Image Distance Measurement with only Camera using OpenCV Object Detection

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Abstract: Image processing combine with machine learning is used widely in image recognition, image classification, and image detection. By using camera to detect an object has been done within several article by Guamán & Naranjo and Shah S.P.. The other usage of image and object detection is in measurement of distance. Distance measurement is possible by using additional peripheral such as sensor and extra camera. In previous research by S.H.Chen, detecting an object by knowing focal length of camera and object using spatial dan disperse technic can produce error percentage of max 5.72%, and deviation of 0.79. The distance used is in meter. Thus the deviation is in 79cm. This research is intended to elaborate the usage of single camera in detecting and measuring distance without using any sensor and can be used without knowing the focal length of a camera. The distance to be measured is between the camera and the object. In this research, author used a square object with different size and different distance range. By using one of the known data as a pivot in calculating other image distance, the average error between 4%-7% . These result was achieved by using different object size. The bigger the size of the object used as reference, the smaller the error percentage of the measurement.

1 INTRODUCTION

Measurement is the act of determining a target's size, length, weight, capacity, or other aspect. The distance between an object is determined by using measurement. Distance measurement can be done by using ruler, sensor, and any other devices. In this journal, author try to find a way to measure distance by using only camera.

The usage of camera is more common in daily live as camera is already part of gadget around us. Camera can be found in almost everyday devices like smartphones and laptop. Many research has been done in order to determine the distance between object and camera (Guamán & Naranjo, 2019; Dirgantara, Rohman, & Yulianti, 2019) (Valocký, Drahoš, & Haffner, 2020). One of the method is by using object classification and machine learning. The most common library for image classification is OpenCv (Gupta, 2017).

In order to help people in extending the function of a camera, this research try to formulate a measurement and experiment the parameter and formula to calculate the distance between a camera and an object. By using only the camera dan method propose, the camera can be used for measurement.

This research will used the image classification and edge detection in detecting the distance between camera and object. The library that is used are OpenCv. This research is used in measuring short distance between 20cm to 200cm.

2 RELATED WORKS

One of the research state how the modified camera and with the help of sensor can enhanced distance measurement (Valocký, Drahoš, & Haffner, 2020). In research by Valocký, Drahoš, & Haffner, the distance measurement is used for object measurement detection in range between 110cm and 163cm with average error of 41µm. The research is about measuring distance between object and pattern.

While Shi-Huang Chen in his research (Chen & Chen, 2011) used distance measurement using camera with car license plate as object reference. In Shi-Huang Chen research, the method used is the method of triangular and founding the focal length of

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camera. The distance measured are between 13m-31m. The image recognition used are with image capture in range of 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44, 47, and 5. The research data present in Shi-Huang Cen article is present in the following table.

Table 1: Recapitulation Of Distance Result Measurment (Chen & Chen, 2011).

Real Distance	Sparse Method			Dense Method		
	Calculated Distance	% Error	Deviation	Calculated Distance	% Error	Deviation
13,8	14.59	5,72	0.79	13,81	0,07	0,01
20,6	21,39	3,83	0.79	20.,97	1,8	0,37
22,7	23,28	2,56	0.58	23	1,32	0,3
23,2	23,7	2,16	0,5	23,46	1,12	0,26
29,9	30,29	1,3	0,39	30,68	2,61	0,78
32,2	31,77	1,34	0,43	32,32	0,37	0,12

From the data presented, the measurement is set in meter, thus the deviation are around 39 cm to 79 cm. The shortest the distance, the bigger the deviation.

In other research to measure distance like (Dirgantara, Rohman, & Yulianti, 2019) and (Gao, Chen, Liu2, & Chen2, 2021) used the same method by using references. In both paper state that by using bottom part of a vehicle image, measuring the distance between the two object can be achieved though it state that it's not accurate in a certain length. As previous test result shown which is not clear, but the average of error percentage are 1% and deviation of 26 cm. Both research using mobile net and Yolo in detecting image. While Jae Moon Lee (Lee, Hwang, & Jung, 2021) in their research, the object detected by using difference between 2 image with same object, where there is a movement distance between 2 image.

2 RESEARCH DESIGN

Implementation of image detection is common especially in image processing.

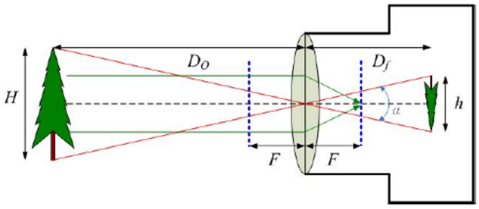


Figure 1: Image Capturing process in camera.

The process of measuring in this research is following the common concept of image capturing in camera lens. The image illustration is describe in Figure 1.

This research will used 2 different object to calculate the distance of the object. The first object is 16cm x 16 cm and 20cm x 20cm. The method propose in this paper are to create a comparison between the measured distance to get the ideal pivot used for measurement.

Different from the process of captured image by the camera, this research will approach by using the concept of triangle. This deduction come from the perspective of image we get from the capture image. The further the distance of an object to camera, the smaller the image captured. Figure 2 can describe the process of image captured.

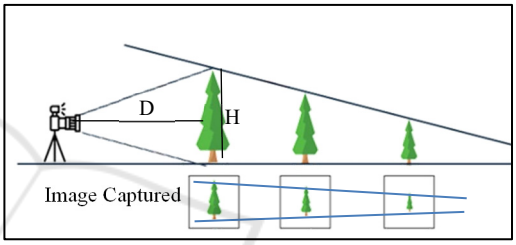


Figure 2: Image Capturing illustration.

The image shown how The further the distance of an object to camera, the smaller the image result. Despite the angel of the camera, the image proportion will remain as long as the direction where the image taken is equal.

To produce the formula, we must assume that the angle at α in Figure 1 is equal both at real distance and image distance. If we assume that the α is a formula of tangent, then the formula can be described as:

$$\tan(\frac{\alpha}{2}) = \frac{H}{2} : D_o = \frac{h}{2} : D_f \quad (1)$$

Thus

$$D_f = \frac{D_o \; x \; h}{H} \quad (2)$$

By using this formula, we can have a base distance. As we follow the rules of triangle similarity, as the image move further, so does the distance and the image grow smaller. We can use one of the image captured and with known distance as a reference. By using this as a reference, we can derive the formula by comparing the distance inside the reference image (D_f) and the height of the measured image captured. The formula for calculated distance D_r is calculated using formula as follow:

$$D_r = \frac{H \; x \; D_f}{h_r} \quad (3)$$

To calculate the distance inside the image, this research will be using this formula.

2.1 Algorithm

The algorithm used in testing the method in this research will be using the opencv image classification and then use an image as reference and calculated the error percentage.

The process is started by collecting and arranging the imaged into array. The image thus choose one by one to be used as a reference. For each reference, the formula will be calculated against other data. The calculated distance is then compared to the image real distance. The errors percentage and the deviation thus calculated to produce the report.

The algorithm proposed is as describe in figure 3.

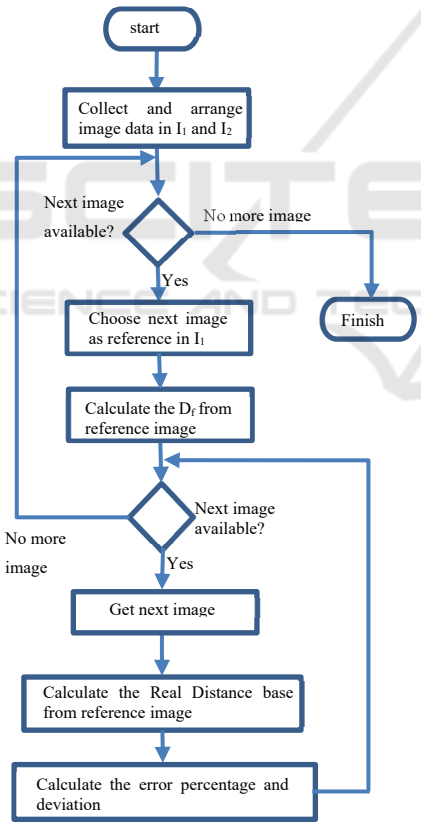
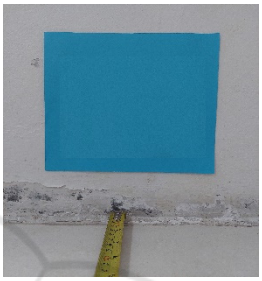


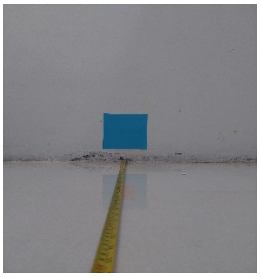
Figure 3: Algorithm Of Distance Measurement Testing.

3 EXPERIMENTAL RESULT

In this paper, the experiment is created by using python programming language. The library used is OpenCv. In experimenting the method, the object used is determined and experiment used 2 object as reference. The first one is a square paper with width of 16cm x 16 cm and square paper with the width of 20cm x 20cm. The object's distance thus measured with ruler and the picture was taken by camera. The distance is arranged in multiplication of 10. The number of sample taken are 20 for each object. Some image of the object taken shown in figure 3.

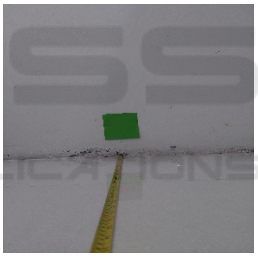


(a) Image 1 taken from 10 cm distance



(b) Image 1 taken from 100 cm distance

(c) Image 2 taken from 10 cm distance



(d) Image 2 taken from 100 cm distance

Figure 4: Image taken from different distance.

The process of calculating distance is done by iterating the image inside the dataset. The process include the image masking, image detection and measuring the area of the reference object. Since the object used is a square, the side of the object can be calculated as a square root of the area. Thus the side of the object can be calculated easily. After the calculation of the sides of the object, the calculation will continue to calculated the distance by comparing the imaginary Distance and then reference distance and will produce the real distance. Since the information of the dataset is available, the process continues to calculate the deviation and the error of the measurement. The calculated data will be written in the image and shown. The simulation is shown in Figure 5.

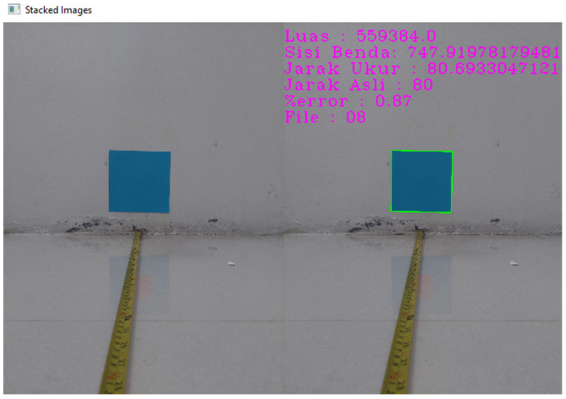


Figure 5: The Process Of Simulation.

The test result of the simulation can be seen in table 2 and table 3. Table 2 shown the testing result of simulation by using object reference of square with dimension of 16 cm x 16 cm. Table 3 shown the testing result of simulation by using object reference of square with dimension of 20 cm x 20 cm.

Table 2: Test Result Using Object Reference of Square Object of 16 cmx 16 cm.

	Error (%)			Deviation (in cm)		
Do	Avg	Max	Min	Avg	Max	Min
10	76.59	99.03	38.6	48.48	99.51	5.57
20	30.19	43.6	9.59	27.04	60.72	2.63
30	20.54	34.17	7.08	19.85	47.36	1.92
40	14.56	38.52	6.18	14.25	36.55	2.12
50	10.22	42.1	0.22	9.26	26.45	0.13
60	10.08	42.23	0.22	9.08	26.06	0.11
70	8.91	43.58	2.34	7.28	21.9	1.31
80	8	44.9	1.01	5.61	17.62	0.9
90	7.72	45.45	0.69	4.97	15.79	0.69
100	7.6	45.83	0.69	4.59	14.51	0.62
110	7.53	46.78	0.1	3.86	11.18	0.13
120	7.51	46.47	0.48	4.04	12.27	0.63
130	7.52	46.73	0.1	3.88	11.36	0.11
140	7.7	47.19	0.4	3.78	9.72	0.6
150	7.84	47.4	0.37	3.79	9.01	0.56
160	7.99	47.6	0.04	3.86	9.08	0.08
170	8.17	47.75	0.26	4.01	9.14	0.46
180	8.01	47.62	0.04	3.88	9.09	0.07
190	8.42	47.93	0.35	4.26	9.21	0.59
200	11.28	49.76	3.5	7.5	9.9	6.51

In order to eliminate unnecessary decrease int error percentage and deviation, the test result using reference image against the reference image itself is remove since the test result always shown no deviation and no error.

Table 3: Test Result Using Object Reference of Square Object of 20 cmx 20 cm.

	Error (%)			Deviation (in cm)		
Do	Avg	Max	Min	Avg	Max	Min
20	27.66	39.52	12.07	25.49	54.19	3.23
30	14.99	24.5	8.59	15.77	36.6	2.41
40	7.48	17.82	2.19	8.29	22.57	1.07
50	5.82	19.58	1.53	6.3	18.69	0.87
60	4.05	22.21	0.08	3.69	13.37	0.06
70	4.06	22.15	0.05	3.73	13.5	0.05
70	4.04	22.33	0.02	3.63	13.12	0.02
80	4.27	21.65	0.33	4.12	14.48	0.33
90	4.83	20.8	0.76	4.96	16.16	0.75
100	4.42	21.39	0.33	4.35	14.99	0.26
110	4.04	22.35	0.02	3.62	13.09	0.01
120	4.07	22.1	0.05	3.75	13.58	0.04
130	4.1	22.63	0.36	3.55	12.52	0.26
140	4.28	23.16	0.07	3.5	11.44	0.11
150	4.3	23.21	0.07	3.5	11.33	0.1
160	4.36	23.3	0.12	3.53	11.14	0.18
170	8.5	28.33	1.61	7.12	11.22	2.94
180	7.17	27.16	0.06	5.54	8.46	0.11
190	7.12	27.11	0.02	5.49	8.36	0.04
200	7.11	27.1	0.02	5.48	8.33	0.04

From the result table can be seen that the deviation of distance measurement is highest when the reference is using smaller image reference. As the pixel size tend to grow small, the accuracy is increased. In the Table 2, the accuracy is the highest when using the object reference of 120cm while using the image larger in Table 3 shown that the accuracy getting better result when the object reference is 110cm. The deviation of measurement is decreasing as the object reference is higher. This happen in both table.

4 CONCLUSIONS

By using comparison method and triangular similarity, this research shown a great accuracy of 96% or 4.04% error. The deviation of measurement achieved from this experiment is average of 3.02%. Although some of the measurement result shown small deviation but against other image captured shown greater deviation. The irregular result in this research show that the method and formula need to be improve. But comparing to greater deviation in other research, this method can be shown in less needed accuracy measurement. By using the calculation formula of:

$$D_r = \frac{H \; x \; D_f}{h_r} \tag{3}$$

We can calculate the distance between object only using object references. Comparing this result with other method in other research cited in this research, which computing and detecting complex image, measuring the distance by using determined object can result to much better accuracy in short distance and greater for further distance. The downside of this method is that the object reference used must be varied according to the distance as smaller object can not be detected in further distance.

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