



Affordable high precision gaze monitoring is at last a reality

The Video Eyetracker Toolbox is an innovative solution that contains everything you need to add reliable gaze tracking to new or existing experimental systems.

The system has been designed for vision scientists and experimental psychologists, and features facilities that they requested.

Priced at under £6000 affordable, high-precision gaze monitoring is at last a reality.

Mounted on headrest and incorporating the camera, illumination and optics, it is simple to add to existing setups. The software is implemented as a server component, a kind of 'eye tracker engine', which can be easily used with almost any Windows programming environment, including MATLAB.



Real-time

Head position and eye rotation are computed in real time and returned as gaze direction or eye rotation. This makes online fixation control and gaze contingent displays a reality. No post-hoc processing is necessary. Data can be manipulated in real-time or recorded to a simple ASCII file.

Flexible Stimulation

The Video Eyetracker Toolbox (VET) is an eye tracking engine, not a closed application with fixed functionality. It can be used with almost any PC controlled visual stimulus source, not just bitmaps.

Simple

The VET is implemented using Microsoft's Object Automation technology (COM). This means it is simple to add gaze tracking to any existing application. Only 8 lines of code are required to create a complete tracking solution and user interface. Not only is the VET simple to program, it is also easy to use. No manual controls have to be configured; calibrate your subject and start tracking in under a minute.



Adaptive

Unlike simple threshold based systems, the VET uses a unique image segmentation system. The technology is fully adaptive and does not need adjustments for changes in ambient illumination, for example, from the stimulus screen.

Behavioral Monitoring

If you incorporate the VET's special software functions into your own laboratory software, you can be sure that your experimental subjects comply with your instructions, even if it's just simple fixation monitoring.

GazeTracker™

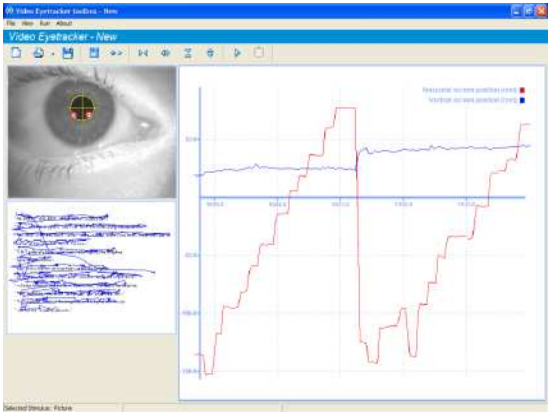
The VET is now also integrated with GazeTracker™, a powerful software package that consolidates stimulus presentation, information synchronization, data analysis and visualization.

GazeTracker™ is a zero-programming solution, and is ideal for studying reading, visual scanning, or any static or dynamic visual stimuli, including third-party software programs and even websites.

Head position and eye rotation are computed in real time and returned as gaze direction



The subject can be seated at the headrest, the camera aligned and focused and the calibration commenced in seconds



Advanced Knowledge Based Adaptive Algorithm

Existing eye tracking systems, which are based on conventional image segmentation algorithms, provide adequate performance most of the time in ideal conditions. The Video Eyetracker Toolbox (VET) engine works all of the time and is immune to subject variability and changing illumination conditions. The image processing algorithms employed are knowledge based; the recursive algorithm uses knowledge about the mechanics of the eye and previous history of eye position to give extremely robust tracking. This results in no 'dropped frames', i.e. occasions when the algorithm was unable to detect the features of the eye.

It works all of the time and is immune to subject variability and changing illumination

The algorithm is also adaptive. By incorporating prior knowledge of what the image should contain, the system is able to rapidly adjust itself to each individual. Conventional solutions all need to be tuned or adjusted for good tracking performance. This is often time consuming and in some cases the system is defeated by ambient illumination. We designed the software so that no adjustments are needed over a wide range of lighting conditions. The subject can be seated at the headrest, the camera aligned and focused and the calibration commenced in seconds.

The VET incorporates an anatomically and physiologically plausible model of the head and eye.

Rather than use a simple sphere to represent the eye, as most published devices do, a more complex model is used incorporating individual parameters for corneal and globe diameters. This increases the theoretical accuracy of measured eye rotation. By modeling possible sequences of eye positions, it is possible to resolve ambiguous measurements to give continuous measurement of eye rotation and gaze direction.

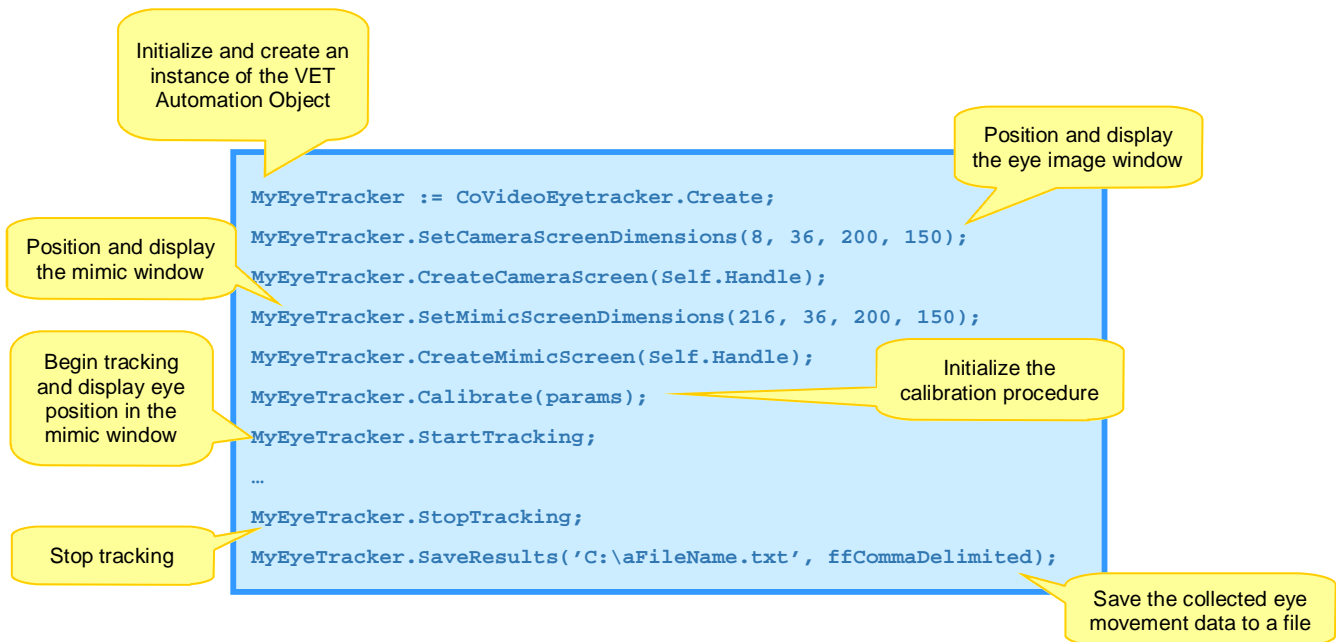
Simple API

The VET is implemented as an OLE Automation Object, built upon Microsoft's COM technology. This results in an extremely simple application programming interface, supported by almost all modern Windows programming systems; for example: Delphi, C++, MATLAB, Visual Basic, even Visual Basic for Applications (imagine your eye tracker controlled from a Word macro!). The VET provides all the functions needed to incorporate eye tracking into experimental software. For example, calibration is performed by one simple call. The opposite page shows the complete code, written in Borland Delphi, to implement an application that calibrates the eye tracking engine, tracks eye position, and displays fixation on a mimic of the subject's display and saves the results to a file. The COM object is highly optimized for performance and is fully threaded; this means that on a modern PC most of the computer's CPU time is available to service your application.



Unlimited Technical Support

Like all CRS products, the VET comes with lifetime unlimited technical support from our team of scientists and engineers.



EyeLock Integrated Headrest

We asked our customers what features they wanted in a headrest for vision science. The overwhelming response was RIGID, RIGID, RIGID. We also looked at headrest designs for laboratory and ophthalmic instruments and took the best features from them, and added a few of our own. The result is a design that is truly rigid and extremely comfortable for the subject. All the important components are fully adjustable. The chinrest height can be varied over a wide range, using a calibrated thumb wheel. The forehead rest is made from soft polythene and deforms to the subject's head creating a firm but comfortable support.

The headrest is available in two versions: a fixed version for bolting to a bench, and portable version incorporating clamps for mounting to table or bench top. A major problem with some other designs is the clamping mechanism, which protrudes beneath the bench and is a hazard to the subject. We've created an entirely new clamp design that adds only millimeters to the table but is incredibly rigid. The headrest is also available as a separate item, without the VET camera and optics.

Camera and Optics

The subject's eye is imaged by a large unobtrusive 'hot mirror' to a dedicated infrared sensitive camera. It provides a clear view of the subject, guaranteeing optimal image quality. The camera assembly incorporates a high quality lens with auto iris and precision focus. Two separate infrared sources provide diffuse illumination to create two bright reflections, or Purkinje images. This results in images with excellent contrast and well defined pupil and Purkinje images. The use of two reflections simplifies the calibration geometry to improve the resolution of all measurements.

We asked our customers what features they wanted...

Vision Science Workstation

An optional custom table is available with the headrest firmly mounted to the table top and space for 21" computer monitor at a wide range of viewing distances. The ergonomic offset table arrangement comfortably accommodates the subject while viewing the stimulus monitor. The powered table lift augments the headrest adjustments to ensure complete subject comfort.





How The Video Eyetracker Toolbox Works

Video eye tracking can be understood from simple geometry. When the eye moves relatively to the head it rotates within the orbit (eye socket). It rotates about three axes through the centre of the eye. Of most importance are the horizontal and vertical rotations, which are made to change the direction of gaze. These are large, up to +/- 50 degrees and can be exceedingly fast, up to 1000 degrees per second. The torsional (clockwise/counter-clockwise) rotation is small and for most applications of no interest.

The clear window at the front of the eye, the cornea, is smooth and kept constantly wet with tear fluid. When the eye is viewed in a dimly lit room on a bright sunny day, a bright image of a window can be seen on the cornea. This reflection is often referred to as the 'First Purkinje Image'. Although the eye is not a perfect sphere, the corneal surface is itself spherical and it is possible to determine its centre when illuminated by two known light sources.

The pupil, being the dark black center of the eye, is easily distinguished from any reflections. With suitable optics, an infrared sensitive video camera can be used to observe the eye while remaining outside of the subject's field of view. By measuring the movement of the Purkinje reflections relative to the pupil, it is then possible to calculate head movement, eye rotation and consequently the direction of gaze. This is modeled by the equation:

$$\begin{bmatrix} T_x \\ T_y \\ T_z \end{bmatrix} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & 1 \end{bmatrix} \begin{bmatrix} C_x \\ C_y \\ C_z \end{bmatrix} + \begin{bmatrix} \alpha & \beta \\ \gamma & \delta \end{bmatrix} \begin{bmatrix} X_0 \\ Y_0 \end{bmatrix} + \begin{bmatrix} X_{offset} \\ Y_{offset} \end{bmatrix}$$

The calibration procedure involves image measurements recorded at a set of known target positions presented on the stimulus display, which are then used to tune the parameters a - h, alpha - delta, X offset and Y offset in the above equation. The eye tracker can then accurately monitor where the subject is looking from subsequent measures of pupil and Purkinje image centers while accommodating both eye and head movement.

Technical Specification

Measurement Technique	Video. Pupil and dual first Purkinje image
Guaranteed Sampling Frequency	50 Hz
Resolution	0.1 Degree
Accuracy	0.5 - 0.25 Degree
Horizontal Range	+/- 40 Degree
Vertical Range	+/- 20 Degree
Allowable Head Movement	+/- 10 mm
Latency	One frame (20) msec
Measurement Units	Fick, Helmholtz coordinates in degrees and screen position in mm
CPU Utilisation	10% for eye tracking with mimic and camera window Typical on 1.8 GHz Athlon processor
Software Triggers	Implemented as Callback to user routine when subject looks into region of interest (ROI)
Number of ROIs	Over 100

Optics

Infrared Illumination Wavelength	930 nm
Camera Type	50 Hz interlaced or progressive scan
Image Capture	Dedicated PCI frame grabber for PC

Supplied Software

In process COM server	Dual interface support late and early binding, with complete type library
videoEyetrace	Complete eye tracking environment, with mimic display and scrolling eye position graph. Stimuli for saccade and smooth pursuit experiments, plus bitmap images for reading and visual scanning experiments
Demonstration Programs	For Delphi, Visual Basic, C++ and MATLAB. Full source code provided

Minimum PC Specification

1.5 GHz Pentium 4 or AMD Athlon, 256 MB RAM, 1 GB HD, ViSaGe or dual VGA display, Windows 98/ME/NT4/2000/XP
