
Facial recognition system for borrowing equipment

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Abstract

This project proposes the development of a smart borrowing and returning cabinet system using Raspberry Pi integrated with infrared sensor and a facial recognition system. The system designs to identify the users through facial recognition before granting access to borrow or return equipment. The cabinet operation has simple two states: when the user's face successfully verified the cabinet unlocks; otherwise, the access is denied. The cabinet shows the status through the LED, if there is an equipment in the cabinet, the light will be on. But if there is no equipment, the light will be off. All borrowing and returning activities are logged in a .txt file to recording the student ID, date, and time. The face recognition methodology is recognizing the user faces without any face covering like hats, glasses, masks, etc. and record in database as reference. The evaluates from 3 volunteers. The results show all samples the face recognition system can be verified when users no face covering. In case of wearing sunglasses, hats or masks or have some covering the face, the system will lower performance. In addition, if another person who does not store information, the system cannot verify as designed.

Keywords: Raspberry pi board, Infrared sensor, Face recognition system, Python language, Lending cabinet

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1. Introduction

The Education is the most essential for national development. The education system is divided from kindergarten to doctoral level. The education system is considered to help each country develop. The educational context is to provide knowledge from generation to generation to apply knowledge in life and in professional careers. The impact that makes the education system continuously develop is the equipment used in various operations, especially tools, which are considered important for learning. Vocational certificate, vocational diploma, and electrical engineering equipment use tools and equipment to learn, such as digital multimeters, analog multimeters, screwdriver boxes, and other equipment. All of these are expensive and are frequently used. What is found and a problem is that these devices are often lost or used in various areas, with or without notification because in each semester, each subject is used, making it impossible to find the person responsible or to check, which causes equipment to be lost every year. It also causes a loss of budget for purchasing these devices, instead of buying other equipment for teaching. The project creator has seen the problem of equipment loss in the Faculty of Engineering, especially equipment in the field of electrical engineering. The reason is that the creator is a student in the field of electrical engineering, so he learned that every year a large amount of equipment must be purchased because some equipment is lost during borrowing. Therefore, a borrowing and return system using a face recognition system has been created to verify borrowers and determine the rights of borrowers and returners[1],[5], which can check the borrowing and return of equipment. The use of a sensor system used with a Raspberry Pi board and a camera to detect faces before borrowing and after returning equipment [2-3] is used to reduce the problem of equipment loss in the field of electrical engineering.

2. Research Methods

2.1 Face Recognition

Face recognition is a processing system that can detect faces and identify individuals in both still and recorded motion pictures, including real-time motion pictures. The system analyzes various characteristics on the face, such as facial structure, nose width, distance between the eyes, and cheekbone size, etc. The system then creates a connection point on the face to compare with images stored in the database in both still and motion pictures. For the accuracy of identifying borrowers who must enter the verification process, high resolution face recognition is used for security and control. The use of face recognition systems to control entry and exit of people in an area is used in places that require special security or surveillance, such as power plants, museums, etc. [1],[5],[6],[7]

2.2 Image Processing

Image analysis into digital data to provide the computer with size and shape information for analysis. The image processing process consists of 3 parts: Part 1 processes the image; Part 2 converts the color image to grayscale; Part 3 finds the edges of the image to compare with the original image.

2.2.1 Machine learning theory is a form of data analysis that uses human thinking and decision making. Machine learning is an AI algorithm that uses prediction to make decisions. It uses mathematical and statistical methods to create models or models from a sample data set, which will

be more or less accurate depending on the amount of data. Models are divided into 3 types: supervised learning, unsupervised learning, and learning things by trial and error. [8]

2.2.2 Edge finding is the process of finding the boundaries of objects that are most prominent and important, leading to the recognition of those objects or the processing or calculation of images by computers to obtain the desired information.

2.2.3 Grayscale Image is a black and white and gray image with a gray conversion intensity level of 0 255 (8-bit). Grayscale image is created by converting the image from the 3 primary colors (RGB) to grayscale image using a mathematical formula as shown in Equation 1.

$$\text{Gray} = 0.299 * R + 0.587 * G + 0.114 * B \quad (1)$$

2.3 Webcam Camera

Webcam is a digital device that records video and audio for real-time communication. Webcam is used for online communication in the form of video calls. In this project, it is used as a camera for face scanning with a resolution of 1920x1080 pixels, USB 3.0 interface [3]

2.4. Raspberry Pi

It is a microcontroller board using the ARM family control. Raspberry Pi board is a simulation of itself as a small computer system that can run the Linux system itself, making it very convenient because it has an OS. Linux can work instead of the network system, communicating with the monitor system, communicating with the sound system, and communicating with the data storage system via a memory card (SD Card). It can be done completely and comprehensively with the Linux operating system running on the Raspberry Pi board [4]



Figure 1 Raspberry Pi

2.5 Python

It is one of the "fundamental" computer languages because it is easier to understand than other types of programming languages. It also has a variety of capabilities such as writing websites, applications, calculating data and collecting statistics, creating user interfaces, etc. [9-10]

2.6 Infrared Sensor

It is a proximity sensor module that works by sending an infrared LED light signal to hit the object detected in the distance and reflecting it back to the photodiode that receives the infrared light, which will output a digital signal. Some modules may also support analog signal output. The R

adjustment is used to adjust the sensitivity to detect infrared light, which will affect the distance the sensor can detect objects. This module is cheap, small, and convenient to use with robots, smart cars, obstacle avoidance robots, etc.

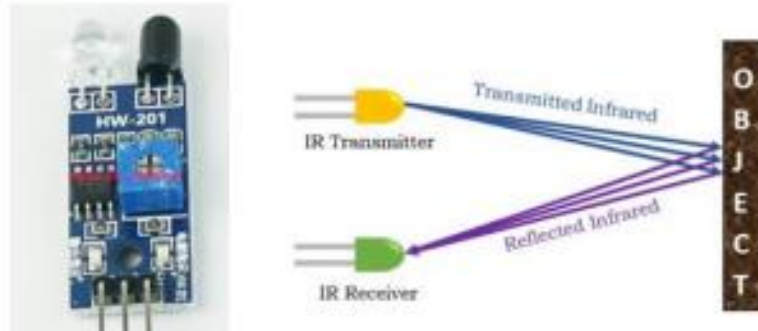


Figure 2 Infrared Sensor is a type of light sensor that uses a reflected beam

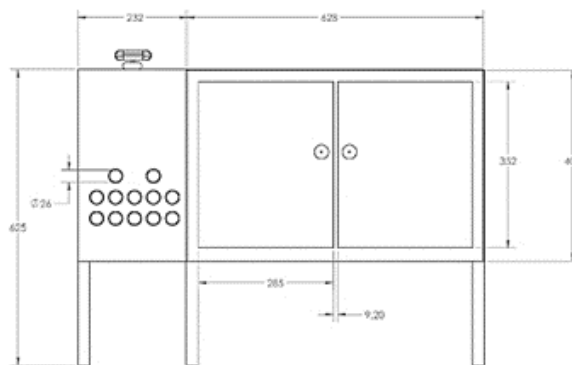
2.7 Related research

C. Rungklin et.al. have applied the face recognition system, which is a process of taking the detected and processed face images and comparing them with the face database to identify which person the detected face matches, to unlocking doors or entrances and exits of buildings, residences for the safety of residents and property. The development of the door opening system with face recognition is divided into 2 parts: the hardware part, which consists of a camera module for capturing face images, a small computer board, and Raspberry Pi. The second part is the processing part, which is the development of a set of commands for the door opening system with face recognition, using the Python language with a notification system when the door is opened via Line Notification.

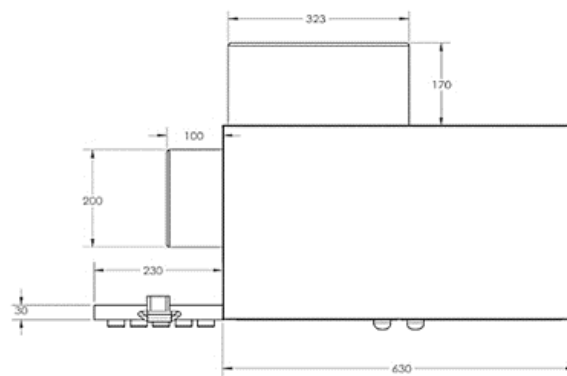
C. Namsai et al. have presented a snake detection system that can provide a timely warning when snakes invade a residence. It uses images of snakes from CCTV cameras connected to a snake detection system using the YOLO method to analyze the snake invasion. [12]

3. Methodology

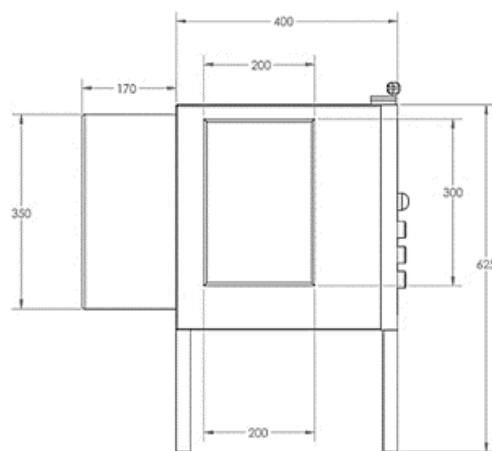
3.1 Cabinet structure design



(a)



(b)



(c)

Figure 3 Cabinet structure design (external) (a) front view, (b) top view, (c) side view

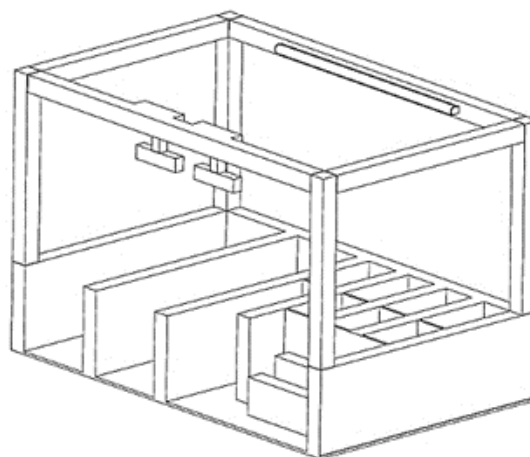


Figure 4 Cabinet structure design (internal)

From Figure 3 is the design of the cabinet structure (external) consisting of Figure 3 (a) front view, (b) top view, (c) side view. Figure 4 is the design of the cabinet structure (internal). The design of the cabinet structure uses the SolidWorks program to design.

3.2 System operation

The webcam is used for face detection. The webcam is connected to the Raspberry Pi to display the image and the Raspberry Pi to process the image. The Raspberry Pi compares the image displayed through the camera and the borrower's recorded face data. Then it will enter the verification process. If the borrower's face does not match the data, it will return to the initial process. However, the borrower's face matches the data of the Raspberry Pi, which is the intermediary in the connection. The system operation is divided into 2 parts:

Part 1 The relay connected to the Raspberry Pi will disconnect the electromagnetic lock. The relay will supply electricity to the coil to convert the voltage into a magnetic field, changing the direction of the electricity flow, causing the electromagnetic lock to stop working.

Part 2 The device detection sensor or infrared sensor is used to detect objects by reflecting the intensity of light to the object and displaying the value as 0, 1. In case the sensor detects the device, it will display the value as 0. In case the device is not detected, it will display the value as 1. The output of the sensor is connected to the input of the LED lamp for display.

4. Results and Discussion

4.1 Facial recognition system test results

The test is divided into 5 cases using data from Figure 5, consisting of 1. Normal face test 2. Hat test 3. Glasses test 4. Mask test 5. Use the face from the mobile phone to test. The test details are as follows: Use 3 people in total, use a distance from the camera of 1 meter, face detection time 5 seconds. In the case of having an image database. The camera detects a face; a square frame will appear with the student ID of that person. In the case of the person who does not have an image database, a frame with the message Unknown will appear. However, the face is not detected, the frame will not be displayed and the student ID will not be notified.



Figure 5 Result of first person face detection.

In all 5 cases tested 10 times, the results are shown in Table 1. The symbol / represents the face detection and shows the student ID. The symbol × in the face detection does not detect or shows the student ID that does not match the person.

Table 1. Results from the first-person test.

Case	Term									
	1	2	3	4	5	6	7	8	9	10
Normal face	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wear a hat	×	×	×	×	×	×	×	×	×	×
Wear glasses	✓	✓	✓	✓	✓	×	×	✓	✓	✓
Wear a mask	×	×	×	×	×	×	×	×	×	×
Photos on phone	✓	✓	✓	×	✓	✓	✓	✓	✓	✓

From Table 1, it was found that in the 10 tests. In the case of normal face, the system was able to detect the face and display the student ID 10 times. In the case of wearing a hat, the system failed to detect the face all 10 times. In the case of wearing glasses, the system was able to detect the face and display the student ID 8 times, with 2 errors. In the case of wearing a mask, the system failed to detect the face all 10 times.

**Figure 6** Result of second person face detection.**Table 2.** Results from the second-person test.

Case	Term									
	1	2	3	4	5	6	7	8	9	10
Normal face	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wear a hat	×	×	×	×	×	×	×	×	×	×
Wear glasses	✓	✓	✓	✓	✓	✓	×	✓	✓	✓
Wear a mask	×	×	×	×	×	×	×	×	×	×
Photos on phone	✓	✓	✓	✓	✓	✓	✓	✓	×	✓

From Table 2, it was found that in the 10 tests. In the case of normal faces, the system was able to detect faces a total of 10 times. In the case of wearing a hat, the system was unable to detect faces a total of 10 times. In the case of wearing glasses, the system was able to detect faces and display student IDs 9 times, with 1 error. In the case of wearing a mask, the system was unable to detect faces a total of 10 times. In the case of photos in mobile phones, the system was able to detect faces and display student IDs a total of 9 times, with 1 error.



Figure 7 Result of third person face detection.

Table 3. Results from the third-person test.

Case	Term									
	1	2	3	4	5	6	7	8	9	10
Normal face	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wear a hat	×	×	×	×	×	×	×	×	×	×
Wear glasses	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wear a mask	×	×	×	×	×	×	×	×	×	×
Photos on phone	✓	✓	✓	✓	✓	✓	✓	✓	✓	×

From Table 3, it was found that in the 10 tests. In the case of normal face, the system was able to detect the face and display the student ID 10 times. In the case of wearing a hat, the system was unable to detect the face 10 times. In the case of wearing glasses, the system was able to detect the face 10 times. In the case of a mask, the system was unable to detect the face 10 times. In the case of a photo in a mobile phone, the system was able to detect the face and display the student ID 9 times, with an error 1 time.

From the test in Tables 1 - 3, it was found that when wearing glasses, there were times when faces could not be detected due to the light from the bulb hitting the glasses lenses, which caused the detection to be incorrect.

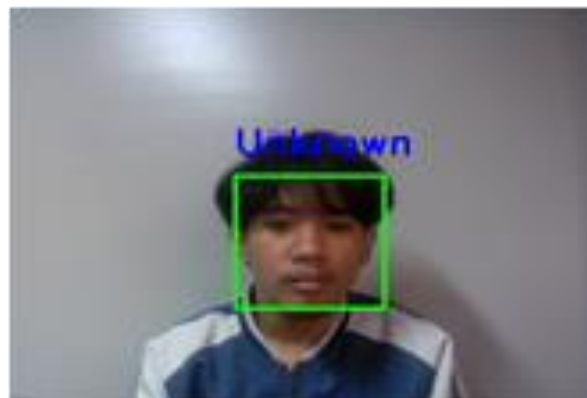


Figure 8 Results in the absence of an image database.

From Figure 8, in the case of a person who does not have information in the database. The test found that the system can check the face capture but will display the message Unknown instead of the student ID and the loan and return cabinet will not work. The test is as shown in Table 4.

Table 4. Results from the fourth-person test.

Case	Term									
	1	2	3	4	5	6	7	8	9	10
Normal face	×	×	×	×	×	×	×	×	×	×

4.2 Cabinet Functional Testing

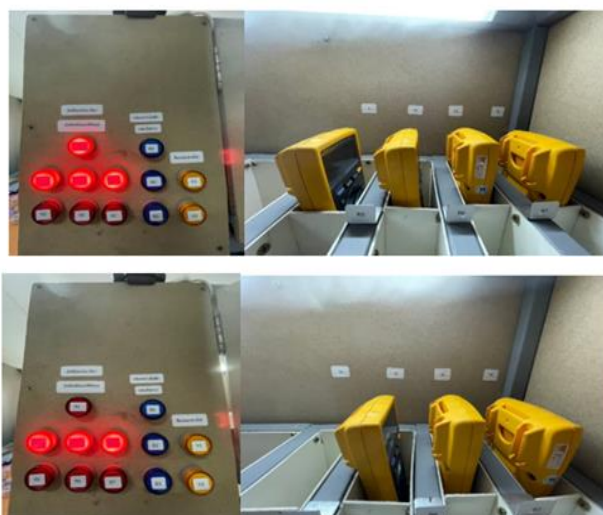
After checking the face through the door, it will open. In the cabinet, there will be 12 devices in total, divided into 3 colors: Red: 4 digital multi-meters, 3 analog multi-meters. Blue: 2 electric drill boxes and 1 screwdriver box. Yellow: 2 wire strippers. Each device will have an identification code: Red R1 R2 R3 R4 R5 R6 R7. Blue B1 B2 B3. Yellow Y1 Y2. In the test, pick up the device in each color to check the infrared sensor that will be used to indicate the status of the device. The infrared sensor detects the device, the LED light on the front of the cabinet will be on. The infrared sensor does not detect the device, the LED light on the front of the cabinet will be off.

**Figure 9** Location of device code on LED strip and device storage compartment.

From Figure 9 shows the location of the equipment storage code. In each compartment, there is a sensor under the equipment compartment inside the cabinet that is connected to the LED light on the front of the cabinet to indicate the ON and OFF status of the equipment in the borrow-return cabinet.



(a)



(b)



(c)



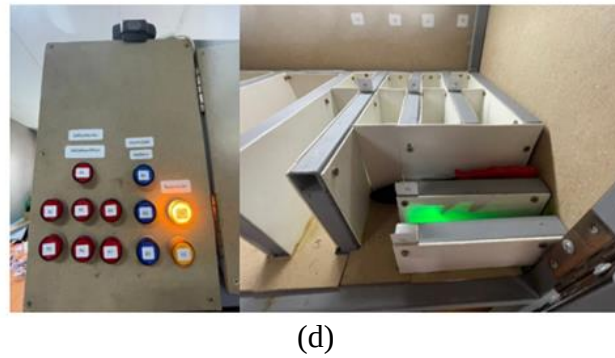


Figure 10 Device status display.

From Figure 10, the status of the borrowed cabinet in the electrical equipment slot is displayed. In the case where the light is displayed, it means that the equipment is there. In the case where the light is not on, it means that it has been borrowed.

4.3 Data collection in Raspberry Pi

It is data collection when the system records, i.e. the system checks the face. The system confirms the data and stores the student ID when the face is detected and the device is borrowed and returned, as shown in Figure 11 The data file will be saved as a .txt extension.

Student ID	Date, Month, Year	Time	Digital meter				Analog meter			Drill box	Screwdriver box			Wire stripping pliers	
			R1	R2	R3	R4	R5	R6	R7		B1	B2	B3	Y1	Y2
6510420042	1/7/2567	13:00	1	1	1	1	1	1	1	1	1	1	1	1	1
6510420052	1/7/2567	13:10	1	1	0	0	1	1	1	1	1	1	1	1	1
6510420042	1/7/2567	13:15	0	0	0	0	1	1	1	1	1	1	1	1	1
6510420045	1/7/2567	13:30	0	0	1	1	1	1	1	1	1	1	1	1	1

Figure 11 Collection of borrowed equipment data.

From Figure 11 is the format for storing borrowed and returned equipment data. It consists of student ID, date, time, and status of the equipment. Status 1 means the equipment is in the cabinet that has not been borrowed and 0 means the equipment has been borrowed. The data is stored in the .txt extension for easy use with other programs.

5 Conclusion

In testing the face recognition system, it was found that in all 10 tests. In the case of normal faces, the system was able to detect the faces and identify the student IDs of all 3 individuals, accounting for 100 percent. In the case of wearing hats, the system was unable to detect the faces of all 3 individuals, accounting for 0 percent. In the case of wearing glasses, Person 1 was correctly detected 8 times, Person 2 was correctly detected 9 times, Person 3 was correctly detected 10 times, accounting for 90 percent. In the case of wearing a mask, the system was unable to detect the faces of all 3 individuals, accounting for 0 percent. In the case of using photos on a mobile phone, Person

1 was correctly detected 9 times, Person 2 was correctly detected 9 times, Person 3 was correctly detected 9 times, accounting for 90 percent.

In testing the face recognition system 10 times, it can be seen that the normal face can detect the face and display the student ID correctly, which is 100 percent. In the case of wearing a hat, the system cannot detect the face, which is 100 percent. In the case of wearing glasses, the system can detect and display the student ID correctly, which is 90 percent. In the case of a mask, the system cannot detect the face, which is 100 percent. In the case of photos on the mobile phone, the system can detect the face, which is 90 percent. The system can detect the face of a person without a database, but will not unlock the cabinet because the conditions are not met. In the infrared sensor, it can detect devices in both red, blue, yellow and display the values 0,1 or ON, OFF to the LED bulb effectively. A record of borrowing and returning data is stored to check the person who borrowed the device. The stored data will be stored as a .txt file.

Regarding the issue of using photos from phones, this can be addressed by examining images from electronic devices, such as cell phones and camera lenses, using the YOLO equation. This can address this issue.

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