Proposal of a Method to Detect Position of Moving Object from a Camera Using LEDs and Markers

Takato Komori, Shiyuan Yang*

Department of Electrical and Electronic Engineering, Kyushu Institute of Technology, Kitakyushu, Japan

*Corresponding Author: yang@elcs.kyutech.ac.jp

Abstract

The authors proposed a new indoor position detection method using a surveillance camera and LED markers for the increasing demand of robots. Robots such as automatic guided vehicles can be expected to be used not only in factories but also in a wide range of fields, so it is necessary to provide position detection system with easy introduction and high accuracy. The proposed method uses a general surveillance camera to capture a moving target with an LED marker. By using the information from camera image and the angles and height of the camera, a high accuracy position detection can be achieved when the height of the target LED marker can be obtained.

Keywords: Position detection, indoor, moving object, LED marker, robot, surveillance camera.

1. Introduction

In recent years, automatic guided vehicles such as robots have been widely used for transporting raw materials, parts, finished products, etc. at manufacturing sites such as automobile manufacturing factories. It is also widely introduced in non-manufacturing fields such as distribution centers that store and ship products. It is expected that the robot market will continue to expand in the future.

An accurate self-position estimation method is required when using an automated guided vehicle especially for indoor. Simultaneous Localization and Mapping (SLAM) technology is widely used by combining with various sensors such as Lidar, camera, acceleration sensor, wheel odometry, etc.

Lidar irradiates a laser beam, measures the time it takes for it to hit an object and bounces off, so that measures the distance and direction to the object. As a feature, the

luminous flux density is higher than that of radio waves, and the position and shape can be detected with high accuracy. However, there is also the problem that it is difficult to detect objects that have low reflectance and it is expensive than other sensors.

Stereo camera method of estimating the distance information of an object contained in images taken by multiple cameras from the characteristics and positional relationship of the cameras. It is possible to detect objects at any distance, and it can also be used for objects with low reflectance. However, at least two cameras are required, and there are problems such as low spatial resolution and difficulty in detecting smooth and curved objects.

We propose a method only use one camera and an LED marker which is easy constructed and cheaper in the next chapter.

2. Construction of Proposed Position Detection Method

In this section, we show the construction for indoor position detection using a camera and an LED marker which is illustrated in Fig.1. Supposing the floor is a horizontal plane and installing the camera parallel to the horizontal plane. The LED marker blinks at a constant low frequency which can be detected by the camera.

Fig. 1 Illustrate of one camera and LED marker position detection system

Fig. 2 Coordinates of one camera and LED marker position detection system

For convenience purposes, we set the coordinates of the measuring system as shown in Fig. 2. The center of the coordinates is set at the center of camera lens, so that the coordinates of the LED marker at horizontal plane are same to the corresponding X and Z . Then we have

$$\frac{X_{cal}}{f} = -\frac{X_c}{Z_c} \quad (1)$$

$$\frac{Y_{cal}}{f} = -\frac{Y_c}{Z_c} \quad (2)$$

where X_c, Y_c, Z_c are the coordinates of the LED marker, and X_{cal}, Y_{cal} are the coordinates of the LED marker focused on the camera image sensor plane, respectively.

Let the heights of camera and LED marker be H and h , respectively, which can be measured previously, we can define $H-h > 0$ because a general surveillance camera is set at high position. Then we have $Y_c = h-H$. Using this condition and combining the above Eqs. (1) and (2), we have the coordinates of the LED marker, X_c, Z_c as follows:

$$X_c = -\frac{(H-h)X_{cal}}{Y_{cal}} \quad (3)$$

$$Z_c = \frac{(H-h)f}{Y_{cal}} \quad (4)$$

The coordinates of the LED marker focused on the camera image sensor plane X_{cal}, Y_{cal} can be calculated from the pixel number (m, n) which are the same directions to the X and Y axes in Fig. 2. That is

$$X_{cal} = m \frac{X_{camera}}{M} - \frac{X_{camera}}{2} \quad (5)$$

$$Y_{cal} = n \frac{Y_{camera}}{N} - \frac{Y_{camera}}{2} \quad (6)$$

where M, N are the total number of camera image sensor and X_{camera}, Y_{camera} are the sizes of camera image sensor in the horizontal vertical directions. Therefore Eqs. (3) and (4) become

$$X_c = -\frac{(H-h)}{Y_{cal}} \left(m \frac{X_{camera}}{M} - \frac{X_{camera}}{2} \right) \quad (7)$$

$$Z_c = \frac{(H-h)f}{n \frac{Y_{camera}}{N} - \frac{Y_{camera}}{2}} \quad (8)$$

Equations (7) and (8) are the coordinates of the LED marker on the floor as shown in Fig. 2.

Next we show the process of coordinate measurement of LED marker.

Step 1:

Input the image from the camera to a computer and binarize the image using a general binarizing algorithm to extract the area of LED maker.

Step 2:

Calculate the center of LED marker with Morphological processing to get the center pixel number (m, n) .

Step 3:

Use Eqs. (7) and (8) to obtain the position of LED marker.

Step 4:

Get the next image from camera and repeat these steps to detect the position of LED marker with real time.

Figure 3 shows the flowchart of LED marker position detection. By repeating the detection of LED marker position, the position of a moving object can be measured at real time.

Fig. 3 Flowchart of LED marker position detection

3. Experiments and Discussions

We show some experimental results using a simple construction with a surveillance camera (Panasonic network camera BB-SW174WA) and an LED light as the maker. The camera sensor sizes are 3.52 mm in horizontal direction and 2.64 mm in vertical direction. The image pixel numbers used in experiments are 640 pixels in Horizontal direction) and 480 pixels in Vertical direction. The camera focus distance is 1.95mm. The center height of camera sensor is set at 850mm and center height of LED light is set at 200mm. Experiments were performed with same intervals of 50mm in Z -axis direction and X -axis direction that the LED light was moved in the areas from 1500mm to 2000mm in Z -axis direction and from -1000 mm to 1000mm in X -axis direction. The vertical distance between the camera and the LED light was set as 700mm.

Figure 5 shows the experimental results of LED light maker at different coordinates on the vertical plane. The measured X -axis direction coordinate values are mostly near to the true value for various distance Z . The maximum of errors in X -axis direction was 50mm.

Figure 6 shows the measured Z -axis direction coordinates when the X -axis direction coordinate is changed with different Z value. The measured Z -axis direction coordinate values are mostly near to the true value for various distance X . The maximum of errors in Z -axis direction was 30mm.

From the experimental results performed with poor set up as shown in Fig. 4, we obtained position detection with errors less than 50mm. This is enough for general usage such as indoor robot guiding and other moving object position detection. Moreover, it would be possible to reduce the errors by using high resolution camera. It is also possible to achieve high accuracy of measurement by using collimation to improve the measurement setup.

4. Conclusions

We proposed a new position detection method for the coordinate measurement of indoor moving object. This new method has the merit that a general surveillance camera can be utilized and a cheap LED marker can be used for easy image processing. It has an enough accuracy for indoor moving object detection purpose. In addition, this system can be combined to other purpose applications with position information supplying. In this study, we only considered the case that the camera is paralleled to the horizontal floor plane.

We will show analysis and experiments for other cases such as using the pan and tilt angles of camera in the near future.

Fig. 4 Image of experimental construction

Fig. 5 Measurement results on X -axis with different Z value

Fig. 6 Measurement results on Z -axis when the X -axis coordinate is changed with different Z value

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