Lie Detector With Analysis Pupil Dilation And Eye Blinks Analysis Using Hough Transform And Decision Tree

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***Abstract*—** *In a social life, lying is a common and frequent thing among the community. Communication is one of the main ways to multiply relationships and build relationships in family, community, and the world of work. In the world of psychology, it can be detected using body parts such as; face, eyes, heartbeat and more.*

In this Final Project the compiler focus to work on the human eye. The lie detector uses the object of pupil diameter change and the number of blinking eyes with the Hough Transform method and the Decision Tree algorithm as the decision maker. From the results of research conducted on the lie detector system obtained an accuracy of 92%. Accuracy is obtained from observations on the change in pupillary diameter using hough circular transform method and increased the number of blinking eye with eye aspect ratio method.

In research conducted, a person who lies pupil eyes will experience enlargement of the pupil diameter of the initial respondent and increased the number of blinks of the eye to more than 8 times from the initial blink of respondents before the question.

Keywords: Lie Detector, Hough Transform, Eye Aspect Ratio, Eye Pupil, Eye Blink, Decision Tree

I. INTRODUCTION

Communication is one of the main ways to multiply relationships and build relationships within the family, the community and the world of work. And communication becomes a medium to make fraud either fraud on a small scale or large scale. Small-scale fraud in question is how a person lies while having a joke or lie that does not have a criminal element, whereas large-scale deception is how a person lies with his own interests and has a criminal element that usually lies with such actions; counterfeiting datas, doing theft and others.

In the world of psychology, lies can be detected by using body parts such as; face, eyes, heartbeat and others [1]. In this final project workman make focus to work on human eye part. Detecting lies using the eyes of the pupils, eye blinks and eye movements, this is somewhat not easy because of indicators that are difficult to be controlled consciously.

Along with technological developments, man began to think intelligently and creatively in accordance with the needs of his day. The lie detector, also called polygraph, has its own charms for the public or an agency. This final project will be made a lie detector by using a video camera with the object observed changes in pupillary width by Hough Transform method and the number of blinking eyes with Eye Aspect Ratio method. Later video cameras will be integrated with software created using an image processing theory. Then the tool is used to record someone being interrogated to then be observed answers from respondents whether the answer is lying or not.

II. RELATED WORK

1. Review of Lie Detector Methods (I. G. A. Gunadi and A, 2012).

   This book explains how a person lies well using body language, speech and even lies can be detected with body parts such as; face, eyes, heartbeat and others. Lying is often used for fraud in verbal or written communication. Other forms of fraud, such as disguise or counterfeiting, are usually not considered a lie, although the underlying intentions may be the same. However, even actual statements can be used to deceive. a lie will feel anxious, worried, this condition can be observed from the pattern of language style used and the words used tends to describe negative emotions (eg: hate, worthless, sad).

2. Lie Detector with Pupil Dilation and Eye Blinks Using Hough Transform and Frame Difference Method with Fuzzy Logic (Respatyadi Hari Nugroho, 2017).

   This study discusses lie detection using the pupil widening object and the number of blinking eyes with the hough transformation method and differance frame method. I took a number of ways from this research related to how to detect objects and the stages of their work, because in my opinion this research is very closely related to my research.

3. Digital Image Processing (R. Gonzalez and R. Woods, 2002).

   This study discusses the image processing, I focus on image processing on the eye area of the pupils. Described also the distance and good way of taking and eye conditions should also be considered because the distance between the lens

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and the imaging area (retina) remains. Each distance between the center of the lens and the retina along the visual axis is approximately 17 mm. The focal length of the range is about 14 mm to 17 mm, the latter occurs when the eye is relaxed and focused at a distance farther than about 3 m.

4. Real-time Eye Blink Detection Using Facial Landmarks (T. Soukupová and J. Cech, 2016).

   This research explains about detecting eye blink using eye aspect ratio method. This method will detect right on the eye area because it is assisted by the haar cascade method and will later calculate the number of flicker detected when someone blinks his eyes.

5. Decision Tree Determination of Student Study Period Informatics Study Program (Case Study: Faculty of Engineering and Computer Universitas Harapan Medan), (Rismayanti, 2018).

   This study describes the decision to determine the graduation of a student from the university department in the city of Medan. I take a job and the method used is a decision tree, because in the decision tree method I research is very important role in making a decision whether the answer of the respondent I interviewed is lying or honest.

Based on the results of the research, the research plan will be done is to take the data of respondents in the form of video which will be in the process using hough circular tranform method and eye aspect ratio, after that the value obtained will be designed into modeling system and assisted by decision tree method as decision-making related answers lie or honest respondents. then after the whole process is complete, then we will test the implementation of the system with different video.

III. RESEARCH METHOD

The idea of this research is to detect answers from a person or a respondent, whether he is lying or honest.

A. Biometrik

The eye is the sense device of a person used to see clearly and the pupil is controlled by the muscle[16], then the pupil is in the center of the eye on the back of the retina. In the science of the function of eye psychology not only for vision, the eye can be used as a parameter to determine a person lying or not. Among them with minor watch or big changes in pupil diameter of the eyes and change the number of people blink our eyes talk[1]. The normal pupillary diameter is approximately 3 - 4 mm[2], and pupillary dilation is another reliable indicator of fraud and is something that the liar will not be aware of or has the ability to control[3]. while the blinks of the eye that is commonly experienced by humans is caused by the tension of the eye muscles caused by someone being in a sense of being threatened or depressed, thus making the eyes unconsciously blink by itself up to 8 times more than a normal flicker[4]. The average person blinks 6-8 times per minute when not lying. When blinking at this level their eyes remain closed for approximately 1 / loth seconds[3]

B. Lie

There is a connection between what people perceive with physical signs. Suppose that if we are angry, then in most humans, the face will be red, blood pressure increases and the increase in human heart rate[5]. Lying is often used for fraud in verbal or written communication. Other forms of fraud, such as disguise or counterfeiting, are usually not considered a lie, although the underlying intentions may be the same. However, even actual statements can be used to deceive[19]. a lie will feel anxious, worried, this condition can be observed from the style used and the words used tends to describe negative emotions (eg: hate, worthless, sad)[6].

C. Lie Detector

Lie detector is an application that implements various branches of science (psychology, medicine, biology, physics, computers, etc.). Application of lie detector is very useful especially among law enforcers, to uncover facts facts. In principle the method of lying detection works on the basis of changes in the physiological response of the human body, caused by its efforts to cover up its lies[6].

D. Digital Image Processing

Digital image processing is an image can be defined as a two-dimensional function, f (x, y), where x and y are spatial (plane) coordinates, and the amplitude f on each pair of coordinates (x, y) is called the intensity or gray level of the image at that point [12][20]. The use of the hough circular transform method is to find the circle which is then entered as the object sought[11]. The main advantage of Hough's change is that it can detect a edge with a gap in the feature and is relatively undisturbed by noise or noise[7][14]. The following formula is used in this method:

$$x = a + R\ \cos\ (\theta)$$
$$y = b + R\ \sin\ (\theta)$$

While the Eye Aspect Ratio (EAR) method is to describe the proportional relationship between its width and its height. This is usually expressed as two numbers separated by colons, for aspect ratio x: y, Thus, the aspect ratio involves a relationship of width to height, not the actual size

of an image. For each video frame, eye landmarks are detected[8]. The eye aspect ratio (EAR) between height and eye width is calculated as the formula below:

$$EAR = \frac{||p2 - p6|| + ||p3 - p5}{2\,||p1 - p4||}$$

From the above formula, there are 6 points in the eyes p1, p2 ……. p6 whose points are positioned as width and height in the eye area which will then detect blinking in the eye area. For more details, it will be explained in the figure in section IV. Described in Figure 1:

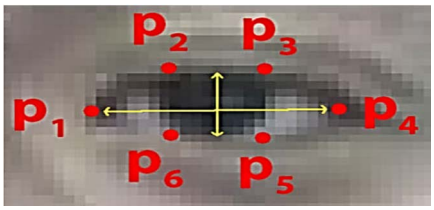


Figure 1. *Final Node Result on Decision Tree*

E. Decision Tree

Decision Tree is a simple representation of the classification technique for a number of finite classes. Where each internal node represents a test in an attribute[9], each branch represents the result of the test, and the leaf node represents the class or class distribusion. Decision tree is one of the most popular classification method because it is easy to be interpreted by many people (human)[13][15].

Generally, Decision Tree is a decision of machine learning analysis to make a decision, before entering decision tree first then use algorithm C4.5[10][17]. In general, the C4.5 algorithm builds a decision tree [18] with the following steps :

1. Preparing Data.
2. Calculating the information gain of each attribute by using the formula:

$$Gain\ (S, A) = Entropi\ (S) - \sum_{i=1}^{n} \frac{Si}{S} \times Entropi\ (Si)$$

Where,

$$Entropi\ (S) = \sum_{j=1}^{k} - p_j\, Log_2\, p_j$$

Information :
S = set of cases
n = number of data
pi = probability gained from class divided by total case
A = All possible values of attribute A
Si = subset of y where A has value i

3. Calculate the gain ratio by using the formula:

$$Gain\ Ratio\ (S, A) = \frac{Gain\ (S, A)}{SplitInfo\ (S, A)}$$

Where,

$$SplitInfo\ (S, A) = \sum_{i=1}^{n} \frac{Si}{S} \log_2 \frac{Si}{S}$$

4. Select the attribute that has the largest gain ratio as the initial or root node.
5. Recalculate entropy, gain information, split info and the ratio of each attribute by removing attributes that have the smallest gain ratio.
6. Creating a node / node of the attribute that has the largest gain ratio.
7. Check if all attributes have formed a tree, otherwise repeat steps 5 and 6 to all branches, until more trees are formed simple.

This research will be done data processing classification of respondents' answers using C4.5 algorithm. The purpose of this research is to implement C4.5 algorithm in classifying the data values obtained from image processing and will be obtained lie or honest results from respondents' answers.

G. Examples of Calculations C4.5 and Decision-Making, Case Studies of Lie Detection

The following is a prediction of lie detection that will be done in research:

Table 1. Example of Training Data Decision Tree

No.	File Name	Early Pupils	Average Pupil	Pupil Enlargement	Total Blinks	Respondents' Recognition
1	Respondents 1	2.65	3.25	0.6	28	Honest
2	Respondents 2	2.12	3.32	1.2	7	Lie
3	Respondents 3	4.5	3.31	-1.18	26	Lie
4	Respondents 4	1.59	3.54	1.95	47	Honest

Table 2. Example of Testing Data Decision Tree

No.	File Name	Pupil Enlargement	Total Blink	Condition
1.	Respondents Trial	Decrease	X > 8	?

The following is a more detailed description of each step in decision tree formation using C4.5 algorithm to solve the problem in table 2.

Counting the number of cases for decisions, number of cases for decisions, entropy of all cases and cases divided by attributes of pupil's initial diameter, pupil averages, pupil enlargement, total number of blips and recognition of respondents. After that, do a gain calculation for each attribute. The calculation results are shown by table 3.

Table 3. Example of Calculation Table

Node	Atribute	Class	Number of Cases	Honest	Lie	*Entrophy*	*Gain*
1	Total		40	13	27	0,909736123	
	Early Pupil						0,019071003
		X ≤ 2	10	8	2	0,721928095	
		X > 2	30	5	25	0,650022422	
	Average Pupil						0,106144515
		X ≤ 3	17	5	12	0,873981048	
		X > 3	23	8	15	0,402176974	
	Pupil enlargement						0,287024086
		Decrease	20	0	20	0	
		Increase	20	13	7	0,934068055	
	Total Blinks						0,398293015
		X ≤ 8	22	0	22	0	
		X > 8	18	13	5	0,852405179	

The total entropy line in Table 3 is calculated by equation 1 as follows:

$$Entrophy(Total) = \left(-\frac{11}{30} \times \log_2\left(\frac{11}{30}\right)\right) + \left(-\frac{19}{30} \times \log_2\left(\frac{19}{30}\right)\right) = 0{,}948078244$$

$$Entrophy(Total, Decrease) = \left(-\frac{0}{15} \times \log_2\left(\frac{0}{15}\right)\right) + \left(-\frac{15}{15} \times \log_2\left(\frac{15}{15}\right)\right) = 0$$

$$Entrophy(Total, Increase) = \left(-\frac{11}{15} \times \log_2\left(\frac{11}{15}\right)\right) + \left(-\frac{4}{15} \times \log_2\left(\frac{4}{15}\right)\right) = 0{,}836640742$$

$$Gain(Total, Pupil\ Enlargement) = Gain(S,A) = Entrophy(S) - \sum_{i=1}^{n} \frac{|Si|}{|s|} \times Entrophy(Sn)$$

$$Gain(Total, Pupil\ Enlargement) = 0{,}948078244 - \left(\frac{15}{30} \times 0\right) + \left(\frac{15}{30} \times 0{,}836640742\right) = 0{,}529758$$

From the calculation table Node 1 produces the max gain is the pupil enlargement attribute, obtained for enlargement of the pupil in the shrink is Honest. perform the same calculation to find the entropy and max gain on each attribute, the result of the final result in the decision tree as follows:

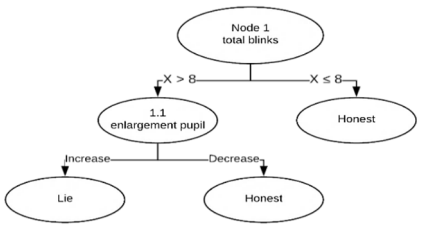


Figure 2. *Final Node Result on Decision Tree*

From the decision tree that formed until the last result of 3 rules or decision rule of target to be achieved that is honest and lie. The rules are:

1. If total blink X ≤ 8 then be honest
2. If the total blink X > 8 and the enlarged pupil increases then lie
3. If the total blink X > 8 and pupil enlargement decreased then honest

From the rules that have been generated will be used to match the case on the target variable entered. Each record will be corrected with the existing rules so that it can be classified in one class based on the target you want to know. Can be seen in Figure 2, explained that the DT method provides a clear path with 3 rules, so this is my reason for using the DT method as a classification. So, using the rule that has been designed, it will be answered case example as described above as the table below:

Table 4. Results Final Decision Tree

No.	File Name	Pupil Enlargement	Total Blink	Condition
1.	Respondents Trial	Decrease	X > 8	Honest

III. SYSTEM DESIGN & OVERVIEW

A. System Overview

This system has been tested able of detecting changes in pupil diameter and counting the number of blinks to determine the condition of a person lying or not. Particularly in this study will be illustrated in the flowchart below:

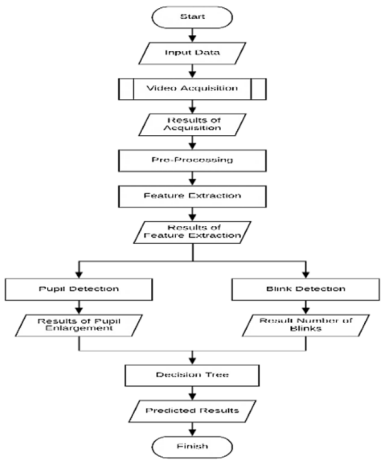


Figure 3. Flowchart System Overview Specifically

Figure 3 is a system flowchart in the form of video recording with varying duration between ± 1 minute recordings. After the next input step is the pre-processing stage to detect pupil dilation and count the number of blinking eyes. Then after processing the pre-processing proceeds for lie determination. To determine the lie parameter of the repondendent is done by using the Hough Circular Transform method in which a person is declared lying if the pupil widens and to determine the lie of the blink of the eye by counting the number of blinks obtained from the Eye Aspect Ratio method.

B. Pupil Detected Use Hough Circular Transform

In this method will be useful to detect a circle on the pupil. The system works will be explained in the flowchart below:

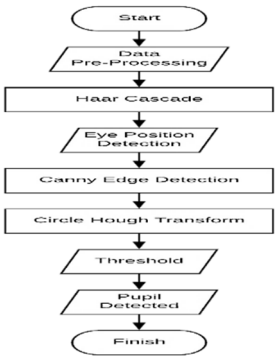


Figure 4. Flowchart Method Hough Circle Transform

Figure 4 illustrates flowchart of Hough Circular Transform. Starting from scratch, video acquisition, preprocessing, adjusting threshold, method of circular hough transform, pupil detected and finished.

C. Blinking Detected Use Eye Aspect Ratio

In this method will be useful to detect the eye area to calculate the number of flickers. The system works will be explained in the flowchart below:

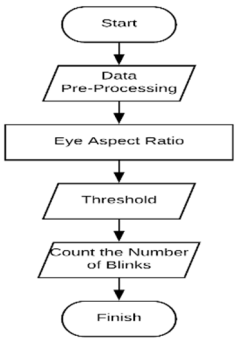


Figure 5. Flowchart Method Eye Aspect Ratio

Figure 5 illustrates the flowchart of the Eye Aspect Ratio. Start from the beginning, video acquisition, preprocessing, adjusting threshold, eye aspect ratio method, blinks detection and finish.

D. Determination of Lies

In determining the lie on penetilian this will be done 2 scenarios that are interview technique scenario and game card game scenario. The question posed is a specific question related to the personal life of the respondent. Decision tree method will help in making decision answer of respondents, whether the answer is false or honest. Explained on the flowchart below:

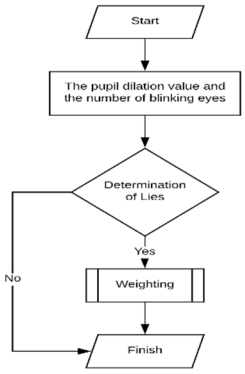


Figure 6. Flowchart Determination of Lies

IV. RESULT

A. Testing for System Modeling

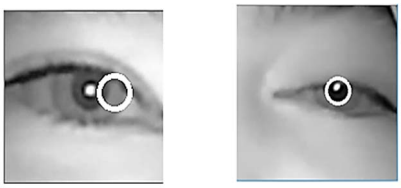
Testing of system modeling in this research is done to know the system has succeeded in detecting pupil dilation and counting the number of blink of eye, then save its data in format ".csv" which contains attribute; the initial diameter, the average diameter, magnification and total flicker. In Modeling This system will contain 40 videos that lasted ± 1 minute and divided into 2 data that is training and testing. Below are the results of 40 data from respondents:

Table 5. Example Some Results of 40 Data

No.	File Name	Early Pupils	Average Pupil	Pupil Enlargement	Total Blinks	Respondents' Recognition
1	Respondents 1	2.65	3.25	0.6	28	Honest
2	Respondents 2	2.12	3.32	1.2	7	Lie
3	Respondents 3	4.5	3.31	-1.18	26	Lie
4	Respondents 4	1.59	3.54	1.95	47	Honest
5	Respondents 5	2.65	3.27	0.63	53	Honest
6	Respondents 6	2.65	2.48	-0.17	0	Lie
7	Respondents 7	1.59	3.36	1.77	51	Honest
8	Respondents 8	3.44	3.32	-0.12	4	Lie
9	Respondents 9	3.44	3.24	-0.19	9	Lie
10	Respondents 10	2.65	3.33	0.68	1	Lie
11	Respondents 11	4.5	3.08	-1.42	4	Lie
12	Respondents 12	4.5	2.78	-1.72	8	Lie
13	Respondents 13	1.32	2.98	1.65	23	Honest
14	Respondents 14	3.97	2.69	-1.28	3	Lie
15	Respondents 15	1.59	3.11	1.53	7	Lie
16	Respondents 16	3.44	2.86	-0.58,	0	Lie
17	Respondents 17	4.5	2.92	-1.58	8	Lie
18	Respondents 18	4.5	3.57	-0.92	2	Lie
19	Respondents 19	1.85	2.89	1.03	13	Honest
20	Respondents 20	1.32	2.92	1.6	9	Honest
21	Respondents 21	4.5	2.71	-1.79	0	Lie

B. Result of Pupil Detected

The system works from the beginning of the video when detecting the speaker has not been given the question and the eye condition of the respondent is still observed under normal circumstances. Watch the recorded video, keep the respondent's position relaxed and not feel any excessive pressure or emotion, the video taken is the answer of the respondent and the question given should make the pupils will resize it. The system detects pupil dilation when there is a change in pupil value higher than the pupil size observed from the pupillary's initial diameter. In this study will be compared with 2 values of threshold, threshold radius 5 - 8 and radius 4 - 18, note the difference of the detection of the pupil in accordance with the threshold specified in the picture below:



Threshold radius 5 – 8 *Threshold* radius 4 - 18

Figure 7. Pupil Eyes Detected

Figure 7 explaining the radius threshold 4 - 18 is the right value in detecting the circle in the pupil.

C. Result of Blinks Area Detected

This study detected the eye using method of eye aspect ratio , for the video retrieval process was the same as detecting the pupil, but this study looked at the blink of the interviewee's eye and the time was ± 1 minute. The threshold value is given for limiting respondents who blink, so this study compares the threshold of 0.2 and 0.15 and the conclusion of the threshold value of 0.15 is the ideal value for this method, because 0.15 is the ratio between the length and width of the eye area. When the eyelids are closed, the person is considered blinking and the value of 0.15 according to the author is ideal because people

with narrow eyes are not considered blinking by the system.

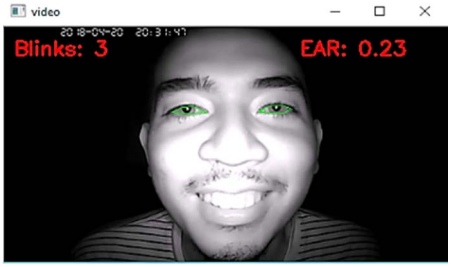


Figure 8. Blinks Area Detected

Figure 8 explains the threshold of 0.15 is the right value in detecting flicker in the eye area of the respondent.

D. Performance of System Modeling

This test serves to determine the decision tree work in classifying data into classes that have been predetermined. In this test experiment provided data testing to test the decision table that has been formed. For the work is obtained by providing the value of confusion matrix by calculating the value of precision, recall, and accuracy of the test results. Testing will be done 5 times and described in the graph below:

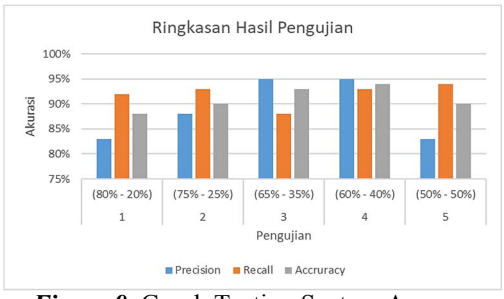


Figure 9. Graph Testing System Accuracy

Figure 9 describes the results of accuracy testing obtained by dividing the classification dataset into two divisions ie training data and data testing performed by the system. From the table and graph above can be seen data testing 60% - 40% has the highest level of accuracy than other tests. The description is data 60% and 40% is the division of 40 data, namely 24 training data and 16 test.

E. System Implementation

In testing the implementation of this system is useful to test the feasibility of modeling systems that have been designed previously. All videos used, the person interviewed in the condition did not know that he was being tested for lie detection. System modeling test will be done using 2 scenario technique that is by interview and card game. There are 5 videos that will be tested for system implementation:

Figure 10. Video Test for System Implementation

After the system implementation test process, the data obtained from the tested video and produce honest output or false answer from the video that was tested based on modeling system previously designed.

Table 6. Example of Test Results from System Implementation

No.	File Name	Class	Value	Output Program	Information
1	Respondents Testing 1	Initial Diameter (mm)	2.65	Lie	Scenarios with Interview Method
		Avarage Diameter (mm)	2.96		
		Pupil Enlargement (Percent)	0.31%		
		Total Blinks	3		
2	Respondents Testing 2	Initial Diameter (mm)	4.5	Lie	
		Avarage Diameter (mm)	3.34		
		Pupil Enlargement (Percent)	-1.16%		
		Total Blinks	39		
3	Respondents Testing 3	Initial Diameter (mm)	2.65	Honest	
		Avarage Diameter (mm)	2.78		
		Pupil Enlargement (Percent)	0.14%		
		Total Blinks	12		
4	Respondents Testing 4	Initial Diameter (mm)	1.59	Lie	Scenario with Card
		Avarage Diameter (mm)	3.25		
		Pupil Enlargement (Percent)	1.66%		
		Total Blinks	1		

From this test many obstacles due to the less dataset and also the constraint is the data required is in the form of video. In the video collection is also very difficult, because it has to adjust the time with each respondent and the availability of time to be interviewed or invited scenarios of card games.

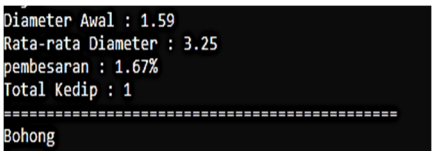


Figure 11. Example screenshot result of testing

Sample of screenshots the results of the study to lie detection in the blinking object and changes in dilated pupil. “diameter pupil” means initial diameter, “tata – rata diameter” means average diameter, “pembesaran” means dilated, “total kedipan” means total blinks and “bohong” means lie.

CONCLUSION

Based on the results of this Final Project, can be drawn some conclusions are:

1. The distance of the eye with the camera is 20 centimeters, because the eye is a small object, so if the record with a distance of more than 20 centimeters of the eye will not be detected by the system.
2. Circular Hough Transform method works best in detecting circle with threshold value radius 4 - 18.
3. The Eye Aspect Ratio method works best in detecting blinks with a threshold value of 0.15.
4. In the process of testing the performance of the system with 60% data sharing for training data and

40% for the test data then obtained the average precision of 95%, recall of 93%, and Accuracy of 94%.

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