

Canny Edge and Hough Circle Transformation for Detecting Computer Answer Sheets

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Abstract— The use of the computer answer sheet media as a medium for writing answers has now become a necessity, this is because the computer answer sheet media is considered to be very easy and fast in the correction process. Some research and implementation applied in solving cases of correction computer answer sheet with various methods, but the use of inappropriate methods will affect the results that are less than the maximum in detecting. Some use the detection of circles which are not precise so that it has the potential to detect answers that should not be detected with clearly. This study propose Canny and Hough circle transformation method for enhanced by calculating the distance between answers to increase accuracy by 95.75%. This can be used as a basic method in making detection devices.

Keywords— *Computer answer sheet, Edge detection, Canny, Hough circle transformation.*

I. INTRODUCTION

The use of computer answer sheet media is a breakthrough for the implementation in the exam or questionnaire that has touched technology inside that aims to facilitate implementation. Recently, Computer Answer Sheet almost applied in various educational institutions and agencies in the process of determining the results of selection or examinations. This is can increasingly proving that technology evolved, especially in education world. Detection of an image is inseparable from the edge detection method as an initial detection when processing images to the next level, choosing the right method and technique is certainly very important because it will affect the expected results.

From some of the explanations above, this study propose the use of Canny and Hough Circle Transformation as a perfect collaboration for circle detecting of Computer Answer Sheet. On the other hand, the application of the Canny and Hough Circles Transformation methods has been applied in other studies with different cases, namely the detection of plug trays for planting seeds automatically which results in an average seedling evaluation of up to 89%[1]. Image is a continuous function of two dimensions intensity. Sources of light illuminate objects, the object reflects a portion of the beam of light. This reflection of light was later captured by optical instruments like human eyes, camera, scanner, etc., so the image of the object called the imagery is captured on film. An

image is stored in the pixel to be computer processing. Pixels are square grates that provide a continuous function of brightness and color imagery information[2]. From an image can be processed to be developed into various forms of application according to their needs, including it uses image processing in determining an answer selected in a computer answer sheet. Of course, there are many media and tools that have developed the tracking of answers from computer answer sheet based on image processing, but the combination of Canny and Hough Circle Transformation is of course still interesting to apply and test in an image detection process. This study will be explained how the flow and process carried out when a computer answer sheet answer detection application will be built using the Canny and Hough Circle Transformation methods.

II. RELATED THEORY

A. Detection of Circle Objects without Canny and Hough Circle Transformation

In previous studies, the detection of circular objects without combination of canny and hough produces less than optimal results. In a case described an Optical Mark Reader (OMR) sheet detection using the edge detection method looks good, but the process after edge detection uses Median Filtered Image as the final process, which is considered inappropriate to capture an object like a circle[3]. Another case that also applies Canny as edge detection processes for the detection of circle objects using thresh image, which results in the detection of circle objects being numerous so that it has the potential to process circles that should not need to be corrected, because circle detection that should be corrected only focuses on the circle which is should be the answer[4].

B. Computer answer sheet

Compared to the charging system of the exam, registrations and online records from hundreds to millions of participants, the use of Computer Answer Sheet is still more optimal because it saves computer supply requirements. With the online system, you have to available 1 computer for 1 response or participants in exam, as for the system offline, only 1 computer answer sheet for 1 response or

participants in exam. The Computer Answer Sheet itself is a form of stuffing paper that result will be checked with the computer. Generally, Computer Answer Sheet is used for multiple-choice, questionnaire, registration and filing form, an illustration of a Computer Answer Sheet can be seen in Fig. 1.

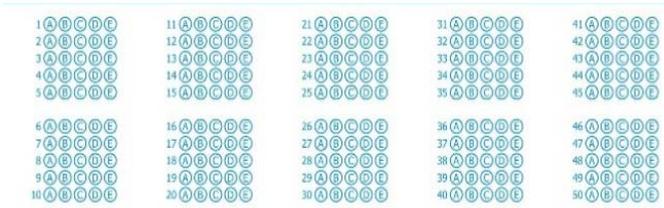


Fig.1. Computer answer sheet sample

C. Open CV

OpenCV (Open Source Computer Vision) is a library open source, that has been optimized for image and video analysis where inside it contains more than 500 algorithms. OpenCV has become the most widely adopted development tool by the developer of computer vision field since its introduction in 1999. OpenCV is also a library of machine learning that has wide variations in various contexts including life science[5]. Computer vision used in finding changes in the sharpness of intensity and object boundary of an image by using a canny edge detector[6].

III. PROPOSED METHOD

A. Canny Edge Method

Edge detection is one of the most basic image analysis operations, as an initial step in the analysis and interpretation of image information, it is necessary to determine the edges[7]. The canny operator is one of the edge detection that is often used. In general, the canny method has 5 stages of completion[8], starting from the process of removing noise to the process of determining the final edge as shown in Fig. 2, from the Canny process image can be explained the following stages:

- Gaussian filter

Gaussian Filter or Image Smoothing is filter 2D convolution operator used to make an image become smoothest and generate or reduce noise, The Gaussian filter mathematically has the following basic shown Eq. (1)[9].

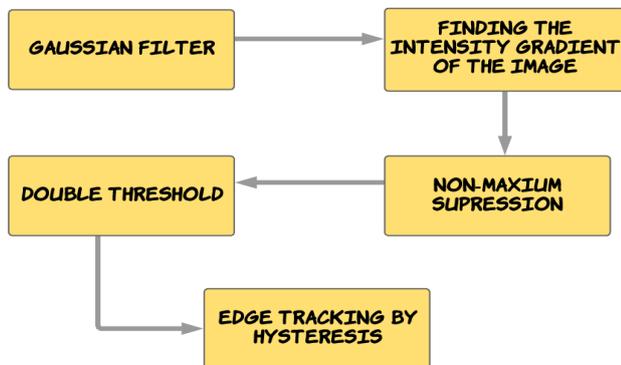


Fig.2. Stage of canny method

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

where x and y are the spatial coordinates and the standard deviation determines the width of the Gaussian function. σ is the standard deviation of the distribution and the assumption that the distribution has an average value of 0. So by integrating the Gaussian value into all pixels (adding up Gaussian with an increase of 0.001), with an integral or integer scheme an array is rearranged so that the angle has a value of 1. Finally, 159 is the sum of all values in the matrix shown in Eq. (2).

$$\frac{1}{159} \begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} \quad (2)$$

- Finding the intensity gradient of the image
Calculation of the magnitude and direction of the gradient using the sobel operator by searching horizontally (G_x) shown in Eq. (3) and vertically (G_y) shown in Eq. (4).

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \quad (3)$$

$$G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \quad (4)$$

- Non-Maximum suppression

Non-Maximum suppression is used to remove false positive lines and obtain final detection lines by determining the gradient direction. Besides these traditional methods, many modern detection methods have such problems with different objects[10] If the pixel is not a local maximum at the edge of the pixel's position, then the Non-Maximum Suppression is streamlined. This aims to remove the potential gradient in a pixel from the candidate edge. Rounding edge angle is made into four corners including vertical, horizontal and two diagonal angles $[0^\circ, 45^\circ, 90^\circ]$ and $[135^\circ]$ as shown in Fig. 3. Each color region selected by edge direction will be set to a certain value such as θ in $[0^\circ, 22.5^\circ]$ or $[157.5^\circ, 180^\circ]$ map to $[0^\circ]$. Intuitively, if the bounding box has a very high overlap with the overlap, then it must be given a very low value, while if it has a low overlap it can maintain its original detection score[11].

- Double threshold

This double thresholding aims to produce binary images, by applying two thresholding namely low thresholding / min and high thresholding / max and providing pixel values when touching or min or max values[12], the results of this threshold determination are very impactful, because capturing a threshold that has a value that is too high will cause loss of important information in the image

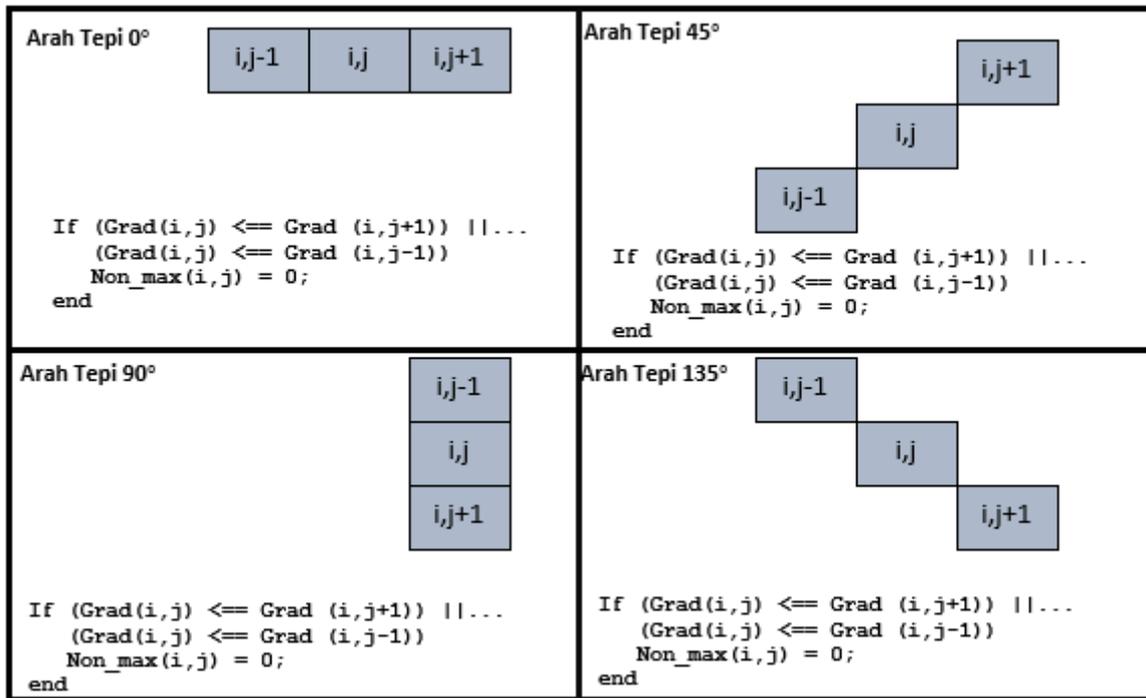


Fig.3. Determining the direction of the gradient

such as pixel or binary information, whereas if it is too low it will cause errors in detection[13].

The "sure-edge" is determined when edge *A* is above Max, edge *C* remains connected to edge *A* even though edge *C* is below Max, because the curve between edge *A* and edge *C* is fully formed as long as it has not touched Min and the curve is not cut so both edges can be said valid edge. Another case with the *B* edge because it is not connected with the other edge *B* edge removed, even though the edge *B* position is the same as the edge *C* and above Min. Such is the mechanism of selecting a border with Min and Max areas to get the right edge results shown in Fig. 4. A pixel value will be given a value of 255 if it is greater than or equal to Max, and if a pixel value is less than or equal to Min then a value of 0 [14].

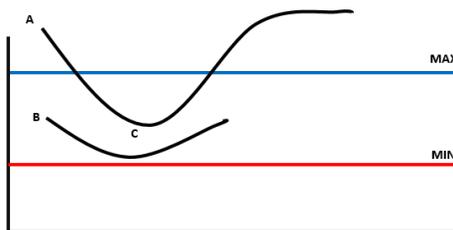


Fig.4. Double thresholding

- Edge tracking by hysteresis

Determine the final edges by pressing all edges that are not connected to the very strong edges. Processed with the pixel neighbor concept shown in Fig. 5. Fig. 5 shows how all pixels with a large gradient are between *T1* and *T2* but connected to neighboring pixels whose gradients are above *T2*, so these pixels are considered edges. If there are

pixels whose gradients are large between *T1* and *T2*, but are not connected and not neighboring with pixels whose gradients are above *T2*, then these pixels are not considered edges.

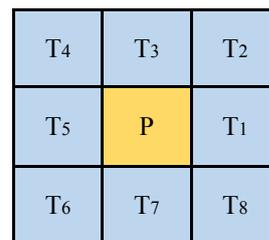


Fig.5. Edge tracking

B. Hough circle transformation

This time a lot of objects designed by humans in the form of a circle such as a ball, warning signs etc., in the circle object contains a lot of information that can be searched by computer vision media[15].

A pattern is often found when building an object detection system, and a circle is one of the patterns that is often found in various cases, therefore detecting a circle is an important component that is applied in computer vision. Hough Circle Transformation is an edge connector for extraction of very strong lines, one of the advantages of Hough Circle Transformation is that it can extract lines with a state of pixel gap (absence of pixels) to reduce noise in these conditions[16].

In the application of hough circle transformation, the minimum radius (*r-min*) and maximum radius (*r-max*) are determined, which later will only recognize the characteristics of the circle according to the predetermined *r - min* and *r - max*[17]. Basically, a circle pattern has something in common:

$$(x - a)^2 + (y - b)^2 = r^2 \quad (5)$$

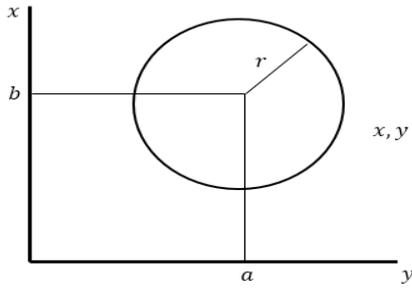


Fig.6. Illustration of coordinates

where a dan b are the center coordinates in the x and y directions according for which is the radius of the circle illustrated Eq. (5) and Fig. 6.

IV. RESULT AND DISCUSSION

A. Pre-Processing Image

In making a model that is needed to be required preprocessing data is used as a step to prepare initial data[18]. Many ways are often applied in data preprocessing such as data management, data transformation and feature selection[19], in clarifying the image line object can through the edge correction process, it can be done using edge detection or with other edge correction methods[20]. Before going to the image processing stage of Canny calculation, there are several image processing processes so that the image

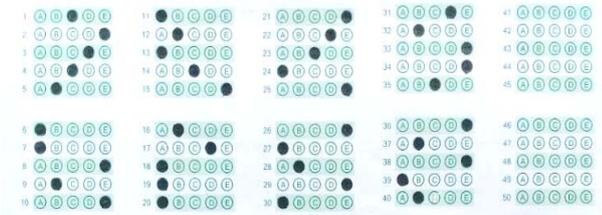


Fig.7. Image resize results

can be read using Canny. Not only Canny, but the edge detection process requires almost an initial process before the image can be processed according to the specified results. The initial process that must be done is to change the image to grayscale. The image produced by the Mobile camera ranges from 3264 x 2448 at 8 Megapixel size, and resizes so that the image changes to 1024 x 768. Then crop it to the part that is only inside the guide line, so that its size changes to 985 x 340 pixels show in Fig. 7, which is then changed in the Grayscale image show in Fig. 8. These Pre-Processing stages can be presented in a list of variables and data types shown in Table 1.

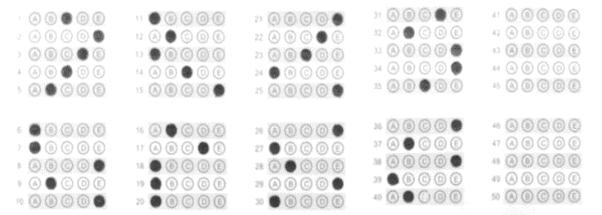


Fig.8. Image grayscale result

TABLE1. Variable of Pre-Process

No.	Variable name	Data type	Information
1	ratio	Int	Ratio between treshold1 and treshold2
2	mFile	File	File location
3	bitmap	Bitmap	Capture result
4	bitmapgray	Bitmap	Image grayscale
5	bitmapcanny	Bitmap	Image canny
6	bmResized	Bitmap	Image after resize
7	bitmaphough	Bitmap	Image has been detected circle
8	croppedImage	Mat (Matriks)	Matrix that stores the results of cropped image
9	imageGray1	Mat (Matriks)	Matrix that stores the results of grayscale image
10	imageCny	Mat (Matriks)	Matrix that stores the results of canny image
11	imageCny1	Mat (Matriks)	Copy of the matrix which stores the canny image
12	circle	Mat (Matriks)	Matrix that stores the results of circle image
13	dp	Double	hough circle accumulation
14	minDist	Double	Minimum distance between circles
15	minRadius	Int	The radius is at least a circle

B. Preprocessing with the Canny Method

One of the goals image preprocessing is reduce noise and sharpen the image before proceeding to the next image processing stage, this preprocessing can also improve the accuracy of data retrieval from the image[21]. The pre-processing stages have been fulfilled and the next step is to apply the canny method to detect the edges of the answers. By using the `Imgproc.Canny` command which is a command provided by the Open CV Library to process the Canny operator and some variables created such as `imageGray1` are the matrix of the grayscale image to be processed, `imageCny` is a matrix where the results of the detection of canny edges are stored shown in Fig. 9.

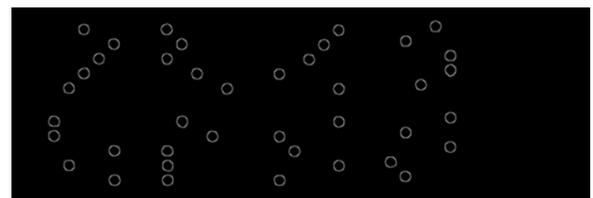


Fig.9. Early canny results in the computer answer sheet

C. Completion with Hough Circle Transformation

Canny's results have been obtained in the form of a circle's outline, the next is detecting the circle from the Canny's results using Hough Circle Transformation. With the specified upper and lower threshold values of 320 and 250, the computer answer sheet image is approaching the result, but there is still some noise, that is the circle detected even though it is not the answer shown in Fig. 10. This happens because the brightness of the camera results varies, thus affecting the Canny's detection process.

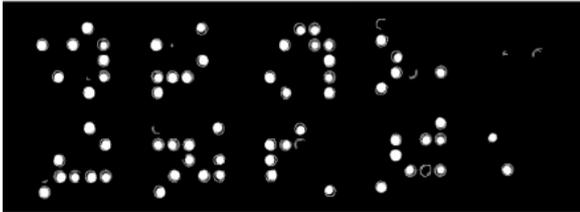


Fig.10. Canny result after hough circle transformation

D. Determination Answers with Coordinate Points between Answers

Seen from the results of the process of canny and hough circle transformation can already capture the image of the answer, but there are still some circles that are detected even though it is not a circled answer, therefore a technique to determine the distance between circles based on the initial coordinates of the answer A number 1 which is used as a reference for other answers. Fig. 11 shows how coordinates and other distances needed include the distance between the midpoint of answer A number 1 and the midpoint of answer A number 6, and also the distance between the midpoint of answer A number 1 to the midpoint of answer A number 11.

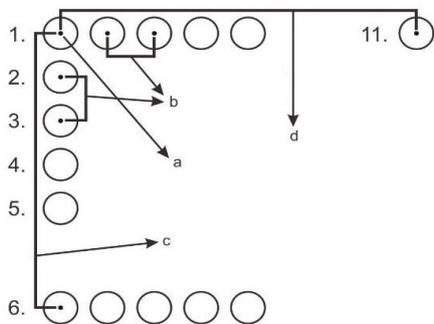


Fig.11. Flow coordinates and distance of detection

where:

a : The coordinate point for answer A number 1 ($x = 62, y = 33$)

b : The distance between the circles is worth 26 pixels and is stored in a variable called jarakAntarLingkaran.

c : The distance between answer A number 1 with answer A number 6 is worth 160 pixels and is stored in a variable named called jarakSatuenam.

d : The distance between answer A number 1 with answer A number 11 is 192 pixels and is stored in a variable called jarakAntarruas.

TABLE 2. Multilevel iteration variable

Iteration variable	Information
forSegm	The process of moving the search for answers from section 1 (answer number 1 to number 10) to segment two (answer number 11 to number 20) and so on up to segment number 4 (answer number 31 to number 40)
forSix	The process of moving the search for answers from answer number 5 to answer number 6, answer number 15 to number 16 and so on.
forColoum	The process of moving the search for answers number 1 to number 5, answer number 6 to number 10 and so on until answer number 35 to answer number 40.
forLine	The process of moving the search for answers from A to E on each number

After determining the coordinate points and determining the distance variable, the next step is to carry out the repetition process (for) which reaches 4 times the level of repetition, this aims to find the selected circle based on rows and columns by the coordinates previously calculated, the variables used in the iteration process can be shown in Table 2.

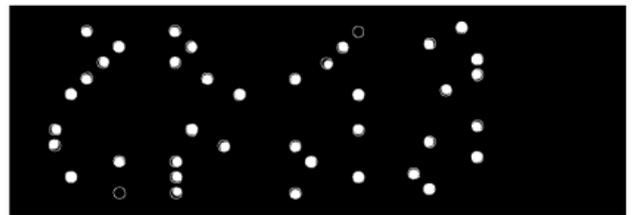


Fig.12. Results after the process of distance and coordinates

Fig. 12 shows the application of determining the distance and coordinates of the answer points, the circle of answers that enter in a predetermined iteration will produce 1 answer selected through the detection of Canny and Hough Circle Transformation. There are still circles that are not detected in the process of determining the distance and coordinates of the answer points, it can be influenced by imperfect rounding so that the Hough Circle Transformation process cannot be captured as a circle object, but in the Canny process, it can be detected as the selected answer. The matrix value of each coordinate of the above answer is stored in the Arraylist form. After obtaining the matrix value of each coordinate of the answers in the image, the next step is to determine the students' answers, whether they are A, B, C, D, E, or not answered. This step is done by using a loop in the Arraylist above and the results of determining the answers will be saved in a new Arraylist to display the results in the application.

TABLE 3. Representation of matrix values in the one answer sample that has been processed with canny and hough circle transformation

No.	Matrix value	No.	Matrix value
1.	0, 0, 255, 0, 0	6.	255, 0, 0, 0, 0
2.	0, 0, 0, 0, 255	7.	255, 0, 0, 0, 0
3.	0, 0, 0, 255, 0	8.	0, 0, 0, 0, 255
4.	0, 0, 255, 0, 0	9.	0, 255, 0, 0, 0
5.	0, 255, 0, 0, 0	10.	0, 0, 0, 0, 0

11.	255, 0, 0, 0, 0	16.	0, 255, 0, 0, 0
12.	0, 255, 0, 0, 0	17.	0, 0, 0, 255, 0
13.	255, 0, 0, 0, 0	18.	255, 0, 0, 0, 0
14.	0, 0, 255, 0, 0	19.	255, 0, 0, 0, 0
15.	0, 0, 0, 0, 255	20.	255, 0, 0, 0, 0
21.	0, 0, 0, 0, 0	26.	0, 0, 0, 0, 255
22.	0, 0, 0, 255, 0	27.	255, 0, 0, 0, 0
23.	0, 0, 255, 0, 0	28.	0, 255, 0, 0, 0
24.	255, 0, 0, 0, 0	29.	0, 0, 0, 0, 255
25.	0, 0, 0, 0, 255	30.	255, 0, 0, 0, 0
31.	0, 0, 0, 255, 0	36.	0, 0, 0, 0, 255
32.	0, 255, 0, 0, 0	37.	0, 255, 0, 0, 0
33.	0, 0, 0, 0, 255	38.	0, 0, 0, 0, 255
34.	0, 0, 0, 0, 255	39.	255, 0, 0, 0, 0
35.	0, 0, 255, 0, 0	40.	0, 255, 0, 0, 0

TABLE 4. Sample test results using canny and hough circle transformation

Sample	Answer detected	Percentage
Sample 1	39	97.50%
Sample 2	38	95.00%
Sample 3	39	97.50%
Sample 4	38	95.00%
Sample 5	39	97.50%
Sample 6	38	95.00%
Sample 7	37	92.50%
Sample 8	38	95.00%
Sample 9	38	95.00%
Sample 10	39	97.50%
Accuracy		95.75%

From the results of the one sample test shown in Tabel 3 there are still answers that are not detected, namely answer number 10 and answer number 21, so the percentage results for one sample are 95%. The answers that are not detected can be caused by lack of lighting or rounding factors that are not comprehensive so that the Hough Circles Transformation cannot capture the circle object. The result for testing with several sample shows in Table 4.

V. CONCLUSION

The results of testing several samples using Canny and Hough Circle Transformation showed the results of the process of accuracy reached 95.75%. This certainly will not be the same if repeated testing using different camera media, pixels and sharpness along with adequate lighting can certainly affect the percentage of accuracy of the results obtained. But the application of Canny and Hough Circle Transformation can be used as a suitable application in computer answer sheet, this is because Canny is the most accurate edge detection method in detecting the edges of shaped objects (circles, squares) and also the most supporting Hough Circle Transformation right because filling computer answer sheet in the form of a circle.

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