image SYSTEMS
MOTION ANALYSIS

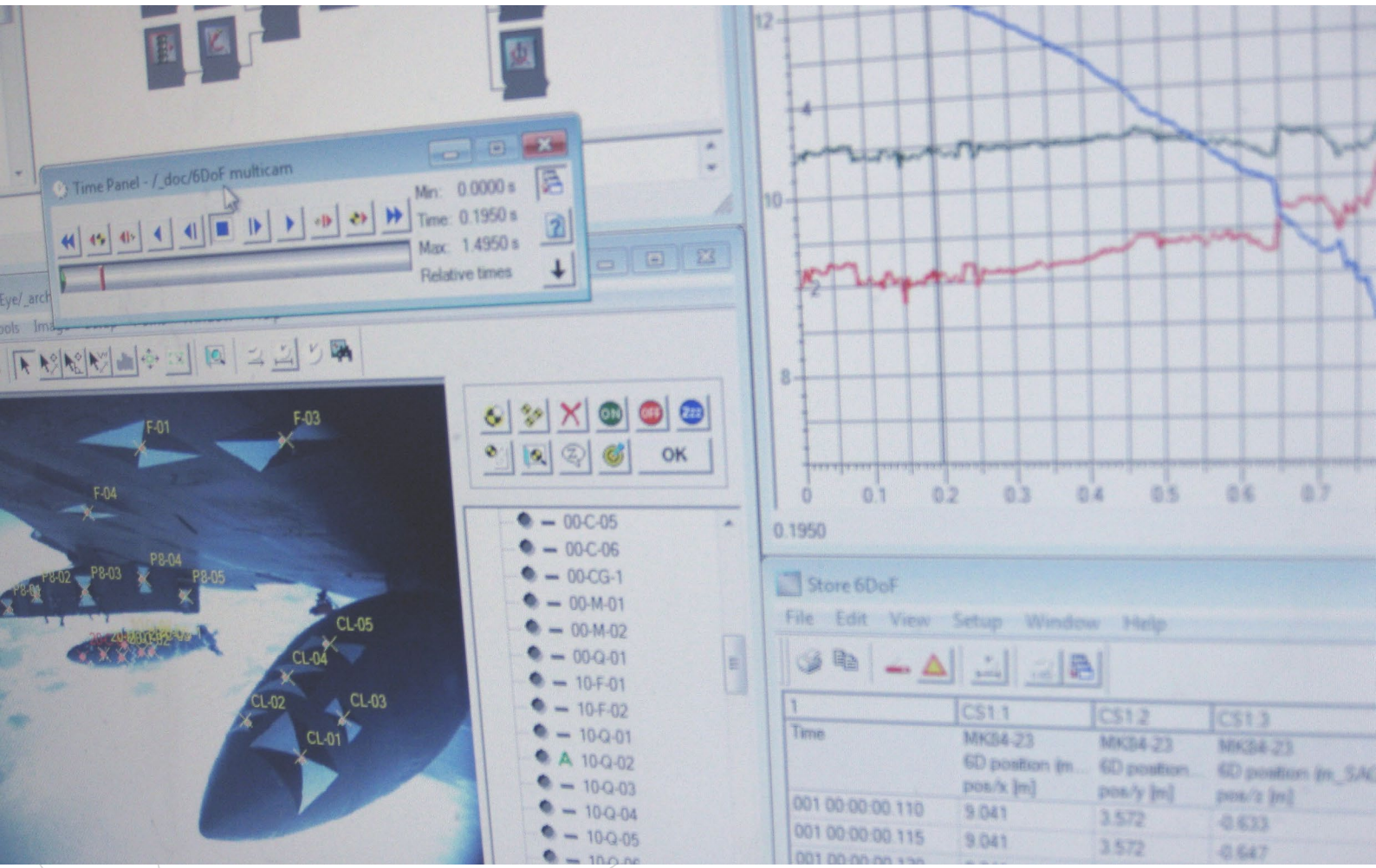


image TRACKEYE

PRODUCT DESCRIPTION

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.

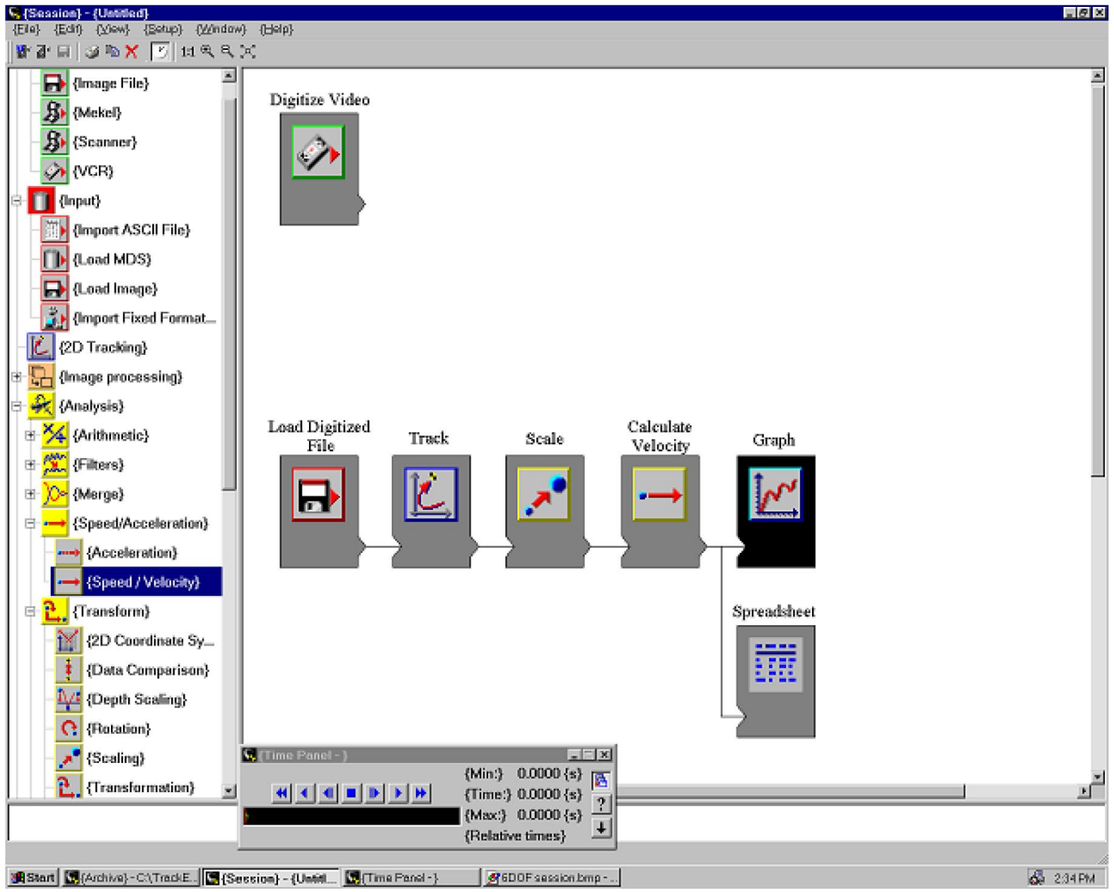
TrackEye handles all major image file formats from all major high-speed camera manufacturers on the market, mixed or individually. The modular design makes it easy to implement new formats or camera types in the

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.

PUSHING THE BOUNDARIES OF MOTION ANALYSIS

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 wthin 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.

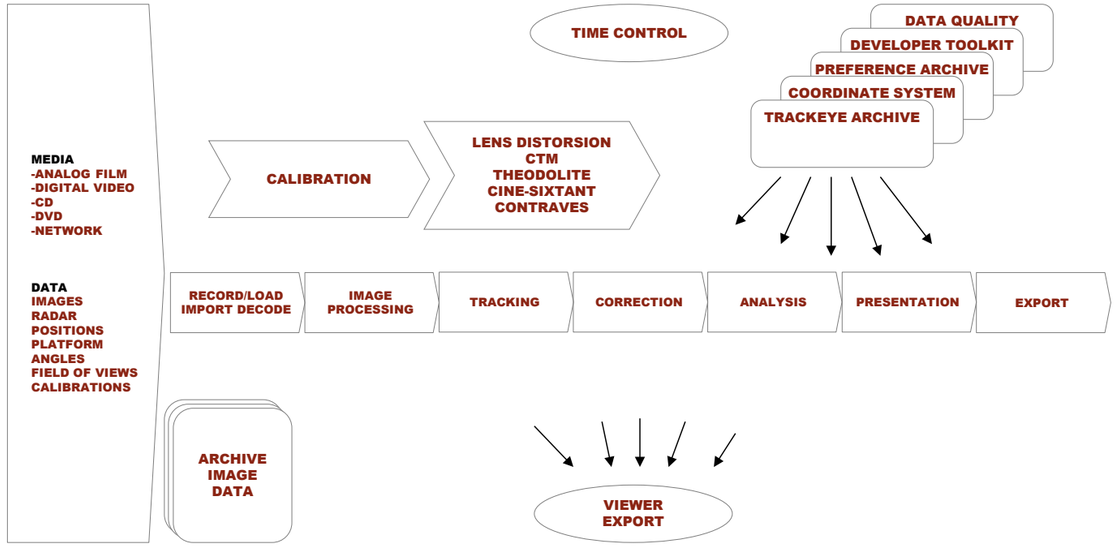
The task of constructing a session is very easy. The operator just chooses a number of icons from the list and connects them into a sequence in the working area. This gives a good overview of what is done and in which order.

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

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.

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 described hereafter.

TRACKEYE SOFTWARE LAYOUT



MEDIAS 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. www.imagesystems.se 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.point to each of those patterns.

DECODING

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

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.

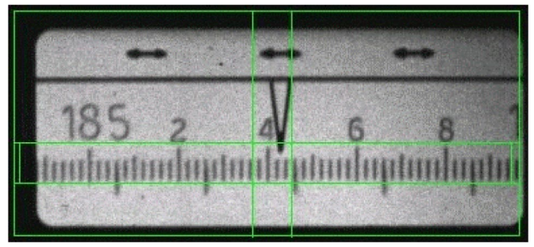
Some examples on supported codes are: Video Left Edge Code, FDRS, Analog scales from contrives C and D, Dot Matrix, OCR, IRIG-B and many more. The modularity of the program makes it very easy to include new codes in the future.

IMAGE PROCESSING

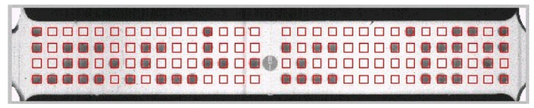
To improve the image quality for the operator or for the tracking algorithms TrackEye includes image-filtering functionality to improve the quality. Examples of filter functionality in TrackEye is:

- 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.

Video Cine #2 code



Contraves B code



Dot matrix code

TRACKING ALGORITHMS

TrakEye has a number of different tracking algorithms available for different applications. All take advantage of the tracking framework and track in subpixel resolution. *The basic outline tracker* analyses threshold values to find the color or grey scale difference between the body and the background. To capture object shapes in test setups with a complex background, an image subtraction can be done. This will convert all non-moving parts of the image into pitch black. *The advanced outline tracker* looks for edges between different surfaces. This is often used when the color or grey scale difference between the object and the background varies, or when the background is complex and dynamic.

CORRELATION

Looks in each successive image for the area that correlates best with the pattern defined in the first image. This method is applicable to most cases, as it doesn't require a marker.

QUADRANT

Finds the symmetry centre of quadrant targets and is invariant to rotation, scale and shading. Quadrant targets are recommended for applications with high demands on accuracy and automation.

CIRDULAR SYMMETRY

Finds the symmetry centre of the image within the search area and is applicable to concentric circles, spokes on a bicycle wheel or combinations thereof.

CENTER OF GRAVITY

Tracks the center of gravity of the contour of a marker or an object. The shape of the target may vary in the sequence and is captured with a user-defined intensity threshold.

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. For instance it can be used to define a part of a rigid body that is not visible in the image sequence.

INTERSECTION TRACKER

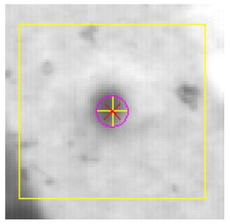
Tracks intersection points (corners) on any object shape. The intersections are between extrapolated straight lines applied on the object shape.

OUTLINE TRACKER

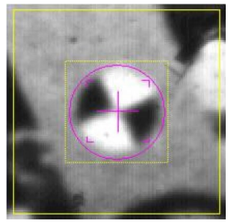
Captures an object boundary to provide an outline around a body. There are two different outline tracker options; one basic and one advanced.

MXT TRACKER

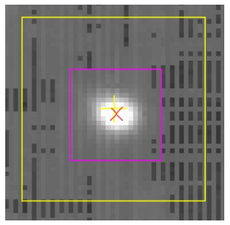
Finds the symmetry centre of the target. The user can set the target to 1+4 and 1+5 MXT target tracking.



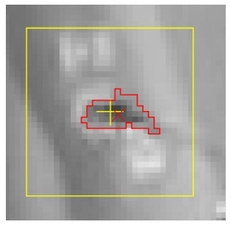
Correlation tracker



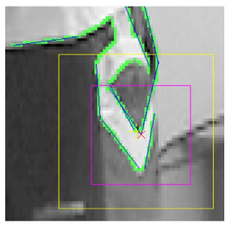
Quadrant tracker



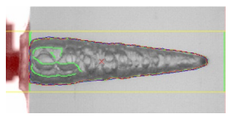
Circular symmetry



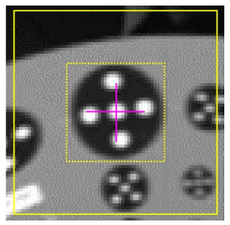
Center of gravity



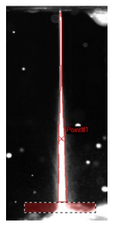
Intersection tracker



Advanced outline tracker



MXT tracker



Basic outline tracker

ANALYSIS

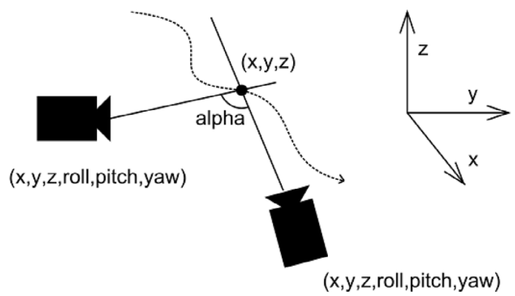
The TrackEye system includes a large set of predefined analysis functions. The functions can operate on image data, imported data and results from prior calculations. The major groups of functions are:

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: 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.

3D ANALYSIS

TrackEye takes the analysis from 2D on the screen to 3D in the real lab. By tracking the object from two or more cameras, the analysis is carried out in 3 dimensions using the concept of intersection. The target observations (tracked 2D pixel coordinates) and poses of the cameras are used to compute the 3D position of the target as the best fit to the observations.



Two different methods are available to calibrate the camera poses: absolute and relative camera orientation. With absolute orientation a few points with surveyed coordinates are used for reference. With relative orientation it is sufficient to identify a few common points of the camera views for reference and add a scale, i.e. there is no need for any coordinate measurement equipment or cumbersome and restricting calibration fixtures.

As a consequence, measurement volumes of any size are supported.

3D from moving cameras is supported by tracking the reference points in the image sequence.

6 DEGREES OF FREEDOM

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.

LENS CALIBRATION

The inaccuracy of a lens is called lens distortion, and all lenses have it built-in to a certain degree. The distortion is most prominent for wide-angle lenses, where images of straight lines become visibly curved. Great accuracy improvements and traceable results are obtained by correcting the image data with a calibrated mathematical model of the distortion.

The calibration is normally performed prior to the test and the result is saved to a file. It is possible to save calibration results for many different camera/lens combinations. During the actual test the operator then chooses which lens calibration to apply.

Using a series of images of a flat calibration pattern in different angles, the calibration is performed in an automated wizard. The output is the focal length and distortion of the lens, as well as the principal point of the sensor.

The calibration pattern can be printed from an included file. There is no requirement on surveying the printout: using a high-quality printer and attaching the printout to a flat surface is sufficient for most applications. Though for the highest accuracy possible, we also have a calibration board (sold separately) available.

WAND CALIBRATION

NO SETUP TIME - NO PREPARATIONS

No need to place reference markers or doing surveys of the measurement volume in order to do the calibration. Just pick up the TEMA Wand and start recording.

QUICK AND EASY TO USE

In a couple of minutes the user has the results from the calibration and can move towards performing the real test. The software 100% automatically performs all procedures to obtain the calibration data.

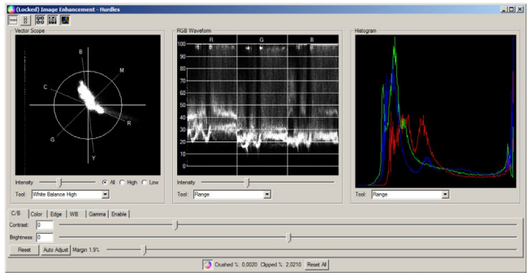
AUTOMATIC CALIBRATION CONTROLS

By using active marker based on LED technology, combined with a very robust tracking algorithm, the software calibration process is fast, robust and provides a high level of accuracy.

TOOLS AND ACCESSORIES

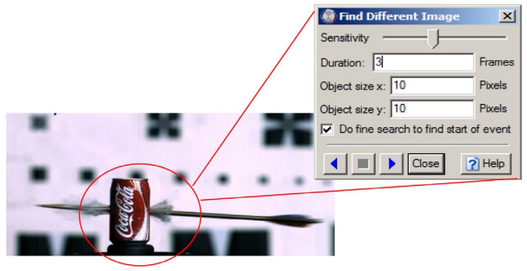
IMAGE ENHANCEMENT

In order to enhance tracking and/or reviewing an image sequence, TEMA Motion contains a complete Image Enhance functionality. RGB waveform diagram and vectorscope helps to improve properties like color balance, contrast, brightness and gamma correction in the image. The enhanced image sequence can be saved or imported to other image formats after adjustments.



EVENT FINDER

The Event finder identifies and finds one image or an interval of images of interest out of a whole sequence.



DATA IMPORT

TEMA imports several different standard data formats like DIADEM, ISO13499, HDF, ISO-2, SDAS, DELL as well as custom specific ASCII data formats.

The imported data is available for all parts of the program and can be used in calculations, graphs and tables.

DATA EXPORT

After tracking and analysis, the result can easily be exported to several different formats like Excel, CASDAS, DIADEM, ISO, Matlab or ASCII files.

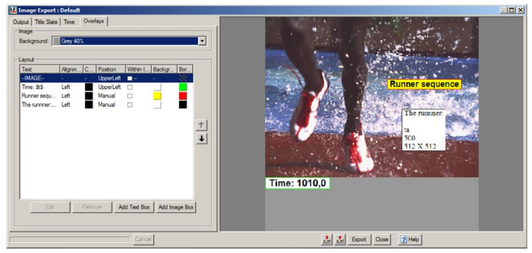
IMAGE SEQUENCE IMPORT

TEMA Motion software uses digital image sequences as input for the analysis. Most raw formats from high speed cameras and a large number of compressed digital formats can be read: AVI, TIFF, BMP, JPEG, MPEG2 and many others. TEMA is continuously updated to support new image formats when they became available.

IMAGE SEQUENCE EXPORT

All image sequences can be exported from TEMA , with or without overlayed tracking data. The Image Export can be extensively customized:

- Settable image size, format, sequence time range and skip count.
- A title slate can be added, acting as the first frame of the exported sequence.
- This can be specified with any describing text.
- Text box overlays on the exported sequence, including text and interactive information like the time for each frame, operator name etc.



PRESENTATION

REPORTS AND DIAGRAMS

TrackEye presents the analysis data and results in a variety of customized graphs and tables. It is easy to add comments and add custom graphics to customize the appearance of a certain view or plot. The main tools for presentations are:

3D DIAGRAMS

Included in 3D and 6DOF options. Plot 3D, 6DOF and camera data on 3 axes in a rotatable 3D box. The plot can also be equipped with curtains to enhance the understanding of the 3D data.

2D DIAGRAMS

Plots data against time or other data (X/Y-diagrams). All data, whether tracking data, or data input separately, can be plotted in single or multi axis X/T or Y/X plots with many options to customize.

TIME TABLES

All type of data can be presented in tabulated form using rows and columns. The rows will be time indexed. The diagram can easily be customized with different headers or combination of data. The row of the current time will always be highlighted.

IMAGE DIAGRAMS

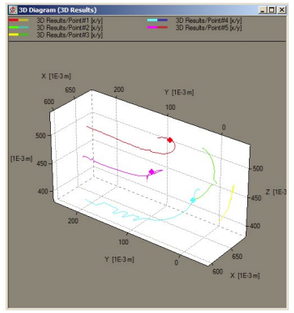
Plots data as overlays on top of image sequence from the tracking view. It is also used to rectify and stabilize images.

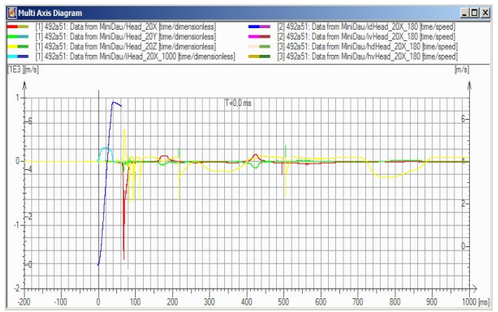
POINT TABLES

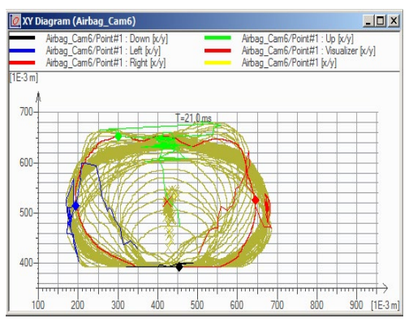
All type of data can be presented in tabulated form using rows and columns. The rows will be indexed per point added to the table. The data in each cell will then update according to the current time. The diagram can easily be customized with different headers or combination of data.

REPORT GENERATOR

Framework to populate a whole set of graphs and tables from a test that can be output using one single command.







Point Table

CS1:1	CS2:1	CS2:2	CS3:1	CS3:2
Point Name	Position x[pixels] vyskoky1-1	Position y[pixels] vyskoky1-1	Position (velocity) x[pixels/s] vyskoky1-1	Position (velocity) y[pixels/s] vyskoky1-1
Point#5	404,35	493,49	37,946	-94,071
Point#4	408,05	344,09	1,750	-111,527
Point#2	413,49	231,37	17,661	-106,393
Point#1	408,12	196,92	-36,179	-101,036
Point#3	412,71	333,33	3,134	-111,884

VIEWER

Tests can be exported to a self-running CD that allows the recipient to rerun the tracking with the images, graphs and spreadsheet data synchronized. Just like in TEMA Motion itself. Data from the viewer can in its turn be copied into another document. The Viewer does not require any extensive program installation to run. Also, the same Viewer can be loaded onto a network for shared use. There are two versions of the Viewer, basic and advanced.

BASIC VIEWER

The user can only review the data using the current graphs and tables. The basic viewer can also export the result.

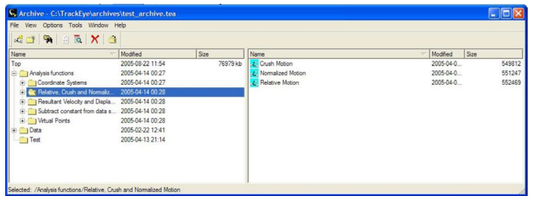
ADVANCED VIEWER

The advanced has all the functionality as the basic viewer, but the user can also add new graphs and tables to the setup. Still, no new data can be added.

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.

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:

FULL SOFTWARE DEVELOPPER'S KIT

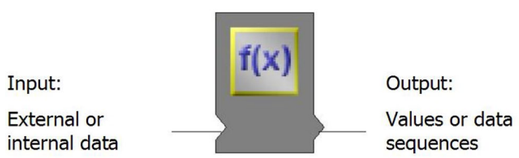
This SDK allows you to build your own functions and add icons to the supplied list in the standard TrackEye program. It is also possible for you to add new tracking algorithms within the supplied tracking function.

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 DEVELOPPER'S KIT LITE

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.



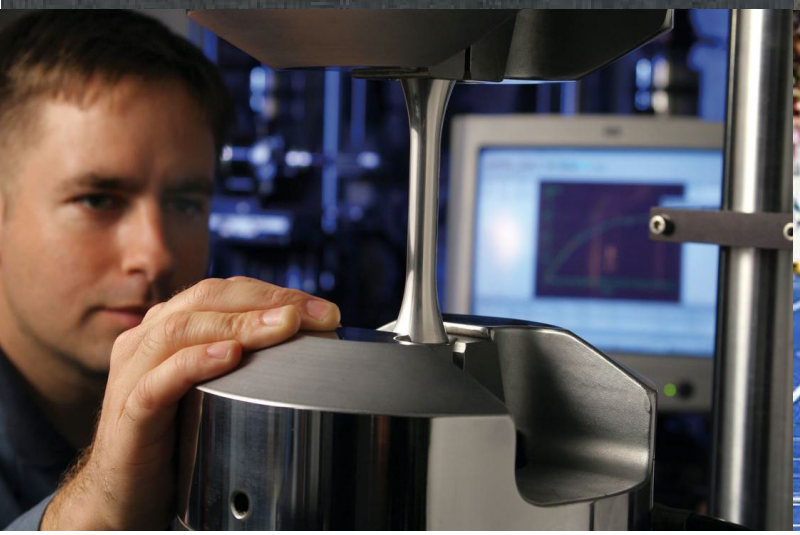
HARDWARE REQUIREMENTS

The TEMA Motion system runs on standard stationary PC or a Laptop. The minimum requirements are:

	MIMINUM	RECOMMENDED
OPERATING SYSTEM	Windows 2000/XP/VISTA/7/8	Windows XP/7
CPU	2.0 GHz	3.0 GHz
RAM	1GB	4GB
SYSTEM DISK	100GB	100GB
IMAGE DISK	Not required	200GB
GRAPHICS	>19" @ 1280 x 1024	>19" @ 1280 x 1024
CD / DVD	CD	CD/DVD

Please note that the required performance specified above only apply for running the TEMA Motion analysis software. Higher performance is normally needed if the system is TEMA camera control for high-speed digital cameras.

IMAGE SYSTEMS



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