# Lie Detector With The Analysis Of The Change Of Diameter Pupil and The Eye Movement Use Method Gabor Wavelet Transform and Decision Tree

Zuhrah Labibah
School of Electrical Engineering
Telkom University
Bandung, Indonesia
zuhrahlabibah@gmail.com

Muhammad Nasrun
School of Electrical Engineering
Telkom University
Bandung, Indonesia
nasrun@telkomuniversity.ac.id

Casi Setianingsih
School of Electrical Engineering
Telkom University
Bandung, Indonesia
setiacasie@telkomuniversity.ac.id

*Abstract— The lie is very detrimental to the fraudulent acts of many people who were cheated. The lies are common in the general population. To be able to reveal a lie we can detect through some limbs that unconsciously will show a different reaction when someone is lying. Among them, through organs of our eyes can detect someone is lying or not.*

*Lie detection discussed in this final Task is the eyes, namely with the object of eye tracking and eye pupil diameter changes by using method of Wavelet Transform to Gabor Image Processing process and afterwards perform the classification to determine the answer someone is lying or not by using a Decision Tree. The existence of this lie detector, is expected to be helpful for people who need to detect lies. With the final test results are accurate. This research has the precision value of 97%, 94%, and recall accuracy 95% of testing has been done.*

*Keywords— Lie Detector, Eye Tracking, Pupil, Gabor Wavelet, Decision Tree*

## I. INTRODUCTION

Human beings are individuals who cannot escape from human error, because it often do lie. Usually people who are lying would indicate the body's reaction is different from the usual. According to psychology when someone is lying then there is some body movement that he pointed out consciously or unconsciously, like face flushed, changes the diameter of the pupil of the eye, speaking more slowly, change in voice, hands and arms look nervous, more rigid body, and avoid eye [1]. One in the eye like movement of the eyeball, the blink of an eye, and the eye pupil happens unconsciously will show different reactions and difficult to control when people are lying.

Along with the development of technology, then the needs lie detection is very important. Discovery of the United States lie detector. Lie detection tools is also known by the name of the polygraph machine. In this thesis the author tried to observe someone who is lying with the changes that occur in the eye by using a video camera that is integrated in the software by using the theory of image processing then analyzed with machine learning to determine whether that person is currently doing a lie or not.

As for this final project on the lie detector analysis process is done through the process of image processing on the eye with the introduction of the extract of characteristic method using Gabor Wavelet and Decision Tree for Machine Learning as a decision making that the person being tested is lying or not. This research has the precision value of 97%, 94%, and recall accuracy 95% of the testing that has been done.

The purpose of this final task is to design the object using the lie detector, i.e. the change of pupil and eye movement of the eyeball method using gabor wavelet as image processing and decision tree algorithm as decision makers.

Restriction problems from this final task is to simply detect the eye is normal and not using tools such as eye glasses or soft lens, parameters will be observed just changes the diameter of the pupil of the eye and the movement of the eyeball, the position of the head of the user must be in an upright and the State of the eyes in the circumstances is not tired, and in one experiment involving only one user for the introduction of the diameter of the pupil of the eye and eye movement.

## II. BASIC OF THEORY

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

### A. Biometrics

The eye is one of the senses of sight, in the eye there is a very important organ. Important parts of the eye, one of which is the iris of the eye or pupils[2]. Eye pupils are the middle of the eye or are called the smallest part of the eye. Pupil eye is the center of the eye. Pupil eyes look black because most of the incoming light is absorbed by the tissue inside the eye, the pupil size is controlled by the muscle. According to Ira Isriana M. Psi. The pupil of the eye can not be consciously controlled, the pupil dilation is caused by a condition that can threaten it like fear [3]. The normal pupil diameter size of the human eye varies from 3 millimeters to 4 millimeters 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[4]. While the movement of the eyeball in humans can move with extraocular muscles. There are six eyeball muscles that work synchronously and precisely so that humans can see normally to look up, down, left and right, and rotate [2]. The eye is the senses that guide the psychologist with the patient because the eye can tell what is going on with the person and can not be consciously controlled[5].

## B. Lie

The lie is very detrimental to the fraudulent acts of many people who were cheated[6]. So when someone is lying some members of his body showed different reactions, for example on the eyes. The person being lied to, changes in the diameter of pupil, blink of an eye, and the movement of the eyeball.

People who lie or be honest have different eye movements. By the time the caller moves his eyes towards the right, meaning she is activate the right brain to think. Eye movement towards the right means as movement that showed the lie because the right brain is used to imagine and think. A person who is lying unconscious will turn toward the right. Eye movement to the top right is a sign that the caller was not comfortable with the conversation that took place. Inconvenience looks like a dreamy, forgery, lies, because in this position the right brain of the person being enabled[7]. Similarly happens to the pupil of the eye, a person who is lying will have enlargement of the pupil of the eye and not blink for lying, and then flashes up to more than eight times after doing the lie[8].

## C. Lie Detector

Lie detector is a tool used to identify a specific party lies. The lie detector is the application that implements the various branches of Science (biology, medicine, psychology, physics, computers, and others). The purpose of this lie detector is a tool to see if the person says the real thing or lied in answering the question-specific questions [7].

In the year 1920 polygraph test began to be developed (tests to detect a lie). A lie detector works by observing changes in the response of body, such as heart rate, body heat, sound, vibration and others. The level of accuracy of the lie detector ranging between 60%-90% [6].

## D. Digital Image Processing

Digital image processing is the process to manipulate and analyze imagery with help of computer. Digital image processing aims to improve the quality in the image, process an information of an image for the purposes of the introduction of objects automatically, and do data compression aims to store data.

## E. Decision Tree

Decision Tree is a representation of simple techniques of classification for a number of classes of finite. Where each internal node indicates a test on an attribute, each branch show the results of the test, and the leaf node indicates the class or class distribution[9]. The main benefits of using the decision tree is the ability to break down a complex decision-making process is becoming more simple, so that decision-making is more interpret the solution of existing problems[10]. Example algorithm used to form decision tree based on induction algorithm decision tree that is C4.5.

The following completion steps of the C4.5 algorithm are as follows[11] :
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.

In this research will be classified related to lie detector with pupil widening object and eye movements on the eyes using Decision Tree method.

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

The following is an example of a prediction of a system created :

Table 1 Example of Training Data Decision Tree

| File Name | Initial Diameter | Average Pupil | Enlargement Of Pupil | Eye Movement | Recognition Of Respondent |
|---|---|---|---|---|---|
| Respondents 1 | 2.38 | 2.3 | -0.08% | Right | Lie |
| Respondents 2 | 2.38 | 2.28 | -0.10% | Right | Lie |
| Respondents 3 | 2.38 | 2.29 | -0.09% | Left | Lie |
| Respondents 4 | 2.38 | 2.37 | -0.01% | Left | Lie |
| Respondents 5 | 2.38 | 2.32 | -0.06% | Right | Lie |

Table 2 Example of Testing Data Decision Tree

| File Name | Change The Diameter Of Pupil | Eye Movement | Conclusion |
|---|---|---|---|
| Respondent's Trial | Decreasing | Right | ? |

Below is a more detailed explanation of the steps in designing a decision tree using C4.5 algorithm in answer the above problems.

Counting the number of cases for decisions, entropy of all cases and cases divided by being attributes of pupil's initial diameter, pupil mean, pupil enlargement, and eye movements. Next do a gain calculation for each attribute. Here's the calculation :

Table 3 Example of Calculation Table

| Node | Attribute | Class | Number Of Cases | Honest | Lie | Entropy | Gain |
|---|---|---|---|---|---|---|---|
| 1 | Total | | 40 | 5 | 35 | 0.543564443 | |
| | Initial Diameter | | | | | | 0.246241625 |
| | | X ≤ 2 | 9 | 5 | 4 | 0.99107606 | |
| | | X > 2 | 31 | 0 | 31 | 0 | |
| | Average Pupil | | | | | | -0.056435557 |
| | | X ≤ 2 | 4 | 2 | 2 | 0.5 | |
| | | X > 2 | 36 | 3 | 33 | 0.41381685 | |
| | Enlargement Of Pupil | | | | | | 0.246241625 |
| | | Decreasing | 31 | 0 | 31 | 0 | |
| | | Enlarged | 9 | 5 | 4 | 0.99107606 | |
| | Eye Movement | | | | | | 0.34012082 |
| | | Left | 22 | 0 | 22 | 0 | |
| | | Right | 18 | 5 | 13 | 0.339072705 | |

The total line of entropy in the above table is calculated by equation 1 as follows :

$$Entropy\ (Total) = \left(-\frac{5}{40} \times log_2 \left(\frac{5}{40}\right)\right) + \left(-\frac{35}{40} \times log_2 \left(\frac{35}{40}\right)\right) = 0.543564443$$

$$Entropy\ (initial\ diameter,\ X \le 2) = \left(-\frac{5}{9} \times log_2 \left(\frac{5}{9}\right)\right) + \left(-\frac{4}{9} \times log_2 \left(\frac{4}{9}\right)\right) = 0.99107606$$

$$Entropy\ (initial\ diameter,\ X > 2) = \left(-\frac{0}{31} \times log_2 \left(\frac{0}{31}\right)\right) + \left(-\frac{31}{31} \times log_2 \left(\frac{31}{31}\right)\right) = 0$$

$$Gain\ (initial\ diameter) = Entropy\ (S) - \sum_{i=1}^{n} \frac{Si}{S} \times Entropy\ (Si)$$

$$Gain\ (initial\ diameter) = 0.543564443 - \left(\frac{9}{40} \times 0.99107606\right) + \left(\frac{31}{40} \times 0\right) = 0.246241625$$

From the calculation table node 1 generated the max gain is the attribute of eye movement with the left eye movement class is honest. So the same calculation is done to find the entropy and max gain in each attribute until the decision tree is obtained as follows :
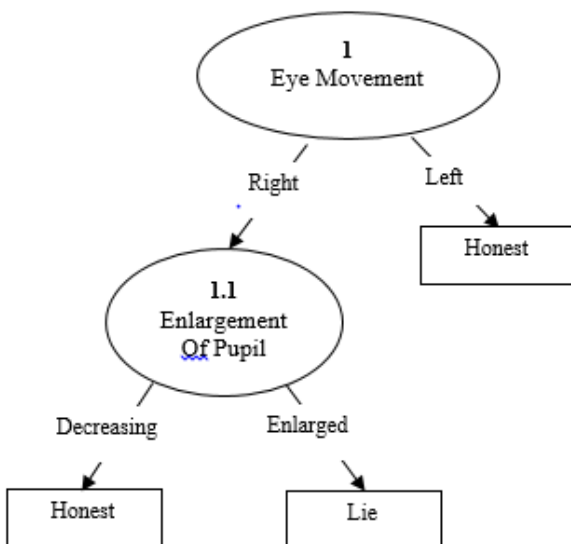


Figure 1 Final Node Result on Decision Tree

Of decision tree formed last produce up to 3 rule or rule the decision from the target to be achieved that is honest and lying. The rule of them is :

1. If eye movements to the left then the honest
2. If eye movements to the right and enlargement of the pupil dilate then lie

3. If the movement of the eye to the right and enlargement of the pupil to honest 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. So it can be concluded the final result in the table below is :

Table 4 Results Final Decision Tree

| File Name | Change The Diameter Of Pupil | Eye Movement | Conclusion |
|---|---|---|---|
| Respondent's Trial | Decreasing | Right | Honest |

## III. SYSTEM DESIGN & OVERVIEW

### A. System Overview

The system is designed using Python 3.5 and OpenCV 2.4.13 as a tool with the help of a camera that has infrared technology. This system is given input in the form of video recording of a person who asked several questions. Then proceed at the pre-processing stage to detect changes in pupil diameter and eye movement. The final stage of lie determination is done by looking at changes in the eyes such as dilated pupil diameter and pupil movements to the right by the wavelet gabor method and the additional method of circular hough transform. From these studies, then compared which parameters are more accurate in detecting lies. The performance to be tested is the percentage of the success of the system to detect lies as a lie or honesty with the Gabor Wavelet Transform method algorithm to detect the eye image and Decision Tree method for decision making that a tested person is lying or not.
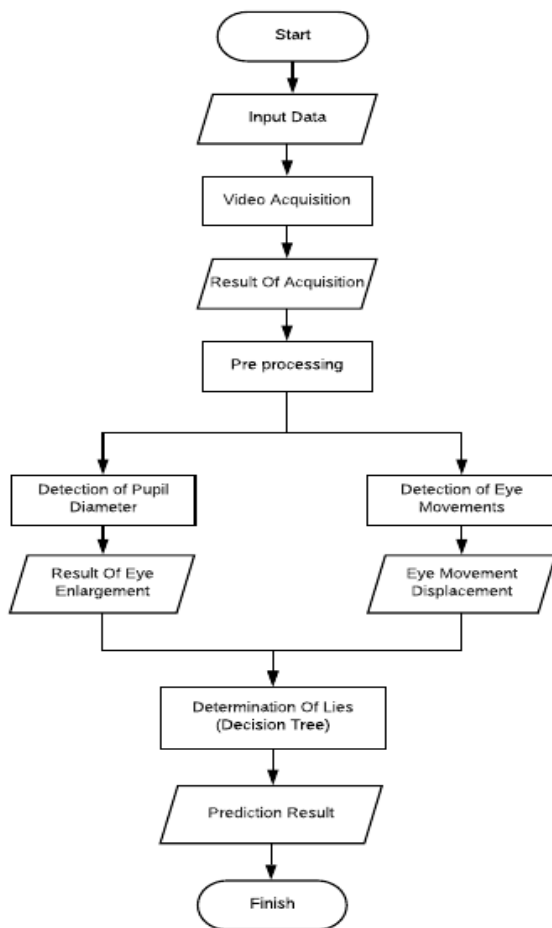
Figure 2 Flowchart System Overview Specifically

In the picture above is a special description of the system, the system stage detects lies ranging from camera input, video acquisition, pre-processing, pupillary diameter detection and eye movement detection will be done together due to later eye conditions that focus on changes in pupils and eye movements, then the results of the data will be followed by the decision stage lie or not from the blink of the eye and meode decision tree.

B. *Pupil Detected Eye Movement Use Gabor Wavelet*
This method serves to detect circles in pupils and eye movements. Here is the working system of the wavelet gabor method :
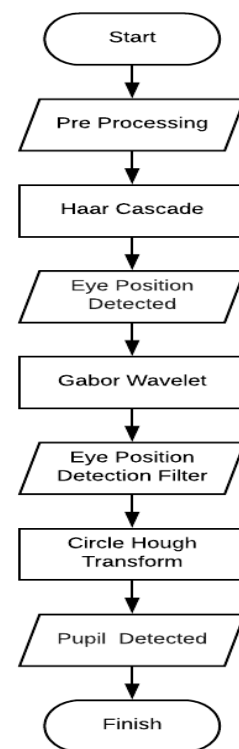


Figure 3 Flowchart Method Hough Circle Transform

This process is done simultaneously after getting the result of preprocessing. Initially the image in face detection first, after the face is detected then the system will detect the eye on the face. At this stage the process of eye detection on the image using the haar cascade method to focus the area to be processed only the eye area only and continued by using the wavelet gabor method to filter the image to bring more part of the pupils. To reveal or to make the system aware of the pupil's part in more detail, additional methods are needed to detect pupil diameter and pupillary motion using the circle hough transform method. The hough transform method will detect the object of a circle on a digital image, then in this case the system will detect the object of the circle on the eye and its movement.

C. *Determination of Lies*
This study aims to determine a person who is lying through the eyes, especially on the change in pupillary diameter and pupillary movement by using the decision tree classification for determining the lie weight performed by humans. Here's a flowchart for deception :
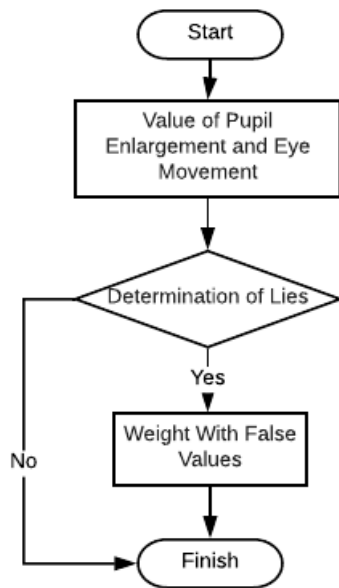
217

Figure 4 Flowchart Determination of Lies

## IV. THE RESULTS

This testing is done using video recording of respondents who have asked questions. The question proposed aims to stimulate respondents answer the question with a lie. Questions asked of some references about general psychology expert answers are generally hoax will be answered by a human being. The following examples are given on the question of the respondent's interview was being conducted and the questions raised is a question that is personal.

Table 5 Sample Question

| Question | Sample Question |
|---|---|
| 1 | You study at Telkom University, is that your choice or your parents? |
| 2 | You enter Telkom University, is your choice or as a backup? Why? |
| 3 | Do you still have love for your ex boyfriend or girlfriend? |
| 4 | Are you currently confident when dealing with someone you like? |
| 5 | What do you do with your current body size that is bigger than before? |

From the results of the video recordings then obtained some parameters which serve as the determination of a person is lying or not. The specified parameter is the initial diameter, average diameter, enlarged pupils, motion to the left, motion to the right, and recognition of the respondent.

To determine lies in pupillary enlargement, if the pupil is said to be lying due to a dilation or dilation of the initial pupillary condition. From the test video analyzed, the respondent's pupils whose initial diameter is enlarged at the final value of the pupil detection then the system will

detect it as a lie. While to determine lies in eye movements, if the movement of the eyes is left then and if right eye movements are lying.

### A. Testing for System Modeling

Testing system modeling system is done to find out how successful the system in detecting lies. The respondent data used to determine the statement or answer respondents honest or lie that is 40 samples of respondents data.

Table 6 Results of 40 Data

| Respondent | Initial Diameter | Average Pupil | Enlargement Of Pupil | Eye Movement | Recognition Of Respondent |
|---|---|---|---|---|---|
| 1 | 2.38 | 2.3 | -0.08% | Right | Lie |
| 2 | 2.38 | 2.28 | -0.10% | Right | Lie |
| 3 | 2.38 | 2.29 | -0.09% | Left | Lie |
| 4 | 2.38 | 2.37 | -0.01% | Left | Lie |
| 5 | 2.38 | 2.32 | -0.06% | Left | Lie |
| 6 | 2.38 | 2.37 | -0.01% | Left | Lie |
| 7 | 1.85 | 2.36 | 0.51% | Left | Lie |
| 8 | 1.85 | 2.09 | 0.24% | Right | Honest |
| 9 | 1.59 | 2.2 | 0.62% | Right | Honest |
| 10 | 2.38 | 2.36 | -0.02% | Right | Lie |
| 11 | 2.38 | 2.33 | -0.05% | Left | Lie |
| 12 | 1.85 | 1.76 | -0.10% | Right | Lie |
| 13 | 2.38 | 2.17 | -0.21% | Right | Lie |
| 14 | 1.59 | 2.33 | 0.75% | Left | Lie |
| 15 | 1.85 | 2.24 | 0.38% | Left | Lie |
| 16 | 2.38 | 2.36 | -0.02% | Left | Lie |
| 17 | 2.38 | 2.32 | -0.07% | Left | Lie |
| 18 | 2.38 | 2.22 | -0.16% | Left | Lie |
| 19 | 2.38 | 2.32 | -0.07% | Left | Lie |
| 20 | 2.38 | 2.25 | -0.13% | Right | Lie |
| 21 | 2.38 | 2.34 | -0.04% | Right | Lie |
| 22 | 2.38 | 2.32 | -0.06% | Left | Lie |
| 23 | 2.38 | 2.37 | -0.01% | Right | Lie |
| 24 | 2.38 | 2.3 | -0.08% | Right | Lie |
| 25 | 1.85 | 2.31 | 0.46% | Right | Honest |
| 26 | 2.38 | 2.37 | -0.01% | Left | Lie |
| 27 | 1.85 | 1.89 | 0.03% | Right | Honest |
| 28 | 2.38 | 2.36 | -0.02% | Left | Lie |
| 29 | 2.38 | 2.37 | -0.01% | Right | Lie |
| 30 | 2.38 | 1.99 | -0.39% | Right | Lie |
| 31 | 2.38 | 2.37 | -0.01% | Left | Lie |
| 32 | 2.38 | 2.35 | -0.03% | Left | Lie |
| 33 | 2.12 | 2.33 | 0.21% | Left | Lie |
| 34 | 1.59 | 1.72 | 0.13% | Right | Honest |
| 35 | 2.38 | 2.26 | -0.12% | Left | Lie |
| 36 | 2.38 | 2.32 | -0.06% | Left | Lie |
| 37 | 2.38 | 2.34 | -0.04% | Right | Lie |
| 38 | 1.85 | 2.13 | 0.27% | Left | Lie |

| Respondent | Initial Diameter | Average Pupil | Enlargement Of Pupil | Eye Movement | Recognition Of Respondent |
|---|---|---|---|---|---|
| 39 | 2.38 | 2.37 | -0.01% | Left | Lie |
| 40 | 2.38 | 2.35 | -0.03% | Left | Lie |

*B. Result of Pupil and Eye Movement Detected*

This stage is done to test and observe what factors affect the system in detecting pupil circle which aims to get the value of accuracy of pupillary detection and high eye movement on the system. From observations made to detect pupils and eye movements, factors that greatly affect the system to obtain high results in detecting pupils and eye movement are the video image threshold values contained in the circular hough transform algorithm.



(a) *Threshold* radius 5-10    (b) *Threshold* radius 6-20

Figure 5 Pupil and Eyes Movement Detected

Figure 5 explaining the radius threshold 5 - 10 is the right value in detecting the circle in the pupil.

*C. Performance of System Modeling*

The performance of the modeling system serves to find out the decision tree work in classifying data into predefined classes. In this test experiment provided data testing to test the decision table that has been formed. How it works is obtained by assigning a confusion matrix value by calculating the precision, recall, and accuracy values of the five test results and described in the graph :
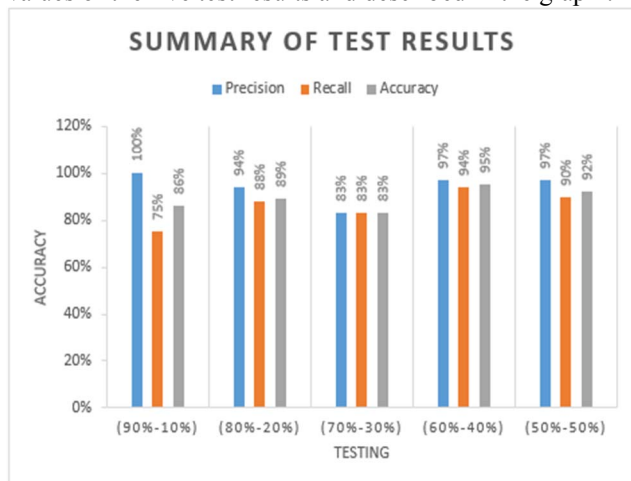


Figure 6 Graph Testing System Accuracy

The graph above shows the results of accuracy graphically, then after doing the classification process of determination of lies using decision tree method then will be done the process of testing the accuracy of the classification results. Testing of classification accuracy is done by using confusion matrix technique with dataset which have. Accuracy test results obtained by dividing the

classification dataset into two divisions of training data and data testing performed by the system. So obtained accurate results in the fifth test with 97% precision results, 94% recall, and accuracy 95%.

*D. System Implementation*

Testing system implementation is useful to test the feasibility of modeling systems that have been designed previously. System modeling testing is done using two scenario techniques, namely by interview and card game.



Figure 7 Video Test for System Implementation

After testing the implementation of the system using five videos, then the following output program :

Table 7 Test Results from System Implementation

| No | File Name | Class | Value | Program Output | Description |
|---|---|---|---|---|---|
| 1 | Respondents Testing 1 | Initial Diameter (mm) | 1.59 | Lie | Scenario Interview Techniques |
| | | Average Pupil (mm) | 2.28 | | |
| | | Enlargement Of Pupil (%) | 0.69% | | |
| | | Motion to Left | 9 | | |
| | | Motion to Right | 10 | | |
| 2 | Respondents Testing 2 | Initial Diameter (mm) | 2.38 | Lie | |
| | | Average Pupil (mm) | 2.38 | | |
| | | Enlargement Of Pupil (%) | 0.0% | | |
| | | Motion to Left | 2 | | |
| | | Motion to Right | 1 | | |
| 3 | Respondents Testing 3 | Initial Diameter (mm) | 2.38 | Lie | |
| | | Average Pupil (mm) | 0 | | |
| | | Enlargement Of Pupil (%) | 0 | | |
| | | Motion to Left | 0 | | |
| | | Motion to Right | 0 | | |
| 4 | Respondents Testing 4 | Initial Diameter (mm) | 2.38 | Lie | Scenario Technique Card Game |
| | | Average Pupil (mm) | 2.23 | | |
| | | Enlargement Of Pupil (%) | -0.15% | | |
| | | Motion to Left | 11 | | |
| | | Motion to Right | 12 | | |
| 5 | Respondents Testing 5 | Initial Diameter (mm) | 2.38 | Lie | |
| | | Average Pupil (mm) | 2.38 | | |
| | | Enlargement Of Pupil (%) | -0.01% | | |
| | | Motion to Left | 30 | | |
| | | Motion to Right | 36 | | |

## V. CONCLUSION

From testing and analysis that has been done, then the conclusion is obtained in the process of testing the performance of the system is obtained by comparison with the best accuracy 60% of data training – 40% of the data with 97% precision parameters, 94% recall, and accuracy 95%.

**REFERENCES**

[1]    S. P. Utama, J. K. L. Yos, S. Km, and N. Tanjung, "Perancangan pendeteksian kebohongan melalui perubahan diameter pupil mata dengan teknik," no. 3, pp. 147–156.

[2]     F. Malik, A. Azis, M. Nasrun, C. Setianingsih, and M. A. Murti, "Face Recognition In Night Day Using Method Eigenface," pp. 103–108, 2018.

[3]     P. Intensitas, K. Clustering, A. Kadiq, A. Y. Wijaya, N. Khotimah, and A. D. Masukan, "Implementasi Deteksi Mata Otomatis Menggunakan," vol. 2, no. 1, pp. 1–5, 2013.

[4]     M. Soorjoo, "The Black Book of Lie Detection: Effective Technique from Profesional Lie Detector," 2009.

[5]     R. H. Nugroho, M. Nasrun, and C. Setianingsih, "Lie detector with pupil dilation and eye blinks using hough transform and frame difference method with fuzzy logic," *2017 Int. Conf. Control. Electron. Renew. Energy Commun.*, pp. 40–45, 2017.

[6]     H. Z. Muhammad, M. Nasrun, C. Setianingsih, and M. A. Murti, "Speech Recognition for English to Indonesian Translator Using Hidden Markov Model," pp. 255–260, 2018.

[7]     N. Octarina, I. I. Tritoasmoro, and A. Rizal, "PERUBAHAN DIAMETER PUPIL MATA DAN JUMLAH KEDIPAN MATA," 2012.

[8]     M. Soorjoo, *Black Book of Lie Detection*. 2009.

[9]     Sunjana, "Aplikasi Mining Data Mahasiswa dengan Metode Klasifikasi Decision Tree," *Seminar Nasional Aplikasi Tknologi Informasi.* pp. 1–6, 2010.

[10]    C. Olivia, Y. Sibaroni, I. Komputasi, U. Telkom, and L. Regression, "Analisis prediksi churn menggunakan metode logistic regression dan algoritma decision tree," vol. 2, no. 2, pp. 1–6, 2015.

[11]    S. Hajrahnur, M. Nasrun, C. Setianingsih, and M. A. Murti, "Classification Of Posts Twitter Traffic Jam The City Of Jakarta Using Algorithm C4 . 5," 2013.