

# Vzense DCAM710 ToF Camera User Manual



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# 1 General Information

The purpose of this document is to familiarize the customer with the correct operation of the Zense ToF Camera. This document provides important information about the camera's features, hardware specification, safe use of the camera, and installation procedures.

DCAM710 camera is a standalone ToF module, developed by Vzense team. It is packaged into small factor and a perfect choice for evaluation or study to the ToF technology. Of course the reliability is enough for many consumer or even industrial scenario.

## 1.1 Terms of Use

Zense offers a 1-year-warranty for this camera.

### Warranty Information

Please do follow the following guidelines when using the Zense camera:

#### **Do not remove the product's serial number label**

Warranty must be void, if the label is damaged or removed and the serial number can't be read from the camera's registers.

#### **Do not open the camera housing**

Do not open the housing. Touching any internal components may damage the camera.

**Prevent any objects or substances from entering the camera housing. Otherwise the camera may fail or damaged.**

#### **Avoid electromagnetic fields**

Do not use the camera near strong electromagnetic fields. Prevent from electrostatic charging.

#### **Transport in original packaging**

Transport and store the camera in its original packaging only. Do not discard the packaging.

#### **Clean with care**

If you have to clean the housing of the camera, follow the guidelines in the notice as below:

- Use a soft, dry cloth that won't generate static during cleaning;
- To remove tough stains, use a soft cloth dampened with a small amount of neutral detergent(Pure water); after that wipe dry;
- Make sure no any residual detergent after cleaning, before reconnecting the camera to power

#### **Read the manual**

Do read the manual carefully before using the camera.

## 1.2 Description and Features

VZense TOF RGBD Camera Module DCAM710 is a long range depth camera that outputs depth video stream. In addition to depth video stream, it can provide RGB video streams. The small size of the DCAM710 subassembly provides system integrators flexibility to design into a wide range of products. The DCAM710 is ideal for system integrators, OEMs, ODM and HVM. Perfect for indoor/outdoor usage with long range depth sensing, e.g. SLAM (Simultaneous Localization and Mapping), Home Automation, Robotics, Augmented Reality, Virtual Reality, TV Entertainment, Drones or Automotive.

DCAM710 comprehend device position and orientation, providing the ability to map and navigate in the world. VZense Depth Camera Middleware enables the ability to Locate, Sense, Identify, and Interact in both the real and virtual world. DCAM710 comes with VZense Depth Camera SDK, an open source and cross platform enabling suite including rappers, sample code and tools.

DCAM710 Features:


- TOF (Time of flight) Camera technology
- Can output RGB Image and Depth Map
- Depth Camera support image size: up to 640\*480@30FPS
- RGB Camera support image size: up to 1920\*1080@30FPS
- Support for output formats: RAW12 (Depth), NV12 (RGB)
- 2 x Microphone to capture sound, record audio(optional)
- 6 x Axis IMU supported(optional)
- Micro USB2.0 interface
- Support OS: Android / Linux / Windows7/8/10
- Depth Sensor SDK, sample code and tools (Open NI SDK Compatible)
- Switchable short and long range modes
- IR VCSEL security level is Class 1


Usages/Markets

- SLAM (Simultaneous Localization and Mapping)
- Home Automation & Robotics
- Augmented Reality & Virtual Reality
- TV Entertainment & Micro-projection
- Drones
- Surveillance
- Automotive

## 2 Precautions

### 2.1 Safe Usage Instructions

DANGER	
	<p><b>Electric Shock Risk</b> Non-standard and improper power supplies may result in fire and electric shock. You must confirm the camera power supply used that meets the Safety Extra Low Voltage(SELV) and Limited Power Supply (LPS) requirements.</p>

CAUTION	
	<p><b>Invisible Radiation</b> This camera uses laser to work, improper use may damage the eye. Lasers are classified as risk group 1 (low risk) according to EN 60825 which means that the product presents no risk related to exposure limits under normal usage conditions. Eye safety is only guaranteed when the camera is used properly</p>

### 2.2 Power

The DCAM710 camera can be powered by standard USB Micro USB, for longer distance application which needs higher power consumption, there is an additional DC Jack power which can accept 5V~6V power. 2 A power adaptor is suggested to be in use.

### 2.3 Usage

Don't try to open the camera housing. Each camera has been calibrated at the factory to achieve precise measurements. Touching internal components may damage the camera and cause calibration data lost.

Incorrect plugging in and unplugging of the camera's power cable can damage the camera.

Don't try to change the position of the lens, may cause damage to the camera.

Do store the camera carefully when not in use, in original package the best.

## 2.4 Temperature

To avoid damaging the camera and to achieve best performance, please observe the maximum and minimum housing temperatures in Section 3.1

# 3 Specifications and Requirement

## 3.1 General Specifications

Specification	DCAM710
Technology	TOF (Time-of-flight) Depth Camera
Depth Sensor Resolution and Frame rate	640 x 480 (VGA)@30 fps
Depth Sensor Lens Focus Type	Fix Focus
Depth Sensor Field of View (FOV)	Horizontal: 69.3° (±3° ) Vertical: 51°(±3° )
Depth Lens Distortion	<-2.6%
RGB Sensor Resolution and Frame rate	1920 x 1080 (1080P) @30 fps 1280 x 720 (720P) @30 fps 640 x 480 (480P) @30 fps 640 x 360 (360P) @30 fps
RGB Sensor Field of View (FOV)	Horizontal: 73°(±3° ) Vertical: 40°(±3° )
RGB Lens Distortion	<-8%
Output Formats	Depth Map: RAW12 RGB Camera: H.264/MJPEG
Use Range	0.35m to 4.40m
Accuracy	<1%*
MMI	RGB LED (Indicator when stereo module is streaming data) System reset button

Power Supply	5V (Micro USB2.0)
Power Consumption	2W Ref. (3m)
Illumination	Indoor: 850nm/ Outdoor 940nm VCSEL
Dimensions (L*W*H)	Module: 103mm x 33mm x 22mm PCBA: 93mm x 28mm x 17mm
Weight	71g
Interface	Micro USB 2.0
Conformity	CE, FCC, FDA, Safety EN 60825-1:2014
Working/Storage Temperature	-10°C-50°C/-40°C-70°C
Development Environment	C/C++ SDK, OpenNI, ROS
Operation System	Windows 7, 8 and 10, Android, Linux

## 3.2 Electrical Specifications

### 3.2.1 Recommended Operating Conditions

Parameter	Symbol	Conditions	Min	Typ.	Max	Units
Supply voltage on USB VBUS	VDD		4.75	5	5.25	V
Supply voltage on DC power	VDC		5	5.5	6	V
Operating Temperature	Ta		-20		50	°C
Operating humidity			20		80	%
Storage humidity			20		80	%
Storage temperature			-30		70	°C

\*: Please consider Vf range is about 1.3V

### 3.2.2 Power Consumption

Parameter	Conditions	Average	Max	Units
Current at near mode	250mm-1200mm @30 frame	307	455	mA
Current at far mode	800mm-4300mm @30frame	482	1011	mA
Current at xfar mode	1200mm-6300mm@15frame	508	1986	mA

Note: 5V input voltage



### 3.3 Mechanical Specifications

This drawing contains information about the dimensions and user mounting location of the ToF Camera.

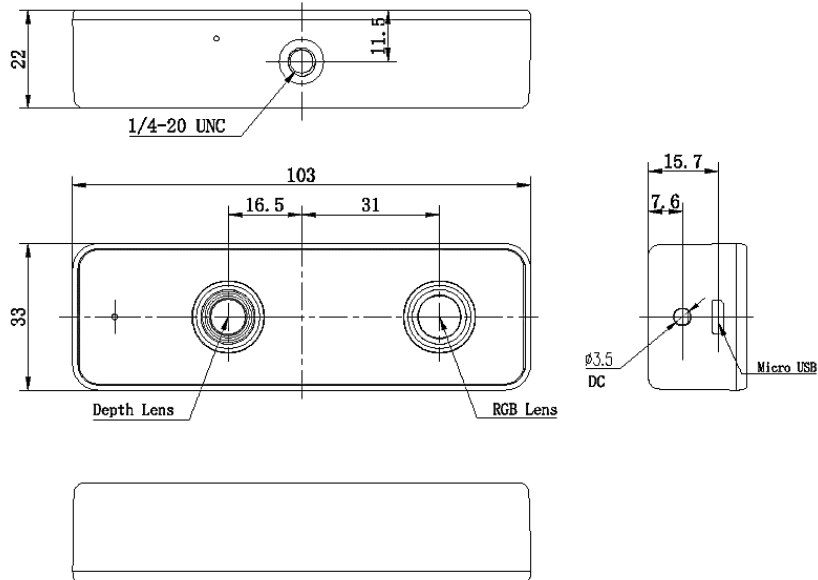


Fig. 1: ToF Camera Dimensions

Unit: mm

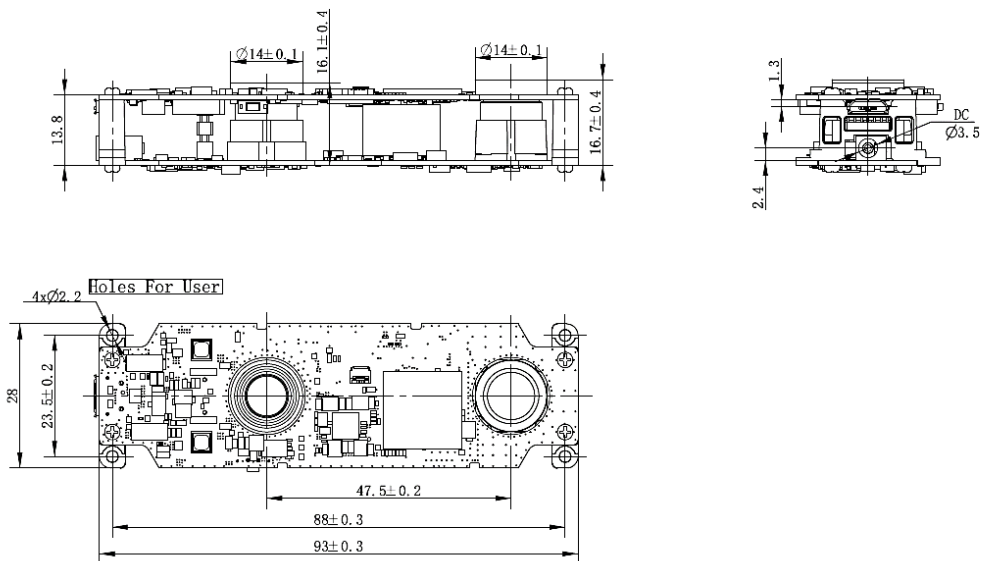


Fig. 2: PCB Module Dimension

## 3.4 Working Condition Requirements

### 3.4.1 Hardware Requirements

#### DCAM710 ToF Camera

- Micro USB Cable (Included in package)

If you need to use your own micro USB cable for some reason, make sure the cable itself can meet the USB standard requirement, otherwise the product may not function well.

Or

- 5V~6V/2A DC Adaptor (Not included in package)

### 3.4.2 Software Requirements

#### Operating system

- 32-bit Windows 7/10
- 64-bit Windows 7/10 (recommended)
- Linux (x86, x64)
- Android 5.0 or above

#### Zense ToF Driver

The Zense ToF Driver software is available for Windows, Linux and Android operating systems and includes the following:

- SDK code
- Sample code
- Software user manual

### 3.4.3 Environmental Requirements

#### Temperature and Humidity

Housing temperature during operation:	-20–50 °C
Humidity during operation:	20–80 %, relative
Storage temperature:	-30–70 °C
Storage humidity:	20–80 %, relative

#### Heat Dissipation

Users can provide sufficient heat dissipation, like mounting the camera on a substantial, thermally conductive component that can act as a heat sink. Or a fan can be used to provide an air flow over the camera.

### 3.4.4 Coordinate of the Camera System

There are two coordinate system need to be understood, one is camera coordinate system (CCS), one is world coordinate system (WCS).

CCS: CCS describe the two-dimensional data, the origin of coordinates is the optic center.

WCS: WCS describe the three-dimensional information.

The CCS data can switch to the WCS data using the camera internal parameters.

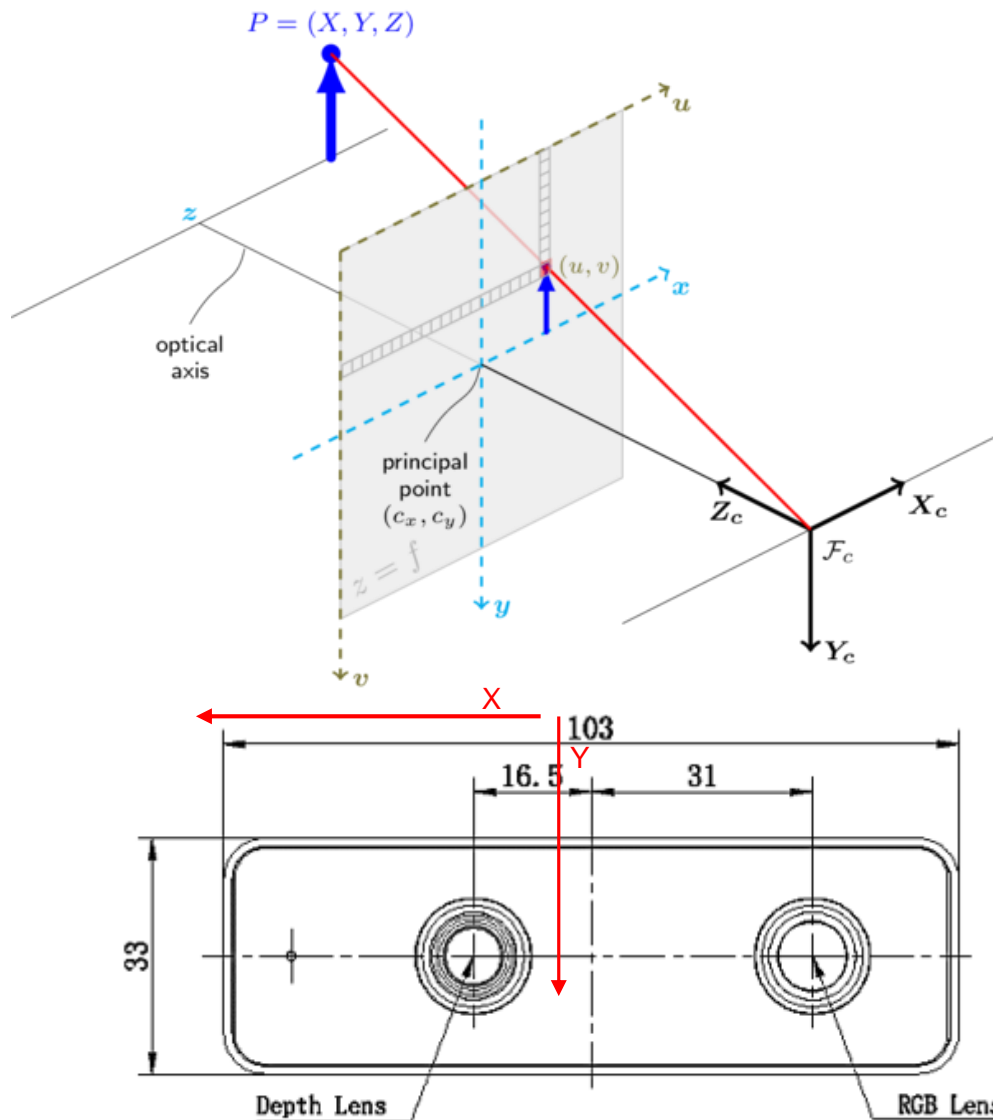


Fig. 3: Origin of the Coordinate System

Meshlab and CloudCompare tools are recommended to analyze the point cloud data saved by Zense software or SDK method.

# 4 Interface with Host

## 4.1 Connectors

DCAM710 ToF Camera is equipped with Micro USB 2.0 and DC power connector at the rear side of its housing as shown in below figure.

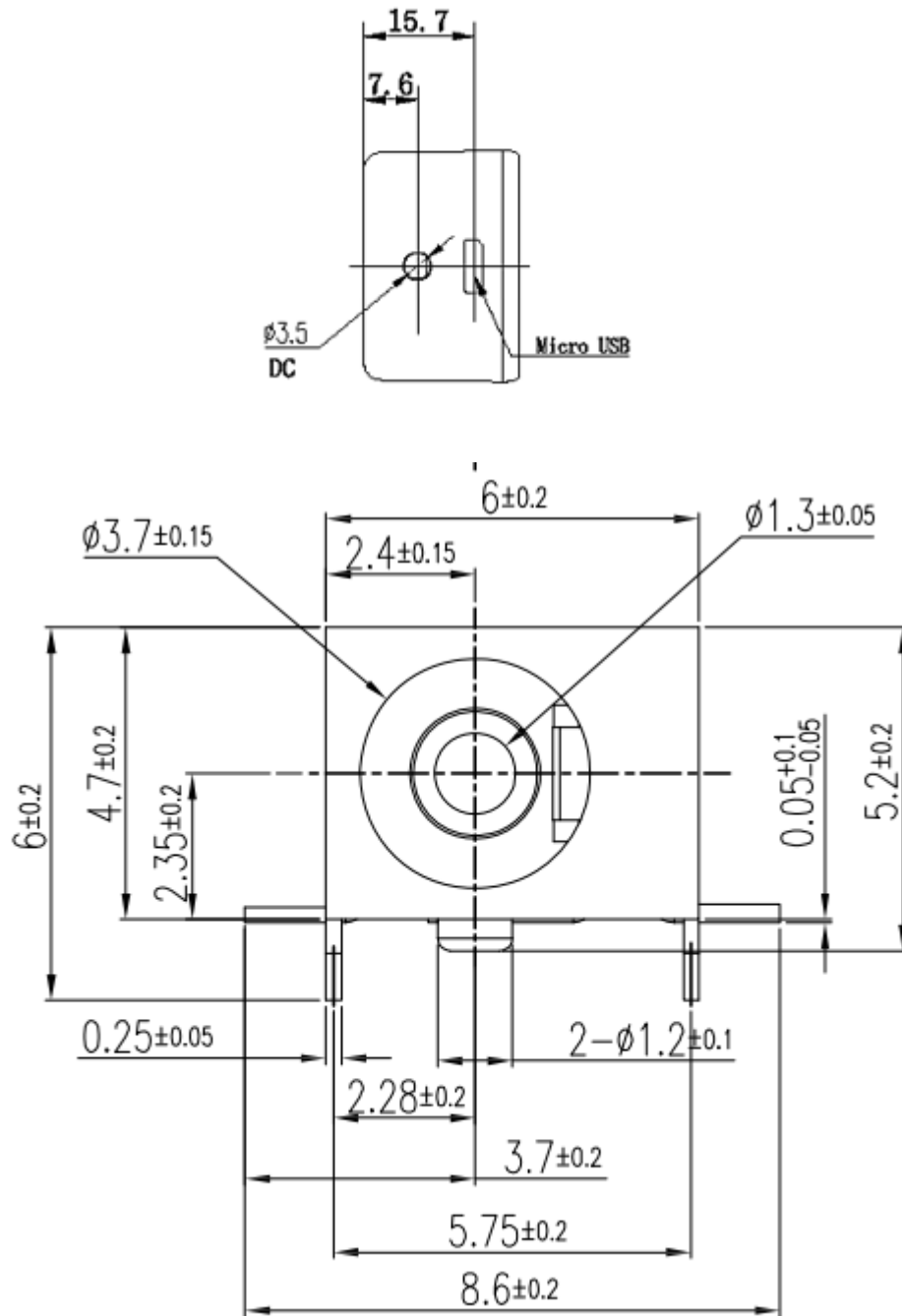


Fig. 4: DC Jack Connector

## 4.2 LED indication

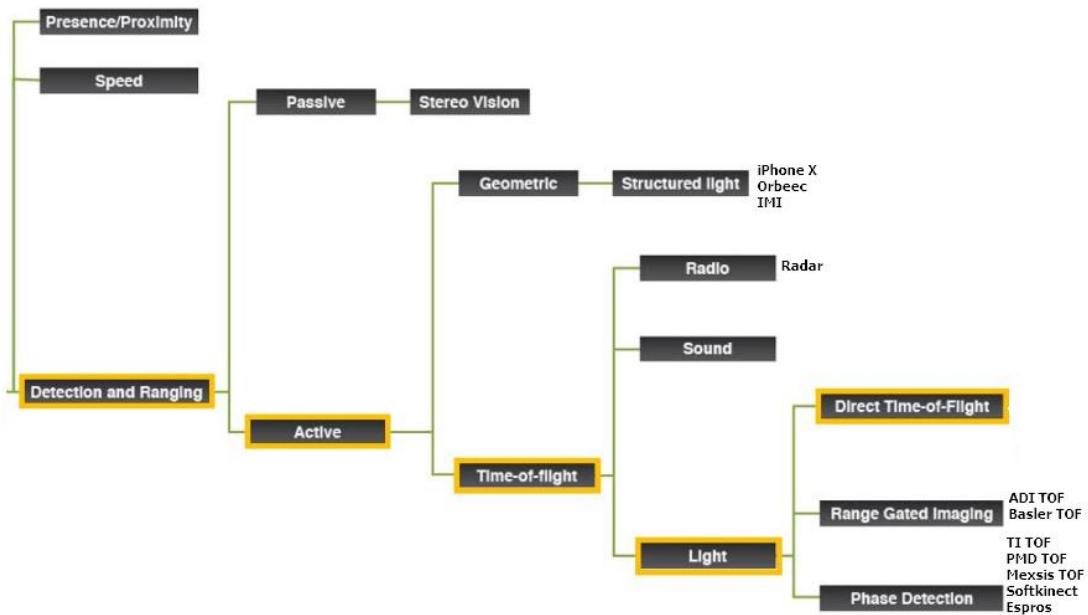
<b>Power supply</b>	<b>LED indication</b>	
Working Mode (Powered by usb2.0)	Solid Green	
Working Mode (Powered by AC Adaptor)	Solid Red	
Standby Mode	Solid Blue	

# 5 Principle of Time of Flight

## 5.1 Scope of remote sensing technology

- **Presence or proximity detection**, where the absence or presence of an object in a general area is the only information that is required (e.g., for security applications). This is the simplest form of remote sensing;
- **Speed measurement**, where the exact position of an object does not need to be known but where its accurate speed is required (e.g., for law enforcement applications);
- **Detection and ranging**, where the position of an object relative to the sensor needs to be precisely and accurately determined.

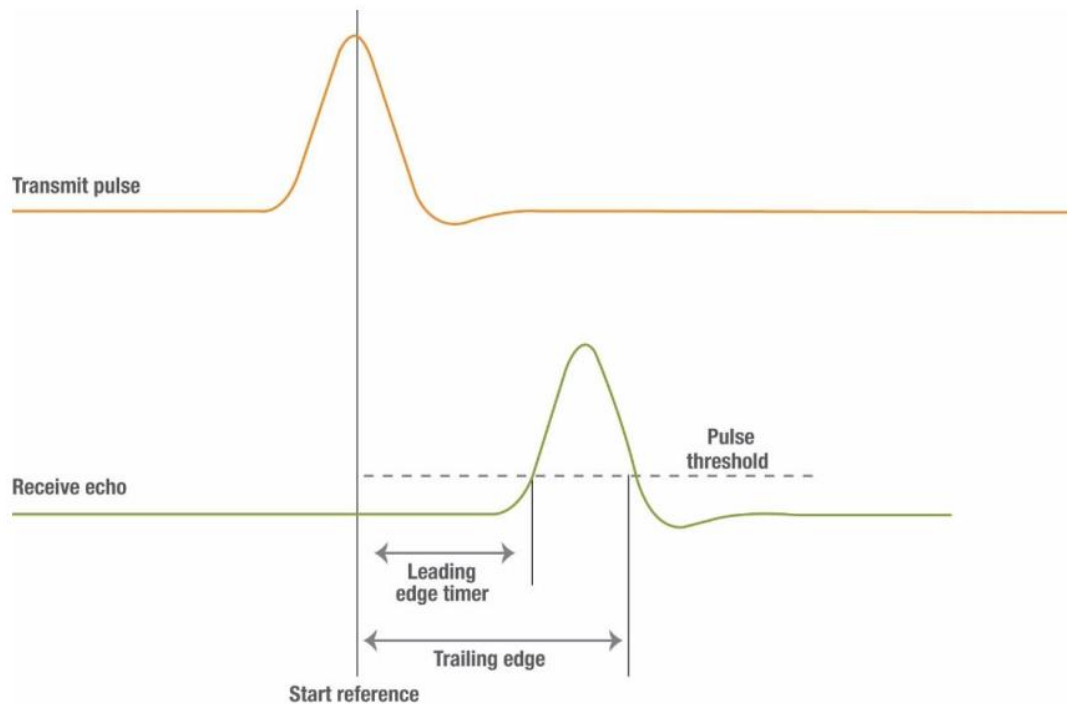
This document will concentrate on technologies capable of providing a detection and ranging functionality, as it is the most complex of the three applications. From the position information, presence and speed can be retrieved so technologies capable of detection and ranging can be universally applied to all remote sensing applications.



### 5.1.1 Direct Time of Flight

In the direct time-of-flight measurement method, a discrete pulse is emitted and one or several timers are used to measure the time difference between the emitted pulse and the return echo, based on threshold detection. This time difference can be directly converted to a distance, based on the following equation:

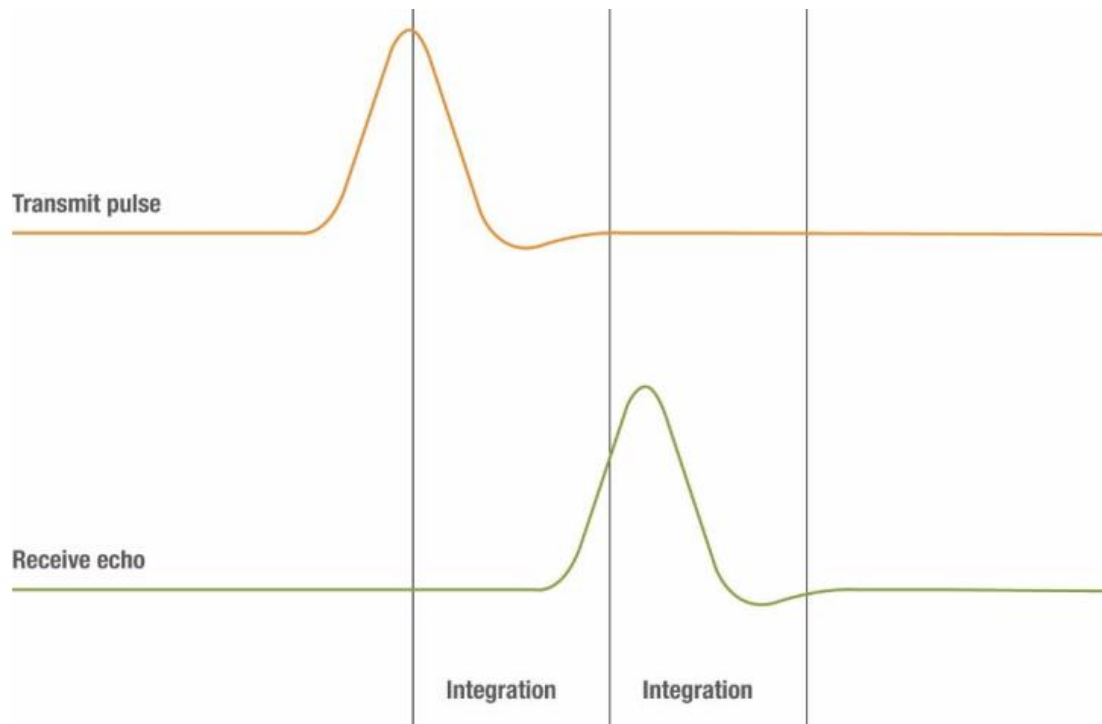
$$d = \frac{C * t}{2}$$



The difficulty in implementing the direct time-of-flight measurement method resides in the time intervals to be measured. In order to resolve a distance to centimeter-level accuracy, the required accuracy for the timers is 67 ps. Implemented in digital logic, this would require a 15 GHz clock speed, which is obviously not practical. Therefore, various time-to-digital conversion methods are typically used.

### 5.1.2 Range-gated Imaging ToF

Whereas direct time-of-flight relies on measurements made on the immediate value of the received signal, range-gated imaging uses signal integration methods, typically with CCD or CMOS imagers.



By measuring the energy received in successive integration intervals, it is possible to extrapolate the distance between the sensor and the measured object, based on the ratio of energy received in the different intervals.

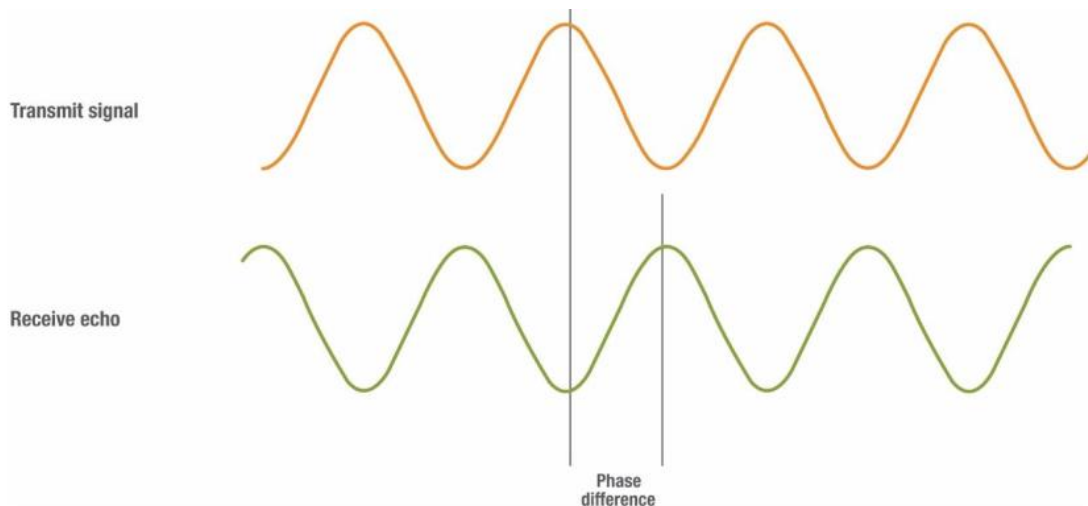
The difficulty with range-gated imaging is that CCD and CMOS imagers have a limited dynamic range; therefore, strong ambient light can easily cause saturation and impair measurement. Furthermore, since neither the emitted and received pulses are perfect rectangle pulses, nor is the sensor perfectly linear, compensation is required and accuracy is ultimately limited.

### 5.1.3 Continuous Waveform ToF

In contrast to the previous two methods, phase difference measurement relies on a modulated light source and evaluates the phase difference between the transmit signal and the receive echo. This phase difference can be converted to a distance, using the following formula:

$$d = \frac{C * \phi}{4 * \pi * f}$$



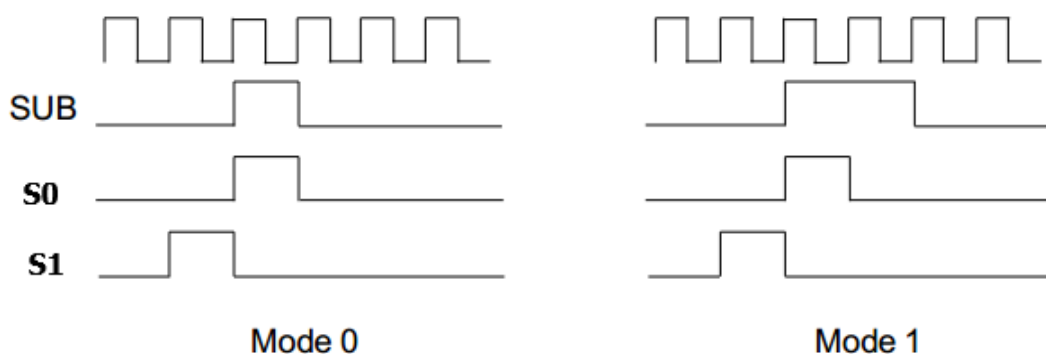


Correlation methods are typically used to measure the phase difference of the receive echo respective to the transmit signal as well as recover the propagation delay and therefore the distance to the object to be measured.

Of course, a phase difference greater than  $2\pi$  is not resolvable; for instance,  $3\pi$  or  $5\pi$  will be measured as a  $\pi$  radian phase difference. Therefore, depending on the chosen modulation frequency, an artefacting phenomenon will occur where far-away objects will appear to be much closer than in reality.

### 5.1.4 Zense ToF Principle

Zense DCAM710 product principle is based on range-gated imaging ToF solution, and the sensor inside is based on Panasonic CCD sensor MN34906.



- ◆ **Mode #0:**
  - 1T,
  - Best LD pulse number,
  - good for distance from 10cm to 3.3m

$$Z = \frac{S_1}{S_0 + S_1}$$

## 5.2 Noise Factors

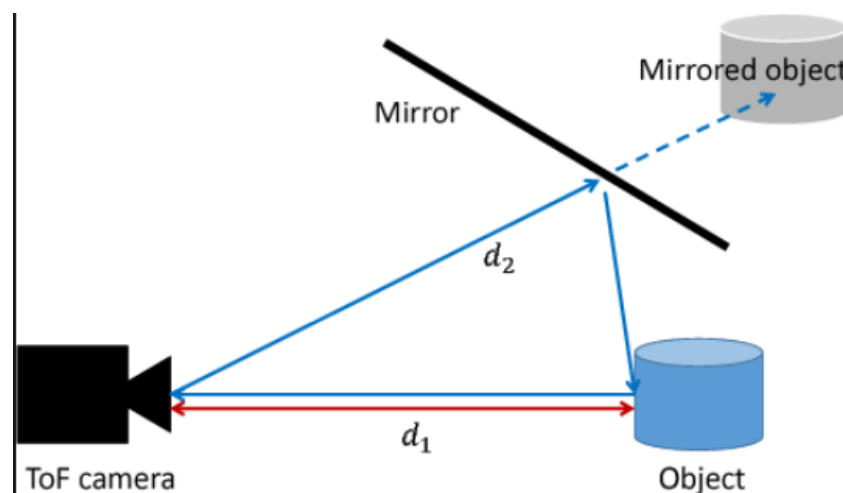
### 5.2.1 Ambient Light

Because the ToF distance measurement relies on the reflection of light sent out by the camera, any additional light, e.g. artificial light sources or sunlight, may influence the measurement results.

A strong ambient light may affect the accuracy and precision of the depth data, the Zense DCAM 800 is suggested to in user below 50K LUX ambient light.

### 5.2.2 Multipath Propagation

Based on the principle of ToF, Multipath effect may happen when the light reflected more one once. Any light that has been reflected several times, by other objects in the camera's field of view or the environment can cause deviation to the measurement result.



To eliminate the multipath effect, you should:

1. Keep the camera working environment as clean as possible;
2. Avoid the camera be placed at concave forms environment, like corners of a room or inside of a narrow space;
3. Highly-reflective object shall be removed far away from the measurement target;

### 5.2.3 Reflectivity of the Target

Please note that different reflectivity of the target may cause measurement result deviation, objects which have 20% to 80% reflectivity to 850nm or 940nm infrared light have the best result.

## 5.2.4 Scattering Effect

Scattering light effect is a noise factor to ToF products, it is caused by multiple reflection inside the lens of camera or the cover of camera.

To eliminate the scattering light effect, you should:

1. Keep the cover glass of the camera clean;
2. Do NOT place any other cover glass in front of the camera;
3. Keep the camera working environment as clean as possible;

# 6 Installation

## 6.1 Hardware Installation

You have read and understood the warnings listed under "Precautions" on Chapter 2;

To achieve reliable distance measurements, please follow below tips:

- Better not using the camera in strong sunlight. If have to, keep the ambient light below 50k Lux.
- Do NOT place any objects in the scene that are not part of your intended target, especially mirrors or other shiny surfaces/objects.
- Maintain a stable housing temperature during operation.
- Take measures to provide cooling to camera
- Mount the camera robustly.
- All accessories are ready

The installation steps are as below:

- 1 Connect the camera module to PC USB interface through USB cable, as Figure

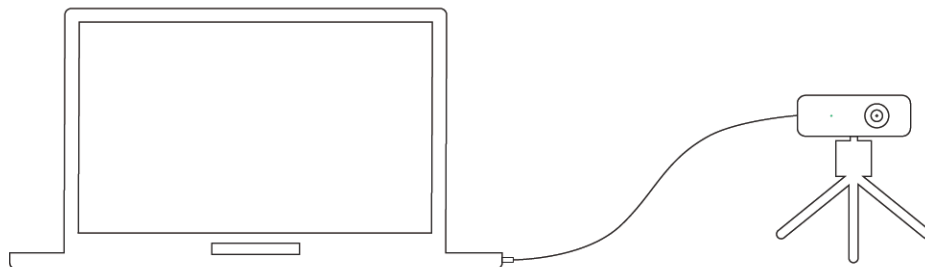


Figure 4.1 Hardware Installation

- 2 In Windows, when the camera module is successfully connected, it will pop up the notice of the device driver installation. After the driver is auto-installed successfully, it will display the VZense RGBD Camera device in Windows Device Manger.

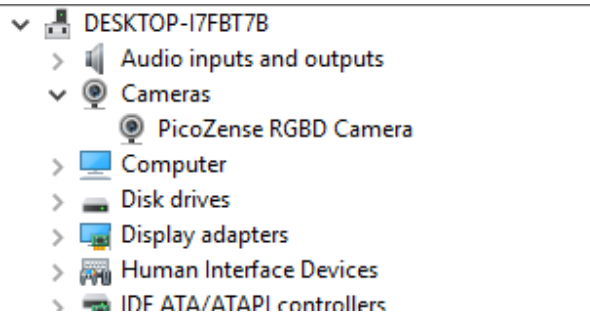


Figure 4.2 VZense RGBD Camera

## 6.2 Software Installation

### 6.2.1 Operating system

- Windows 7/8/10
- Linux
- ArmLinux
- Android

### 6.2.2 VZense SDK and VZenseUtool

VZense SDK is available for above systems. Download SDK from below link:

China: <https://gitee.com/Vzense>

Oversea: <https://github.com/Vzense>

#### **VZenseUtool**

VZenseUTool is ToF camera frame tool on windows OS that can help user evaluate product.

Download the uTool from below link

China: <https://github.com/Vzense/UTool>

Oversea: <https://gitee.com/Vzense/UTool>

Please select the suitable version based on the product and system.

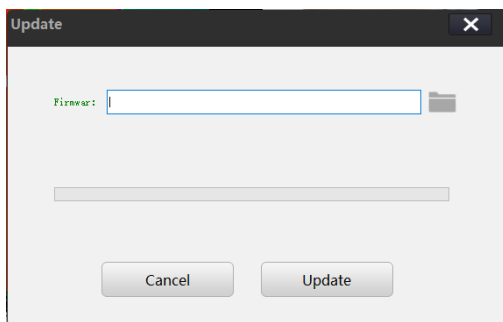
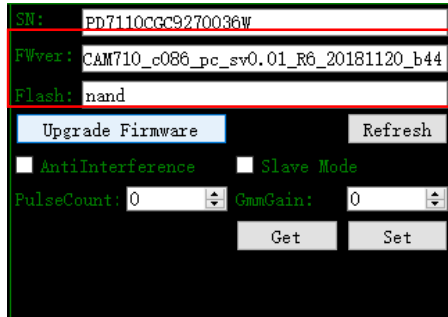
### 6.2.3 Firmware Upgrade

You can use our VZenseUtool to upgrade DCAM710 firmware and the detailed steps as below:

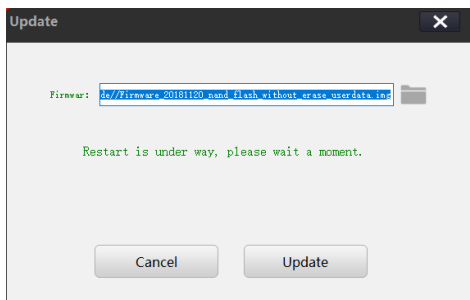
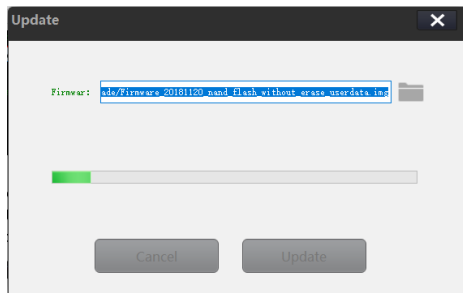
1. Run `VZenseUtool\Upgrade\DriverAssitant_v4.5\Driver\Install.exe` to install driver;
2. Connect DCAM710 to PC, and then run `VZenseTool.exe` after LED indicator

is lighting;

3. Please check the current firmware version and Flash type. Click “*Upgrade Firmware*” button as below picture, and then select “Yes” to enter into firmware upgrade window, meanwhile the LED indicator will go out;



4. Please load the image file of the firmware to be upgraded in “*Firmware*” option (Please note the flash type must match accordingly, Nand or Nor), and then click “*Update*” and the software will carry out firmware upgrade automatically as below picture;



5. When the firmware upgrade is completed, the upgrade window will show “*Restart is under way, please wait a moment*”. System will auto-restart camera and the upgrade window will auto-close the upgrade window. Finally

check the current firmware version to confirm whether the upgrade is successful or not.

SN:	PD7110CGC9270036W
FWver:	CAM710_c086_pc_sv0.01_R6_20181120_b44
Flash:	nand
<input type="button" value="Upgrade Firmware"/> <input type="button" value="Refresh"/>	
<input type="checkbox"/> AntiInterference	<input type="checkbox"/> Slave Mode
PulseCount: 0 <input type="button" value="↑"/> <input type="button" value="↓"/>	GainGain: 0 <input type="button" value="↑"/> <input type="button" value="↓"/>
<input type="button" value="Get"/> <input type="button" value="Set"/>	

# 7 Features

## 7.1 Multiple Camera Synchronization

If you need to use more than one camera in a same narrow space, multiple camera synchronization method shall be in use, to avoid the light source interference among each other.

## 7.2 Range Customization

By default, there are 3 different range modes calibrated for DCAM710, please see below table for more information:

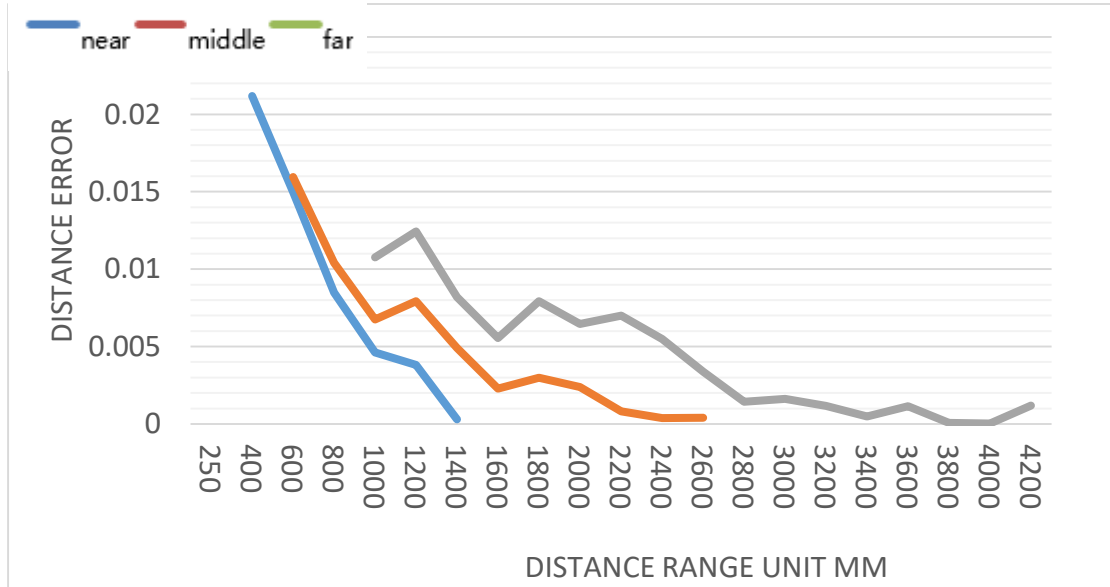
Range number	Distance range
Range 0	0.35m~1.5m
Range 2	0.8m~4.4m
Range 5	1.2m~6.2m

Please do NOT use uncalibrated modes, the measurement data will not be guaranteed. If you need other range mode requirement, you can ask Zense team to do range customization, reasonable NRE fee will be charged.

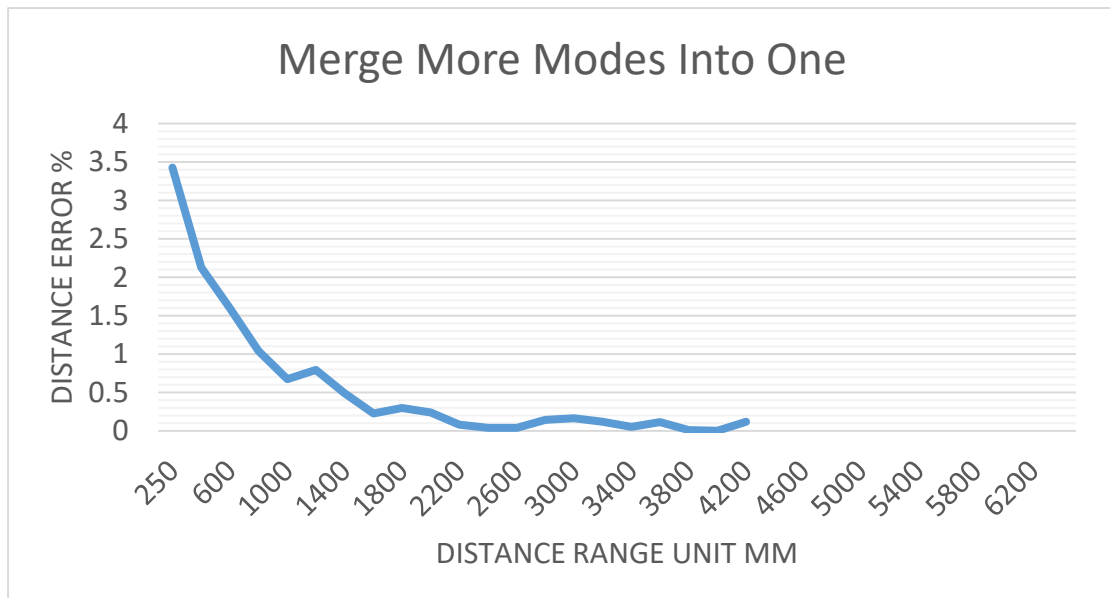
One range mode of the Zense DCAM710 camera can fulfill furthest distance be at most 5 times of nearest distance. For example, if the near limitation is 0.4m, then the furthest distance in this mode can reach about 2m.

## 7.3 Wide Dynamic Range

As mentioned above, Most of the ToF based 3D sensing technology has range limitation to nearest and furthest distance, due to the sensor saturation of weak light strength to far objects. One range mode of the Zense DCAM710 camera can fulfill furthest distance be at most 5 times to nearest distance. For example, if the near limitation is 0.4m, then the furthest distance in this mode can reach about 2m.



Wide dynamic range means that the camera can work at more than one range modes alternately, then the camera itself will combine the result into one depth frame, therefore can expand the range limitation from furthest distance to nearest distance.



This feature requires customization service for Zense team, you can refer to Chapter 8 in this document for WDR mode experience.

## 7.4 Data Filtering

In the software SDK and UTool, we implemented data filtering to improve the depth data performance.

The filtering algorithm includes:

- Median filtering;
- Gaussian filtering;
- Bilateral filtering;



- Timing filtering;
- Flying pixel removing;

## 7.5 IR Image

Besides the depth image, Zense DCAM710 camera can also output a VGA resolution IR image. And the IR image is strictly timing synchronized with the depth image. Pixel to pixel mapping is also strictly aligned.



## 8 DCAM710 Accessories and Package

### In package item list:

Item	Part number	Description	Quantity
1	DCAM710	Zense DCAM710 Depth Camera Module	1
2	Micro USB Cable		1

You can ask Zense to do customization to the cable or adaptor for any reason, for example extending the cable length.

Please do NOT use the accessories from other parts except Zense Company, otherwise warranty will void.

### Optional item list:

Item	Component	Description	Quantity
1	VZENSE-DC-5V2A-A	Additional Power Adaptor for Long Range	1

Optional items need customer to pay for.

## 9 Customization Service

Zense team has rich experience in ToF product design and delivery, we welcome customer to send customization requirement besides the standard module. Reasonable NRE fee shall be charged depends on the requirement.

## Appendix

### ROHS Declaration

Part Name	Hazardous Substances or Elements					
	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Hexavalent Chromium (Cr6+)	Polybrominated Biphenyl (PBB)	Polybrominated Diphenyl Ethers (PBD)
Structural Components	×	○	○	○	○	○
Circuit Module	×	○	○	○	○	○
Optical Lens	×	○	○	○	○	○
Cable	○	○	○	○	○	○
Pouch	×	○	○	○	○	○
○: Indicates that this hazardous substance contained in all the homogeneous materials for						
×: Indicates that this hazardous substance contained in at least one of the homogeneous						

## Eye Safety Declaration

Dcam710 is classified as a Class 1 Laser Product under the EN/IEC 60825-1, Edition 3 (2014) internationally and IEC60825-1, Edition 2 (2007) in the US.

This product complies with US FDA performance standards under 21 CFR 1040.10 for laser products except for deviations pursuant to Laser Notice No. 50 dated June 24, 2007.

Camera	US FDA Accession Numbers
DCAM710	1820835-000

## Reliability Declaration

## Revision History