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Door Lock and Attendance Management System Using Facial Recognition for MZR Global Sdn.Bhd.

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Abstract: MZR Global Sdn.Bhd. is a company provides technology services and creative services to clients and they are having problems on their fingerprint system. MZR Global Sdn.Bhd wishes to have a door lock and attendance management system by using facial recognition for staffs unlock door and record attendances, visitors record visitations and administrators manage attendance records. The hardware requirements are Raspberry Pi 4 Model B and a solenoid door lock while the software requirements are MariaDB and Visual Studio Code. Waterfall model is used to design the proposed system. The suggestion for future work is setting a temperature measuring as a feature of the system.

Keywords: Facial Recognition, Door Unlocking, Attendance Management System

1.   Introduction

A facial recognition system is a technology capable of matching a human face from a digital image or a video frame against a database of faces, typically employed to authenticate users through ID verification services, works by pinpointing and measuring facial features from a given image, same as the description by Parmar and Mehta [1]. In the early stages, facial recognition system is using in computer applications and now it has been used widely for more areas such as phone applications, robotics and automatics which is similarly with Kar et al. [2]. Same as the iris recognition and fingerprint recognition, facial recognition system also applied the method of biometrics authentication from human with geometry of face as the measurement.

MZR Global Sdn.Bhd. is a company that provides information technology services and creative services to clients for building their imagination into the technical system. The headquarter building of MZR Global Sdn.Bhd. is located at Shah Alam, Selangor and many of staffs work in it every day. A fingerprint system is set up in front of the main gate as security measurement when staffs want to get into the office. Besides that, the fingerprint machine is also repurposed to record the working time of each staff. Each staff is required to thump print twice which before and after the working time as the record of daily attendances.

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Fingerprint system is a system with highly security that can make sure no anonymous or non-relevant person walk in and out the office. This cause the problem that there are no any records of the visitors and clients when they come for business talks. The main purpose of the system is to unlock the main door and thence it not fulfills for attendance recording. Furthermore, fingerprint machine that may causes multiple contacts make each of staff worries about their health during this peak period of spreading virus COVID-19.

By replacing the fingerprint system with facial recognition system, it can maintain the security level of MZR Global Sdn.Bhd. and solve the problems of fingerprint system simultaneously. Facial recognition system is able to record visitors' faces instantly during every visitation. This can ensure company's benefits during accident cases such as losing of any assets. In additions, facial recognition system is a totally contactless system which is opposite with fingerprint system. Each staff can relieve to use the facial recognition system which can reduce the risk of infected by virus COVID-19.

The section 2 will discuss about the related works for the project while section 3 is discussing about the methodology used in the project. The section 4 is about the results and discussion for the project.

2. Related Work

In section 2.1, it is discussing about the face recognition-based door unlocking system while the visitors identification system is discussed in section 2.2. The section 2.3 discusses about the fingerprint attendance system.

2.1 Face Recognition-Based Door Unlocking System

Face recognition-based door unlocking system is a security system that applied the method of biometric authentication from human. The system contains three important modules which is face detection, face recognition and door unlocking. The security measurement of face recognition-based door lock is according to the geometry of face from the image captured. To authorize an identity of a person, the camera of the system will capture the image of the person who is facing to it. The captured image is then compared with the dataset images that stored in database. As Vamsi et al. [3], the authorization is successful when the captured image matches with the dataset images and the door will be unlocked.

In face detection and face recognition module, OpenCV library is used to read and write the images from the dataset. As Howse [4], the supported formats of image are different according to the system but PNG, JPEG and TIFF are the basic formats that supported by OpenCV library. When face detection is progressing, OpenCV can create a named window to show the current frame of the camera via namedWindow() function. Then, OpenCV will capture the camera frames from the live video that conducted by the camera. A keyboard input can be set for the capture command or exit command via waitKey() function in OpenCV. The return value for the keyboard inputs is represented as an ASCII keycode or value -1 is returned if there is no any keyboard input. If the named window is done for use, the destroyWindow() function in OpenCV will be used to close it.

Besides the OpenCV library, Haar cascade classifier is the important technology on the face detection and face recognition module in the system. From the research result conducted by Sharifara et al. [5], Haar cascade is an effective detection classifier which have high accuracy and low false positive rate in face detection. Haar cascade classifier requires a lot of images with positive images (contain faces) and negative images (not contain faces) for the training process. The Haar cascade classifier will identify the faces with the edge or line detection features. Haar cascade classifier is then extract the features in the image which features in white pixels have the value 0 while features in the black pixels have the value 1. Then, the different between the sum value of pixels in white and the sum value of pixels in black. In normally, the result of the calculation is around 1 which means the comparison of the images is more accurate when the result is close to value 1.

When the face recognition is successful, the solenoid door lock will receive the command to unlock. Oppositely, when the captured image is not matches with any of the images in dataset, the identity of the person is not authorized and the door will not be unlocked. This is good in security aspect to restrict access from anonymous or non-relevant person.

2.2   Visitor Identification System

Visitor Identification system is one of the systems using face recognition technology for authorizing visitor identity. The basic concept of the visitor identification system is almost same with the face recognition-based door lock system. Both of the systems are built with face detection and face recognition module to complete the identification process. The visitor identification system will capture the face of visitor to compare with the dataset stored in database. The identity of visitor will be authorized when there are matches in the comparison result.

The efficiency of visitor identification system is affected by two major factors which is database and comparator, as mentioned by Kukharev and Nowosielski [6]. Every known visitor will have a set of face images that stored in the database of the system for face recognition process. As the number of images in database getting more, it will decrease the face recognition speed and also the reduce the efficiency of the system. Thus, it is necessary to make sure that the images in database are contain the face of visitor and remove the images with non-relevant information such as background image without face of visitor. Comparator in the system has the rule to compare the captured image from camera with the images stored in the database. To improve the efficiency of the system, features extractor can be used to take the task for verification process. The features extractor can extract the features which will identify the captured images explicitly.

The face recognition process of the system is installed with specified algorithm to handle some special conditions. The face recognition process will authorize the identity of a person properly when he or she is facing forward with the camera of the system. This is an intelligent way to ensure that the system will not simply start face recognition process when there are people appear in the scene even his or her records are in database. Due to the face detection is constraint to the frontal face of visitor, the images in database are not restricted by the size of face area.

The visitor identification system is important on recording and restricting access from visitors to improve the security level. Compare to manual recording visitation system, it is more secure and efficient with using face recognition technology. The system can also collect the information of the visitation frequency of visitor and create the report automatically.

2.3   Fingerprint Attendance System

As the technology becomes advance, manually recording attendance system is replaced with most of the biometrics technology methods. Once of the biometrics technology methods that commonly used in attendance system is fingerprint recognition just like the system created by Chitresh Saraswat et al [7]. This is because fingerprint recognition can avoid the case of signing attendance for friends due to the unique of each fingerprint pattern.

The fingerprint attendance system is built with two main components which is a fingerprint scanner device and a local host computer device. The fingerprint scanner device is the machine to register the fingerprint at the first time and scan the fingerprint after that. Fingerprint scanner device has three major kinds of material which is optical fingerprint scanner, semiconductor fingerprint scanner and ultrasonic fingerprint scanner, same as mentioned by L. Jian-po et al. [8]. Semiconductor fingerprint scanner is major used due to the smaller size, lower price and efficient in scanning fingerprint under most of the condition such as dry or wet fingerprint. To visualize the fingerprint recognition process, a monitor is connected to the fingerprint scanner device for displaying the result of the process.

In the local host computer device, there is a Graphical User Interface of application to manage the attendance records. It is a subsystem of the fingerprint attendance system and it can only be accessed by authorized admins. Every result of fingerprint recognition will be synchronized to the local host computer device as the recorded data, regardless of successful or unsuccessful result. An admin is granted authorization to manage the attendance records such as view record, edit record, search record and delete record. The attendance records will be saved in the local host computer device as the Microsoft Excel file. The application can generate most kinds of monthly report for admin in collecting information.

In the conclusion, fingerprint attendance system is more effective and efficient than the manually recording attendance system. The fingerprint attendance system can perform more efficient than manually recording attendance system even there are a large number of people involved. Fingerprint attendance system also make sure that no cheating cases occur when signing the attendance. Therefore, the system is highly recommended for academic environment and workplaces.

3.   Methodology/Framework

The section 3.1 is discussing about the waterfall model while the section 3.2 is discussing about the functional and non-functional requirements in the project. Business workflow is presents in section 3.3 while data flow diagram is presented in section 3.4.

3.1   Waterfall Model

The methodology used for the project is waterfall model. As Balaji and Murugaiyan [9], waterfall model is known as sequential development model which the input of each stage is take from the outputs in previous stages. In waterfall model, all the requirements should be stated clearly before proceed to design the project. The phases included in waterfall model is requirements gathering and analysis, design, implementation and testing. All the phases have to proceed in sequential order without overlapping in the project.

3.2   Functional and Non-Functional Requirements

According to Malan and Bredemeyer [10], functional requirements refer to the functions or services should be performed in the system. Functional requirements are important for developers to create the system which enable the users can accomplish their tasks. In this system, the functional requirements for each user are different. Non-functional requirements are referring to the attributes or constraints of a system which also described by Lawrence and Julio [11]. If a system working without achieve the non-functional requirements, the system may not achieve the user expectations or the business requirements.

Functional requirements:

- Register and login attendance management system
- Manage staff information and images
- Manage attendance records
- Print attendance records as PDF file
- Attendance recording
- Door unlock

Functional requirements:

- Performance
- Security
- Compatibility

3.3   Business Workflow

A business workflow presents the overview of processes work through in the system from the beginning until the end. It is useful to show the processes step by step and assign the roles for the users. Business workflow can improve the efficiency of business since users can easily understand the processes through the business workflow diagram.
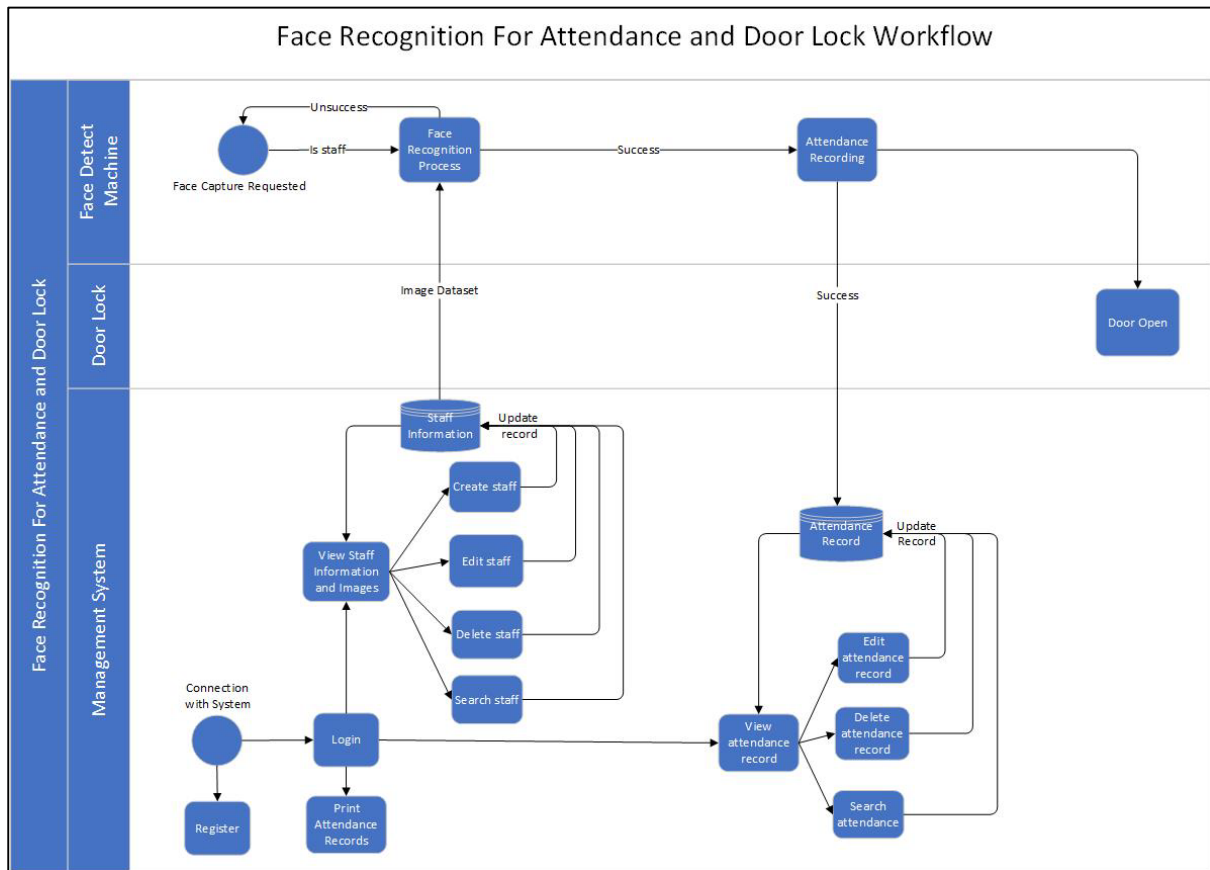

Figure 3.1: Business workflow of the project

3.3   Data Flow Diagram (DFD)

According to Li and Chen [12], data flow diagram (DFD) is method to illustrate the flows of data and the functions in a system. DFD presents the steps of a process and the flow of information in system by using a graphical diagram. There are four main components with different shapes in DFD which is external entity, process, data store and data flow. A data flow diagram can be divided into many layers which starting from level 0 to level 1, level 2 beyond.
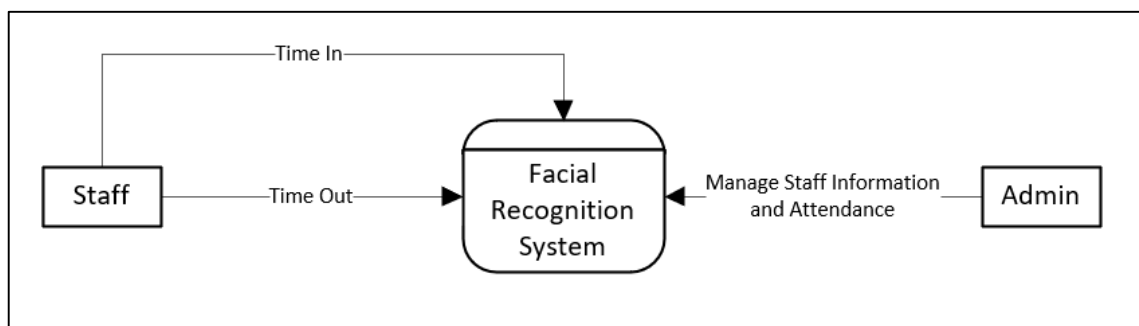
Figure 3.2: Context Diagram of the system
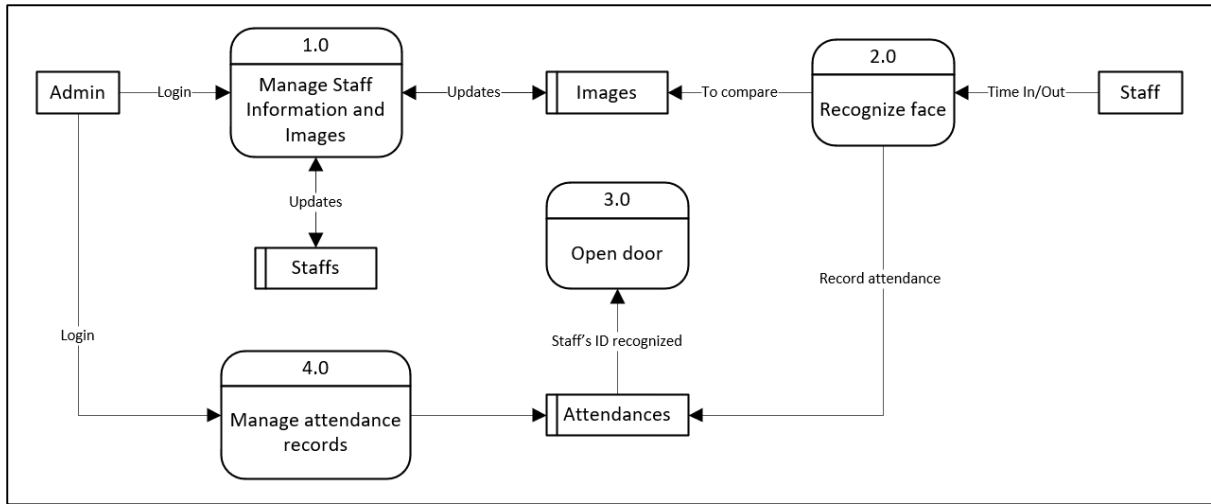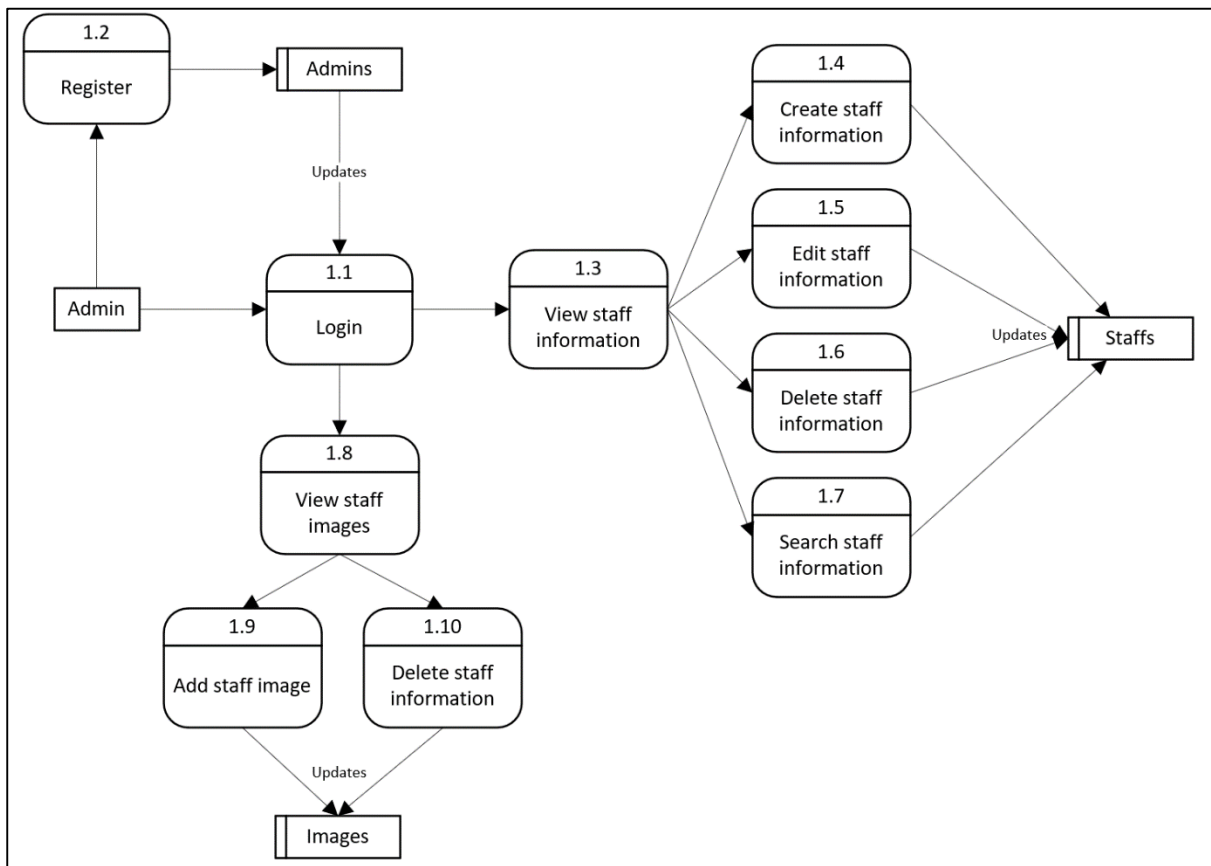
Figure 3.3: Level 1 DFD of the system

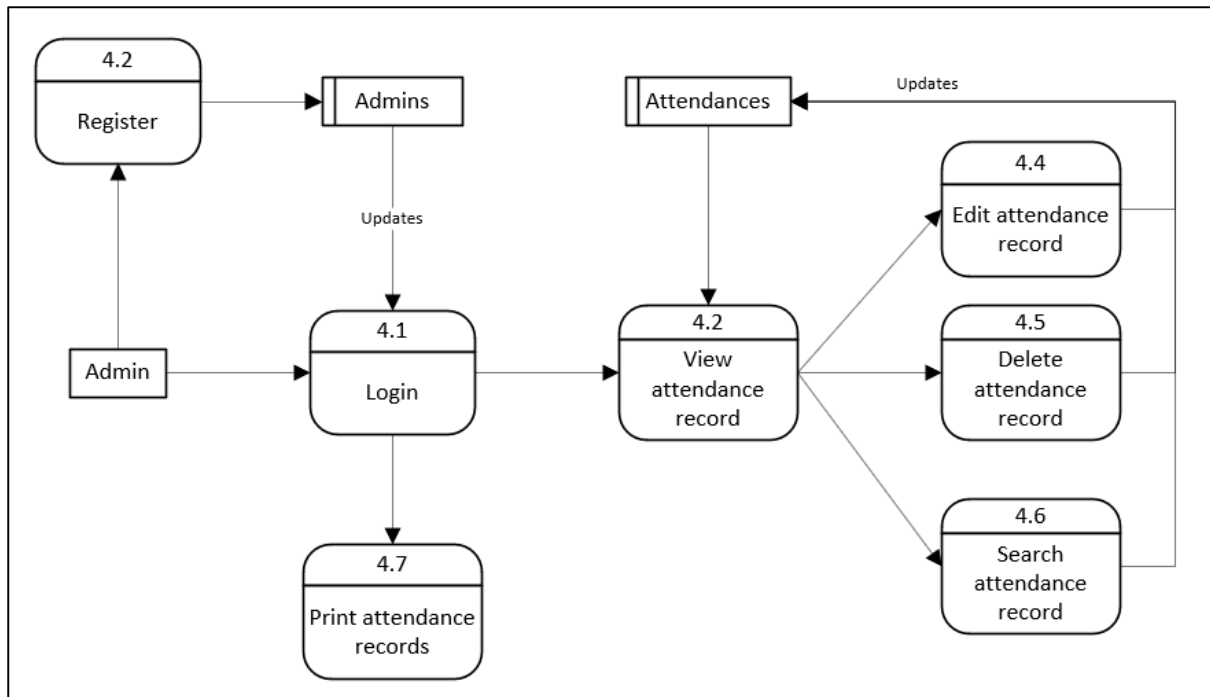

Figure 3.4: Level 2 DFD of the process 1.0

Figure 3.5: Level 2 DFD of the process 4.0

4.   Results and Discussion

In section 4.1, the tables created in Raspberry Pi were presented with the attributes while the functional modules in Raspberry Pi were discussed in section 4.2.

4.1   Tables

There are four tables created for the proposed system which is Admins, Staffs, Images and Attendances. Table 4.1 shows the attributes of Admins table while table 4.2 shows the attributes of Staffs table. The table 4.3 shows the attributes of Images table and table 4.4 shows the attributes of Attendances table.

Table 4.1: Attributes of `Admins` table.

Attributes	Data Type	Size	Key	Descriptions
id	INT	20	Primary	Admin id in table
name	VARCHAR	255	None	Admin full name
email	VARCHAR	255	None	Admin email address
password	VARCHAR	255	None	Admin login password
created_at	TIMESTAMP		None	Time of admin created
updated_at	TIMESTAMP		None	Time of admin updated

Table 4.2: Attributes of `Staffs` table.

Attributes	Data Type	Size	Key	Descriptions
id	INT	20	Primary	Staff id in table

staff_id	VARCHAR	10	None	Staff id in office
staff_name	VARCHAR	255	None	Staff full name
staff_email	VARCHAR	255	None	Staff email address
deleted_at	TIMESTAMP		None	Time of staff deleted
created_at	TIMESTAMP		None	Time of staff created
updated_at	TIMESTAMP		None	Time of staff updated

Table 4.3: Attributes of `Images` table.

Attributes	Data Type	Size	Key	Descriptions
id	INT	20	Primary	Image id in table
staff_id	VARCHAR	10	Foreign	Staff id refer to staff_id in Staffs
image	VARCHAR	255	None	Image file name
file_location	VARCHAR	255	None	Image file location
file_ext	VARCHAR	255	None	Image file extension
deleted_at	TIMESTAMP		None	Time of image deleted
created_at	TIMESTAMP		None	Time of image created
updated_at	TIMESTAMP		None	Time of image updated

Table 4.4: Attributes of `Attendances` table.

Attributes	Data Type	Size	Key	Descriptions
id	INT	20	Primary	Image id in table
staff_id	VARCHAR	10	Foreign	Staff id in office
staff_name	VARCHAR	255	Foreign	Staff full name
clock_in	VARCHAR	255	None	Time of staff clock in
clock_out	VARCHAR	255	None	Time of staff clock out
deleted_at	TIMESTAMP		None	Time of staff deleted
created_at	TIMESTAMP		None	Time of staff created
updated_at	TIMESTAMP		None	Time of staff updated

4.2   Functional Module in Proposed System

Figures below show the functional modules created in proposed system:

Figure 4.1: Register page

Figure 4.2: Login page

Figure 4.3: Staffs information page

Figure 4.4: Staffs attendance page
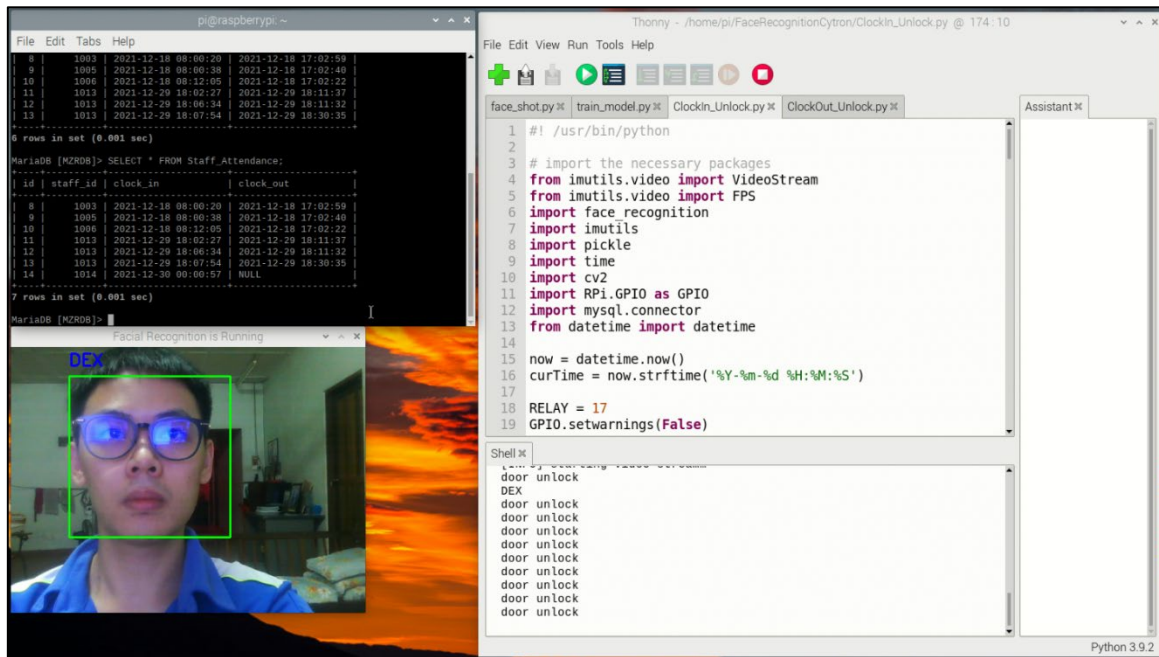

Figure 4.5: Print report page
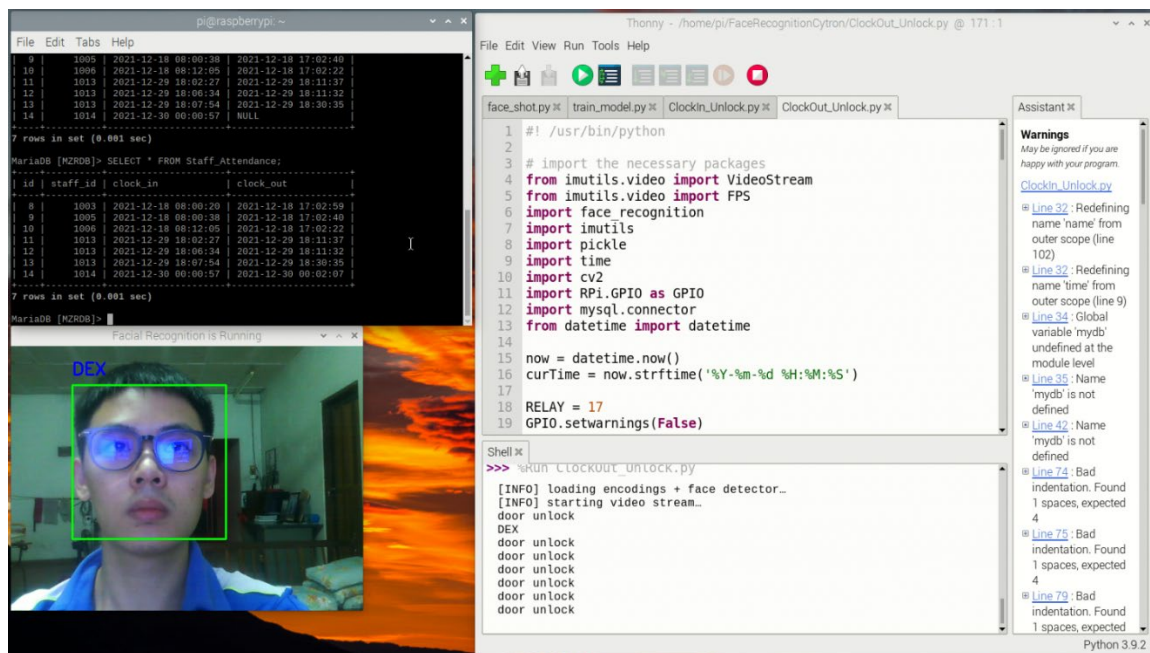
Figure 4.6: Clock in function

Figure 4.7: Clock out function

5.   Conclusion

In the conclusion, this report has presented the analysis and methodology of the project. The functional and non-functional requirements are stated clearly before the development phase start. The business workflow and data flow diagram also illustrated the processes flow smooth from start until the end. The functional modules in Raspberry Pi are complex so far and achieve the objectives of this project. The interface of the attendance management system module is also developed well. The proposed system has achieved the objectives but there are still some improvements can be done to enhance its functionality.

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