the current configuration. To do so go to the [Setup](#)<sup>[290]</sup> [Hardware](#)<sup>[290]</sup> dialog. Go to section **Eye Tracker** and select **Falcon** board. Also click on the [Advanced](#)<sup>[295]</sup> button to set the video input accordingly.

### 8.1.2 Grablink Board



*For safety reasons do not connect or disconnect any components while the iView X computer is turned on!*



The Grablink board is the eyetracker frame grabber card for [Hi-Speed](#)<sup>[129]</sup>. The data transmission is digital and, thus, lacks the quality losses typical for analog signal transmission.

One end of the *CamLink and power supply cable* must be connected to the camera, the other end to the CamLink interface of the Grablink board. See also [Hi-Speed wiring](#)<sup>[14]</sup>.

After having connected everything, you have to tell the iView X system the current configuration. To do so go to the [Setup](#)<sup>[290]</sup> [Hardware](#)<sup>[290]</sup> dialog. Go to section **Eye Tracker** and select **Grablink** board. Also click the [Advanced](#)<sup>[296]</sup> button to set the video input accordingly.

### 8.1.3 MPEG/Vidac Board



*For safety reasons do not connect or disconnect any components while the iView X computer is turned on!*

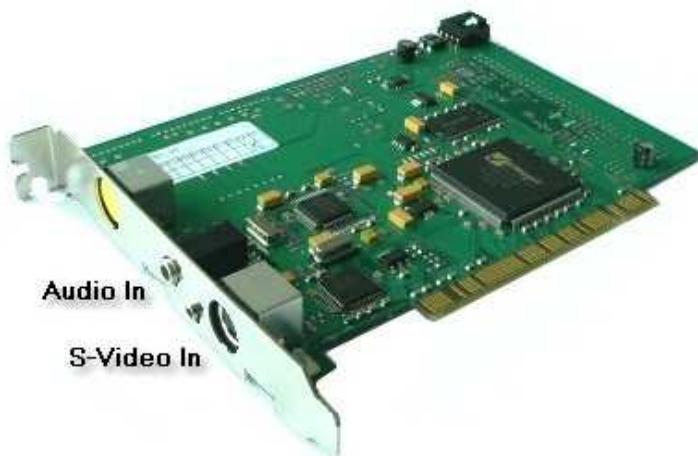
The MPEG Vidac board is an mpeg recording card with the following connectors:

- 2x S-Video In

- Audio In, 3.5 mm stereo cinch

Older versions may have a *Video In Composite* connector. If you upgrade iView X to a newer version, this board must be upgraded as well.

In current version only one *S-Video In* may be used. The second connector is covered:



The video out connector of the scene overlay card should be connected to the not covered S-Video input connector of the Vidac Board.

After having connected everything, the iView X software must be told the current configuration. To do this go to the [Setup](#) <sup>[290]</sup> [Hardware](#) <sup>[290]</sup> dialog. Go to section **Scene Video Compression** and select **Vidac**.



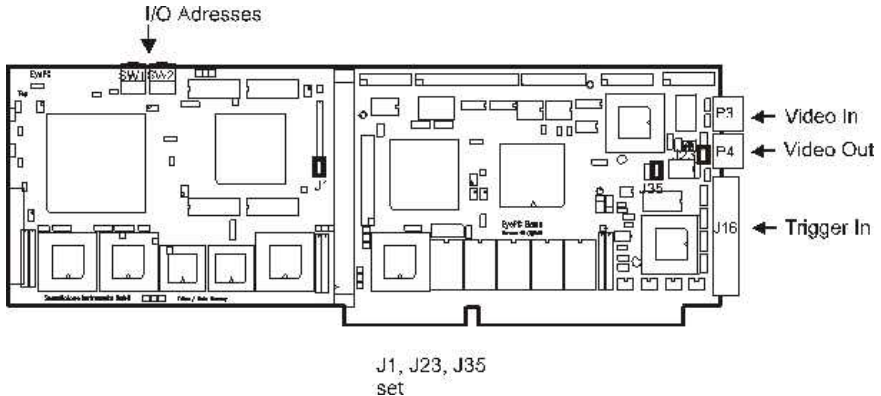
Currently recording time is limited to 2 h.



### 8.1.4 EyePC Board



*For safety reasons do not connect or disconnect any components while the iView X computer is turned on!*



The EyePC connectors are two female cinch plugs and one HD-SUB 44 female.

*Video In* should be connected to the video output of the eye camera.

*Video Out* should be connected to the red cinch connector of the Screen Machine cable.

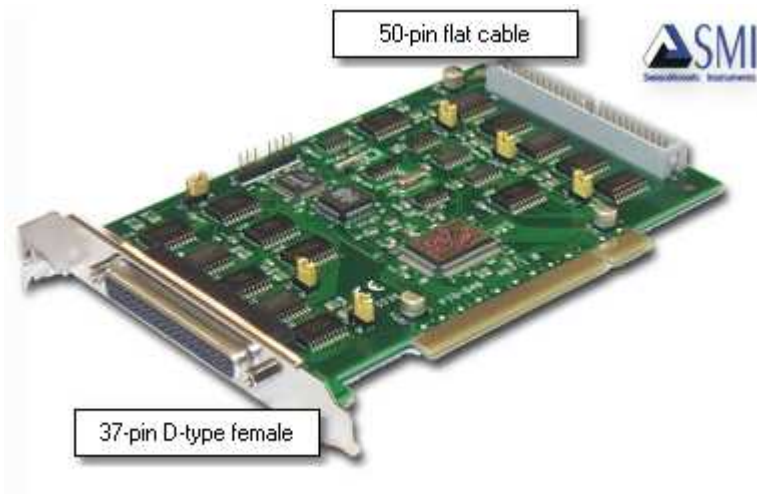
*Trigger In* is an optional connector for trigger signals.

For further details please refer to the *EyePC Installation Manual*.

### 8.1.5 Digital I/O Board



*For safety reasons do not connect or disconnect any components while the iView X computer is turned on!*



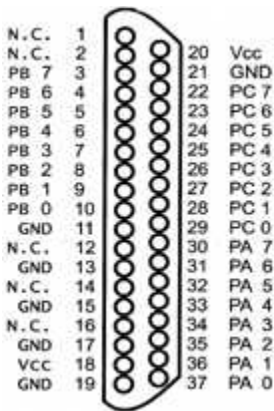
The Digital I/O card has 6 ports with 8 pins each, that means a total of 48 channels.

The card has two connectors, one is at the front of the card, and one is at the rear side.

iView X has 16 output and 16 input channels. The following describes the pin assignment.

### External 37-pin D-Sub female connector

The front external connector can be accessed by plugging in a 37-pin male connector. The 37-pin connector contains three ports, port 0, 1 and 2. The pin assignment is as follows:



Port A (**PA**) = Port 0 = iView Out  
 Port B (**PB**) = Port 1 = iView Out  
 Port C (**PC**) = Port 2 = iView In  
 GND = Ground

Port A and B is used for output signals, port C for input signals.

### Assignment iView Out

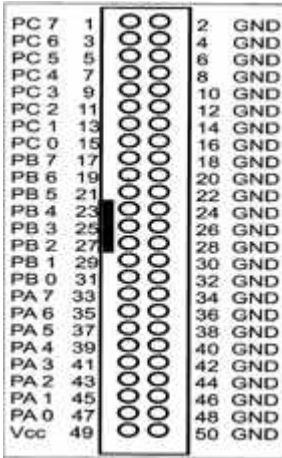
Pin No.	iView Channel No.	iView I/O
37	0	Out
36	1	Out
...	...	...
30	7	Out
10	8	Out
...	...	...
3	15	Out

### Assignment iView In

Pin No.	iView Channel No.	iView I/O
29	0	In
28	1	In
...	...	...
22	7	In

## Internal 50-pin flat cable connector

The internal 50-pin connector can only be accessed from the inside. It also contains three ports, port 3, 4 and 5. The pin assignment is as follows:



Port A (**PA**) = Port 3 = iView In  
 Port B (**PB**) = Port 4 = not assigned  
 Port C (**PC**) = Port 5 = not assigned  
 GND = Ground

Port A is used for input signals.

### Assignment iView In

Pin No.	iView Channel No.	iView I/O
47	8	In
45	9	In
...	...	...
33	15	In

### Jumper settings

The jumpers determine for each port, if they are set to high (5V) or to low.

If the jumpers are set to 1-2, port is set to high. If the jumpers are set to 2-3, port is set to low. By default, the jumpers are set to 2-3, so port is low. The default settings need not be changed in normal applications.

### Jumper-Port assignment

Port no.	Jumper
0	JP2
1	JP3
2	JP4
3	JP5
4	JP6
5	JP7

### Related topics

[Input via Digital I/O card](#)<sup>435</sup>

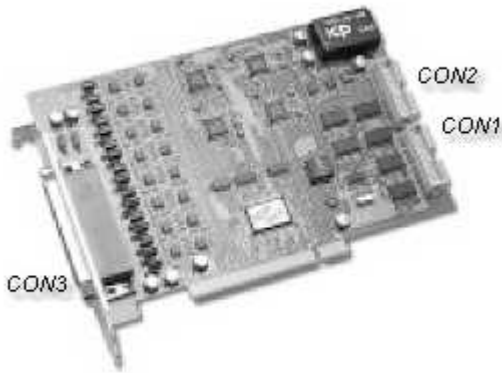
[Output via Digital I/O card](#)<sup>436</sup>

## 8.1.6 Analog Out Board



*For safety reasons do not connect or disconnect any components while the iView X computer is turned on!*

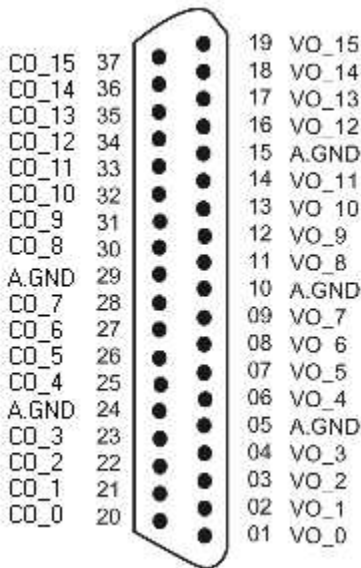
## PIO-DA4 Board



The PIO-DA4 board is a combined digital I/O and analog out board.

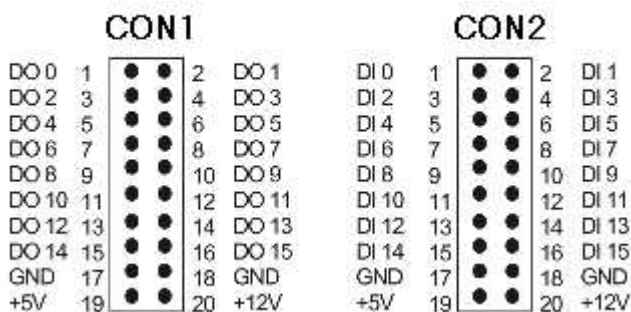
## Analog Out PIN Assignment CON3

The PIO-DA4 board CON3 is connected to a cable that provides 4 analog voltage output (VO) channels which can be assigned in the [Analog Output Configuration](#) <sup>[307]</sup>. The board provides also current output (CO).

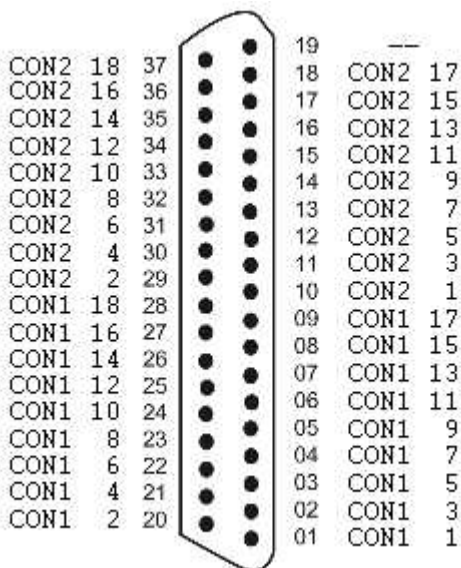


## Digital I/O PIN Assignment:

TTL output (DO) is provided at CON1, while TTL input (DI) is to be connected to CON2.



CON1 and CON2 are led to a 37-pin D-Sub female connector with the following assignment:





## PIO-DA4 Resolution & Pin-Out

The resolution of each range is given as follows

Configuration	Equivalent bit	Resolution
-10V ~ +10V	14bit	1.22mV
0V ~ +10V	13bit	1.22mV
-5V ~ +5V	13bit	1.22mV
0V ~ +5V	12bit	1.22mV
0mA ~ 20mA	13bit	2.70μA
4mA ~ 20mA	13bit	2.70μA

Related topics:

[Analog Out Option](#) <sup>[437]</sup>

[Analog Output Configuration](#) <sup>[307]</sup>

## 8.2 I/O Interfaces

iView X is capable of interacting with other computers by using various input/output options. This is useful if you want to synchronize 3rd party stimulus software with iView X.

There are several ways to communicate with other devices:

### Trigger Signals

Trigger or TTL signals can be send or received through various interfaces. See [Trigger Signals](#) <sup>[430]</sup>.

### Serial COM port

[Serial Input](#) <sup>[433]</sup>

[Serial Output](#) <sup>[433]</sup>

### Parallel LPT port

[Parallel Input](#)<sup>[434]</sup>  
[Parallel Output](#)<sup>[435]</sup>

## Digital IO card

[Input via Digital I/O card](#)<sup>[435]</sup>  
[Output via Digital I/O card](#)<sup>[436]</sup>

## Ethernet

[Ethernet Input](#)<sup>[436]</sup>  
[Ethernet Output](#)<sup>[437]</sup>

## Analog out card

[Analog Out Option](#)<sup>[437]</sup>

## 8.2.1 Trigger Signals

### Interfaces

iView X is capable of receiving TTL signals through

- [Parallel Input](#)<sup>[434]</sup> or
- [Input via Digital I/O card](#)<sup>[435]</sup>.

Depending on the interface iView X may receive up to 16 TTL signals on 16 lines at the same time.

### Shape

To be recognized as a trigger signal, the signal should comply with a certain [shape](#)<sup>[431]</sup>.

### Trigger Signal in IDF file

The trigger signals will be timestamped and recorded in the [IDF file](#)<sup>[260]</sup>. In the IDF export the trigger signals will build an additional *Trigger* column. The *Trigger* column will be exported, if you select *Show Trigger* under **Misc. Data** in the [Export Options](#)<sup>[262]</sup>. Additionally, you can select, if the

trigger signals should be represented as *hexadecimal* or *decimal* values.

## Trigger Signal Representation

The value in the *Trigger* column is either a *hexadecimal* or *decimal numerical representation* of the 16 lines of the digital input.

## Remote Control with Trigger Signals

The TTL signal can actually trigger something in iView. You can configure that always when a certain pin changes its state a certain command will be invoked or a message be written to the IDF file. Through this mechanism it is possible to remotely control iView X through trigger signals.

To configure this option go to [Setup](#) - [Hardware](#) - [Communication](#). The commands will be executed, if **Accept Trigger** is checked. Click on [Configure](#) next to **TTL IO**. In this dialog you can also see the status of all 16 lines.

Back to [I/O Interfaces](#).

### 8.2.1.1 Trigger Signal Shape

A trigger signal is an electrical low-voltage TTL signal.

#### Possible states:

Trigger high: 5 V  
Trigger low: 0 V

#### Duration:

The trigger signal should be at least 1.5 samples long depending on the used sample rate.

Examples:

sample rate	min. duration
50 Hz	30 ms
240 Hz	6 ms

### 8.2.1.2 Trigger Signal Representation

iView X can receive 16 TTL signals on 16 lines at the same time. The status of the 16 lines will be represented by a numerical value. You can choose, if iView X shows the value as a *hexadecimal* or *decimal* number.

#### Hexadecimal Representation

Each line can have a high or a low state (see [shape](#)<sup>[43†]</sup>). If high is represented as 1 and low as 0, a numerical representation for the status may be

```
1111111111111111
```

which, in this case, means that all lines are high. We call this a *binary* representation, because every place in this number can only take two values: 0 and 1.

We can better grasp the number if we group it in parts of four places each:

```
1111 1111 1111 1111
```

We can then represent the four-number-group 1111 with only one number, which must be capable to take  $2^3 = 16$  values. For this reason we call it a *hexadecimal* number. It can take the following 16 values: 0...9, A...F.

In the above example the hexadecimal representation of the all-lines-high-state is FFFF.

We can see that the hexadecimal number visually corresponds to the 16 lines of the digital input.

#### Decimal Representation

The number can be converted to a decimal number. We assume that H1 is the first place of the hexadecimal number, H2 the second place, H3 the third place etc. Then the conversion formula is:

$$H1 * 16^0 + H2 * 16^1 + H3 * 16^2 \dots$$

In our example FFFF hexadecimal equates to 65535 decimal.

## 8.2.2 Serial Input

The serial interface of the iView X system can be used to remotely control iView X. Just send a command string over the COM port.

To activate the COM port select **RS232** in the [Setup-Hardware Communication](#) <sup>[292]</sup> dialog under **Remote**.

Go to the [Config tab](#) <sup>[301]</sup> to select COM port and speed.

The remote control device can send a string via com port to iView X. Before iView X understands commands you first have to activate COM port reception by checking *Accept Remote Commands*.

For an overview of available commands see [Remote Command Reference](#) <sup>[438]</sup>.



You can test the serial port by using a terminal program, such as Microsoft's *HyperTerminal* to be found under *Start-Programs-Accessories-Communications*.

Back to [I/O Interfaces](#) <sup>[429]</sup>.

## 8.2.3 Serial Output

iView X is capable of sending commands via COM port. Optionally eye data can be sent together with the commands.

To activate the COM port select **RS232** in the [Setup-Hardware Communication](#) <sup>[292]</sup> dialog under **Remote**.

Go to the [Config tab](#) <sup>[301]</sup> to select COM port and speed.

As soon as the COM port is activated iView X starts sending command messages over the COM port, so the remote control device can interact. If you additionally want eye data being sent over the COM port you have

to check *Stream Data*.

For an overview of available commands see [Remote Command Reference](#)<sup>[438]</sup>.



You can test the serial port by using a terminal program, such as Microsoft's *HyperTerminal* to be found under *Start-Programs-Accessories-Communications*.

Back to [I/O Interfaces](#)<sup>[429]</sup>.

## 8.2.4 Parallel Input

To activate the LPT port select **Lpt IO** in the [Setup-Hardware Communication](#)<sup>[292]</sup> dialog under **TTL IO / Analog Out**.

### Digital input

The remote control device can send TTL trigger signals to iView X which are interpreted accordingly. To assign a command to a trigger signal click on [Config](#)<sup>[304]</sup>. Note that not all available commands can be assigned, only those that are given in the dialog box. To activate trigger reception check *Accept Trigger*.

Four lines of the LPT port can be used as input as given in the following table:

channel no.	pin no.
4	15
5	13
6	12
7	10

The other channels are ignored.

See also [Trigger Signals](#)<sup>[430]</sup>.

For an overview of available commands see [Remote Command Reference](#)<sup>[438]</sup>.

Back to [I/O Interfaces](#)<sup>[429]</sup>.

## 8.2.5 Parallel Output

To activate the LPT port select **Lpt IO** in the [Setup-Hardware](#)<sup>[290]</sup> [Communication](#)<sup>[292]</sup> dialog under **TTL IO / Analog Out**.

### Digital output

For interaction iView X can send a TTL trigger signal every time gaze data enters an [Area of Interest \(AOI\)](#)<sup>[371]</sup>. The signal is HIGH if the gaze position is inside of the AOI, and LOW if it is outside. To activate sending signals check *Send Trigger*.

Eight lines of the LPT port are used as output as given in the following table:

AOI no.	pin no.
1	2
2	3
...	...
8	9

Back to [I/O Interfaces](#)<sup>[429]</sup>.

## 8.2.6 Input via Digital I/O card

To activate digital I/O, a [Digital I/O Board](#)<sup>[421]</sup> must be installed.

Select the IO card in [Setup-Hardware](#)<sup>[290]</sup> [Communication](#)<sup>[292]</sup> dialog under **TTL IO / Analog Out**.

Up to 16 lines can be used as input.

See also [Trigger Signals](#)<sup>[430]</sup>.

For an overview of available commands see [Remote Command Reference](#) <sup>[438]</sup>.

Back to [I/O Interfaces](#) <sup>[429]</sup>.

## 8.2.7 Output via Digital I/O card

To activate digital I/O, a [Digital I/O Board](#) <sup>[421]</sup> must be installed.

Select the IO card in [Setup-Hardware](#) <sup>[290]</sup> [Communication](#) <sup>[292]</sup> dialog under **TTL IO / Analog Out**.

### Digital output

For interaction iView X can send a TTL trigger signal every time the gaze data enters an [Area of Interest \(AOI\)](#) <sup>[371]</sup>. iView X must have a digital IO card installed to send signals. The signal is HIGH if the gaze position is inside of the AOI, and LOW if it is outside. See also: [TTL Output](#) <sup>[305]</sup>. To activate sending signals check *Send Trigger*.

Back to [I/O Interfaces](#) <sup>[429]</sup>.

## 8.2.8 Ethernet Input

The network interface of the iView X system can be used to remotely control iView X.

To activate this feature select **Ethernet** in the [Setup-Hardware](#) <sup>[290]</sup> [Communication](#) <sup>[292]</sup> dialog under **Remote**.

Go to the [Config tab](#) <sup>[302]</sup> to set ethernet address and port.

The remote control device can send a string via Ethernet to iView X. Before iView X understands commands you first have to activate reception by checking *Accept Remote Commands*.

For an overview of available commands see [Remote Command Reference](#) <sup>[438]</sup>.





You can test the ethernet connection using the [iRemote](#) tool.

Back to [I/O Interfaces](#).

## 8.2.9 Ethernet Output

iView X is capable of sending commands via Ethernet. Optionally eye data can be sent together with the commands.

To activate this feature select **Ethernet** in the [Setup-Hardware Communication](#) dialog under **Remote**.

Go to the [Config tab](#) to set ethernet address and port.

As soon as the port is activated iView X starts sending command messages over the network, so the remote control device can interact. If you additionally want eye data being sent you have to check *Stream Data*.

For an overview of available commands see [Remote Command Reference](#).



You can test the ethernet connection using the [iRemote](#) tool.

Back to [I/O Interfaces](#).

## 8.2.10 Analog Out Option

If you purchased iView X with Analog Out option, gaze position, raw pupil and diameter data can be converted into analog voltage values and is then available as input for external voltage controlled devices, such as plotters etc. The analog signals are accessible through BNC connectors of the break-out cable which is connected to the D-sub 37 connector of the board.

To use this option, an [Analog Out Board](#) must be installed. Go to

[Setup-Hardware](#) <sup>[290]</sup> [Communication](#) <sup>[292]</sup> and select *PIO DA* under **TTL IO / Analog Out**.

To configure Analog Out click on [Config](#) <sup>[307]</sup>.

To enable data output check *Activate Output*.

Back to [I/O Interfaces](#) <sup>[429]</sup>.

## 8.3 Remote Commands

The remote command interface is an OS-independent, language-independent, protocol-oriented programming interface.

It consists of a set of commands, with which iView X can be controlled by other computers.

The following describes the command format and gives an overview of available commands.

### 8.3.1 General Command Format

Only standard ASCII characters are used for the remote control command set. All remote control commands start with "ET\_" followed by 3 more characters which indicate the associated action. Optional parameters may follow, separated by a single blank character (20h) each. The command is completed by a line feed (LF = 0x0A = '\n') character. Command execution starts directly after one of the terminating characters is received.

### 8.3.2 Remote Command Reference

Overview of available commands:

	Calibration
<a href="#">ET_CAL</a> <sup>[443]</sup>	Starts <a href="#">calibration</a> <sup>[18]</sup> .
<a href="#">ET_ACC</a> <sup>[442]</sup>	Accepts calibration point.

<a href="#">ET_BRK</a> <sup>443</sup>	Cancels calibration.
<a href="#">ET_CHG</a> <sup>444</sup>	Indicates calibration point change.
<a href="#">ET_CPA</a> <sup>446</sup>	Sets and gets calibration parameters
<a href="#">ET_CSZ</a> <sup>447</sup>	Sets size of calibration area.
<a href="#">ET_DEF</a> <sup>448</sup>	Resets calibration points to default positions.
<a href="#">ET_FIN</a> <sup>451</sup>	Notifies end of calibration.
<a href="#">ET_LEV</a> <sup>457</sup>	Sets check level for calibration.
<a href="#">ET_PNT</a> <sup>458</sup>	Sets position of calibration point.
<a href="#">ET_RCL</a> <sup>459</sup>	Starts <a href="#">drift correction</a> <sup>289</sup> .
<a href="#">ET_VLS</a> <sup>468</sup>	Validates calibration accuracy.
<a href="#">ET_VLX</a> <sup>468</sup>	Starts extended calibration validation.
<a href="#">ET_RES</a> <sup>460</sup>	Request calibration results.
<a href="#">ET_CPL</a> <sup>446</sup>	Notifies calibration samples.
<a href="#">ET_LOC</a> <sup>457</sup>	Loads a calibration file.
<a href="#">ET_SAC</a> <sup>461</sup>	Saves a calibration to file.

	<b>Eye data recording</b>
<a href="#">ET_REC</a> <sup>459</sup>	Starts data recording.
<a href="#">ET_CNT</a> <sup>445</sup>	Continues recording after pause.
<a href="#">ET_INC</a> <sup>456</sup>	Increments trial number during recording.
<a href="#">ET_PSE</a> <sup>459</sup>	Pauses data recording.
<a href="#">ET_STP</a> <sup>466</sup>	Stops data recording.

<a href="#">ET_AUX</a> <sup>442</sup>	Stores auxiliary data.
<a href="#">ET_CLR</a> <sup>445</sup>	Clears internal data buffer.
<a href="#">ET_REM</a> <sup>460</sup>	Sends a remark to the data buffer.
<a href="#">ET_SAV</a> <sup>462</sup>	Saves data buffer to a data file.

	<b>Video recording commands</b>
<a href="#">ET_VRE</a> <sup>469</sup>	Starts video recording.
<a href="#">ET_VST</a> <sup>470</sup>	Stops video recording.
<a href="#">ET_VCL</a> <sup>467</sup>	Clears video buffer.

<a href="#">ET_VSV</a> <small>470</small>	Saves video buffer to file.
---	-----------------------------

<b>Data output (streaming)</b>	
<a href="#">ET_STR</a> <small>466</small>	Starts data streaming.
<a href="#">ET_EST</a> <small>450</small>	Stops data streaming.
<a href="#">ET_FRM</a> <small>454</small>	Sets format for data output.
<a href="#">ET_SPL</a> <small>464</small>	Notifies data sample generation.

<b>Eye video image commands</b>	
<a href="#">ET_SIM</a> <small>464</small>	Starts eye video transfer.
<a href="#">ET_EIM</a> <small>448</small>	Stops eye video transfer.
<a href="#">ET_IMG</a> <small>455</small>	Notifies eye video image transfer.
<a href="#">ET_EVB</a> <small>449</small>	Starts eye image recording.
<a href="#">ET_EVE</a> <small>450</small>	Stops eye image recording.
<a href="#">ET_EQE</a> <small>448</small>	Records eye images during RED calibration.

<b>Scene video image commands</b>	
<a href="#">ET_SSV</a> <small>465</small>	Starts scene video transfer.
<a href="#">ET_ESV</a> <small>451</small>	Stops scene video transfer.
<a href="#">ET_SVF</a> <small>467</small>	Notifies scene video image transfer.

<b>Online Fixation Detection</b>	
<a href="#">ET_FIX</a> <small>451</small>	Starts online fixation detection.
<a href="#">ET_EFX</a> <small>448</small>	Stops online fixation detection.

<b>Other commands</b>	
<a href="#">ET_AAD</a> <small>441</small>	Auto Adjustment for hi-speed devices ( $\geq 500$ Hz)
<a href="#">ET_BED</a> <small>442</small>	Requests or changes binocular eye distance for hi-speed devices ( $\geq 500$ Hz).
<a href="#">ET_BMP</a> <small>443</small>	Loads Windows bitmap file.
<a href="#">ET_CFG</a>	Shows system configuration.

<a href="#">444</a>	
<a href="#">ET_EXE</a>	Executes an application.
<a href="#">451</a>	
<a href="#">ET_INF</a> <a href="#">456</a>	Returns information on the current used eye tracker.
<a href="#">ET_PNG</a>	Tests whether iView X is reachable.
<a href="#">457</a>	
<a href="#">ET_SFT</a>	Controls eye tracker parameters
<a href="#">463</a>	
<a href="#">ET_STI</a> <a href="#">466</a>	Sets the default directory for stimulus images.
<a href="#">ET_SRT</a>	Returns current sample rate.
<a href="#">465</a>	
<a href="#">ET_SRP</a>	Requests information about RED
<a href="#">464</a>	

### Realtime and non-realtime commands

The following commands are processed in *real time*:

- [ET\\_INC](#) [456](#) Increments trial number.
- [ET\\_REM](#) [460](#) Sends a remark to the data buffer.

All other *non real time* commands will be put in a message queue and will be processed consecutively. A delay of 10 ms or less may be possible.

#### 8.3.2.1 ET\_AAD

Available only for [Hi-Speed](#) [129](#) systems with a sampling rate of 500 Hz or higher.

If sent, an automatic adjustment process will be started, in which the camera image will be balanced and the pupil detection threshold will be set.

Parameters: none

Success: ET\_AAD after automatic adjustment process has been completed.

[Back to overview](#) [438](#).

### 8.3.2.2 ET\_ACC

Accepts the current calibration point during the calibration process, and switches to the next calibration point. Returns the number of the next calibration point if successful. Available only during calibration.

Parameters: none

Success: ET\_CHG next\_cal\_point#

The command is sent by iView everytime a calibration point is accepted during calibration, either manually by the user or automatically.

[Back to overview](#)<sup>438</sup>.

### 8.3.2.3 ET\_AUX

Puts a message into the data buffer (same as [ET\\_REM](#)<sup>460</sup>). Only included for compatibility reasons.

Parameters: aux\_data (string)

Example:

```
ET_AUX "hello world"
```

[Back to overview](#)<sup>438</sup>.

### 8.3.2.4 ET\_BED

Requests or changes binocular eye distance for hi-speed devices.

Parameters: value

Example:

```
ET_BED 10
```

[Back to overview](#)<sup>438</sup>.

### 8.3.2.5 ET\_BMP

Loads a bitmap file (.BMP) from a drive and displays it in the scene view. If no path is given, iView will search the images in a default directory. The default directory can be set with the [ET\\_STI](#)<sup>[466]</sup> command.

Example with path:

```
ET_BMP "C:\My Files\Pictures\image01.bmp"
```

Example without path:

```
ET_BMP "image01.bmp"
```

[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.6 ET\_BRK

Cancels the calibration procedure.

Parameters: none

Success:

```
ET_BRK
```

The command is sent by iView everytime a calibration is cancelled.

[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.7 ET\_CAL

Starts a calibration. Returns calibration information if successful.

Parameters:

```
2:    2-point  
5:    5-point  
9:    9-point  
13:   13-point
```

Optional parameter only for binocular mode:

```
1:    right eye  
2:    left eye
```

Success:

```
ET_CAL n
ET_CSZ x y
ET_PNT i xi yi (for all calibration points)
ET_CHG current_cal_point
```

Examples:

```
ET_CAL 9
ET_CAL 13 2
```

The command is sent by iView everytime a calibration is started.

[Back to overview](#) <sup>438</sup>

### 8.3.2.8 ET\_CFG

Shows the current system configuration, including calibration type, position of calibration points, size of calibration area etc.

Parameters: none

Success:

```
ET_CAL n
ET_CSZ x y
ET_PNT i xi yi (for all calibration points)
```

[Back to overview](#) <sup>438</sup>

### 8.3.2.9 ET\_CHG

Indicates calibration point change. Available only during calibration.

Parameters: cal\_point\_number

Success:

```
ET_CHG cal_point
```

The command is sent by iView everytime the system changes between calibration points.



[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.10 ET\_CLR

Clears the internal data buffer.

Parameters: none

Success:

```
ET_CLR
```

The command is sent by iView everytime the user creates a new file. You can send this command to iView to clear the internal buffer. This command cannot be sent during recording.

[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.11 ET\_CNT

Continues a recording without incrementing the trial number. Available only when recording is paused.

**Optional parameter:** text

**Example:**

```
ET_CNT "any text "
```

iView X will send ET\_REC back and generates the following message in the data file:

```
<Timestamp>      MSG # Message: any text
```

**Success:**

```
ET_REC
```

See also:

[ET\\_REM](#)<sup>[460]</sup>

[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.12 ET\_CPA

Sets and gets calibration parameters.

**Parameters:** *parameter type, state*

with

*parameter type:*

- 0: wait for valid data
- 1: randomize point order
- 2: auto accept

*state:*

- 0: off
- 1: on

**Example:**

```
ET_CPA 1 1
```

**Result:**

Switches on "Randomize point order" and returns current status.

**Example:**

```
ET_CPA 1
```

**Result:**

Returns current status of "Randomize point order".

[Back to overview](#)<sup>[435]</sup>

### 8.3.2.13 ET\_CSP

Send by iView X after an [ET\\_RES](#)<sup>[460]</sup> command is received. ET\_CSP notifies the gaze data acquired for a specific calibration point.

**Parameters:** *timestamp, eye\_type, x, y*

with

<i>timestamp</i> :	timestamp at which the gaze point is taken
<i>eye type</i> :	eye type information, possible values: l: left r: right b: binocular
<i>x</i>	x gaze data for monocular data x (left), x (right) for binocular data
<i>y</i>	y gaze data for monocular data y (left), y (right) for binocular data

If data is binocular, the data is doubled for left and right pupil. First left x and right x data, then left y and right y data will be sent.

### 8.3.2.14 ET\_CSZ

Sets the size of the calibration area.

**Parameters:**

*sizeX sizeY*

**Success:**

ET\_CSZ *sizeX sizeY*

The command is sent by iView X when the size of the calibration area is changed.

**Example:**

ET\_CSZ 800 600

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### 8.3.2.15 ET\_DEF

Sets all calibration points to default positions.

Parameters: none

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### 8.3.2.16 ET\_EFX

If sent to iView X: Stops online fixation detection. This function does not take parameters.

If sent by iView X: Announces end of current detected fixation. This command is followed by a list of result values. See [ET\\_FIX](#) <sup>451</sup> for details.

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### 8.3.2.17 ET\_EIM

Ends transfer of mime-encoded eye video images. The transfer is started with the [ET\\_SIM](#) <sup>464</sup> command, after which iView X sends [ET\\_IMG](#) <sup>455</sup> with the images.

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### 8.3.2.18 ET\_EQE

Performs [eye image recording for quality evaluation](#) <sup>389</sup>. The eye images are recorded during a [RED](#) <sup>101</sup> calibration.

#### Syntax

ET\_EQE

ET\_EQE 0

ET\_EQE 1

#### Meaning

requests current state

disables recording

enables recording

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### 8.3.2.19 ET\_EVB

Starts eye image recording. Recording will be stopped with [ET\\_EVE](#)<sup>[450]</sup>.

#### Syntax:

```
ET_EVB IFT filename
ET_EVB IFT filename path
ET_EVB IFT filename path duration
```

with

#### IFT:

Image file type. It can have one of the values:

IFT	file type that will be created
0	JPG
1	BMP
2	XVID
3	HUFFYUV
4	ALPARY
5	XMP4

#### filename:

File base name. File name containing spaces must be in quotation marks. After the base name the following information will be automatically added to the file name, separated with an underline "\_":

- . image number
- . offset (x component)
- . offset (y component)
- . size in pixels (x component)
- . size in pixels (y component)
- . timestamp

If no path is given, eye images will be saved in the *eyeImages* subfolder of the iView X installation directory.

**path:**

Path in which the eye images are stored. Paths containing spaces must be in quotation marks.

- . If a path without a drive letter is given, the path will be created as a subdirectory of the iView X installation directory.
- . If the path starts with a drive letter, it is regarded as the full path in which the eye images are saved.

**duration:**

Duration in [ms] of the recording. After the duration time has elapsed recording stops automatically and iView X sends an ET\_EVE.

- . Without a duration given, the images will be immediately recorded to hard disk. Image loss is possible.
- . If a duration is given recording will be buffered. No images will be lost.

**Examples:**

```
ET_EVB 0 my_file
ET_EVB 0 "my file" "my path"
ET_EVB 0 "my file" "C:\my path" 10000
```

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**8.3.2.20 ET\_EVE**

Stops eye image recording. Recording will be started with [ET\\_EVB](#) <sup>449</sup>.

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**8.3.2.21 ET\_EST**

Stops continuous data output (streaming).

Parameters: none

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### 8.3.2.22 ET\_ESV

Stops transfer of compressed scene video image. The transfer is started with the [ET\\_SSV](#)<sup>[465]</sup> command, after which iView X sends [ET\\_SVF](#)<sup>[467]</sup> with the images.

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### 8.3.2.23 ET\_EXE

Executes an application.

Example:

```
ET_EXE "MyApplication.exe"
```

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### 8.3.2.24 ET\_FIN

The command is sent by iView X when a calibration has finished successfully.

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### 8.3.2.25 ET\_FIX

Starts online fixation detection. To stop fixation detection use [ET\\_EFX](#)<sup>[448]</sup>.

**Parameters:** duration dispersion

duration : minimum fixation duration in [ms]  
dispersion : maximum dispersion in [px] or [°deg].  
Data unit is [px] for non head tracking systems and [°deg] for head tracking systems.

**Example:** ET\_FIX 300 20

**Result Values:**

ET\_FIX eye posX posY

If a start of a fixation is detected, iView X returns ET\_FIX with a list of result values. This message is sent at least *duration* ms after the actual start of the fixation.

eye: eye type, l or r  
 posX,  
 posY: x,y coordinate of mean gaze position between start of fixation and current point in time in [px]

ET\_EFX eye duration posX posY

If the end of a current fixation is detected, iView X returns ET\_EFX with a list of result values.

eye: eye type, l or r  
 duration: total duration of fixation in [ms]  
 posX,  
 posY: mean gaze position between start and end of fixation in [px|mm] . If no plane was hit, this value is (0,0).

**Result Values (head tracking):**

ET\_FIX eye eyeBallX eyeBallY eyeBallZ gazeVec0  
 gazeVec1 gazeVec2 posX posY plane

If a start of a fixation is detected, iView X returns ET\_FIX with a list of result values. This message is sent at least *duration* ms after the actual start of the fixation.

eye: eye type, l or r  
 eyeBallX,



eyeBallY,  
eyeBallZ: mean eyeball position between start of fixation and current point in time in [mm]  
gazeVec0  
gazeVec1  
gazeVec2: mean gaze vector between start of fixation and current point in time  
posX,  
posY: mean gaze position between start of fixation and current point in time in [mm]. If no plane was hit, this value is (0,0).  
plane: number of plane. If no plane was hit, this value is -1

ET\_EFX eye duration eyeBallX eyeBallY eyeBallZ  
gazeVec0 gazeVec1 gazeVec2 posX posY plane

If the end of a current fixation is detected, iView X returns ET\_EFX with a list of result values.

eye: eye type, l or r  
duration: total duration of fixation in [ms]  
eyeBallX,  
eyeBallY,  
eyeBallZ: mean eyeball position between start and end of fixation in [mm]  
gazeVec0  
gazeVec1  
gazeVec2: mean gaze vector between start and end of fixation  
posX,  
posY: mean gaze position between start and end of fixation in [mm]. If no plane was hit, this value is (0,0).  
plane: number of plane. If no plane was hit, this value is -1

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### 8.3.2.26 ET\_FRM

Sets data format for data output. The syntax is similar to the 'C' string formatting syntax. The format specification string is enclosed in quotation marks. Each format specifier is marked by a preceding percentage (%) symbol.

Parameters: format\_string

Format specifiers:

- TS: timestamp in milliseconds (0 ... $2^{64}$ /1000 ms)
- TU: timestamp in microseconds (0 ... $2^{64}$   $\mu$ s)
- DX, DY: pupil diameter (0 ... $2^{32}$  pixels) x 32
- PX, PY: pupil position ( $\pm 2^{31}$  pixels) x 32
- CX, CY: corneal reflex position ( $\pm 2^{31}$  pixels) x 32
- SX, SY: gaze position ( $\pm 2^{31}$  pixels)
- SC: scene counter
- ET: eye type information, possible values:  
l: left  
r: right  
b: binocular

for Head Tracking only:

- EX, EY, EZ: eye position ( $\pm 99.999$  mm) relative to the transmitter cube
- GX, GY, GZ: normalized gaze vector ( $\pm 1.000000$ )
- HX, HY, HZ: head position ( $\pm 99.999$  mm) relative to the transmitter cube
- HA, HE, HR: head rotation ( $\pm 180.00^\circ$ ) given in degrees as azimuth (A), elevation (E) and roll (R).
- IP: plane number that was hit by the gaze (1...16)

for RED 4 (FireWire) systems only:

- PD: returns pupil diameter for left and right eye in [mm] and a validity value (1 = valid, 0 = not valid)  
result: ET\_SPL LeftDiameter RightDiameter Validity

If data is binocular, the data is doubled for left and right pupil. First left x and right x data, then left y and right y data will be sent.

Example for monocular data:

```
ET_FRM "%TS: %SX, %SY"
```

Result:

```
ET_SPL 28437864110: 400, 202
```

Example for binocular data:

```
ET_FRM "%ET %SX %SY"
```

Result:

```
ET_SPL b 399 398 200 199
```

where the data output is as follows:

eye type binocular, left SX, right SX, left SY, right SY

See also [ET\\_SPL](#)<sup>[464]</sup>.

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### 8.3.2.27 ET\_IMG

Sent by iView X with single mime-encoded eye video images, after the [ET\\_SIM](#)<sup>[464]</sup> command has been received.

Transfer will be stopped when iView X receives the [ET\\_EIM](#)<sup>[448]</sup> command.

**Parameters:** width height data

width,

height : eye image size in pixel

data : image data

**Example:**

```
ET_IMG 384 288 <data>
```

[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.28 ET\_INC

Increments trial number during recording. If recording is not running, the command is inactive. Returns new trial number if successful.

Parameters: none

Success:

```
ET_INC <new trial number>
```

The command is sent by iView X every time the trial number is incremented.

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### 8.3.2.29 ET\_INF

Returns information on the current used eye tracker.

#### Syntax

```
ET_INF ver
```

```
ET_INF dev
```

#### Result

version number: major.minor.build

device name

*Device name* can be one of the following:

- Hi-Speed
- Hi-Speed Primate
- HED 4 (USB)
- RED
- MRI-LR
- MRI-SV
- MRI-NNL
- Custom

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### 8.3.2.30 ET\_LEV

Sets check level for calibration. Returns the new check level if successful.

Parameters:

- 0: none
- 1: weak
- 2: medium
- 3: strong

Success:

```
ET_LEV <new check level>
```

Example:

```
ET_LEV 2
```

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### 8.3.2.31 ET\_LOC

Loads a calibration file.

Example:

```
ET_LOC test.cal
```

See also:

[ET\\_SAC](#) <sup>461</sup>

### 8.3.2.32 ET\_PNG

Tests whether iView X is reachable ('ping'). If iView X has been reached, it sends an ET\_PNG back.

Example:

```
ET_PNG
```

Result:

```
ET_PNG
```

### 8.3.2.33 ET\_PNT

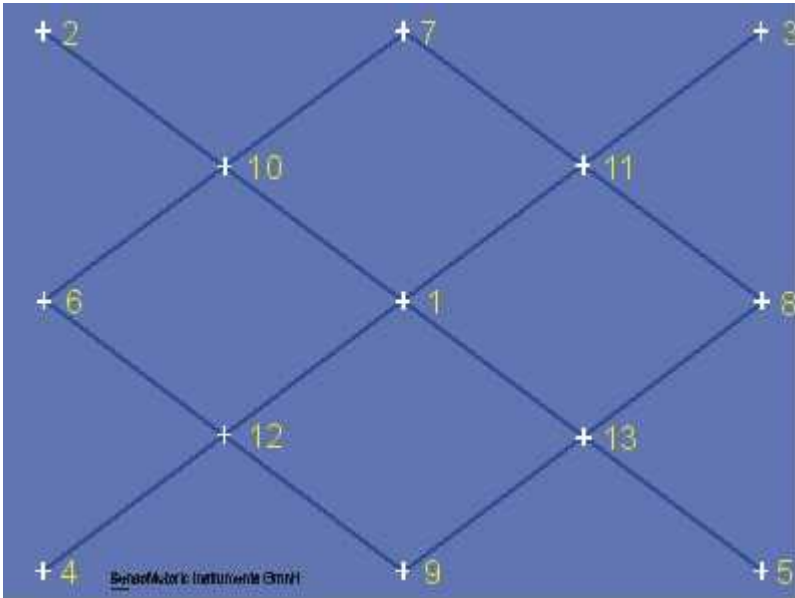
Sets the position of a given calibration point.

Parameters: point\_number X Y

point\_number : a value from 1 to 13  
X : x coordinate on the screen in pixels  
Y : y coordinate on the screen in pixels

The origin of the coordinate system lies in the upper left corner.

The points are enumerated as follows:



Example:

```
ET_PNT 1 400 300
```

Result: the first calibration point will be moved to the position 400 pixels to

the right and 300 pixels down from the upper left corner.

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### 8.3.2.34 ET\_PSE

Pauses the current data recording. The recording may be continued with the ET\_CNT command.

Parameters: none

Success:

```
ET_STP
```

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### 8.3.2.35 ET\_RCL

Starts [drift correction](#) <sup>289</sup>.

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### 8.3.2.36 ET\_REC

Starts a recording. On start the trial number is incremented.

The optional duration parameter specifies the length of the recording in seconds. If not set, the recording must be stopped manually using the ET\_STP command.

Parameters: duration

Example:

```
ET_REC 5
```

Success:

```
ET_REC
```

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### 8.3.2.37 ET\_REM

Puts user-defined text lines into the eye data stream during recording. The text will be linked to the eye data sample acquired directly after the last character has been received.

**Parameters:** text

**Example:** ET\_REM "any text"

iView X generates the following message in the data file:

```
<Timestamp>      MSG # Message: any text
```

See also:

[Message Output Format](#)<sup>[279]</sup>

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### 8.3.2.38 ET\_RES

Requests iView X for calibration results and returns the gaze data acquired for a specific calibration point.

**Parameters:** none

**Result:**

```
ET_PNT number x y  
ET_CSP timestamp eye_type gaze_x gaze_y  
...  
ET_RES
```

with

```
number:      number of calibration point  
eye type:    eye type information, possible values:  
              l: left  
              r: right  
              b: binocular
```



*gaze\_x*      x gaze data for monocular data  
                  x (left), x (right) for binocular data

*gaze\_y*      y gaze data for monocular data  
                  y (left), y (right) for binocular data

If data is binocular, the data is doubled for left and right pupil. First left x and right x data, then left y and right y data will be sent.

#### Example for binocular data:

```
ET_RES
```

#### Result:

```
ET_PNT 1 640 512
ET_CSP 68343004 b 242 242 336 336
... (all samples for point 1)
ET_PNT 2 64 51
...
ET_RES
```

See also:

[ET\\_PNT](#)<sup>[458]</sup>  
[ET\\_CSP](#)<sup>[446]</sup>

### 8.3.2.39 ET\_SAC

Saves a calibration to file.

Example:

```
ET_SAC test.cal
```

See also:

[ET\\_LOC](#)<sup>[457]</sup>

### 8.3.2.40 ET\_SAV

Saves data file. Data is saved in binary format. Use the [IDF Converter](#)<sup>260</sup> to convert to ASCII format.

The first parameter is the filename. More parameters are optional and must be set in a fixed order.

Description and user information can be given. With the OVR command an already existing filename will be overwritten. If OVR is not set and the given filename already exists, the existing file will not be overwritten and the command will not be executed. Note, that OVR must always be the 4th parameter, see examples below.

#### Path specification

The filename can be given with or without full path specification. If the filename is given without path specification, the file will be stored in the in the iView X installation directory.

ET\_SAV can also handle UNC syntax for Windows systems as follows:

```
\\ComputerName\SharedFolder\Resource\name IDF.
```

#### Parameters:

filename with or without path

#### Optional parameters in fixed order:

description  
user  
OVR

#### Examples:

```
ET_SAV "test.idf"  
ET_SAV "c:\iViewX\test.idf"  
ET_SAV "c:\iViewX\test.idf" "my description"  
ET_SAV "c:\iViewX\test.idf" "" "my user"  
ET_SAV "c:\iViewX\test.idf" "" "" "OVR"  
ET_SAV "c:\iViewX\test.idf" "my description" "my  
user" "OVR"  
ET_SAV "\\my_computer\Docs_Exchange\test.idf"
```

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### 8.3.2.41 ET\_SFT

Command to remotely control the [tracker parameters](#) <sup>[349]</sup>.

Parameters: *eye type*, *parameter type*, *value*

with

*eye type*:

- 0: left eye
- 1: right eye

*parameter type*:

- 0: Pupil Threshold
- 1: Reflex Threshold
- 2: Show AOI On/Off
- 3: Show Contour On/Off
- 4: Show Pupil On/Off
- 5: Show Reflex On/Off
- 6: Dynamic Threshold On/Off
- 11: Pupil Area [min max]
- 12: Pupil Perimeter [min max]
- 13: Pupil Density [min max]
- 14: Reflex Perimeter [min max]
- 15: Reflex Pupil Distance [min max]

Examples:

```
ET_SFT 0 0 136
ET_SFT 0 11 100 3000
```

If the third parameter is missing ET\_SFT returns range [min max] and current setting [min max].

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### 8.3.2.42 ET\_SIM

Starts transfer of mime-encoded eye video images. [ET\\_EIM](#) <sup>[448]</sup> ends transfer. After receiving an ET\_SIM message iView X will send [ET\\_IMG](#) <sup>[455]</sup> messages until it receives an ET\_EIM. ET\_IMG messages consist of the size of the mime-encoded video plus a data set.

Example:

```
ET_SIM
```

Result:

```
ET_IMG 384 288 <data>
```

where <data> is the data of the eye video image.

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### 8.3.2.43 ET\_SPL

The command is sent by iView everytime a data sample is generated and data streaming is on.

The format of the data sample output is set with the [ET\\_FRM](#) <sup>[454]</sup> command.

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### 8.3.2.44 ET\_SRP

If sent to iView X, returns information about [RED](#) <sup>[101]</sup>.

Parameters: none

Return values for *Monitor Integrated*:

```
0 monitor_size cal_type cx1 cy1 ...
```

Return values for *Stand Alone*:

```
2 width height cal_type cx1 cy1 ...
```

with

<code>monitor_size:</code>	diagonal monitor size in inch, e.g. 19 or 22
<code>width</code>	width of calibration area
<code>height</code>	height of calibration area
<code>cal_type:</code>	calibration type or number of calibration points, e.g. 5 or 9
<code>cx1 cy1 ...</code>	x and y values of all calibration points

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### 8.3.2.45 ET\_SRT

Returns current sample rate.

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### 8.3.2.46 ET\_SSV

Starts transfer of compressed scene video images. [ET\\_ESV](#) <sup>[451]</sup> ends transfer. After receiving an ET\_SSV message iView X will send [ET\\_SVF](#) <sup>[467]</sup> messages until it receives an ET\_ESV. ET\_SVF messages consist of the size of the compressed video image plus a data set.

**Parameters:** (optional) framerate

framerate    values: 1..10

**Examples:**

```
ET_SSV
ET_SSV 10
```

**Result:**

```
ET_SVF 752 480 19562 <data>
```

where <data> is the data of the scene video image.

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### 8.3.2.47 ET\_STI

Sets the default directory for stimulus images. All subsequent calls of [ET\\_BMP](#) <sup>443</sup> will search for the images in this directory.

Example:

```
ET_STI "C:\Temp"
```

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### 8.3.2.48 ET\_STP

Stops the current recording.

Parameters: none

Success:

```
ET_STP
```

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### 8.3.2.49 ET\_STR

Starts continuous data output (streaming) using the output format specified with the ET\_FRM command. Optionally, the frame rate can be set at which the data will be streamed.

**Parameters:** (optional) frame rate in Hz

frame rate values: 1...<sample rate of system>

**Examples:**

```
ET_STR  
ET_STR 10
```

Success: data stream

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### 8.3.2.50 ET\_SVF

Sent by iView X with single scene video images, after the [ET\\_SSV](#)<sup>[465]</sup> command has been received.

Transfer will be stopped when iView X receives the [ET\\_ESV](#)<sup>[451]</sup> command.

**Parameters:** *width height length data*

*width,*

*height :* image width and height in pixel

*length :* size of compressed image data in byte

*data :* image data

**Example:**

```
ET_SVF 752 480 19562 <data>
```

[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.51 ET\_VCL

Clears the video buffer.

Parameters: none

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### 8.3.2.52 ET\_VLS

Performs a validation of the calibration accuracy. This command is available only if a successful calibration has been performed previously. The result shows the accuracy of the calibration and therefore indicates its quality. With the return values you can estimate before starting the experiment, how good the measurement will be.

**Return values:** eye, x, y, d, xd, yd

If successful, returns:

- eye: left or right
- x, y: RMS (root mean square) values for the x and y components of the deviations
- d: RMS of the deviating distances
- xd, yd: mean deviation in degrees of x and y components

The units will be in pixels (standard systems) or in mm (HT systems).

**Parameters:** none

**Example:**

```
ET_VLS
```

Returns for monocular:

```
ET_VLS left 16.2 16.3 20.4 0.5 0.5
```

Returns for binocular:

```
ET_VLS left 16.2 16.3 20.4 0.5 0.5
```

```
ET_VLS right 15.2 16.1 20.5 0.5 0.5
```

See also: [Validation](#)<sup>251</sup>.

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### 8.3.2.53 ET\_VLX

Performs an extended calibration validation of a single point. This command is available only if a successful calibration has been performed previously. The result shows the accuracy of the calibration and therefore indicates its quality. With the return values you can estimate before



starting the experiment, how good the measurement will be.

**Parameters:**

x y: x and y coordinates of a point.

A remote application starts a validation with

```
ET_VLX x y
```

In case of an error it returns:

```
ET_VLX
```

If no error occurs, iView X starts with its fixation analysis.

Data will be returned either

- . after a certain time if "accept points automatically" is selected or
- . if ET\_ACC is sent to iView X.

**Result:**

```
ET_VLX xl yl dxl dyl xr yr dxr dyr
```

with

- xl, yl, xr, yr: RMS (root mean square) values for the x and y components of the deviations for left (l) or right (r) eye.
- dxl, dyl, dxr, dyr: mean deviation in degrees of x and y components for left (l) or right (r) eye.

The units will be in pixels (standard systems) or in mm (HT systems).

See also

[ET\\_VLS](#)<sup>[468]</sup>  
[Validation](#)<sup>[25]</sup>

[Back to overview](#)<sup>[438]</sup>.

### 8.3.2.54 ET\_VRE

Starts video/MPEG recording.

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### 8.3.2.55 ET\_VST

Stops video/MPEG recording.

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### 8.3.2.56 ET\_VSV

Saves video buffer to file.

With the optional OVR command an already existing filename will be overwritten. If OVR is not set and the given filename already exists, the existing file will not be overwritten and the command will not be executed.

#### Path specification

The filename can be given with or without full path specification. If the filename is given without path specification, the file will be stored in the iView X installation directory.

The default

#### Parameters:

filename with or without path

#### Optional parameter:

OVR

#### Examples:

```
ET_VSV "test.mpg"  
ET_VSV "c:\iViewX\test.mpg"  
ET_VSV "c:\iViewX\test.mpg" "OVR"
```

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# Known Limitations

**Chapter**



**IX**

## 9 Known Limitations

Here are some known limitations listed.

### 9.1 Changing screen resolution

Do not change screen resolution while iView X is running. If you do so, the system will freeze and the computer must be rebooted. This behaviour cannot be fixed. If you need to change the screen resolution, close the iView X application first, before doing the changes.

### 9.2 iView X and NetMeeting

Do not use NetMeeting on the iView X computer. NetMeeting causes a driver malfunction, after which the graphics adapter will not work.

### 9.3 iView X and virus scanner

Do not use a virus scanner as a background task. Instead, set your virus scanner to a scheduled scan policy.

# Abbreviations

**Chapter**



## 10 Abbreviations

AOI	Area of Interest
ASCII	American Standard Code for Information Interchange, character encoding
CurVid	device to draw the gaze cursor on a video stream
CR	cornea reflex
fMRI	functional Magnetic Resonance Imaging
HDD	Hard Disk Drive
HED	Headmounted Eyetracking Device
HT	Head Tracking
HMD	Head Mounted Display
IEEE	Institute of Electrical and Electronics Engineers
IO	in / out
IP	Internet Protocol
JPG	an image file format using a lossy compression method
MHT	Magnetic Head Tracker
MPEG	Moving Picture Experts Group for audio/video encoding standards
MRI	Magnetic Resonance Imaging
NTSC	National Television Systems Committee, video standard
PAL	Phase Alternate Line, video standard
POR	Point Of Regard
RAM	Random Access Memory
RED	Remote Eyetracking Device
ROI	Region of Interest
TCP	Transmission Control Protocol, internet protocol
TTL	Transistor-Transistor-Logic
UDP	User Datagram Protocol, internet protocol
UTC	Coordinated Universal Time
WLAN	Wireless Local Area Network
XviD	a video codec using a lossy compression method

# **Declaration of Conformity**

**Chapter**



**XI**

# 11 Declaration of Conformity

The following lists our declarations of conformity.



## 11.1 Declaration of Conformity HED 4



### DECLARATION OF CONFORMITY

**Type of Product:** Eyetracking Equipment  
**Product Name:** iView X™  
**Model Designation:** HED 4

**Manufacturer:** SensoMotoric Instruments GmbH  
Warthestr. 21  
14513 Teltow  
Germany

This product complies with the requirements of the following European directives:

**89/336/EEC** Directive of the council on the approximation of the laws of the Member States relating to electromagnetic compatibility (**EMC Directive**) changed by directive 91/263/EEC, 92/263/EEC and 93/68/EEC of the council.

Compliance was proved by the application of the following electromagnetic compatibility standards:  
**EN 60601-1-2 + EN 55011, Class B**

Teltow, November 2007

SensoMotoric Instruments GmbH

Dr. Winfried Teiwes  
Managing Director

## 11.2 Declaration of Conformity RED 4 (FireWire)



### DECLARATION OF CONFORMITY

**Type of Product:** Eyetracking Equipment  
**Product Name:** iView X™  
**Model Designation:** RED 4

**Manufacturer:** SensoMotoric Instruments GmbH  
Warthestr. 21  
14513 Teltow  
Germany

This product complies with the requirements of the following European directives:


**89/336/EEC** Directive of the council on the approximation of the laws of the Member States relating to electromagnetic compatibility (**EMC Directive**) changed by directive 91/263/EEC, 92/263/EEC and 93/68/EEC of the council.

Compliance was proved by the application of the following electromagnetic compatibility standards:

**EN 60601-1-2 + EN 55011, Class B**

Teltow, November 2007

SensoMotoric Instruments GmbH



Dr. Winfried Teiwes  
Managing Director

## 11.3 Declaration of Conformity Hi-Speed



**DECLARATION OF CONFORMITY**


<b>Type of Product:</b>	Eyetracking Equipment
<b>Product Name:</b>	IView X™
<b>Model Designation:</b>	Hi-Speed 500/1250
<b>Manufacturer:</b>	SensoMotoric Instruments GmbH Warthestr. 21 14513 Teltow Germany

This product complies with the requirements of the following European directives:

**89/336/EEC** Directive of the council on the approximation of the laws of the Member States relating to electromagnetic compatibility (**EMC Directive**) changed by directive 91/263/EEC, 92/263/EEC and 93/68/EEC of the council.

Compliance was proved by the application of the following electromagnetic compatibility standards:  
**EN 60601-1-2 + EN 55011, Class B**

Teltow, June 2007

SensoMotoric Instruments GmbH  
  
Dr. Christian Teiwes  
Managing Director

## 11.4 Declaration of Conformity MEG



### DECLARATION OF CONFORMITY

**Type of Product:** Eyetracking Equipment  
**Product Name:** iView X  
**Model Designation:** MEG

**Manufacturer:** SensoMotoric Instruments GmbH  
Warthestr. 21  
14513 Teltow  
Germany

This product complies with the requirements of the following European directives:

**89/336/EEC** Directive of the council on the approximation of the laws of the Member States relating to electromagnetic compatibility (**EMC Directive**) changed by directive 91/263/EEC, 92/263/EEC and 93/68/EEC of the council.

Compliance was proved by the application of the following electromagnetic compatibility standards:

**EN 60601-1-2 + EN 55011, Class B**

Teltow, December 2007

SensoMotoric Instruments GmbH

Dr. Winfried Teiwes  
Managing Director

## 11.5 Declaration of Conformity MT-LR



### Declaration of Conformity

**Type of Product:** Eyetracking Equipment  
**Product Name:** iView X  
**Model Designation:** MEyeTrack-LR

**Manufacturer:** SensoMotoric Instruments GmbH  
Warthestr. 21  
14513 Teltow  
Germany

This product complies with the requirements of the following European directives:

**89/336/EEC** Directive of the council on the approximation of the laws of the Member States relating to electromagnetic compatibility (**EMC Directive**) changed by directive 91/263/EEC, 92/263/EEC and 93/68/EEC of the council.

Compliance was proved by the application of the following electromagnetic compatibility standards:

**EN 61326-1:1997 + EN 61326/A1:1998 + EN 61326/A2:2001**

Teltow, Jan 04, 2006

SensoMotoric Instruments GmbH  
  
Dr. Winfried Teiwes  
Managing Director

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