



celepixel

# **Operation Instructions**

IMU Calibration Tool

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# 1、 Calibration Apparatus

## 1.1 Accessory

The necessary accessories are listed in Table 1-1.

Table 1-1 List of accessories

Name		Function
Compass × 1		Measuring the south-north direction
Strip sticker × 1		Marking the measured south-north direction
Holder	Tripod × 1	Holding sensor, ball head and L-type holder (selected)
	ball head × 1	Adjusting the position of sensor
	L-type holder × 1	Adjusting the position of sensor

《A Guide to Purchase Accessories and Tools》 is available for those accessories.

## 1.2 Calibration Platform building

3 steps to build the platform:

- i. Find out the south-north direction. Paste a strip sticker along south-north direction that can be measured by a compass on a horizontal platform as shown in Fig 1-1(a). The minimum distance to a magnetic object (magnets, metal, electronic devices etc.) should be larger than 50cm to avoid interruption.
- ii. Assemble the holder. L-type holder should be fixed on the ball head, and the joint should not loose during a whole calibration. A screw hole for tripod is on the bottom of the ball head, as shown in Fig 1-1(b).
- iii. Install the holder on a stable and appropriate tripod. Fig 1-2 shows the well prepared calibration platform. Fig 1-2(a) shows the holder connecting to a desktop tripod, while in Fig 1-2(b), the holder is on a larger tripod.

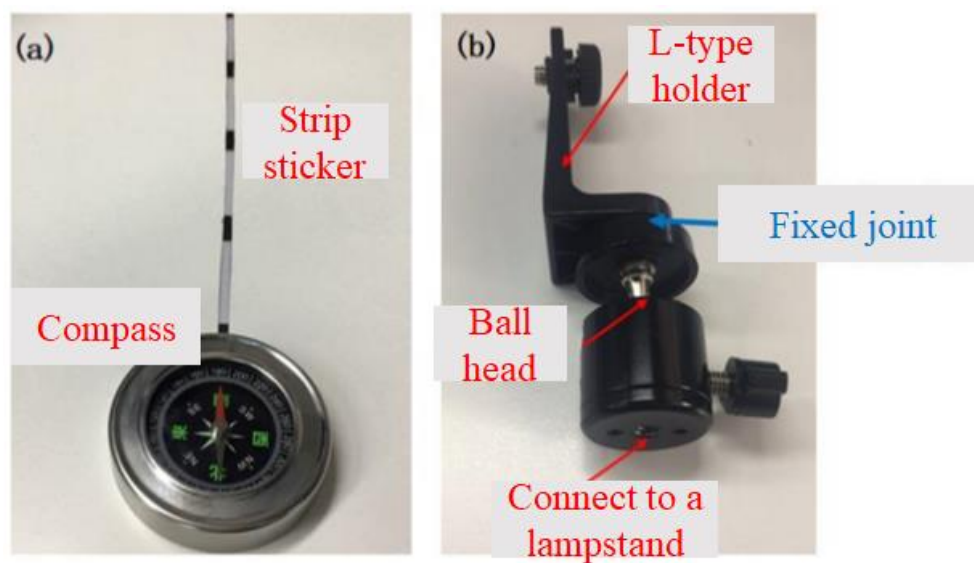


Fig 1-1 A photograph for accessories



Fig 1-2 Calibration platform

## 2、 Calibration process

### 2.1 Brief Introduction

Four functions are included.

1. Online calibration which is generally started by user at first.
2. Online calibration after interruption which inherits the data from function 1 to avoid repeating. Though, remaining data should also be continually calibrated.

3. Offline calibration where all data (a set of data of 36 positions) have been recorded. Calibration parameters can be calculated directly.

4. Real-time display for IMU raw data on the screen.

The coordinate of the accelerometer-ACC, the gyroscope-GYRO and the magnetometer-MAG on the IMU should be aligned with the camera. Fig 2-1(a) is the definition of the coordinate of the CeleX5\_MP, the other side Fig 2-1 (b) is the coordinate of CeleX5\_Z.

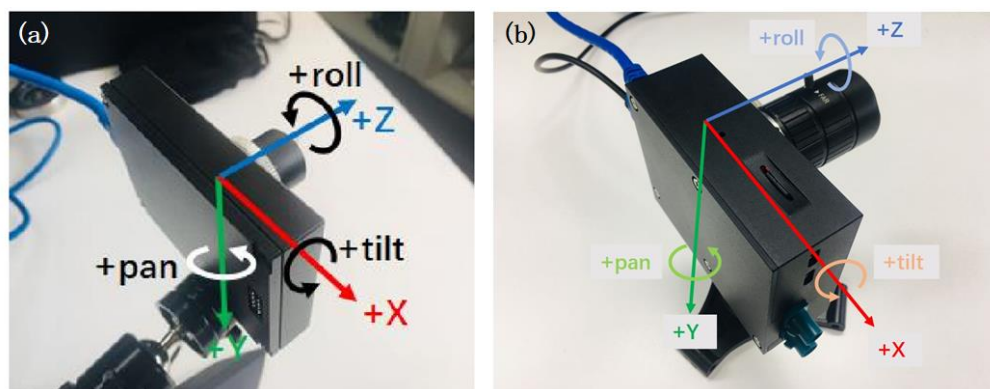


Fig 2-1 Camera coordinate: (a) CeleX5\_MP, (b) CeleX5\_Z

We highly recommend user to get start from Chapter 2.2 if user has never used this tool so far.

### 2.2 Configuration before Calibration

#### i. 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>.

### 2.3 Method 1: Online Calibration

Please make sure all the configuration has been well done (ref: Chapter 2.2). The online process will cost about 5 min. Details are listed as:

- i. Open “IMU\_Calibration\_Verificaiton” file, and start “IMU\_Calibration.exe”, chose 1.

Console window displays the operation station of the sensor.

---

#### CeleX5\_MP:

Once the sensor is started successfully, console window displays as the following figure.

```
***** HHXmlReader::importCommands_CeleX5 Begin *****
***** HHXmlReader::importCommands_CeleX5 End *****

--- Disable PLL ---

--- Load PLL Parameters ---
CeleX5::writeCSRDefaults: PLL_Parameters
--- Enable PLL ---

--- Disable MIPI ---

--- Load MIPI Parameters ---
CeleX5::writeCSRDefaults: MIPI_Parameters

--- Enable MIPI ---

--- Enter CFG Mode ---
CeleX5::writeCSRDefaults: Sensor_Core_Parameters
CeleX5::writeCSRDefaults: Sensor_Core_Parameters
CeleX5::writeCSRDefaults: Sensor_Core_Parameters
CeleX5::writeCSRDefaults: Sensor_Core_Parameters
CeleX5::writeCSRDefaults: Sensor_Operation_Mode_Control_Parameters
CeleX5::writeCSRDefaults: Sensor_Data_Transfer_Parameters

--- Enter Start Mode ---
[IMUCalibration] Open files.
[IMUCalibration] Open the file : config/IMUAvg.csv
```

Otherwise, sensor is not opened. The following figure shows a failure start. Then, reconnect and restart the sensor several times.

```
***** HHXmlReader::importCommands_CeleX5 Begin *****
***** HHXmlReader::importCommands_CeleX5 End *****

[IMUCalibration] Open files.
[IMUCalibration] Open the file : config/IMUAvg.csv
```

If it still cannot be started, it is possibly a firmware problem.

---

#### CeleX5\_Z:

Once the CeleX5\_Z is started successfully, console window is look like the following figure.

```
Sensor gets ready.  
connect to ZYNQServer successfully!  
CeleXTcpSocket::sendCmd: cmd = 10  
CeleXTcpSocket::sendCmd: cmd = 10  
CeleXTcpSocket::sendCmd: cmd = 1  
[IMUCalibration] Open files.  
[IMUCalibration] Open the file : config/IMUAvg.csv  
-----  
(No.1) position as shown in the window. Click 's' to get IMU data.
```

If the information on console window indicates “connect failed” as shown in the following figure, please reconnect and restart.

```
Sensor gets ready.  
connect failed, try to connect again, please wait...
```

If trial fails several times, check IP, Port, firmware version or configuration on SD card.

- ii. The instructions describe calibration process with CeleX5\_MP as an example which is also appropriate for CeleX5\_Z. Details are listed as follow:
- iii. No. = 1, assemble and place holder as shown in Fig 2-2(a), and install the sensor on the holder as Fig 2-2 (b) shown. The horizontal Z-axis of the sensor is vertical to the south-north direction. The position of sensor should be similar to the current picture.

*Note: Console window shows “(No.\*\*\*) position as shown in the window. Click 's' to get IMU data.”. A No.\*\* picture is displayed. Now, the position of the sensor should be adjusted corresponding the current picture.*

- iv. Keep stationary for a while, press “s” key to record IMU data. Console will print “Get IMU data.” as a feedback of successful recording. If “Warning, no imu data! Please restart.” is printed, instead, recording is failed (as no IMU data is acquired. Please check the connection and restart the Method 1 process or Method 2 instead.).

*Note: It should be noted that the tool will automatically check the stability and the position of the sensor right after each clicking “s”. If printing “Keep stationary and wait.” on the console, press “s” again until sensor is stationary. If printing “Position is wrong!” which indicates the position is the same as the last one, change the orientation according to the picture.*

If everything works right, the console window print “Save (No.1) data successfully.”, the first set of data will be written to config/IMUAvg.csv. Then another 35 sets of data should be recorded as the same method.

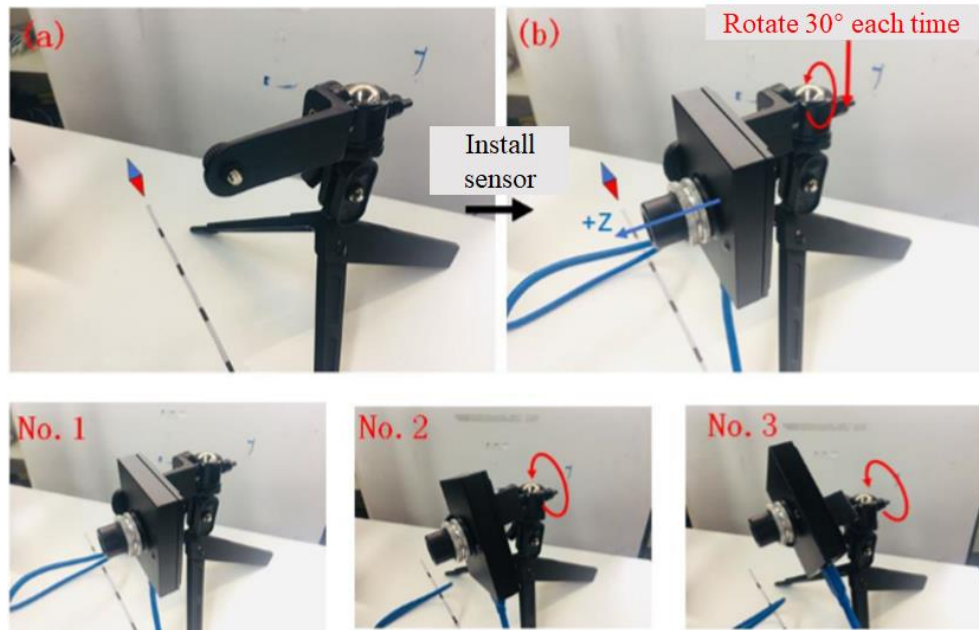


Fig 2-2

- v. For No. = 2~12 sets of data, the sensor rotates 30 degrees along the Z-axis for one set of data. Fig No.2 and Fig No.3 are two examples. Fig 2-3 shows the operation method to rotate a ball head: loosen the knob first, rotate the ball head with the joint fixed between the L-type holder and the ball head, ending with fastening the knob.

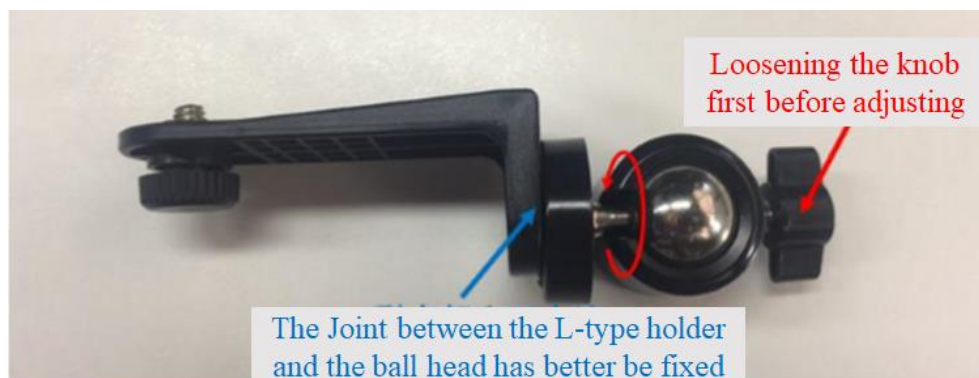


Fig 2-3

- vi. When it comes to No.= 13, the orientation should be adjusted by a large margin as shown in Fig 2-4 where X-axis is vertical to the south-north direction.



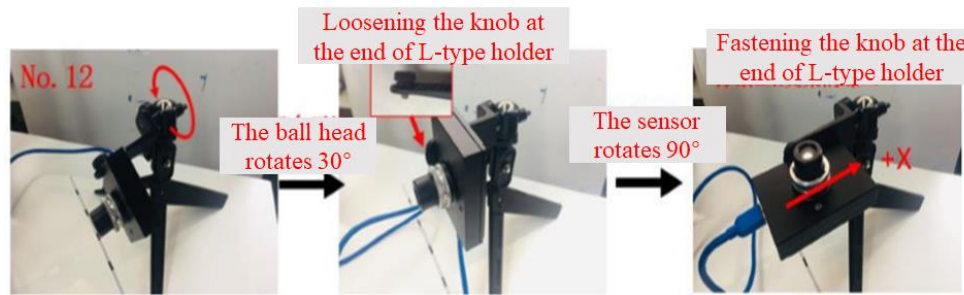


Fig 2-4

- vii. For No.= 14~24, the sensor rotates 30 degrees along the X-axis for each set of data which is similar to the former step-v.
- viii. When No. = 25, the orientation should be adjusted by a large margin again as Fig 2-5 shown where Y-axis is vertical to the south-north direction.

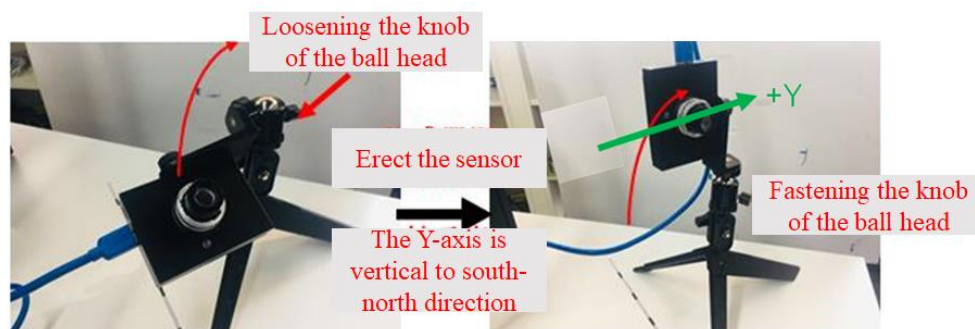


Fig 2-5

- ix. For No.= 26~36, rotate the sensor 30 degrees along the Y-axis as shown in Fig 2-6.

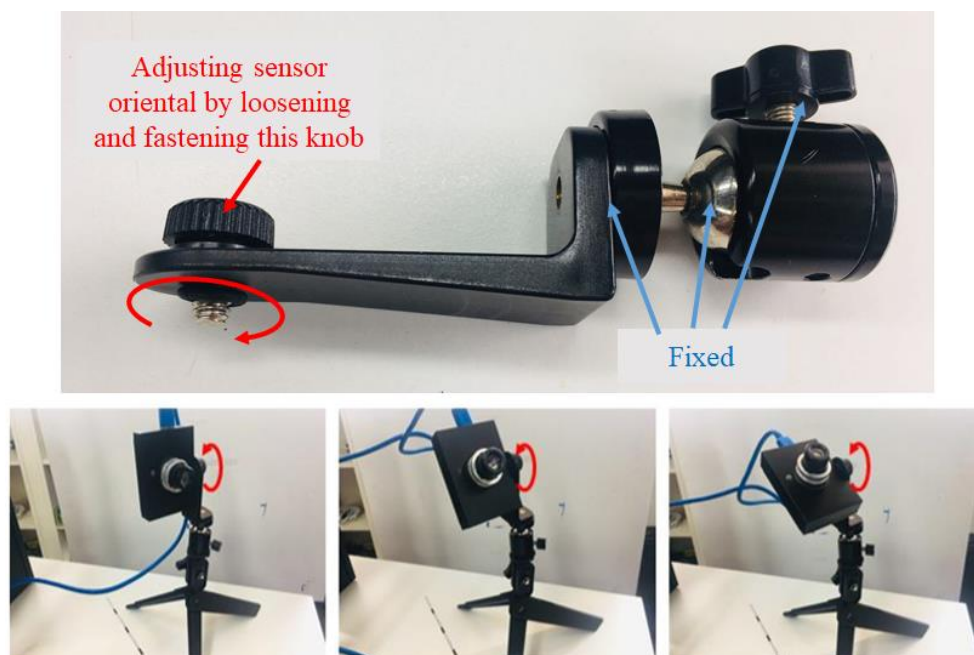


Fig 2-6

- x. After recording 36 sets of data, console prints words of “Finish recording IMU data”.
- xi. Keep stationary do not move the sensor for a while.
- xii. The console window, now, prints “Keep waiting until temperature is stable. d\_temperature should be smaller than temp\_threshold = 0.02.”. When sensor is in thermal equilibrium state, all needed data have been recorded.
- xiii. The console prints some calibration results and “Create a new IMUCalib.ini.”.
- xiv. If the error of calibration results is acceptable, “Finish calibration!” will be printed. Otherwise, the console indicates “Calibration might be error! The error of the calibration is too large. please calibrate again.”, so other more careful calibration is needed.

*Note: six windows are created which can verify the quality of raw data. The better the shape of the circle, the better the quality. The three windows on first row are No.1~12, No13~24 and No.25~36 sets of ACC data, respectively. The three windows on second row are data of MAG.*

*Fig 2-7 is an example of a group of high-quality data.*

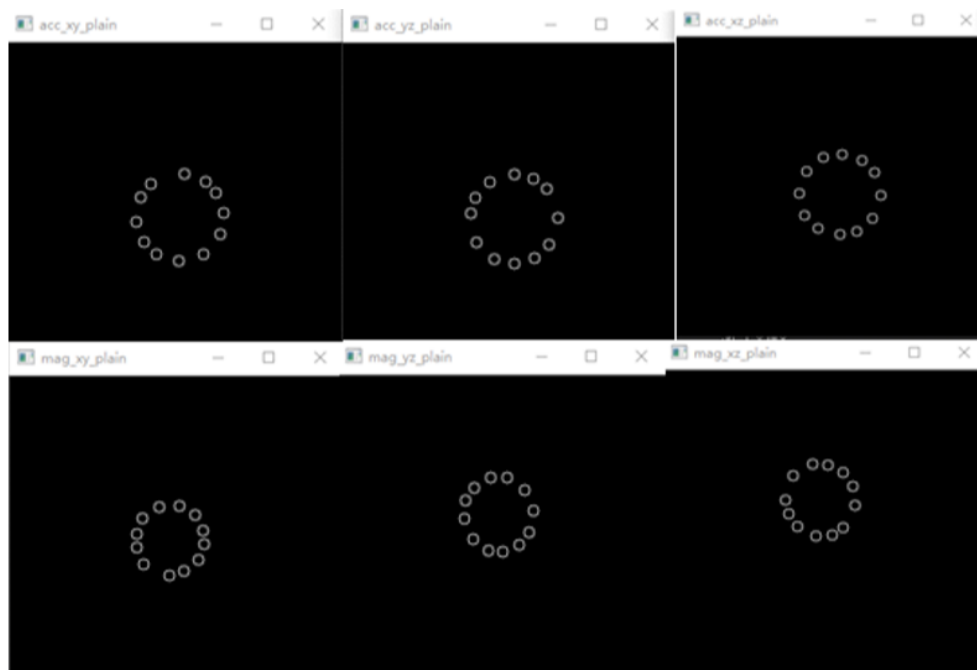


Fig 2-7

## 2.4 Method 2: Online Calibration after interruption

If online calibration (Method 1 or Method 2) is interrupted for any reason, this method can

inherit the exist data and continue the remaining process. Details are listed:

- i. Open config/IMUAvg.csv to get the maximum of the first column “rotation\_no” (range from 1 to 36).
- ii. Open config/ imu\_calib\_config.ini, and set latest\_rotation\_no as the maximum value of step-i.
- iii. Open IMU\_Calibration.exe and chose 2. The console will print “Calibration should be started at No.?”. Check the printed value No.? which should be equal to the number on the supplementary picture. Otherwise, return to 2.4-i step and 2.4-ii step to check the number carefully.
- iv. Finish remaining process (please refer to chapter 2.3).

## 2.5 Method 3: Offline Calibration

Once “config/IMUAvg.csv” having been created via online or offline calibration, offline calibration can load the IMU data and repeat the calibration again. Detail steps are listed:

- i. Check “config/IMUAvg.csv” whether 36 rows of data are recorded. If less than 36 rows, the data still can be used, though the precision is worse.
- ii. Open IMU\_Calibration.exe and chose 3 to finish this calibration. Calibration parameters will be recorded in config/IMUCalib.ini.

## 2.6 Real-time display for IMU raw data (for test)

- i. (For CeleX5\_Z) Set IP and Port at “config/Zynq\_config.ini” first.
- ii. Open IMU\_Calibration.exe and chose 4. Console displays real-time IMU raw data, the format is “time\_stamp =, GYROS >> x =, y =, z =, ACC >> x =, y =, z =, MAG >> x =, y =, z =,TEMP >>”.

## 2.7 Attention

- i. Avoid magnetic disturbance from metal and electronic devices.

- ii. The rotation angle of 30° is not so rigid, as the manipulation by hand is not accurate. Some deviation is acceptable. For higher resolution, the ball head should be equipped with rotary scale.
- iii. After calibration, a verification tool is provided.

## 2.8 Document description

Relative documents are listed in Table 1-2.

Table 1-2 List of relative documents

Name	Path	Function	Modifiable parameters
imu_calib_config.ini	config/	Main configuration of the calibration	latest_rotation_no
Zynq_config.ini	config/	Configuration of CeleX5_Z sensor	IP, Port
IMUCalib.ini	config/	Recording calibration parameters	Sensor ID(selected)
IMUAvg.csv	config/	Recording raw imu data in detail each calibration loop	-

## Appendix A: Q&A

- i. After CeleX5\_MP sensor starting, “FrontPanel Device not found...” is printed on console window.

Possible problem: Sensor fails in opening.

Solution: Check the power and USB cable, restart the sensor.

- ii. No response from console, even though key have been pressed.

Possible problem: Console is not activated.

Solution: Click at the title bar of the console, but do not click on the console window.

## Appendix B: Change Control

Version	Description	Date	Author	Proof
v3.1	Create calibration tool for CeleX5_Z	2019.07.19	Qisheng He	Yu Zhang