

# TRACKEYE

## Product information



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# Introduction

TrackEye is the world leading system for motion analysis on military test ranges and automotive crash test labs. TrackEye covers the entire process from digitizing images (film or video) through automatic tracking to a complete predefined report.



Typical applications are:

- 2D, 3D and/or 6D motion analysis on flying objects at military test ranges. The analysis often involves images from fixed cameras as well as cameras on tracking mounts.
- 6D analysis on objects in store separation. The analysis normally involves images from cameras mounted on wing tips or under the fuselage of an aircraft.
- 2D and 3D analysis of different parts of a vehicle during a crash test in the automotive industry.

TrackEye handles all major image file formats from all major high-speed camera manufacturers on the market, mixed or individually. The modular design makes it easy to implement new formats or camera types in the system.

The icon-based user interface gives a quick and flexible way to design reusable sessions for motion analysis using input from one or several cameras, fixed or moving. External data from GPS, Radar, tracking mount pointing angles and accelerometers can easily be imported and synchronized with the image data.

The implemented functionality handles tracking in several levels, from 2D, 3D and 6D to the most sophisticated range motion analysis tracking requirements.



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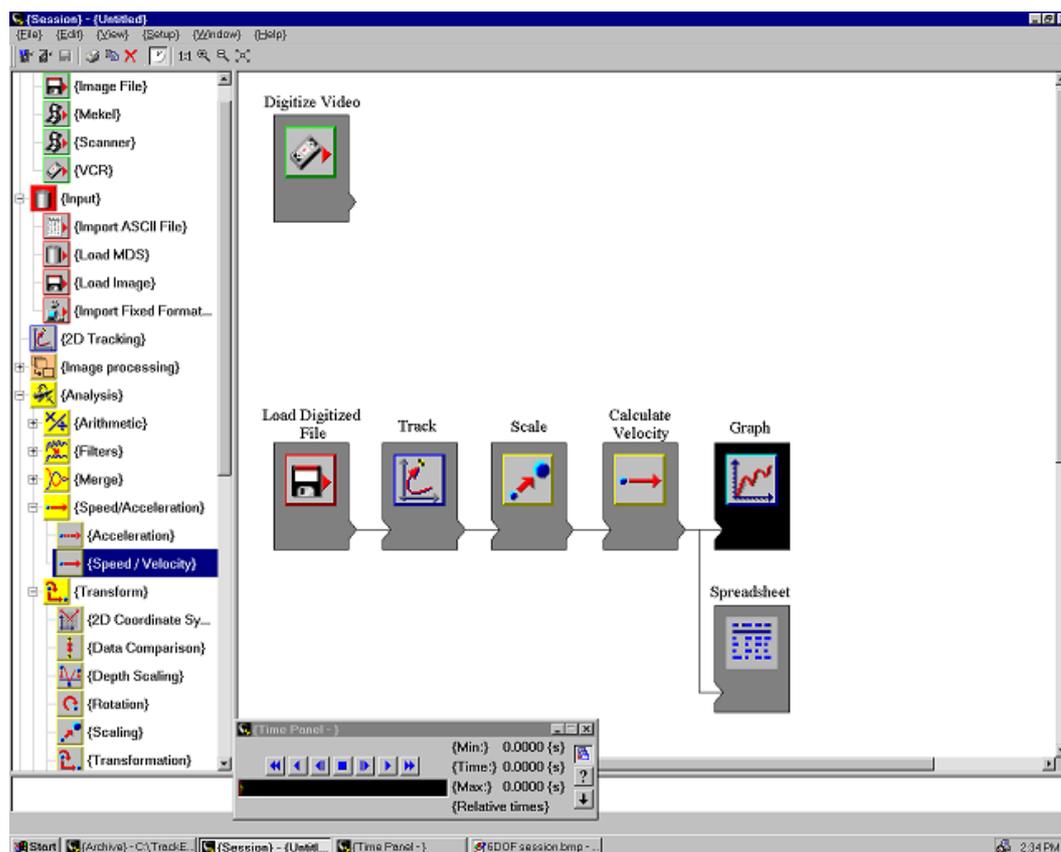
# System Description

## Using TrackEye

The TrackEye system has a state-of-the-art user interface that conforms to the Microsoft Windows standard. This makes the interface easy to learn and use. When using the TrackEye system the operator works within a session that is managed via the session window. The session window consists of a working area, menus and a function palette where all available functions are presented. The functions are represented by icons.

The task of constructing a session is very easy. The operator just chooses a number of icons from the list and connects them into a sequence in the working area. This gives a good overview of what is done and in which order.

The result of any change of parameters or functionality in any one function will instantly be available in all other functions in the chain.



User interface

There is no limit to the number of icons that can be used and chained in one session. One session can have several branches operating in parallel.



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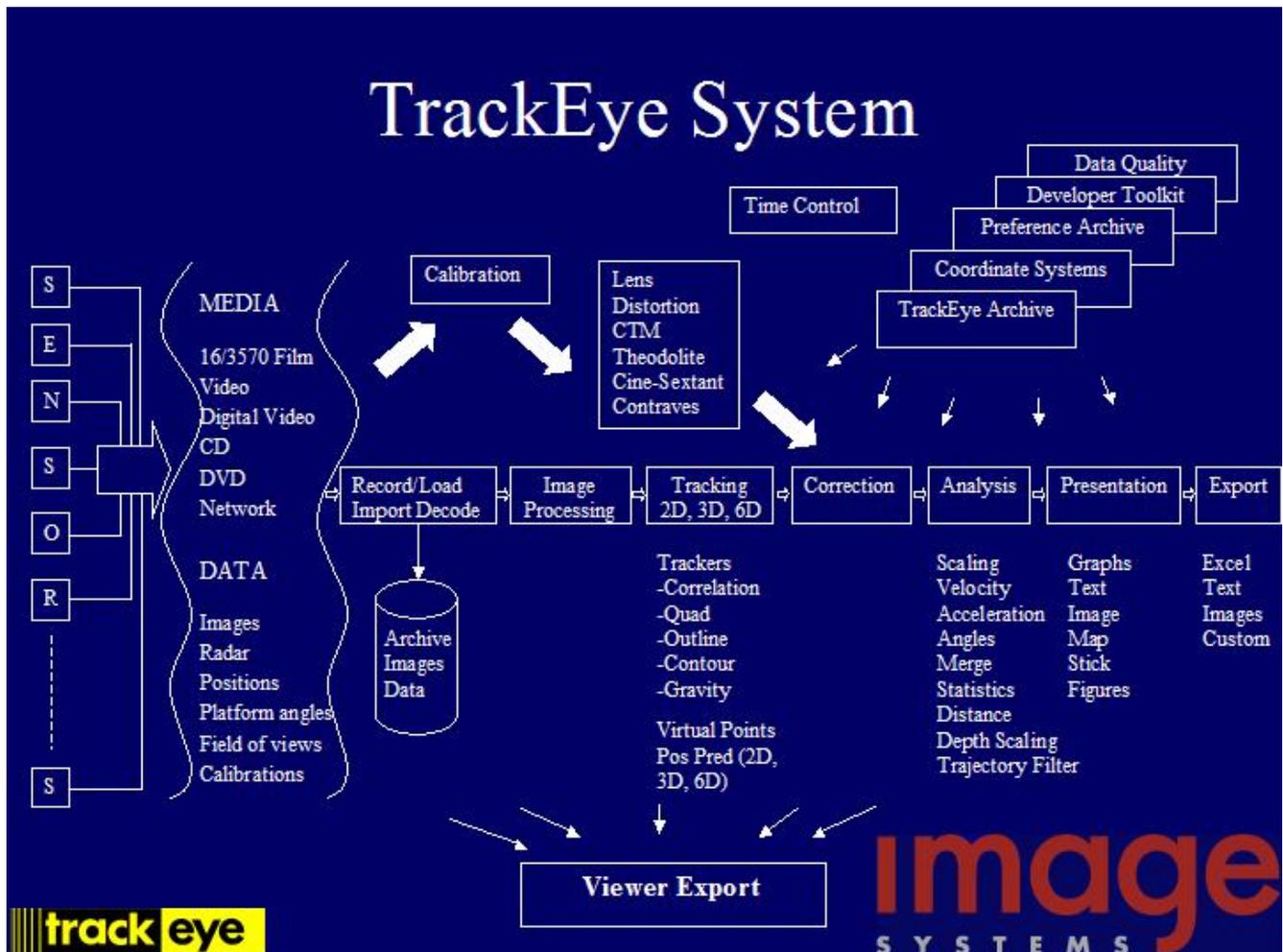
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# TrackEye Software layout



System flow diagram

The figure above is a data flow diagram for the complete program. TrackEye handles all stages in the process from bringing the image data file into the system to the final predefined report containing any number of images, tables, graphs and text. The main parts are:

## Media and data type

TrackEye handles many type of different media and data types as input to the tracking analysis.

## Image types and formats

The TrackEye software uses digital image sequences as input for the analysis. A large number of digital formats can be read directly during tracking: AVI, TIFF, BMP, JPEG, MPEG2 and many others, including camera specific formats. TrackEye continuously develops support for new image formats on the market.

Some customers use analog cine film for image storage. The optional TrackEye Film scanner can digitize cine film without loss of resolution and present it to the motion analysis software. Please refer to TrackEye Film Scanner product information for details.

Standard video (SVHS, Umatic, BetaCam, etc.) can also be brought into the TrackEye by connecting a VCR to an optional frame grabber in the computer. Software for control of the recorder is available as an option.

### **Data types**

TrackEye uses different types of external data for the analysis and can synchronize data from different sources. Typical data types are:

- GPS coordinates. TrackEye uses the time stamps provided by a GPS system for synchronization of images and data.
- Radar positions. TrackEye can use distance measured by radar together with 2D measurement from one camera to generate 3D coordinates.
- Surveyed positions. Fixed cameras and/or fixed targets are often used in the test. The lat./long. coordinates of the cameras and the targets are surveyed prior to the test and transferred to the TrackEye system.
- Acceleration data. The automotive industry often uses accelerometers while performing crash tests. TrackEye can import and synchronize this and other test data into the analysis.
- Custom data. TrackEye can import any custom data formats and use it in the analysis.

### **Load / Recording**

The first step in a tracking/analysis session is to load data and digitized image information to make it available for the program. This can be done by loading a digitized image file from disk or by recording from VCR or Digital Video. Recorded information can be stored to disk.



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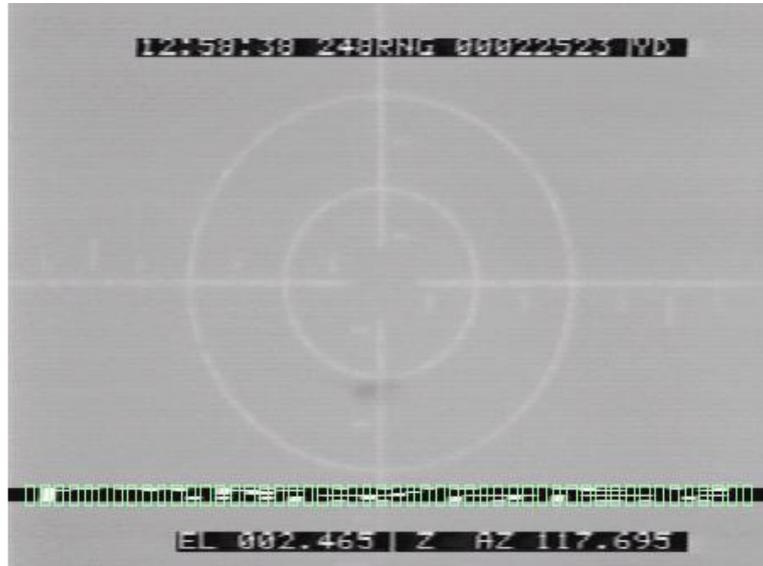
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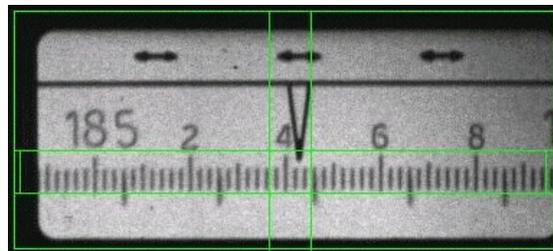
## Decoding (Option)

Timing and angular information are normally embedded in the images from tracking mount cameras.



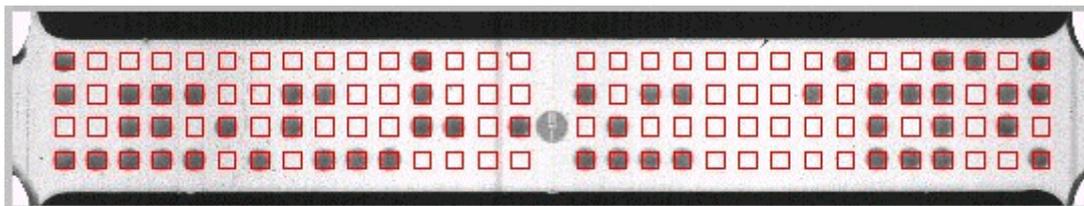
Video Cine #2 code

The TrackEye system automatically decodes the embedded information and makes it available for the program. The system can handle all major types of embedded information. New types are added on request.



Contraves B code

Some examples on supported codes are: Video Left Edge Code, FDRS, Analog scales from contrives C and D, Dot Matrix, OCR, IRIG-B and many more. The modularity of the program makes it very easy to include new codes in the future.



Dot Matrix code



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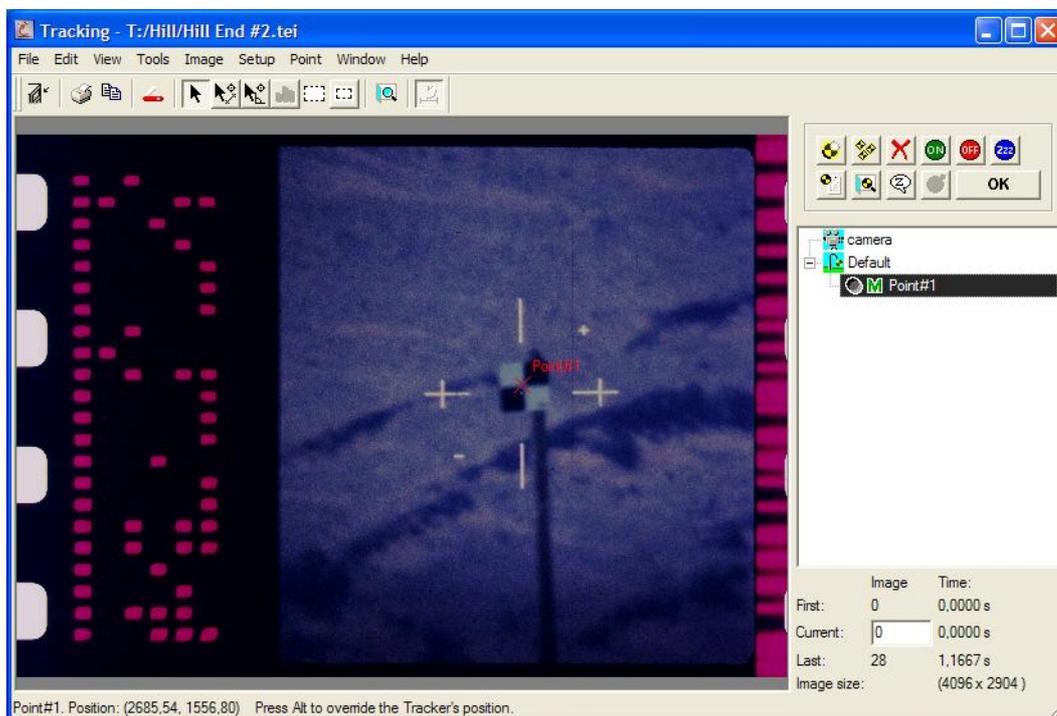
## Image processing (Option)

To improve the image quality for the operator or for the tracking algorithms TrackEye includes image-filtering functionality to improve the quality. Examples of filter functionality in TrackEye is:

- Image filters: The user chooses between a set of predefined filter kernels or creates his own.
- Time filters: Adjusts the output sequence with respect to one or more previous input sequences.
- Arithmetic filters: Performs a pixel-by-pixel arithmetic operation between two images or one image and a constant.

## Tracking algorithms

The most common use of TrackEye is to track or follow different targets in the image sequence and to analyze the movement of these points. Different applications have very different requirements on how to follow a defined target. The image quality and appearance of the point could vary which means that different approaches are needed.

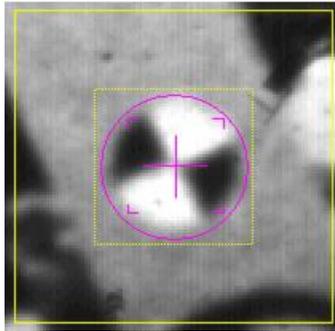


The user can choose between manual, semi-automatic and automatic tracking. In manual mode the operator decides the position for each point. In automatic the tracking algorithm finds the target without help. In semi automatic TrackEye suggests a position that the operator must accept or reject.



TrackEye has a number of different tracking algorithms available for different applications:

- Correlation: looks in each successive image for the area that correlates best with the defined pattern. This method is applicable to most cases
- Circular: finds the symmetry center of the image within the search area and is applicable to circular symmetries.
- Center of gravity: tracks a regular, roughly homogenous object that does not change size and shape during the tracking process.



- Quadrant: finds the symmetry centre of the Quadrant targets.
- Outline: In outline, the color or grayscale difference at the object boundary provides an outline around the body, for instance a white air bag against a darker background.
- Virtual points: Specifies that the point is virtual, i.e. its position in successive images is calculated from the positions of the other points in its target group, rather than by measurement. It is used, for instance, to define a part of a rigid body that is not visible through the image sequence.

## Tracking applications

A number of different tracking applications are available and each of them is described below:

### 2D Tracking

2D tracking is the basic functionality of TrackEye. The basic tracking function operates in two dimensions and produces 2D pixel coordinates for each tracked point in each image.

Multiple image sequences can be tracked simultaneously and the output plotted on the same graph or spreadsheet.



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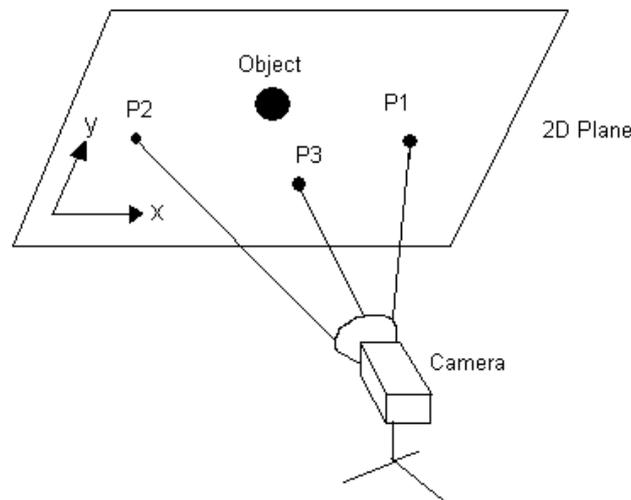
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If the camera is mounted on a tracking mount, the platform azimuth and elevation are used together with the 2D positions tracked by TrackEye to compute the bore sight angle to the target.

### 2,5D Tracking (Option)

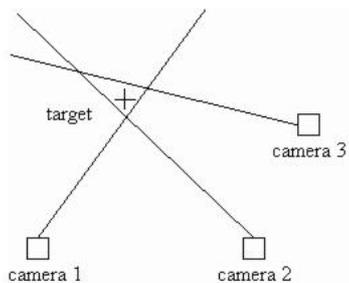
The TrackEye system can make 3D positions calculations from a single camera view. The camera position and orientation has to be known in the lab coordinate system. With this , 3D positions of points with visible targets can be calculated.

In the 2,5D function a 3D coordinate system is formed by combining the 2D coordinates with the distance between the camera and the plane where the 2D coordinates are oriented.



### 3D Tracking (Option)

With two or more fixed cameras and a series of defined fixed targets in any one image, the tracking can be carried out in 3 dimensions. TrackEye takes the tracked pixel coordinates from each camera, computes the direction from each camera to the target, and finds the target position that is the best fit to the observations.



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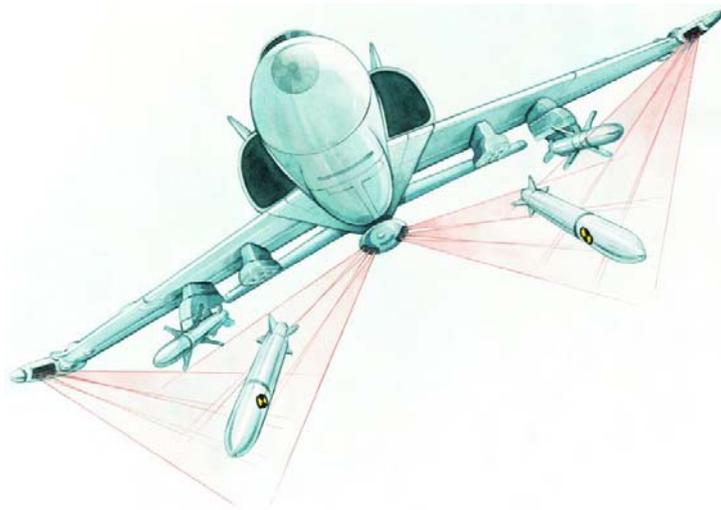
With one camera mounted on a tracking mount, and with recorded azimuth and elevation and also range data from radar or other source, a 3D position can be calculated

Similarly with two cameras mounted on two tracking mounts, and with recorded azimuth and elevation on both mounts, a 3D position can be calculated

### **6 Degrees of Freedom (Option)**

Tracking in 6 degrees of freedom (6DOF), also known as 6-dimensional (6D) tracking is an optional feature that computes the position and orientation of a rigid body tracked object from a single camera view. The rigid body must have multiple visible targets at any point in time.

The motion of the rigid body can be described with six parameters: three position coordinates ( $x$ ,  $y$  and  $z$ ), which gives the position of a specific point on the body, and three attitude angles (roll, pitch and yaw), which gives its orientation in space. The term 6DOF refers to these six parameters. TrackEye often refers to these parameters as the *6D position* of the body.



TrackEye can compute the 6D solution from one or multiple camera views. The 6D position can be computed in a camera related coordinate system, relative to camera position or in an external coordinate system, for instance a coordinate system related to an aircraft.

### **Calibration and Correction**

The inaccuracy of a lens is called **lens distortion**. TrackEye uses a mathematical model of the distortion to correct the image data from the camera.



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The need for a calibration rises from the fact that most camera/lens systems have a number of random and systematic errors. The calibration will calibrate for these systematic errors.



Lens distortion

TrackEye contains the following calibration functions

- Lens calibration (Option): The lens calibration is carried out by taking a sequence of images of a target board, importing into the program the coordinates of the target positions relative to the lens center, and tracking each target through the sequence.



Calibrating camera



Aicon calibration board

TrackEye uses two methods for calibration. One is for custom made calibration targets and runs with Image systems Software and the other uses targets and software supplied by Aicon 3D Systems GmbH and incorporated into the TrackEye program.

- Special Calibration Options: TrackEye also includes a number of special calibration functions like: Camera position, Camera orientation and various forms of tracking mount calibration.

The calibration is normally performed prior to the test and the result is saved. It is possible to save and store calibration results for many different camera/lens combinations. During the actual analysis the operator chooses the appropriate combination and after that the TrackEye analysis automatically makes necessary corrections.



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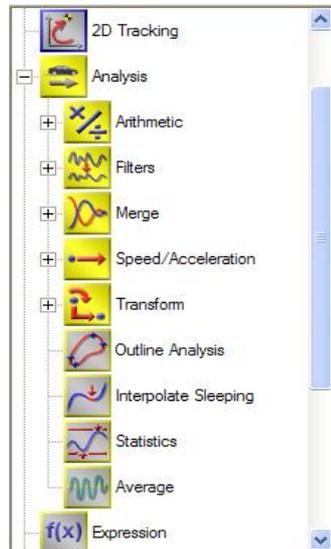
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## Analysis

The TrackEye system includes a large set of predefined analysis functions. The functions can operate on image data, imported data and results from prior calculations. The major groups of functions are:



- Arithmetic functions: The arithmetic functions include operations like angles between points, distances between points, multiplications, sum/differences and others.
- Filters: Includes filters like FIR and CFC that can be applied to any data sequence.
- Speed & acceleration: Functions to calculate speed, acceleration and acceleration rate of e.g. point position and angles.
- Transformations: Includes functionality for transformations, translations and scaling of 2 and 3 dimensional data.
- Expressions (Option): Add custom expressions into a session in order to customize calculations and presentation of data.
- Other functions: TrackEye also includes functions for outline analysis, interpolation of hidden points and statistics.

## Presentation

A big benefit with the TrackEye system is the possibility to present data and results in customized graphs, tables and sessions summaries. It is easy to add comments and custom graphics and to customize the appearance of a certain view. The main tools for presentations are:

- 2D diagrams: Diagrams where data can be plotted against time or other data (X/Y-diagrams). All data, whether tracking data or imported data can be plotted in single or multi axis X/T or in Y/X plots with many possibilities to customize the diagram.



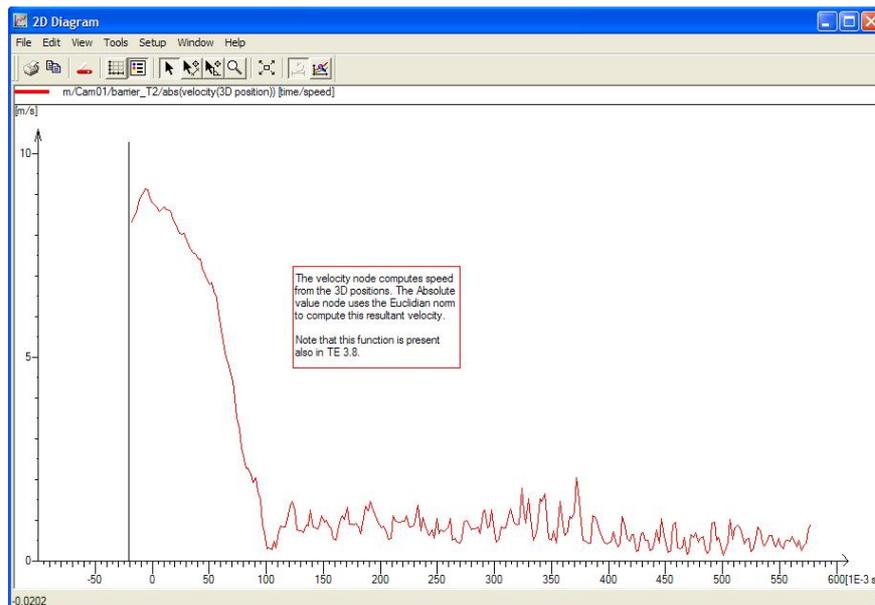
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Motion graph

- Image diagrams: An image diagram is a function to display a curve overlaid on an image. The images can be exported into various formats.
- Text diagrams: All types of data can be presented in tabulated form using rows and columns. The diagram can easily be customized with different headers or combinations of data.

| Time [s]      | CS1:1<br>Default tracking tar...<br>object/3D position<br>x [m] | CS1:2<br>Default tracking tar...<br>object/3D position<br>y [m] | CS1:3<br>Default tracking tar...<br>object/3D position<br>z [m] | CS1:5<br>Accuracy x | CS1:6<br>Accuracy x/y | CS1:7<br>Accuracy x/z | CS2:1<br>Default tracking tar...<br>object/Usage m_Se...<br>counter |
|---------------|---|---|---|---------------------|-----------------------|-----------------------|---|
| 13787174.5675 | -   | -   | -   | -                   | -                     | -                     | 1   |
| 13787174.5897 | 7877.272  | -5887.468   | -2727.590   | 19.7303             | 19.7303               | 19.7303               | 1   |
| 13787174.6120 | 7878.406  | -5889.188   | -2730.241   | 19.6926             | 19.6926               | 19.6926               | 1   |
| 13787174.6343 | 4454.934  | 1920.886  | 836.802   | 49.895              | 49.895                | 49.895                | 1   |
| 13787174.6565 | -11872.881  | -9143.560   | 9407.528  | 50.8457             | 50.8457               | 50.8457               | 1   |
| 13787174.6788 | -95835.743  | -79542.621  | 63611.901   | 41855.1             | 41855.1               | 41855.1               | 1   |
| 13787174.7010 | -1851509.315  | -1620559.516  | 1208411.926   | 4.90254e+007        | 4.90254e+007          | 4.90254e+007          | 1   |
| 13787174.7233 | -   | -   | -   | -                   | -                     | -                     | 1   |
| 13787174.7456 | -   | -   | -   | -                   | -                     | -                     | 1   |
| 13787174.7678 | -   | -   | -   | -                   | -                     | -                     | 1   |
| 13787174.7901 | -   | -   | -   | -                   | -                     | -                     | 1   |
| 13787174.8123 | 7888.074  | -5902.894   | -2754.495   | 19.3453             | 19.3453               | 19.3453               | 1   |
| 13787174.8346 | 7888.723  | -5904.296   | -2756.584   | 19.3104             | 19.3104               | 19.3104               | 1   |
| 13787174.8569 | 4404.041  | 1972.752  | 889.455   | 50.1363             | 50.1363               | 50.1363               | 1   |

- TrackEye Viewer (Option) The results of a tracking session can be exported to a self-running CD that allows the recipient to rerun the tracking with the images, graphs and spreadsheet data synchronized. This viewer does not require any program installation.



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## Report Generator(Option)

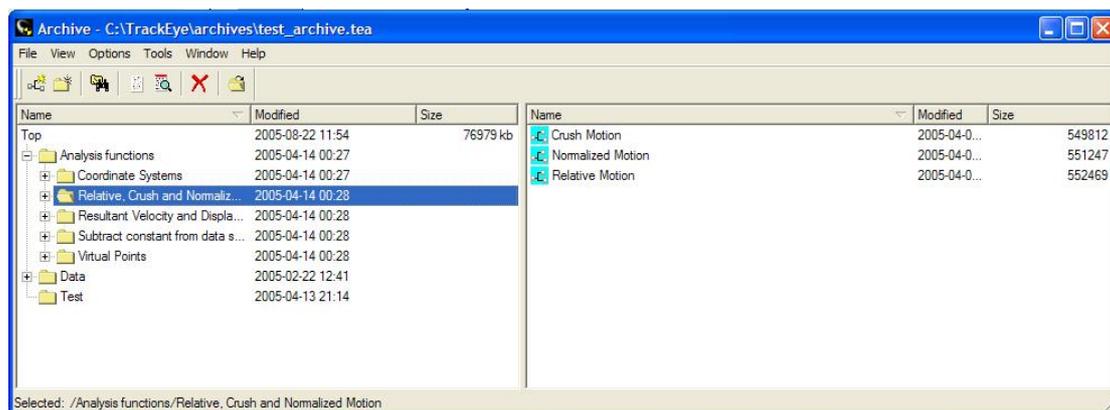
The report generator allows a predefined, and unlimited, number of image diagrams, graphs, text diagrams and text to be directed to one report output. This report is then ready to print or transmit immediately after tracking is complete.

## Export

There are several possibilities in TrackEye to export data and result to other formats like Excel spreadsheets, custom ASCII data and other.

## The Archive structure

An Archive system is used where each archive file contains all data for a given project, starting with a pointer to the image file, and including all calibrations, sensor definition, imported data, tracking data, graphs and text diagrams.



Archive window

The archive features a Window Explorer® type file structure display with icons to represent the different data types, such as digitized images, calibrations and output data.

Each operation within an archive is saved as a session, which includes all the data with a pointer to the image file. The session can further be saved as a template and reused for a different image sequence.

## Customizations

Sometimes TrackEye will not do exactly what you need it to do. In such cases it is possible to add custom functionality or modules. The modules can be developed by Image Systems or by the users using the developer's kit (SDK). The developer's kit can be delivered in different levels:



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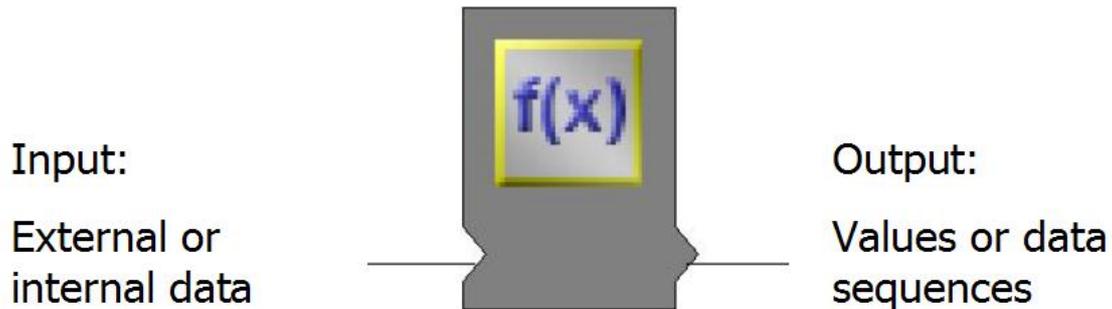
## Full Software Developer's Kit (SDK) (Option)

This SDK allows you to build your own functions and add icons to the supplied list in the standard TrackEye program. It is also possible for you to add new tracking algorithms within the supplied tracking function.

This involves C++ programming at a fairly advanced level and training from the TrackEye development team. It is recommended that this training is held in the factory, but it can be held at your facility at an extra cost.

## Software Developer's Kit Light (SDK Lite) (Option)

The SDK Lite involves an expression function, any number of which can be written by the user and linked into the sequence of functions in a session. The expressions are built up from a list of mathematical functions and can operate on all data in the current session. The data can then be fed back into the next TrackEye function.



This involves a sound mathematical background but no C++ programming knowledge.



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## Hardware requirements

The TrackEye system can run on a standard stationary PC or a Laptop. The requirements are:

|                  | Minimum                      | Recommended             |
|------------------|------------------------------|-------------------------|
| Operating System | Windows XP/2000 Professional | Windows XP Professional |
| CPU              | 2.0 GHz                      | 3.0 GHz                 |
| RAM              | 1GB                          | 1GB                     |
| System disk      | 100 Gb                       | 100 GB                  |
| Image disk       | Not required                 | 200 GB                  |
| Floppy Drive     | 1.44Mb                       | 1.44Mb                  |
| Graphics         | 19" @ 1280 x 1024            | >19" @ 1280 x 1024      |
| CD / DVD         | CD                           | CD / DVD                |

Please note that the required performance specified above only applies for the TrackEye software. Higher performance may be needed if the system controls a TrackEye film scanner, a video recorder or a high-speed camera.

## Other Image Systems Products

### TrackEye Film scanner

The TrackEye Film Scanner is a high-resolution, digitizing unit for 16 and 35mm cine film, which digitizes film without loss of resolution. The TrackEye Film Scanner is available in 10-bit monochrome 6k sensor, and 12 bit color, 2k and 4k sensor.

The Film Scanner is integrated with the TrackEye system for storage of digitized film sequences and is completely software-controlled from TrackEye's convenient menu system.

Please see TrackEye Film Scanner product information for more details.

### TEMA

TEMA is the world leading system for camera control and advanced motion analysis in the automotive and many other industries. It is built on the TrackEye software, uses the same algorithms and calculations, but provides a simpler user interface for applications where film and video digitization is not required and where there are no movable cameras, like cameras mounted on tracking mounts. It does not include some of the advanced features of TrackEye such as image processing, expression, etc.

Starting with digital image sequences the customer uses TEMA to track objects in images, make analysis of the movement and present result in tables and graphs.

Typical applications are:



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- Crash tests in automotive industry. 2D and 3D analysis.
- Airbag analysis, both contours and volume measurement. (Volume requires at least 3 camera views).
- Fuel injection. Tracking of fluid object development.
- Any other application in different industries, i.e. drop tests, manufacturing, etc.

## Need more information?

Please contact Image Systems headquarter or local representatives



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