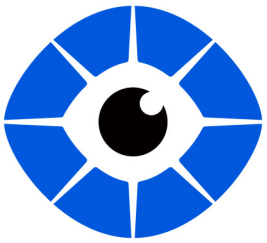

POINT SPREAD

Okulo IMU Calibrator User's Guide

Release 1.0

Point Spread Technology Co., Ltd.

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CHAPTER

ONE

INTRODUCTION

Okulo ™ P1 series cameras produced by Point Spread use RGB and ToF sensors to capture the RGB and Depth images for 3D applications. Along with the real-time RGB and Depth imaging, a P1 camera uses an Inertial Measurement Unit (IMU) to simultaneously capture 3-axis accelerations and 3-axis angular velocities. In some applications, the camera users would like to freely define the axis and coordinates for the camera. For example, users may choose to use the right hand, left hand, orthogonal, or skew coordinates. To satisfy such requirements, Point Spread provides a utility program to perform IMU calibration. This document guides users on using the IMU Calibrator utility step-by-step.

Within the IMU, there is also a temperature sensor. Users can obtain the accelerations, velocities and temperature values from the camera, which are of 32-bit float type in the unit $\mathrm{m/s^2}$, $\mathrm{rad/s}$ and ℃ respectively. For developers who want to fetch these values from SDK, it is recommended to check out the Okulo Software Developer's Guide.

The current version of the IMU calibrator is 0.9. It supports Linux OS only and has been tested under Ubuntu 18.04 and later operating systems.

CHAPTER

TWO

SPECIFICATIONS

Table 2.1 lists the specifications of the IMU sensor. Zero drifts of gyroscope and accelerometer can be eliminated by IMU calibrator. It is recommended to calibrate the camera after working at least 30 minutes in the real working environment. If more precise drift elimination is needed, it's the user's responsibility to accurately measure the zero drift coefficients and compensate zeros by using temperature.

Table 2.1: Specifications

Parameter	Typical Value	Units	Notes
Gyroscope (angular velocities)			
Full-scale	± 2000	$^\circ/\mathrm{s}$	
	± 34.9	$\mathrm{rad/s}$	
Resolution	0.061	$^\circ/\mathrm{s}$	
	1.07	$\mathrm{mrad/s}$	
Nonlinearity	0.1%		Max error to best fit straight line.
Noise spectral density	0.008	$^\circ/\mathrm{s}/\sqrt{\mathrm{Hz}}$	
	140	$\mu\mathrm{rad/s}/\sqrt{\mathrm{Hz}}$	
Zero drift	± 0.1	$^\circ/\mathrm{s}/^\circ\mathrm{C}$	
	± 1.7	$\mathrm{mrad/s}/^\circ\mathrm{C}$	
Bandwidth	20	Hz	
Noise bandwidth equivalent	31	Hz	
Accelerometer (accelerations)			
Full-scale	± 16	g	
	± 157	$\mathrm{m/s^2}$	
Resolution	0.488	$\mathrm{m}g$	
	4.79	$\mathrm{mm/s^2}$	
Nonlinearity	0.5%		Max error to best fit straight line.
Noise spectral density	250	$\mu g/\sqrt{\mathrm{Hz}}$	
	2.45	$\mathrm{mm/s^2}/\sqrt{\mathrm{Hz}}$	
Zero drift	± 1	$\mathrm{m}g/^\circ\mathrm{C}$	
	± 9.8	$\mathrm{mm/s^2}/^\circ\mathrm{C}$	
Bandwidth	21	Hz	
Noise bandwidth equivalent	33	Hz	
Temperature			
Full-scale	-30 ~ $+85$	$^\circ\mathrm{C}$	
Resolution	3.06	$\mathrm{m}^\circ\mathrm{C}$	
Accuracy (Max error)	± 2	$^\circ\mathrm{C}$	

CHAPTER

THREE

USAGE

3.1 Installation

Before using the IMU Calibrator, please install Okulo SDK by referring to the *Okulo SDK Installation* section in Okulo User's Guide. IMU Calibrator is a single standalone executable file. After the Okulo SDK is installed, IMU Calibrator can be run in a Linux console as below:

```
>>> ./okulo_p1_imu_calibrator
```

Or, by double clicking it in File Explorer. There will prompt a window as shown in Fig. 3.1.

If there are errors about package missing, please try to install the GTK packages as below:

```
>>> sudo apt install libgtkmm-3.0-dev
```

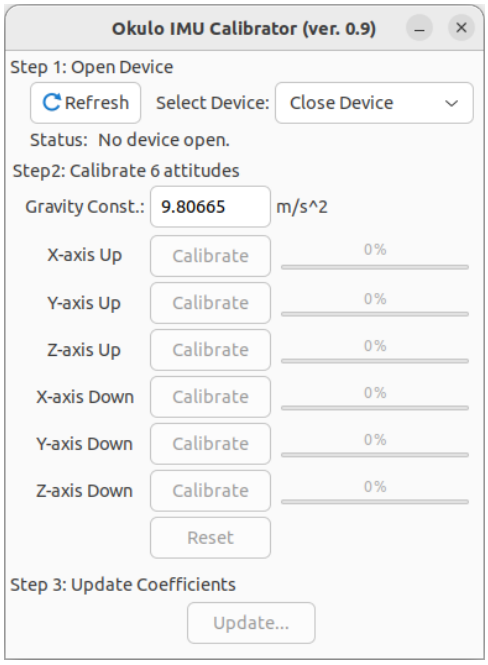

Fig. 3.1: Run the utility

3.2 Step-by-step Operations

The IMU Calibrator (referred as "the utility" below) commands camera to capture IMU data in 6 different attitudes and calculate the intrinsic matrix and zero offsets for converting the vectors in IMU coordinates to those in user-defined coordinates.

3.2.1 Preparation

Make sure you have a proper workbench with its surface level to place your camera steady with each of the 3 axes you defined upwards (referred to the gravity direction) and downwards.

It is recommended to stick a label with the axis arrows on the camera to help yourself not get confused when doing the remaining steps.

3.2.2 Run IMU Calibrator

If no camera is connected or powered on before running the utility, you can connect one or more now; if the camera you want to calibrate is already connected and powered on, go to the *Open device* step.

Note that the default gravitational acceleration in the utility is $9.80665\mathrm{m/s^2}$, which is the average value at the sea level of the Earth. If you have a more accurate value on your local region or altitude, you can enter it in the `Gravity Const.:` edit box.

3.2.3 Refresh device list

Click `Refresh` button to refresh the devices list on its right side, all connected and powered-on cameras will be shown in the drop-down list similar to Fig. 3.2.

Fig. 3.2: Refresh device list

3.2.4 Open device

Click the serial number of the camera you need to calibrate in the drop-down list. The camera will be soon turned on. Please wait for about 3 seconds to let the camera finish its reset and boot-up procedures. Note that you can also select the `Close Device` item in the drop-down list at any time to turn off any opened camera. After opening a camera, the utility window will be similar to Fig. 3.3.

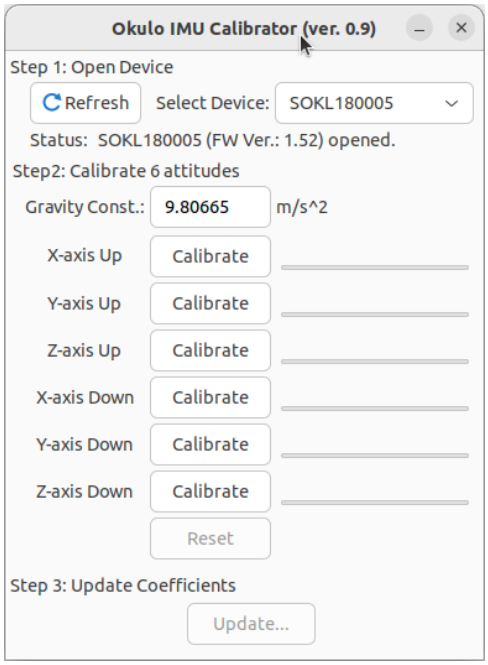

Fig. 3.3: Open device

3.2.5 Calibrate

Click the `Calibrate` button on the right side of the label `X-axis Up`, and a prompt message will pop up to ask you to place the camera steady with your defined X-axis upwards.

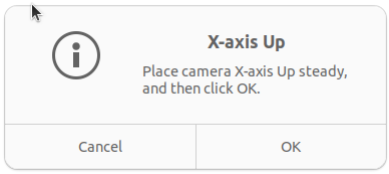

Fig. 3.4: Calibrate

Place the camera steady with your defined X-axis upwards, and then click `OK`, the camera will acquire the IMU data.

In seconds, the `Calibrate` button will become inactive and the progress bar on its right will show `Finish`.

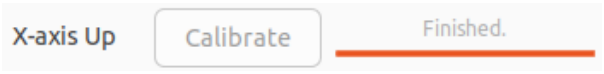

Fig. 3.5: Calibrate finish

Similar to the procedure as the `X-axis Up` step, you can proceed to do the `Y-axis Up`, `Z-axis Up`, `X-axis Down`, `Y-axis Down` and `Z-axis Down` steps one by one. Note that you can do these calibrations of 6 attitudes in any order for your convenience. And at any time you want to do the calibration again, just click the `Reset` button.

3.2.6 Update camera

After all six attitudes have been calibrated, the `Update...` button will become active as shown in Fig. 3.6.

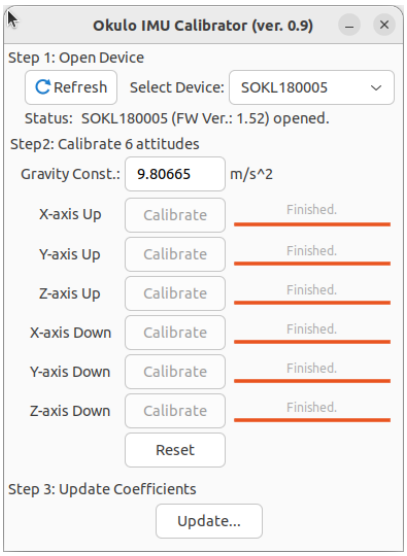

Fig. 3.6: Update Camera

Now you can click the `Update...` button. A new conversion matrix and zero offsets will be calculated, as shown by a message in Fig. 3.7.

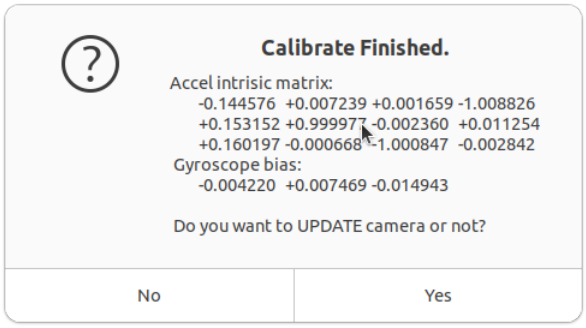

Fig. 3.7: Conversion matrix

Click `Yes` if you want to update your camera and **make sure the power cable and USB cable are connected firmly**, or `No` if you want to give up or do calibration again. After clicking `Yes`, the utility will update the conversion matrix and zero offset in the camera with new ones, and a `Success` message will pop up. Note that if a `Failed` message pops up, please try the calibration procedure again. Before there is a `Success` message, please do not use the IMU calibration data. If the `Failed` message pops up frequently, please contact questions@pointspread.cn.

If you need to calibrate another camera(s), repeatedly perfoming the *Open device*, *Calibrate* and *Update camera* steps.

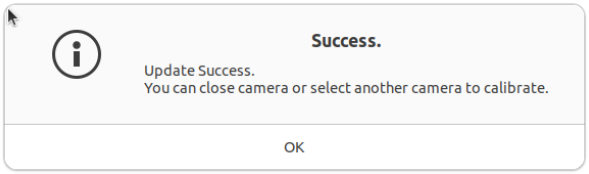

Fig. 3.8: Success message

3.2.7 Finish

If the calibration process is completed, you can power off your camera(s), disconnect the USB cables, and close the utility. It's recommended to click the `Close Device` button or close the utility before powering off the camera and disconnecting the USB cable.

3.3 Check Updated Coordinates

Please use the Okulo Viewer described in the Okulo User's Guide, or the example program described in Okulo Software Developer's Guide.

CHAPTER

FOUR

ABOUT US

Point Spread Technology Co., Ltd. is committed to revolutionize computational photography, computational optics with its world-leading computational imaging technology. We vow to push forward imaging in the consumer electronics, vehicle-mounted and other related industrial fields, to initiate the automotive optimization era in optics design and the joint-optimization for optics and image signal processing.

Point Spread Technology Co., Ltd. is located in China and have multiple branches in Shenzhen and Nantong. Please feel free to get help by contacting support@pointspread.cn.