



Eye Tracking Systems

User's Guide

April 2000

Note: This document is a pre-production prototype only.

Table of Contents

1. INTRODUCTION	2
1.1 SYSTEM SUMMARY	2
1.2 PURPOSE OF THIS MANUAL	2
1.3 SYSTEM REQUIREMENTS.....	2
2. INSTALLATION INSTRUCTIONS.....	4
2.1 SYSTEM COMPONENTS (PICTURES).....	4
2.2 SELECTING A LOCATION FOR THE TRACKER	4
2.3 PLUGGING IN THE CABLES.....	4
2.4 INSTALLING THE SOFTWARE.....	5
3. QUICK START INSTRUCTIONS	6
3.1 STARTING THE ET SERVER	6
3.2 STARTING THE CALIBRATION CLIENT	ERROR! BOOKMARK NOT DEFINED.
3.3 STARTING THE ET CLIENT	ERROR! BOOKMARK NOT DEFINED.
3.4 WEARING THE EYE TRACKER CORRECTLY	7
3.5 THE CALIBRATION PROCEDURE.....	8
3.6 TRACKING THE EYE.....	10
3.7 RUNNING A COLLECTION THROUGH THE DCB	ERROR! BOOKMARK NOT DEFINED.
3.8 STOPPING AN EYE TRACKING SESSION	10
3.9 EXITING THE EYE TRACKING SYSTEM	10
4. THE MONITOR TAGS.....	11
4.1 WHAT THEY DO	11
4.2 HOW TO PLACE THEM/WHERE TO PLACE THEM	11
4.3 MONITOR TAG COORDINATE SYSTEM	12
5. EYE TRACKER CONTROL SOFTWARE	13
5.1 THE EYE TRACKER CLIENT	13
5.1.1 Starting the Eye Tracker Client	<i>Error! Bookmark not defined.</i>
5.1.2 Eye Tracker Client GUI.....	13
5.1.3 The Action Menu.....	13
5.1.4 The Configure Menu	14
5.1.5 The Connections Menu	20
5.1.6 The Help Menu.....	21
5.1.7 Command Window Messages.....	21
5.2 THE EYE TRACKER SERVER	22
5.3 THE CALIBRATION CLIENT.....	23
6. USING THE EYE TRACKER THROUGH THE DCAE.....	25
6.1 OPERATING THE EYE TRACKER WITH THE DCB	25
6.2 THE STREAM VIEW	26
6.3 VIEWING DATA IN REAL TIME	27
6.4 OTHER SUGGESTED VIEWERS.....	28

1. Introduction

1.1 System Summary

This document describes the software and hardware relevant to Cybernet's Eye Tracking System (ETS).

The eye tracking system provides software algorithms and applications that perform pupil detection and gaze determination using a video-based eye tracking hardware device. The eye tracking hardware consists of a head mounted eye tracking device that captures a video image of the eye and a video image of the user's view. The software system follows a client/server model. The client application provides the user interface and relays operational commands to the server application. The server application receives video from the eye tracking device, controls the real-time video acquisition loop, processes the images, displays live video, and handles the requests of the client by inserting tasks into the video acquisition loop. Tasks include tracking, data output, information updates, etc. The eye tracking system may be used independently or as part of the Human Performance-Based Measurement System (HPBMS), where eye tracking results are recorded through the Data Collection Broker (DCB) software.

1.2 Purpose of this Manual

The purpose of this manual is to familiarize you with the eye tracker hardware, the accompanying software, and their use.

1.3 System requirements

Currently, the eye tracking system is configured to run on a single machine that functions as both *Server* and *Client*. That machine is shipped as follows:

- 550 MHz
- 128 MB RAM
- 1 Video Capture image acquisition card
- FreeBSD Operating System
- Ethernet Networking hardware

However, it can be configured to run with two machines (client/server) communicating over a network. The computer components can be broken down into server requirements and client requirements.

Server Requirements

The server machine is responsible for all of the video capture and processing, which requires a fast processor to obtain an adequate update rate. Minimum requirements have not yet been determined, however, operation has been verified on a 200 MHz Pentium Pro with 64 MB of RAM, yielding a frame rate of approximately 12Hz (with full video image display). Faster machines will provide higher frame rates. The Server must also operate the image acquisition hardware.

Client Requirements

Cybernet's eye tracking client is not as computationally intensive as the server and therefore does not require an equally capable system. For user defined client applications, the client machine should be chosen to meet the requirements of that application. We have not yet determined the minimal system computer performance requirements, however Cybernet's eye tracking client has been tested on 100 MHz Pentium, with 64 megabytes of RAM, and faster machines. The client machine must have the following additional components:

- Ethernet Networking hardware
- Windows Operating environment (95/98, NT)
- Java Virtual Machine
- 3.6 MB of free space

Calibration Client

For situations where eye tracking is to be performed while the subject uses a computer interface (and the ET Client will not be used for this interface), a Calibration Client application is available that allows for calibration of the eye tracker on the subject interface PC. (Otherwise calibration is performed on the Client machine or using a grid of points placed on the wall). The Calibration Client currently operates under Windows (95/98, NT) operating systems. Since the application simply displays points on the screen and communicates with the Client machine, the system requirements are minimal. Operation has been tested on 100MHz Pentium and faster machines. The Calibration Client system must have Ethernet networking hardware.

- Ethernet Networking hardware
- Windows Operating environment (95/98, NT)
- 1 MB of free disk space

2. Installation Instructions

2.1 System Components (pictures)

The Cybernet ETS (Eye Tracking System) is composed of the following parts:

Head Mounted Eye Tracking Device (shipped systems may vary in appearance)



Camera Control Unit and Power Cube (shipped systems may vary in appearance)



Eye Tracker Server/Client PC w/Image acquisition card and cables (not pictured, individual units may vary in appearance)

2.2 Selecting a location for the tracker

When setting up the ETS, it is important to first determine where the ET Server/Client machine should be located, taking into consideration where the eye tracker itself will be used. In most situations ET Server/Client will need to be located in close proximity to the head mounted eye tracking device (which must be connected to the ET Server). While the ET Client machine can be located anywhere on the network, the operator will generally need to see the ET Server output to verify proper operation.

2.3 Setting up the Hardware

Before using the system, you must make the following connections:

1. Connect the cable from the eye tracker head piece to the power module. This connector is a 9 pin connector.

2. Connect one end of the red RCA cable to the B port on the power module. Connect the other end to the second RCA jack on the top frame grabber card. (If you are looking at the back of the machine, you will see two PCI cards each with two RCA jacks. The top row of jacks is the top frame grabber. The second jack is the one furthest from the S-video port).
3. Connect one end of the white RCA cable to the A port on the power module. Connect the other end to the second RCA jack on the bottom frame grabber board.
4. Plug the power module into the an outlet. Note: The system expects 110 Volts at 60 Hz. A converter must be used for any other power supply.

Once the connections are made, turn the switch on the power module to on.

2.4 Installing the software

The ETS software is already installed on the supplied Server/Client machine. It is highly suggested that you do not erase any of the software.

3. Quick Start Instructions

This section contains only the basic procedures necessary to start and stop a single session of eye tracking. For more detailed instructions, please consult chapter 5.

3.1 Starting the ET Server and the ET Client

Once the ET Server has started, you will be presented with a login prompt. There is one login already configured when you first receive your server:

- login: root, password: eyetrack - this login allows root access to the ET Server, and allows root access to the rest of the machine.

After you have successfully logged in, at the command prompt type: `startx`

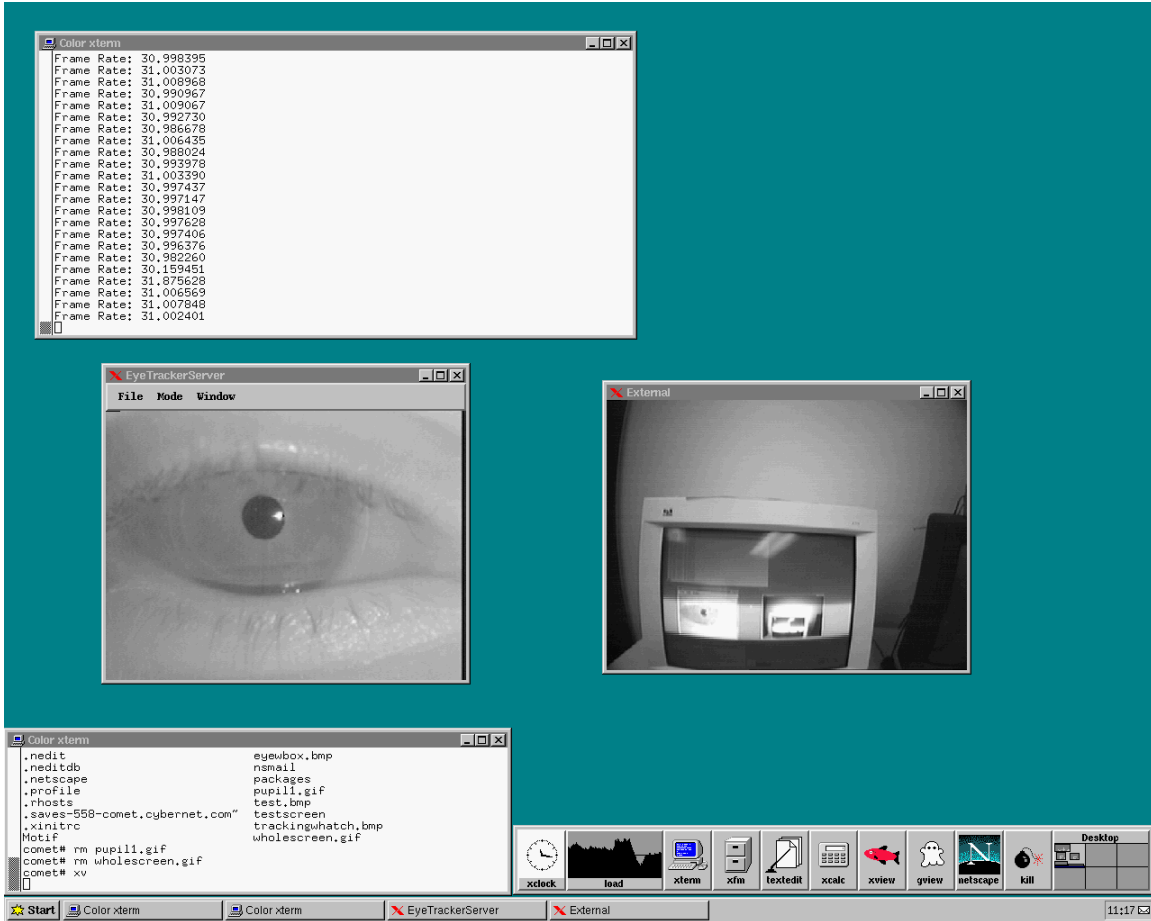
This will start the X-Windows interface from which the ET Server is run.

All operations from here on are performed in the 'xterm' window on the desktop.

At the prompt, type in `./Start_EyeTracker`.

The main window of the interface will appear, and the following will appear in the text window, and 2 video feed windows, "External" and "EyeTrackerServer," will display.

The two video windows may appear overlapping each other, and you will want to move them so that you have an unobstructed view of each.

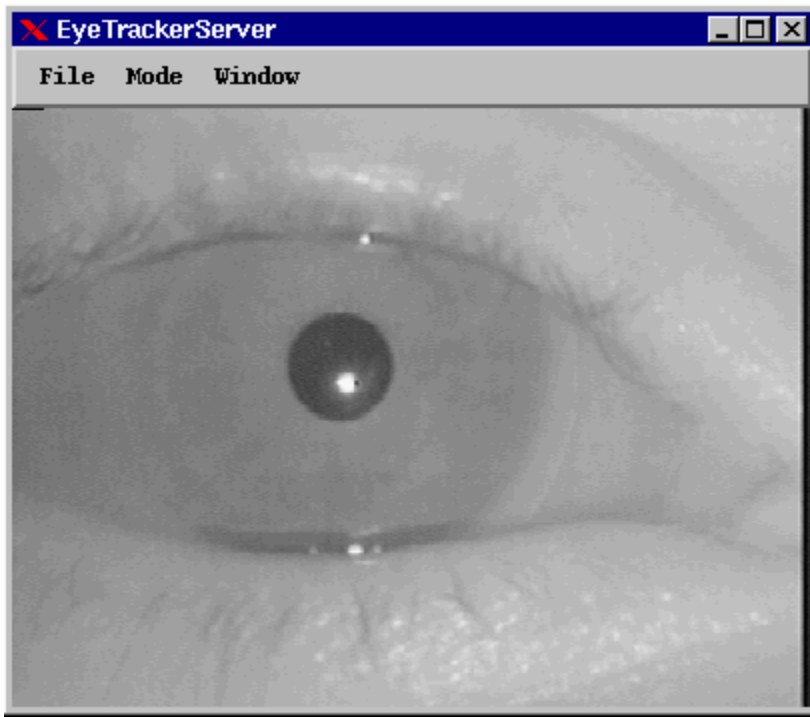


3.2 Wearing the Eye Tracker Correctly

The Eye Tracker should be placed on the head so that the arms sit above the ears, much like a pair of glasses, and the brim should stick out in front like the rim of a baseball cap. The subject's left eye should be situated directly in front of the glass mirror. The mirror should not be resting against the subject's cheek. The Eye Tracker is designed to fit tightly, to avoid motion artifacts, but not painfully. If the Eye Tracker bands are too tight, they can be adjusted slightly with a flathead screwdriver.



The Eye Tracker must be placed so that the subject's pupil is completely visible in the EyeTrackerServer window. This can be achieved by manipulating the placement of the Eye Tracker on the subject's head.



If you are using Monitor Tags, then use the External window to make certain that at least 3 of these tags are visible in the External video feed. You may need to move the position of the subject, or adjust the angle of the external camera.

3.3 The Calibration Procedure

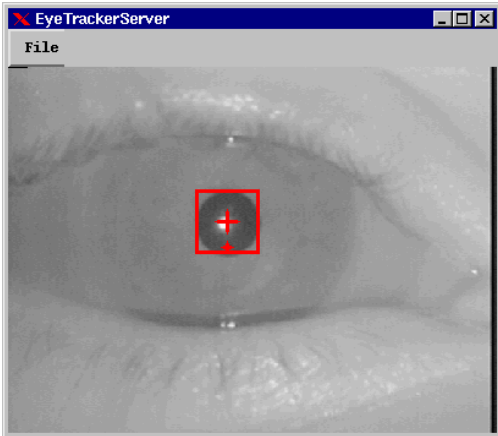
Once the ET Server is running, and the Eye Tracker is arranged on the subject's head and they are positioned in front of a wall-mounted calibration grid or a monitor running a Calibration Client, click the Calibration button. The subject will then focus on each point on the grid either as they appear (monitor calibration) or as indicated by an audio tone (wall grid calibration).

The points should be followed in a top-to-bottom, left-to-right manner.

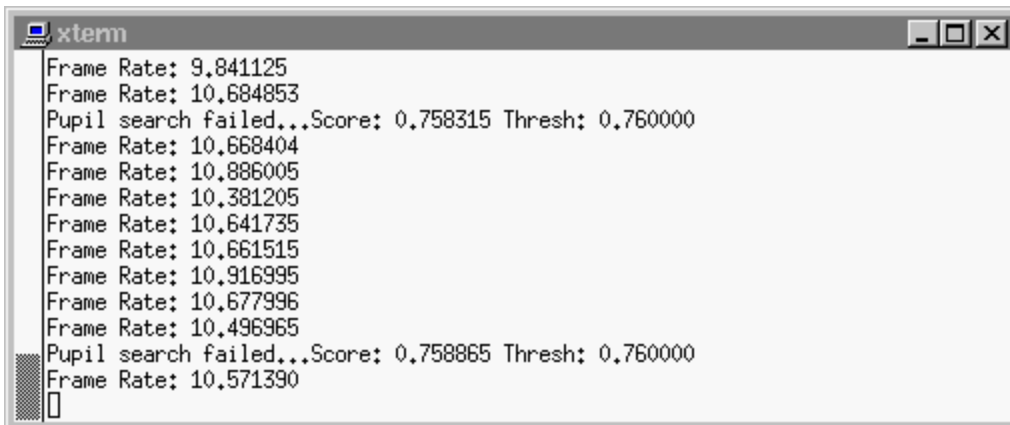
You can check calibration by watching the External view on the ET Server. When the software has calibrated a point, you will see a red circle and crosshairs appear in the External view at the location the software thinks the subject is looking.

If calibration is running slowly, and/or you think there is an error with the system, you can cancel calibration by clicking the mouse into the calibration window and pressing CTRL-X on the keyboard. The most common problem is that the software is not finding the pupil. While the ET Server is active, and a subject is wearing the eye tracker, you should see a red box surrounding the pupil as an indicator that the software is finding the

pupil. This box (and sometimes a small crosshairs inside the box) will blink on and off. *The red box should be on more than it is off.* If you do not see the red box, it means that the software is not finding the pupil, and therefore cannot track the eye.



Another means of determining if you are finding the pupil is by watching the output in the xterm window on the ET Sever machine. When the algorithm is finding the pupil, a listing of the frame rates will scroll down the window.

A screenshot of an xterm window showing terminal output. The output consists of several lines of text: "Frame Rate: 9.841125", "Frame Rate: 10.684853", "Pupil search failed...Score: 0.758315 Thresh: 0.760000", "Frame Rate: 10.668404", "Frame Rate: 10.886005", "Frame Rate: 10.381205", "Frame Rate: 10.641735", "Frame Rate: 10.661515", "Frame Rate: 10.916995", "Frame Rate: 10.677996", "Frame Rate: 10.496965", "Pupil search failed...Score: 0.758865 Thresh: 0.760000", and "Frame Rate: 10.571390". The window has a title bar with "xterm" and standard window control buttons.

When the algorithm is not finding the pupil, the window will display that the pupil search failed.

```

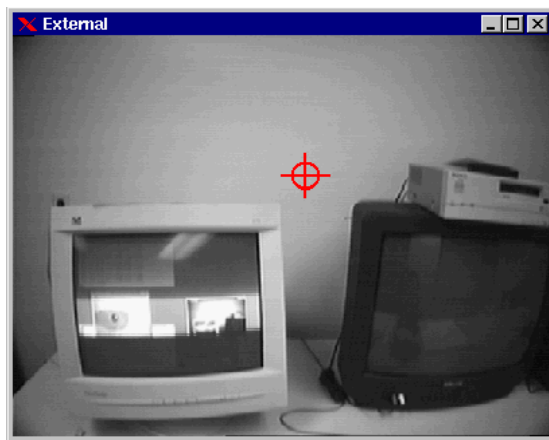
xterm
Pupil search failed...Score: 0.715727 Thresh: 0.760000
Pupil search failed...Score: 0.742746 Thresh: 0.760000
Frame Rate: 5.493459
Pupil search failed...Score: 0.759171 Thresh: 0.760000
Pupil search failed...Score: 0.724644 Thresh: 0.760000
Pupil search failed...Score: 0.749225 Thresh: 0.760000
Pupil search failed...Score: 0.744173 Thresh: 0.760000
Pupil search failed...Score: 0.723196 Thresh: 0.760000
Pupil search failed...Score: 0.670728 Thresh: 0.760000
Pupil search failed...Score: 0.719467 Thresh: 0.760000
Frame Rate: 5.601264
Pupil search failed...Score: 0.752263 Thresh: 0.760000
Pupil search failed...Score: 0.759154 Thresh: 0.760000

```

Generally, no matter what settings you are using, the algorithms will occasionally fail to find the pupil. A good tracking session will find the pupil more often than it does not. If you are having trouble calibrating a subject, you may need to adjust the settings. See section 5.1.4.

3.4 Tracking the Eye

After calibration, all red indicators in the External and EyeTrackerServer windows will disappear. By clicking the Track button, the software will begin to track gaze position, and that will be indicated in the External view by a red crosshairs. The pupil should also again be surrounded by a red box in the EyeTrackerServer window.



3.5 Stopping an Eye Tracking Session

To stop tracking the eye, simply click on the Stop Eyetracking button.

3.6 Exiting the Eye Tracking System

Before exiting the ET Client, disconnect from the ET Server through the Connections Menu. This will also shut down the ET Server. You should also disconnect from the Calibration Client at this time, if you were running one.

To exit the Eye Tracker, simply click the corner X button of the main ET Client window, or select the Exit option from the Action Menu.

4. The Monitor Tags

4.1 What They Do

The Monitor Tags are 2 inch diameter red circles. There are 4 of them, and they are used to mark out a rectangular area in which the software will compute X and Y coordinates. They were designed to be placed on the frame of a monitor, to calculate the gaze position on the screen, however, they can be placed on a wall, floor, ceiling, vehicle windshield or any flat surface to provide a coordinate system.

4.2 How To Place Them/Where To Place Them

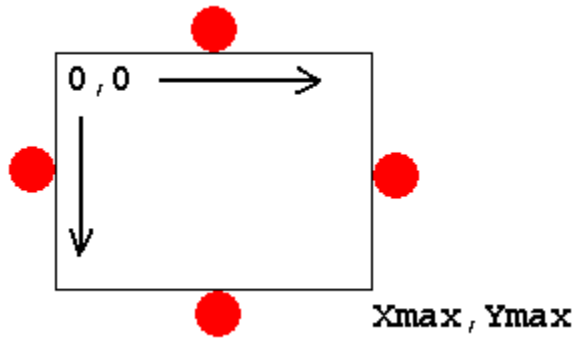
Monitor Tags must be placed in a diamond formation, with the intersection of the horizontal pair and the vertical pair being at the center of the area in which you wish to determine a coordinate system.

The picture below demonstrates Tag positions for the screen area of a typical computer monitor.



4.3 Monitor Tag Coordinate System

The Monitor Tags form a coordinate system based on the following diagram:



5. Eye Tracker Control Software

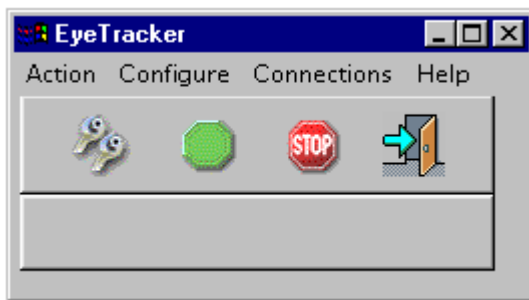
This section describes the use of the eye tracker client.

5.1 The Eye Tracker Client

The Eye Tracker Client is the program that acts as the interface between the ETS and the user. It is a graphical user interface which uses a mouse-controlled interface of buttons, menus, and editable fields.

5.1.1 Eye Tracker Client GUI

The eye tracker client GUI is composed of menu bars (Action, Configure, Connections, Help), push buttons (Calibrate, Start/Continue Tracking, Stop/Pause Tracking, Exit), and a message pane. The details of the commands performed by these inputs are described in the following sections.

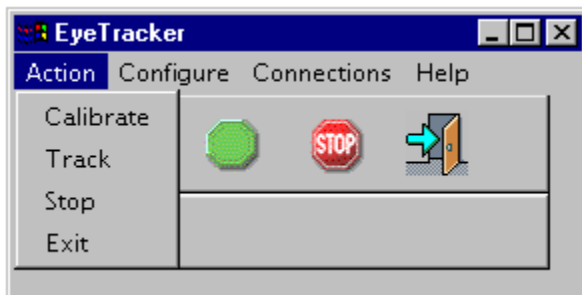


The 4 icon buttons are shortcuts to the primary functions of the ETS:

- Calibrate (dual wrenches, leftmost button)
- Start/Continue Tracking (green octagon, left-center button)
- Stop Tracking (stop sign, right-center button)
- Exit (door with arrow, rightmost button)

5.1.2 The Action Menu

This section details what occurs when a given command is specified.



Calibrate

The client will respond differently to the calibrate command depending on the current configuration. If monitor-based calibration is selected then upon receipt of the calibrate command, the client will read the calibration file specified in the Files tab of Configuration Options. During calibration, the client will successively display a point at the x and y coordinates of each point given in the file (see section 5.1.4, *Files Options* for details on this file). The user will see the screen turn a blank black. Then the first point will appear as a small black dot at the location specified by the calibration file. The client will inform the server that a new calibration point is being displayed. When the server determines that the user has focused on this point, a message is sent back to the client. The client will then display the next point and send the appropriate message to the server. This will continue until all the points in the file have been processed (9 calibration points is the most typical configuration).

For wall-grid calibration, the client is only responsible for telling the server when calibration starts. There is no file that needs to be read and no information that needs to be displayed by the client. The server will determine when calibration is over based on finding the 9 calibration points successfully. During calibration, the client will display a window detailing the fact that it is in calibration mode.

Track

Once calibration is complete, the user can instruct the client to pass the tracking message to the server. If the user has selected mouse deltas as the output type, then the mouse on the client machine will be under eye control (assuming the proper serial connections have been made). Otherwise, the server will output pupil and gaze information to the output file, `eye_track.dat`.

Stop

The stop tracking command will stop the server from producing tracking information (it will no longer calculate gaze position).

Exit

Exits eye tracker.

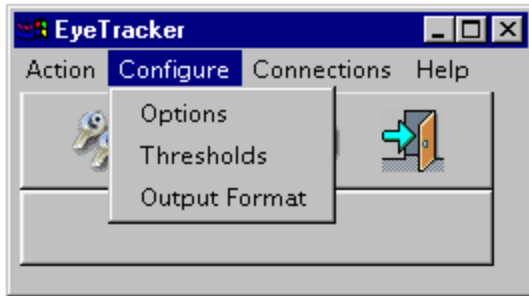
5.1.3 The Configure Menu

This menu has three selections: Options, Thresholds, and Output Format.

Options contains a tab menu for control of the basic operations available to the software, and also acts as the 'Preferences' controls.

The Thresholds menu allows you to control the sensitivity of the cameras when looking for and recording eye positions.

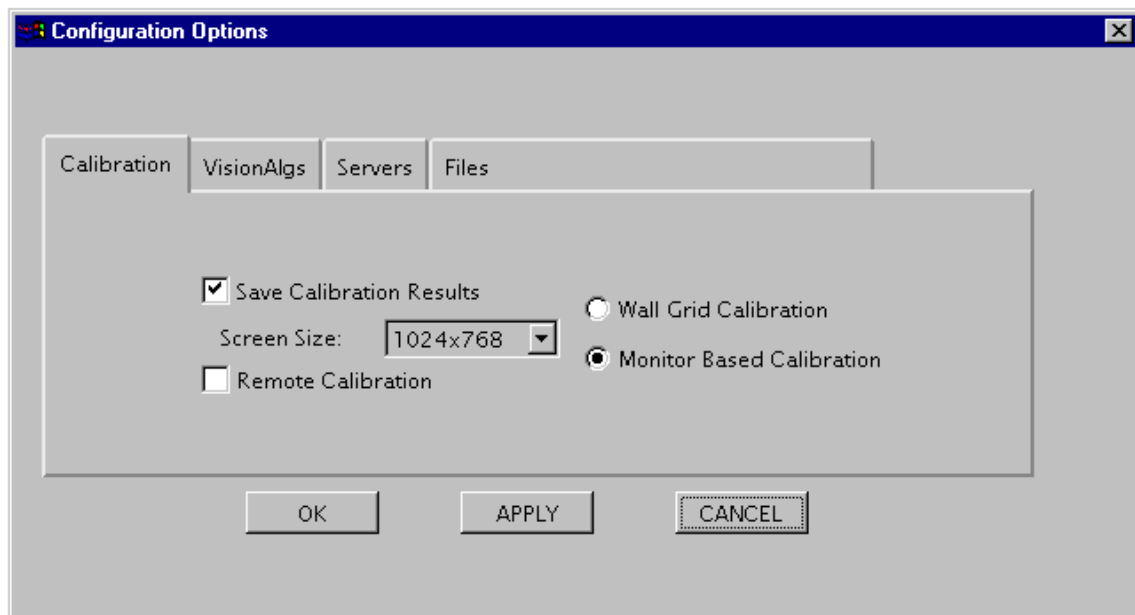
From the Output Format menu you can control the data that the software will write to a file.



5.1.3.1 Configuration Options

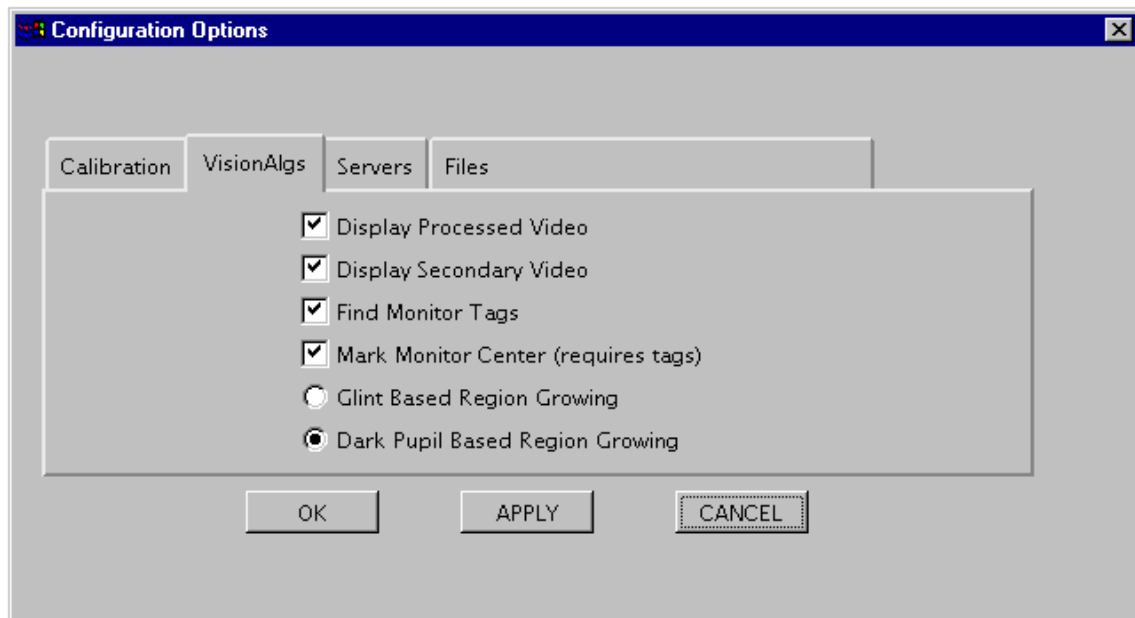
To configure the eye tracker, select Options from the Configure Menu. This GUI has 4 tab boxes that can be selected: Calibration, VisionAlgs, Servers, and Files.

Calibration Options



The following options can be modified under the Calibration tab:

1. Save calibration results on/off.
2. Screen Size - this is for determining the size of the screen where the computerized calibration grid will be displayed.
3. Remote Calibration - checking this box will display the calibration grid on a remote machine. That remote machine must be running the Calibration Client, and the ET Client must be connected to it (see the Connections Menu).
4. Calibration Type Selection:
 - Wall Grid Calibration - this is for using a wall grid calibration
 - Monitor Based Calibration - this is used to select the computer to display a calibration grid on a screen. It is used in conjunction with Remote Calibration and Screen Size options.

VisionAlgs Options

The following options can be modified under the VisionAlgs tab:

1. Display Processed Video on/off.

Choosing display processed video will inform the server to display live video of the users eye on the server's monitor. The video will be marked with a square to show pupil diameter, a large cross to show pupil center, and a small cross to show seed location. For optimum performance processed video should not be displayed as this slows the system down considerably.

However, having the processed video displayed can often be of great assistance in centering a subject's eye in the camera view (for better performance), and can be used to 'debug' why certain subjects have poor performance.

2. Display Secondary Video on/off.

Choosing display secondary video will inform the server to display the video from the second camera (the external world view). The video will be marked with a single red cross to indicate gaze location. It may also be marked with a small red box indicating the center of the Monitor Tags if they are being used.

Since the information gathered from the eye tracker is mostly visual, display secondary video should be on. However, it can be turned off to increase the update rates if the results are to be viewed in another form (such as the raw data stored in the output file, or collected through the DCB software).

3. Find Monitor Tags

This will indicate that the software should look for 4 red dots arranged in the standard positions. This is used to give a set of coordinates when the subject is looking within the area of the tags.

4. Mark Monitor Center

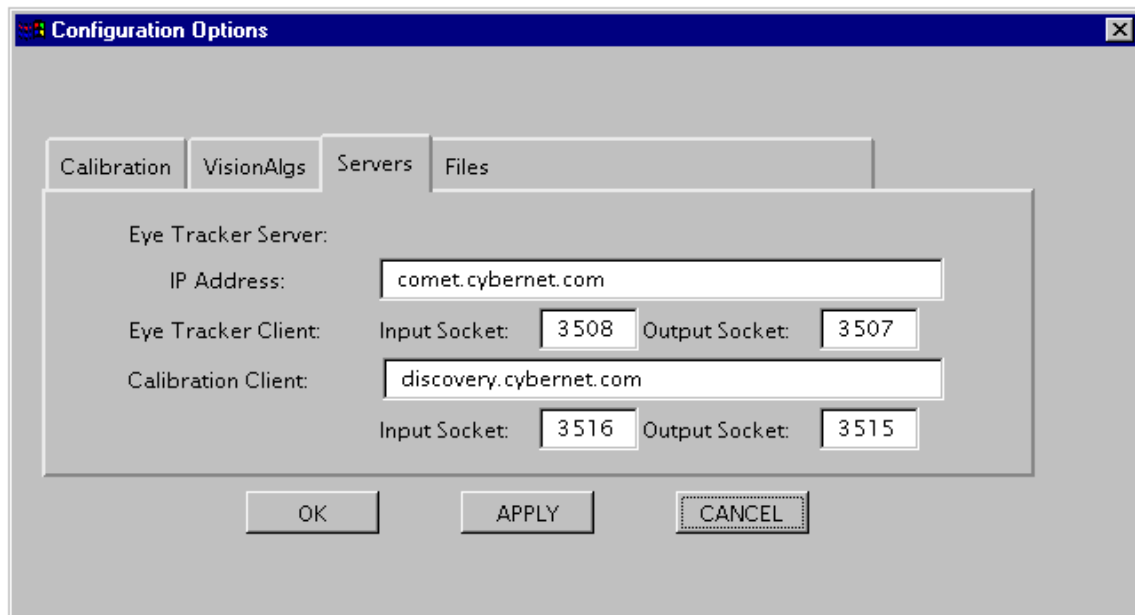
This is useful only if you are displaying the secondary video, and using Monitor Tags and the Find Monitor Tags box is checked. It will place a small square at the intersection of the lines created by the Monitor Tags, and appear in the Secondary Video window.

5. Glint Based Region Growing / Dark Pupil Based Region Growing radio buttons

The region growing routine can determine the pixels which makeup the pupil when supplied with one pixel within the pupil. There are two methods to finding a point inside the pupil:

- Glint Based Region Growing uses the IR reflection (glint) as a guide to pupil location. It is assumed that the pupil will be within a certain area above the glint. Therefore, a vertical offset is added to the glint location and the result is used as the seed location.
- Dark Pupil Based Region Growing uses the dark characteristics of the pupil to find a point within the pupil. Basically, the dark areas of the image are analyzed to determine where the pupil is most likely to be. Then this location is used as the seed to the region growing algorithm to produce a more accurate determination of the pupil center. This is the default setting because it generally produces the best results with the eyetracker supplied.

Servers Options



The following parameters can be modified under the Servers tab:

1. Eye Tracker Server IP Address
2. Eye Tracker Client Input and Output Sockets

Input Socket defaults to 3508.

Output Socket defaults to 3507.

Both of these values must be the same as the Eye Tracker Server, and are by default. If they need to be changed, refer to the Eye Tracker Server Section in this manual.

Whenever socket numbers are changed, the client must be restarted before they will take effect.

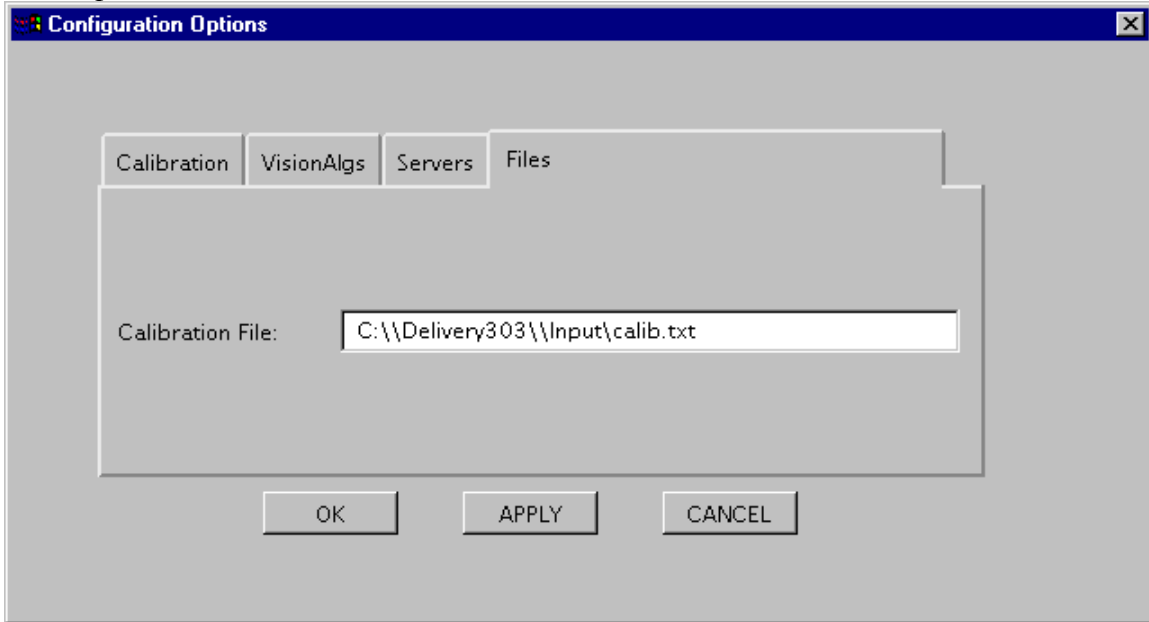
3. Calibration Client IP Address
4. Calibration Client Input and Output Sockets

Input Socket defaults to 3516.

Output Socket defaults to 3515.

Both of these values must be the same as the Calibration Client, and are by default. If they need to be changed, refer to the Calibration Client section in this manual. Whenever socket numbers are changed, the client must be restarted before they will take effect.

Files Options



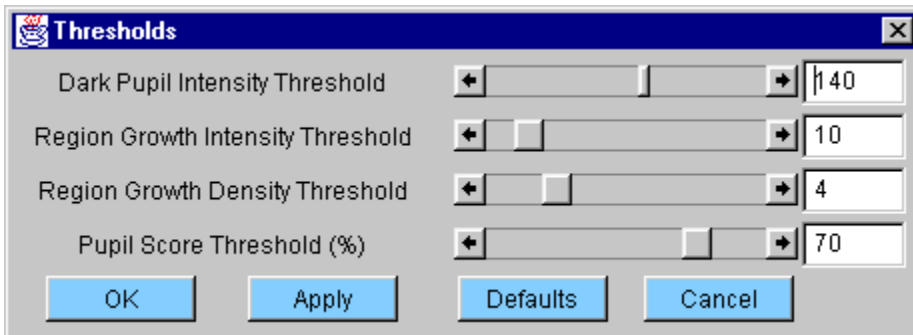
The following parameters can be modified under the Files tab:

1. Calibration File

Used to create calibration grid for computer screen calibrations. This file is nothing more than a list of X and Y coordinates, 1 coordinate set per line, that indicate where on the screen points should be placed. Points are used for calibration one at a time, from the top of the file to the bottom:

```
100  100
200  200
300  300
...  ...
```

5.1.3.2 Thresholds



The Threshold window is used to adjust the mathematics of the algorithms used to detect and track the pupil. Difficulties that occur because the software is not 'finding' the pupil can be corrected here.

The following parameters can be modified under the Thresholds Option:

1. Dark Pupil Intensity Threshold

This value indicates the brightness or darkness that the software expects the pupil to be.

The lower the value, the software looks for a darker pupil; the higher the value, the software looks for a brighter pupil. This is examined on a pixel by pixel basis across the entire image captured by the Matrox cards.

2. Region Growth Intensity Threshold

The range that a nearby pixel must be within in order to be considered a part of the dark pupil. This value is used to look for the edges of the dark pupil. This variable should generally be set low to avoid the software blending the pupil and the surrounding white eye together.

3. Region Growth Density Threshold

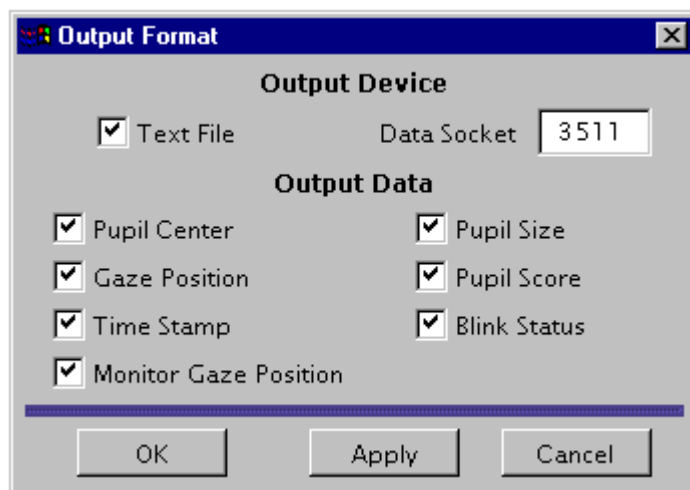
The number of neighboring pixels that must meet the above two criteria in order for the initial pixel to be considered part of the pupil.

4. Pupil Score Threshold (%)

The Pupil Score is a measure of how well the shape of the detected pupil matches the shape of the ideal pupil. Requirements for a perfect match would be 100%, but this is unrealistic. Generally, a 70% match (the default setting) produces good performance.

5.1.3.3 Output Format

The Output Format Window is used to determine which bits of data are included in any data files created or exported to the DCB software. When running the eyetracker through the DCAE, all fields must be selected to be a part of the Output Data.



The following parameters can be modified under this window:

1. Text File on/off

Toggles the creation of a text file (containing the data indicated below) named eyetrack.dat. The created file will appear in the directory that the ET Client is in.

2. Data Socket

This is the value of the data socket connection to the DCAE. It must match the socket number listed in the eyetracker.ini file. For more information, consult the DCAE Software manuals (specifically the DCB User's Guide).

3. Pupil Center on/off

Toggles the inclusion of the X and Y pupil center data

4. Gaze Position on/off

Toggles the inclusion of the X and Y gaze position data

5. Time Stamp on/off

Toggles the inclusion of the ET Server time stamp data. (The DCB time stamp will have some transfer delays, so the ET Server time stamp can be used to provide the most accurate timing information, when desired).

6. Monitor Gaze Position on/off

Toggles the inclusion of the gaze position data which has been set to a coordinate system based off of the Monitor Tags. If Monitor Tags are not going to be used during a collection, this data field will return incorrect data.

7. Pupil Size on/off

Toggles the inclusion of Pupil Size data.

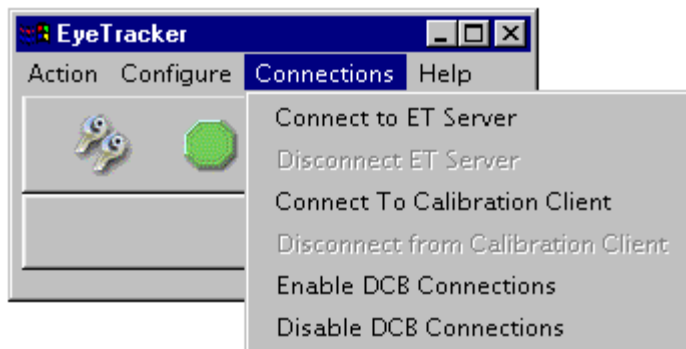
8. Pupil Score on/off

Toggles the inclusion of the Pupil Score data. The Pupil Score is a rating of how well the software thinks it captured and tracked the pupil during a particular frame.

9. Blink Status on/off

Toggles the inclusion of the Blink Status data. Blink Status is a field indicating if the eye was blinking during a particular frame.

5.1.4 The Connections Menu



Through this menu you can connect and disconnect to different parts of the Eye Tracker Control software:

1. Connect/Disconnect to ET (Eye Tracker) Server

In order to operate the eye tracker and actually collect data, you must connect to the ET Server. However, you do not need to connect to the server while you configure the system. If there is a problem with the server, you can disconnect from it using that menu option.

2. Connect/Disconnect to Calibration Client

These options are only necessary if you are performing calibration on a monitor connected to a different computer than the one running the Main Eye Tracker Client. The remote Calibration Client needs to have been started on the second computer *before* this connection can be made.

You do not need to connect to a Calibration Client if you are performing calibration on the computer running the Main ET Client, or if you are using a wall grid for calibration.

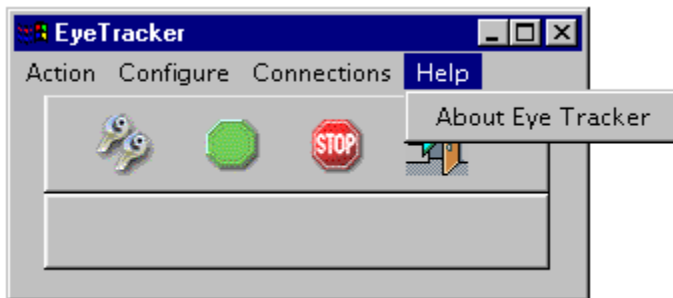
3. Enable/Disable DCB Connections

If you wish to export data directly to the DCB (Data Collection Broker) software you must enable the DCB connection. Data selected to be transferred can then be recorded to a data collection stream (refer to DCAE Software Documentation for details).

While a DCB Connection is enabled *and* eye tracking is underway, you can use the Analysis and Playback System (APS) software to view the eye tracking data in real time.

5.1.5 The Help Menu

In the current version of the Eye Tracker Software, there is no online help. Online help is expected to be implemented in a later version.



5.1.6 Command Window Messages

The eye tracker client provides feedback to the user in the form of messages, warnings, and errors displayed in the command prompt window (minimized on start-up). If the client isn't behaving properly, this window should be checked for messages. The following tables describe the possible messages. Error messages are delivered when an unexpected event occurs that causes the program to terminate. Warning messages are delivered when an unexpected event occurs but the program is able to proceed. Information messages are delivered to present information about what is going on inside the program.

Message	Type	Meaning
<i>Initialization Messages</i>		
Could not open initialization file.	Error	Initialization file, EyeTracker.ini, could not be opened. Client will not be started.
<i>Calibration Messages</i>		
Could not open calibration file.	Warning	Calibration file

Message	Type	Meaning
		could not be opened. Calibration not performed.
Starting Calibration	Informational Message	The calibration process has started.
<i>Tracking Messages</i>		
Starting Eye Tracker	Informational Message	Tracking and data collection started.
Stopping Eye Tracker	Informational Message	Tracking and data collection stopped.
<i>Communication Messages</i>		
Input Socket = SOCKET	Informational Message	Input Socket number has been set to SOCKET
Output Socket = SOCKET	Informational Message	Output Socket number has been set to SOCKET
The input socket type must be an integer Default: Using 3508 for input socket	Warning	The input socket number specified is not formatted properly. Default value will be used.
The output socket type must be an integer Default: Using 3507 for output socket	Warning	The output socket number specified is not formatted properly. Default value will be used.
Server not initialized correctly ..	Warning	Eye tracker server not initialized properly. Problem must be fixed and server connected before eye tracking can be performed.

5.2 The Eye Tracker Server

The eye tracker server is designed to be executed under the FreeBSD operating system running XWindows. The command is:

```
EyeTrackerServer [-loutfile] [-isocket_in] [-osocket_out]
```

In this command `outfile` is the prefix of a file name where messages should be written. The default is to write these messages to the screen. Writing to the screen is relatively slow, so a file should be given if speed is important.

`socket_in` is the socket port number to be used as the input socket port for the server (output for the client). The default value is 3507.

`socket_out` is the socket port number to be used as the output socket port for the server (input for the client). The default value is 3508.

Once started, the eye tracker server will wait for the client to connect to the sockets. While waiting it displays the message:



```

xterm
comet#
comet# ./EyeTrackerServer
Waiting for calibration client connection,....

```

After the client connects, the server will continue with execution. The client will send initialization information to the server, thereby properly configuring the server to the user's wishes.

There is a loop utility included with the ET Server. It can be executed by issuing the command `./ets.csh`. This utility puts the ET Server into a continuous loop. Every time the program exits (via a disconnection command issued by the ET Client), the utility will wait 2 seconds and then restart the Server. The utility will also create directories with the name `TEST_#` every time an output file is created. The first time the Server is executed, the directory will be `TEST_0`, then `TEST_1`, and so on. The Nth time will be `TEST_N-1`. The numbering scheme is not dependent on which directories are actually created - remember, they are only created if an output file is generated by the ET Server. All of the existing output files will be moved into the newly created directory. Make sure to save any data to new directories between runs of `ets.csh`, because it will overwrite existing `TEST_#` directories.

`Ets.csh` can be exited by typing CTRL-C while the xterm window that started it is active.

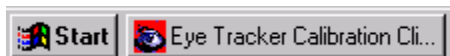
5.3 The Calibration Client

The Calibration Client is the software that allows a subject to perform calibration on a remote machine from the one running the ET Client. This program will need to be started before remote calibration can be performed.



Eye Tracker
Calibration
Client

It will run in the background, and appear minimized on the taskbar as "Calibration Client". The application is a console window that shows only information used for status and software debugging, and does not accept commands.



To terminate the program, you must maximize the window then exit the program using the X button on the window. You will be prompted by the Task Manager if you want to the end the task; select the 'End Task' option.

6. Using the Eye Tracker through the DCAE

This section details the use of the ETS as an integrated component of the Data Collection and Analysis Environment (DCAE) software. It assumes that the ET Server and DCAE have been installed on the same machine and that the user is familiar with the DCAE software. The Data Collection Broker (DCB) p For more information on the DCAE not covered here, please consult the DCAE documentation.

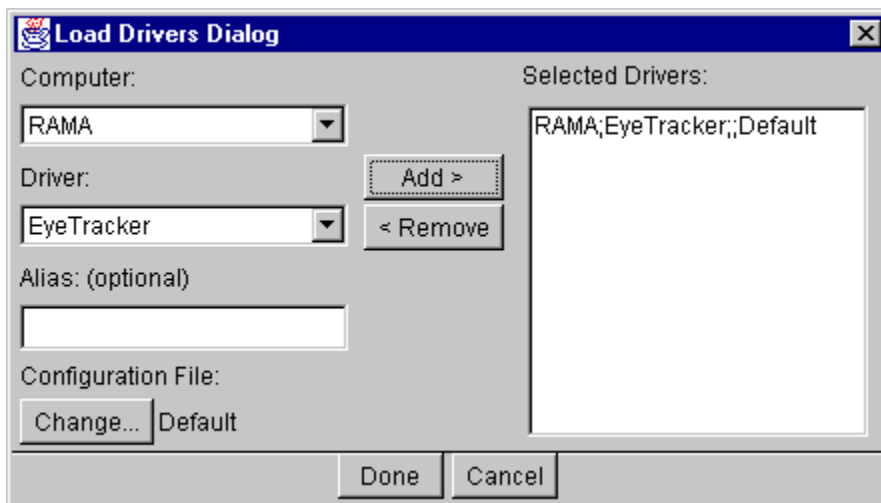
6.1 Operating the Eye Tracker with the DCB

The operation of the Eye Tracker as a part of a DCB collection is the same as when it is being used as a separate system. The ET Client, ET Server, and Calibration Client (if used) are operated in the same manner as detailed in section 3, Quick Start, and Section 5.

In the Connections menu of the ET Client, you must select 'Enable DCB Connection'. Both the 'Enable' and 'Disable' selections are always available – the operator must keep track of whether or not the DCB connected is enabled or disabled. DCB connections are enabled by default.

To include the Eye Tracker in a DCB collection, you must load the EyeTracker driver for the node on which the ETS software resides. In the DCB main window, click the 'Load Driver' button.

In the 'Load Drivers Dialog', select the computer on which the ETS software resides and on which the EyeTracker driver can be found. (The DCB and the ETS software will normally be on the same machine.) Select the EyeTracker driver, click 'Add', and then 'Done'. This will load the EyeTracker driver and prepare the DCB for collecting eye tracking data.



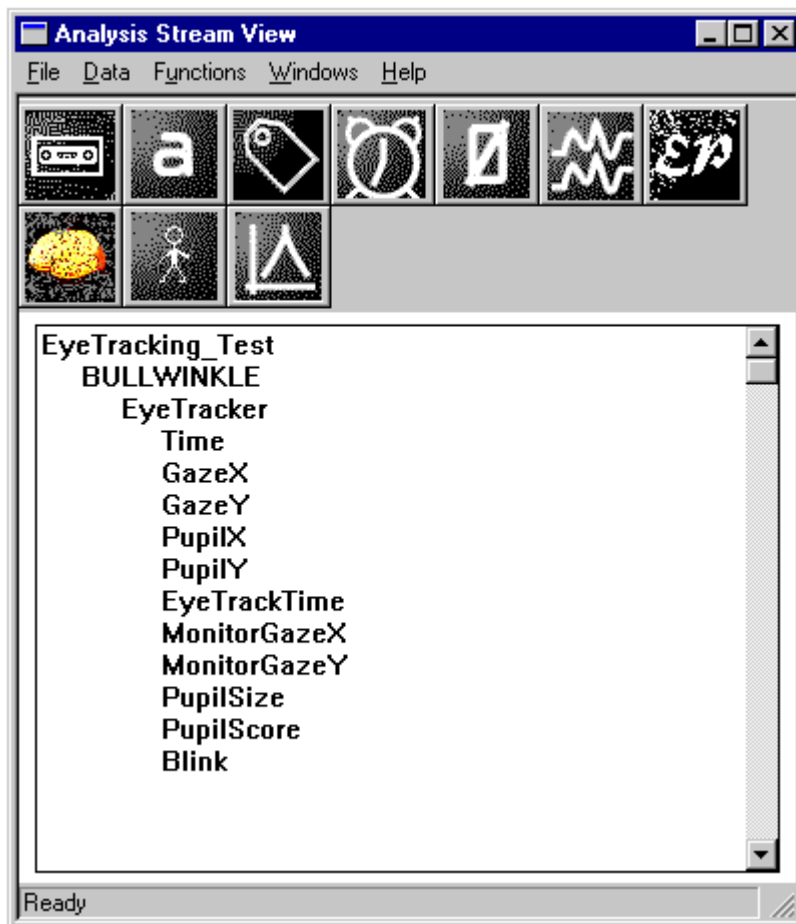
DCB collections can be started and stopped independently of the starting and stopping of a tracking session with the Eye Tracker. *However, the ETS will only send data to the*

DCB while it is actually tracking eye movements (meaning the 'Start Tracking' button has been clicked.)

For more detailed information on the operation of the DCB, please refer to the DCB User's Manual.

6.2 The Stream view

Eyetracker data will appear in the main window the APS in the format standard for the DCAE: test name, node name (the computer that the data was collected on), driver name (the driver that the DCAE was running to collect the data – also called the stream name), and then the individual data fields (a time field is always included as the first field).



The fields contain data as follows:

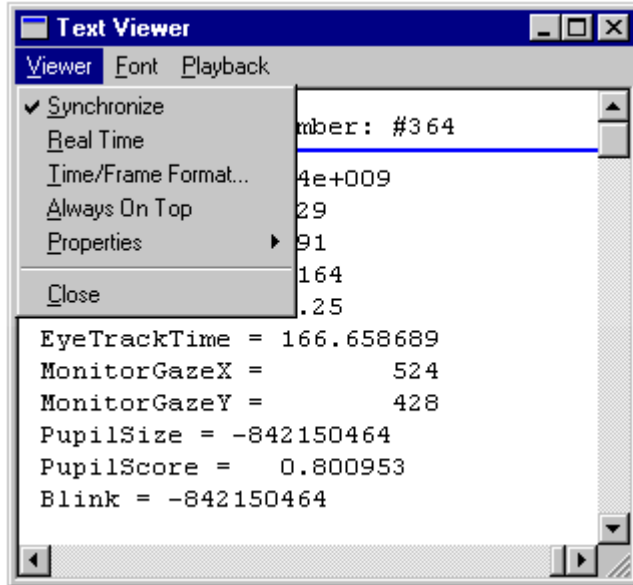
- Time - the standard DCAE timestamp
- GazeX - the x-coordinate of where the subject is looking within the frame of the 'External View' window, 0-400, where 0 is the top edge of the screen
- GazeY - the y-coordinate of where the subject is looking within the frame of the 'External View' window, 0-300, where 0 is the left edge of the screen

- PupilX - the x-coordinate of the center of the pupil as seen in the 'EyeTrackerServer' window, 0-400, where 0 is the top edge of the screen
- PupilY - the y-coordinate of the center of the pupil as seen in the 'EyeTrackerServer' window, 0-300, where 0 is the left edge of the screen
- EyeTrackTime - the ETS places it's own timestamp on the data. That timestamp is recorded here.
- MonitorGazeX - the x-coordinate of where the subject is looking within the frame of the Tag coordinate system
- MonitorGazeY - the y-coordinate of where the subject is looking within the frame of the Tag coordinate system
- PupilSize - the diameter of the pupil, in pixels
- PupilScore - the quality of the pupil, as determined by the software. This value can be used as an indicator of whether or not that frame of data was used.
- Blink - a value of 0 indicates eyes open normally, a value of 1 indicates the subject was in the process of blinking

6.3 Viewing Data in Real Time

Data from the ETS can be viewed in Real Time through the APS if desired. However, the usefulness of this is often limited (compared to the video display available in the ET Server), except to confirm that the tracker and DCB interface is operating correctly by confirming that field values are within appropriate ranges. The suggested viewer for this is the Text Viewer. For more information on this viewer, please consult the APS documentation.

To view ET data in Real Time, the ETS must be actively collecting data during a tracking session (not during calibration or idle times) and the APS must be running. From within the APS, select the fields you wish to view from the Stream View, then select the Text Viewer from the icon menu. In the Text Viewer, open the 'Viewer' pull down menu and select the 'Real Time' option.



The data displayed will jump from the first frame of the collection to the most current frame of the collection, and then update the window with each new frame of data as it is received.

6.4 Other Suggested Viewers

Eye tracker data can be viewed with any of the other viewers, but some are more appropriate than others. Suggested eye tracker data viewers are: Multi-Channel Strip Chart, Text Viewer, and Tag Viewer. Refer to the APS User's Guide for more information on these and other viewers.