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Smart Management Attendance System with Facial Recognition Using Computer Vision Techniques on the Raspberry Pi

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ABSTRACT- In this study, a smart attendance system was created using computer vision techniques embedded in the Raspberry Pi device. The initial process is carried out by recording students taking certain courses and taking facial images for the needs of the system database. In the next stage, the system will be regulated according to the time of lecture entry to determine which students will attend the lecture. Every student who wants to enter the classroom is identified by taking facial images with a camera from the Raspberry Pi device to identify and determine the time students enter to attend lectures. Each image taken will be processed to detect the presence of a face using the Viola-Jones method and to extract features using the LBP method to obtain the feature value of each image. The results obtained will be stored in the system for the facial recognition process. The final stage of the system being built is to perform face recognition according to the initial image to carry out the attendance process. This process will be carried out using the normalized cross correlation (NCC) technique, in which the highest feature similarity obtained between the initial image and the newly captured image is the result of recognition by the system. From the trials that have been carried out, the developed system gives good results in obtaining attendance management in a fairly efficient manner, and the algorithm proposed for facial recognition obtains good results with an accuracy rate of 97.54%.

KEYWORDS- Smart Attendance System, Face Recognition, Raspberry Pi, LBP, Normalized Cross Correlation

I. INTRODUCTION

Face recognition plays a very important role in identifying a person by utilizing their biometric characteristics. Facial recognition is a biometric technology that has been used in many fields, such as: security systems, machine-human interaction, and image processing techniques [1]. The most commonly used identification technique is based on facial recognition, which takes little time and is very efficient, despite being difficult to implement [2]. The facial recognition process can be done using various techniques, one of which is computer vision. Computer vision is a technique used in object recognition that uses various approaches so that a person can be properly recognized. Several applications of facial recognition can be found in applications used in smart management attendance system. Techniques used in facial recognition to build smart attendance system, such as deep transfer learning, obtain good recognition results of 98.76% [3]. In addition, facial recognition for attendance systems can be built using the Multi Task Cascaded Neural Network (MTCNN) technique, with results that are practical, reliable, eliminate noise, and save time compared to traditional attendance systems [4].

Computer vision can be applied to electronic devices to provide facial detection and recognition in smart attendance system applications that are easy to use and work automatically by utilizing Internet of Things technology. An attendance system built by applying artificial intelligence has several advantages, namely: an automated time tracking system that is cost-effective, time-saving, and easy to manage [5]. This system is created by evaluating facial images during the training and testing process to identify which students are present and which students are absent through the images that have been taken and compiling them in the attendance report [6]. The application of this technology can be done on controller devices, such as the Raspberry Pi, and with the help of the OpenCV library as software for facial recognition [5].

Systems built with the Raspberry Pi for facial recognition-based attendance systems are safer and can verify themselves automatically. A greater level of recognition will be generated from the device by implementing a good facial recognition algorithm. Individual use of the Raspberry Pi can enhance attendance management capabilities and function as a standalone piece of hardware [7]. Research conducted for employee attendance management using the Raspberry Pi has been built, and the developed system will record attendance using face matches. After marking attendance, names are stored in a file and then sent automatically in real-time [8]. In addition, the automatic attendance system helps in increasing accuracy and speed to achieve real-time attendance with high precision and can evaluate attendance [9].

A facial recognition-based attendance system can be applied to manage student attendance and is a solution to reduce the time needed to calculate attendance, which can be done automatically [1]. Manual attendance management takes time away from lectures and teaching staff [10]. The use of face-based attendance management is more advantageous than RFID and manual techniques. This is because RFID is more easily influenced by hackers. In addition, if the RFID reader and receiver do not match properly, then lower read rates occur, resulting in attendance not being processed properly [2]. An attendance system that is implemented manually in an institution is a tedious process. This is because the data collection on student attendance in various departments takes quite a long time. The manual work done in the maintenance and management of traditional attendance sheets is difficult [4]. Collecting and managing student

attendance is one of the most time-consuming jobs in schools, universities, and any education system. So, we need a system that can help process attendance automatically with electronic devices with the help of computer vision techniques.

In this study, a system will be built that can automatically process attendance based on facial recognition using techniques from computer vision embedded in the Raspberry Pi device. Computer vision is used to perform object recognition that works by imitating human visual abilities [11]. The human brain can recognize objects based on those that have been seen and store them as initial knowledge. When the object is shown again, the brain can respond to it and classify it based on its resemblance. Computer vision will imitate this way of working by applying various algorithms embedded in the Raspberry Pi to carry out the process of recognizing an object to carry out attendance management.

The process of developing the system has three important steps, namely: face detection, face recognition, and attendance management. Face detection is done to determine the existence of a face when the image capture process is carried out. Meanwhile, face recognition is used to identify a person's face so that it can be recognized by the system. Meanwhile, attendance management is a data collection process carried out by the system based on recognized faces, which records the time the process occurred.

The initial process of the system is carried out by taking all the facial image data of all students who are used as research objects and storing them in a database for initial knowledge of the proposed system. The next stage is the testing phase, where the system will take an image to mark student attendance. The system will detect faces, take their images using the camera, and compare their features with the initial image from the previous database. When the identification process is successfully carried out, the system will mark attendance and generate a report that can be viewed. In the developed system, the algorithm used for face detection is Viola-Jones. The detected faces will be cropped and resized and stored as a test dataset for recognition.

II. METHODOLOGY

This study conducted facial recognition using the normalized cross correlation method, which was applied to the Raspberry Pi device to process attendance automatically. The architecture of the system proposed to build an intelligent attendance system based on face recognition in this study can be seen in Figure 1 below.

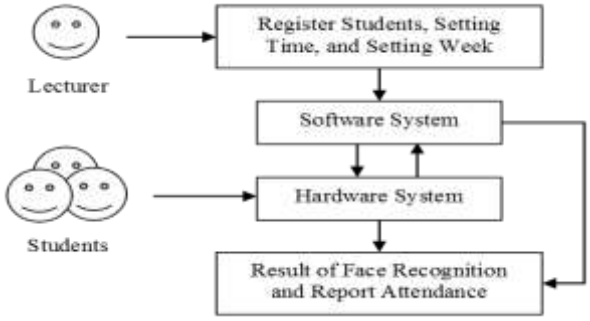

Figure 1: Smart management attendance system architecture

In Figure 1, the initial process involves registering students, setting the time, and setting the week of meetings. This process is carried out to run the system in order to obtain attendance results for each week. The system is built using a display that makes it easy for teachers to manage attendance with a website-based application. Meanwhile, the hardware used to record student attendance uses a Raspberry Pi device, which is supported by computer vision techniques to recognize each student's face in attendance. The results of the introduction will be sent to the database to determine students who are present, late, and absent in a report that can be imported into the Excel view. The steps taken for facial recognition in this study can be seen in Figure 2 below.

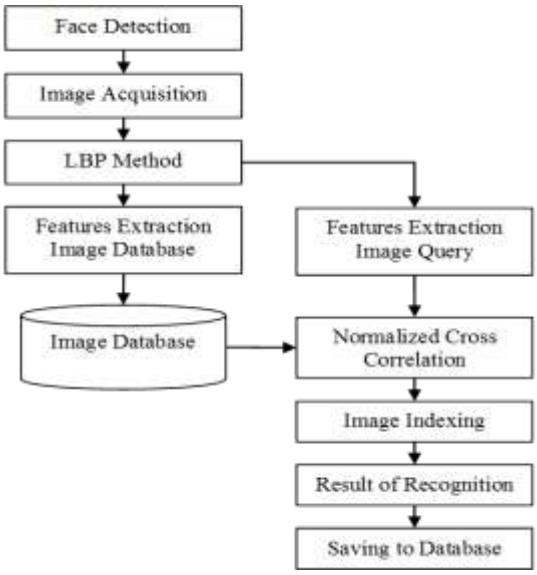

Figure 2: Proposed method for face recognition

In Figure 2, the process is the algorithm used for facial recognition, which will be uploaded to the Raspberry Pi device. The Raspberry Pi device is used as a controller and information processor for the image that will be used for facial recognition for the built-in attendance system. The block diagram on the Raspberry Pi device used can be seen in Figure 3 below.

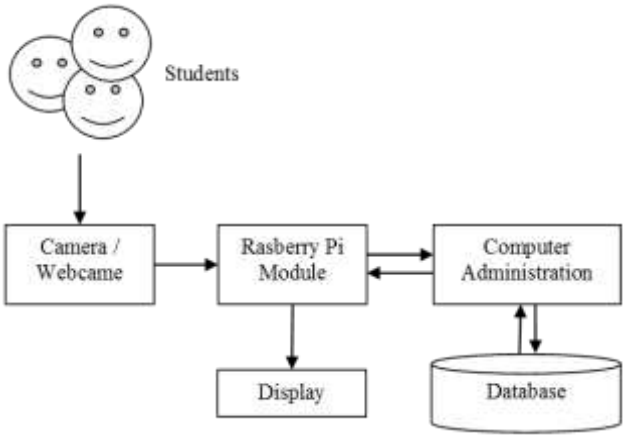

Figure 3: Raspberry Pi module for face recognition

In Figure 3, the Raspberry Pi will detect each facial image through the connected camera. When there is a face object, the Raspberry Pi will take the image to be processed and obtain attribute information. When the information has been

processed, Raspberry Pi will retrieve the initial image data from the database to compare its features with the new image. When the image is recognized, the Raspberry Pi will display the data on the display device, record the time taken, and store it in the database for student attendance management.

A. Face Detection

Face detection is a necessary first step for a facial recognition system, where the aim is to localize and explore faces and remove the background [12]. Face detection has also been applied to several applications for various needs, such as image capture and control in public places. There are several methods that can be used, but generally, use the Viola-Jones method.

The Viola-Jones algorithm is the most widely applied method for detecting facial features in real-time with high performance and accuracy in an image [13]. Viola-Jones is supported by four main components in its application. The first component is Haar features, which are used to form a simple square feature by subtracting the pixel values in the black area from the pixels in the white area. The second is an integral image that allows features or characteristics to be used as detectors, which will calculate very quickly. The third is AdaBoost machine learning, which is used to select certain Haar features to use and set threshold values. The third component is a classifier incorporation method in a "cascade," which allows the image background area to be ignored in determining the face area. The process of the Viola-Jones algorithm can be seen in Figure 4 [12].

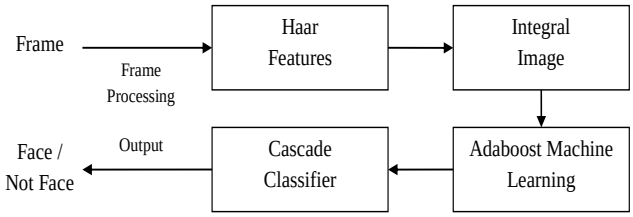

Figure 4: Viola-Jones algorithm process

By using the Viola-Jones algorithm, the image captured by the camera will be marked and cropped, as shown in Figure 5 below.

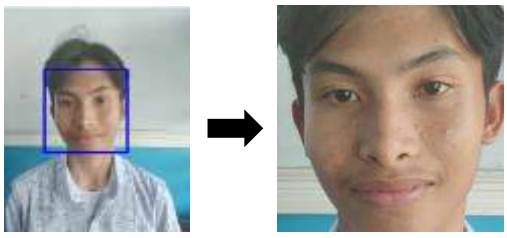

Figure 5: Result of face image detection using the viola-jones algorithm

In Figure 5, these results are obtained by applying the Viola-Jones algorithm to detect the presence of faces. This algorithm will carry out the cropping process according to the detected face parts and discard the other parts.

B. Image Acquisition (Face Image Capture)

Acquisition is the process of capturing or taking an image using a tool so that a digital image is obtained. This process uses a tool that can record the image using a digital camera. Image acquisition is carried out after the face has been successfully detected using the Viola-Jones algorithm. This process will be carried out during the initial student data collection and the attendance process. In this study, the initial image capture will be carried out by 25 students taking basic electronics courses. The initial image of students can be seen in Figure 6 below.

Figure 6: Results of initial image taking of students

C. Databases

After carrying out the process of taking facial images, the next step is storing the data in the database for facial recognition needs in the attendance system. Each image will be labeled according to the identity number provided by the campus. The next step is to create the database needed to collect data on student attendance. The database displays in the attendance system developed can be seen in Table 1 below.

Table 1: Database for attendance systems

No.	Name Data	Data Types
1	id_att	int
2	id_student	int
3	week	int
4	date	date
5	time_in	time
6	image_in	varchar
7	description	varchar

D. Features Extraction

Image feature extraction is an important step in the face recognition process, which aims to extract biometric feature values from the image. The feature values obtained are then used as input for the machine learning model to retrieve the image information and can be automatically differentiated [14]. The selection of the best method for obtaining the input features of an image greatly influences the recognition accuracy when training the algorithm used [15]. One of the methods in feature extraction is the local binary pattern

(LBP) method.

Local binary pattern (LBP) is a local spatial structure that describes an image that has gray invariance and has good resistance to background noise and visible light [16]. LBP is used to perform face recognition, where the technique surrounds each pixel with a central pixel value, labels image pixels, and generates binary values [17]. The equation used in finding LBP features uses equations 1 and 2, as follows [18].

$$LBP_p = \sum_{i=0}^{p} s(g_i - g_c)2^i \quad (1)$$

$$s(x) = \begin{cases} 1 & x \geq t \\ 0 & x < t \end{cases} \quad (2)$$

Where: p is the center pixel value, g_c is the brightness, g_i is the brightness of adjacent pixels, and t is the threshold value.

E. Recognition Process

The similarity of an image can be measured based on the correlation function using the normalized cross correlation (NCC) method with a value interval of 0–1, where 1 indicates the best match [19]. This technique is used for various needs, such as facial recognition. NCC has been commonly used as a metric to evaluate the degree of similarity between two images being compared. Face recognition using this technique has various advantages and can be done automatically [20]. The equation for finding the similarity value between the image data can be stated using equation 3 as follows: [21].

$$NCC = \frac{\sum_{x=1}^{N}\sum_{y=1}^{M}[a(x,y).b(x,y)]}{\sqrt{(\sum_{x}^{N}\sum_{y}^{M}[a(x,y)]^2).\sqrt{(\sum_{x}^{N}\sum_{y}^{M}[b(x,y)]^2)}}} \quad (3)$$

Information:

a : The first image features value
b : The second image features value
N : Number of record data
M : Number of column data

By using equation 3, each query image features will be compared with the database images to obtain the highest data similarity. The highest similarity result is the result of facial recognition, which will be stored in the system. This method was chosen because of its simplicity, because it can be used in image retrieval systems, and because it obtains good accuracy in face recognition [22].

F. Saving Attendance

The results of the recognized image will be stored in the database to determine the student's attendance time. This will make it easier for lecturers who want to record students who attend lectures and save time.

III. RESULT AND DISCUSSION

A. Results of System Implementation

The interface on the system is built using a website application to make it easier to manage student attendance. The initial stage of the system is carried out by registering each student who attends lectures. The data needed is in the form of name, student ID, email, gender, and a photo taken as a database image for the facial recognition process. The registration interface displays of the system being developed can be seen in Figure 7 below.

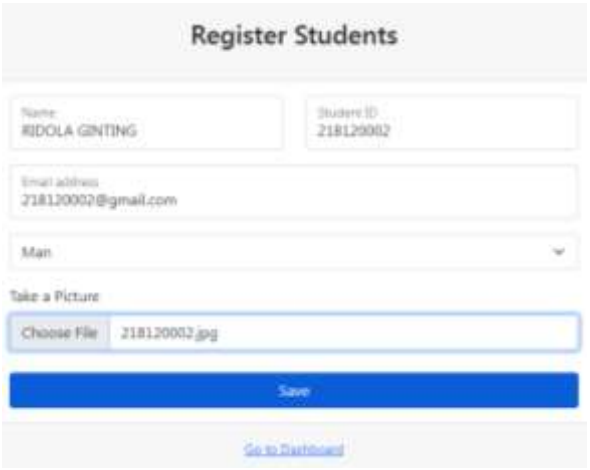

Figure 7: Process of student registration

In this study, the data used were those of 25 students who took basic electronics courses. The results of the registration will then be stored in the database for initial knowledge of the system's ability to perform facial recognition. Data and facial images that have been stored in the database can be seen in Figure 8 below.

Figure 8: Registration results and facial image storage

In Figure 8, the system will be given an initial image for the face recognition process in the smart attendance system. The image will have attribute values calculated using the LBP method. This image will be used as a reference in carrying out the identification process, which is also called a database image. After registering, the next step is to set a lecture schedule. The display settings can be seen in Figure 9 below.

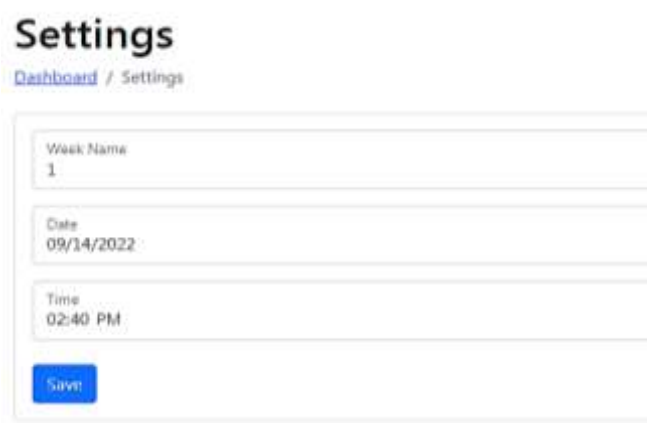

Figure 9: Creating a lecture schedule

In Figure 9, the system will be arranged according to the lecture schedule, such as the class schedule, date, and time of entry. When students want to enter the classroom, each student must do a face scan using the device that was developed. When the device detects a face, the system will mark and crop the image, and the recognition process will be carried out. The image that has been captured will be compared for similarity with the database image for face matching using the NCC method. The image with the highest similarity measure between them will be used as the result of recognition, and the system will automatically record the time the image was taken and store it in the database for display. The results of testing the attendance system can be seen in Figure 10 below.

Figure 10: Student attendance system test results

In Figure 10, the system will determine the results of face matching, which is done when you want to enter lectures with the previous database image. After performing face scanning and face matching, the system will record student attendance when it has successfully identified them. The data specified in the built system is classified into three categories: present, late, and absent. "Present" is a description that appears when the attendance process is carried out according to the time of lecture entry with a delay tolerance of 10 minutes. "Late" is a statement that appears when a student is absent beyond the specified time limit. When students fail to perform facial recognition or are late for more than 30 minutes, While Absent will appear. Besides that, there is also an indicator on the LCD with the caption "Attendance Successfully Done!" This process can be done when the image is captured and recognized by the system. When a student exceeds the specified time threshold, or in other words, exceeds the entry time, the system will record that the student is late, and the LCD will display "You're late!" "Please be more disciplined."

The attendance system built will be used each week according to the lecture schedule. In this study, the system will record the results of student attendance for 12 weeks, and each week the attendance results will be stored in the database. You can view the report by selecting the week of the meeting. The display of student attendance can be seen in Figure 11 below.

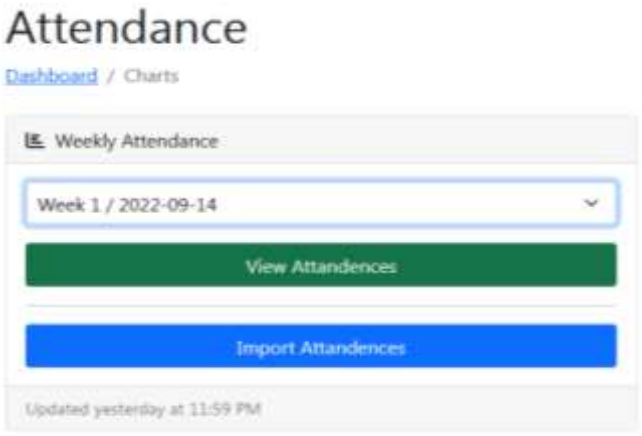

Figure 11: Results of student attendance reports

After selecting the week of the meeting, the system will display a graph to show the percentage of student attendance, as shown in Figure 12 below.

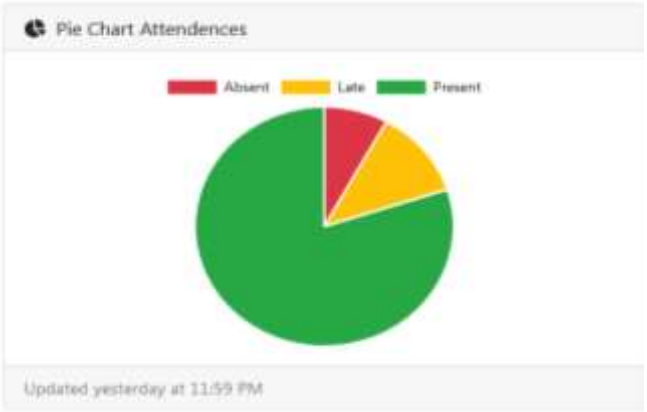

Figure 12: Percentage of student attendance

After the lecture is finished, the teacher can import the attendance results that were previously recorded in Excel format. This is done to find out which students are present, late, and absent. The results of import attendance from the developed system can be seen in Figure 13 below.

	A	B	C	D	E	F	G
1	No.	Student ID	Week	Date	Time In	Image	Description
2	1	218120031	1	9/14/2022	14:40:00	218120031_1.jpg	Present
3	2	218120019	1	9/14/2022	14:40:00	218120019_1.jpg	Present
4	3	218120041	1	9/14/2022	14:41:00	218120041_1.jpg	Present
5	4	218120035	1	9/14/2022	14:42:00	218120035_1.jpg	Present
6	5	218120013	1	9/14/2022	14:43:00	218120013_1.jpg	Present
7	6	218120002	1	9/14/2022	14:44:00	218120002_1.jpg	Present
8	7	218120014	1	9/14/2022	14:45:00	218120014_1.jpg	Present
9	8	218120018	1	9/14/2022	14:46:00	218120018_1.jpg	Present
10	9	218120003	1	9/14/2022	14:48:00	218120003_1.jpg	Present
11	10	218120020	1	9/14/2022	14:48:00	218120020_1.jpg	Present
12	11	218120009	1	9/14/2022	14:48:00	218120009_1.jpg	Present
13	12	218120017	1	9/14/2022	14:48:00	218120017_1.jpg	Present
14	13	218120029	1	9/14/2022	14:48:00	218120029_1.jpg	Present
15	14	218120024	1	9/14/2022	14:48:00	218120024_1.jpg	Present
16	15	218120012	1	9/14/2022	14:49:00	218120012_1.jpg	Present
17	16	218120022	1	9/14/2022	14:49:00	218120022_1.jpg	Present
18	17	218120037	1	9/14/2022	14:49:00	218120037_1.jpg	Present
19	18	218120010	1	9/14/2022	14:49:00	218120010_1.jpg	Present
20	19	218120034	1	9/14/2022	14:49:00	218120034_1.jpg	Present
21	20	218120021	1	9/14/2022	14:50:00	218120021_1.jpg	Present
22	21	218120026	1	9/14/2022	14:51:00	218120026_1.jpg	Late
23	22	218120038	1	9/14/2022	14:51:00	218120038_1.jpg	Late
24	23	218120004	1	9/14/2022	14:59:00	218120004_1.jpg	Late
25	24	218120007	1	9/14/2022	-	-	Absent
26	25	218120011	1	9/14/2022	-	-	Absent

Figure 13: Import of student attendance data results

As for the total number of students in attendance as a whole, it can be seen using the graph in Figure 14 below.

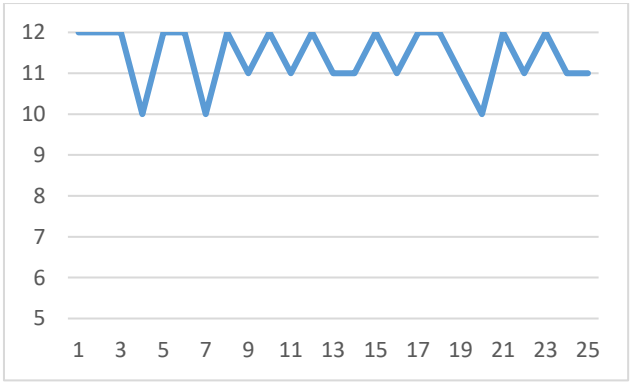

Figure 14: Results of student attendance

Overall, the proposed system performs well in terms of managing student attendance. This system can record student attendance for each week and report the total attendance according to the class schedule.

B. Face Recognition Accuracy Testing

This research was developed for a smart attendance system using computer vision techniques embedded in the Raspberry Pi device as the hardware used for the detection process, image processing, and facial recognition process. All computing processes will be performed on the device, and the results will be sent to the database system. Every face captured by the Raspberry Pi camera will immediately undergo a face detection process and produce an image in the form of a snippet of the detection results from the Viola-Jones method. The image results will be used as an image query and for feature extraction using the LBP method.

The next step is to calculate all the images in the database (initial image) for the value of the LBP feature and compare the closeness of the value with the query image. This value will be calculated using the NCC method, and the highest value of the equation will be used as the result of the recognition made by the system. The stages of face recognition can be illustrated in Figure 15 below.

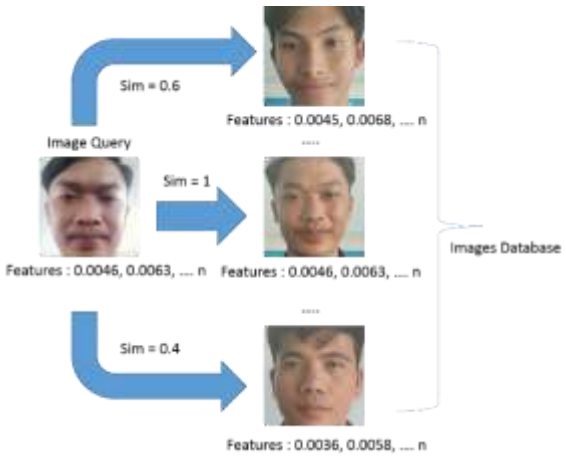

Figure 15: Face recognition results

Based on Figure 15, the highest level of similarity is worth 1 and is the result of recognition from the attendance system that was built. This process will be carried out in 12 meetings with a total of 285 query images, and the results of the introduction that has been carried out for each student can be seen in Table 2 below.

Table 2: Face recognition results using the proposed method

No.	Student ID	Total Attendance	Correct Number	Incorrect Number
1	218120002	12	12	0
2	218120003	12	11	1
3	218120004	12	11	1
4	218120007	10	10	0
5	218120009	12	11	1
6	218120010	12	12	0
7	218120011	10	10	0
8	218120012	12	11	1
9	218120013	11	11	0
10	218120014	12	11	1
11	218120017	11	11	0
12	218120018	12	12	0
13	218120019	11	11	0
14	218120020	11	11	0
15	218120021	12	10	2
16	218120022	11	11	0
17	218120024	12	12	0
18	218120026	12	12	0
19	218120029	11	11	0
20	218120031	10	10	0
21	218120034	12	12	0
22	218120035	11	11	0
23	218120037	12	12	0
24	218120038	11	11	0
25	218120041	11	11	0
Total		**285**	**278**	**7**

In Table 2, the face recognition process was carried out by 25 students during the attendance process. The total testing was carried out 12 times, so the images used to carry out the

recognition process were 285 images. From these results, there are 278 images that are well recognized. The total facial recognition accuracy with the proposed method is 97.54%. Some face recognition is not carried out correctly, which is influenced by various conditions, such as the brightness level during the retrieval process, and others, so that the attendance filling process is carried out manually.

From the overall test results of the system being built, the facial recognition-based attendance system can be carried out well with a recognition result of 97.54%. This system can be implemented effectively for managing attendance and works automatically. In addition, the system developed makes it easy to record and process student attendance as a condition for conducting an assessment process for lectures that have been conducted.

IV. CONCLUSION

Based on the results of the attendance system developed to achieve good results, student attendance management can be done easily, and attendance reports can be obtained automatically for each week. In addition, the proposed system provides a good level of success or accuracy in performing facial recognition for the attendance process of 97.54%. These results indicate that the proposed system for conducting attendance management provides better results than the traditional attendance system.

V. FUTURE SCOPE

The problems found in testing the developed system include the inability to perform facial recognition on two or more students at the same time. The development of this research that might be done is to develop an algorithm that can perform facial recognition for two or more students at once, or in other words, multiface recognition. This method may be more difficult to do using a facial recognition algorithm, but it is an effective one in terms of time and saves image data storage for the facial recognition process.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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