CE30-A Solid State Array LiDAR

Specification

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1. Product Overview

Figure 1 CE30-A

Characteristics

➢ Complete solid-state design
➢ Area-array detection
➢ Horizontal FOV > 120°
➢ Vertical FOV 9°
➢ ROI setting for obstacle avoidance mode
➢ Imbedded algorithm: nearest obstacle calculation, transferred by CANBUS

Table 1 CE30-A Specification

Parameter[1]	Typical Value
Method	Time of flight
Peak Wavelength	850nm
FOV[2]	132*9 degree
Pixel Resolution	320*24
Frame Rate	20fps
Ranging Resolution	1cm
Detecting Range[3]	0.1~4m

[1]Specific parameters may differ due to the testing environments and the test modes. Whiteboard with reflectivity 90% is used in the following as default, and the data obtained from the central pixels are used for evaluation.

[2]The detection can be customized.

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Repeatability（1σ）	≤3cm
Accuracy	≤6cm
Ambient Light Resistance[4]	60klux
Data Interface	CAN
Operating Temperature	0~50℃
Storage Temperature	-30~70℃
Supply Voltage	DC 12V（≥2A）
Power Consumption	≤6W
Dimensions	79*47*50mm
Enclosure Rating	IP65
Eye Safety Class	EN 62471
Weight	219g

2. Principle of Ranging

The ranging principle of CE30-A is based on Time of Flight (TOF). CE30-A emits modulated near-infrared light, which will be reflected by the object and received by CE30-A again. CE30-A calculates the phase difference and the time difference between the emitted and received light, which will be further converted to the distance of the obstacle.
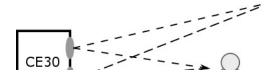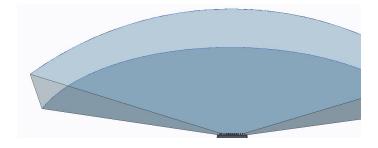

Figure 2 Schematic of the detecting principle

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[3]The result is based on the whiteboard with reflectivity 90%. The detection range of the blackboard with reflectivity 10% is around 1.5m. Different angles also lead to different maximum detection range. For details, please refer to Principle of Ranging.

[4] In strong ambient light, the accuracy may be reduced. Please refer to the manual for more details.

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Figure 3 Illustration of CE30-A detection area. Compared with single-channel LiDAR, CE30-A has a wider vertical FOV.
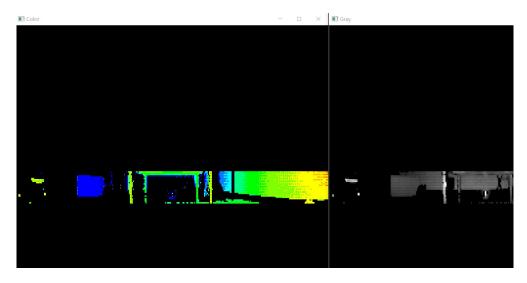

Figure 4 A real detected scene. Depth image (left) and corresponding grey image (right). In practical use, some cylindrical objects can be clearly captured (such as table leg).
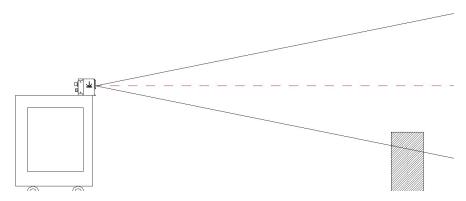

Figure 5 Application in the obstacle avoidance mode. Compared with the 2D Scanning LiDAR (the red line), CE30-A can detect obstacles lower than the mounting height.

CE30-A captures the distance information of all the obstacles within the detecting range and the FOV. The detecting area is shown in Figure 6.
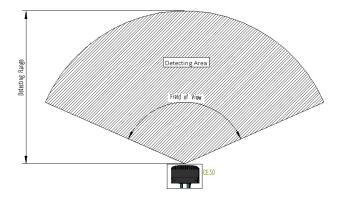
Figure 6 Illustration of Detecting Range and Area

The farthest detecting range of each angle has been optimized for general obstacle avoidance scenarios, which are different from regular detecting range. The schematic diagram is shown in Figure 6 (Customization is available for special requirements).
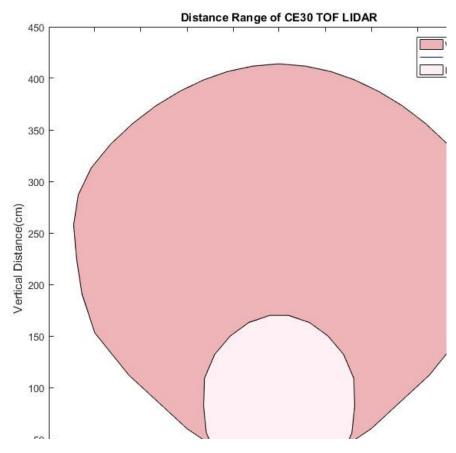

Figure 7 Optimized Detecting Area for Obstacle Avoidance Application

3. Description of Obstacle Avoidance Mode

3.1. Obstacle Avoidance Mode

The obstacle avoidance mode of CE30-A is especially developed for the application of robot's obstacle avoidance. In this mode, CE30-A will select the most critical obstacle and upload the distance information to the robots.

The principle of the obstacle selection is as follows: CE30-A selects the nearest obstacle to LiDAR. Then it gathers detecting and computing resources, to calculate the azimuth and the projected distance of the obstacle more precisely.
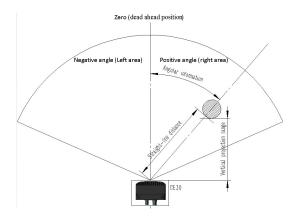
Figure 8 Testing Data Illustration (Top View)

Among them, azimuth represents the angular deviation between the obstacle and the central line of the LiDAR's HFOV (0 for central line, negative for left and positive for right) and the degree of trajectory deflection required to avoid the obstacle.

Projected distance represents the projected distance from the obstacle to the robot (the robot is square at default and LiDAR is installed on the front surface of the robot). It also indicates the emergence level of avoiding the obstacle.

3.2. Setting Warning Region in Obstacle Avoidance Mode

In many cases, not all objectives within the FOV worth the warning or the response of obstacle avoidance. The warning region can be set up in the obstacle avoidance mode. Once it is set up, though the detection range is the same, only the information of the obstacles in the warning region will be reported to the robot.

We could set the region of interest (ROI) by the width and depth:

1)   Width: the width of a LiDAR-centered area extending symmetrically. It's usually the same as that of the robot, i.e. the width of the robot in the direction of forward motion.

2)   Depth: the projected distance to the LiDAR, for which the front surface of LiDAR is set to be the zero plane. Usually, it corresponds to the distance that the robot needs to make brake in response to obstacles.

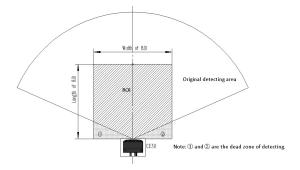*Figure 9 Schematic Diagram of ROI Function Description*

In the obstacle avoidance mode with ROI setting, CE30-A will preferentially trace the obstacles in the ROI. For example, Objective A inside the ROI and Objective B outside the ROI exist simultaneously. Even though Objective B is nearer to CE30-A than Objective A, CE30-A still returns the information of Objective A rather than Objective B, as shown in Figure 10.
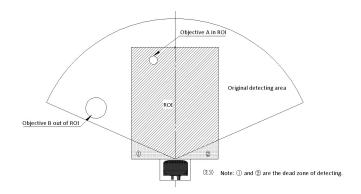
Figure 10 Schematic of ROI Function Determination

4.   Communication Protocol

The following sections describe the communication protocol between CE30-A and external devices. The interface supports Ethernet/TCP protocol and CAN bus. Currently only the CAN bus protocol is available for the obstacle avoidance mode.

4.1. CAN Bus (Obstacle Avoidance Mode)

CE30-A uses CAN standard frame, with interface rate 500kbps.

4.1.1.   CAN Command Frame Format

Table 2 CAN Command Frame Format

MPU-->CE30-A ID:0x606	Byte length	Description
Start command	1	bit7-6:11 bit5-1:00000 bit0： 1 - Start ranging and sampling 0 - Stop ranging and sampling
Spare	1	
Width	1	Unit: cm. 0: no width limit
Depth	1	Unit: dm. 0: no depth limit
Version number inquiry	1	0xaa 0x5a, 1: central line calibration. Please refer to the manual for more details.

1)   Depth is the ROI length of the test distance, in dm;

2)   Width is the ROI width of the test distance, in cm;

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3) The Spare field is temporarily retained.

4.1.2. Data Frame Format

Table 3 CAN Data Frame Format

CE30-A-->MPU ID:0x586	Data location	Explanation
The projected distance of nearest obstacle point	Byte0, Byte1: bit0_3	Unit: cm
The distance from the obstacle at its left point	Byte1: bit4_7, Byte2	Unit: cm
The distance from the obstacle at its right point	Byte3, Byte4: bit0_3	Unit: cm
The state of the obstacle	Byte4: bit4_7	bit4: 1 – Obatacle,.0 - No obstacle
The angle of the nearest obstacle point	Byte5	Degree
The angle of the obstacle at its left point	Byte6	Degree
The angle of the obstacle at its right point	Byte7	Degree

1) The data provided by the LiDAR is the projected distance of the obstacle to the front surface of the machine, and the angle of the nearest point of the obstacle, i.e. (z, θ). The center of the FOV is 0 degree, the left is negative and the right is the positive. See Figure 6.

2) The left point is on the left of the nearest obstacle; the right point is on the right of the nearest obstacle. The data of the two points provided now are the same as the central values (the internal algorithm has removed the untrusted value).

3) Distance data is 12bit, and transmitted by the means of little-endian, in cm.

4) All angle values are signed 8bit angle values, in degree.

4.1.3. Heartbeat Information

Table 4 Heartbeat Information

CE30-A-->CPU ID:0x587	Byte length	Description

Heartbeat packet	1	bit0: 1 - Start 0 - Stop bit1: 1 – Valid version number 0 - Invalid version number bit2_4: Heartbeat value (From 0 to 7 in turn) bit5_7: 00
Version number	2	*100 (version number data format ××.××; here magnified by 100 for integer value uploading)

The time interval of the heartbeat packet is 200ms. If there is a version inquiry, the heartbeat packet (including the version number) will respond immediately.

4.1.4.   Description

1)   The system will send a heartbeat packet at the interval of 200ms, with the format as follows:

id: 0x587   payload: byte0 (0 0 0 x x x 1 0)   byte1 (0 0 0 0 0 0 0 1), byte2 (0 0 0 0 0 0 0 0)

x x x: 0-7, the heartbeat value adopting circular order counting

2)   Start obstacle detection mode:

Host sends the instruction downward

id: 0x606 payload: 0x01 0x00 width distance xx

distance: set up the maximum detection range, in dm.

width: set up the maximum detection width, in cm.

xx: in case of 0xaa, CE30-A will return a heartbeat packet immediately. Since it is in running status, bit0 in payload byte0 of the heartbeat packet is 1.

3)   After starting the depth mode, the CE30-A will send the data frame at 20 fps.

4)   The data format uploaded in depth mode is defined in the protocol specified above. The payload data is 0 when there is no valid point, i.e. no obstacle in the set up detecting range.

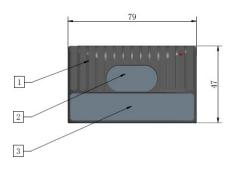*Note: See the attachment of reference code Benewake_Lidar_Reference.rar for details*

4.2. Ethernet (TCP/IP)
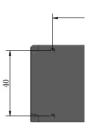
Please refer to the data sheet of CE30-C.

5.   Product Dimensions

Dimensions and installation instruction (customizable configuration structure)

1. Shell
2. Receiving panel (working area, no coving)
3. Sending panel (working area, no coving)
4. Power supply/CANBUS   (M8 aerial socket)
5. Ethernet port (M8 aerial socket)
6. Equipment installing hole (M3)

Figure 11 Structure and Dimension of DELiDAR CE30-A

6.   Aerial Socket Interface Description

Female: Ethernet connector - aerial socket with 8 mm diameter.

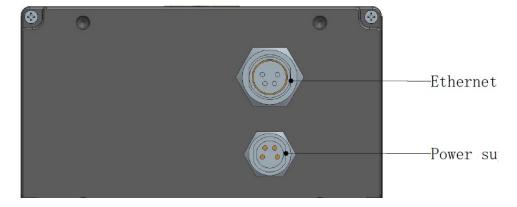Male: Power supply/CANBUS connector - aerial socket with 8 mm diameter.

Figure 12 CE30-A Aerial Connection Description

Power supply/CANBUS	Pin number	Explanation
	1	CAN_L
	2	CAN_H
	3	GND-
	4	12V +

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Figure 13 Power Supply/CANBUS Socket Pin Definition

Ethernet	Pin number	Explanation
	1	ETH_RX_P
	2	ETH_RX_N
	3	ETH_TX_P
	4	ETH_TX_N

Figure 14 Ethernet Socket Pin Definition

7. Package & Accessories

Accessories	Image	Remark
Aerial Connection – Power Supply&CANBUS		Power supply and CAN protocol
Aerial Connection – Ethernet (optional)		TCP protocol
Thermal Dissipation module (optional)		Support and Thermal Dissipation
Demonstration Kit (optional)		Windows Demonstration Kit (Windows 7/10 64)^

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