Mobile Robot Vision Expert

MRDVS Technology

3D Vision Obstacle Avoidance Guide

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Content

1. Application Introduction

The visual obstacle avoidance system, developed independently by MRDVS, utilizes the S series cameras and TOF RGBD cameras. By integrating deep learning with traditional 3D computer vision algorithms, it offers real-time, customizable solutions for various scenarios, supporting multi-camera collaboration with proactive prediction capabilities.

Key features of this system include real-time dynamic detection, adaptive ground detection, dynamic target tracking, support for multiple signal outputs, multiple mode switching, five operational modes, and multi-camera collaborative operation.

2. Installation and Selection

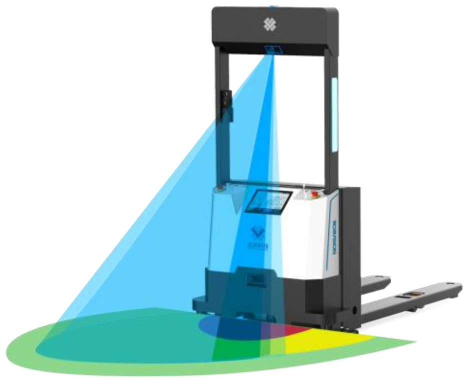
Low-profile AGV Installation:

For low-profile AGVs, the camera must be mounted at a relatively low height due to the AGV's compact size. The recommended camera model is the S2, which should be installed on the front surface in the direction of the AGV's movement. Ensure the structural design avoids visual interference to maintain clear visibility.

Low-profile AGV Installation Illustration

AGV Forklift Installation:

When installing on smart forklifts, the camera should be positioned higher. The recommended model is the S2 Max camera, which should be mounted at a downward angle of 30°-55° on the forklift's mast. The camera's field of view should align with the front surface of the forklift, and the installation height should not exceed 2 meters.



AGV Forklift Installation Illustration

3. Camera Connection Settings

3.1 Before connecting the camera, ensure the following preparations are complete:

1. Set the Local Network Port IP:

   The factory IP of the camera is 192.268.100.82. Set the local network port IP to the same segment (e.g., 192.268.100.X).

2. Disable the Firewall:

   Disable the firewall to ensure a smooth connection.

3. Download and Open GUI LxCameraViewer

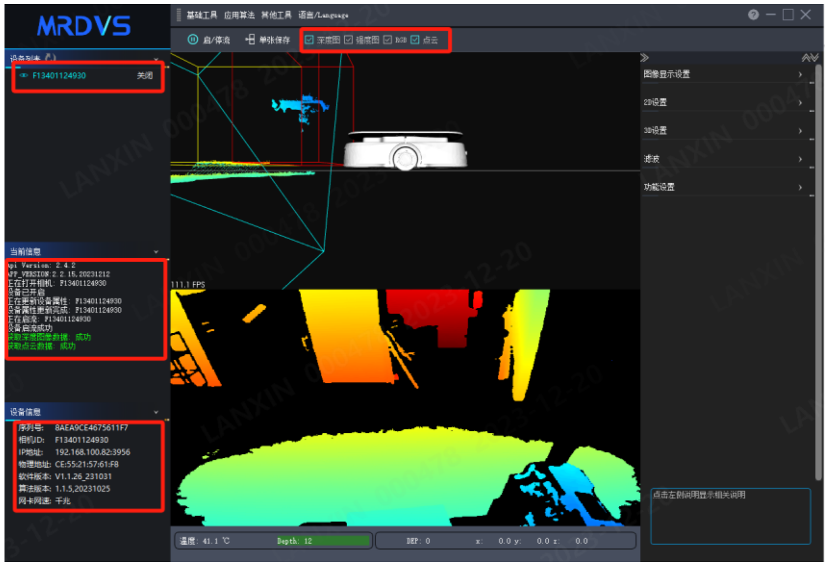
   a. Download the GUI LxCameraViewer from the MRDVS GitHub repository.

   b. Install the GUI LxCameraViewer.

3.2 Connect the camera with the host:

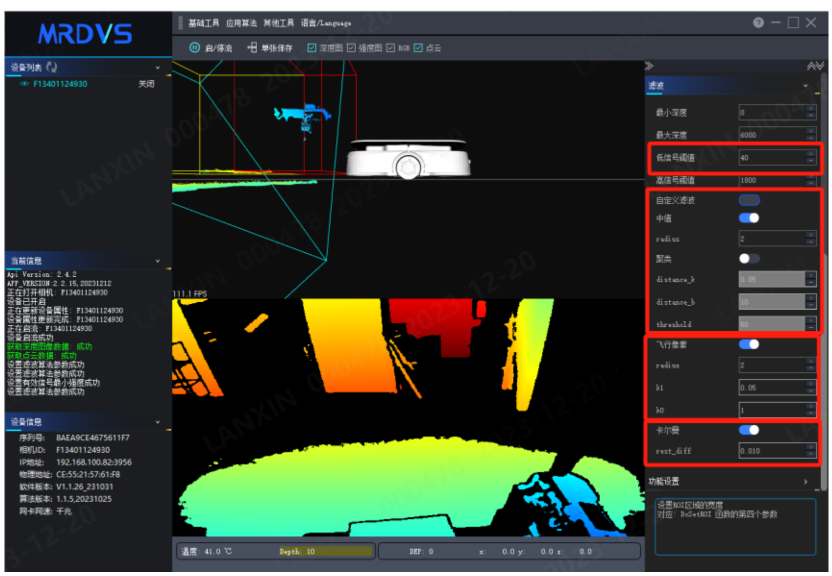
1. Open the GUI LxCameraViewer, which will automatically detect the connected camera.

2. Click to open the camera. it will display the depth map and point cloud map, as shown in the figure below.



3.3 Adjust the Camera Parameters:

1. Adjust the parameters for obstacle avoidance applications with the following recommended settings:
    - High integration: 650
    - Low integration: 200
    - Low signal threshold: 30-50
2. Enable the de-flying pixel algorithm and Kalman filtering algorithm to reduce stray pixel interference in obstacle avoidance results.



4. Obstacle Avoidance Parameter Configuration

After setting the camera parameters, click the "Apply Algorithm" button. The status bar on the right will display algorithm settings. Configure them to be always on or off when disconnected, and select the obstacle avoidance algorithm. The algorithm version number will be displayed below.

The obstacle avoidance parameters are divided into camera installation external parameters and obstacle avoidance area configuration parameters. Once the camera external parameters are set and saved, all four configuration areas will automatically update to the current external parameters. The obstacle avoidance parameters include five operational channels for the AGV, which can be switched based on the operating environment. For example, switch to narrow channel settings when the AGV moves into narrow spaces and to wide channel settings for wide spaces using communication methods.

5. External Parameter Settings

5.1 Parameter Description

Parameter Item	**Parameter Value**	**Description**
Obstacle Avoidance Function	-	Switch between different obstacle avoidance parameters by setting different modes
Camera Angle Roll (x-axis)	180	Camera external parameter, roll angle (roll), default camera installation is 180
Camera Angle Pitch (y-axis)	90	Camera external parameter, pitch angle (pitch), default vertical installation is 90
Camera Angle Yaw (z-axis)	90	Camera external parameter, yaw angle (yaw), default is 90
Camera Position (distance x)	430	Distance from the camera to the front and rear of the AMR in the X direction, unit: mm
Camera Position (width y)	0	Distance from the camera to the left and right of the AMR in the Y direction, unit: mm
Camera Position (height z)	120	Camera installation height parameter, i.e., the height from the camera to the ground, unit: mm

5.2 Parameter Setting

When the camera is installed on the front surface of the AGV, close other images and use only the point cloud image to debug the camera parameters. Prioritize setting the camera installation height, then fine-tune the roll angle RX to adjust it to level, followed by the pitch angle RY. Adjust the effect as shown in the figure, then click to complete the setting. The camera installation external parameters will be synchronized to the other four configurations.

6. Obstacle Avoidance Area Setting

6.1 Area Parameter Description

Parameter Item	Parameter Value	Description
Warning Distance (x far)	1300	Obstacle avoidance range, distance from the vehicle center in the x direction. Obstacles beyond this distance are considered safe; between the warning distance and alarm distance is considered a warning slowdown, shown as a yellow area. Unit: mm
Alarm Distance (x near)	700	Obstacle avoidance range, distance from the vehicle center in the x direction. Obstacles within this distance are considered an alarm stop, shown as a red area; between the warning distance and alarm distance is considered a warning slowdown, shown as a red area. Unit: mm
Obstacle Avoidance Range Left (y left)	500	Obstacle avoidance range, distance from the vehicle center to the left in the y direction. Unit: mm
Obstacle Avoidance Range Right (y right)	-500	Obstacle avoidance range, distance from the vehicle center to the right in the y direction. Unit: mm
Obstacle Avoidance Range Down (z down)	-50	Obstacle avoidance range, height from the ground. Objects below this height are not processed. If set too small, measurement errors may cause false alarms; if set too high, larger ground obstacles may be filtered out, causing missed detections. Unit: mm
Obstacle Avoidance Height Up (z up)	400	Obstacle avoidance range, height from the ground. Objects above this height are not processed. Unit: mm

6.2 Obstacle Avoidance Area Setting

The current obstacle avoidance application has five built-in obstacle avoidance areas. After completing the camera parameter configuration, users can configure the obstacle avoidance area. When the AMR moves to a different obstacle avoidance range, it switches to the corresponding configuration area to control the obstacle avoidance range.

- Warning Distance (X far): indicates the warning (deceleration) obstacle avoidance range of the camera 2300, i.e., warning distance 2300-430=1870mm.
- Alarm Distance (X medium): indicates the alarm (stop) obstacle avoidance range of the camera 1200, i.e., alarm distance 1200-430=770mm.

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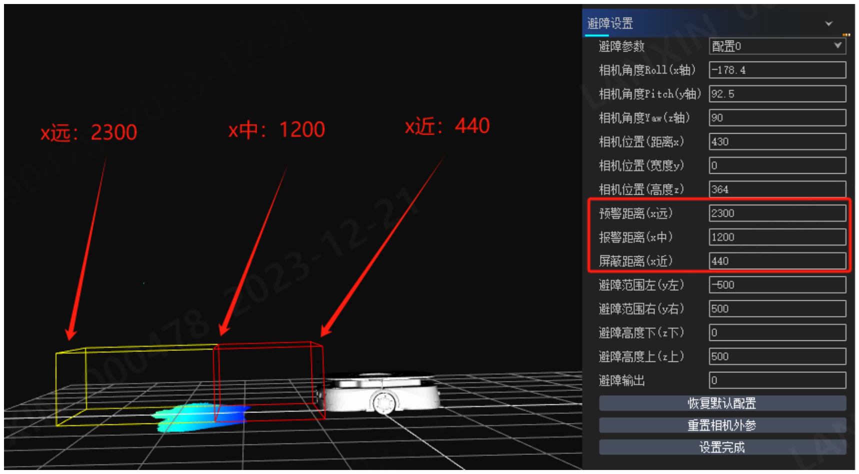
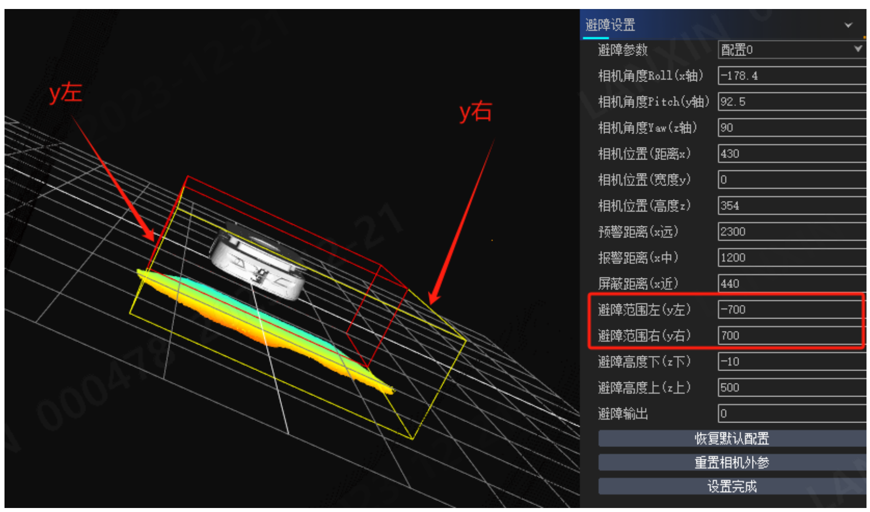
- Shielding Distance (X near): indicates the shielding range of the camera 440, i.e., shielding camera front 440-430=10mm.



- Obstacle Avoidance Range Left (y left): indicates the obstacle avoidance range of the camera detecting obstacles within -700mm on the left.
- Obstacle Avoidance Range Right (y right): indicates the obstacle avoidance range of the camera detecting obstacles within 700mm on the right.



- Obstacle Avoidance Height (Z down): indicates detecting obstacles within 10mm below the installation height.
- Obstacle Avoidance Height (Z up): indicates detecting obstacles within 500mm above the ground.

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Obstacle Avoidance Output: 0 indicates no obstacle, 1 indicates an obstacle detected in the warning area (yellow box area), 2 indicates an obstacle detected in the alarm area (red box area).

7. Communication Methods

7.1 API Call Method

The API call method supports C++, C#, JAVA, ROS1, ROS2 environments in Windows, Linux, and ARM environments. After installing the SDK in the Windows environment, the SDK files and sample code are in the installation path (e.g., D:\Program Files\Lanxin-MRDVS). The Linux environment SDK can be obtained from from the MRDVS GitHub repository.

- The Document folder contains the SDK and upper computer usage instructions.
- The Firmware folder stores the camera firmware packages.
- The Sample folder stores the sample code source files, selectable according to the development environment.
- The SDK folder stores the SDK library files, configurable as per the development environment.

7.2 485 Communication Method

485 communication supports only the M4 pro camera. Below is the camera harness definition:

Port	Pin	Signal	Description	Remarks
Socket Definition	1	GND	Signal ground	Blue
-	2	485_A	RS485_A	Gray
-	3	485_B	RS485_B	White
-	4	VIN +	24V power input positive end	Brown

-	5	VIN -	24V power input negative end	Black

485 Debugging Method:

1. When connecting via RS485, set the baud rate to 9600 in the debugging assistant, and select hexadecimal send/receive data.

2. For example, in send mode 1, send hexadecimal data and receive the return value as a successful connection, as shown in the figure.

7.3 UDP Communication Method

Obstacle Avoidance Function Type Fields

Transfer Direction	Message	Obstacle Avoidance Result
Camera -> Device	ACED041000000000	No Obstacle
	ACED041000000001	Warning Deceleration
	ACED041000000002	Alarm Stop
Device -> Camera	ACED041A00000000	Obstacle Avoidance Setting Mode 1
	ACED041A00000001	Obstacle Avoidance Setting Mode 2
	ACED041A00000002	Obstacle Avoidance Setting Mode 3
	ACED041A00000003	Obstacle Avoidance Setting Mode 4
	ACED041A00000004	Obstacle Avoidance Setting Mode 5

1. When connecting via UDP, use the network debugging assistant to test communication with the camera, select hexadecimal send/receive data.

2. Set the local host address and port, then click open.

3. The remote host is the camera, fill in the camera IP port: 192.168.100.12:6688. If the camera IP has been changed, it will be: camera IP: 6688.

4. For example, in send mode 1, send hexadecimal data and receive the return value as a successful connection, as shown in the figure.

7.4 CAN Communication Method

The communication protocol uses CanOpen. CanOpen protocol operates on the standard CAN bus, using the common "master-slave" communication mode in industrial communication protocols, i.e., the network consists of one master station and multiple slave stations. Slave stations do not communicate directly with each other; all communication occurs between the master and slave stations. The master is also known as the "client," and the slave is known as the "server." The underlying communication uses the CAN standard frame format, with a CAN ID of 11 bits (0x000~7FF) and 8-byte data.

For CAN ID usage conventions: The 11-bit ID is divided into a 4-bit function code and a 7-bit node ID. The CAN ID is also referred to as COB ID.

CAN ID										
10	9	8	7	6	5	4	3	2	1	0
Function Code				Node Number						

The CAN baud rate is defined as 250K. SDO communication messages are a basic protocol format in CanOpen. The 8-byte data in the CAN message is defined by the communication protocol as follows:

Data							
0	1	2	3	4	5	6	7
Command Code	Index		Subindex	Data			

Obstacle Avoidance Module Communication Protocol: Device -> Equipment Device sends COB ID: 0x212

Data							
0	1	2	3	4	5	6	7
0x40	0x0000		0x00	MODE CTRL			

MODE CTRL is the obstacle avoidance mode, currently only 0 and 1. Equipment -> Device Device sends COB ID: 0x392

Data							
0	1	2	3	4	5	6	7
0x43	0x0000		0x00	result			

Result is the obstacle avoidance result, type INT, 0 indicates no obstacle, 1 indicates a distant obstacle, 2 indicates a near obstacle.

7.5 I/O Communication Method

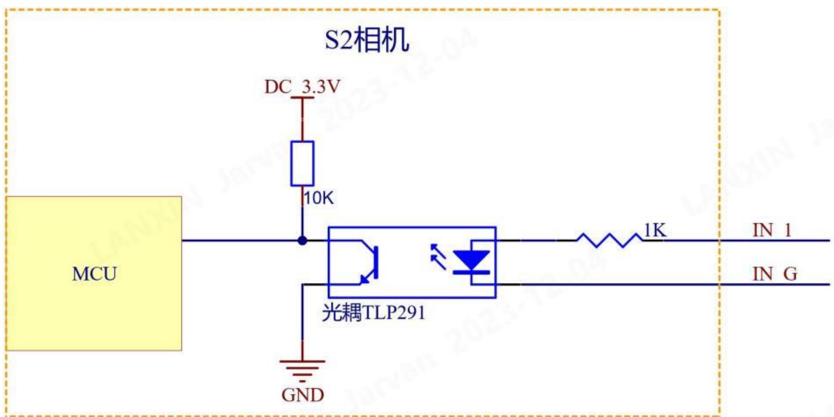
Wiring Method for S2 Camera I/O:

The external wiring details with power labels are as follows:

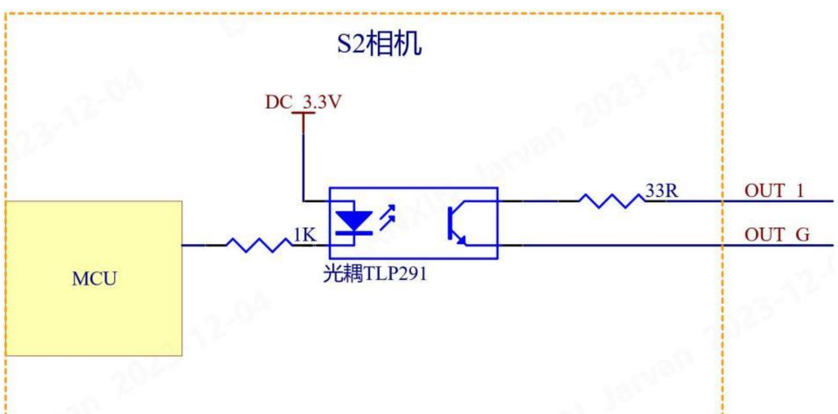
Label Name	Color	Attribute	Remark

24V+	Brown	Power+	S2 camera power supply, positive
24V-	Black	Power-	S2 camera power supply, negative
IN_1	Red	Input	Discrete input signal, high effective, supports 24V/closing access
IN_2	White	Input	Discrete input signal, high effective, supports 24V/closing access
IN_G	Blue	GND_in	Common point for discrete input signals (connected to OUT_G)
OUT_1	Green	Output	Discrete output signal, ground/open signal, supports 24V pull-up
OUT_2	Purple	Output	Discrete output signal, ground/open signal, supports 24V pull-up
OUT_G	Yellow	GND_out	Common point for discrete output signals (connected to IN_G)

Input/Output Circuit as shown below:



Input End Internal Circuit Diagram



Output End Internal Circuit Diagram

Working Principle Explanation:

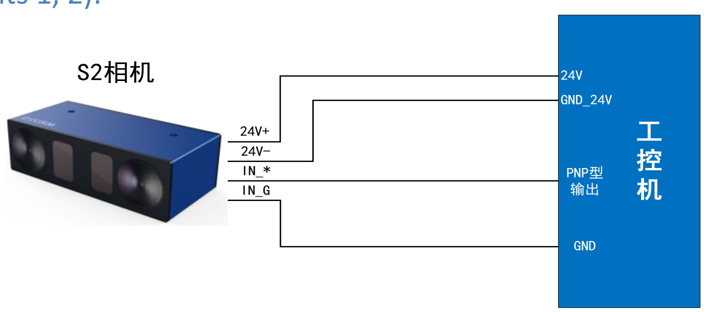
Input End: When the external input is high impedance or low level, the LED inside the optocoupler does not light up, the photosensitive transistor inside the optocoupler does not conduct, and the MCU inside the camera receives a high level. When the external input is high level, the LED inside the optocoupler lights up, the photosensitive transistor inside the optocoupler conducts, and the MCU inside the camera receives a low level.

Output End: When the S2 camera MCU outputs a high level, the LED inside the optocoupler does not light up, the photosensitive transistor inside the optocoupler does not conduct, and there is an open circuit between OUT* *and OUT_G. When the S2 camera MCU outputs a low level, the LED inside the optocoupler lights up, the photosensitive transistor inside the optocoupler conducts, and there is a short circuit between OUT** and OUT_G, i.e., ground (because IN_G and OUT_G are connected to the ground plane).

Wiring Method with IPC

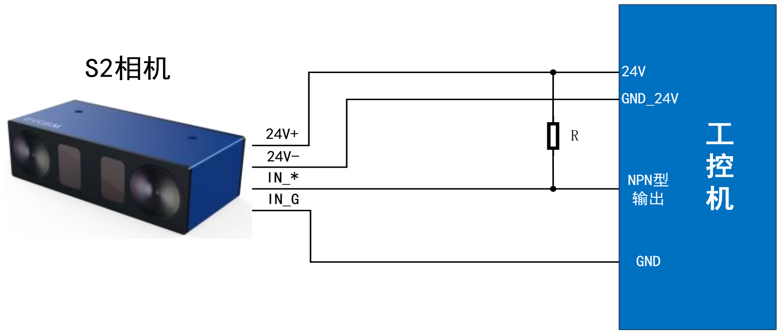
Note that the camera's 24V- should be connected to the industrial computer's power ground, and IN_G and OUT_G should be connected to the industrial computer's signal ground. Customers can modify the common ground connection method according to actual conditions. If the industrial computer does not distinguish between power ground and signal ground, the camera's 24V-, IN_G, and OUT_G can all be connected to the industrial computer's GND.

Input End IN* *Wiring Method The following figure shows the wiring method for the industrial computer PNP type output and S2 camera input end (abbreviated as IN*,* where * represents 1, 2):



Industrial Computer PNP Type Output Wiring Method

The following figure shows the wiring method for the industrial computer NPN type output and S2 camera input end:



Industrial Computer NPN Type Output Wiring Method

Due to different manufacturers' designs of the industrial computer output circuit, it is necessary to determine whether a pull-up resistor and its value are needed based on actual conditions. Test steps are as follows:

1. Measure the impedance between the industrial computer output and 24V with a multimeter. If it is <50kΩ, no pull-up resistor is needed, direct connection is possible. If it is ≥50kΩ, a pull-up resistor is needed. It is recommended to use a metal film resistor with a resistance of 10kΩ and a power of ≥1W. Other resistors can be used temporarily but long-term use affects reliability, and the resistance should not be less than 3kΩ or connected directly to 24V.

2. After confirming the connection, pull up the output of the industrial computer and measure the voltage between the output and ground with a multimeter. If the voltage is ≤2V, disconnect the camera circuit and check if the industrial computer can pull up the level. If the voltage is >2V, pull down the output and check if the S2 camera input changes. If there is a change, it means it can be used normally. If there is no change, pull down the output of the industrial computer, measure the voltage between the output and ground. If the voltage is greater than 1V, it indicates that the pull-up strength is difficult to pull down, increase the pull-up resistor value and remeasure. If the voltage is less than 1V, disconnect the industrial computer connection, connect the camera IN_* through a resistor to 24V and GND, check if there is a change in the camera input. If there is a change, check if the connection between the industrial computer and the camera is correct. If there is no change, contact technical support to troubleshoot the problem.

Input End IN_ Wiring Method

Since the S2 camera output end is a ground/open signal, the wiring method for connecting the S2 camera output end to the industrial computer input end does not distinguish between the PNP and NPN types of the industrial computer input, but mainly distinguishes whether the normal state is high level or low level, i.e., whether

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there is a pull-up inside the industrial computer, to determine whether a pull-up resistor is needed.

The following figure shows the wiring method for the industrial computer input end and S2 camera output end (abbreviated as OUT_*, where * represents 1, 2):

Judgment Standard for Whether a Pull-Up Resistor R is Needed If the industrial computer is powered on, the input end is left floating (not connected to the camera), and the input end voltage to ground is measured directly. If the voltage to ground is ≥5V, no pull-up resistor R is needed; if the voltage to ground is ≈0V, a pull-up resistor R is needed. It is recommended to use a metal film resistor with a resistance of 10kΩ and a power of ≥1W. Other resistors can be used temporarily, but long-term use affects reliability, and the resistance should not be less than 3kΩ or connected directly to 24V.

Note: In some industrial computers, the input end may have a large series current limiting resistor. The main fault manifestation is that when the S2 camera OUT is pulled low, the industrial computer input end does not change. In this case, measure the industrial computer input end voltage to ground with a multimeter. If the voltage is high, adjust the pull-up resistor value until the voltage enters the industrial computer's low level range.

8. Troubleshooting Common Issues

8.1 Black Objects

Due to the TOF principle, the S series cameras are affected by the reflectivity of black pallets. Black pallets with a 5% reflectivity can achieve imaging effects within a range of 2 meters. During debugging, the imaging effect of black pallets can also be optimized through high integration time and low signal threshold in the upper computer software. If there are black fork arms in the obstacle avoidance scene, it is recommended to add auxiliary obstacles with higher reflectivity on the fork tips, such as painting the front of the fork tips with a different color.

8.2 Objects on the Ground Cannot Be Avoided

In obstacle avoidance applications, we generally configure the external parameters based on the ground. If low obstacles on the ground cannot be avoided:

1. If the point cloud map in the upper computer does not frame the obstacle, confirm whether the obstacle avoidance height (lower) is a positive value. If it is a positive value, set it temporarily to 0 to determine if the obstacle can be detected. If it still cannot be detected, adjust the camera installation height.
2. If the point cloud map in the upper computer frames the obstacle, but the obstacle avoidance result is 0, this may be caused by incorrect camera

installation height configuration. It is recommended to adjust the camera installation height.

8.3 Obstacle Avoidance Parameters Are Not Effective

1. Parameters were not saved by clicking "Complete Setup".
2. Modifying illegal parameters led to setup failure.
3. Unstable camera connection caused parameter setup failure.

8.4 Installation Structure Interference

1. There are structures blocking the camera's field of view during installation, causing abnormal camera data.
2. During structural design, the camera is designed too far back, causing visual interference and abnormal camera data.
3. The camera's protective film has not been removed, causing abnormal camera data.
4. Other protective glass installed on the camera lens caused abnormal data.