OPTICAL TRACKING: TECHNICAL DETAILS

How does optical tracking work?

The object whose position shall be tracked is equipped with markers. Markers can be light reflectors („passive markers“, e.g. retroreflectors) or light emitters („active markers“, e.g. LEDs). To also measure the orientation of a body, several (>= 3) of these markers have to be arranged at a known geometry.

Tracking cameras scan a certain volume and detect the light that comes from the markers. Their images are processed to identify and calculate potential marker positions (in image coordinates, 2DOF) with high accuracy; a mean accuracy of 0.04 pixels is standard in ART tracking systems.

These 2DOF data are combined to calculate 3DOF positions of single markers or 6DOF poses of rigid arrangements of several markers („rigid bodies“ or „targets“). Some additional information about the tracking system is necessary for this, which has to be collected in calibration processes beforehand: position and orientation of the tracking cameras, as well as the geometry of rigid bodies (i.e. the positions of the markers within a body).

The result of each measurement are coordinates that describe the position of the markers, and hence the position and orientation of the body carrying the markers.

The Tracking Process

A short description of how 2D data get transformed to a 6D data experience:

Step1 (2D data)

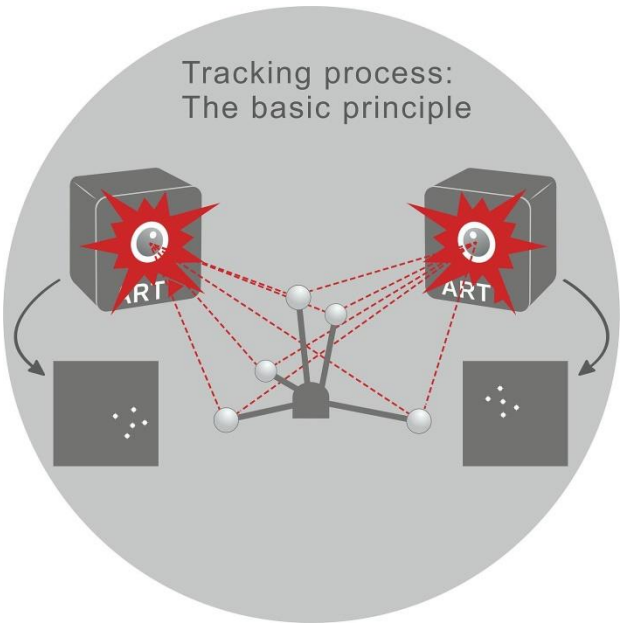
- Cameras illuminate markers
- Sensor records image
- Find marker centers in camera image

Step2 (3D data)

- Find viewing rays that intersect
- Triangulate positions of markers in 3D

Step3 (6D data)

- Match with known 3D patterns
- Identify objects
- Calculate rotation in space



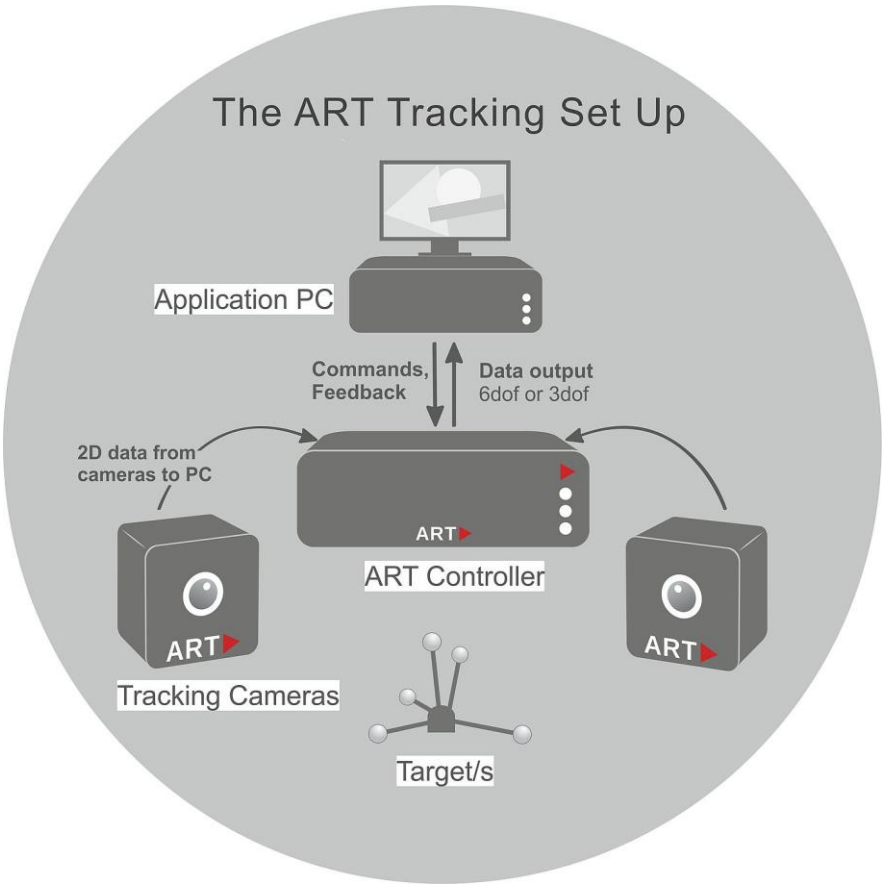
The ART Set Up

ART tracking cameras are equipped with CCD or CMOS image sensors, working in the near infrared light spectrum. An infrared light flash (not visible for the human eye) illuminates the measurement volume periodically.

The figure on the right shows the principle of the system setup: At least two tracking cameras are connected with the central unit („ARTTRACK Controller“ or ATC) via ethernet or firewire, depending on the camera type.

The ATC supplies a synchronization signal for the tracking cameras; it allows the input of an external synchronization signal (rectangular or video sync signal), or is able to generate an internal sync signal. All sync signals are transferred via BNC connections or twisted pair cables to the cameras, depending on the camera type. Note that in SMARTTRACK tracking systems two cameras and the central unit are combined within a common housing.

The ART Controller transfers 3DOF and 6DOF data via Ethernet to an application software. For a list of graphics software applications that are running with ART tracking systems please click here.



Calibration of the Camera

To achieve a high-accuracy tracking system one has to consider the camera's remaining lens distortions. ART uses a camera model with up to 11 parameters (“inner orientation”) to correct residual distortions during tracking.
ART adjusts each tracking camera's focus and aperture to the customer’s requirements before delivery. Lens distortions are determined and the set of parameters is stored in the camera’s memory. This kind of calibration can only be performed in the ART labs. When tracking is active, the parameters are read out and used for image correction.
The camera parameters are only valid for certain settings of focus and aperture. If these settings are changed, a recalibration has to be done in the ART labs.

Calibration of the Room

After setting up the tracking system, i.e. after camera mounting and cabelling, the exact position and orientation (“external orientation”) of each camera has to be determined. This is done by a simple calibration procedure that takes not more than five minutes in all. This “room calibration” process uses an L-shaped tool („angle tool“) with four markers, which defines the coordinate system, and a stick with two markers (“wand”) which has to be moved in the tracking volume.
If just an update of the calibration is wanted, the calibration process can be performed without the angle tool („recalibration“); the process then maintains the existing coordinate system.
Room calibration hardware is included in all standard packages. The calibration process can be controlled by the DTrack2 software.

Body Calibration

In order to identify a three dimensional arrangement of markers as a “target” (or “rigid body”), i.e. as an object to be tracked, the geometry of this marker configuration has to be calibrated. In other words, the target is shown to the tracking system and the special geometry of marker positions is determined, which is the base for target identification and tracking.
This fast (30 sec) and simple calibration process is included in the DTrack2 software. DTrack2 also offers many customisation possibilities in adjusting the measured geometry to the customer's needs.
Calibration has to be redone if the target geometry had changed. For this a special calibration process can be performed that preserves the existing geometry as much as possible („recalibration“). Recalibration is not necessary if just the room calibration was refreshed. Body calibration data can be transferred from one tracking system to another.