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A Method for Determination of Object-Camera Distance by Using Single Camera

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Abstract

In this study, widely used in many areas of the detection object using image processing methods, depending on the technological development in recent years and has been studied determining the distance from the camera of the specified object. The method can be used in robotic applications more cost-effective to measure the distance of the object to the camera using a single webcam proposed. An algorithm has been developed out of the results obtained are optimized algorithm can be used to determine the object distance. The system has been tested and the results are monitored in real time. Comparison with other method (Euclidean distance and histogram thresholding) has been developed algorithm used. The algorithm developed in MATLAB.

Keywords: Object-Camera distance, Image processing, Determination distance

INTRODUCTION

Nowadays, people are consistently changing and because of the move was aimed to design and production of mobile robots. Recognize the environment of mobile robot was required to collect information from their environment and the development of decision-making in accordance with this information. Robots are needed for various types of sensors that can detect the environment ability to meet these requirements [1]. Developing technological work, vision-based mobile robot has paved the way for the work. The distance from the object of an object, size and movements, and efforts to have gained weight in recent years through the use of cameras. Image processing necessary for this purpose is a very long time. Therefore, most of the sensors in the robot system for the non-visual controls of the camera are also used outside the robot. However, the objects for determining the distance of the robot in terms of increased cost of the use of a plurality of these sensors is emerging as a disadvantage. Thus, the practice became a more advantageous position to use the camera in the robot controls. [2].

In this study, the object detection using image processing methods, and has been studied determining the distance to the camera detected object. The distance from the camera of objects using various objects in different ways have been tried to be calculated. Applicable in the method of distance measurement commonly used in image processing is examined. It was compared from the methods used in determining performance. An algorithm has been developed that can be used to determine the results obtained from the object through. System tested and the results are monitored in real time.

METHODOLOGY

Object Estimation

Security is becoming more important to people day by day. One of the most important are the surveillance system of a robust security system. A security system can usually be expressed as a spotter or surveillance system. Such a system is monitored electronically using image processing techniques.

To monitor and identify the desired location and tracking of moving objects (T-and-T) can. To follow a moving object or objects, it is a major problem discussed on a computer [3].

For a variety of objects, object estimation was made using different methods. The distance from the camera with the help of different mathematical algorithms are calculated for the specified object. The method used during operation is as follows.

Object estimation

- HSV space in thresholding
- Histogram thresholding
- Filtering [median filter]
- Connected-Component Labeling
- Distance calculation
- Classification
- Euclidean distance

Object estimation is very important for the study. Distance measurement object is done by looking at the pixel area occupied by the object after the estimation made.

HSV Space in Thresholding

The brightness of the RGB color space has the effect of all components. In the HSV space, as opposed to just the brightness RGB space has the effect of H values. The operation of the system, the effect of brightness that causes instability to minimize the received image is drawn to the HSV space. HSV space, a threshold determined by trial and error on the converted images are applied. Thus, the estimation object is achieved even more stable operation under various environmental conditions. In Figure 1, it has been the RGB space to HSV space and were followed thresholding the image is shown. In cases where changes of light intensity, the noise are formed. To eliminate the noise generated morphological operations is used. Also, the image filtering operation is applied if necessary. As a filter, the median filter is used. 15 m until, post-Connected-Component Labeling thresholding method is used to get rid of the noise generated. The algorithm and the Euclidean distance estimation method of the HSV object when thresholding is used. Methods have been tried for the various objects.

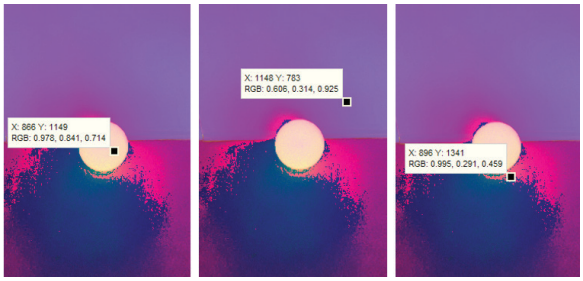

Figure 1. Comparison of RGB values at different pixels

Histogram Thresholding

A histogram is a graph showing how many units the numerical value of each color in a picture. Referring to this graph, knowledge of the state image brightness or hue may be [4]. Abscissa axis shows the gray level, and the ordinate axis shows the frequency of occurrence. In Figure 2, a histogram graph of the object and the object is shown. It shows the object's range of gray levels the red circle in Figure. The vertical axis, it shows how many pixel gray level. When the camera closer to the subject, the range of gray levels to be the same, but will increase the number of pixels of gray levels. Because objects closer to the image area that will be covered more pixels.

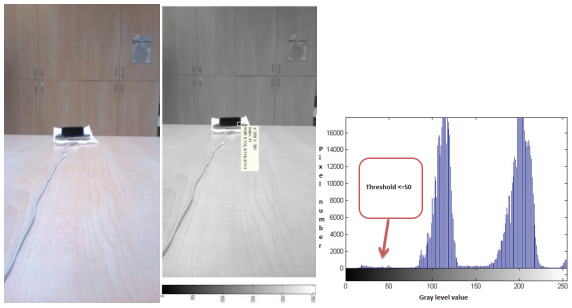

Figure 2. Histogram Thresholding

As can be seen from the figure, the number of pixels in the value range representing the gray level of the object. Objects closer to increasing the number of pixels representing the object, the object farther the number of pixels is reduced. The logic of the system is, the more pixels will occupy the nearby object applied to the histogram thresholding method. The object is determined optimal gray level range. Taking appropriate gray level range of the object is made estimation. According to the number of pixels of the specified object, the object distance is determined using equation 1. The system as a result of movement of objects in the range of gray levels in real time, is implemented by looking at the change in the number of pixels. The accuracy of the measured distance to the object and used according to the light intensity varies. The success rate is around 90.7% in the best conditions.

Filtering

The filtering process, image processing is a technique frequently used as a pretreatment. In image processing, it is necessary to select the most appropriate filter [5]. In this study, the Media Filter is used to remove noise.

As a result of the thresholding process, the resulting black and white image noise are formed. These noises are usually known as salt and pepper noise is noise in the literature. Median filters are very successful in removing salt pepper noise. In this study, the median filter is used for the detection of some object.

Connected-Component Labeling

This image processing method is a method commonly used. This method is implemented on binary images. On the individual components are tagged with a different color. This makes it easier to identify the position of the different components [6]. In this study, it was used in the measurements made up to 15 m. Because it is far distance images, more noise occurred. Thresholding results in black-and-white image in the search object is obtained with the largest pixel area. Noise from going filtering is done using a direct method of detecting objects. Method also gives the number of pixels occupied by the object. For this study, a method is useful for the desired number of pixels of the object.

Distance Calculator and Implementation of Real-Time Systems

Distance calculation process, the image of distant objects by near objects is made according to the more pixels coating logic. Therefore, reference is made once accepted image objects detected in the image of the object is calculated how many pixels are covered. Then, the number of the pixels of the second image on a second image processing result of the same was calculated. The objects in the image being taken as a reference was adopted as a reference the distance from the camera. Obtained by dividing the number of pixels is multiplied by the reference distance. Thus, the object distance from the camera of the second image is determined.

The distance from the camera reference image, the reference image pixels (P1) and the number of pixels of the image to be taken in each iteration (P2) is known. In this case, inverse proportion established distance from the camera to objects in the image taken through the iterations can be calculated.

Reference_Distance (L) Reference_Image_Pixel_ Number (P_1)

Search_Distance Taken_Image_Pixel_Number (P_2)

$$\text{Search\_Distance} = Lx\left(\frac{P_1}{P_2}\right) \quad (1)$$

Using Equation 1 is made from calculations using various objects. For the distance calculation object, it uses the following flow diagram.

The system was tested in the range of 20 to 110 cm. Using equation 1 is used as the reference image 50 cm. The obtained results are shown in Figure 4.

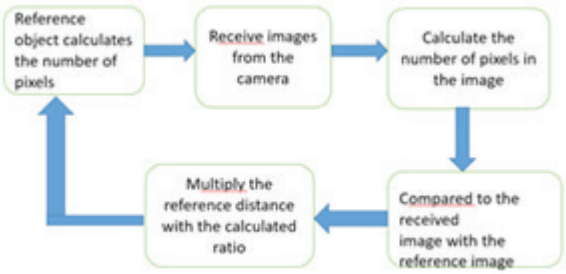

Figure 3. System flow diagram

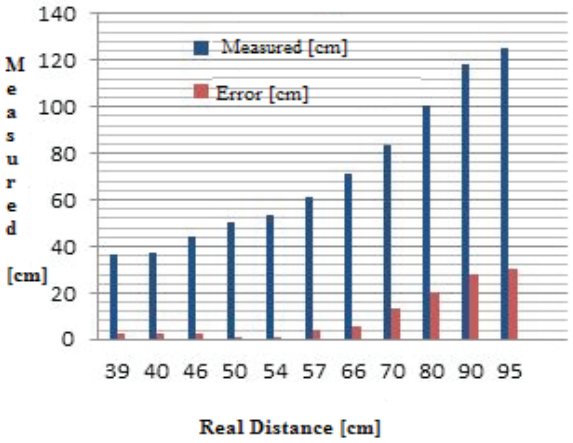

Figure 4. The measurement results based on the reference image 50 cm

The system gives incorrect results with distance from the object reference. No matter how far away the object error rate is increasing too. The reason for this is determined by the distance of the object as changing the number of pixels corresponding to 1 cm. For example, when using a single reference image "of the received image is 315 pixels, change the position of objects in the number of pixels is changed to 1 cm" comment was made. However, between 20-30 cm 1 cm change 1419 pixels, 53 pixels between 80-90 cm is 1 cm change. Normally, to determine the overall number of pixels for a 1 cm change of the object is incorrect.

The system object reference from a larger range 1-5mm was tested at 2.5 m. Measurements were made for 2,3,4,5 m. The number of pixels and the measurement results are given in Table 1 based on the reference image.

Table 1. Pixel count and the measurement results by 1 meter reference image

Distance [m]	Pixel	Measured distance [m]
2	2334	1.87
3	1368	3.19
4	941	4.64
5	743	5.88

While in Figure 5 to 2.5 m away from the reference image obtained as a result of measurements made in the range of 1-5 m results are shown graphically.

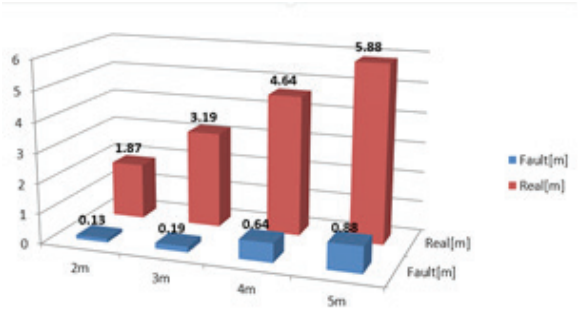

Figure 5. Measurement results on the 2.5 m for the reference image

Classification

Classification is a decision-making process that is used in many disciplines [6]. The aim of image classification process, in all classes that correspond to the pixels in an image or work space automatically assign themes into to place.

In this study, samples were taken periodically for used objects. 20-110 cm intervals of 10 samples were taken at 10 cm intervals for the measurement of a system. Taken by estimation object in each color it is calculated pixel occupied by the object. According to the pixels in succession in the two samples taken object image classes it was created. 20-cm to 110 cm. in reference images of the object taken, it is shown in Figure 6. Received reference images formed by classes, are shown in Table 3.

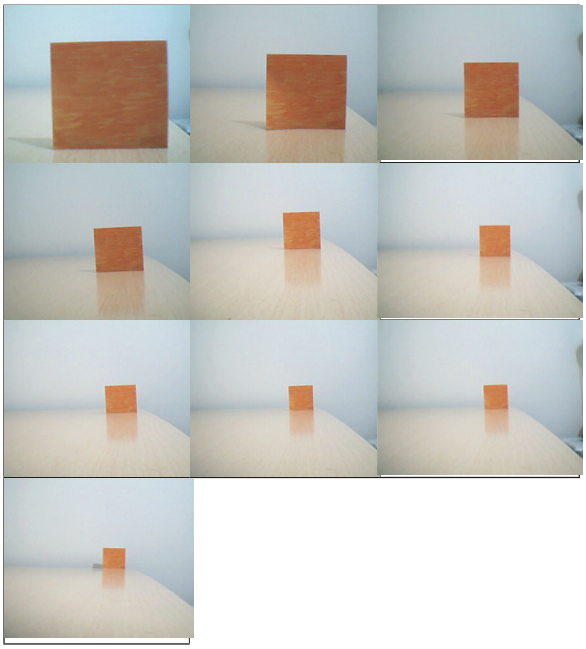

Figure 6. 20-cm to 110 cm. in reference images of the object taken

Calculated according to the number of pixels for the object is determined from the camera to the subject. The number of pixels of the objects in the reference images with the reference Images from Table 2 are also shown. In calculating the distance to the object, the object is made estimation, firstly. The object is calculated as the estimated number of pixels covered. Calculated according to the number of pixels is determined by the object class from the reference images. The object occupies the number of pixels varies depending on the distance logarithmically. Thus the number of pixels from 1 cm is determined more accurately. For example, 1000 pixels camera calculate the distance to the object is between 30-40 cm. The number of pixels that change equivalent to 1 cm (16166-9710) / 10 = 645.6 [pixels / cm] is determined. Limit the range of the calculated number of pixels in the pixel is viewed from

the difference. For all intervals, the border pixel is always made by the lower. After determining the difference of the pixel difference of 1 cm until the change is translated into pixels cm attending provisions. Again using the object used to limit cm difference is calculated by the number of pixels cm provision is determined the distance of the camera. According to the developed algorithms, object distance measurement accuracy of 97.2% is working. The runtime system can be about 95 ms.

Table 2. Classification of sample image from 20 cm to 110 cm

Reference Image Distances [cm.]	Number of pixels in the image of the object reference
20	30365
30	16166
40	9170
50	6621
60	4952
70	3825
80	3127
90	2592
100	2240
110	1960

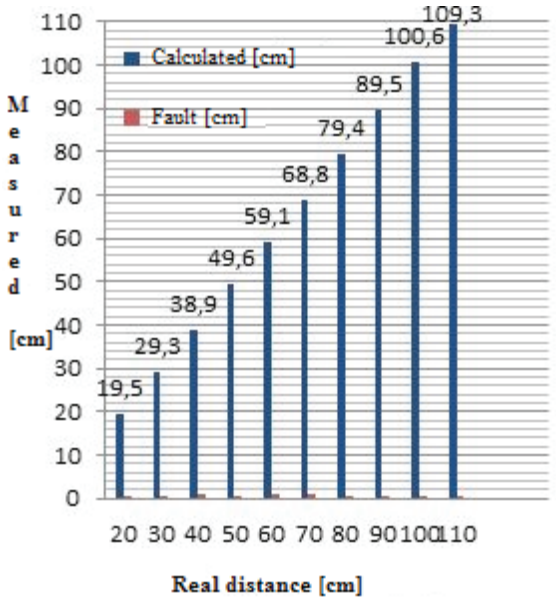

Figure 7. The results of the developed method.

Euclidean Distance

Euclidean distance is the most basic method to measure the distance between two points in space [7]. Classification, the average for the comparison with the new data and objects by scanning the entire data set is assigned to the closest cluster. N-dimensional Euclidean space $X=(x_1, x_2,..,x_n)$ and $M=(m_1,m_2,...,m_n)$ Euclidean distance between points, Equation (2) is calculated [7].

$$\sqrt{(x_1-m_1)^2+(x_2-m_2)^2+...+(x_n-m_n)^2}=\sqrt{\sum_{i=1}^{n}(x_i-m_i)^2} \quad (2)$$

According to the number of pixels that the object reference from the finish and was found Euclidean distance. Euclidean distance from the reference method was applied according to the number of pixels in Table 2.

$$Euclidean_{20cm}=\sqrt{\left(\mu_{ref\_20cm\_pixel}-\mu_{m-calculated\_pixel}\right)^2} \quad (3)$$

$$Euclidean_{30cm}=\sqrt{\left(\mu_{ref\_30cm\_pixel}-\mu_{m-calculated\_pixel}\right)^2} \quad (4)$$

$$Euclidean_{110cm}=\sqrt{\left(\mu_{ref\_110cm\_pixel}-\mu_{m-calculated\_pixel}\right)^2} \quad (5)$$

For from the investigated object it is determined 10 Euclidean distance. Euclidean distance to the lowest appropriate reference distance, is the distance from the object of the camera.

$$\min[Euclidean_{20cm}Euclidean_{30cm}...Euclidean_{110cm}] \quad (6)$$

Euclidean distance method is adapted to work for the object distance. According to the received reference image number it is determined from the object. Reference image from the distance of the object in the intermediate values are determined outside. According to the Euclidean distance, object distance measurement accuracy of %92.7 is working. The object occupies the number of pixels varies depending on the distance logarithmically. Thus the number of pixels from 1 cm is determined more accurately. For example, 1000 pixels camera calculate the distance to the object is between 30-40 cm. The number of pixels that change equivalent to 1 cm (16166-9710) / 10 = 645.6 [pixels / cm] is determined. Limit the range of the calculated number of pixels in the pixel is viewed from the difference. For all intervals, the border pixel is always made by the lower. After determining the difference of the pixel difference of 1 cm until the change is translated into pixels cm attending provisions. Again using the object used to limit cm difference is calculated by the number of pixels cm provision is determined the distance of the camera

CONCLUSIONS

Different methods are used to determine the distance of objects. In determining the distance from the object, one camera or two cameras can be used. Using the Kinect camera, obtaining the depth information from the display method is also used. Kinect camera consists of two cameras.

This study was performed to follow color-based object using a webcam and methods have been developed that can be used in object distance. Improved performance in the object distance method was compared with the histogram thresholding method and Euclidean distance. The results obtained are shown in Figure 8. The success rate of the developed method is 97.2%. The response time of the system is approximately 95 ms. The method was tested between 20-110 cm. But in the wider operating range, the success rate will not change much. The success rate depends on the number of received reference image. How many reference image is taken and success rate if it will increase depending on how many classes created so. cubic and cylindrical objects to the system is working very successful. By the way you use it for a variety of surface area, the system makes the wrong distance measurement.

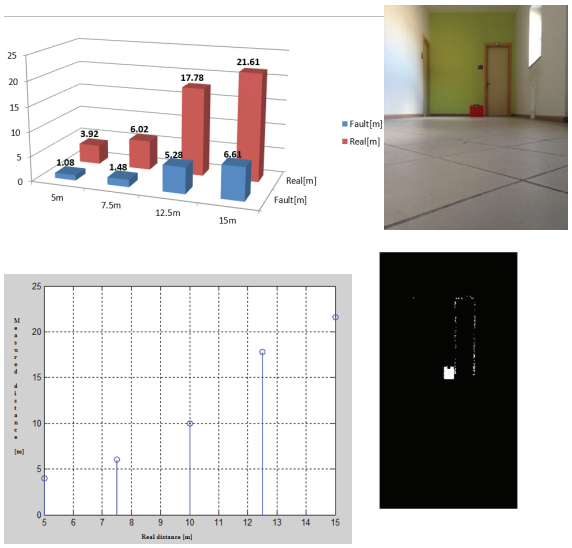

Figure 8. Ref image while 7.5 mm, and measuring between 5-25 m

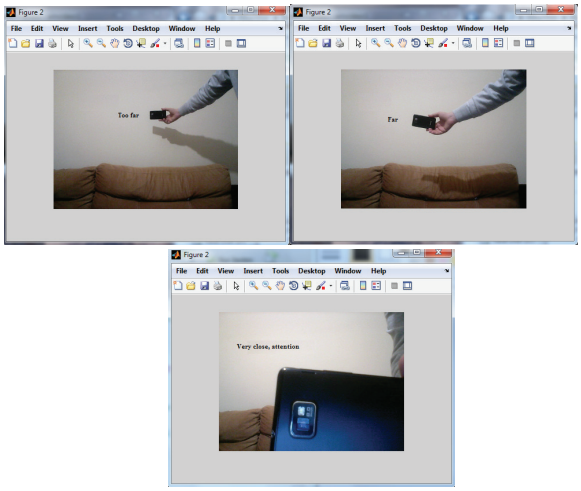

Figure 9. Real-time information application object warning

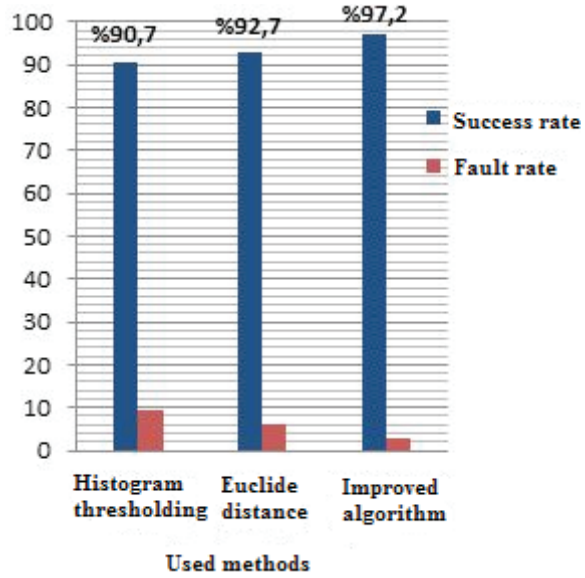

Figure 10. Comparison of methods

Thus, a method was developed to measure from one camera in various robotic applications without sensor

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