



celepixel

Operation Instructions

IMU Verification Tool

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1、 Brief of IMU Verification

By verifying the results of IMU calibration, many errors induced by calibration manipulation can be quickly found.

1.1 Gyroscope

Ideal bias of gyroscope should be zero in stationary condition. In this case, the corrected gyroscope output should also be close to zero. For our tool, a small bias of less than 0.002(rad/s) regards as an acceptable bias. The smaller the bias, the better precision the calibration results.

1.2 Accelerometer

The modulus of the corrected 3-axis output vector should be close to the ground truth of gravity $G (= 9.80665\text{m/s}^2)$. Thus, after calibration, the any deviation between the modulus of the corrected output and G should be less than 0.05m/s^2 . In this verification, three positions are used where X-, Y- and Z-axis are erect, respectively. The smaller the deviation, the better precision the calibration results.

1.3 Magnetometer

The 3-axis corrected output of a magnetometer should be symmetric to the centre of $[0, 0, 0]$. In another word, the absolute of maximum and minimum should be the same. Considering the earth magnetic field, the deviation of the absolute of maximum and the absolute of minimum should be less than $\pm 4\mu\text{T}$. The smaller the deviation, the better precision the calibration results.

1.4 Camera coordinate

Please refer to the chapter 2.1 of << Operation Instructions IMU Calibration Tool >>.

2、 Verification process

2.1 Configuration before verification

- i. Checking the calibration results

Make sure the calibration result “IMUCalib.ini” is created in the path of config/.

- ii. Configuration for CeleX5_Z

please configure sensor IP and port in config/Zynq_config.ini firstly before calibration and verification.

For more support of connection and use of CeleX5_Z, please refer to <https://github.com/CelePixel/CeleX5-Zynq>.

2.2 Main process

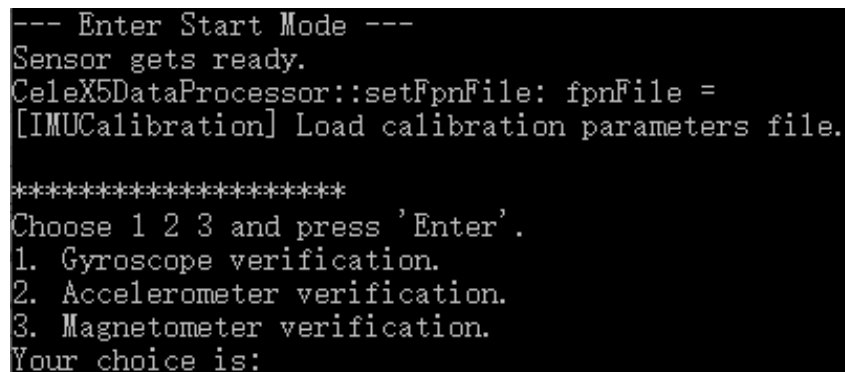
The entire process will cost about 5 minutes. Details are listed:

- i. Open “IMU_Verification.exe”.

Console window indicates whether the sensor is open or not.

CeleX5_MP:

If sensor is successfully opened, console prints “Sensor gets ready!” as shown in the following figure.



```
--- Enter Start Mode ---
Sensor gets ready.
CeleX5DataProcessor::setFpnFile: fpnFile =
[IMUCalibration] Load calibration parameters file.

*****
Choose 1 2 3 and press 'Enter'.
1. Gyroscope verification.
2. Accelerometer verification.
3. Magnetometer verification.
Your choice is:
```

Instead, if words of “Sensor cannot open!” is printed, the open process fails. Please restart the sensor. If “INI file missing in configured path: config/IMUCalib.ini” and “Load file error in setCalibParam()” are printed, IMUCalib.ini is not in the path of config/.

CeleX5_Z:

The following figure shows a successful opening:

```
create socket successfully!
Sensor gets ready.
connect to ZYNQServer successfully!
CeleXTcpSocket::sendCmd: cmd = 10
CeleXTcpSocket::sendCmd: cmd = 10
CeleXTcpSocket::sendCmd: cmd = 1
[IMUCalibration] Load calibration parameters file.

*****
Choose 1 2 3 and press 'Enter'.
1. Gyroscope verification.
2. Accelerometer verification.
3. Magnetometer verification.
Your choice is:
```

Otherwise, sensor is not opened correctly. Please check connected cable, IP and memory card.

-
- ii. Input number 1, 2 and 3 can start gyroscope verification, accelerometer verification and magnetometer verification, respectively. The manipulation for CeleX5_MP and CeleX5_Z is similar.
 - iii. Please input 1. Then the console shows “Keep stationary.”, keep stationary for a while until “Finish the verification for gyroscope.” is printed on the console window. If the 3-axis output are all smaller than 0.002(rad/s), the calibration results is acceptable. Generally, waiting period is less than one minute. If a warning of “Warning, no imu data! Please restart.” appears, please check the connection, firmware, IP and restart.
 - iv. To verify accelerometer, please adjust the position according to the following steps first. Each time 2 is pressed in console, the corrected accelerations of a certain position are obtained. Therefore, operation for several times is needed for verification at three different positions.
 - a) Adjust the sensor to the position where X-axis is erect, as shown in Fig 1(a). After keeping stationary for about 5 minutes, input 2. “Keep stationary.” is printed in the console window. Keep stationary again until the final comparison results are given. Check the $\|Acc\|$ and compare it to G . The deviation should be smaller than $0.05(m/s^2)$.
 - b) Adjust the sensor to the position where Y-axis is erect, as shown in Fig 1(b), then input 2. Check the deviation and compare to $0.05(m/s^2)$ again.
 - c) Adjust the sensor to the position where Z-axis is erect, as shown in Fig 1(c), then input

2. Check the deviation and compare to $0.05 \text{ (m/s}^2\text{)}$ again.

- d) If all deviations of a), b) and c) should be smaller than $0.05 \text{ (m/s}^2\text{)}$, the calibration parameters are acceptable. Otherwise, the calibration had better to repeat carefully.

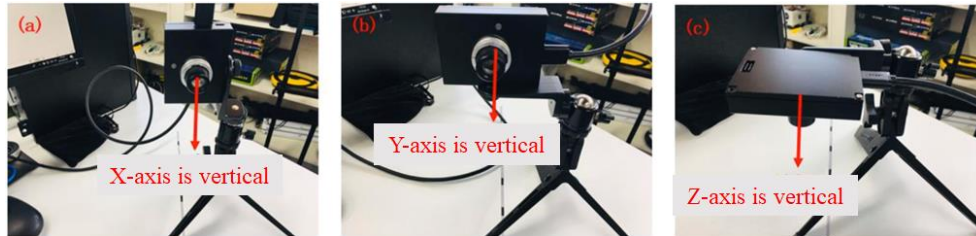


Fig 1

- v. Input 3, and rotate the sensor continually. The orientation of the sensor should point to different directions as many as possible. While the maximum and minimum of X-, Y-, and Z-axis are stable (the values do no change in 10 seconds), stop rotation. The deviation of the absolute of maximum and the absolute of minimum should less than $\pm 4\mu\text{T}$. Click “q” to quit the process.

Some tips are listed:

- a) *Acceptable results: range of magnetic data is $-32 < X < 33 \mid -31 < Y < 33 \mid -35 < Z < 38$.*
- b) *Larger deviation results: range of magnetic data: $-32 < X < 33 \mid -31 < Y < 33 \mid -35 < Z < 42$ ”.*
- c) *The minimum distance to a magnetic object (magnets, metal, electronic devices etc.) should be larger than 50cm to avoid interruption.*

Appendix A: Change Control

Version	Description	date	Author	Proof
v1.3	Add the description for CeleX5_Z. Combine IMU_Calibration and IMU_Verification.	2019.07.19	Qisheng He	Yu Zhang