EYESTAR® Superb H1

AI Sensing and Following Monocular Camera

User Manual

Version 003

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Revision History

Versions	Revisions	Dates
001	Initial Release	2024-06-01
002	Updates to startup and configuration, video preview, and ranging accuracy	2024-07-25
003	Add the ranging diagram, improve the content of the agreement, and improve the product description	2024-08-08

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1 Product Description

1.1 Introduction

EYESTAR's Superb H1 is a monocular AI camera capable of sensing objects and their depth, which integrates a high-performance AI computing chip to accurately identify various objects and directly output depth information (including distance and orientation). The camera features human/object recognition and locking for precise vision-based tracking. It can be used after installation without any secondary development, especially suitable for mobile robots, intelligent driving, unmanned agriculture, golf following cart and other fields.

1.2 Features

- **Lighter:** it can directly obtain the depth information of the object, which is low cost and more convenient to use.
- **Large field of view:** HFOV 120°, VFOV 40°, meets the needs of robots and vehicles with large field of view.
- **Highly integrated:** integrated high-performance processor, ready to use at start-up, no SDK and secondary development required.
- **High precision:** distance measurement error <1%.
- **Low latency:** information output frequency up to 50Hz.
- **Easy to use:** aviation plug, standard USB 3.0 output.

2 Illustrate

2.1 Purpose and scope of the document

This document describes the product specifications, performance indicators, functional features, and scope of application of the EYESTAR AI sensing and following camera – Superb H1, as well as how to install, start, and connect.

2.2 Terms and definition

Table 2-1 Terms and definitions

Terms	Definitions
FOV	Field of view, which is used to describe the range of angles that the camera can image in the horizontal and vertical directions, mainly includes horizontal field of view (HFOV), vertical field of view (VFOV) and diagonal field of view (DFOV).
SoC	System-on-chip
Bounding Box	In AI visual inspection tasks, the position of an object is usually represented by a bounding box (BBox), which is a rectangular box that can contain an object.

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Rolling Shutter	A common way to expose a camera sensor. At the beginning of the exposure, the sensor scans the exposure line by line until all pixels have been exposed. All the actions are completed in a very short time

2.3 AI visual recognition technology

As a major branch of artificial intelligence technology, AI visual recognition has made significant breakthroughs in technology in recent years. Advances in deep learning algorithms have enabled computer vision systems to understand and interpret image information more accurately. In addition, the construction and opening of large-scale image datasets provide rich resources for model training and lay a solid foundation for the application of AI visual recognition technology.

At the same time, with the optimization of algorithms and the improvement of hardware performance, the speed and accuracy of AI intelligent visual recognition are also improving. This enables the machine to process and analyze image information more quickly and accurately, enabling real-time responses. The technological breakthrough of AI intelligent visual recognition is also manifested in the ability to adapt to complex environments. Through the continuous iteration and improvement of algorithms, the current visual recognition system has been able to maintain stable recognition performance in a variety of complex environments such as lighting changes, occlusion, and deformation, which makes AI visual recognition more robust and adaptable in practical applications.

In short, AI visual recognition is a comprehensive technology field, involving deep learning, computer vision, image processing and other technologies. These technologies complement each other and jointly promote the development of AI visual recognition applications.

3 Composition and Specifications

3.1 Appearance

Figure 3-1 Appearance

3.2 Components

The components of the Superb H1 device are shown in Table 3-1, and its core components include an image

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sensor (Camera), an inertial measurement unit (IMU), and a multi-core heterogeneous graphics acceleration processing chip (Graphics Processing SoC).

Table 3-1 Device components

Components	Quantity	Description
Camera	1	Color image sensor with a large field of view
Graphics Processing SoC	1	Accelerate image processing and deep learning operations
Others	-	Aluminum housing, covered glass, etc

3.3 Specifications

Table 3-2 Specifications

	Items	**Value**	**Unit**	**Comments**
Structure	Long	100	mm	-
	Wide	79	mm	-
	Height	30.5	mm	-
	Weight	268	g	-
	Interface	Aviation plugs	-	-
		USB 3.0	-	Type-A
Optics	Resolution	1920×1080	Pixel	-
	Frame rate	30	FPS	-
	Exposure type	Rolling Shutter	-	-
	HFOV	120	°	-
	VFOV	40	°	-
Performance	The number of recognizable objects	80	Type	See Appendix A
	Detection range	0.2~10	m	In case of good light
	Ranging accuracy	0.02	m	Distance: 2m
	Output frequency	50	Hz	Configurable
Electric	Voltage	9.0~18.0	V	-
	Power consumption	5.0	W	Typical
Projection	Waterproof and dustproof	IP65	-	-
	Operating temperature	-40~85	℃	-

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Working environment	Operating humidity	0~80	RH	-
	Storage temperature	-40~85	℃	-

4 Data Protocols

4.1 Input protocol

In order to obtain the best performance, the user needs to measure the installation height of the device and enter the equipment installation height information through serial port commands before the first installation and operation of the device. The installation height (*h*) refers to the vertical distance between the center of the camera and the ground, as shown in Figure 4-1.

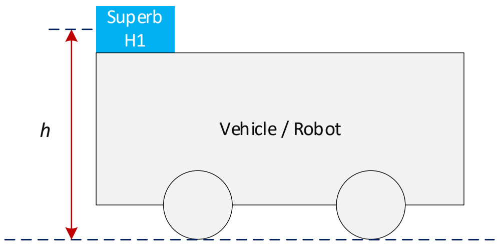

Figure 4-1 Measurement and acquisition of the installation height of the equipment

Table 4-1 describes the input message parameters.

Table 4-1 Input message protocol

Field	Date format	Range	Unit
Message prefix	Fixed characters: $	-	-
Company identifier	Fixed strings: ESTAR		
Message sub-prefix	Fixed strings: DEVHGT	-	-
Camera installation height	Strings: ddd.ddd	0~100	m
Checksum prefix	Fixed strings: *	-	-
Checksum	Two ASCII characters in hexadecimal	-	-
End of message	Fixed strings: \r\n	-	-

4.2 Output protocol

4.2.1 Message arrange

Superb H1 has the ability to perceive objects and their depth, and directly outputs the information of the recognized objects to the user, including the number and type of objects, the pixel coordinates of the bounding box, the distance of the object, etc.

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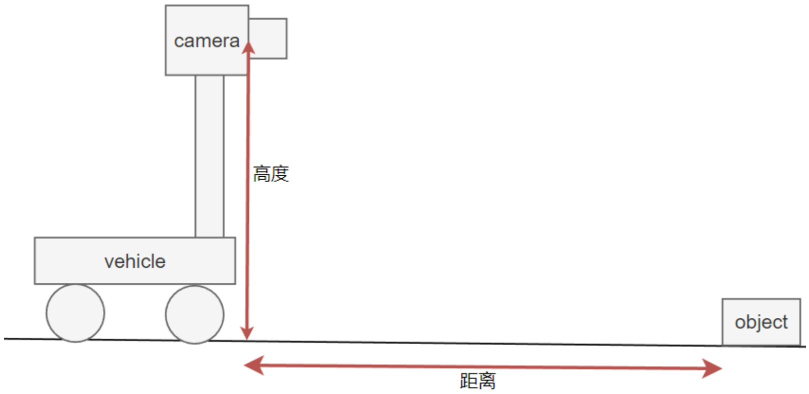

Figure 4-2 Installation height and measurement distance of equipment

The output data is transmitted using ASCII code, and the message content and orchestration format are detailed in Section 4.2.

4.2.2 Parameter description

Table 4-2 describes the parameters of the output message.

Table 4-2 Output message protocol

Filed		Date format	Range	Unit
Message prefix		Fixed characters: $	-	-
Company identifier		Fixed strings: ESTAR		
Message sub-prefix		Fixed strings: INSSEG	-	-
Local time		Strings: yymmdd.hhmmss.mmm	-	-
Message number		16-bit integer	0~65535	-
Image number		16-bit integer	0~65535	-
Number of recognized objects output		8-bit integer	0~16	-
Object information	Object type	8-bit integer	0~255	
	Object ID	16-bit integer	0~65535	
	Top left horizontal axis of BBox	16-bit integer	0~65535	Pixel
	Top left vertical axis of BBox	16-bit integer	0~65535	Pixel
	Bottom right horizontal axis of BBox	16-bit integer	0~65535	Pixel
	Bottom right vertical axis of BBox	16-bit integer	0~65535	Pixel
	Object distance	Float	0~999.999	m

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	Object orientation	Float	-90~90	Degree (°)
Checksum prefix		Fixed strings: *	-	-
Checksum		Two ASCII characters in hexadecimal	-	-
End of message		Fixed strings: \r\n	-	-

The above parameters are described as follows:

1）Message prefix

Identifies the start of message transfer. It is represented by a fixed string "$", and is separated by a comma "," between the following fields.

2) Company Identifier

Identifies Beijing EYESTAR Technology Co., Ltd (EYESTAR). It is represented by a 5-digit fixed string "ESTAR", separated from subsequent fields by a comma",".

3) Message sub-prefix

Identifies the start of the message with valid content. It is represented by a fixed 6-digit string "INSSEG", which is separated by a comma "," between the preceding and following fields.

4) Local time

Identifies the local time when the message was generated. It is represented by a 17-bit string in the form of "yymmdd.hhmmss.mmm" (i.e., Years, months, and days. Hours, minutes, and seconds. Milliseconds), and the preceding and posterior fields are separated by a comma ",".

5) Message number

Identifies the sequence number generated by the message. It is represented by a 16-bit integer, and is divided by a comma "," between the preceding and posting fields. The count starts at 0, adds 1 to the count after each message transmission, and resets to 0 after the count reaching 65535.

6) Image number

Identifies the sequence number of the image in the message, which is used to distinguish the different images to which the example belongs. It is represented by a 16-bit integer, and is divided by a comma "," between the preceding and posting fields.

7) Number of recognized objects output

Identifies the number of recognized objects which are transmitted in this message. It is represented by an 8-bit integer, with a maximum limit of 16, and is divided by a comma "," between the preceding and posting fields.

8) Object information

Used to provide the information of the recognized object, including:

a) Object type: represented as an 8-bit integer, see Appendix A for specific definitions;

b) Object ID: represented as a 16-bit integer;

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c) Top left horizontal axis of BBox: represented as a 16-bit integer in pixels;

d) Top left vertical axis of BBox: represented as a 16-bit integer in pixels;

e) Bottom right horizontal axis of BBox: represented as a 16-bit integer in pixels;

f) Bottom right vertical axis of BBox: represented as a 16-bit integer in pixels;

g) Object distance: represented by a float type in the form of "xxx.xxx" in unit of m; there are 3 placeholders before and after the decimal point, and 0 is added if it is insufficient;

h) Object orientation: represented by a float type in the form of "xxx.xxx" in unit of degree (°).

Fields a) to h) are advertised in a loop until the number of objects transmitted at this time is reached. Fields a) to h) are also separated by a comma "," but note that the last field h) is not followed by a comma, but is directly connected to the checksum prefix identifier "*".

9) Checksum prefix

Identifies the beginning of the message checksum, denoted by the fixed character "*".

10) Checksum

Two characters are used to represent the checksum of all characters from the message prefix "$" to the checksum "*" (XOR operations are performed on each byte to obtain the checksum, and then converted to ASCII characters in hexadecimal format).

11) End of message

Identifies the end of the message transfer, using the fixed string "\r\n".

4.2.3 Demonstration

In this section, the Superb H1 output data protocol is further explained through a demonstration.

(a) Original image (b) Image annotated by Bounding Box

Figure 4-3 Demonstration diagram

Assuming that Superb H1 captures the image shown in Figure 4-3 (a), and identifies several objects as shown in Figure 4-3 (b). In this case, Superb H1 outputs the following ASCII message:

```
$ESTAR,INSSEG,240509.111850.000,12,56,5,0,1,417,192,66,92,003.916,62.322,0,2,508,189,594,274,003.088,45.714,33,3,164,83,525,342,001.011,10.445,24,4,4,154,37,171,013.805,-51.672,24,5,60,154,103,172,011.264,-45.265*hh\r\n
```


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According to the data protocol, the message is parsed as:

1) The message time is May 9, 2024, 11:18:50, 000 milliseconds;

2) The message number is 12, and the image number is 56;

3) This message transmits the Bounding Box information of 5 objects, namely:

- <0,1,417,90,503,284,003.916,62.322>: represents that the object type is "human", the pixel coordinates of the upper left corner of the Bounding Box are (417,90) and the pixel coordinates of the lower right corner are (503,284), with a distance of 3.916 m from the camera and an azimuth angle of 62.322°;
- <0,2,508,116,594,274,003.088,45.714>: represents that the object type is "human", the pixel coordinates of the upper left corner of the Bounding Box are (508,116) and the pixel coordinates of the lower right corner are (594,274), with a distance of 3.088 m from the camera and an azimuth angle of 45.714°;
- <33,3,164,83,525,342,001.011,10.445>: represents that the object type is "kite", the pixel coordinates of the upper left corner of the Bounding Box are (164,83) and the pixel coordinates of the lower right corner are (525,342), with a distance of 1.011 m from the camera and an azimuth angle of 10.445°;
- <24,4,4,154,37,171,013.805,-51.672>: represents that the object type is "bag", the pixel coordinates of the upper left corner of the Bounding Box are (4,154) and the pixel coordinates of the lower right corner are (37,171), with a distance of 13.805 m from the camera and an azimuth angle of -51.672°;
- <24,5,60,154,103,172,011.264,-45.265>: represents that the object type is "bag", the pixel coordinates of the upper left corner of the Bounding Box are (60,154) and the pixel coordinates of the lower right corner are (103,172), with a distance of 11. 264 m from the camera and an azimuth angle of -45.265°.

5 Installation Guide

5.1 Structural drawings

As shown in Figure 5-1, there are a total of 9 M3 screw holes reserved on the shell of Superb H1 for equipment fixation, installation, and grounding. Among them, there are 5 on the back and 2 on each side. The camera should be installed on the metal parts of the entire machine (vehicle, robot, etc.) as much as possible, or the space around the camera should be increased as much as possible to facilitate equipment heat dissipation.

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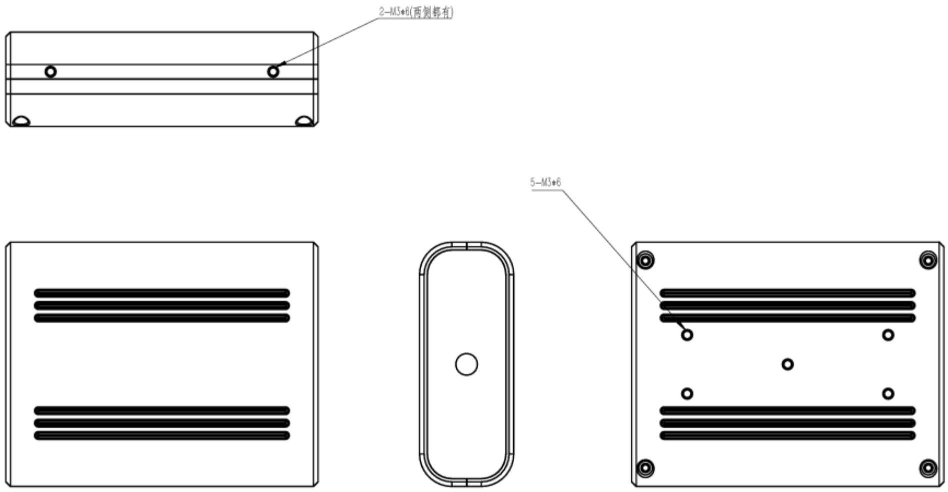
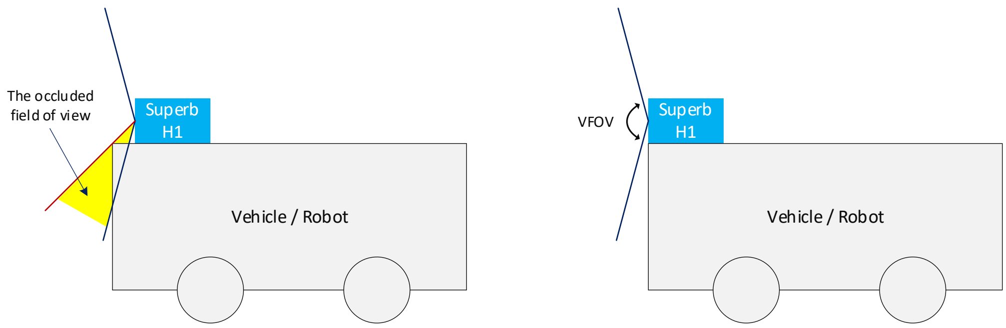


Figure 5-1 Structural drawings

5.2 Avoid occlusion

To improve the perception ability and detection quality of the Superb H1 AI camera, efforts should be made to avoid covering, blocking, or obstructing the camera FOV during installation (whether integrated into the entire machine or used as a peripheral accessory). Taking the robot as an example, Figure 5-2 compares and illustrates the installation methods of the equipment.



(a) Bad Placement (b) Good Placement

Figure 5-2 Avoid obstructing the camera

5.3 Blind area

If you are focusing on nearby objects on the ground, you need to pay attention to the blind spots in the field of view caused by the limitations of the camera VFOV range during installation, as shown in Figure 5-3 (a).

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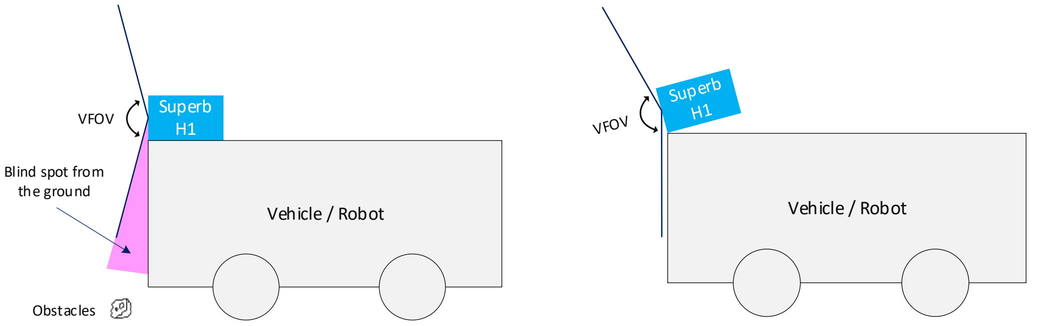

(a) Blind spot from near the ground

(b) Adjust the mounting angle to avoid blind spots on the ground

Figure 5-3 Adjust the camera installation angle to better observe objects near the ground

6 Connection and Startup

6.1 Connection

Use the aviation plug adapter cable provided in the package to connect one end to the camera’s aviation plug interface, and the other end to the camera’s RS232 serial port and 12V power supply. As shown in Figure 6-1, the red box represents the RS232 serial port, the yellow box represents the power interface, and the blue box represents the aviation plug interface.

Figure 6-1 Connection of the camera's aviation plug adapter cable

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6.2 Configuration and startup

After being powered on for 30 seconds, the camera can start working automatically. The default installation height of the camera is 0.5 m. Before the official starting work, users need to measure and configure height information according to the actual installation situation of the equipment, as described in Section 4.1. As shown in Figure 6-2, enter the height value in the “SuperH1_Encode” software and click OK to convert and generate the command for serial port delivery.

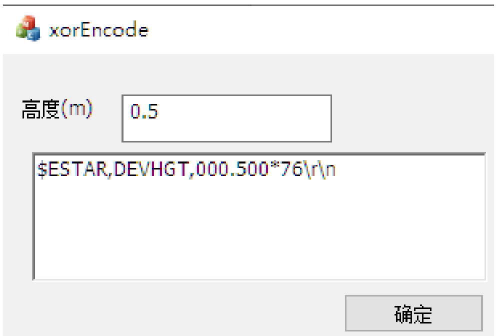

Figure 6-2 Use the "SuperH1_Encode" software to generate the serial port command

Use SSCOM to deliver commands to the serial port, as shown in Figure 6-3.

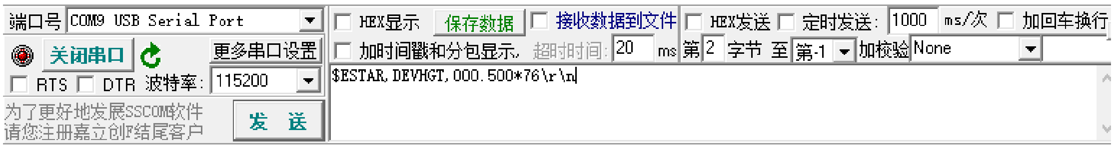

Figure 6-3 Configure the installation height of the device through the serial port

6.3 Video preview

Set the serial port baud rate to 115200bps for communication with the host. To use the preview function, you need to first connect to the Windows host via USB, and then use the Potplayer to connect to the camera and open the video. The opening method of Potplayer is as follows:

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Figure 6-4 The opening method of Potplayer

The setup method for Potplayer is as follows:

Select "Options ->Devices ->Camera ->UVC Camera", and choose the format as "I420 640x360 15", as shown in Figure 6-5.

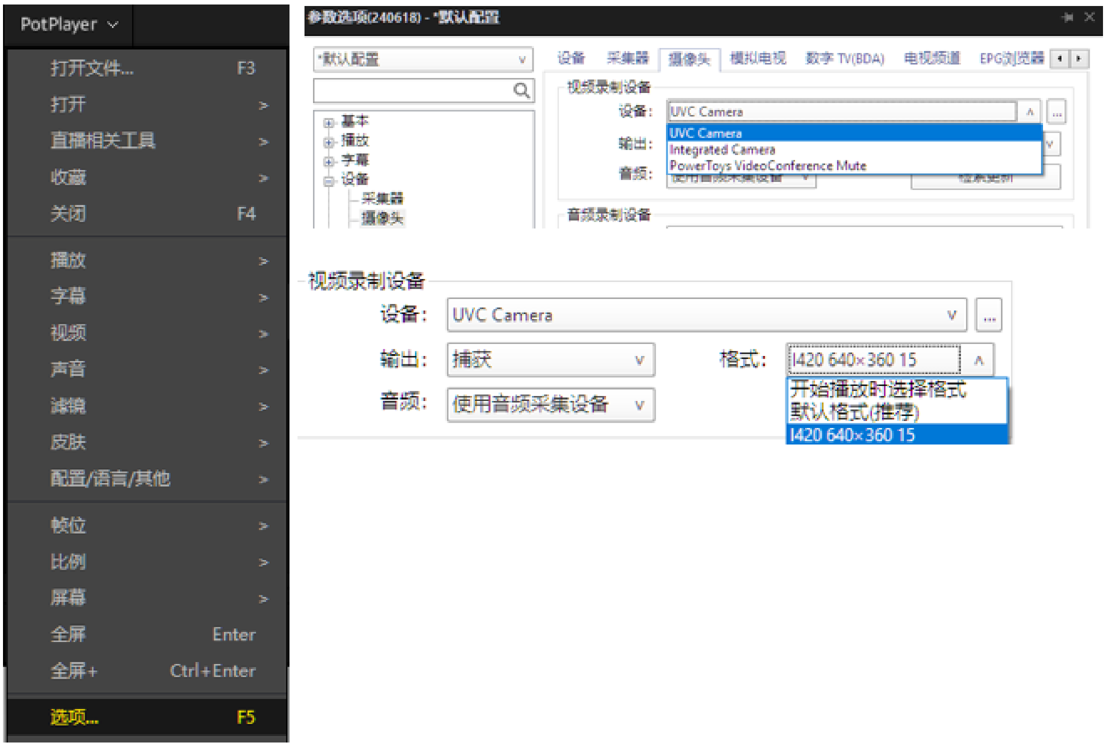

Figure 6-5 Configuration selection of Potplayer

Once the settings are complete, click the play button to preview the video and identify the situation in real time. The identified object and its depth information are displayed in the video image, as shown in Figure 6-6.

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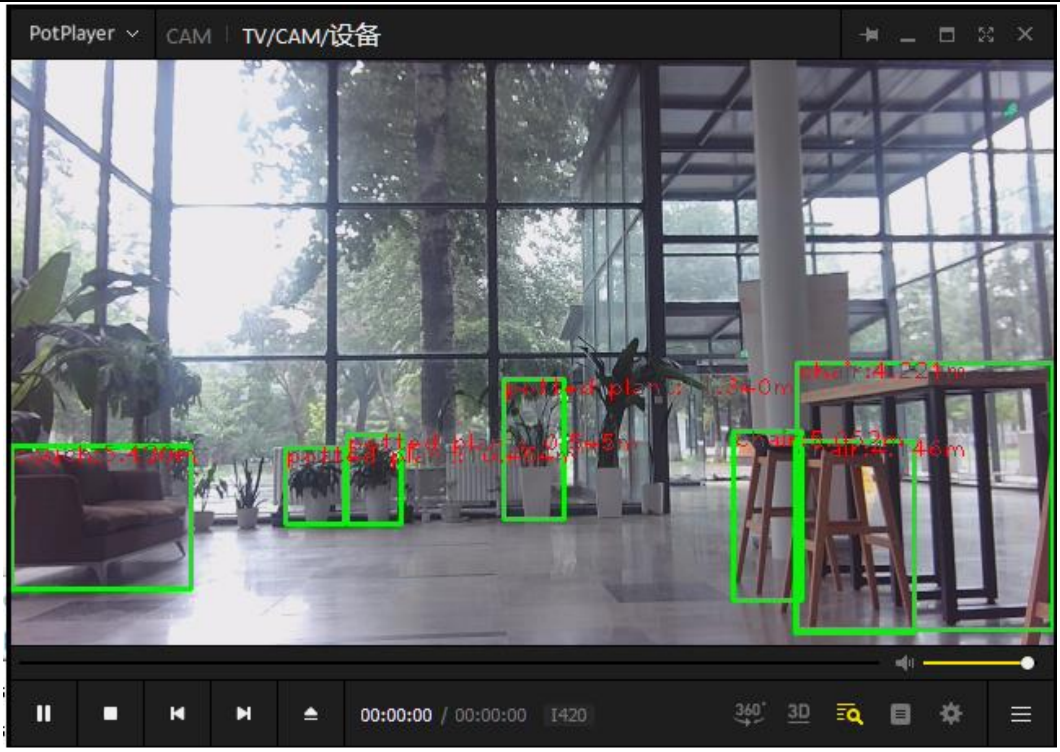

Figure 6-6 Video preview

7 Notices

- Please follow the instructions to operate the equipment correctly to avoid damage to the internal components caused by illegal operation;
- Please avoid the equipment falling from a height to avoid damage to the internal components and structural parts;
- Do not attempt to disassemble the equipment by yourself, so as not to cause damage to the internal components and structural parts;
- Please keep the lens clean to avoid leaving foreign objects that may affect the working performance of the device;
- Please choose high-quality or original wire rod to avoid unstable factors caused by material quality, thickness, etc.;
- The increase in operating temperature of the equipment is a normal phenomenon, and prolonged exposure to sunlight should still be avoided as much as possible;
- Please communicate with our engineers in advance about the heat dissipation, installation and electronic design of the equipment to get a better application experience.

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8 More Information

Please contact EYESTAR for more information and technical support:

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Attachment A: Identifiable objects

The Superb H1 deep learning model can currently recognize over 80 common objects, including pedestrians, cars, motorcycles, animals, etc. (see Table A-1), and is continuously being upgraded. The new model will be provided to users for free upgrade through firmware updates and other means.

Table A-1 Identifiable objects list

Type	Label	Type	Label
0	Person	40	Wine glass
1	Bicycle	41	Cup
2	Car	42	Fork
3	Motorcycle	43	Knife
4	Airplane	44	Spoon
5	Bus	45	Bowl
6	Train	46	Banana
7	Truck	47	Apple
8	Boat	48	Sandwich
9	Traffic light	49	Orange
10	Fire hydrant	50	Broccoli
11	Stop sign	51	Carrot
12	Parking meter	52	Hot dog
13	Bench	53	Pizza
14	Bird	54	Donut
15	Cat	55	Cake
16	Dog	56	Chair
17	Horse	57	Couch
18	Sheep	58	Potted plant
19	Cow	59	Bed
20	Elephant	60	Dining table
21	Bear	61	Toilet
22	Zebra	62	TV
23	Giraffe	63	Laptop
24	Backpack	64	Mouse
25	Umbrella	65	Remote

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26	Handbag	66	Keyboard
27	Tie	67	Cell phone
28	Suitcase	68	Microwave
29	Frisbee	69	Oven
30	Skis	70	Toaster
31	Snowboard	71	Sink
32	Sports ball	72	Refrigerator
33	Kite	73	Book
34	Baseball bat	74	Clock
35	Baseball glove	75	Vase
36	Skateboard	76	Scissors
37	Surfboard	77	Teddy bear
38	Tennis racket	78	Hair drier
39	Bottle	79	Toothbrush

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Attachment B: Object ranging error

The object ranging error (ΔZ) of Superb H1 at different detection distances (Z) is tested and statistically analyzed under normal indoor or outdoor lighting conditions, as shown in Table B-1.

Table B-1 Object ranging error

Z (m)	ΔZ (m)	ΔZ/Z (%)
0.2	0.002	1.00
0.4	0.003	0.75
0.6	0.002	0.33
0.8	0.002	0.25
1.0	0.002	0.20
1.2	0.002	0.17
1.4	0.002	0.14
1.6	0.003	0.19
1.8	0.004	0.22
2.0	0.004	0.20
2.4	0.006	0.25
3.2	0.008	0.27
3.5	0.006	0.17
4.0	0.005	0.13
4.5	0.004	0.10
5.0	0.006	0.12
5.5	0.060	1.10
6.0	0.064	1.11
6.5	0.080	1.20
7.0	0.102	1.40
7.5	0.090	1.20
8.0	0.123	1.50
8.5	0.136	1.53
9.0	0.152	1.67
9.5	0.175	1.79
10.0	0.211	2.10

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