Distance Measurement Between Camera And Object Using Canny Edge Detection And Bounding Box Parameters

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Abstract— **In order to measure the distance of an object from a point, a measurement technique using a single camera is proposed in this paper. The main aim is to find the distance of an object that is placed in front of the camera. In this method the first step is to capture the image of the object. Then the captured image undergoes filtering to remove noise. After removing noise a bounding box is created based on the size of the object. By considering the parameters of the bounding box and the dimensions of the object the distance calculation is performed. The proposed model is applicable for the objects that are moving. Experimental results are carried out by using MATLAB to estimate the measured distance by the proposed method.**

Keywords— Distance measurement, Camera , Bounding box, Object, Noise.

I. INTRODUCTION

Distance measurement is a major role for an intelligent robot or an agent to understand its workspace. This feature has been embedded in many of Driver Assistance Systems [1, 2] and mobile robot applications [3]. There are many methods used to find the distance to objects or obstacles for various operating environments. Some tools send signals to object such as laser or ultrasonic rangefinder. However, some methods only get information about the object position such as measurements based on vision algorithms.

Vision algorithms have been used to extract lines and points to determine the location of robots [3]. In vision methods, the standard form is to use the stereo systems which require at least two cameras or changing camera position and parameters. Moreover, this requirement increases system cost and power consumption. Therefore, effective methods can be provided that can be used in single-camera systems are required. Holzmann and Hochgatterer built a mobile phone for indoor and outdoor distance measurement [4]. Lamza, Wrobel and Dziech measured distance with different focus settings [5]. However, they need modification in camera or the lens parameters . Di, Shang and Wang measured distance with a single rotating camera by using Perspective Projection Model with a relative accuracy about 3% [6]. Sugimoto, Kanie, Nakamura and Hashizume used single camera and ultrasound for 3D localization [7]. Ali,Kurokawa and Uesugi used a method that is having a single camera in order to improve the precision measurement in machining technology [8]. Zhang, Stahle, Gaschler, Buckl and Knoll presented an approach based on Random Finite Set (RFS) Statistics to estimate a vehicle's trajectory in complex urban environments by using a fixed single camera [9]. Dong offered a vision measurement method for estimating the distance of the object in static scene, which requires single camera with 3-axis accelerometer sensor and rotated around a fixed axis [10].

In this paper, a method based on a single-camera is proposed where vision techniques is used to measure the distance of objects by assuming camera is stationary. The proposed method can be employed especially for object that are not stationary.

A filter could be applied to reduce noise from the imaging system [11]. In this study, Median filter has been employed to improve the image quality. To obtain a binary image, an optimal automatic threshold detection method based on the image histogram is used (the Otsu's method [12]). Also, the morphological operations, which are useful for the separation and characterization of shapes [13], have been applied to the extracted components from binary images. However, using edge detection here the objects are identified and the distances are measured.

Experiments are carried out in MATLAB platform to observe how much the measured distance by the proposed method converges to the actual distance of the object.

The rest of this paper is as follow. In the next section, a distance measurement system based on the proposed method is presented. In the third section, the results of the experiments are demonstrated and discussed. The last section is the conclusion.

II. DISTANCE MEASUREMENT IMPLEMENTATION

The overview of the proposed distance measurement system is shown in Fig. 1. The implementation of this system can be divided into three main stages: pre-processing, establishment of correspondence, and calculating the distance.

A. Pre-processing Stage

At this stage, the required features of each image are extracted in order to use in subsequent processes. Firstly, the snapshots that taken from the camera are considered in both color and grayscale forms in order to perform next operations in parallel on the both image forms. The color image is used for detection and extraction of the objects, while the grayscale one is used to extract edges of the object. To detect the object from the background, the color characteristic is used. Here, the object's color is red. In this stage, the color image is subtracted from the corresponding grayscale one. Then, the object is detected and extracted from the background. Detection of the object with red color is shown in Fig. 2.

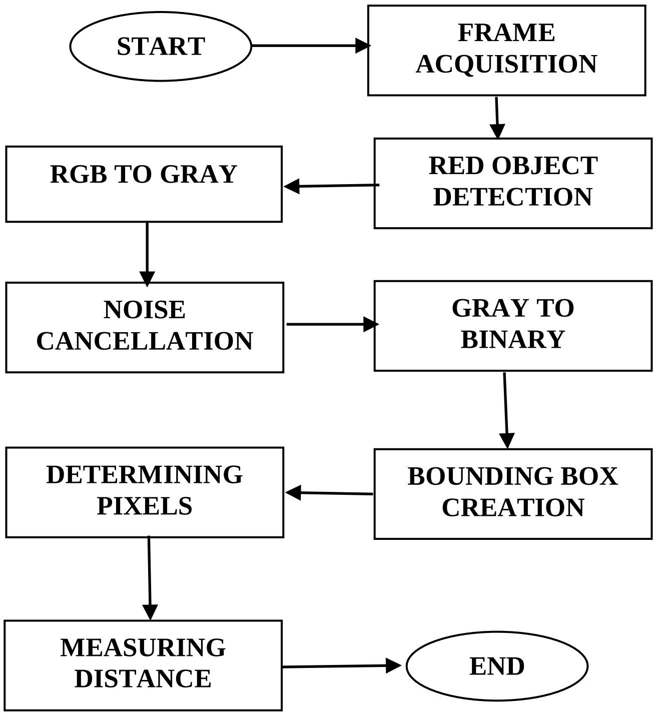

Fig. 1. Flow diagram of the system implementation

Afterwards, Median filtering operation is used to reduce noise in color and grayscale images so that the objects and floor lines can be detectable better. In this filter, the noisy values are replaced with the median value of the neighborhood by the mask.

After filtering operation, the next step is to convert the color and grayscale images to binary images. This method assumes that the pixels are the components of foreground or background. The threshold value is found as so it minimizes the sum of the foreground and the background distribution. Details are mentioned as follow.

(a)

(b)

Fig. 2. (a) Color snapshot, (b) subtracting color image from corresponding grayscale to detect the red object.

The next step operates on binary images. Binary morphology consists of basic operations: dilation and erosion, and several combinations of them. This operation uses structural elements as 4- or 8- neighbor. However, the structural element values can be 1 or 0. Here, these values are considered as 1.

Dilation causes to expand the connected sets of 1 in a binary image. It can be used for expanding the shapes and filling small holes, gaps and empty spaces. Assuming the mask B is the 3x3 matrix whose all cells are 1, the area of A under B becomes 1 if any cell of B intersects with 1-valued pixel of A. Erosion causes to shrink the connected sets of 1 in a binary image. If all cells of B intersect with 1-valued pixel of A, the area of A under B becomes 1, else all pixels become 0.

Thus, erosion can be used for shrinking shapes and removing small protrusions.

Opening and closing operations are useful combination of dilation and erosion. Either closing or conditional dilation operations are used to fill small holes on a binary image. Opening operation can be used to remove the slim connections. In the proposed system, noise has been partially reduced by using the combination of the above operators. The result of these operations is shown in Fig. 3 for an example image.

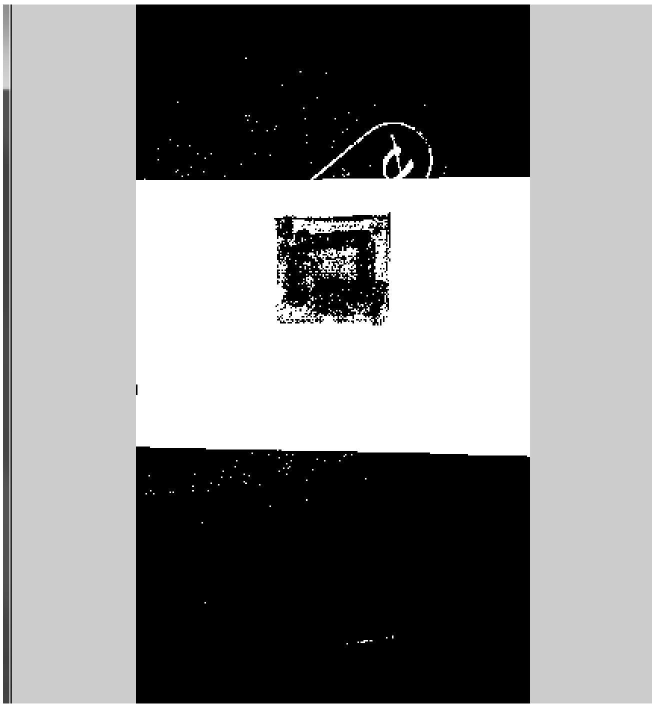

Fig. 3. Color snapshot after getting binary form.

B. *Creating Bounding Box*

In order to extract the edges, the binary form of the grayscale image is sent to the Edge detection algorithm. **Edge detection** consists of a variety of mathematical methods. They aim at detecting points in a digital image at which the image brightness changes sharply, has discontinuities. The points at which image brightness changes sharply are termed *edges*. The problem of finding discontinuities in 1-D signals is known as step detection. Also the problem of finding discontinuities over time is known as amendment detection. Edge detection is a basic tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction.

Based on the edges of the object the **Bounding Box** is created. The object that we need to detect is identified by drawing a bounding box around that object. The creation of bounding box can be observed in the following Fig.4

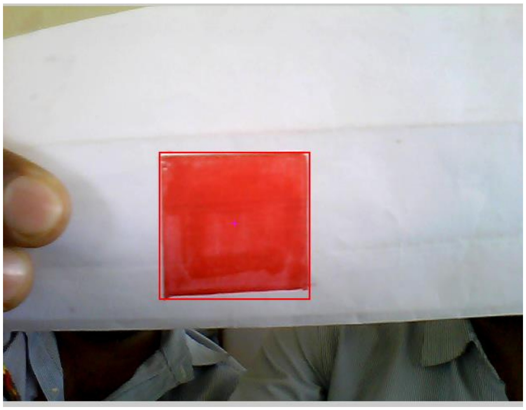

Fig. 4. After creating Bounding Box.

C. *Distance Calculation*

As shown in the Fig.1 i.e, from the flow chart. After the creation of the bounding box the pixels are to be determined. The pixels can be determined by considering the starting value and ending value of the bounding box in the x-axis. To know the width of the box we need to subtract the ending value from the starting value of the bounding box. Then we get the width of the bounding box in terms of pixels.

Since to calculate the distance of an object from camera, the size of the object will vary as the object moves from the camera. i.e. as the object comes closer, then the size of the object will be increased and when the object moves away from the camera then the size of the object will be decreased. So based on this, the bounding box is created so that the size of the bounding box also varies along with the size of the object.

By considering the parameters such as, Length of the object(cm), Focal length of the camera and Width of the bounding box(in pixels) we can calculate the distance of the object as,

$$D = (L \times F) / W$$

Where, D is the distance of the object from camera

L is the known length of the object

F is the focal length of the camera

W is the width of bounding box in pixels.

By using the above formula the distance can be measured and is shown as in the Fig.5(a,b). The Fig.5(a) shows the measured distance and Fig.5(b) shows the varying distances with respect to time.

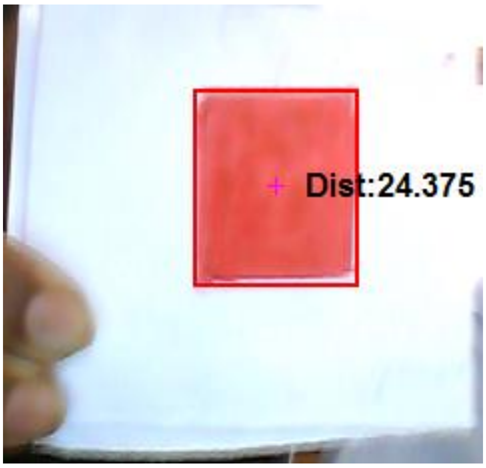

Fig.5(a). *Measured distance*

Fig.5(b). *Varying distances with respect to time*

III. CONCLUSION

This paper presents a successful implementation of a distance measurement method based on edge detection algorithm. The main idea is quite new and it can be implemented with simple image processing techniques. The proposed method is designed for a single-camera condition. However, edge extraction and pixel identification is the main stage of the method. The distance is calculated in pixels. Experimental results are carried out to observe the relationship between real and measured distances. Results of experiments prove that the proposed method has a good performance and it can be applied to real time applications.

IV. FUTURE SCOPE

This distance measurement technique can be used in the automotive industry. This is also helpful in the robotics for the better understanding of the distances for robots. As this model is limited only for the detection of red object this method can be further implemented for different colored objects with different dimensions.

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