# FalCon MovXact – Accuracy of 2D Motion Analysis FAQ

- ***How accurate can I measure positions by means of 2D motion analysis?***

The following details affect the achievable accuracy:

**a) Selection of markers:**

**MXT markers** are best "crash proven"; they are extremely robust with regard to variations of illumination and geometrical changes (rotation, shearing).

**DOT markers** can be used in case of small physical space.

The markers should show a high contrast and should be absolutely mat, i.e. not glossy.

**b) Video quality:**

The images should not show strong post-processing artifacts from sharpening filter or video compression. (See also settings for the recommended video codec **x264**.)

The noise at quasi static test points should be significantly below the absolute measurement accuracy.

**c) Accuracy in image [pixel]:**

The tracking algorithms measure point coordinates in the unit pixel.

In case of automatically measured standard markers the achievable **accuracy** is (in most cases) **better than 0.2 pixel**. Comparative studies in undisturbed environment show accuracy even below 0.1 pixel.

Measuring the positions manually the accuracy is rather lower:
in the analysis image $\geq$ 1 pixel or in the zoom window $\geq$ 1/magnification pixel.

**d) Accuracy at measuring object [mm]:**

The absolute image resolution with respect to the size of the measuring volume determines the theoretical accuracy at the measuring object in physical units:
Given a scale with length in *mm* and its length in the image in *pixel* results in a scaling factor in *mm/pixel*.

**Example:**
Assuming a field of view = 1500 mm and an image width = 600 pixel results in a scaling factor of 2.5 mm/pixel. Taking the tracking accuracy of 0.2 pixel, you get the **theoretical accuracy** of 0.2 pixel $\times$ 2.5 mm/pixel = **0.4 mm**.

**e) Lens quality & camera calibration:**

Distortion errors cause nonlinear errors, which have negative impact especially in the outer image areas.

The *Distortion Index* according to ISO/SAE is a simple index for the lens quality.

The mean residual error of all point measurements during a camera calibration gives a quantity for the optimum achievable measuring accuracy.

Using calibrated cameras additionally makes sure, that the principal point as reference of the parallax correction is set correctly.

**f) Accuracy of the depth values:**

The distances of the object points need to be measured parallelly to the camera view axis; which means perpendicular to an imaginary camera or scale plane.

Imprecision has more influence in case of small camera distance (= mostly with short focal length); see weighting of the correction factor = $(d_R + d_C) / d_C$

**g) Permanence of the depth values = adherence to the motion plane:**

Deviations cannot be corrected by a constant correction factors!

**h) Accuracy of the orthogonal orientation:**

The hereby caused numerical errors can hardly be estimated. They increase with increasing distance to the image center.

Check a linear scale crossing the field of view:
Measure the length of the scale, which is defined in a start image, by tracking start and end point over time. Does it remain constant? Which standard deviation does it show? Is there a slope, which is a hint for a yaw angle error?

Check by a horizontal and a vertical check scale: differences indicate a pitch angle error.

**i)** Synchronicity of the time basis, motion blur etc.

Note: The correction of parallaxes depends on the accuracy of several factors:

- A calibrated principal point of the camera, which is used as optical axis (see e).
- Well pre-measured depth distances from camera to scale and to the objects (see f).
- A truly perpendicular view (see h).

Because the weighting of the single details strongly depends on the single test, **no numerical statement about the overall accuracy** can be evaluated – except theoretical limit, see d.

The following **recommendations** are to be considered:

1. Add **check scales** in the test scene:

   Vertical and horizontal as well in different planes, if possible.
   Check the reproducibility = compare given and measured values statically in one frame and dynamically in the sequence.

2. Compile an **inspection record** according to **ISO 8721** (2010) using the FalCon tool:

   The efficiency of the optical metrology is checked by means of a comprehensive set of indices and individual user defaults.

   This procedure enables an overall view of the achievable accuracy.