Raspberry Pi Zero Door Locking System with Face Recognition using CNN (Convolutional Neural Network) and Fingerprint Sensor

Jimmy Linggarjati
Department of Computer Engineering
Bina Nusantara University
Kebon Jeruk, Jakarta, Indonesia
jimmyl@binus.edu

Abstract

Door-locking system with face recognition and fingerprint sensor is a system of door's lock that uses two security parameters. These two parameters must be fulfilled for the door to be opened. When one of these two parameters do not grand the permission, then the door will not open. This system uses a Raspberry pi zero as a control centre and a dataset storage for the faces' images. For the input process, a Raspberry pi camera and a fingerprint sensor are used. And the output uses a Relay and a Solenoid Door Lock. The results showed that only faces and fingerprints that are recognized by the system, that could successfully open the door.

Keywords

Face recognition, Fingerprint, Solenoid Door Lock, Raspberrypi Zero and CNN – Convolutional Neural Network.

1. Introduction

Feeling secure improves productivity and it consequently improves our life's quality as a society. According to Statistical Bureau of Indonesia, in 2011-2018, burglary has occurred in 45% from the total towns and villages based on (BPS RI 2020). This high percentage of burglary has impacted our economy both in the towns and villages (Delia 2009).

In this research, a System of door lock using a web-camera, fingerprint's sensor, and a Raspberry pi Zero W, is introduced as an alternative for a more secure system in a residential area. Furthermore, the selection of the cheapest Raspberry pi Zero W, has proven that despite its low specification amongst other Raspberry pi's products, it can still perform person's detection software, that requires a powerful computing machine.

1.1 Objectives

The goal of this research is to prove that a Raspberry pi Zero W can run a deep-learning model to recognize a person. Figure 1 shows the block diagram of the door-lock's design.

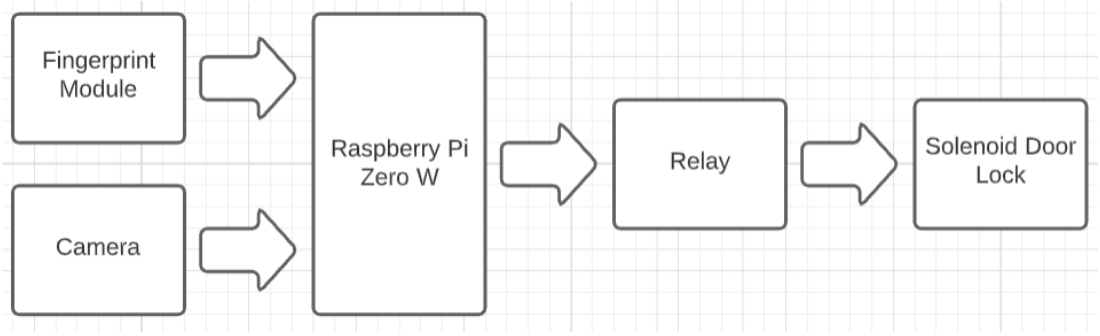

Figure 1. The door-lock Block Diagram

2. Literature Review

2.1 The Fingerprint – AS608

Fingerprint sensors have been used for a reliable security sensor. Memon et al. (2008) showed in Figure 2 that optical fingerprint sensor technology is more reliable compared to other technologies. Qiu (2014) explained that capacitive fingerprint sensor technology is gaining popularity due to its smaller size compared to optical ones. Fingerprint is used a lot in assisting security (Fingerprint Analysis). Barua et al. (2011) explained a different technology for extracting the fingerprint pattern that is said to be more reliable to the finger's movement during scanning. The AS608 fingerprint sensor is categorized as an optical fingerprint sensor. Wu et al. (2018) have used it for their classroom identification project. While win and Oo (2019) have added wireless capabilities into their student attendance fingerprint system. It is a versatile sensor, because it uses serial port to communicate directly with the microcontroller, whether the current finger's image is registered or not. Therefore, the usage of this sensor is easy.

Figure 2. The AS608 - Fingerprint Reader Module

2.2 Raspberry Pi Zero W with Camera

Raspberry Pi Zero is the least expensive product from the Raspberry Pi Foundation UK. But it can process the algorithm for the face recognition (Nagpal et al. 2018). (Figure 3) While, in this paper, a newer face recognition's algorithm is used, and it will be explained further in the next section - 2.3.

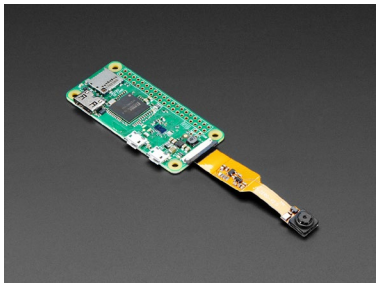

Figure 3. Raspberry Pi Zero W with Camera

Mahesh et al. (2020) have used Raspberry Pi 3 to detect a face, while in here a cheaper version of Raspberry Pi Zero W is used instead, to lower the overall cost of this system.

2.3 Face Recognition Algorithm

Early face recognition algorithm uses Haar Detection (Gupta et al. 2016) and Eigenface (Gunawan et al. 2017) for face detection and followed by PCA (Principal Component Analysis) as face classifier. In this paper, it uses the HOG (Histogram of Oriented Gradient) for face detection (Dalal and Triggs 2005) and CNN for face recognition (Schroff et al. 2015). Zhou et al. (2019) which CNN method is best for the person category.

3. Methods of Software Algorithms

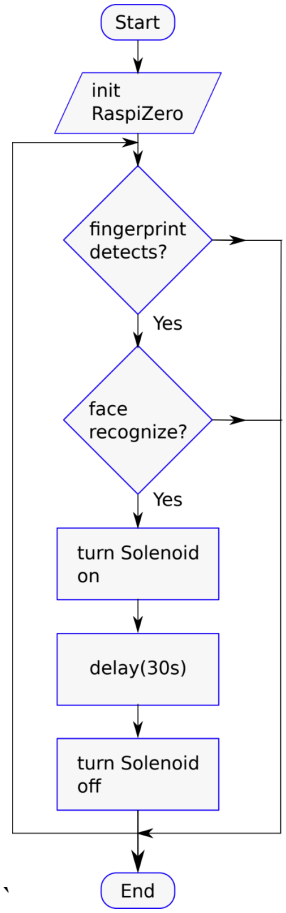

Figure 4. Flowchart Diagram of Door Security System

4. Hardware-Software Implementation and Data Collection

4.1 Hardware

Figure 5 shows the implementation of the Door-locking System. Figure 5 on the left shows the overall look of the system, while the right figure shows the internal components inside the enclosure.

Figure 5. Implementation Door-locking System using Raspberry Pi Zero W (inside the box), a Webcam OV5467, AS608 – Optical Finger scanner, and Led for Illumination

4.2 Software

Python language is used to process the image taken from the web-camera and to control the door locking mechanism through a solenoid valve. Figure 6 shows how the software of fingerprint scanner works. The function get fingerprint

(Figure 6) will return “True” if it found a registered fingerprint’s image. And it will return “False” otherwise if it does not find any registered fingerprint’s image.

```
########################################
def get_fingerprint():
    """Get a finger print image, template it, and see if it matches!"""
    print("Waiting for image...")
    while finger.get_image() != adafruit_fingerprint.OK:
        pass
    print("Templating...")
    if finger.image_2_tz(1) != adafruit_fingerprint.OK:
        return False
    print("Searching...")
    if finger.finger_search() != adafruit_fingerprint.OK:
        return False
    return True
```

Figure 6. Fingerprint function in Python.

Figure 7 shows the function that detects the face image taken from the web-camera.

```
def get_face():
    while True:
        success, img = cap.read()
        imgS = cv2.resize(img, (0, 0), None, 0.25, 0.25)
        imgS = cv2.cvtColor(imgS, cv2.COLOR_BGR2RGB)

        facesCurFrame = face_recognition.face_locations(imgS)
        encodesCurFrame = face_recognition.face_encodings(imgS, facesCurFrame)

        cv2.imshow('Camera', img)
        cv2.waitKey(1)

        for encodeFace, faceLoc in zip(encodesCurFrame, facesCurFrame):
            matches = face_recognition.compare_faces(encodeListKnown, encodeFace)
            faceDis = face_recognition.face_distance(encodeListKnown, encodeFace)
            matchIndex = np.argmin(faceDis)

            if matches[matchIndex]:
                nameDetected = classNames[matchIndex].upper()
                print(nameDetected)
                print("Face Identification Done")
                faceIdentification = 1

        if faceIdentification:
            break
    if faceIdentification:
        return True
    else
        return False
```

Figure 7. Face Recognition Function in Python

5. Results and Discussion

The prototype is built and tested for the following conditions, the distance between the web-camera and the person’s face. The elapsed-time to detect a fingerprint and the elapsed-time to detect and recognize a person’s face.

The distance that a person's face can be detected and recognized by the web-camera, is shown in Figure 8. And it takes approximately 0.7 seconds for the software to detect a person’s fingerprint. While for the person’s face detection and recognition, it takes a bit longer, approximately 2.5 seconds. Further improvement for this face time detection and recognition can be explored by using STM32 microcontroller (Lin and Hu 2020), that has approximately the same clock speed as the raspberry pi zero, i.e., 400Mhz.

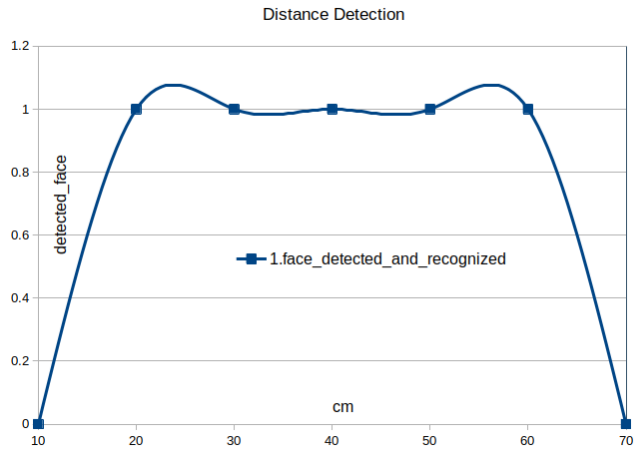

Figure 8. Distance for Face Detection and Recognition

6. Conclusion

The prototype of door-lock system using fingerprint sensor and face recognition camera, has been developed and tested. It shows that the output can detect a person's face within a normal distance range from the web-camera. This also proved that current face recognition's algorithm has good ability to detect face in a real-time

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Biography

Jimmy Linggarjati S.Kom., MSc. graduated from Bina Nusantara University in 1999 majoring in Computer Engineering and received a master's degree from TU-Delft University in 2002 majoring in Electrical Engineering. He is currently a lecturer at Bina Nusantara University. His research interests include on-device machine learning and control systems.