3D CAMERA BASED LASER PROXIMITY SENSOR

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ABSTRACT

This article describes principle of camera based 3D laser proximity sensor that has been developed for the purpose of mapping in mobile robotics. There are also presented some basic algorithms for data processing and map building.

1 INTRODUCTION

In present day, there is high accent on research in the area of the autonomous mobile robotics. Autonomous behavior of mobile robots is rewarding especially in areas, where the human activity is difficult, hazardous or impossible. Autonomy of robotic system is interpreted as ability to pursue activity without human control.

The basic requirement for such behavior is familiarity with environment, where the robot works. There is a lot of ways how to receive and represent knowledge about environment. The most common is to measure distances of obstacles either by ultrasonic sensors or by laser proximity scanners. For distance count is usually used known speed of propagating (sound, light) and time of receiving the reflected beam. Measured data are then stored and represented in matrix – map of area. In the case of common industrial electro optical sensors the light beam is projected into the space by rotating mirror. The time of flight of reflected beam is then detected by the light sensitive device.

Presented construction of the proximity scanner is based on the principle of active triangulation. Laser line is spitted from point by the lenses. The entire sensor is completed of the commonly available parts. This reality should influence especially the price of the scanner. Also the weight of such sensing devices is remarkably low, than the weight of industrial sensors, that are principally determined for other purposes i.e. safety of industrial processes and process automation.

2 MEASURE FOR DISTANCE DETERMINING

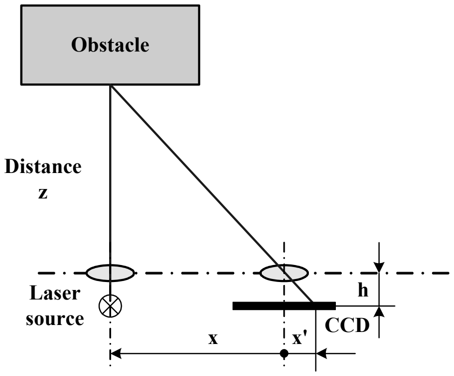


Fig. 1: *Active triangulation*

The principle of developed sensor is an active triangulation. Into the observed space is projected light beam. Thanks to known distance of sensor and light source, focus and resolution (given by mechanical and optical configuration) is possible to determine distance on the basis of triangles similarity.

$$z = h\frac{x}{x'} \qquad (1)$$

From the equation (1) is obvious, that there is necessary only to measure the value of variable x'.

2.1 CAMERA BASED LASER PROXIMITY SENSOR

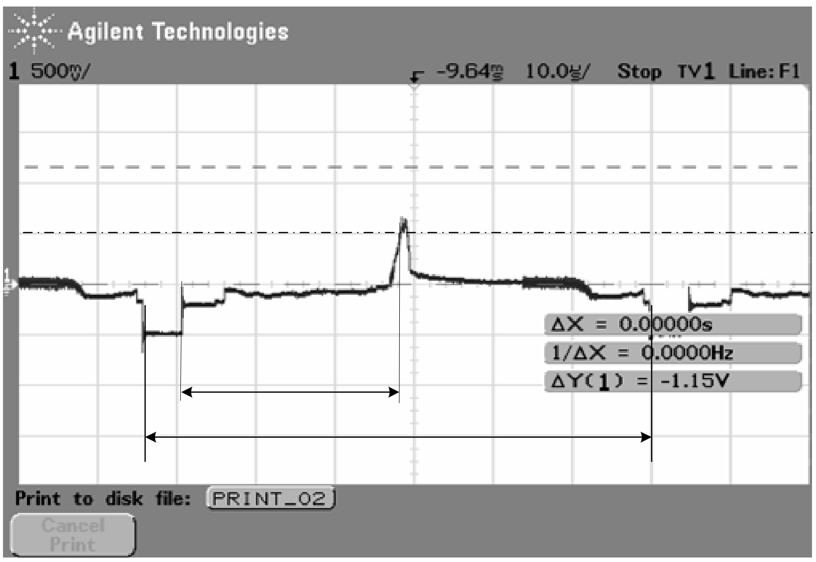
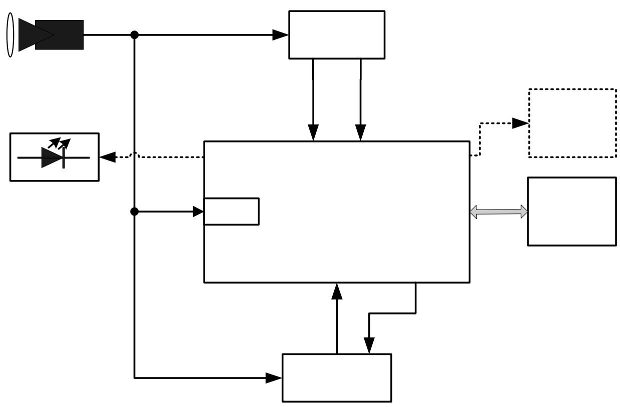


Fig. 2: *Video Signal with laser spot pulse*

The reflected laser beam is in picture represented as a spot with high intensity. In video signal this high intensity is proven as a peak with value bigger than surrounding signal. Position of this peak is expressed as a time since the start of video signal line (horizontal pulse). The time, when pulse has come is determined by hardware comparator. From this time and known mechanic-optical constant is then computed distance of obstacle.



Because CCD chip is sensitive about the entire visible spectrum in front of lenses is installed optical filter that releases only the light of wavelength corresponding the wavelength of laser source (680 nm).

Fig. 3: *Proximity sensor schematic diagram*

Oscilloscope Cursor

The hardware solution is based on Motorola DSP56F800 line. Time measurement is started by interrupt signal from the sync separator. Timer is running since the peak is received. The threshold level of hardware comparator is possible to set either by hardware or PWM regulator of the DSP. All measured times are stored into the memory and sent via serial line to computer, that creates maps of entire environment. The control computer also can send commands for the sensor.

3 MAPPING ALGORITHM

The mapping is complex task that comprises many of sub stages. In this time there are proposed and tested stages for data acquisition and data segmentation. Output data of the acquisition block are in the form of matrix. The line and row number correspond to dimension of the picture in gray level (color).

For data segmentation has been used gradient method that looks for boundaries of he object in the depth image. The value of gradient matrix G points is count by the:

$$G_{(x,y)} = \left|P_{(x,y)} - P_{(x,y-1)}\right| + \left|P_{(x,y)} - P_{(x-1,y)}\right| \qquad (2)$$

x,y - coordinates of depth picture (matrix)

P - measured value - depth

The coordinates of boundaries are then passed into Data Approximation block, where individual parts of space are fitted by the planes by the method of least squares.

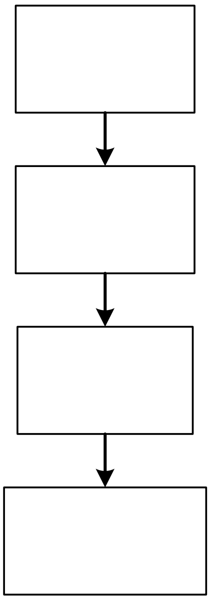


Fig. 4: *Mapping algorithm*

Measured data depicted in following pictures are not calibrated yet. Depth data correspond to time of laser pulse multiplied by unknown mechanic-optical constant. The calibration is the next step for completing the data acquisition unit.

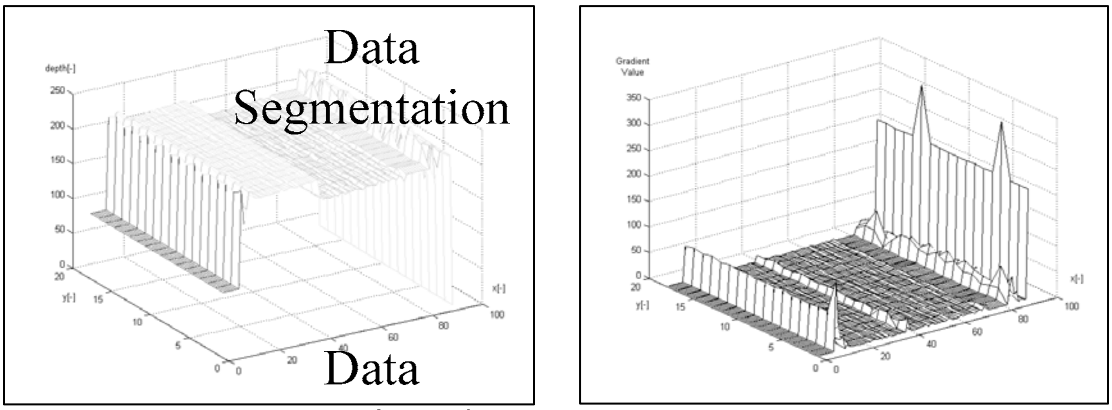


Fig. 5: *Measured depth data and values of gradient in each point of environment*

4 CONCLUSION

In this time the sensor is equipped with fixed focused camera. In the future would be possible to use camera with focusable lenses and with the possibility of setting the aperture. Also algorithm for mapping should be supplemented with the routines for sensor calibration and with the block for approximation and data storage.

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