EyeLink® II Scene Camera User Manual

(Tracker Version: 2.0)

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1. EyeLink II Tracker Application: Scene Camera Components

The EyeLink scene camera option works in combination with an external video overlay box, which generates the overlay graphics with video inputs from the scene camera and a portion of the EyeLink VGA display, indicating the current gaze position. While the standard EyeLink II setup allows the users to record eye movements at a fixed viewing distance (e.g., computer monitor, TV screen, etc), the EyeLink scene camera option provides a powerful extension so that participants' eye movements at different viewing depths can also be tracked with high accuracy in the same recording. The current document serves as a supplement to the "EyeLink II User Manual" and only highlights those operations and components that are relevant to the use of scene camera option on the EyeLink II host application.

The *EyeLink* II tracker interface consists of a set of setup and monitoring screens, which may be navigated by means of the host PC mouse, shortcut keys, or from the Display PC application via link commands. The following sections summarize those screens related to the scene camera operations.

1.1 Camera Setup Screen

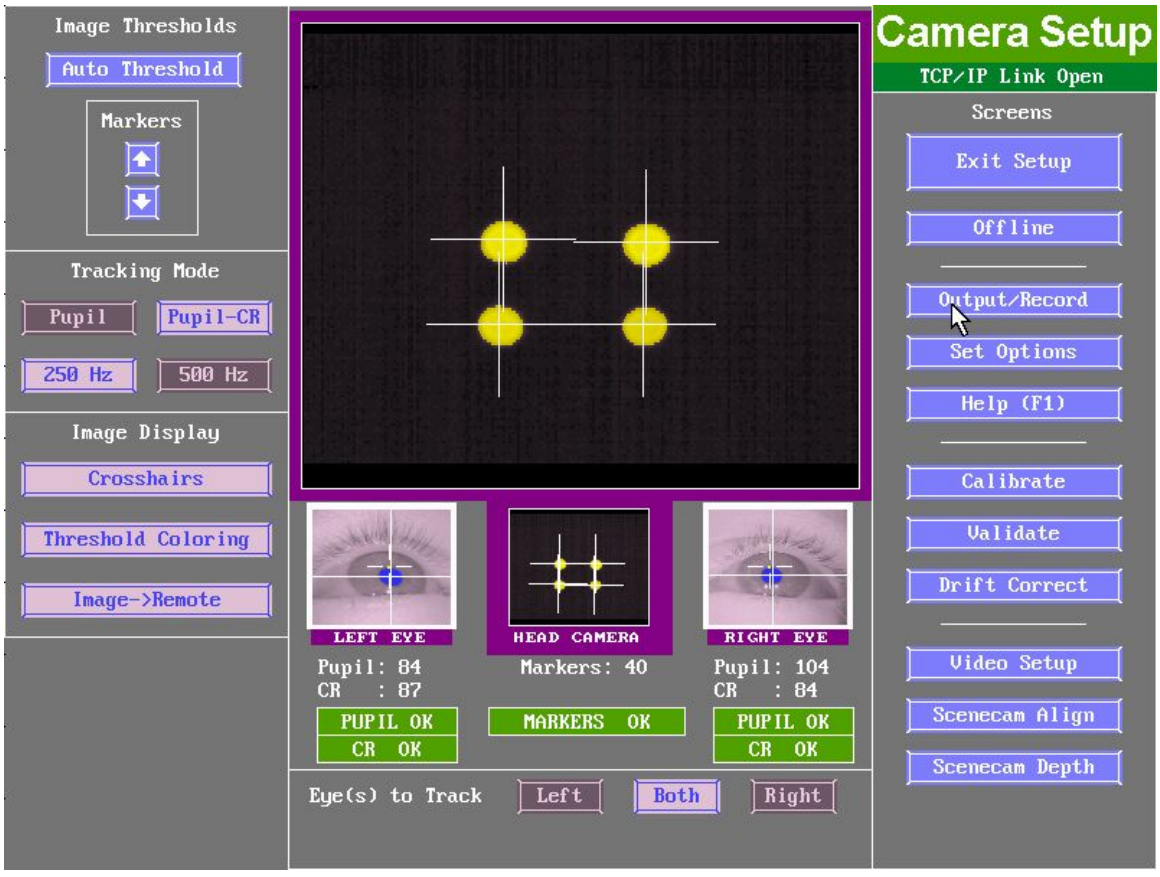
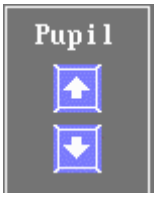
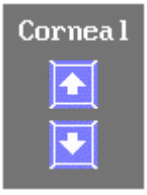


Figure 1: EyeLink II Camera Setup Screen

1.1.1 Purpose

This is the central screen for most EyeLink II setup functions. From this screen the eye and head tracking cameras can be set up, and their images can be thresholded. Eye(s) to be tracked, tracking mode and options can also be set. Calibration, validation, drift correction, and scene camera operations (e.g., video setup, camera alignment, and depth correction) can also be performed from this screen.

1.1.2 Main Functions

	Press Auto Threshold to threshold the selected camera image. In most cases auto thresholding will set the correct image threshold for the camera. Keys: A = Auto threshold selected image
	Use the arrow buttons to manually increase or decrease the selected camera's pupil threshold. Keys: ⇑ and ⇓ = increase and decrease threshold
	If available, use the arrow buttons to manually increase or decrease the selected camera's corneal threshold. Keys: + and - = increase / decrease corneal reflection threshold
	If available, use the arrow buttons to manually increase or decrease the head camera threshold. Keys: ⇑ and ⇓
	Select the tracking mode for recording. Here the Pupil-Corneal Reflection mode is selected. Keys: P toggles Pupil only or Pupil-CR mode selection

	Select the sampling rate for recording. Here 250 Hz is selected. Note that in Pupil-CR mode, 500Hz is not available. Keys: F = toggles sampling Frequency selection
	Toggles display of crosshair in eye camera images. Keys: X = toggle crosshair display
	Toggles display of threshold coloring in eye camera images. Keys: T = toggle threshold coloring display
	Select to present the camera display image on the Display Monitor.
	To select the camera to display as a large image click on the desired image thumbnail. The selected image thumbnail has a heavy border around it. Here the Right Eye camera is selected. Image thresholds and status are indicated below each thumbnail. Keys: ⇐ and ⇒ to move left or right on image row
	Select the eye(s) to track during recording. Here the Right eye is selected. Press the "Lock Tracked Eye" button to lock the current selection on the Display PC. Keys: R = select Right Eye L = select Left Eye B = select Both Eyes
	Press Exit Setup to go to the screen that was available prior to accessing the Camera Setup window. Keys: ESC = exit camera setup
	Press Offline to be returned to the EyeLink II offline screen. Keys: ESC = go to Offline screen

	Select Output / Record to go to the output screen, from which you can start a manual recording session. This button is usually only accessed when using the EyeLink II in standalone mode. Keys: O = go to Output screen
	Select Set Options to go to the EyeLink II options screen, where a variety of system options and settings can be configured. Note that any value on this screen can be programmatically overridden by the API during experiment setup. Keys: S = go to Set options
	Press Help (F1) to access the online help page for Camera Setup. All available key shortcuts are also listed on the Help screen. Keys: F1 = open Help screen
	Select Calibration to go to the Calibration screen. After setting up the eye cameras and thresholding, you need to Calibrate the system. Keys: C = go to Calibrate screen
	Select Validation to be taken to the Validation Screen. Validation allows you to get a sense of the gaze position accuracy of your Calibration. Validation should always be run after Calibration. Keys: V = go to Validate screen
	Select Drift Correction to go to the Drift Correction Screen. Drift Correction can be performed before and during an experiment; allowing gaze position to be realigned if headband slippage or significant pupil size change has increased gaze

	calculation error. Keys: D = go to Drift correction screen
	Perform video overlay or scene camera setup. This is used to ensure accurate gaze position mapping onto the overlay device. If video alignment is not properly carried out, the accuracy of gaze on overlay will be negatively influenced. Keys: W = go to Video Setup screen
	Perform alignment between the scene camera and head camera. This must be done anytime the relative position between the scene camera and the head camera changes. Keys: Y = go to Scene Camera Alignment screen
	Perform correction to the gaze cursor drawing in the overlay display to improve accuracy for recordings that track eye movements at uncalibrated depths. Please note it is only possible to perform depth correction for a binocular recording. Keys: Z = go to Scene Camera Depth Setup screen

1.1.3 Key Shortcuts

Key	**Function**
⇐ and ⇒	Select between left eye camera, head camera and right eye camera.
R	Select Right eye for recording
L	Select left eye for recording
B	Select both eyes for recording
P	Toggle Pupil only or Pupil-CR mode selection
F	Toggle sampling frequency selection
A	Auto threshold selected image
X	Toggle crosshair display
T	Toggle threshold coloring display

⇑ and ⇓	Increase and decrease threshold
C	Go to the Calibration screen
V	Go to the Validate screen
D	Go to the Drift correction screen
O	Go to the Output screen
S	Go to Set Options page
F1	Open the Help dialog, in the help screen there is a brief overview of the role of this page and the key functions for it
W	Go to the Video Setup screen
Y	Go to the Scene Camera Alignment screen
Z	Go to the Scene Camera Depth Setup screen

1.2 Video Setup Screen

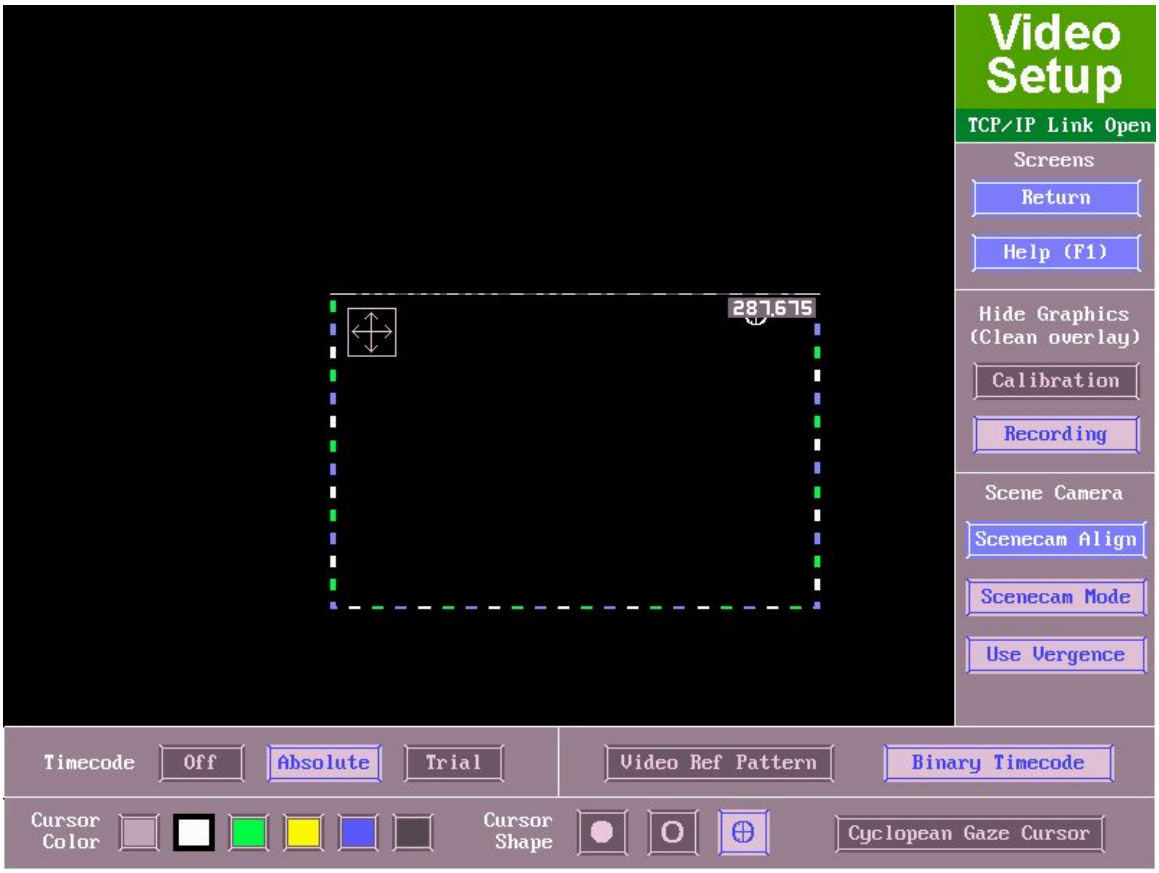
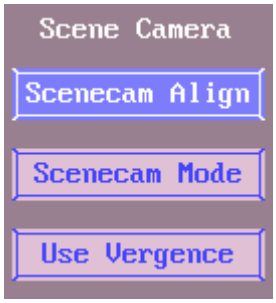


Figure 2: EyeLink II Video Setup Screen

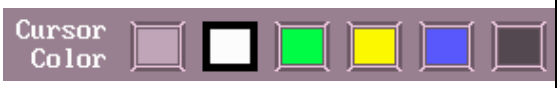
1.2.1 Purpose

This screen is used to perform video overlay or scene camera setup. This is essential to ensure accurate gaze position mapping onto the scene camera overlay display.

1.2.2 Main Functions

	Press Return to the EyeLink II tracker setup screen. Keys: Enter = return to camera setup
	Press Help (F1) to access the online help page for Camera Setup. All available key shortcuts are also listed on the Help screen. Keys: F1 = open Help screen
	If "Calibration" button is disabled, additional feedback values are printed out on the overlay graphics during validation. If the "Recording" button is disabled, the user-drawn graphics can be drawn on the host PC screen and therefore displayed behind the gaze cursor during recording. These graphics may aid analysis or serve illustrative purposes. Keys: X = Toggle feedback/cursors in calibration/validation screen. R = No user-drawn graphics in recording
	These buttons are related to the scene camera setup operations. "Scenecam Align": Pressing this button will take the use to the Scene Camera Alignment Screen (see sections 1.1.3 and 4.1 for details). "Scenecam Mode": If enabled, adjustments are made to the gaze cursor position in the overlay graphics, taking into consideration the scene camera alignment settings, as well as the camera distortion correction. This mode should be enabled when a recording using scene camera for tracking gaze positions

	involving different scene depths. When using the standard overlay mode, SC mode should be disabled. "Use Vergence": If enabled, depth correction, if available, will be applied to the gaze positions in the overlay graphics (see sections 1.1.4 and 4.3 for details). Keys: S = Scene Camera cursor mapping in recording; D = Enable/Disable scene camera depth correction. Y = Go to the scene camera alignment screen.
	The timecode may be set to "Absolute", which displays the actual tracker time in milliseconds that is used for the timestamps for samples, events, and messages recorded in the EDF file or as real-time link data. If the "Trial" mode is selected, the timecode displays the milliseconds elapsed since the start of the trial. No timecode will be shown if "Off" is selected. Keys: T = Select timecode type
	"Video Ref Pattern": (Unimplemented) Will be used by future scene camera AVI saving application to provide proper alignment between the AVI file and eye tracker video overlay. "Binary Timecode": Turns on/off the binary timecode, which represents the machine-readable EDF time. This will be used in the future AVI saving application for millisecond-accuracy alignment between the AVI clip and the EDF timing. Keys: V = Show video alignment pattern M = Toggle on/off the machine-readable

	timecode line
	Several cursor colors can be selected from the Video Setup screen, the most useful of which are yellow and white. Keys: C = Gaze cursor color.
	Gaze cursors for use in the video overlay have a selectable shape, which may improve visibility. Cursors may either be a solid circle, a hollow circle, or a hollow circle with a cross in the center. Keys: G = Gaze cursor type
	If enabled, draws a single gaze cursor, representing the average of the two eyes. If disabled, gaze cursors are drawn separately for each eye. Keys: B = Binocular or Cyclopean cursor

1.2.3 Key Shortcuts

Key	**Function**
G	Gaze cursor type
C	Gaze cursor color
T	Timecode type
X	No feedback cursors in the calibration/validation screen
R	No user-drawn graphics in recording
S	Scene Camera cursor mapping in recording
V	Show video alignment pattern (setup only)
M	Show machine-readable timecode line
B	Binocular or Cyclopean gaze cursor
Arrow keys	Move the selected corner of the overlay window
Tab	Toggle the corner of overlay window to move
F9	Reset overlay window to default position
Enter / ESC	Return to Set Options screen
F1	HELP (this screen)

1.3 Scene Camera Alignment Screen

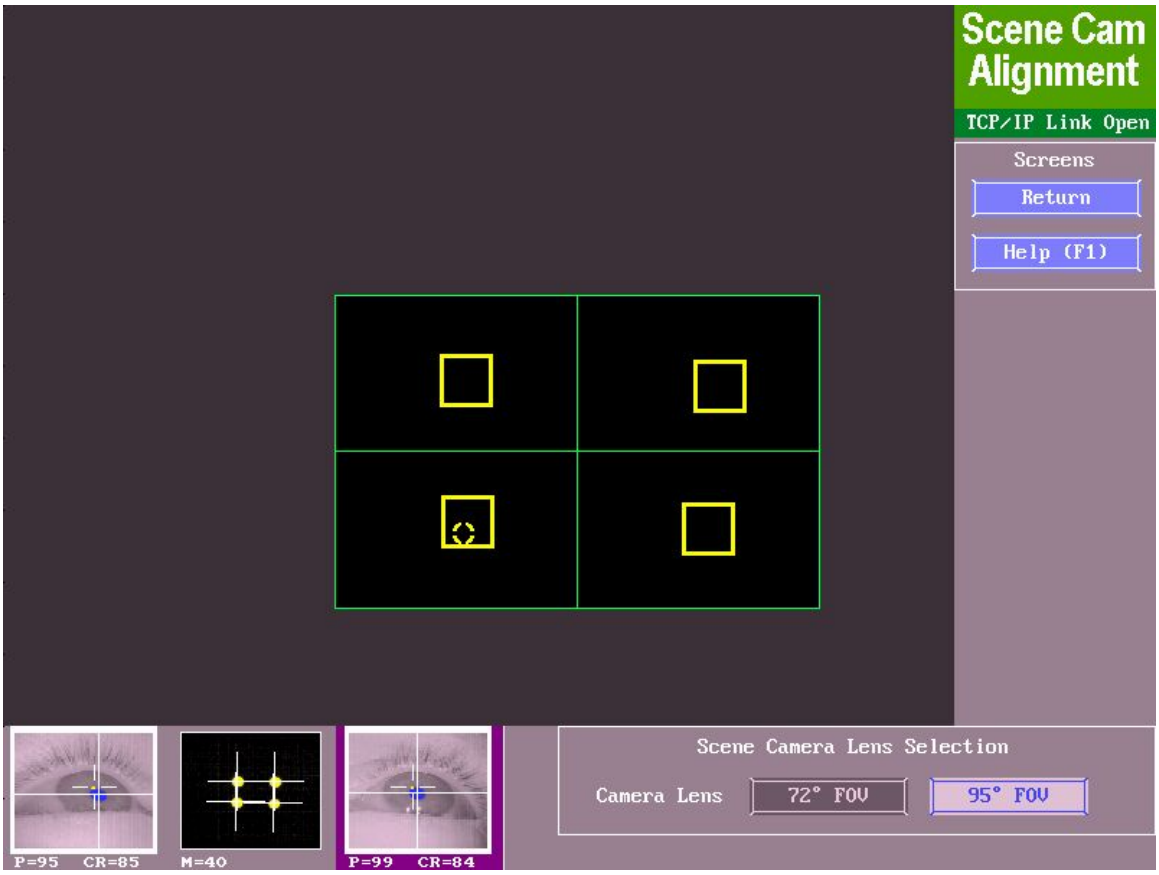


Figure 3: EyeLink II Scene Camera Alignment Screen

1.3.1 Purpose

This screen is used to align the scene camera to the head camera. This is done by selecting the proper lens type, then using the mouse to place the four boxes around the four IR markers on the calibration monitor. The alignment should be done anytime the relative position of the scene camera changes from the head camera (see section 4.1 for details).

1.3.2 Main Functions

	Press Return to the EyeLink II tracker setup screen. Keys: Enter = return to camera setup
	Press Help (F1) to access the online help page for Camera Setup. All available key shortcuts are also listed on the Help screen.

	Keys: F1 = open Help screen
	This allows the user to select the camera lens type. Make sure that this setting matches exactly with the actual type of lens installed in the scene camera. Keys: L = Select the scene camera lens type

1.3.3 Key Shortcuts

Key	**Function**
L	Select the scene camera lens type;
Enter / ESC	Return to Set Options screen
F1	HELP (this screen)

1.4 Scene Camera Depth Setup Screen

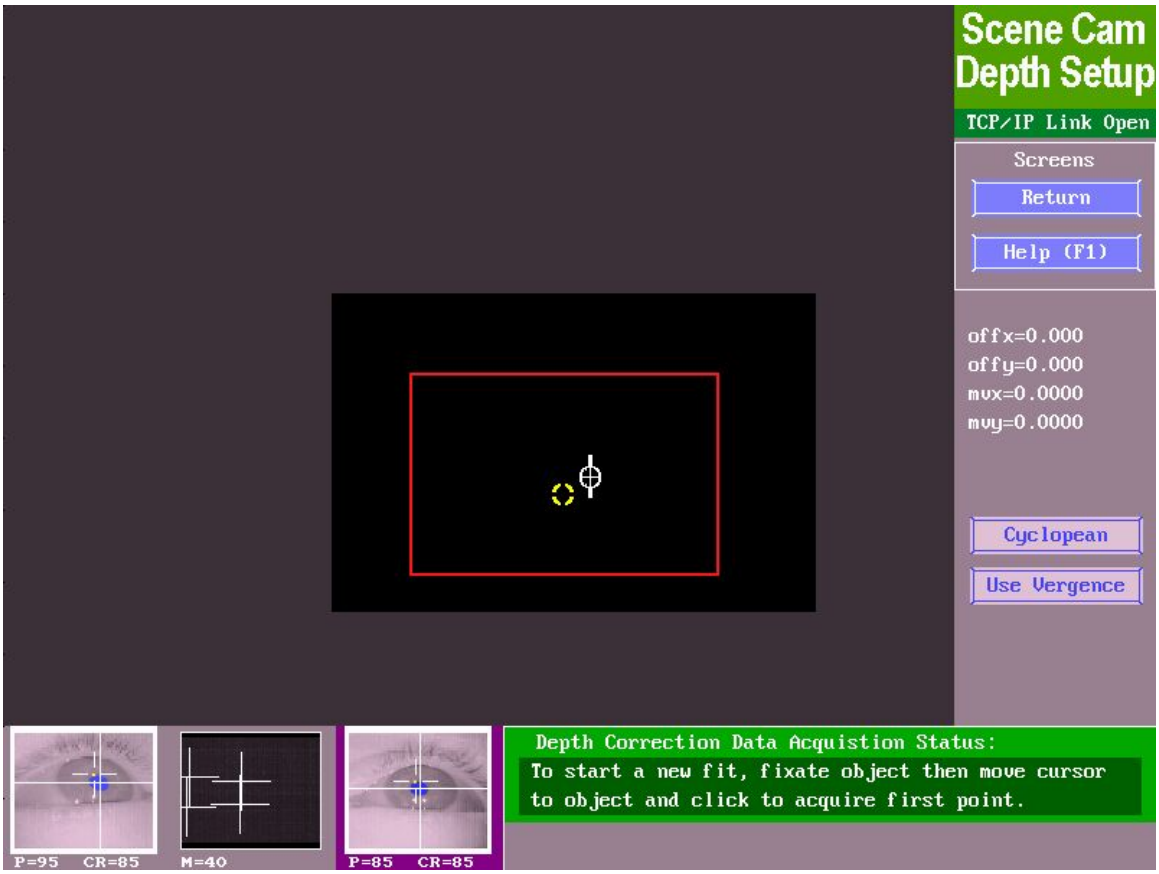


Figure 4: EyeLink II Scene Camera Depth Setup Screen

1.4.1 Purpose

This screen is used to correct for depth parallax (i.e., inaccuracy in the gaze cursor drawing) in the scene camera overlay caused by the separation between the participant's eye and the scene camera. If both eyes are being tracked, the binocular data can be used to correct at other viewing depths. This screen allows the experimenter to collect several extra fixations on targets presented at significantly different depths (see section 4.3 for full details).

1.4.2 Main Functions

	Press Return to the EyeLink II tracker setup screen. Keys: Enter = return to camera setup
	Press Help (F1) to access the online help page for Camera Setup. All available key shortcuts are also listed on the Help screen. Keys: F1 = open Help screen
	If enabled, draws a single gaze cursor, representing the average of the two eyes. If disabled, gaze cursors are drawn separately for each eye. Keys: B = Binocular or Cyclopean gaze cursor
	If enabled, depth correction, if available, will be applied to the gaze positions in the overlay graphics (see sections 1.1.4 and 4.3 for details). Keys: D = Enable/Disable vergence-based depth correction for gaze cursor drawing.
	If pressed, this will clear all of the data points collected for depth adjustment. Keys: R = Restart collection (clear data).
	If pressed, this will keep the existing data points collected and improve upon the last fit by adding more data points. Note that this button will only be visible following an initial depth

	correction. Keys: I = Improve last fit.
	If pressed, this will abandon the newly collected data points and revert to the previous parameters. By clicking this button again, both the previous data points and the more recent data points collected will be kept. Note that this button will only be visible following an initial depth correction. Keys: V = Revert to last entry or restart.

1.4.3 Key Shortcuts

Key	**Function**
Enter / ESC	Return to Set Options screen
F1	HELP (this screen)
B	Binocular / Cyclopean cursors
D	Enable/Disable vergence correction
R	Restart collection (clear data)
I	Improve last fit
V	Revert to last entry or restart

1.5 Record Screen

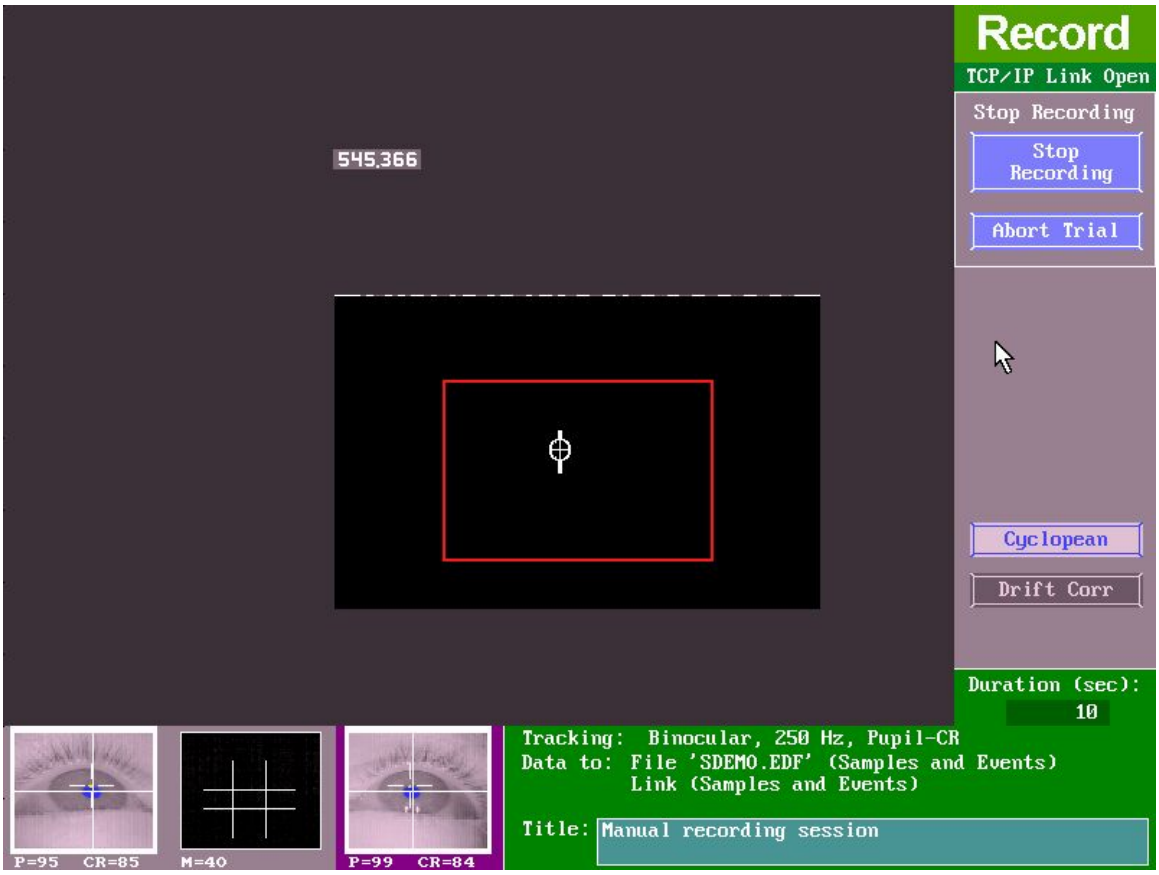


Figure 5: EyeLink II Record Screen

1.5.1 Purpose

A menu of options allows opening and closing (EDF) files, setting data to be recorded, and other output-related options. This mode always precedes manual entry into Output mode, to allow parameter preview.

1.5.2 Main Functions

	Stops the recording of data to the EyeLink Data File. Keys = ESC
	If enabled, draws a single gaze cursor, representing the average of the two eyes. If disables, gaze cursors are drawn separately for each eye. Keys: B = Binocular or Cyclopean gaze

	cursor
	If this button is pressed, an online drift correction can be performed (see section 4.4 for full details). Keys: F = Online offset correction;

1.5.3 Key Shortcuts

ESC	Exit to output screen
CTRL + ALT + A	Abort trial menu
F	Online offset correction
B	Cyclopean binocular display
After Trial Aborted	
S	Setup (Calibrate, camera setup)
R	Repeat Trial
N	Next Trial
CTRL + ALT + T	Terminate Experiment
CTRL + ALT + Q	Terminate program

2. System Requirements and Configuration

The following items are required to perform an EyeLink experiment with scene camera and gaze overlay functionality:

- A VGA overlay device supplied by SR Research, including necessary cabling.
- A good monitor with either S-video input or composite video input for use in analysis and setup. Small monitors may be obtained from professional video suppliers, or a larger high-end TV/monitor may be used.
- Scene cameras (with cables and power supply) supplied by SR Research.

2.1 Installing Scene Camera

If the scene camera option is purchased after the base system, follow the instructions below for installing the scene camera on the headband:

- Use an SR Research supplied screwdriver to remove the four screws on the head camera bracket (see Figure 6).

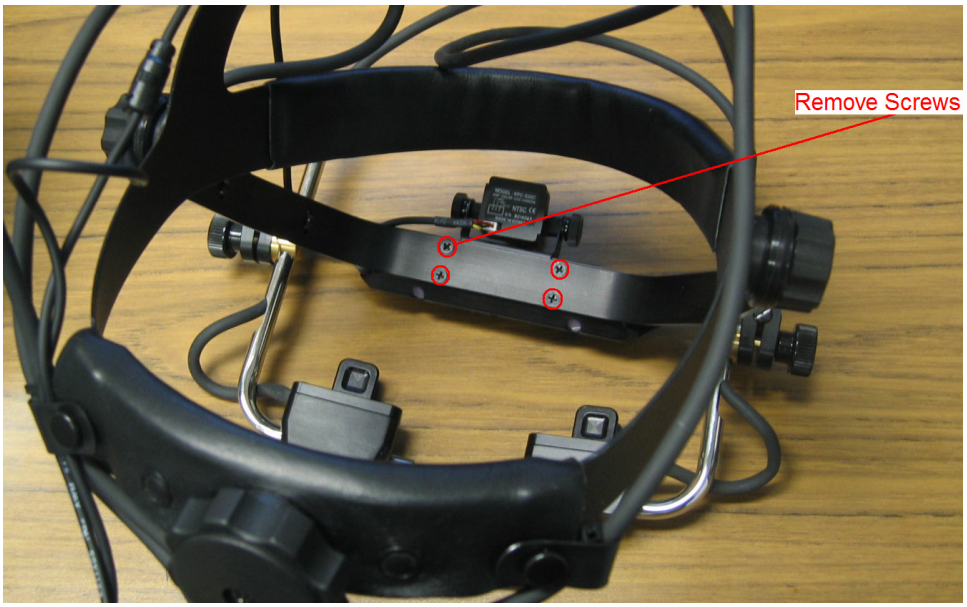


Figure 6: Remove Screws on the Head Camera Bracket

- Insert the scene camera bracket between the head camera bracket and the head camera clamp (see Figure 7).

- Align the holes on the head camera clamp, scene camera bracket, and the head camera bracket, and put back the screws. Plug the power adapter to the scene camera.

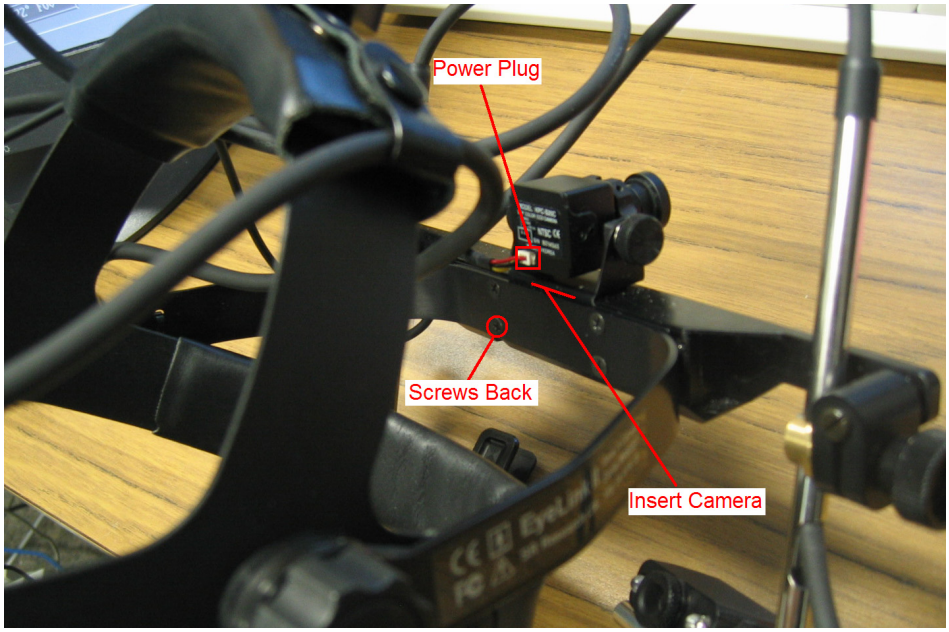


Figure 7: Insert Scene Camera between the Head Camera Clamp and the Head Camera Bracket

- Dress the cables of the scene camera with buttons on the headband frames as illustrated in Figure 8. Wire the scene camera cable between the headband frame and head camera cable (see A). Loose buttons B and C, put the scene camera cable through, and fasten the button back.

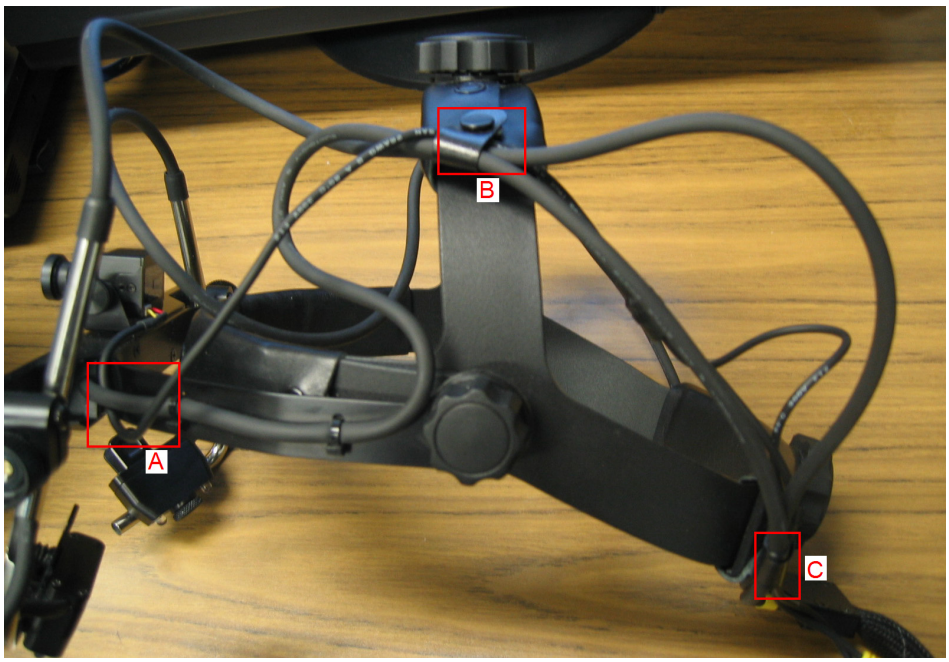


Figure 8: Dress the Scene Camera Cables

- Loosen the screws of the scene camera and angle the scene camera appropriately so that it sees as much of the scene of interest as possible, and then tighten the camera screws.

2.2 Wiring and Configuration.

Connect the "VGA-IN" of the scan converter box to the VGA card of the EyeLink II host computer and "VGA-OUT" to the monitor of the host PC. Next, connect the scene camera output to the overlay input and the overlay output to a monitor with proper cables. The following figure illustrates the connection between the RCA plug from the scene camera and the "V-IN" of the overlay box and the connection between the "S-OUT" and the S-Video input on an overlay monitor. (If a VCR is being used, it would be connected between the overlay box and the monitor). Plug in the power adapter of the overlay box.

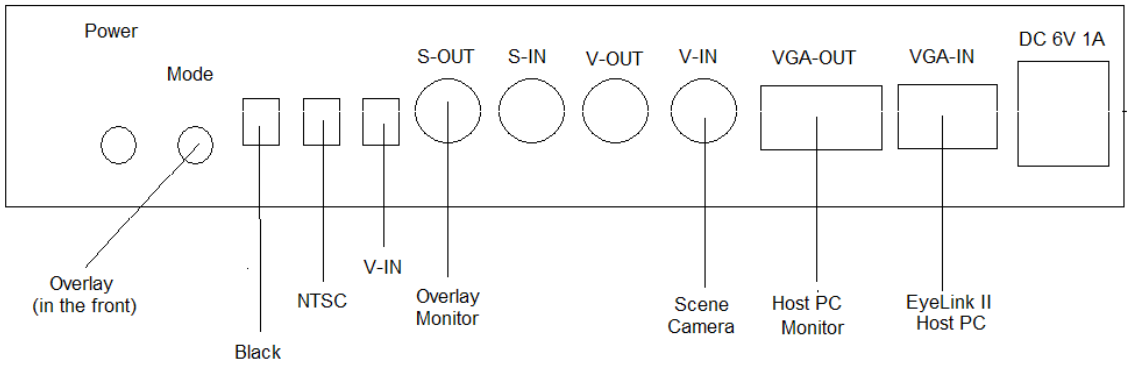


Figure 9: Wiring Diagram for Scene Camera Option.

For best overlay quality, the following settings may be used:

Overlay (Key) switch: black

TV System: NTSC in North America and PAL in Europe.

Video Input: S-IN (if S-Video In is used for the scene camera input); V-IN (if V-In is used.)

2.3 Software Installation

Copy the existing EyeLink2 directory on the host PC to a new folder as a backup. Then copy the supplied files into the EyeLink2 folder. These should overwrite the eyelink2.ini and the eyelink2.exe files, and add a number of extra files (final.ini, scenecam.ini, and vidovl.ini). The vidovl.ini and scenecam.ini contain all of the settings for using the video overlay option and scene camera

option respectively. If changes to these default settings are required, please cut and paste the commands to the final.ini and make the modification in that file for the ease of future maintenance. Please also make sure that you have either track.exe or cal_popup.exe installed on your display PC to perform calibration, validation, and depth fixation for the scene camera operations.

3. Setting up and using the EyeLink Video Overlay

The EyeLink Scene camera option works in combination with an external video overlay box, which generates the overlay graphics with video inputs from the scene camera and a portion of the EyeLink VGA display. When the scene camera and video overlay option are enabled, the gaze display window of the Offline, Calibration, Validation, Drift Correction, Output, and Recording screens have a black central window in the area where the video overlay is generated, with the remainder of the window filled with dark gray.

In the overlay graphics, gaze cursors have a selectable shape and color. Either Cyclopean or binocular gaze cursors can be drawn for a binocular recording. Finally, a timecode may be placed anywhere in the overlay area, displaying the time from the start of the trial or displaying the tracker timestamp that is being placed in the EDF file.

3.1 Setting Up the Video Overlay

The video overlay is enabled and disabled from the Set Options screen. Two buttons have been added: an "Enable Overlay" toggle button (press the 'O' key as a shortcut), and a "Video Setup" button (press the 'V' key as a shortcut) that switches to the Setup Video screen. These buttons are only available on EyeLink systems configured for scene camera and video overlay support.

To set up the video overlay:

- Go to the Video Setup screen
- Press the mode button of the overlay remote control to select the "overlay" mode
- Press button 5 of the overlay remote control to set the overlay box to 2X zoom.

A number of functions may be performed and options set with the Video Setup screen:

- The video overlay can be calibrated to match the size of the scene camera video, allowing accurate alignment of the overlay gaze cursor with the point of gaze (see section 3.2).
- The color and shape of the overlay gaze cursor may be selected (see section 3.3).
- The timecode display may be positioned, enabled, disabled or set to absolute or trial time (see section 3.4).

- Calibration, validation, and drift correction displays can be set to support use with an external video display. To do this, EyeLink will suppress feedback cursors and graphics, and to use a gray background to blank scene camera video (see section 3.5).
- Last but not least, the Video Setup screen contains buttons for scene camera operations, such as aligning scene camera or enabling/disabling scene camera mode (see section 4.2).

3.2 Calibrating the Overlay Display

Calibrating the overlay graphics display to scene camera video and overlay device are very simple to do, once the overlay device has been configured to use part of the EyeLink display. The scene camera video is displayed on a video monitor, in combination with graphics from the EyeLink display. A box consisting of a highly visible moving pattern is then adjusted in size and position to match this region. After this is done, the overlay is ready to use.

To calibrate the overlay, perform these steps:

- Go to the Video Setup screen
- On the EyeLink display, note the drawing of a box with arrows, located just inside the top-left or bottom-right corner of the calibration box. This corner of the box may be moved with the arrow keys (the mouse is not used because of the high precision required).

Figure 10: Calibrating the Overlay Display.

- While viewing the video display, adjust the box so that the outside of the moving pattern of the calibration box is on or just inside the desired area of the video.
- Once one corner is adjusted, switch to adjusting the other corner by pressing the "Tab" key.
- The box can quickly be reset to the size of the dark gray default area by pressing the "F9" key.

Note: The overlay display adjustment needs to be done only once as long as the overlay settings haven't been changed. However, at the beginning of each recording session, the user needs to press button 5 of the overlay remote control to set the overlay box to 2X zoom. This ensures the scene camera display and EyeLink display stay properly aligned.

3.3 Selecting the Gaze Cursor Appearance

Gaze cursors for use in the video overlay have a selectable shape and color to improve visibility. Cursors may either be a solid circle, a hollow circle, or a hollow circle with a central cross. For cyclopean gaze cursors, several cursor colors can be selected, the most useful of which are yellow and white. In a binocular mode, the cursors are blue and yellow for the left eye and right eye respectively (see the settings in the vidovl.ini configuration file). Select a cursor shape by clicking on the appropriate button at the bottom of the Video Setup screen. Colors can be selected in the same way (the currently selected color is indicated by a solid black border).

3.4 Setting the Timecode Display

The timecode display is enabled by selecting a timecode mode option using the buttons at the bottom of the screen (use the "T" key to step through options). The timecode display may then be positioned by dragging it with the mouse cursor to its new position. It may be possible to place the timecode display above or below the video, if a blank area has been left as recommended.

The timecode may be set to "Absolute", which displays the actual tracker time in milliseconds that is used for the timestamps of samples, events, and messages recorded in the EDF file or as real-time link data. This may be used to match times to a raw ASC file, for example. If the "Trial" mode is selected, the timecode displays the milliseconds elapsed since the start of the trial. This is defined either as the start of recording, or as the time of the last "SYNCTIME" message placed in the EDF file. This message may also include a time offset,

placed before or after the “SYNCTIME” keyword, indicating the delay in milliseconds from the start of trial to when the message was actually sent.

A symbol at the left side of the timecode display indicates the timecode mode. A small “T” at the top indicated “Trial” mode with time elapsed since the start of recording. If a “SYNCTIME” message has been received, a “U” at the bottom indicates that a user-defined start time is being used. No symbol indicates that “Absolute” timecode mode is active.

The timecode is displayed as up to 9 digits (8 digits in “Trial” mode), with a decimal point indicating the transition between seconds and milliseconds. It is unlikely that the last digit of the milliseconds will be useful, however, because of the timing of video displays and the nature of most overlay devices.

3.5 Graphics Options

In some cases, calibration graphics need to be presented on the video display. These graphics can be generated by the EyeLink overlay, when the “Calibration” button is selected. For this purpose, the overlay background on the Calibration, Validation, and Drift Correction displays is set to gray (or any other color specified in the vidovl.ini file) to hide source video. In addition, all feedback graphics are suppressed within the calibration display until the end of calibration, to eliminate distractions.

User-drawn graphics can be displayed behind the gaze cursor during recording. These graphics are also useful in video overlays and may aid analysis or serve illustrative purposes. However, some experiments may create bright or distracting graphics that will block the source video. The “Recording” button can be selected to block the display of these graphics, and to preserve a clean overlay.

4. Setting up and Using the Scene Camera

With the scene camera option, overlay graphics can be generated with video inputs from the scene camera and a portion of the EyeLink VGA display, indicating the current gaze position. In addition to the usual steps for EyeLink recordings, using the scene camera option requires extra steps to perform scene camera alignment and depth correction. For a recording session, the user should perform the experiment setup in the following order:

- Perform (or check) scene camera and head camera alignment
- Do eye/head cameras setup
- Calibration and validation
- Perform depth correction
- Recording and if necessary, drift correction

The following sections explain each of the above steps in detail.

4.1 Aligning the Scene Camera

The optical alignment between the scene camera and head camera must be done when the scene camera is used for the first time. By performing the alignment, the gaze accuracy on the overlay display at the calibrated depth is ensured. The scene camera alignment should be done only if the relative position between the scene camera and the head camera is changed or if the lastrun.ini file in the eyelink2\exe directory is modified. However, it is a good practice to check the alignment at the beginning of each recording session.

To perform the alignment:

- From the Camera Setup Screen, press the “Set Options” button. In the following screen, make sure that “Head Tracking” button is enabled. Press the ENTER key to return to the previous screen.
- From the Camera Setup Screen, press the “Alignment” button; or go to the Video Setup screen, press the “Scenecam Align” button.
- In the Scene Camera Alignment screen, first check for the scene camera lens selection. Make sure that this setting (72° or 95° field of view) matches exactly with the actual type of lens mounted on the scene camera bracket.
- Have a participant sit in front of the display PC monitor with IR markers properly positioned. Place the headband on the participant’s head.

- If necessary, loosen the screws of the scene camera, angle the scene camera appropriately so that it sees as much of the scene of interest as possible if the participant looks at the target area/depth. Tighten the camera screws.
- Ask the participant to fixate at the center of the display PC monitor. Head movements may be required to ensure that there is only one marker in each quadrant of the overlay display (separated by green lines) and that each marker is reasonably distant from other markers. Avoid having the markers showing up too close to the corner of the overlay display as the optical lens distortion is less well compensated there.

Figure 11: Optical Alignment between the Scene Camera and Head Camera.

- For each quadrant of the overlay display, move the host PC mouse and place the cursor over the center of IR marker. Click the left mouse button. This must be done carefully to achieve best accuracy.
- If working properly, the yellow boxes in the overlay display will move accordingly if the participant moves head. The yellow boxes should be always on top of the center of the markers if the head tracking is enabled.

4.2 Calibration and Validation

For best scene camera performance, binocular recording in corneal reflection mode must be used. The corneal reflection mode is used for the headband slippage compensation whereas the binocular tracking is used for parallax fixup at the non-calibrated depths. For high gaze accuracy, the calibrated region should be where most of the recording activities happening. If you are performing a binocular recording, participants should be calibrated in a standard vertical display to minimize nonlinearity in the calibration mapping. The depth correction can then be performed on several depth levels in the target space (e.g., by fixating at several points on a desk). If a recording must be done in a monocular mode for some reason, try to perform the calibration and validation as close to the target plane as possible. This is because depth correction is not possible in a monocular recording -- the user must be aware of the ramifications of doing this (i.e., gaze inaccuracy at uncalibrated planes).

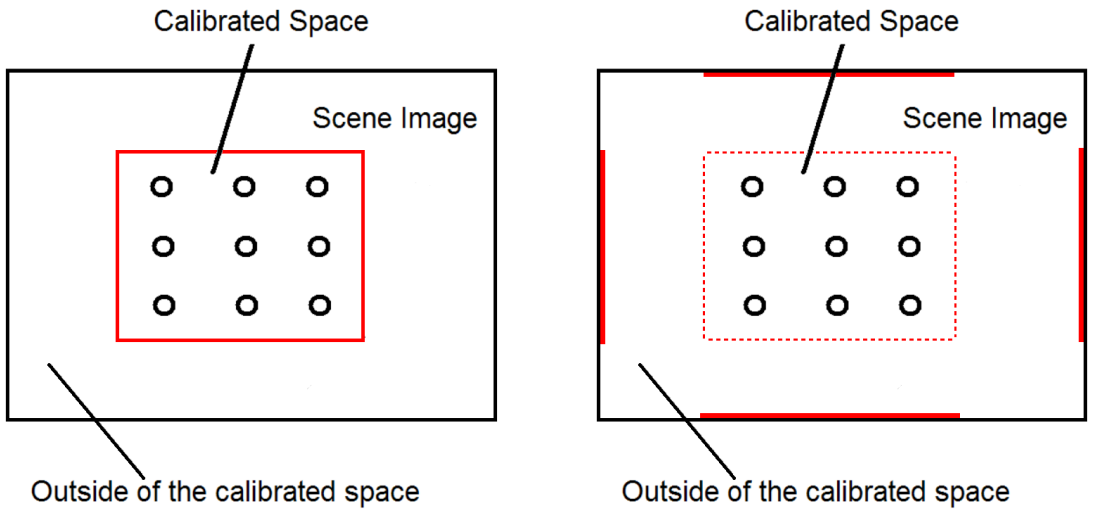
Start the eyelink program on the host computer and track.exe (or the popup calibration program) on the display PC. Perform the video setup as mentioned in the previous section. Make sure that the "Scenecam Mode", "Use Vergence", and "Cyclopean Gaze Cursor" buttons are enabled. Scene camera mode, if enabled, will apply adjustments to the gaze cursor position in the overlay graphics, taking into consideration the scene camera alignment settings, as well as the camera distortion correction. This mode should be enabled for a recording using the scene camera for tracking gaze positions involving different scene depths. With a recording using the standard overlay mode, "Scenecam Mode" button should be disabled – as a result, the "Scenecam Align" and "Use Vergence" buttons will also be disabled on the camera setup screen. Enabling the "Use Vergence" button will apply depth correction (see below) to the gaze positions in the overlay graphics. Finally, enabling the "Cyclopean Gaze Cursor" button will draw the gaze cursor midway between the gaze cursors for the two eyes.

Set up the participant in a binocular CR tracking mode and perform a calibration by typing 'C' on either the host or display PC keyboard. Note that several types of calibration algorithms have been provided by SR Research Ltd. If a large calibration region (greater than ±25°) is involved in an experiment, the "HV13" calibration type (selected from the "Set Options" screen) should be used for best calibration accuracy. By default, a nine-point calibration type ("HV9") is used. If the calibration result is good, proceed with validation by clicking on the "validation" button or by typing 'V' on either computer and press the space bar to initiate the process. Click "Scenecam Depth Setup" to proceed with correction for depth parallax in the scene camera overlay following a good validation.

4.3 Performing a Depth Correction

In the overlay graphics, if "cyclopean gaze cursor" option is enabled, the "ball" of the cursor is positioned at the average X and Y gaze position of the two eyes. When a participant is fixating on a target at an uncalibrated plane, the ball of the cursor may be drawn at a different position from where the participant intends to look at. This error is caused by the difference in the viewing angles between the scene camera and the eyes (i.e., parallax error). Therefore, a depth correction following calibration is critical for any experiment involving viewing targets at different viewing depths.

In a binocular recording, the gaze cursor drawing, if uncorrected, will be shifted primarily vertically relative to the actual eye line. This is reflected by the relative offset of the gaze "ball" along a vertical bar in the overlay graphics. If centered, the participant is looking at the calibrated depth. If the ball appears at the bottom of the bar ( ), this indicates that the participant is fixating at a plane closer than the calibration depth. If the ball appears at the top of the bar ( ), the participant is looking at a plane further away.



Scene Camera Depth Setup Screen

Recording Screen (the user will see either the box in the center of the screen or the four bars at the edge of the display)

Figure 12: Calibrated Space Viewed in the Overlay Display

To correct for the parallax error, a correction should be performed across several depths within the calibrated space.

- The Scene Camera Depth Setup screen will be brought up following a validation, drift correction or by simply clicking on the "Scenecam Depth" button in the Camera Setup Screen. If a calibration has been

successfully done, a red box will be displayed on the screen representing the calibrated space.

- For the depth correction, the first data point, behaving like a drift correction point, performs a global offset adjustment and changes the value of "offx" and "offy" in the fitting function. The subsequent data points change the correction slope "mvy" (and "mvx" as well if '`scenecam_depthfix_xy`' is enabled). Therefore, the first data point in the depth correction procedure should be placed on the calibrated plane whereas the subsequent points could be chosen from very different depth levels within the calibration space to make the correction more precise. For a calibration that is done close to the participant, the second point of the depth correction should be placed at a point in the calibrated space (i.e., area bound by the red box in the overlay display; see Figure 12 left panel) that is distant from the participant, and vice versa. As a rule of thumb, collecting 4-5 points across various depth planes should be sufficient for a good depth correction.
- Specify a fixation target at a particular depth within the calibrated space and ask the participant to fixate on the target precisely. While the participant is fixating on the target, move the host PC mouse, place the cursor over the fixation target and click the left mouse button **once only**. One correction data point will be added with each mouse click.
- The depth correction will fail if no stable fixation data is available or the distance between the fixation target and the current gaze cursor position is too large. Pay attention to the text message displayed at the bottom of the tracker screen to make sure that the data point is successfully added and that only one data point is added for each sampling.

Typically, the experimenter will perform a scene camera depth correction after calibration and validation and then proceed with data acquisition. However, depth correction can be improved or redone if necessary by pressing the "Scenecam Depth" button from the Camera Setup Screen.

- If the user wants to restart the depth correction anew, simply click the "Clear & Restart" button. This will clear the previous depth correction data points as well as the offset and slope values. A new data collection process can be started and another set of offset/slope parameters be derived to correct for parallax error.
- The user may also keep the existing data points and improve upon the last fit by adding more data points. This is done by clicking on the "Improve Last Fit" button. While collecting more data points, the user can click "Clear & Restart" button to remove all existing data points and

to start the data collection afresh, or abandon the new data points and revert to the previous parameters by clicking on the "Revert" button. Clicking the "Revert" button again will keep the previous data points as well as the more recent data points collected – this is indicated by the text messages displayed at the bottom of the tracker screen.

4.4 Recording and Online Drift Correction

Following the depth correction, a recording session can be started by pressing the 'O' key from the camera setup screen. In the recording display, the gaze cursor will be drawn overlaid on the scene camera image. By setting the `'scenecam_record_show_calbox'` command differently, the user can mark the calibrated space in the recording display by either a box in the center of the screen (1 or ON) or by line segments drawn at the edge of the display (2). In the latter case, the left and right line drawings indicate the position and relative extent of the calibrated space along the vertical dimension and the top and bottom lines indicate the position and extent of the calibrated space along the horizontal dimension (see Figure 12 right panel).

During recording, if the experimenter notices excessive drifts in the gaze cursor drawing, a runtime drift correction can be perform:

- Click on the "Drift corr" button on the Record screen, which will flash periodically if enabled.
- Move the mouse cursor over the intended drift correction target, preferably a point on the depth plane where the participant was originally calibrated, and instruct the participant to fixate on the target precisely. Press the button only once when the participant fixates stably.
- The drift correction may fail if there is no stable fixation data or if there is a large error between the current fixation and the target item. By default, the maximum acceptable error value (set by the `'scenecam_dcorr_maxangle'` command) is 20.0°.
- If the data quality is not improved following the drift correction, the experimenter should check the camera setup and redo calibration, validation, and depth setup.

Note: Please be aware that for a recording with scene camera option, the "Drift Correct" button in the Camera Setup screen behaves differently from a recording without using the scene camera. After performing a depth correction, clicking this button will bring up the Scenecam Depth Setup Screen and erase the original offset and slope parameters of the fitting function. So please be careful when using this functionality.

5. Troubleshooting

5.1 Problem 1: The scene camera option buttons are not shown in the Camera Setup screen.

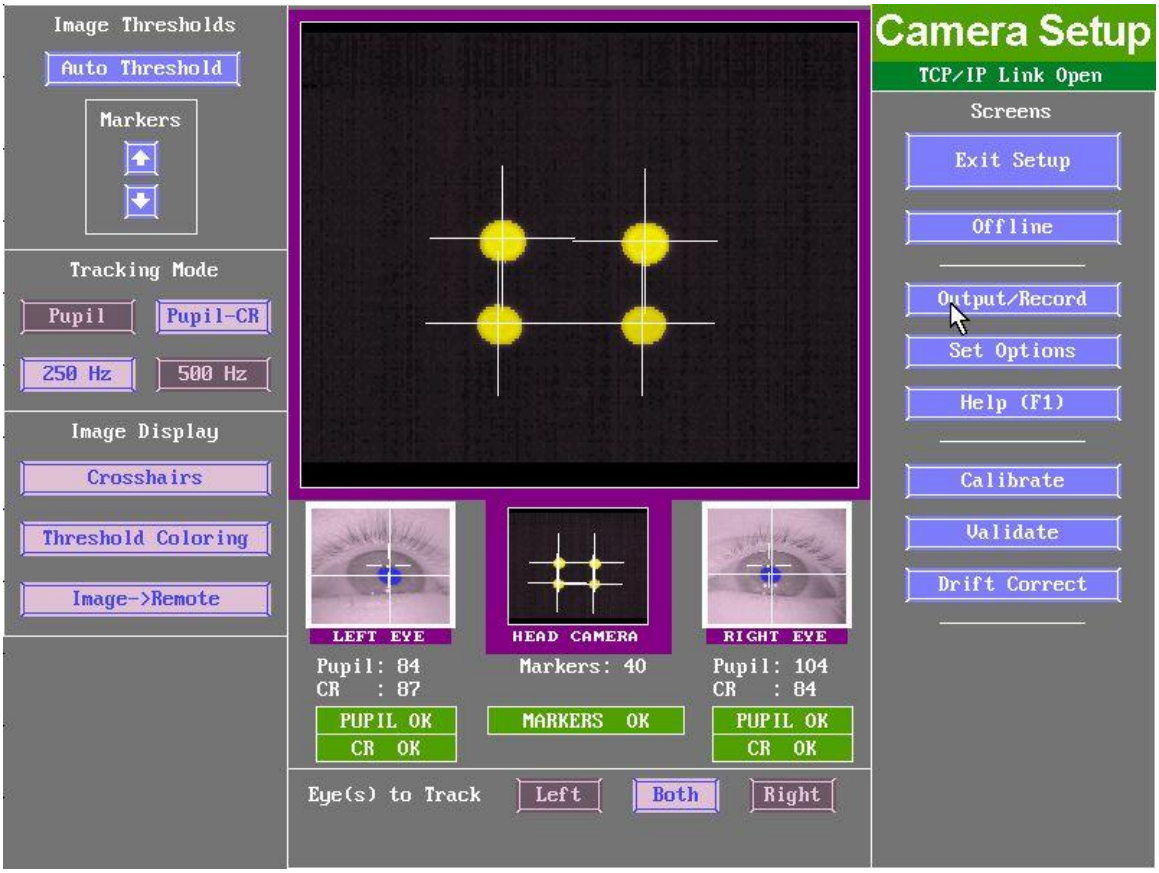


Figure 13: EyeLink II Camera Setup Screen without Scene Camera Options

Solution:

1) Go to the Set Options screen. Make sure that the "Enable Overlay" button is selected. Click on the "Overlay Setup" button. In the following video setup screen, make sure that the "Scenecam Mode" button is selected.

2) If the "Enable Overlay" button is not visible in the Set Options Screen, quit the EyeLink host application. Do a search on the eyelink2\exe directory for the "vidovl.ini" and "scenecam.ini" files. Make sure that both files are present. Also, open the eyelink2.ini file to make sure that the following two lines are included.

```
include "vidovl.ini"        // vidovl settings
include "scenecam.ini"      // scene camera setting
```

3) If there is no problem with steps 1) and 2), open the Scenecam.ini and/or final.ini to make sure that both `'scene_camera_enabled'` and `'scene_camera_gazemap'` are set to "ON" or "YES".

5.2 Problem 2: Following the wiring instructions, there is no overlay video on the recording device or TV monitor.

Solution:

1) Make sure that the scan converter box power is turned on. Check that the mode of the box is set as "Overlay".
2) Check that the connection type of scene camera output to the scan converter box input matches the "Video Input" switch setting (i.e., "S-IN" if S-Video input is used and "V-IN" if composite video input is used).
3) If the problem still exists after the above two steps are taken, check for the video output from the scene camera. Plug the scene camera output directly to the TV monitor or the recording device to check. If there is no video output, check that the scene camera is powered on and that the cable connection is not broken.
4) Contact SR Research Ltd if this problem still remains after taking all of the above steps.