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Prototype of an Automatic Entrance Gate Security System Using a Facial Recognition Camera Based on The Haarcascade Method

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Abstract. This article aims to test a facial recognition-based front door security system, which can also convey relevant information to the owner's mobile phone via an SMS gateway. This system is necessary to prevent unwanted criminal activity by the owner. The method used is Hercascade as face recognition for security. Use a set of webcam settings to compare human face objects in the background with face data already stored in the database. Capture images using a Raspberry PI connected to a USB webcam for the sensor, move the front door using a servomotor as a drive, and own the system in the form of a short message from basic communication process data Notify to. There is also an ultrasonic sensor as an activation system to detect human objects when they approach the door and invade. Based on the results of 90 tests on a system with varying distances of objects on the camera (30 cm, 40 cm, 50 cm), the average pass rate of the tests is 91.11%. We can conclude that face recognition by the Hercassette method can be applied as an entrance security system.

1. Introduction

A house is a building used as a place of life, where one can enjoy a comfortable life, a place of family activities and, above all, a place of life. As a key asset, it is very important to make sure security level in your home is maintained at all times and you can avoid unwanted negative events such as break-ins and illegal activity, other criminal activity. As an example, is when there is a stranger come inside the house without the permission.

To recognize the people who come inside the house we need the system namely face recognition to mark of the owner and stranger. In [1], one of the biometric technologies is the system of face recognition which many experts have developed it to be aghoritm of face recognition to distinguish one individual based on existing data.

To implemented this technology, we need to learn about image processing [2] as a special key to recognize the owner and cannot duplicate. Using the embedded system [3], being able to remember that everyone has another face is stored in a face database to identify an individual's face. It can be used to predict various criminal acts in a security system that can be used for unrecognized face. In this research is create an application of security system based on face recognition in front of the entrance gate for identification some activities which is can give feedback that provide information and notification to the owner.



2. Literature Review

2.1 Data acquisition of the image

Between computers and humans there is an interaction which play key role to recognize one human and the others that called face recognition [2]. Basically, its system works by capturing the data of digital face which coming from an image of video frame, need to distinguish between background images and faces, and the data will stored to a database to make comparison. Occasionally face recognition and image processing systems will increase accuracy. Long hair covering the center of the face, photos that are too bright or too bright due to improper lighting, or low resolution photos have some other factors that interfere with the analysis as if they were taken from a distance [3]. It identifies the ROI (Region of Interest) at which the image is converted to binary format and the object being analyzed, sets the threshold level, and captures the area of the projected image until the boundaries are visible, clearly. The next, marks the covered area according to the original coordinates (x, y) by the ROI. The pixel width and the pixels height in to be the border ROI [4]. Image processing for comparing the faces of objects involved in pattern recognition is any feature or function that can be used as an aspect that distinguishes objects from other objects. A pattern is an object which is combined by several characteristic [5]. The Haar cascade is the model for recognizing the pattern, which is commonly used to determine similarities between both pixels, samples or curves to identify and understand the shape of an image in the process of image processing.

2.2 Objects detection using haar cascade from Open CV

Algorithms is able to learn to divide a region of a digital image into segments or subsections (cascades) and detect functional objects by processing rectangular regions. This method does not sum the areas of the object. Although it is a pixel, it embeds a square pixel area in the feature rule. For the Type of the features, there are three features, they are feature of the: a) edge, b) line, and c) four rectangular. The math performed is to focus on the foreground area of the object, remove the background area, and get the object detected by the Haar layer, that is, completely shrink the black box area of the pixel oand the white box pixels. This is applied the above three types of functions too. Based on [6], the square box area is described as shown figure 1 below:

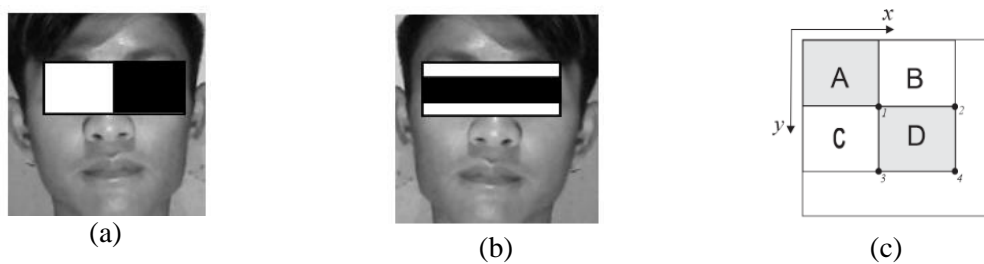


Figure 1. (a) Application of Edge features; (b) Application of Application of Line features; (c) Application of Four-rectangle features

Figure 1 is the illustration of the types of haarcascade algorithmic methods. In a study using the haarcascade algorithm, line features, the treatise [6] clarifies that the box D area is the consensus result of on pixels with $(4 + 1) (2 + 3)$. Where the original image is $i(x, y)$ and a key part of the overall function of the image is $ii(x, y)$. The cumulative number of lines in the image at $s(x, y)$ is $s(x, 1) = 0$ and $ii(1, y) = 0$. It was created as shown below.

$$s(x,y) = s(x, y-1) + i(x,y) \tag{1}$$

$$ii(x,y) = ii(x-1, y) + s(x,y) \tag{2}$$

In Equations 1 and 2, we used an intermediate representation of the image [6] in order to be able to quickly calculate the number of pixels in the image above. This is called the integral image,

starting from the computed values. left. The Equation 3 is used to derivative function, do the following :

$$ii(x, y) = \sum_{x' \leq x, y' \leq y} i(x', y') \tag{3}$$

From Equation 3, it is an API (application programming interface) for the low-level and the high-level image processing and optimization of real-time application included in the OpenCV library.

2.3 *Embeded System Raspberry PI*

Raspberry PI is a portable device with Flexibility that is currently being developed, which is supported by multi-platform flexibility and can accommodate image processing with ARM processor support with an open-source operating system. This makes the Raspberry Pi chosen to be used in this study, especially the type of Raspberry Pi 3 Model B+ which has been supported by GPIO (General Purpose Input-Output) to communicate between modules. In addition, this device is equipped with built-in wifi IEEE 802.11.b/g/n/ ac, LAN Bluetooth 4.2 BLE, in Figure 2 is the profile and general architecture of the Raspberry Pi 3.

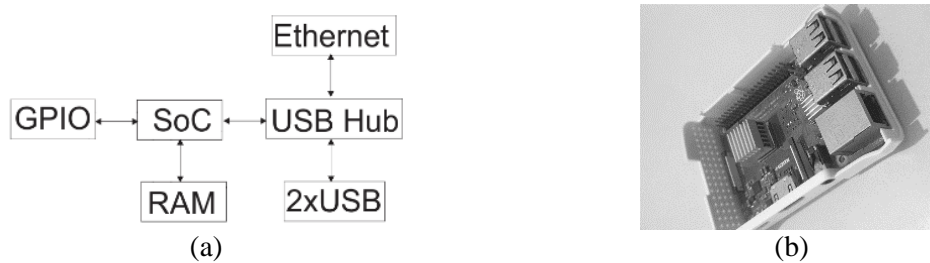


Figure 2. (a) The architecture of Raspberry Pi 3; (b) Raspberry Pi 3

2.4 *The gateway system of cloud short messages*

An important thing to deliver notifications in a system, to provide feedback of the status of the security device which is working to users. The system which is using an API with Nexmo from a cloud-based service to send notification, because the device, Raspberry Pi is connected by internet. Nexmo provides an API too that able to be used to integrate with applications that we create and develop or services of website platform [6].

2.5 *Object distance detection*

An ultrasonic sensor is a sensor device that works based on the principle of sound wave reflection as a detector for the presence of certain objects. The working frequency of this sensor is above sound waves with frequencies from 20 kHz to 2 MHz [7]. This type of ultrasonic sensor HC-SR04 is a tool used to measure the distance of an object or object with a working concept as described previously. The measuring capability of the HC-SR04 ultrasonic sensor ranges from 2 cm – 450 cm [8], with an accuracy of 3mm [9].

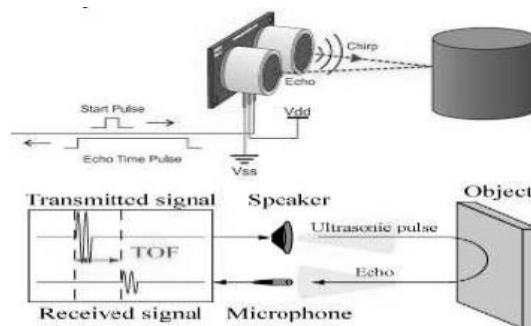


Figure 3. HC-SR04, ultrasonic module working principle [7].

2.6 Capturing image from web-camera

Capturing images using Webcam[10] are more flexible, just connected the I/O USB port to the Raspberry Pi USB port, using 1.3 Mega pixels web-camera features, it is more than enough to identify the object in the the area which actually being used by applying a cropping of resolution. As a base reference in object detection, where images or previews can be accessed from a live video capture from web camera via browser, programs of instant messaging , or applications of video call [12].

2.7 Actuator of the door leaf

A small DC motor called servo motor[13] is equipped with a potentiometer and a gear system so that the servo angle can be positioned at position which the desired. A close-loop system which is using this motor, and the potentiometer is a component that giving a feedback to the system[5] so that the characteristics[15] can be maintained motor position which desired. A servo motor has a "horn" At the end of the coupling contact.

3. Method

The following is a flowchart of the work system in this research.

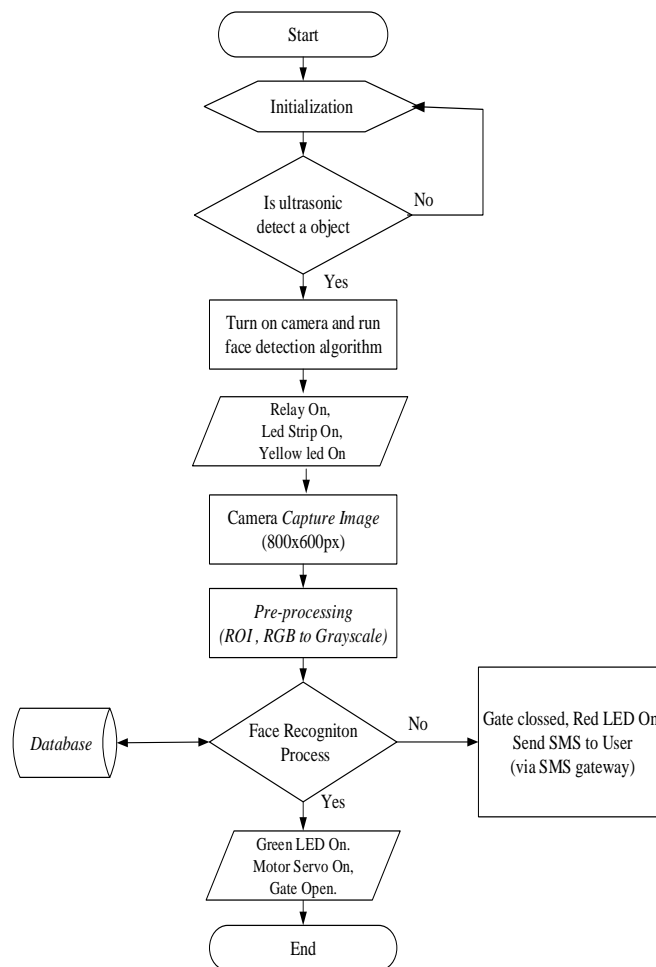


Figure 4. Flowchart system

From Figure 4 above, it is explained that the first process is the initialization of the ultrasonic sensor to detect objects. If an object is detected at a distance of 30 to 40 cm from the sensor, the yellow indicator light will activate which then activates the face detection system. Next, the camera will capture the face of the object with a resolution of 800x600 pixels. Images that are still in RGB format are converted to a greyscale format which aims to simplify the face match detection process.

Through the haar cascade method on OpenCV, the face matching process is carried out which then the cascade value is matched with the data stored in the database. If there is a match, the raspberry will give a command to activate the green light and move the servo motor by 90 degrees to open the door. If there is no match then the red light will be on.

3.1 Schematic of the system circuit

The following is a schematic drawing of the control circuit used in this research.

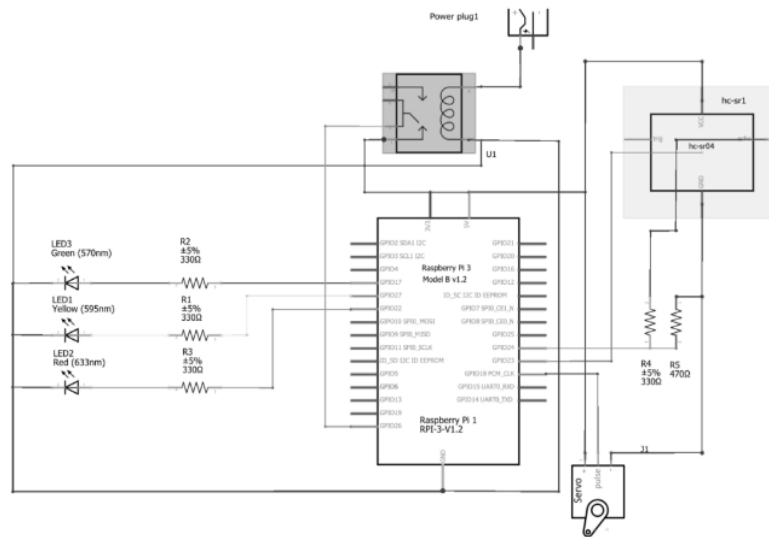


Figure 5. Schematic of the System Circuit

In Figure 5 it shows that the control system is supplied by a 5Volt system. The GPIO Raspberry Pi controlling the servo motor, and the lights indicator of the system status too and also directly connected to the ultrasonic sensor pin.

3.2 Prototype security system

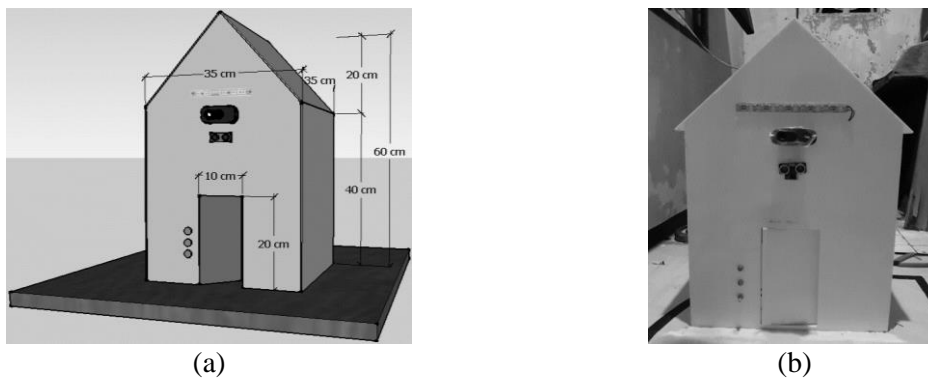


Figure 6. (a) The prototype of hardware design; (b) the proximity sensor front view and the camera front view be accompanied by a lighting object

Figure 6 above is the result of a mechanical design in the form of a miniature house. The position of the camera is located above the door with the ultrasonic sensor under the camera. The ultrasonic sensor functions to detect the presence of a person or object in front of it at a predetermined distance so that when an object is detected, the system will work.

4. Result and Discussion

4.1 Ultrasonic sensors test distance

To determine the accuracy of sensor readings against the distance of the object to be detected, ultrasonic sensor calibration and testing is needed. The following are the results of distance testing on the ultrasonic sensor.

Table 1. 20 cm distance calibration data of ultrasonic sensor











No	Measure Distance 20 Cm (before calibration)	Measured difference (before calibration)	Measured Distance 20 Cm (after calibration)	Measured difference (after calibration)
1	17.39	2,61	19,6	0,4
2	17.28	2,56	19,6	0,4
3	17.96	2,04	20	0
4	17.90	2,10	20	0
5	18.96	1,04	20	0

Table 1 above shows more accurate distance measurement data after the calibration process is carried out by compensating the value of the sensor with a measuring instrument. Experiments 1 and 2 produce less accurate values because the object is perpendicular to the sensor so the results are less accurate.

4.2 Testing of Face Detection

The test is done by placing the object at a distance of 10-15 cm from the camera using 2 face samples. The accuracy of reading the face database from the image capture can be determined by testing using the haar cascade. At a distance of 10 cm, there was a failure in the face detection process, this was due to the object being too close to the camera which made the face not fully captured. For all the results of the haar cascade test, they are presented in table 2 below:

Table 2. Results of the test Data At 100 Lux of Light Intensity

No	Image stored on database	Capture object	Light intensity	Object Capture distance	Face recognition
1			100 lux	10 cm	Failed
2			100 lux	20 cm	Successful
3			100 lux	30 cm	Successful
4			100 lux	40 cm	Successful
5			100 lux	50 cm	Successful

4.3 Testing of SMS Gateway

Testing the SMS gateway in this section uses the nexmo library which has previously been installed on a raspberry device.

Table 3. Results Test of the SMS Gateway as a notification

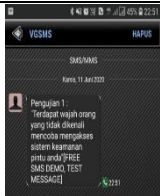

No.	User Number	Phone	Delivery Status	Phone screenshot for incoming SMS alert
1.	08383*****7		Successful	
2.	08383*****7		Successful	

Table 3 above shows the results of message notifications on the HP display sent by the system on the device that is currently being accessed and equipped with parameters.

4.4 Testing from overall system

The system is tested as a whole starting from the face detection process until the entrance gate opens automatically. From the tests that have been carried out, the following are the overall results of the tests which are presented in the table below:

Table 4. Overall system results













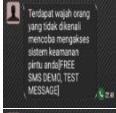



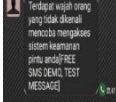
No	Image stored on database	Capture object	Gate status (open or close)	SMS send status	Conclusion for system
1				-	Successful
2				-	Successful
4				-	Failed
5					Successful
6					Successful

Table 4 uses two comparison objects that have been stored in the database and send commands from the face detection results so that the gate is open or closed. Sending SMS can fail even though

the detection is successful like experiment number 4 and the experiment is successful until sending SMS to the user is shown in experiment numbers 5 and 6.

4. Conclusion

After carrying out the design process to testing the system, the following conclusions were obtained. Overall system testing was carried out 90 times, with 2 recognized faces and 2 unrecognized faces, the camera capture distance to the object was 30cm, 40cm and 50cm. The overall results of the experiment on 4 sampling objects of people's faces and the distance, the average success is 91.11%, this happens because several factors influence the intensity of light in the room and the position of the face is not perpendicular to the camera, sending notifications in the form of SMS to the user's mobile phone can be sent properly and by the message parameters that have been set, so it can be concluded that the security system and information able to provide information related to the activities that occur on the security system based on human face recognition.

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