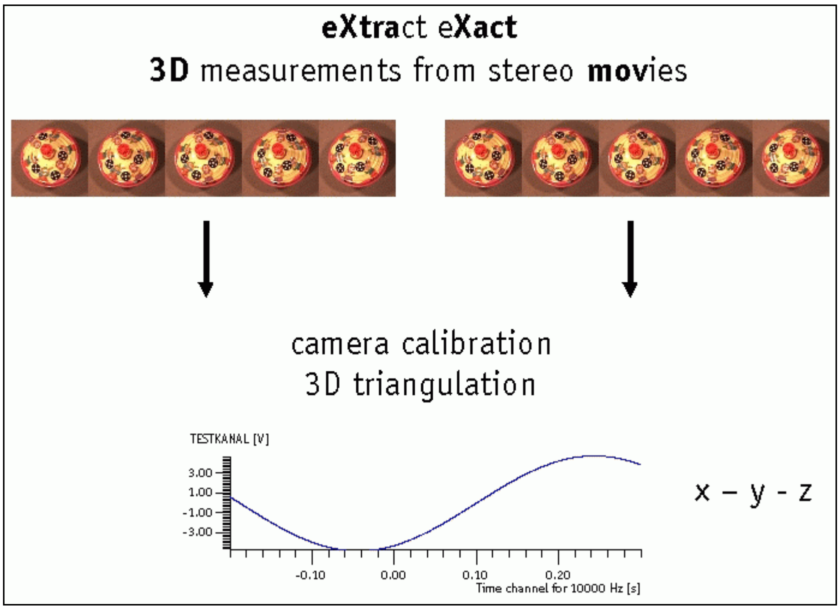
MovXact3d

The image analysis software **Mov3D** offers you the possibility of analyzing 3D motion of dynamic recordings:

Using the 2D module **MovXact** you track objects in several stereoscopic views. Photogrammetric methods (“triangulation”) enable you to calculate 3D curves.

Features:

- Easy management of multiple views within one test file
- Interface to 3D control points
- New type of marker CODE (= coded ring marker, by AICON)
- Calculation of camera position using known control points
- Calibration of camera and lens with powerful distortion correction. (Use Drag and Drop from the CamFolder module)
- 3D calibration and output of x-y-z displacement/time diagrams (with a-v differentiation etc. see MovXact)

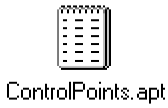


Overview

Data necessary for successful **3D analysis**:

Data

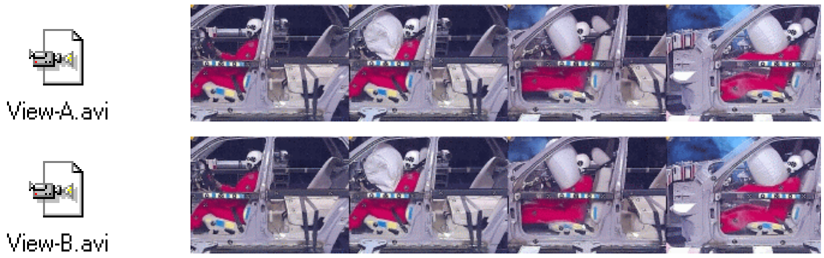
Control point data



Tracking data: control and unknown points

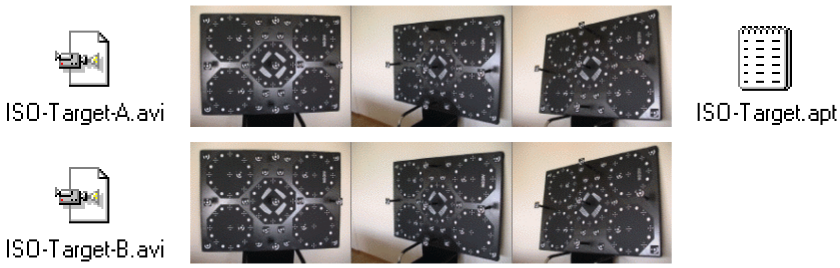
Image sequence

(per view)



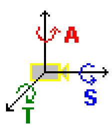
Calibration measurements

Sequence of test target +
Camera - lens - data
(per camera)
+
Control point data
in ASCII file



? Position measurements

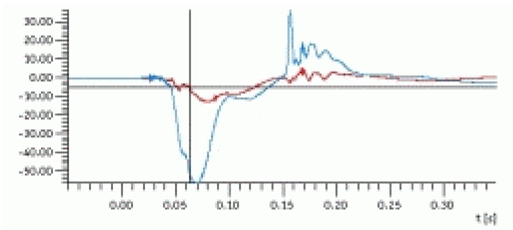
3D control points with
tracking data +
calibration measurement
(per view + per image)

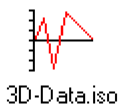


? 3D measurements

Tracking data of unknown
points +
calibration measurements +
position measurements

*(n * 2D ? 3D)*





Terms

Camera Parameters	Interior orientation = calibrated focal length + principal point + distortion parameters (incl. fixed second zero crossing)
Camera Calibration	Calculation of the camera parameters – incl. camera position – (method = extended resection in space)
Camera Position	Exterior orientation = station/location (3D coordinates) and axis (3 angles)
Camera Axis	The camera can rotate by three angles: Tilt ("move up or down") Axis ("move left or right") Swing ("rotate around line of view")
Control Point	Point on object or test target with known 3D coordinates
Image Point	Point in image with 2D coordinates
Unknown Point	Point to be measured: calculation of actual 3D coordinates with measured image coordinates, camera parameters and camera positions (method = intersection in space)
Object Point	Point in 3D space
Test Target	Object with pre-measured control points, also "test panel"

Requirements for 3D Measurements

A successful 3D measurement requires the following calibration settings:

At least two views from different points are included in the analysis session.

(Same) control points and marker targets with the same name are set up and measured in the single views.

The **3D Measuring** option is selected in all views that should be involved during 3D analysis.

Time calibration is valid in all 3D views.

Assumption: All cameras run synchronously (as possible within 1 line).

The frequencies of the image sequences need to be equal or integer parts of the maximum occurring frequency *(= max. frequency / n).*

The T0 start times should be in the raster of the maximum frame rate: *T0(n) – T0-min. = 1 / max. frequency*

The camera positions are calculated within the overlapping time interval; for this measurement data of at least 4 control points per image are necessary. Alternatively the positions may be defined as "static".

Pay attention that the cameras should be calibrated before this calculation.

A triangulation on the basis of the measured image coordinates must be possible ("intersection in space").

Own scales or rulers are not necessary for calibration.

The scaling is implicitly included in the control point information.

Work Steps

Mov3D is based on a number of image sequences (= **views**) of a test.

As before (2D), you can use measurement of trajectories (setting up and tracking markers) to go to two-dimensional raw measured image data.

A new feature is that a few (at least 4) “control points”, as they are known, must now be previously measured in space and their spatial coordinates must be saved in an ASCII file.

If the cameras have not yet been calibrated in a pre-calibration or lab calibration, specific calibration image sequences must also be analyzed and distortion parameters must be calculated.

Work steps:

Perform the work steps of a 3D evaluation in the following order:

1. Create new analysis

2. Read control point data

Enter one **view** per camera with the corresponding image sequence.
In the **Defaults** property tab of the document window, import **control points** as "Prepared", i.e. markers that have not gone through Setup yet from files with the corresponding file extension ***.apt** (= ASCII Point Table). The measured 3D coordinates x-y-z are listed in a table. When they are read in, different table layouts are supported. We recommend you use the FalCon eXtra ASCII format and indicate the marker type.

3. Set-up markers (control + unknown points)

The task of setting up markers is facilitated by a defaults list from which you can draw the necessary control points and pinpoint them in the image. The CODE marker type facilitates rough orientation.

As with previous marker types, the markers to be evaluated are set up as “new points”.

4. Track markers

Track all markers within the overlapping interval of views.
If the control points are fixed in space and the camera is limited to one exact point in space, there may be no need to track the control points.

5. Calibrate cameras

Enter the characteristic values for the camera and lens. After you have measured a test field, calculate the distortion parameters. For information in this regard, please refer to the operating instructions of the **CamFolder** module. You can also accept a previously performed calibration measurement from the **CamFolder** document window using Drag and Drop. The status should be “Calibrated/Calculated”. A status of “Calibrated/Edited” or even “Not Calibrated” is possible, but only for test purposes.

6. Calculate camera positions

The location and orientation of each camera is calculated one image at a time if 3D spatial coordinates and 2D measured image data are available for at least 3 control points (selection of active control points is possible). Assuming the control points are fixed in space and the position of the camera in space is also fixed, calculation in a reference image is sufficient.

7. Set calibration parameters

Select **3D Measuring** in the Calibration dialog in **each** view that will be used for the 3D measurement. If all requirements for 3D calculation are fulfilled (see below), a green check mark appears by the side.

You can use the **Preview** button for detailed information.

8.Output diagrams

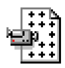
You can generate one-dimensional trajectories of new point coordinates x, y or z in the **T-Diagrams** dialog. Additional processing, for example for differentiation or forming references, is similar to MovXact, as is data export.

Note that coordinates of new points are present in the coordinate system specified for the control point field!

9. Output 3D measurements

In the **Export** dialog you can generate calibrated 3D results in the coordinate system of the control point field. File type **ASCII Table *.txt**. In addition to 3D coordinates, the corresponding standard deviation of measurements as well as a list of control points used is generated.

Calibration Measurement



Mov3D and **CamFolder** contain the measurement of camera calibration parameters:

Work steps:

Perform the work steps for a calibration measurement in the following order:

1. Enter camera and lens features

Enter the descriptive features and manufacturer-specific data for each camera/lens combination. The measurement itself is identified by the focussing distance.

2. Read control point data

Import **Control Points** from files with the corresponding file extension ***.apt** (= ASCII point table). Different table layouts are supported for the read process. We recommend you use the FalCon eXtra ASCII format and indicate the marker type.

3. Measure image points

First set up two points manually.

A 2D model (similarity transformation) is calculated with the aid of two image points for **Prediction** of the remaining points. For three or more points the 2D model(**+**) is written by a compatible transformation.

The actual prediction (®) with the aid of a 3D-model can only be turned on by explicitly selecting a "…3D" **target prediction** (with 4 or more points).

4. Calculate parameters

Depending on the distribution of measurement points in the image view, the tilt of the test field and the number and type of measurement images, select a specific **method** with an explicit selection of distortion parameters.

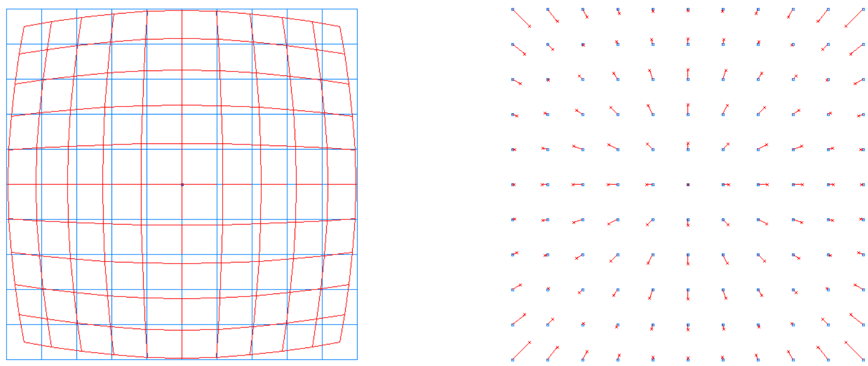
The calibration measurement may have the following states:
- not calibrated
p positions only calculated
e distortion parameters edited
+ successfully calibrated

In the **Positions...** sub-dialog you can generate the camera rules and orientations after the calculation is successfully complete.

5. Evaluate the results

The **Evaluation** property tab only allows for numeric and graphic analysis of the measured parameter.

If a test target is present in accordance with **ISO/SAE**, start the determination of the “Distortion Index” here.



For information on the theoretical background and practical information on camera calibration, please visit the FalCon homepage and go to: **Download/Documentation**.

Layout of ASCII Point Tables

Control point coordinates are provided in files with the extension **.apt**. The following are supported as table layout:

```
x   y   z   Name
```

```
Name     x   y   z
```

```
x   y   z                    : Name implicit = Index
```

```
Header: IMETRIC_Software_(C)
Text     Name     x   y   z   : Imetric Format, marker type = DOT
```

```
FalCon eXtra-Header
x   y   z   Name    Type    : FalCon eXtra file format
```

Note:
The marker name can also be (just) a number or an index. Coded AICON markers should have the name **C_#** (where **#** = code number).

Only **mm** is set (at first) as the unit of measure.

Coded Markers

Coded markers are available for orientation in test fields or defined coordinate systems. Markers according to the **AICON** specification are supported in **Mov3D** and **CamFolder**:

To make it possible to assign the same points of an object in images from different cameras, points must generally be numbered. Point numbers may be coded in the form of a binary code arranged around the actual measurement point for an automatic measurement. The appropriate image processing procedures are then used to measure the image coordinates of a point, and then to detect and immediately assign its point number. Markers are invariant to rotation, i.e. the alignment and position on the object play no role in detecting the marker number. The code is unique and unambiguous for all positions.

If an object has been provided with coded markers, no manual assignment of point numbers needs to be made for these points. This not only speeds up measurement, but also prevents incorrect numbering, which could result in problems for a subsequent calculation. Depending on the design and coding depth (12-bit or 14-bit), varying numbers of different point numbers can be distinguished. 12-bit coding, with a total of 147 different numbers, is sufficient for most applications. The 14-bit version makes it possible to distinguish 516 numbers. Depending on the application, markers of different point size and different materials can also be used (standard foil, retro-reflective foil).

For crash test applications a subset of 79 codes has been selected.

The markers exhibit the following radial ratio:

```
Outer diameter of the code ring : diameter of the center dot =
                              3 : 1
```

```
Inner diameter of the code ring : diameter of the center dot =
                              2 : 1
```

Examples of coded markers