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SEPARATOR PROTOTYPE FOR FOUR TYPES OF OBJECTS BASED ON CANNY EDGE DETECTION METHOD

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Abstract:-

The development of current technology makes easier for human beings in overcoming work. One of them is a selection of objects on industry. On a large-scale industry, the process of selection objects is done continuously, and it requires a high degree of accuracy. The work goes on for 24 hours unceasingly, which is hard for human. Therefore, it needs an instrument that works automatically to ease the selection process of objects. In this research, a prototype that separates objects based on shape is conducted. Shape recognition process utilizes canny edge detection method with microcontroller ATmega16 as a whole system controller. According to the testing result, the prototype can recognize and separate objects a circle, square, rectangular, and equilateral triangles. The ratio roundness (metric) values for circle, square, rectangular, and equilateral triangle are 1.00-0.90, 0.90-0.83, 0.81-0.70, and <0.70, respectively. Moreover, the level of success for separating circle object, square object, rectangular object, equilateral triangle object, and whole system are 100%, 80%, 100%, 100%, and 85%, severally.

Keywords: - *Canny Method, Microcontroller ATmega16, Metric*

INTRODUCTION

Indonesia is a developing country with many industries that require high technology. Automation in industry is performed in order to reduce human error. Because the human tends to become tired and ineffective when perform the continuous work for a long-time [1]. The purpose of industrial automation itself not only to improve the productivity and reduce the cost of the work, but also on their production quality and flexibility. Currently, the industry tries to minimize man power to produce an object in large numbers, e.g., the job of separating. This separating job is done continuously, and it requires a high degree of accuracy, which is hard done by human constantly for 24 hours. Therefore, it needs a medium in order to ease the work [2].

In addition, the image processing in the world today has received great attention because it leads to the possibility of wider application in various fields of high technology [3]. One of the image processing methods that can be utilized industrial automation is edge detection method. The detection method is used to characterize the edges which represents the image that can be analysed further and implemented. Canny edge detection is one method that can be used to detect the edges [4] and is the best method compared to other methods of edge detection [5], [6]. One implementation of image processing in industrial automation is the ability to distinguish type of objects [3]. In the manufacture of separation tool objects that uses digital image processing and microcontroller, the system needs the ability to communicate and exchange data with one another by using communication using USART (Universal Synchronous Asynchronous Receiver Transmitter) [7]. The main contributions of this research are creating a design and providing a prototype of separation controller for four types of objects based on shape using canny edge detection method. The prototype utilizes microcontroller ATmega16 as the main controller.

The remainder of this paper is structured as follows. In Section 2, the research method using Canny Edge detection is described in detail. In Section 3, we expose the results and analysis of the proposed prototype. Finally, in the last section, concluding, remarks are presented.

1. Method

In this section, we describe the design of separator prototype for four types of objects based on shape. In generally, the plan of separation system of the objects based on the shape is shown in Figure 1.

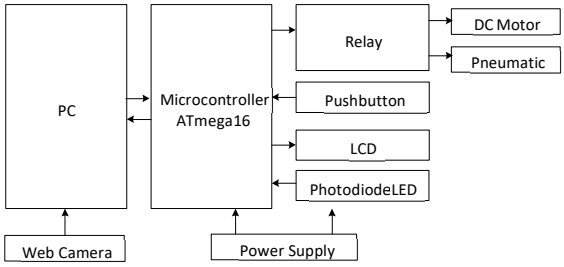


Fig. 1. Block diagram prototype separator 4 types of objects by shape

The proposed prototype consists of web camera, personal computer (PC), microcontroller ATmega16, photodiode and LED, LCD display 16x2, push button, relay-DC 5V, dc motor 12V with gearbox, pneumatic actuator, and power supply. The prototype utilizes object sensor, web camera, and push button as inputs. The object sensor is used to detect the arrival of object in the conveyor. The web camera is utilized to capture the object image. The LCD is applied to display the detected object shape. The PC has a Matlab program for image processing purpose. There are four pneumatics for separating the detected objects, i.e.; circle, square, rectangular, and equilateral triangle.

The process starts when the object sensor detects the object. The microcontroller then sends data to the PC, which orders the PC for preparing of sensing object shape. Furthermore, the computer grabs the webcam image in order to capture the detected object. The image data that has been obtained by webcam, hereafter is performed in digital image processing using Matlab program. The processed data from PC will be sent back by microcontroller to relay in order to move the actuator in the form of pneumatic.

Furthermore, there are two main steps of separation of objects in our research, which are image processing using canny edge detection and identifying the shape, will be described as follows.

2.1 Image processing with the Canny Edge Detection

In the designed prototype, we use the controller as the decision-maker. Moreover, the prototype utilizes canny edge detection method in order to generate the forms of the objects being sensed. Input of this design is the result from the detected sensor objects. While the output value of the metric is obtained by performing a detection process of the edge overall. Image processing of objects starts with the webcam does screenshots on objects above the conveyor. The screenshot yields the color image, which is then converted into a gray-scale image. The next process is performing process morphology. The process begins with the increase morphologic contrast using the histogram and followed by the process

of dilation-erosion. If there is a hollow in the structure of image, then the hollow could be closed. Afterwards, detection process is performed using the next canny edge detection, which is described as follows.

1. Eliminating noise of the image with a Gaussian filter.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

2. Performing edge detection by calculating the difference between two dots, so great neighbourly gradient image obtained. Big gradient can be calculated through equation 2.

$$|G| = |G_x| + |G_Y| \quad (2)$$

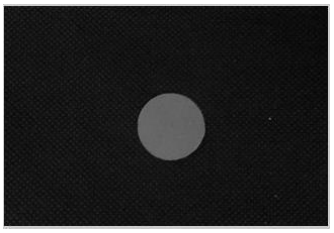
3. Determining the direction of the banks that are found by using equation 2.

$$\theta = \arctan[G_y, G_x] \quad (3)$$

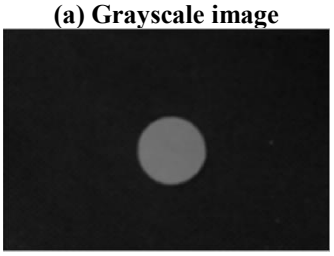
4. Reducing line edge appears by applying non-maximum suppression resulting in a slimmer margin line.

5. The last step is binary by applying two thresholding. If the pixel value is greater than the upper threshold value, so that the pixel is known as the strong edge. If the pixel value is smaller than the lower threshold value, then the pixels identified as weak banks.

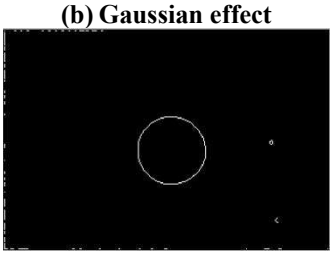
Fig. 2 exposes results of each process of canny edge detection, from grayscale image to canny operator results (a) – (e).



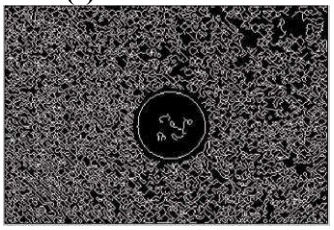
(a) Grayscale image



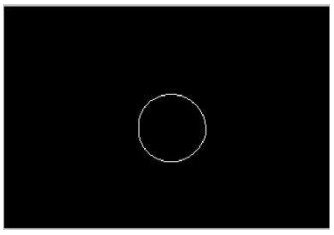
(b) Gaussian effect



(c) Gradient scale



(d) Non-maximum excision



(e) Canny operator results

Fig. 2. Canny edge detection process

2.2 Identification of the Shapes

In this sub section, we describe the step the identification of the shape. The identification process is performed by the PC. This process is exploring the area and perimeter of object. The area and perimeter parameters have been obtained, and then are used to get the metric value of each object that was detected through the Equation 4.

$$Metric = 4\pi \frac{Area}{Perimeter^2} \qquad (4)$$

Where Area and Perimeter denote area and perimeter of object respectively. The result of the calculation on the metric Equation 4, is used as a determinant of the shape that have been processed. This determinant then is defined as the shape of object. The results of this form of identification will be sent serially to the microcontroller.

3. Results

In this section, we expose the results of experiments and analysis of separator prototype for four types of objects based on shape. We perform two main test categories, which are test on objects sensor and test on system. The value results of the designed prototype are conducted in two values, which are output voltage and metric value. The former value is the output voltage which is picked at sensor objects. The latter value is the metric that can be used to determine the types of objects and the success rate of the system.

3.1 Test on Objects Sensor

The designed system uses five sensors. The testing of sensor objects is done to know the output voltage of sensor at the moment an object is detected and when an object is not detected. The output voltage of sensor is measured by using a digital MultiMate. The examination measures the output voltage on 5 sensors objects. Table 1 shows result of 5 sensors objects examination, the average voltage of sensor output is 4.60 V when an object detected and 2.43 V when object not detected.

Table 2. Object sensors examination result

Sensor Objects	Condition Detected Objects	Detected no Objects
1	4,59 V	2,58 V
2	4,60 V	2,41 V
3	4,57 V	2,16 V
4	4,66 V	2,61 V
5	4,62 V	2,42 V
Average	4,60 V	2,43 V

3.2 Test on System

Testing of the separation system were done when the system starts running from the early stages up to the final stage. From this point, we observe the changes of input/output step by step until the process is completed. In addition, the items must be selected in the form object whether a circular, square, rectangular, or equilateral triangle with variations of testing as many as 5 times.

3.2.1 Detection of Circle Object Experiments

Detection of circle object experiments is done in order to find out the success rate in detecting system and separation of circular objects based on the value of the metric. The obtained data of test are shown in Table 2.

Table 2. The Test Results Circle Objects

No	Objects	Object Condition	Sensor Objects 1	*Metric*	Sensor Objects 2	The Observations
1	Circle	Read	Active	0,921173	Active	*Pneumatic* 1 pushed
2	Circle	Read	Active	0,914629	Active	*Pneumatic* 1 pushed
3	Circle	Read	Active	0,927316	Active	*Pneumatic* 1 pushed
4	Circle	Read	Active	0,904173	Active	*Pneumatic* 1 pushed
5	Circle	Read	Active	0,912181	Active	*Pneumatic* 1 pushed

Based on the test results on the Table 2, the testing can be said to be successful. The results show the proposed prototype could separate objects circle appropriately. From the table, we obtained metric with values on average more than 0.9. Moreover, the object sensors are able to detect the presence of objects, thus causing the pneumatic 1 in the active state in all tests. So that, we conclude the level of success achieved on this test with value of 100%.

3.2.2 Detection of Square Object Experiments

This test is performed in order to find out the success rate in detecting system and separation of the square objects. Table 3 shows that the square object testing has error experience in the 3rd test. This error was caused by the obtained metric value of less than 0.8. This value causes sensor objects 3 inactive and pneumatic 3 driven. The level of success achieved on this test of 80%.

Table 3. The Test Results of Square Objects

No	Objects	Object Condition	Sensor Objects 1	*Metric*	Sensor Objects 3	The Observations
1	Square	Read	Active	0,833038	Active	*Pneumatic* 2 pushed
2	Square	Read	Active	0,820304	Active	*Pneumatic* 2 pushed
3	Square	Read	Active	0,799181	Inactive	*Pneumatic* 3 pushed
4	Square	Read	Active	0,801459	Active	*Pneumatic* 2 pushed
5	Square	Read	Active	0,845314	Active	*Pneumatic* 2 pushed

3.2.3 Detection of Rectangle Object Experiments

This test is done to find out the success rate in sensing and cleave apart the rectangular objects. Table 4 exposes the test results of rectangle objects.

Table 4. The Test Results Rectangular Objects

No	Objects	Objects Condition	Sensor Object 1	*Metric*	Sensor Object 4	The Observations
1	Rectangular	Read	Active	0,760224	Active	*Pneumatic* 3 pushed
2	Rectangular	Read	Active	0,739976	Active	*Pneumatic* 3 pushed
3	Rectangular	Read	Active	0,709080	Active	*Pneumatic* 3 pushed
4	Rectangular	Read	Active	0,742548	Active	*Pneumatic* 3 pushed
5	Rectangular	Read	Active	0,725527	Active	*Pneumatic* 3 pushed

The result of the rectangular object testing has been conducted as many as 5 times. Table 4 exhibits the result testing that has been performed in accordance with predetermined parameters for rectangular objects. The result shows the sensor objects 4 active when it detects an object. Thus it causes the pneumatic 1 is driven. Since all test show the pneumatic is driven, so that the level of success achieved on this test of 100%.

3.2.4 Detection of Triangle Object Experiments

This test is done to find out the success rate in detecting system and splitting the equilateral triangle shaped objects based on the value of the metric that has been obtained. So that the data obtained as a result of testing which can be seen in Table 5. Based on the results of testing the equilateral triangle-shaped objects that are conducted as many as 5 times, the result shows no error on testing because the value of the ratio obtained less than 0.7 causing sensor object 5 active and 4 pneumatic driven. The success rate in detecting system of triangular shaped objects equals 100%. The separation process is done on an object for 20 times using 5 pieces of each form. The testing was performed randomly. On the precision of the results obtained by this test tool in performing a separation report in accordance with the value of the specified roundness ratio for each of the objects. The results of these tests can be seen in Table 6.

Table 5.The Test Results Equilateral Triangle Objects

No	Objects	Object Condition	Sensor Object 1	*Metric*	Sensor Object 5	The Observations
1	Equilateral Triangle	Read	Active	0,636079	Active	*Pneumatic* 4 pushed
2	Equilateral Triangle	Read	Active	0,639576	Active	*Pneumatic* 4 pushed
3	Equilateral Triangle	Read	Active	0,621896	Active	*Pneumatic* 4 pushed
4	Equilateral Triangle	Read	Active	0,621057	Active	*Pneumatic* 4 pushed
5	Equilateral Triangle	Read	Active	0,659362	Active	*Pneumatic* 4 pushed

Based on Table 2 we can see that in the results of testing the separation of objects is still insufficient because there is an error that caused the object detected does not match the type. That is because the obtained value of the roundness ratio is not as has been determined. This can occur because the object that is above the conveyor lanes when done catching images are not in a position perpendicular to the camera sensor that caused the other side of these objects come into unreadable and processed by the PC. So there is a mismatch in the process of determining the shape of the object detected. Based on the results of these tests, then it brings the success rate on the overall system with calculation as in equation 2.

So it brings the success rate of the reading tools of 85%. In the process of testing this prototype, a prototype can be said to have not worked to the maximum because of the process of separation of objects still performed alternately, cannot be done ongoing basis due to the sensor objects that made the decisive presence of goods not able to distinguish objects that should be detected by the actuator. This is caused by a microcontroller which works reading programs in sequence.

Table 6. The Test Results Overall

Type object	of Number of Objects	Number of Objects Read	Unsuitable Amount (Error)
Circle	5	5	0
Square	5	2	3
Rectangle	5	8	0
Triangle	5	5	0

4. Conclusion

In this paper, we propose the prototype of separation controller of four types of objects, which are circle, square, rectangle, and triangle. The generated process control of this proposed prototype has been running well with overall system success rate of 85%. The level of success for separating circle, square, rectangular, and equilateral triangle objects are 100%, 80%, 100%, and 100%, respectively. In addition, the sensors used goods can already detect the presence of objects properly. This system can be examined further by using a camera sensor on each actuator and the usage of the raspberries in order to obtain the system more effective and efficient.

5. References

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