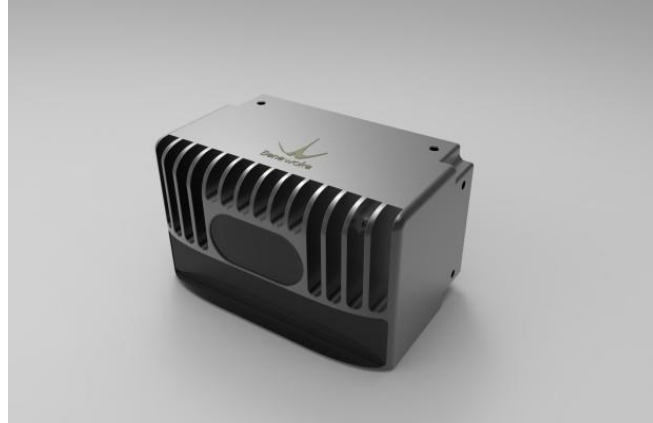


CE30-A Solid State Array LiDAR Specification

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1. Product Overview



CE30-A is a solid-state infrared LiDAR which is developed based on the ToF principle. Equipped with its special hardware design, it could complete the measurement of wide horizontal FOV and output the grey and depth information at the same time.

With its specially optimized obstacle avoidance mode, the detecting area of interest could be set, and the single-point projection distance information of the nearest distance point could be transferred through CANBUS. Compared with single-line scanning LiDAR, CE30-A does not contain any rotating compartments, which could ensure the reliability of the long-time work and a wider vertical detecting range.

Table 1 CE30-A Specification

Parameter ¹	Typical Value
Method	Time of flight
Peak Wavelength	850nm
FoV	132*9 degree
Pixel Resolution	320*24
Frame Rate	20fps
Ranging Resolution	1cm
Detecting Range ²	0.1~4m
Repeatability (1σ)	≤3cm

¹Specific parameters may be slightly different due to the testing environment and the test mode. White backdrop with the reflectivity of 90% is used in the following as default, and the data detected by the central pixels are used for evaluation.

²Different reflectivities result in different detecting ranges and different angles also lead to different maximum detecting ranges. For details, please refer to the section of “Principle of Ranging”.

Accuracy	≤5cm
Ambient Light Resistance	60klux ³
Data Interface	CAN
Operating Temperature	0~50°C
Supply Voltage	DC 12V (≥2A)
Power Consumption	≤4.5W
Dimensions	79*47*50mm
Enclosure Rating	IP65
Eye Safety Class	Risk group 0 in accordance with EN 62471
Weight	216g

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 time difference between the emitted and received light, which will be further converted to the clearance of the shot scene.

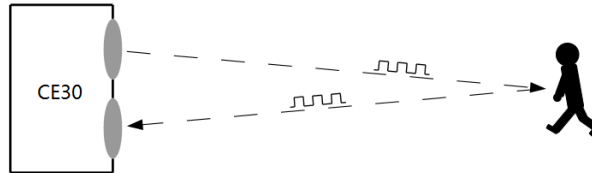


Figure 1. Schematic Diagram of CE30-A Detecting Range

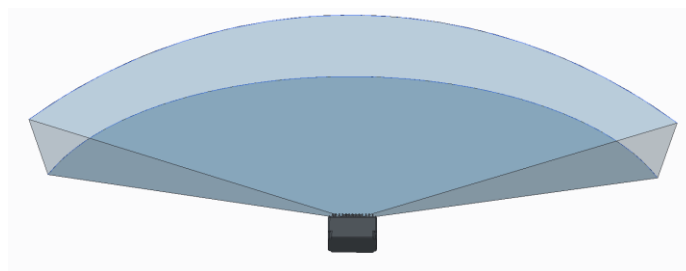


Figure 2. Illustration of CE30-A Detecting area. Compared with single-line LiDAR, CE30-A has a wider vertical FOV and therefore is able to identify obstacles in front.

³It can be used outdoors, but the detecting range and the accuracy will decrease.

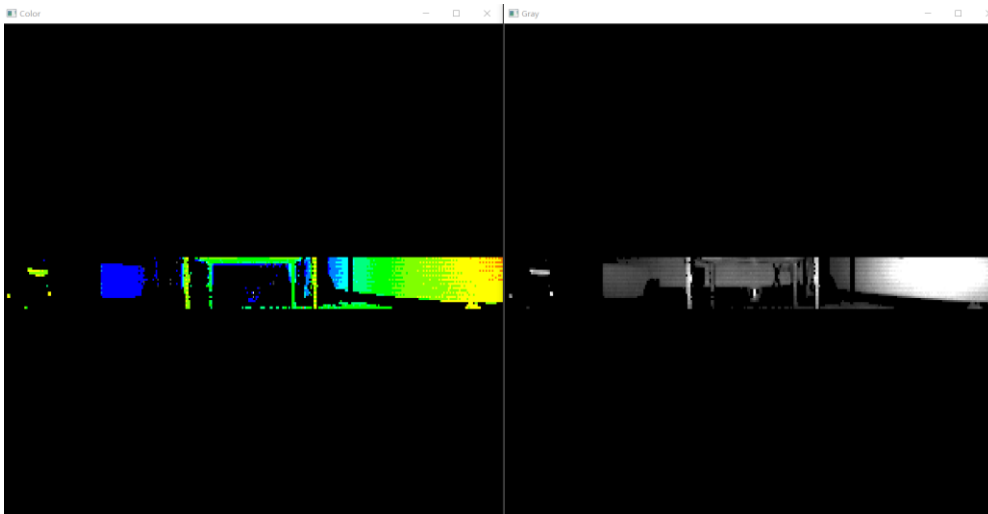


Figure 3 Illustration of Real Detecting Area; Depth image (left) and corresponding grey image (right). In the practical use, some rod-type objects are clearly visible (such as table leg).

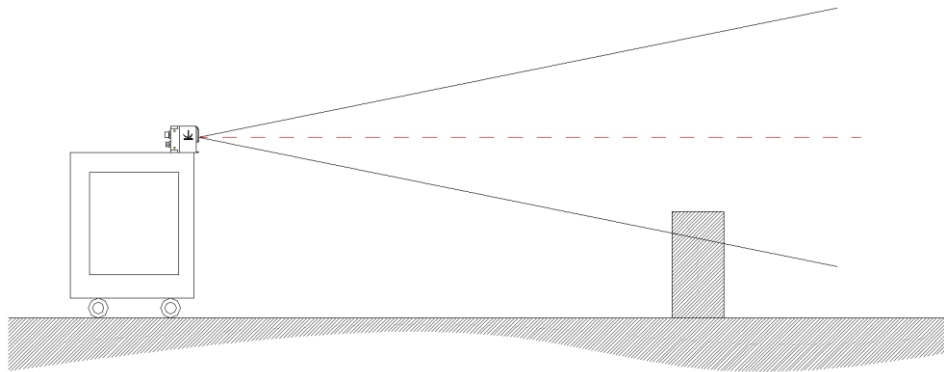


Figure 4 - Application in obstacle avoidance mode. Compared with the single horizontal detection of the 2D Scan LiDAR (Check the red line), the CE30-A can better avoid the low obstacles on the ground.

On the working mode, CE30-A could detect all positions within the detecting range (within the detecting FOV) and return the distance information. Results of distance and detecting area are shown in Figure 5.

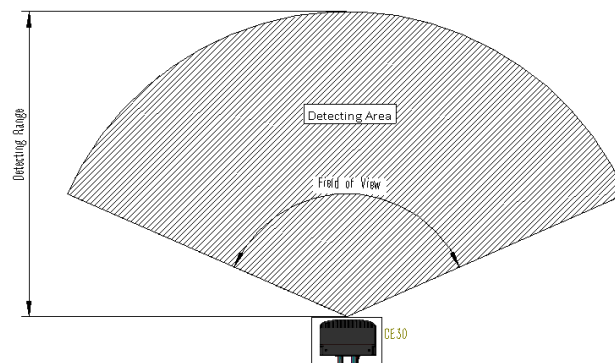


Figure 5 Illustration of Detecting Range and Area

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



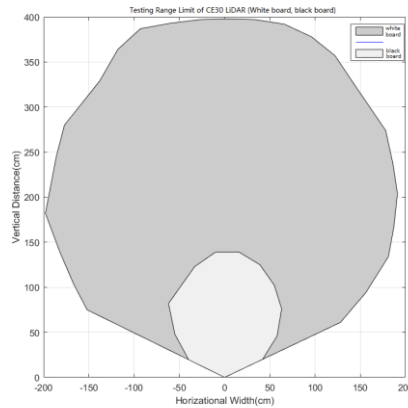


Figure 6. Optimized Detecting Area for Obstacle Avoidance Application

3. Description of Obstacle Avoidance

3.1. Obstacle Avoidance Mode

The obstacle avoidance mode of CE30-A is especially developed for the robot obstacle avoidance application. Under this mode, CE30-A will select out the most critical obstacle for the robots and provide the information to the robots.

The principle of the obstacle selection is as follows: CE30-A selects the nearest obstacle to LiDAR and handles detecting resources and computing resources in a centralized manner, to return the azimuth and vertical distance of the obstacle more precisely.

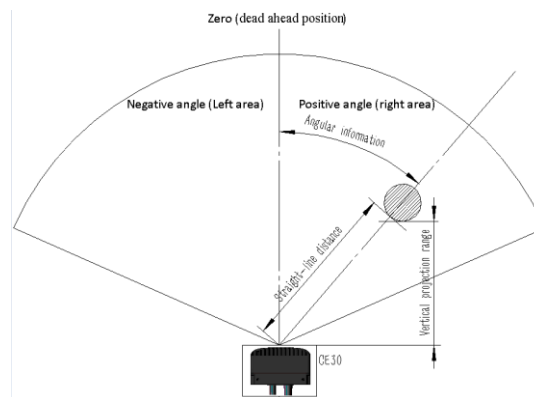


Figure7 Testing Data Illustration (Top View)

Among them, azimuth represents the angular deviation between the obstacle and the dead ahead position of LiDAR (0 for dead ahead position, negative for left and positive for right) and the degree of trajectory deflection that the robot requires to avoid the obstacle.

Vertical distance represents the distance from the obstacle to the robot (the robot is square at default and LiDAR is installed on the front surface of the robot) and the emergent level for the obstacle avoidance.

3.2. Setting Warning Region under Obstacle Avoidance Mode

In many cases, not all objectives within the detecting range deserve the warning or obstacle avoidance response of the robot. We set the function of warning zone under the obstacle avoidance mode. With the function, though CE30-A still detects the whole detecting range, it only sends warning signals and obstacle information to the robot when there are objectives in the warning area.

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

- 1) Width refers to a 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 refers to the vertical 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 response to obstacles.

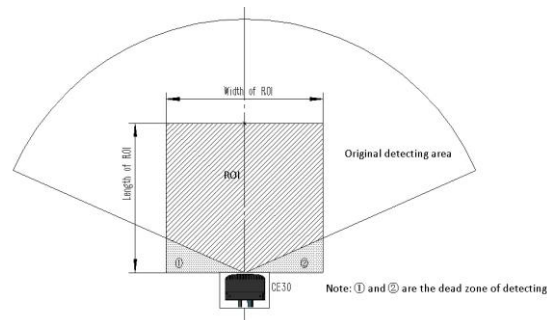


Figure 8. Schematic Diagram of ROI Function Description

Under 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 9.

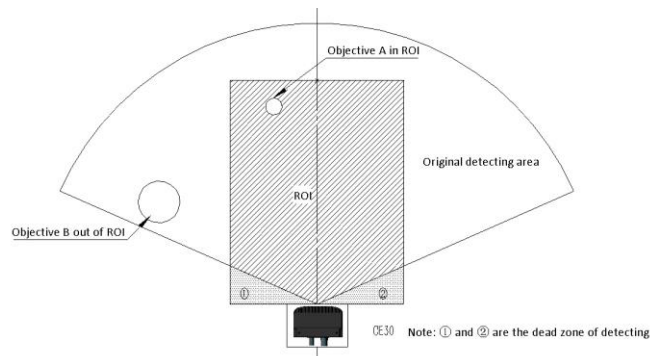


Figure 9 Schematic Diagram of ROI Function Determination

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. Among them, obstacle avoidance mode has been opened currently under CAN bus protocol.

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	Byte length	Explanation
ID:0x606		
Start command	1	bit7-6:11 bit5-1:00000 bit0: 1 - Start LiDAR's ranging and sampling 0 - Stop LiDAR's ranging and sampling
Spare	1	
Width	1	Unit: cm. In case of 0, there is no area limit
Depth	1	Unit: dm. In case of 0, there is no area limit
Version number inquiry	1	0xaa

- 1) Depth is ROI length of the test distance, in dm;
- 2) Width is ROI width of the test distance, in cm;
- 3) The Spare field is temporarily retained.

4.1.2. Data Frame Format

Table 3 CAN Data Frame Format

CE30-A-->MPU	Data location	Explanation
ID:0x586		
The distance from the 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 obstacle state	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
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- 1) The data provided by the LiDAR is the vertical distance (projection 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 dead ahead of the LiDAR is 0 degree, the left is negative value angle and the right is the positive value angle. See Figure 5 Definition Graph for Detecting Range and Detecting Area.
- 2) The left point is the point on the left of the nearest point of the obstacle; the right point is the point on the right of the nearest point of the obstacle; the data values 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 means of little-endian, in cm.
- 4) All angle values are signed 8bit angle values, in degree.

4.1.3. Heartbeat Information

Table 1.Heartbeat Information

CE30-A-->CPU	Byte length	Explanation
ID:0x587		
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 $\times\times.\times\times$; here magnify 100 times for integer value uploading)

The time interval of the heartbeat packet is 200ms. If there is a version inquiry instruction, the heartbeat packet (including the version number) will return in real time.

4.1.4. Explanation

- 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 1), byte2 (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: Send the instruction downward



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

distance: Set up the maximum detecting range, in dm.

width: Set up the maximum detecting width, in cm.

xx: In case of 0xaa, CE30-A will return a heartbeat packet in real time; because 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 a rate of 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.

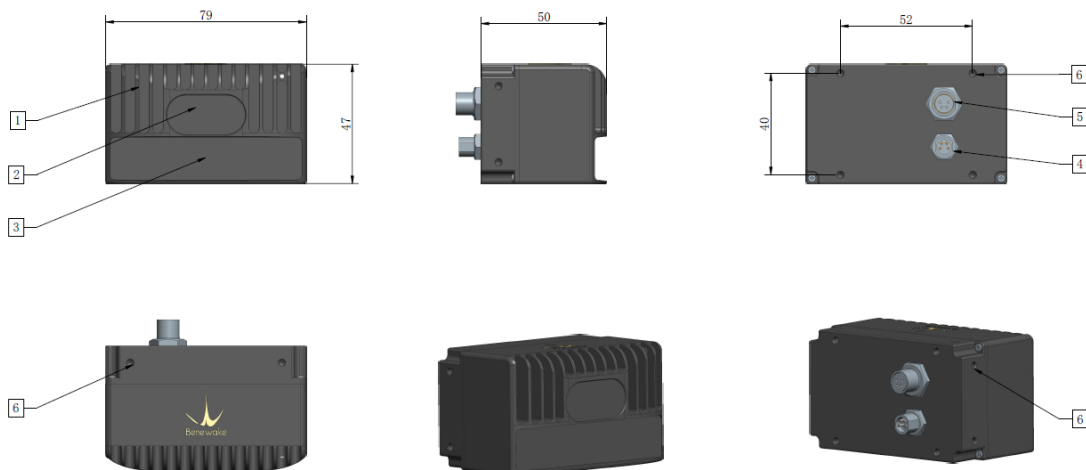
Note: See the attachment of reference code Benewake_Lidar_Reference.rar for details

4.2. Ethernet (TCP/IP)

(TBD)

5. Product Dimensions

Dimensions and installation location description (customizable configuration structure)



- | | | |
|---|--|--|
| 1, Shell | 2, Reception panel (working area, no covering) | 3, Sending panel (working area, no covering) |
| 4, Power/CANBUS port (M8 aerial socket) | 5, Ethernet port (M8 aerial socket) | 6, Equipment installing hole (M3) |

Figure 10 Structure and Dimension of DELiDAR CE30-A

6. Installation Instruction

1. CE30-A is fixed with the robot by installing the location hole.
2. The work area should not be blocked after installation.
3. All parts of the robot should be placed behind the front working area of the CE30-A, i.e. the CE30-A needs to be protruded, or at least the working area is flush with the front surface of the robot.

Note: see Attachment DE-LiDAR CE30-A Installation Instruction for detailed installation and use process

7. Aerial Socket Interface Description

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

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

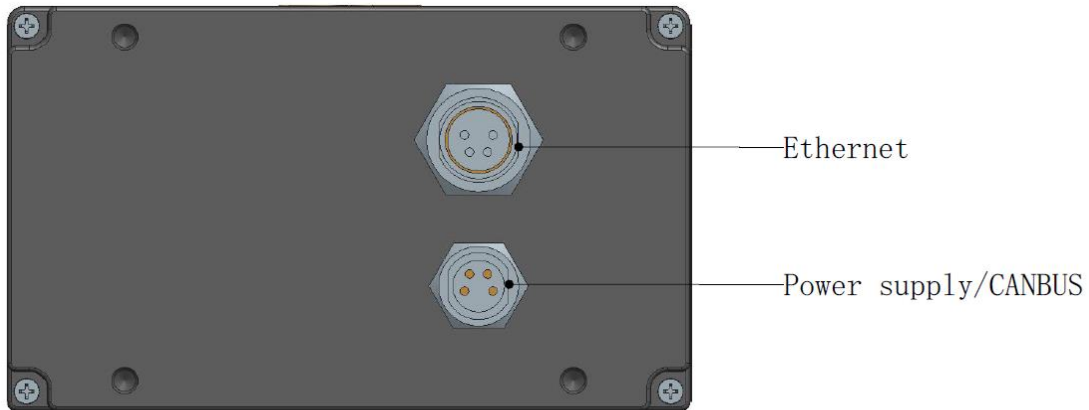


Figure 11 CE30-A Aerial Connection Description

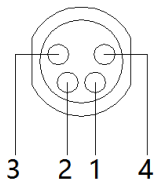
Power supply/CANBUS	Pin number	Explanation
	1	CAN_L
	2	CAN_H
	3	GND-
	4	12V +

Figure 1 Power Supply/CANBUS Socket Pin Definition

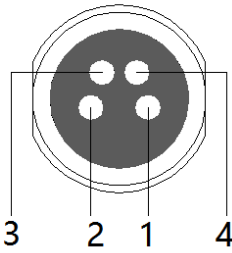
Ethernet	Pin number	Explanation
	1	ETH_RX_P
	2	ETH_RX_N
	3	ETH_TX_P
	4	ETH_TX_N

Figure 23 Ethernet Socket Pin Definition

8. Package & Accessories

The complete suite includes one CE30-A LiDAR, one power supply & CAN aerial connection, two fix screws, and one Ethernet port aerial connection (optional).