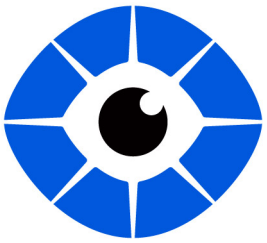

POINT SPREAD

Okulo C1 Product Manual

Release 0.1

Point Spread Technology Co., Ltd.

Dec 13, 2023

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CHAPTER

ONE

OVERVIEW

1.1 Description

Okulo ™ C1 is an RGB-Depth camera based on iToF imaging technology. It is equipped with a 1920x1080p RGB sensor and a 640x480p resolution ToF sensor. The RGB and depth image data are transmitted to host computers through USB 3.2 cables and abide by the standard UVC (USB Video Class) protocol. Point Spread Technology Co., Ltd. provide the Vidu Software Development Kit (SDK) for customers to easily obtain the depth and color image data from the camera. The Vidu SDK is compatible with Windows and Linux/Ubuntu, and can be used together with third-party software such as OpenCV and ROS. Moreover, the camera is powered by the Horizon X3 processor, which provides 5 TOPs of computing power for customers' AI model deployment.

Fig. 1.1: Okulo ™ C1 camera

The Okulo ™ C1 camera comes with high accuracy of depth data and large FOV (Field of View). The camera can be operated under various distance modes and frame rates according to different application scenarios. For the ToF sensor part, HDR and Binning mode are supported, which can improve the signal-to-noise ratio of depth image for low-light environments and low-reflectance objects. The Okulo ™ C1 camera natively align the depth and color images captured by two sensors located at different position. From the perspective of exposure time, the depth and color image are also synchronized. Furthermore, the camera provides accelerometer and gyroscope by a six-axis IMU sensor, which can assist with tasks such as SLAM and 3D reconstruction. The camera also supports external trigger and synchronization control, which can be used to achieve multi-camera synchronization for multi-view 3D reconstruction and multi-camera motion capture usecases.

Okulo ™ C1 meets the diverse development needs in the field of AIoT (Artificial Intelligence of Things). It can be used in various scenarios, including 3D reconstruction, human body modeling, motion fitness, behavior analysis, and volume measurement.

1.2 Product Features

- ToF Resolution: VGA (640x480)
- RGB Resolution: 1080P (1920x1080)
- Large FOV: 106.5.0 ° (H) × 81.2 ° (V)
- Illumination Wavelength: 940 nm
- IMU: 6DoF
- Processor: Horizon X3
- Data interface: USB 3.2 Gen 1 Type-C
- Power: DC-12V
- Trigger/Sync Control: Yes and Optional
- OS: Windows/Linux
- Operating temperature: -5 ° C ~ 55 ° C

1.3 Product Characteristics

- Integrated Horizen X3 with 5 TOPs for AI model deployment
- In-camera ToF ISP
- Supports HDR and Binning mode
- Multiple distance modes for various apllications
- Supports multi-camera synchronization
- Cross-platform software development kit (SDK)
- Continuous firmware upgrade services

1.4 Software Services

- **Vidu Software Development Kit**[1]**:** to provide cross-platform APIs to both Linux and Windows operating systems and is compliant with the GenICam Standard;
- **Vidu Viewer**[1]**:** a GUI tool for users to experience the capability of the P1 camera;
- **Okulo ™ Firmware Update tool**[2]**:** a GUI tool for updating the firmware of the P1 camera.

[1] https://github.com/point-spread/ViduSdk
[2] http://dev.pointspread.cn:82/Okulo_Firmware_Update_Tool_User's_Guide.pdf

1.5 Documentation

- **Okulo C1 Product Manual**[3]**:** to introduce camera features, specifications and briefly introduce the Software Development Kit to customers;
- **Okulo User's Guide**[4]**:** to guide users to have a quick start of Vidu Viewer with the P1 camera;
- **Vidu Software Developer's Guide**[5]**:** to help developers interact with the P1 camera by software programming;
- **Okulo IMU Calibrator User's Guide**[6]**:** to help developers customize the axis and coordinates of the camera;
- **Okulo Multi-Camera Synchronization User's Guide**[7]**:** to help developers to understand the algorithms and steps to achieve multi-camera synchronization.

1.6 Content Organization

In the following sections:

- Section 2 will give a comprehensive description of the Okulo ™ C1 camera in your hand;
- Section 3 will show you how to use Okulo ™ C1 camera, as well as safety and handling.
- Section 4 will show glossary of terms in this document.
- Section 5 will give you a brief introduction about the Point Spread Technology Co., Ltd..

[3] this document
[4] http://dev.pointspread.cn:82/Okulo_User's_Guide.pdf
[5] http://dev.pointspread.cn:82/Vidu_Software_Developer's_Guide.pdf
[6] http://dev.pointspread.cn:82/Okulo_IMU_Calibrator_User's_Guide.pdf
[7] http://dev.pointspread.cn:82/Okulo_Multi_Camera_Synchronization_User's_Guide.pdf

CHAPTER

TWO

SPECIFICATIONS

2.1 General Specifications

Below lists the general specifications of the Okulo ™ C1 camera.

Table 2.1: General Specifications

Specifications	Parameters
Technology	RGB-Depth Camera
Depth Technology	indirect Time of Light
ToF Sensor	Melexis MLX75027
ToF Sensor Resolution	640 × 480 (Normal Mode) or 320 × 240 (Binning Mode)
ToF Sensor Shutter	Global shutter
ToF Lens Parameters	f=3.38mm, F1.0, 1/2.0"
ToF Lens Field of View	106.5.0 ° (H) × 81.2 ° (V), 127.5 ° (Diag)
ToF Illumination	VCSEL × 2
Illumination Wavelength	940 nm
Distance Mode	5/10 m
ToF Frame Rate	15/30 fps
Depth Accuracy	±(1% + 5mm) & 81% ROI
ToF Working Mode	Normal/Binning
ToF HDR Mode	Yes
ToF Auto-Exposure	Yes, with adjustable EV and can be disabled
ToF ISP	– Non-linear (Wiggling) correction – Pixel phase pattern correction – Temperature Drifting correction – Flying-pixel removal – Spatial filter
Depth Data Format	Y16/Z16/INZI
RGB Sensor	OV2718
RGB Sensor Resolution	1920 × 1080, 2.0MP
RGB Sensor Shutter	Rolling shutter
RGB Lens Parameters	f=2.28mm, F2.2, 1/2.9"
RGB Lens Field of View	144.0 ° (H) × 77.6 ° (V), 170.2 ° (Diag)
RGB Dynamic Range	>90dB

continues on next page

Table 2.1 – continued from previous page

Specifications	Parameters
RGB Frame Rate	30 fps
RGB Auto-Exposure	Yes, with adjustable EV and can be disabled
RGB Data Format	NV12/JPEG/YUYV
RGB and ToF Synchronization	Yes and Optional
Multi-Camera Synchronization	Yes
External Trigger	Yes and Optional
SDK support	Vidu SDK
Data Streams	RGB, IR, Depth, PointCloud
IMU Sensor	6-Axis (3D accelerometer & 3D gyroscope) Accelerometer full scale: $\pm 16\mathrm{g} (\approx 156.9\mathrm{m/s^2})$ Gyroscope full scale: $\pm 2000^\circ (\approx 34.9\mathrm{rad/s})$ Fully customizable coordinate system
Average Power Consumption	13.0W (RGBD, 30fps, maximum ToF exposure time)
Maximum Instant Power Consumption	30.0W (RGBD, 30fps, maximum ToF exposure time)
Power Supply	6.0~15V DC
Data Connectio	USB 3.2 Type-C, Gen 1
Heat Dissipation	Passive
Working Temperature	-5 ° C ~ 55 ° C (in still air) -5 ° C ~ 85 ° C (in proper convective air)
Working Humidity	20 % ~ 80 % Relative Humidity , Non-Condensing
Product Certification	– RoHS – REACH – LASER Class 1 – IP54
Outfit Dimension	90mm × 43mm × 45mm
Weight	**TBD**
Product Warranty	1 year
Product Life-Cycle	10 years expected

2.2 Mechanical Specifications

The Fig. 2.1 illustrates the mechanical overview of Okulo ™ C1 camera. ToF VCSELs and lens are on the left of the front view, while RGB lens is on the right of the front view.

The mechanical dimension is listed as in Table 2.2:

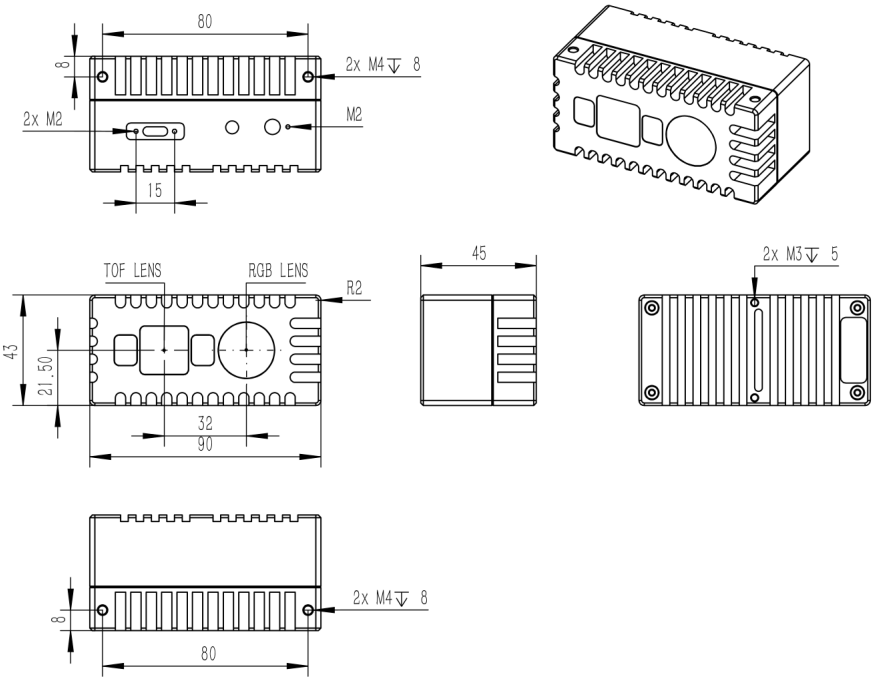

Fig. 2.1: Okulo ™ C1 camera Mechanical Specification View

Table 2.2: Mechanical Dimension

Dimension	Min	Typical	Max	Units
Width	89.9	90	90.1	mm
Height	42.9	43	42.1	mm
Depth	44.9	45	45.1	mm

2.2.1 Coordinate System of the Camera

The coordinate definition for IMU data is fully customizable. Any Cartesian or Oblique coordinate system with user-defined X, Y and Z directions can be used, both left-handed and right-handed coordinate systems are acceptable. Please use the IMU Calibration utility to define and calibrate your coordinate system.

2.3 Product Interfaces

As shown in Fig. 2.2, we can see there are three slots for type-C USB3.2 connection, external trigger and DC power connection respectively.

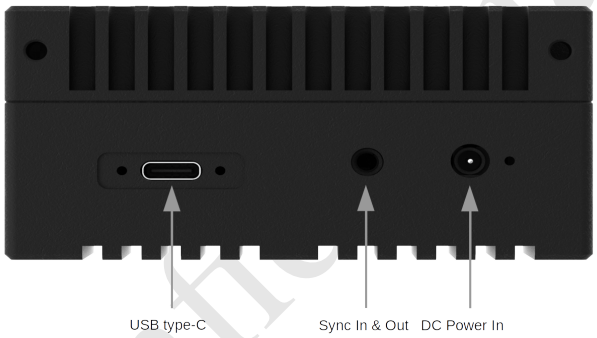

Fig. 2.2: Interfaces of Okulo C1

CHAPTER

THREE

USAGE

3.1 Camera Setup

3.1.1 Package List

You can find the following items:

- Okulo ™ C1 device
- USB Type-C data cable
- AC to DC Power Supply/Adapter

3.1.2 Initialization and operation

- Mount the camera in an appropriate fixture, e.g., a camera bracket.
- Connect data cable and power adapter to Okulo ™ C1.
- Connect the other side of Type-C data cable to the host PC.
- Connect the power adapter to the power source.
- Validate that the camera enumerates correctly on the host computer by **lsusb**, and you can see device with **PointSpread Tech Co., Ltd OkuloC1 Camera** in the list, i.e.:

```
>>> lsusb
Bus 002 Device 066: ID 367a:c101 PointSpread Tech Co., Ltd OkuloC1 Camera
Bus 002 Device 002: ID 05e3:0626 Genesys Logic, Inc. USB3.1 Hub
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 005: ID 05e3:0610 Genesys Logic, Inc. 4-port hub
Bus 001 Device 006: ID 3044:520c
Bus 001 Device 004: ID 1a40:0101 Terminus Technology Inc. Hub
Bus 001 Device 003: ID 046d:c53f Logitech, Inc. USB Receiver
Bus 001 Device 002: ID 0cf2:7750 ENE Technology, Inc. 6K7750
Bus 001 Device 007: ID 8087:0033 Intel Corp.
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
```

- Download Vidu Software Development Kit from https://github.com/point-spread/ViduSdk by:

```
>>> git clone https://github.com/point-spread/ViduSdk.git
```

- Install Vidu Software Development Kit by following **README.md** file in the Downloaded **ViduSdk** repositories.

- Run Vidu Viewer as below:

```
>>> cd ViduSdk
>>> ./SDKbin/vidu_viewer
```

- Use Vidu Viewer to validate that images can be streamed from camera with the following setting:
  - ToF Stream Enable
  - RGB Stream Enable
  - PCL Stream Enable
  - IMU Stream Enable
- If for any reason that the camera is not responding or not being detected, please remove all cables from the camera and unplug to the host PC for resetting the camera state.

3.2 Installation Guide

- Please leave sufficient clearance during the installation process to facilitate camera cooling.
- When installing the camera, please make sure that the illuminators of the Time-of-Flight (ToF) sensor are not obstructed.
- During the installation process, avoid applying external forces to the camera chassis.
- If the computer fails to recognize the camera, verify if the cable meets the power and data transfer requirements. Try reinserting the USB cable for further inspection.

3.3 Safety and Handling

3.3.1 Safety Precautions

- Follow the instructions to operate the camera. Improper operation may cause damage to internal components.
- Do not drop or hit the camera with external force.
- Do not attempt to modify the camera in any way. Any modification may cause permanent damage or inaccuracy.
- It is expected that the temperature of the camera may increase during prolonged usage.
- Do not touch the lens. Finger prints on the lens may affect image quality.
- To avoid switch-on surges damaging the camera, please plug the power cable into the camera before getting a power supply.
- The camera sensors need to be working under an appropriate temperature. Typical working temperatures are allowable between -5 °C to 55 °C. Please refer to Table 2.1 for more details.
- **Class 1** laser is used in this product, see **Class 1 Declaration** below Looking at the laser for more than 15 s is not recommended.

Class 1 Declaration

A Class 1 laser is safe under all conditions of normal use. This means the maximum permissible exposure (MPE) cannot be exceeded when viewing a laser with the naked eye or with the aid of typical magnifying optics (e.g. telescope or microscope). To verify compliance, the standard specifies

the aperture and distance corresponding to the naked eye, a typical telescope viewing a collimated beam, and a typical microscope viewing a divergent beam. It is important to realize that certain lasers classified as Class 1 may still pose a hazard when viewed with a telescope or microscope of sufficiently large aperture. For example, a high-power laser with a very large collimated beam or very highly divergent beam may be classified as Class 1 if the power that passes through the apertures defined in the standard is less than the AEL for Class 1; however, an unsafe power level may be collected by a magnifying optic with a larger aperture. Often, devices such as optical drives will be considered class 1 if they fully contain the beam of a more powerful, higher-class laser, such that no light escapes under normal use.

3.3.2 Cleaning

- To clean the camera body, gently wipe away dust and debris using a clean, soft cloth.
- For removing stains from the lens, apply a lens cleaning solution and carefully wipe with a clean, soft cloth that is free of lint.
- Avoid using alcohol, gasoline, kerosene, or any corrosive or volatile solvents for cleaning the camera.
- Refrain from using pressure washers or hoses to spray the camera.

3.3.3 Storage

- Prior to storing the camera, ensure to disconnect the power supply.
- When not in use, store the camera carefully, preferably in its original packaging.
- Avoid pointing the lens directly at the sun and refrain from exposing the lens to strong light sources for prolonged periods.
- Keep the camera out of reach of children or animals to prevent accidents.

CHAPTER

FOUR

GLOSSARY OF TERMS

Terms	Definition
ToF	Time of Flight (ToF)
HDR	High Dynamic Range
ISP	Image signal processor, which is used for image post-processing.
EV	Exposure Value, it represents a combination of aperture, shutter speed, and ISO to determine proper exposure in photography.
IR Image	Infrared Image.
Point Cloud	A point cloud is a discrete set of data points in space.
VCSEL	VCSEL stands for Vertical-Cavity Surface-Emitting Laser. Efficient semiconductor laser diode emitting light vertically, used in communication, sensing, and optical devices.
IMU	Inertial Measurement Unit, a sensor that measures an object's motion, orientation, and position in 3D using accelerometers, gyroscopes, and magnetometers.
USB	Universal Serial Bus, a widely used standard for connecting and transferring data between electronic devices.
UVC	USB Video Class, a standard for video streaming and communication over USB connections.
GenTL	Generic Transport Layer," providing a standardized software interface for communication and control of machine vision devices.
SDK	Software Development Kit, a set of tools, libraries, and documentation to build software applications for a specific platform or framework.
TBD	To Be Determined. In the context of this document, information will be available in a later revision.

CHAPTER

FIVE

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.