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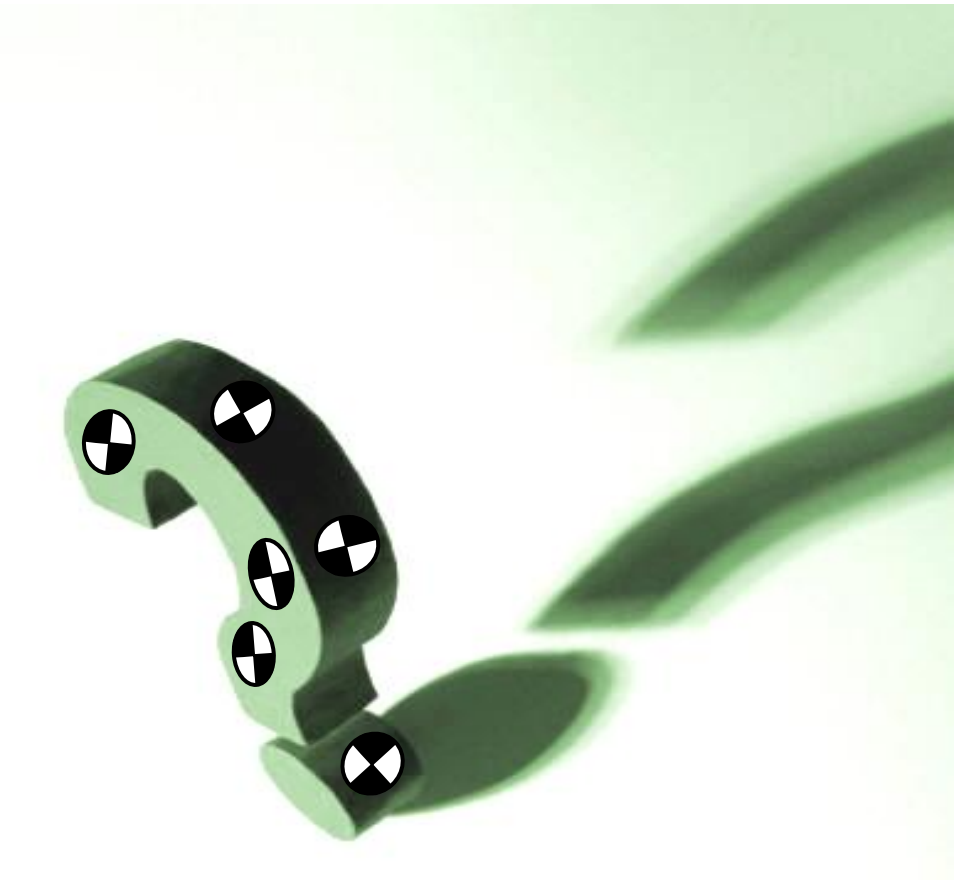
MicronTracker3.6
Frequently Asked Questions

September 2010



Contents

1 General

1.1 Are there models of the MicronTracker other than the one I am evaluating?

The MicronTracker's product line currently consists of the following models:

Specification \ Model	H3-60	Sx60	S60	H40/Hx40	H60/Hx60
FOM, spherical section (radius x width x height)	240x200x160 cm	115x70x55 cm	115x70x55 cm	120x120x90 cm	200x130x100 cm
Measurement rate	16 Hz	48 Hz	30 Hz	15Hz / 20Hz	15Hz / 20Hz
Calibration accuracy[1]	0.20 mm RMS	0.25 mm RMS	0.25 mm RMS	0.20 mm RMS	0.35 mm RMS
Jitter, static target[2]	0.007mm RMS	0.007mm RMS	0.007mm RMS	0.015mm RMS	0.015mm RMS
Jitter, moving target[2]	0.07 mm RMS	0.07 mm RMS	0.07 mm RMS	0.14 mm RMS	0.14 mm RMS
Processing time/frame (3GHz CPU, 6 markers)	30~35 ms	10-12 ms	10-12 ms	15-20 ms	15-20 ms
Lag	~100 ms	~30 ms	~45 ms	~85 ms	~85 ms
Sensors resolution	1280x960	640x480	640x480	1024x768	1024x768
Lenses / H°xV°	6 mm 50°x38°	6 mm 50°x38°	6 mm 50°x38°	4 mm 70°x52°	6 mm 50°x38°
Case dimensions (WxHxD, approx.)	283x43x49 mm	172x57x50/ 164x43x54 mm	172x57x57 mm	172x57x50/ 164x43x54 mm	172x57x50/164x43x54 mm
Weight (approx.)	505gr	342gr	790gr	675gr/342gr	790gr/342gr
Electrical Interface	IEEE-1394b (FireWire), 800 Mbps	IEEE-1394a (FireWire), 400 Mbps			
Mount	1/4" thread tripod mount				
Operating temperature	15-35°C (59-95°F)				
Warm-up period	~30 mins	~15 mins			
Warm-up period Template-based correction enabled	~10secs	~10secs			
Max. # of marker templates	practically unlimited				
Max. # of markers concurrently tracked	100				
Illumination range	50-100,000 Lux (5-400,000Lux in HDR mode)				
Max illumination variation between markers	6:1[3] (1000:1 in HDR mode)				
Certifications	CE and Part 15 Class A of FCC, RoHS and WEEE compliant		Class II medical device: IEC 60601-1, CAN/CSA C22.2, CSA 601.1, UL 60601-1 (Certification pending for Sx60/Hx40/Hx60 and H3-60 models)		

Drift: temperature, pressure, light intensity, marker orientation, motion blur, exposure settings	insignificant
Hazard warnings issued	Marker out of FOM; Thermal instability; Temperature out of range; Shadow over target
Operating system	MS-Windows 2000/XP/Vista/Windows 7, Linux, Mac OSX – 32bit and 64bit
Minimal computer hardware	2 GHz CPU, 512MB RAM, 500MB disk space

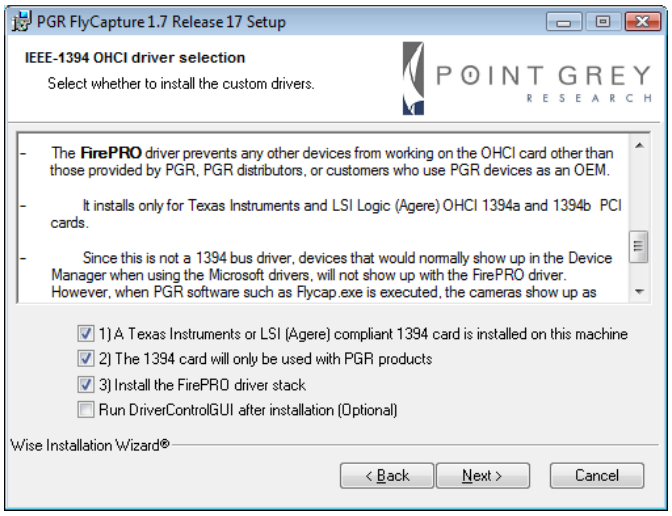
1.2 What is the viewing angle of markers?

XPoints will be reliably detected and measured at off-axis tilt angles of up to 60°. This provides good support for multi-facet markers with facets positioned perpendicular to each other (a minimum of 45° is needed to prevent detection gaps).

Note that the XPoint's "footprint" on the image shrinks in proportion with the cosine of the tilt angle. This, in turn, proportionately reduces the maximum detection range of a tilted XPoint compared to one directly facing the camera (0°). Enabling small marker detection (which uses smaller XPoint "footprint") in the Options dialog can increase the detection range of a tilted XPoint.

1.3 H3-60 Camera is connected to the computer but it is not detected?

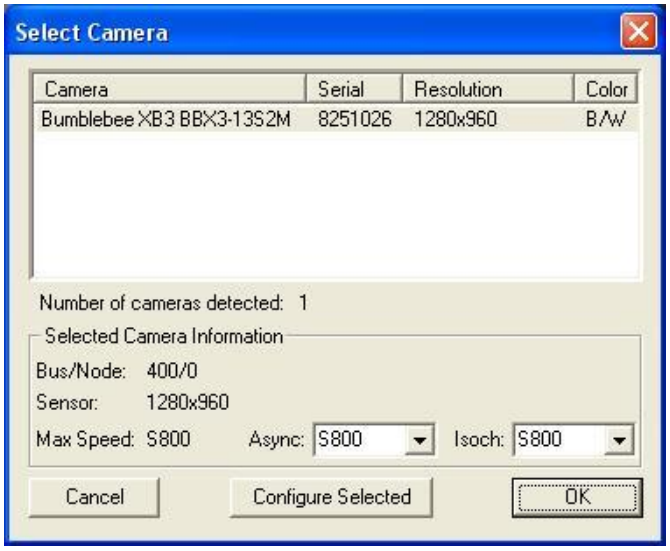
During FlyCapture installation process, the user has the option of installing the FirePRO driver to ensure full FireWire speed (both signed and unsigned drivers). If this option is chosen, the signed version is installed. The FirePRO driver (pgr1394.sys) is a replacement for the Microsoft low-level 1394 host adapter drivers (ohci1394.sys and 1394bus.sys), and directly interfaces with the FlyCapture library to provide enhanced functionality.



If the user declines the FirePRO driver, the signed PGRCAM driver is installed. You can upgrade to these versions using DriverControlGUI utility. This is a graphical utility installed by default in the \bin folder of the SDK installation directory, and is an easy way to switch between different

drivers. It is also available from the Start menu. The interface is divided into two panes. The upper pane lists detected cameras and the lower pane lists detected host adapter cards. After selecting a device, the area below each pane displays the available drivers for that device. To switch drivers, select a driver, and then click Switch.

To ensure that the driver is installed correctly run FlyCap.exe in the \bin folder of FlyCapture SDK. Following picture shows a correct configuration of a H3-60 camera. Please note that the H3-60 requires bus speed of 800Mbps.



1.4 I am using 64bit release of the Microntracker but MicronTracker doesn't recognize the camera and the FlyCap application reports incorrect configuration error message.

There are two possible solutions for this kind of issues:

1. Download and install the vcredist_x64 SP1. This should have been installed together with the 64-bit FC2, but it doesn't hurt to reinstall it again. The package can be found at:

http://www.microsoft.com/downloads/details.aspx?familyid=90548130-4468-4BBC-9673-D6ACABD5D13B&displaylang=en

2. Please verify that the Flycap2.exe was launched from the "bin64" not the "bin" folder? If it was from the "bin" folder, then it's a 32-bit application, and the 32-bit vcredist was not installed. If this is the case, you can install the 32-bit vsredist_x32 package which can be found at:

http://www.microsoft.com/downloads/details.aspx?FamilyId=32BC1BEE-A3F9-4C13-9C99-220B62A191EE&displaylang=en

1.5 Why do I get torn images from the Microntracker?

Did the torn image happen with all resolution settings? Could you give the latest CPU power state utility: PGRIdleStateFix a try? This utility helped many users to get rid of the image tearing on multi-core systems. The utility can be found in the following knowledge base article:

http://www.ptgrey.com/support/kb/index.asp?a=4&q=263

2 Accuracy

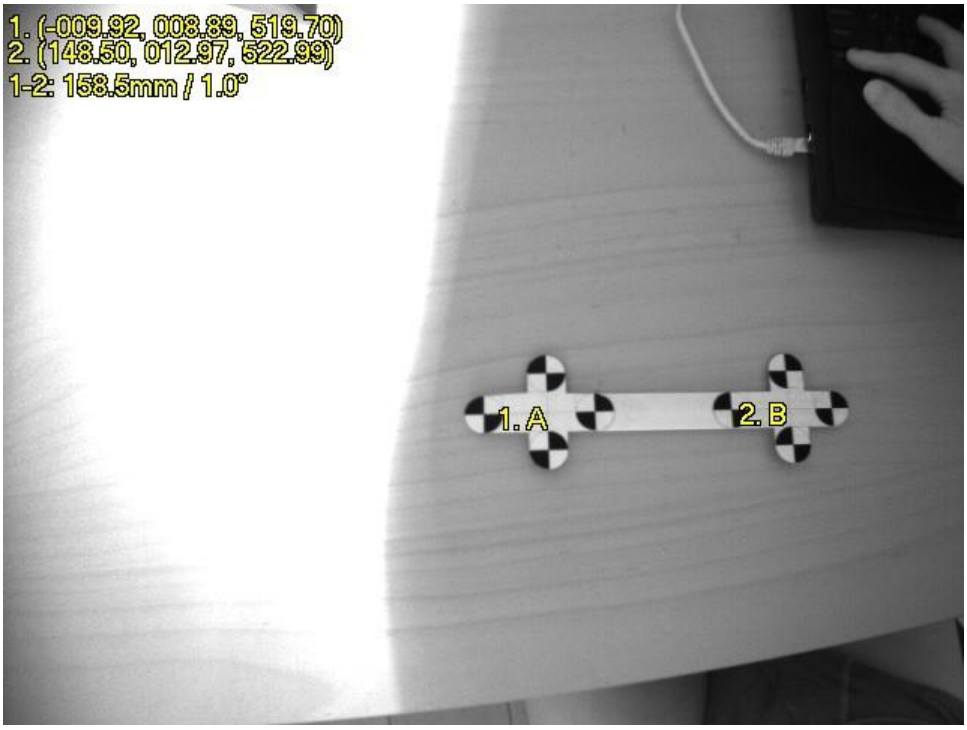
2.1 Does the MicronTracker require a warm-up period before stable measurements can be obtained?

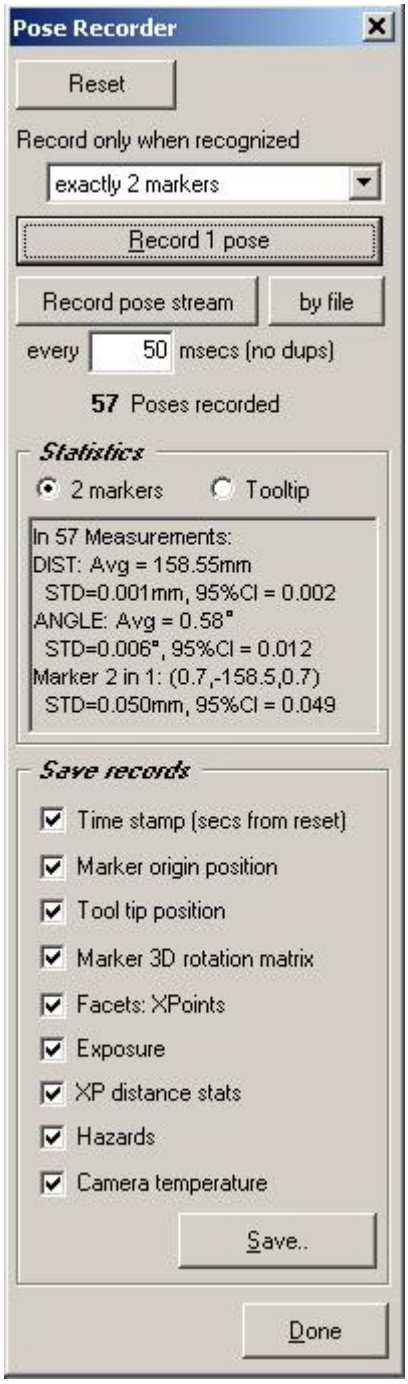
The MicronTracker reaches its maximum bias error after about 15 minutes from a cold start at room temperature. During this period the measurement issued by the MicronTracker will have a thermal instability warning attached to them. After this initial instability period, the MicronTracker will track temperature changes and compensate for any variation within the accepted temperature range.

2.2 What is a simple and quick way to validate accuracy?

A good way to evaluate accuracy is to use the distance between markers in the dual marker tool. One comes pre-registered in the MT evaluation box, and you can easily create others to your specification. To register it, you only need to cover one of the markers, register the first with a name (A in this example), then uncover the second and register it under another name (B in this example). When you have two markers visible the MicronTracker demo application automatically shows the distance between the marker origins and angle between the markers' long vectors. You can use the pose recorder to record a stream, then view the "2 markers" Statistics section in the Pose Recorder dialog to see the average distance, standard deviation and 95%CI for both distances and angles. Note that these statistics are available for each marker in the camera space, as well as for the 2nd marker in the 1st marker's coordinate space.

Here is an example of such tool and the output of the pose recorder statistics display.

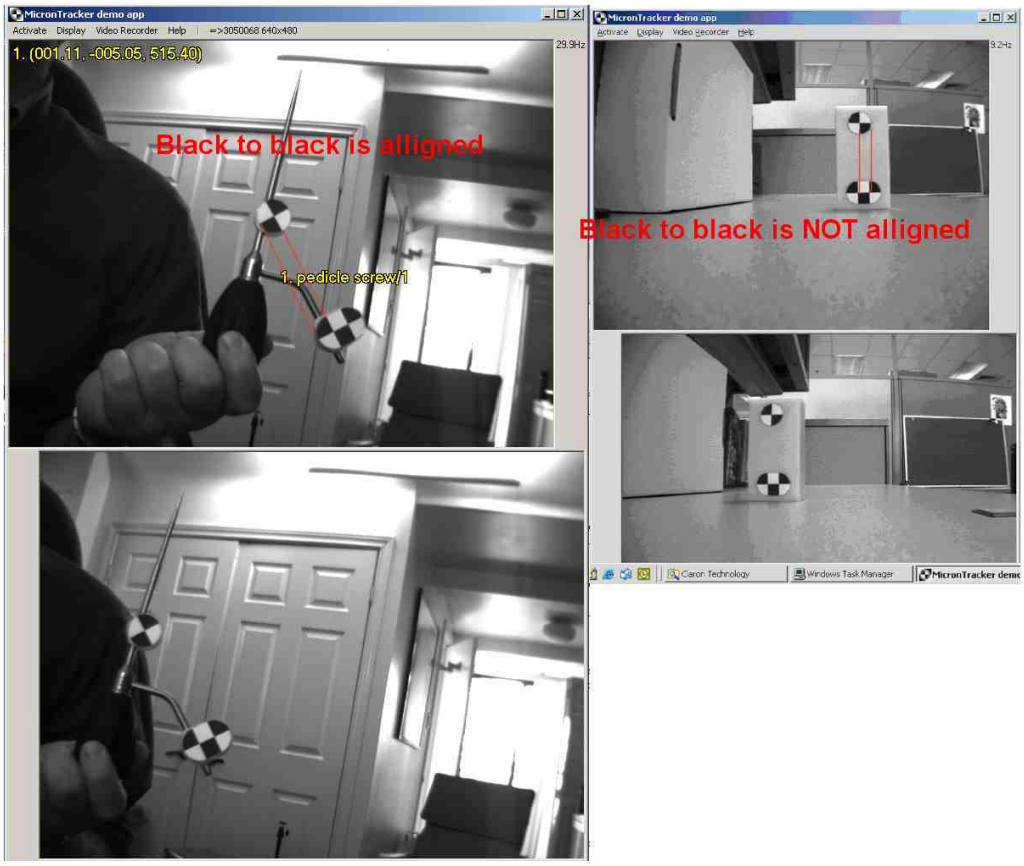



Pose Recorder
Reset
Record only when recognized
exactly 2 markers
Record 1 pose
Record pose stream
by file
every 50 msecs (no dups)
57 Poses recorded
Statistics
2 markers
Tooltip
In 57 Measurements:
DIST: Avg = 158.55mm
STD=0.001mm, 95%CI = 0.002
ANGLE: Avg = 0.58°
STD=0.006°, 95%CI = 0.012
Marker 2 in 1: (0.7,-158.5,0.7)
STD=0.050mm, 95%CI = 0.049
Save records
Time stamp (secs from reset)
Marker origin position
Tool tip position
Marker 3D rotation matrix
Facets: XPoints
Exposure
XP distance stats
Hazards
Camera temperature
Save..
Done

3 Marker Design

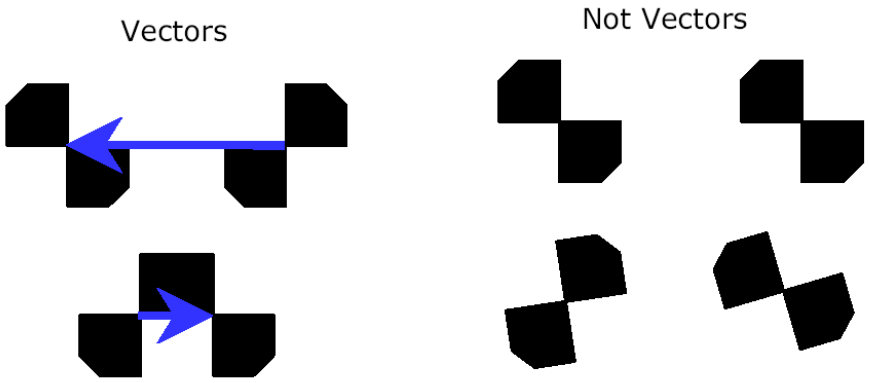
3.1 Why can't I get MicronTracker to register my marker design? I attach a screen shot of my marker here.

The problem is that you have not aligned black to black. See below for explanation



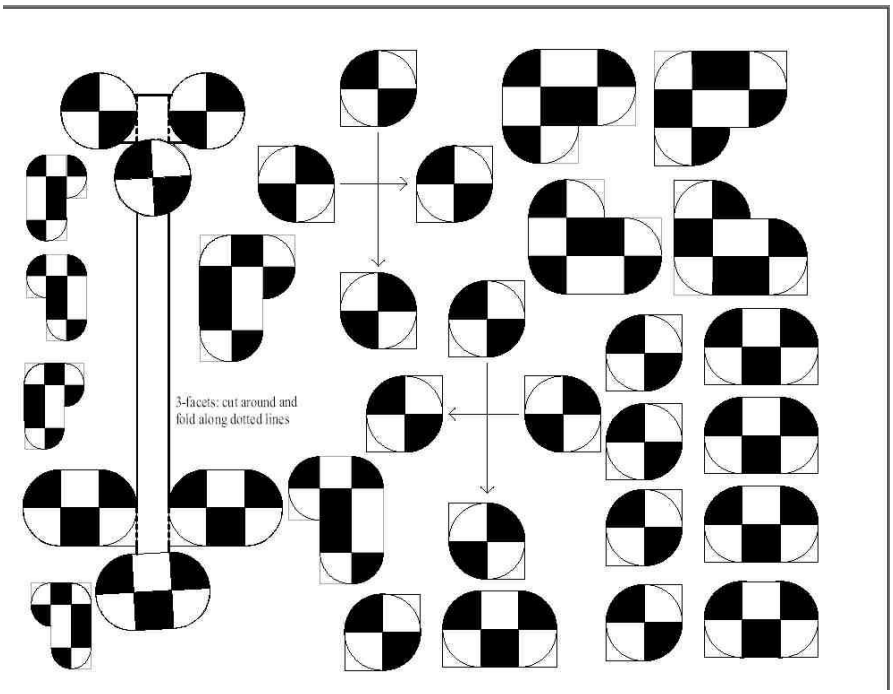
From the MicronTracker Development Manual:

NOTE: *By definition, to form a vector, one of the Xlines of one Xpoint must be aligned with one of the Xlines of the other Xpoint, with black facing black and white facing white. The Xpoint regions at both ends should lie on the same plane. The MicronTracker software uses a tolerance of 5 degrees between the Xline and the line connecting the two Xpoints in recognizing Xline alignment in the Xpoints' projection in an image.*



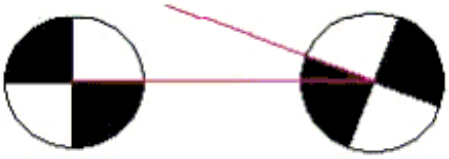
3.2 Do you include any rigid bodies in your evaluation kit?

There are several markers (i.e. rigid bodies) available in the MT evaluation kit. The marker patterns included in the MT box are also available in the CD in pdf format. The package contains a sample of the different marker configurations possible. They can also be used to verify the performance of MT with multiple targets, by registering them all in the MT template database. Some of the markers are "open design": they are composed of two separate parts that can be placed at different distances from each other. You can print the patterns and use them to effectively generate as many unique markers as you like.



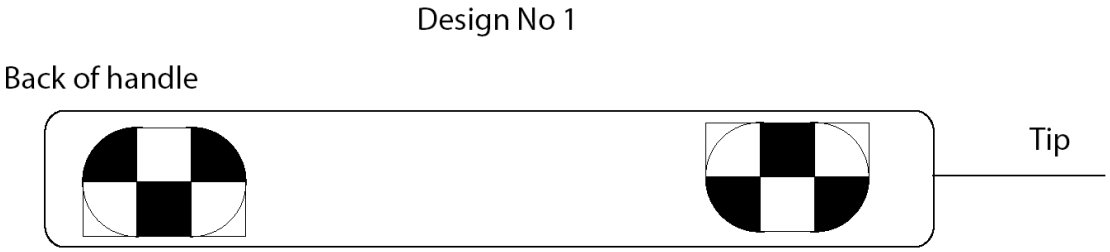
Example of a pre-printed markers sheet included in the SDK

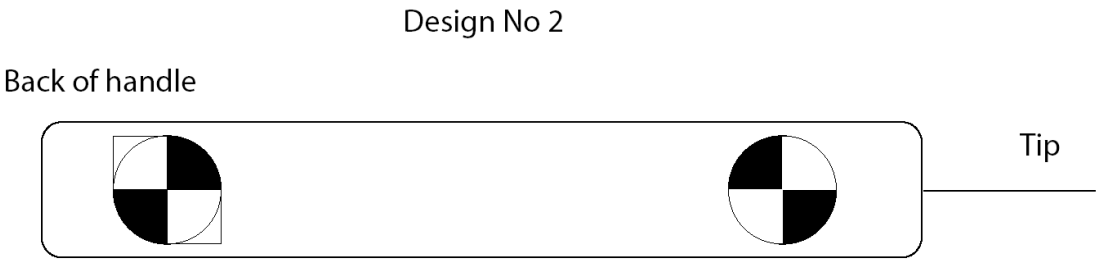
3.3 With open markers, it is possible to end up with misalignment between the Xlines (5 degrees in the example image). Does this have any effect on accuracy?



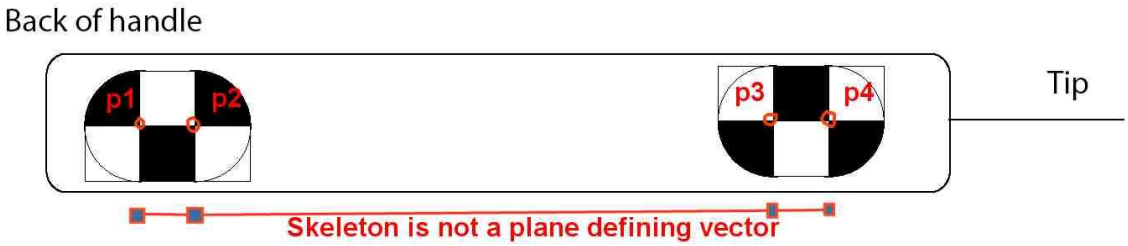
The rotational misalignment has no effect on accuracy, but a misalignment reduces the likelihood of correct recognition of a marker. The recognition software allows a rotational tolerance of 8 degrees between the line connecting the XPoint centers and the relevant XLine at each end (base or head), as projected on the image plane. However, this tolerance includes measurement noise (it is applied before various noise reduction filters are applied). We suggest maintaining less than 3 degrees of misalignment.

3.4 I have drafted two simple designs for how to place markers on a pointer tool. Which one is better for accuracy?





Unfortunately both of these designs would not work. Design # 2 only has 2 Xpoints so it's not recognized as an MT vector. Design #1 has 4 Xpoints forming four vectors (two short and two long ones). None of the four vectors forms an angle between 20 and 160 degrees with any of the others.



The 4 rules for forming a proper marker facet are:

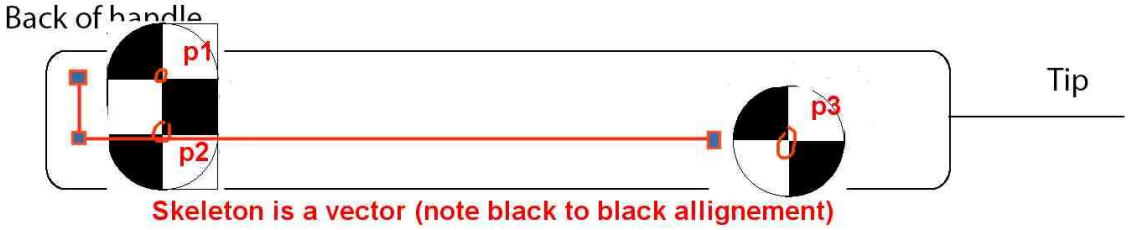
1. A facet contains exactly two vectors.

2. The angle between the facet's vectors is between 20 and 160 degrees.

3. One of the facet's vectors is longer than the other by more than 2mm

4. The position of at least one end of its two vectors (in the facet's own coordinates) needs to be different than the corresponding end position in all other facets registered with MicronTracker's by at least twice the value of `Markers.TemplateMatchToleranceMM`, ie, at least 2 mm with the default settings.

If the tool's tip is roughly aligned with the tool's handle, extrapolating the tip's position from a marker mounted on the handle is influenced far more by the angular accuracy along the tool's main axis than by the angular accuracy around its axis. Angular accuracy around an axis is improved with increased distance between XPoints perpendicular to it. A pointer with one long vector along the handle and one short one perpendicular to it is thus recommended.



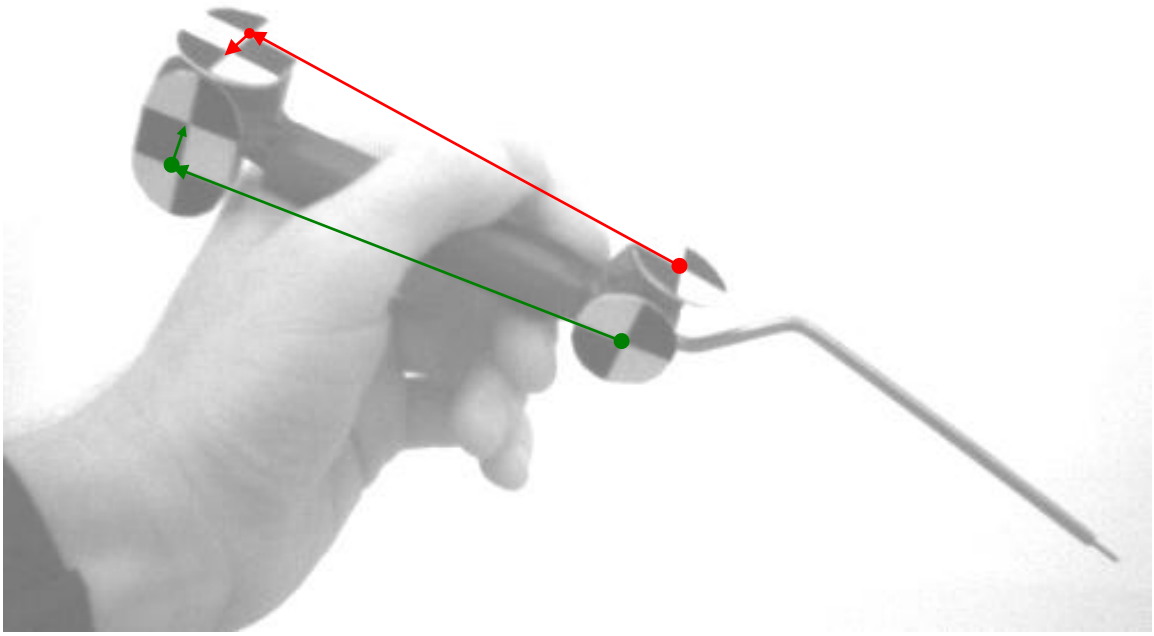
3.5 Is it a requirement that all the XPoints of a facet lie on the same plane?

The two XLines of the XPoints at both ends of a vector need to be aligned (ie, point at the other XPoint). This can be easily achieved with all XPoints being on the same plane. It is also possible to achieve such alignment by having the XPoint regions at each end of the vector twisted around the imaginary line connecting the XPoints, but why would you want to do that?

If the facet is made of two separate vectors (4 XPoints), the two vectors do not need to be co-planar. However, if the facet is made of 3 XPoints, one of the XPoints participates in two vectors. Since it needs to be co-planar with each of the other two, all 3 XPoints need to be co-planar

3.6 The figure in the MT 1.3 Developer's Manual, section 2.1.2 shows the vector base once at the BW end and once at the WB end. How is the vector base distinguished from the vector head?

There is an error in the figure, which will be corrected in future releases of the manual. The vector base is always at the BW side. The corrected figure below shows the correct vector orientation (hopefully ☺).



4 The Pose Recorder

4.1 What are the various columns of numbers in the text file that is saved by the pose recorder? How do I load it into MS-Excel?

Aside from the distance and angle statistics, a list of pose measurement records can be saved in a text file for exporting to an external analysis software program (e.g. Excel). The pose recorder offers a few checkboxes to indicate what should be the included in the exported file (they do not affect the contents of the pose records, so you can save the records multiple times with different options enabled). The options are:

a] timestamp for each measurement, in seconds

b] marker origin position (middle of the long axis)

c] marker tooltip position (same as marker origin if the tooltip is not calibrated)

d] marker orientation (full rotation matrix)

e] hazard warning code for each marker (0 if no hazard)

f] 3D positions of XPoints for each marker (base and head of both vectors V1 and V2)

g] camera shutter and gain settings

h] internal camera temperature

i] XPoint distance statistics (average, standard deviation and 95% confidence interval), for each possible pair of XPoints.

For the example described in question 2.2 this is the first row of the file, with all options selected. It explains the content of the various columns, as in the order above. Note that the first column is the measurement number, followed by the timestamp.

```
"#" "t" "A X" "A Y" "A Z" "A tip X" "A tip Y" "A tip Z" "A R11" "A R12"
"A R13" "A R21" "A R22" "A R23" "A R31" "A R32" "A R33" Hazard? "A V1B
X" "A V1B Y" "A V1B Z" "A V1H X" "A V1H Y" "A V1H Z" "A V2B X" "A V2B Y"
"A V2B Z" "A V2H X" "A V2H Y" "A V2H Z" "B X" "B Y" "B Z" "B tip X" "B
tip Y" "B tip Z" "B R11" "B R12" "B R13" "B R21" "B R22" "B R23" "B R31"
"B R32" "B R33" Hazard? "B V1B X" "B V1B Y" "B V1B Z" "B V1H X" "B V1H
Y" "B V1H Z" "B V2B X" "B V2B Y" "B V2B Z" "B V2H X" "B V2H Y" "B V2H Z"
Shutter Gain Deg C
```

In addition, XPoint distance statistics is appended to the end of the file, following the recorded pose measurements.

The file can be opened directly in Excel (File/Open, File of type: Text files). In the Text Import Wizard, step 1, select original data type as “delimited”. In step 2, check “Tab” in delimiters, and the character “ as a text qualifier (the default). In step 3, select the column data format as “General” (the default).

4.2 I’d like to record the measured positions of the XPoints themselves, rather than the whole marker, how do I access them?

You should enable “XP distance stats” option in the Pose Recorder. XPoint positions are obtained using the property EndPos2x3 of each Vector object in the IdentifiedVectors collection, which is in turn obtained from each of the Facet objects in the Marker’s IdentifiedFacets collection.

4.3 How do I record the pose of one marker with respect to a second marker?

In the MicronTracker's SDK, a pose is represented by a Xform3D object. So, let A2C (A to Camera) and B2C be the poses of objects A and B in camera space.

The pose B2A that you are interested in is obtained by the following code fragment:

```
dim B2A as Xform3D
Set B2A = B2C.concatenate(A2C.inverse) 'B->A = B->C + C->A
```

The statistics for the tracked pose of a marker in another marker's coordinate space is available in the "2 markers" Statistics section in the Pose Recorder dialog (see question 2.2).

5 Misc.

5.1 What computation is done by the host computer vs. in the camera itself?

All the computations to identify markers and position are done by the host computer. The camera only performs synchronized acquisition and provides video images back to the MicronTracker software. With the latest CPU model, MicronTracker's operation can be optimized to require less than 40% of the CPU power at full measurement rate, and, by Moore's law, that percentage should drop by a factor of 2 every 18 months. The SDK provides a few controls to allow the user to experiment with the tradeoffs between CPU consumption and detection performance. Reducing the measurement rate reduces the CPU load proportionately.

With multiple cameras, it may make sense to have a dedicated CPU for detection and tracking. This could be economically done with a dual CPU system, or with a small SBC (single board computer) that communicates with the main navigation host machine with a standard communication protocol (TCP/IP - SOAP etc).

5.2 I've noticed that the exposure changes constantly between video frames. What is going on and does this affect the accuracy?

MT uses an advanced dynamic exposure control algorithm that continuously adjusts the shutter and gain to be able to keep the currently detected markers "locked" and to still detect new markers coming into the field of view. We believe the exposure control available in SDK release 2.0 and up covers most of the conditions relevant to operating room usage, but we are also working on improvements to allow good detection even in extreme conditions (some markers under strong OR lights, others in the dark).

The lighting level has an effect on shutter speed. In low lighting, shutter speed is reduced, causing increased sensitivity to motion with resulting transient errors. If the shutter speed is kept at a minimum level to prevent loss of tracking during motion, image signal gain is increased, raising image noise, which, in turn, increases measurement jitter. We recommend doing accuracy validation and experiments in lighting levels comparable to the environment in which your target application will be used.

5.3 My camera has been experienced a rough handling and now it is not as precise as before. Is there any way to retain its initial accuracy?

To address the issue of a potential degradation of calibration accuracy, **R-Fine** software application has been added to the MicronTracker kit. R-Fine provides a fast and intuitive method to *evaluate* the camera's calibration accuracy and the possibility to *refine* the calibration, if required. Calibration refinement in the field is a convenient alternative to shipping the camera back for full re-calibration. The R-Fine procedure is recommended to be performed every few months or if the camera has been subjected to physical stresses. Please consult the MicronTracker Developer Manual to find out more about the R-Fine and how to use it.

5.4 How can I synchronize the MicronTracker with another device to grab an image and record the pose just right after getting an external signal?

The MicronTracker Sx60 camera has a 12-pin GPIO connector on the back to allow the camera to be synchronized with external devices. It can be configured to trigger on an external electrical signal or output a similar signal to control external devices. To configure the GPIO pins, consult the MTC documentation or MicronTracker Developer Manual.

The GPIO pins are TTL 3.3V pins. Inputs can be configured to accept external trigger signals. When configured as inputs, the pins are internally pulled high using weak pull-up resistors to allow easy triggering of the camera by simply shorting the pin to ground (GND).