Automotive Start-Stop Engine Based on Face Recognition System

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Abstract. There are so many security devices such as code pin, dual control procedures, and ID card. However, those devices have the potential to be lost, stolen or duplicated by someone. Due to that reason, the authentication for driver by using their face is one of the potential solutions. In this proposed system, the real time person's face is detected using a camera. The detected face is then processed in the system which will recognize. The recognized face is then used as input to the Arduino, which connected to the automotive relay to active the engine's starter vehicle. Viola-Jones method is applied as a method to detect and crop face area of the face image. The Canny edge method is applied as a method for segmenting the detected face. The Canny edge method will detect a wide range of edges from face also reducing noise image. Fast Fourier Transform is applied as a feature extraction technique to extract the segmented face image. The extracted image is then used as input to the Artificial Neural Network (ANN) in order to recognize the face of the authorize person. Experimental results show the training and testing accuracy of 100 % and 100 %, respectively.

Keywords: Face detection, intelligent automatics start engine, support vector machine.

1 Introduction

Currently, the emergence of industrial revolution 4.0 in the autonomous vehicle sector is experiencing rapid growth. The advance autonomous technology involve many aspect in the vehicle, such as autonomous self driving, and full autonomous self driving [1−4]. One of the importance aspect in advance autonomous vehicle is security system. Security system plays important rule in vehicle safety system, specially theft case and anauthorized person [5].

Nowadays, conventional security systems such as key, code pin, ID card, are very popular in many countries. However, the conventional security system has potential to be lost, stolen, or duplicated by someone [6, 7]. Furthermore, many of the traffic accidents occur mostly due to young vehicle drivers and theft due to vehicle security system [5]. Based on these circumstances, it is necessary a security system able to prevent from car

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theft. One of the solution to the problem is by applying the security system which capable of activating only by the authorize person. The biometric identification system is one of the solution to authorize the person.

The biometric recognition system is unique and personal which very good implement for identification of a person. There are many recognition system based on biometrics, such as face of the person, fingerprint, signatures, and eyes. Biometric authentication refers to the formation of identity based on the physiological and behavioral characteristics of a person such as face, fingerprint, hand geometry, iris, keystroke, signature, voice, etc [8, 9]. The advantages of biometrics systems are, they cannot be lost or forgotten; biometric traits are difficult to copy, share and distribute; and they need people who are being confirmed to be present at the time and place of authentication [10]. Many reaseachers have observe the biometrics for security system, such as Bhagnagare [11] has applied the iris recognition for security system, Liu and Yin [12] used keystroke as biometrics characteristic for security system, the keystroke of the password applied to identify the authorize person, but Varchol and Levicky [13] used hand geometri for security system.

In this work, the method of biometric identification as access to vehicles, will be used as a tool that can provide security and as the driver's profile. The facial recognition system will be used as authorized by means of camera users installed on the system. The proposed system will then decide whether the person is an authorized person or unauthorized ones. Furthermore, an intelligent systems approach is used to develop an authorized person model based on their face. An approach to identify people based on their face recognition will be to use Artificial Neural Network (ANN) to be displayed in this work. This system will identify authorized and unauthorized persons.

2 Literature review

This section presents, the basic general process consists of four important parts, namely image acquisition, face detection, feature extraction, face recognition [14]. Image acquisition process to take the image by using the camera. The next process of the image will be extracted by feature extraction. In this process, the extraction data is the use as input to the face recognition part. Finally, the face recognition to do the training process to recognition the person based on their face.

2.1 Face detection

In this stage, the image is taken from the camera sensor, the face image is the detected based on Viola-Jones method [15]. Viola-Jones detector was chosen as a detected image because of its high detection rate, and its ability to run in real time. Position detection is the most effective on frontal images of faces. It comprises four stages namely: Haar feature selection, creating an integral image, adaboost training and cascading amplifiers [16].

Haar feature selection matches the commonalities found in face images. Integral image calculates rectangular area in fixed time which benefits it over other sophisticated features. Integral image coordinates X (width), and Y (height) gives the pixel sum of the coordinates above and on to the left of the X, and Y. Adaboost constructs a strong classifier as a linear combination of weighted simple weak classifiers. In figure showing Haar features used in Viola-Jones method [17].

2.2 Segmentation image

Segmentation process using Canny Edge method. Generally acknowledged as the best 'all-round' edge detection method developed to date. The Canny edge method has three key criteria [18]:

i. *A low error rate*. It is important that edges occurring in images should not be missed and that there should be no response where edges do not exist.
ii. *The detected edge points should be well localized.* The distance between the edge pixels as found by the detector and the actual edge should be a minimum.
iii. There should be only *one response to a single edge.*

The procedure can be summarized in the following steps:

i. The image is first smoothed using a Gaussian kernel: Gradient operators are sensitive to noise and this preliminary step is taken to reduce the image noise.
ii. Find the edge strength: this is achieved by taking the gradient of the image with the Sobel operators in the horizontal and vertical directions and then adding the magnitude of these components as a measure of the 'edge strength', as shown in equation 2.1 below;

$$E(x,y) = |G_x(x,y)| + |G_y(x,y)| \quad (1)$$

Where E is Edge of the image, and G is a Gaussian operator in x and y direction.

iii. Calculate the edge direction, as shown in equation 2:

$$\theta = \tan^1 \frac{G_y(x,y)}{G_x(x,y)} \quad (2)$$

Where is θ the edge direction.

iv. Digitize the edge direction: Once the edge direction is known, we approximate it to an edge direction that can be traced in a digital image. Considering an arbitrary pixel, the direction of an edge through this pixel can take one of only four possible values—0° (neighbors to east and west), 90° (neighbors to north and south), 45° (neighbors to northeast and southwest) and 135° (neighbours to north-west and southeast). Accordingly, the calculated θ can be approximated by whichever of these four angles is closest in value to it.
v. Non maximum suppression: After the edge directions is known, non maximum suppression is applied. This works by tracing along the edge in the edge direction and suppressing any pixel value (i.e. set it equal to zero) that are not considered to be an edge. This will give a thin line in the output image.
vi. Hysteresis: After the first five steps has been completed, the final step is to track along the remaining pixels that have not been suppressed and threshold the image to identify the edge pixels. Critical to the Canny edge method, however, is the use of two distinct thresholds—a higher value T2 and a lower value T1. The fate of each pixel is then determined according to the following criteria: If $|E(x,y)| < T1$, then the pixel is rejected and is not an edge pixel; If $|E(x,y)| > T2$, then the pixel is accepted and is an edge pixel; and if $T1 < |E(x,y)| < T2$, then the pixel is rejected except where a path consisting of edge pixels connects it to an unconditional edge pixel with $|E(x,y)| > T2$.

2.3 Feature extraction of the image

Feature extraction process using Fast Fourier Transform (FFT) [19]. FFT helps to decompose an input 2D image into real and imaginary components which is a representation of the image in the frequency domain [20]. Each point in the domain is represented as frequencies in Fourier or frequency domain. For an input image of size [M × N], FFT is given by [21], as shown in Equation 3:

$$F(u,v) = \sum_{i,j=1}^{M,N} I(i,j) e^{-i*2\Pi(ki/M+Ij/N)} \quad (3)$$

Where *I* is input matrix from the image.

2.4 Face recognition

In this section, the method applied for recognized the face data using Artificial Neural Network (ANN). ANN can be trained to perform a particular function by updating the value of connections (weight) between elements. Commonly ANN are trained, so that particular input leads to a specific target output [22].

Artificial Neural Network (ANN) consist of three layers (input layer, hidden layer, and output layer). These layers of elements put together independent computation of data and pass it to another layer. The computation of processing elements is completed on the basis of weight addition of the inputs. The output is compared with the target value and the mean square error is computed which is certainly processed back to the hidden layer to adjust its weights. This process would be having iteration for each and every layer to decrease the error by repeatedly adjusting the weight of each layer. Neural Network with Multi-layer feed-forward supervised learning is shown in Figure 1 [14].

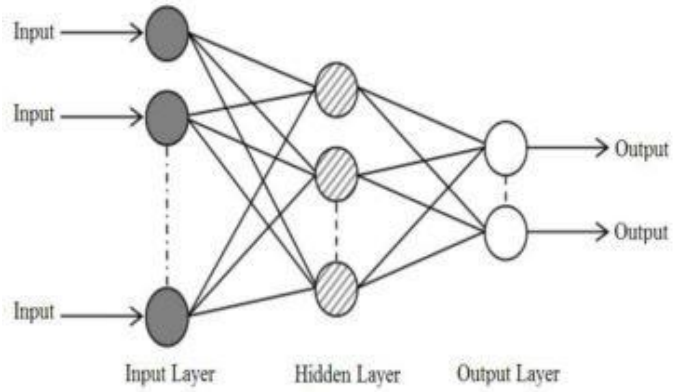


Fig. 1. ANN basic structure [14].

3 Research methodology

This project involves sample images as data collection of the face recognition system. Sample images taken through the camera, which used 10 sample images from two different people. Sample images will make the training process in order to find out how good the system when comparing detected image with sample images.

The overall model of the proposed is Automotive start-stop engine based on face recognition system. Sample face image taken through the camera, the image is processed in the computer through face recognition system. The result of a face recognition system is

then used as input to Arduino to trigger the relay. Connected relay will directly turn on the vehicle.

In order to achieve the objective of this project, the following procedures will be considered:

i. This project will start with the understanding of image processing, artificial intelligent technique, and hardware development.
ii. Development of face detection, and feature extraction technique.
On this step, some sub-step will be done, these are:
    a) Face detection using the Viola-Jones method applied for detecting the face in the image. It able to run in real time condition. Creating bounding box specified face in the image, and cropping that image.
    b) Feature extraction using the Canny edge method to detect a wide range of edges from face also reducing noise image. Combining with Fast Fourier Transform to extract the segmented face image get the graph data.
iii. Development of face recognition system.
The development of face recognition system is done in this step using ANN as an intelligent recognition system.
iv. Development of Matlab for automatic start-stop engine based on Face recognition system.
Matlab® used as a tool to develop start-stop engine program.
v. Development of hardware integrated system for automatic start-stop engine based on Face recognition system.
Hardware used Arduino in order to get the input from Matlab and trigger the relay to activate the engine.
vi. Analysis the performance of the system and improves the performance of the proposed system.
Effectiveness system of the proposed automatic start engine based on Fast Fourier Transform (FFT) and Artificial Neural Network (ANN) is evaluated.

4 Experimental work

This section presents the performance of the proposed to Automotive start-stop engine based on face recognition system. This section consists of three important subsections, they are experimental setup, experimental result and experimental analysis.

4.1 Experimental setup

Figure 2 shows the proposed system description, the system basically consists of three main components, namely external camera, Arduino, and two automotive relays. One relay is to turn on a starter motor and the other is to turn off a capacitor discharge ignition (CDI) pulse to an ignition coil. A camera used for tracking and capturing a face image person. The captured face image, then processed in an intelligent face recognition system which will recognize the person's identity based on his/her Face. Recognized face is then used as an input to the Arduino which will activate the automotive relay to activate the engine's starter or turn off the ignition pulse. A personal computer (PC) of 2.1 MHz Intel Core i7 processor equipped with external camera is used for face recognition system implementation. In this system, all of the face data processing and face recognition algorithms are implemented in the PC using MATLAB and its toolbox. As a result of the face recognition system, a decision signal which will switch on or off the engine is sent through the parallel port of the PC to the Arduino. This decision signal is sent from Arduino to one of the automotive

relays. The automotive relay works on 12 volts DC power supply and it is set in normally open (NO) condition.

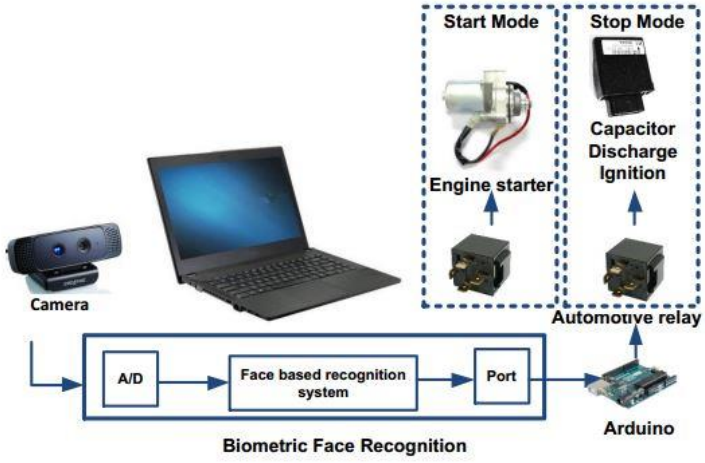


Fig. 2. Proposed system for starter engine.

4.2 Experimental results

In order to evaluate the effectiveness of the proposed intelligent system on automotive start-stop engine based on face recognition system, the proposed system is installed at starting engine equipment. In this proposes system the specification camera using 720p, it has good quality image when detecting image and capturing images. Detection system using Viola-Jones method for detecting specify face on the image, as shown in Figure 3.

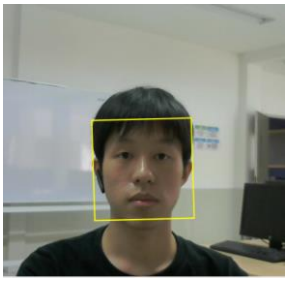


Fig. 3. Face detection.

Once a face is detected, it will crop the face image and make it into a new image, as shown in Figure 3. In the Figure 4, the face detection image, is then changed from a color image, RGB, into a grayscale image in order to proses in segmentation steps.

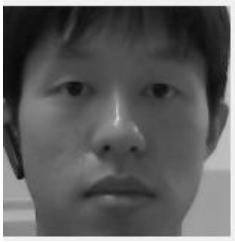
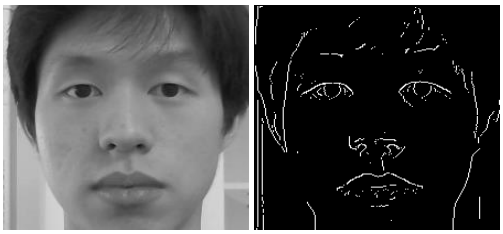


Fig. 4. Grayscale image.

Segmentation process using the canny edge method generally for detecting edge and reducing noise from image face. The best result of the edge calculation face image depends on two distinct thresholds which are higher value (T2) and lower value (T1). In this experiment, sample image use threshold T1 = 0.05, and T2 = 0.15. The segmented result as shown in Figure 5, the left side is the image after the face detection method is applied, the right Figure is the image after segmentation method is applied to the detection image.

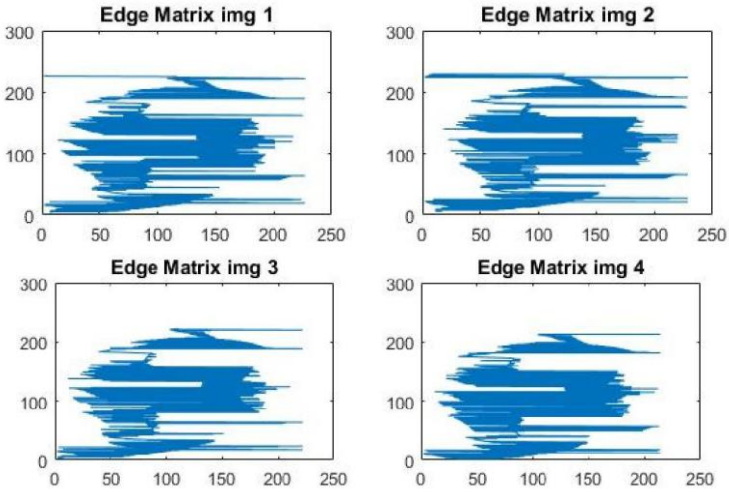


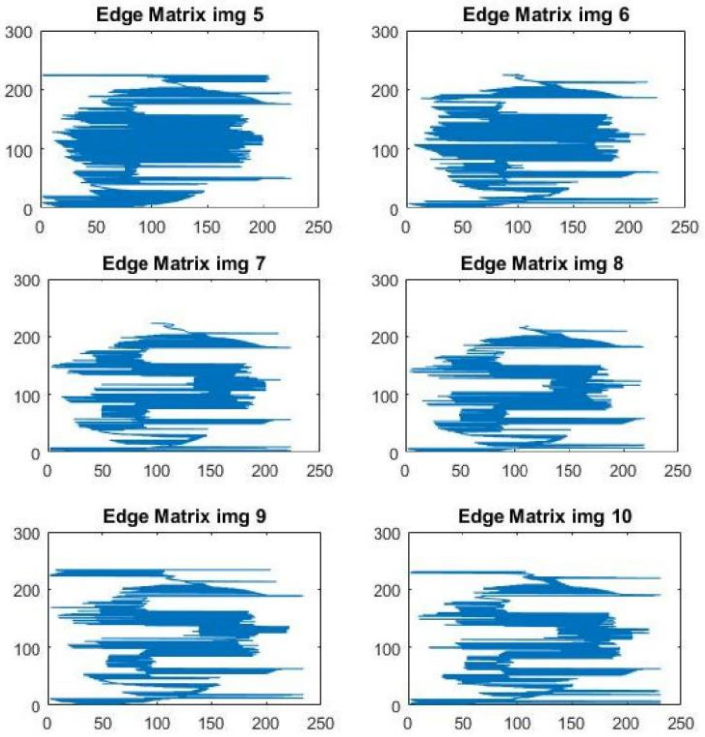
(a) Image before and after segmentation on sample 1

(b) Image before and after segmentation on sample 2

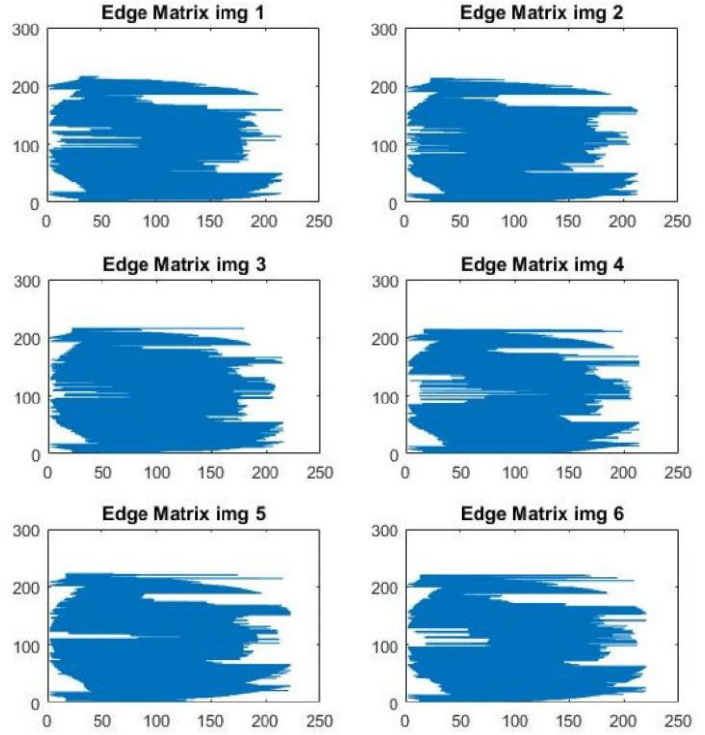
Fig. 5. Before and after segmentation step of the image.

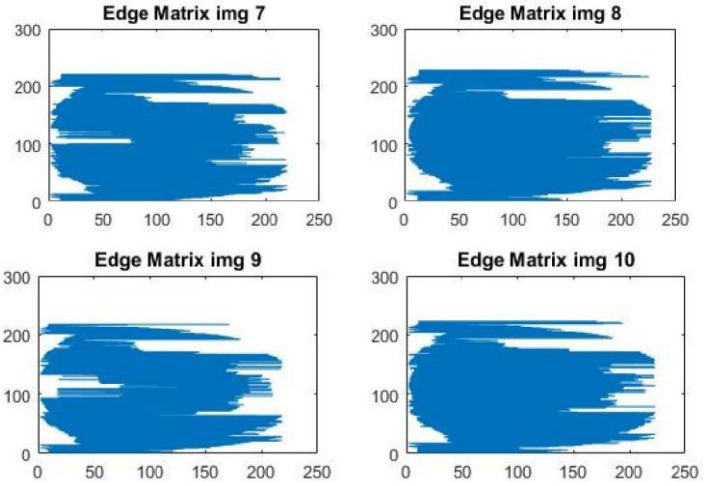
After the segmentation stage of the image, pixel image will change into 0 on black edge and 255 on white edge matrix. White edge with 255 pixels will become the main point to get the graph X, Y of the data, as shown in Figure 6.





(a) Edge matrix image sample 1





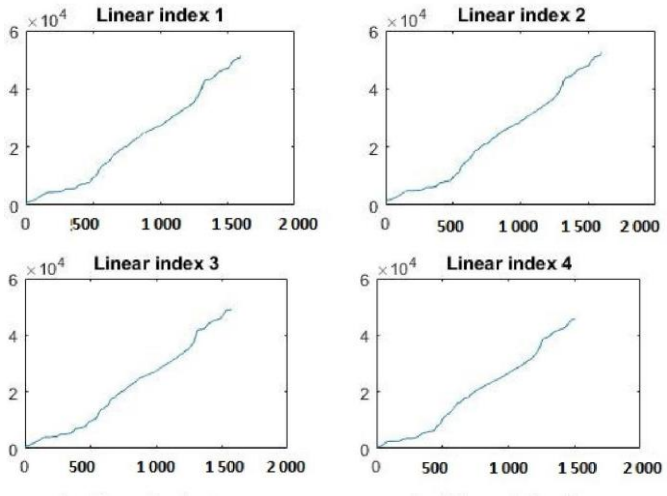
(b) Edge matrix image sample 2.

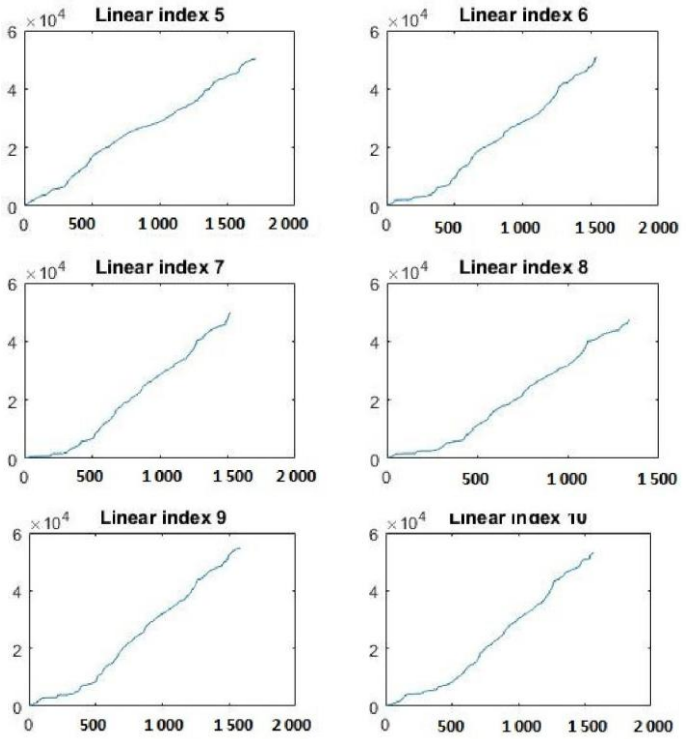
Fig. 6. (a)-(b) Edge matrix image.

Edge matrix has two element vector which is X and Y, row side and column side, respectively. In order to know the significant data, the edge matrix resulting data convert to a linear index, which is only 1 element vector as shown in Figure 7.

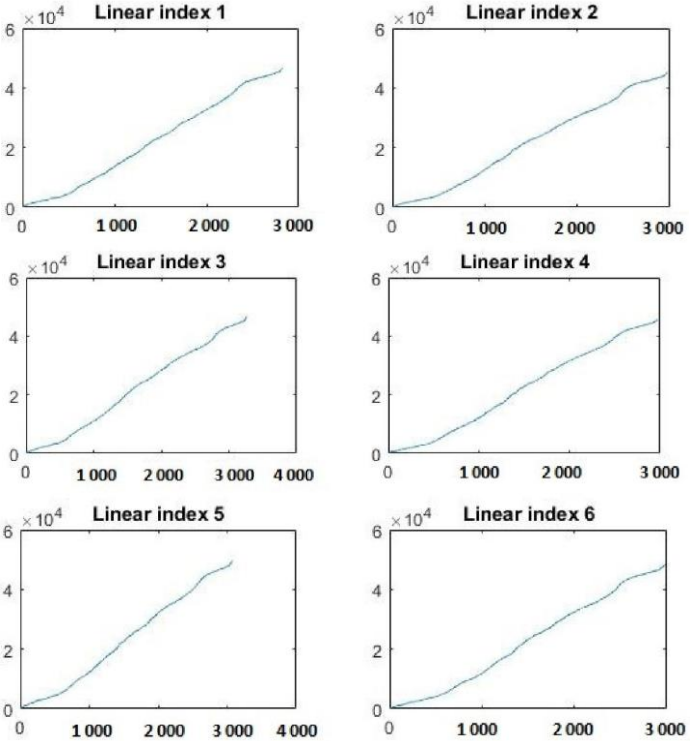
The segmented image is then applied to the feature extraction technique, Fast Fourier Transform, in order to get the highest amplitude of the frequencies, as shown in Figure 8. Using FFT (Fast Fourier Transform) to get the peak amplitude of the image. Each image has a different peak amplitude. From this experiment, there are 10 sample peak amplitude with two different people.

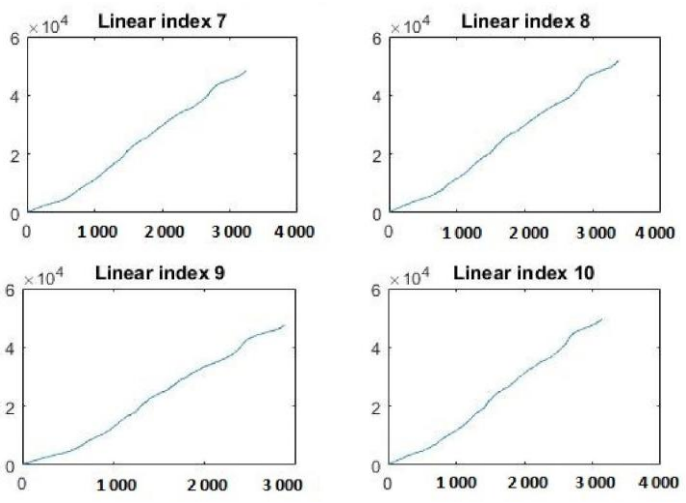
From 10 samples peak amplitude, five samples with two different people used for training and testing the data by using ANN (Artificial Neural Network). Training ANN must be done multiple times in order to get zero error in the system. In this experiment hidden layer is used for increasing recognition system and at the same time reducing error.





(a) Linear index sample 1





(b) Linear index sample 2

Fig. 7. (a)-(b) Linear index samples.

Table 4.2 experimental result of training and testing phase

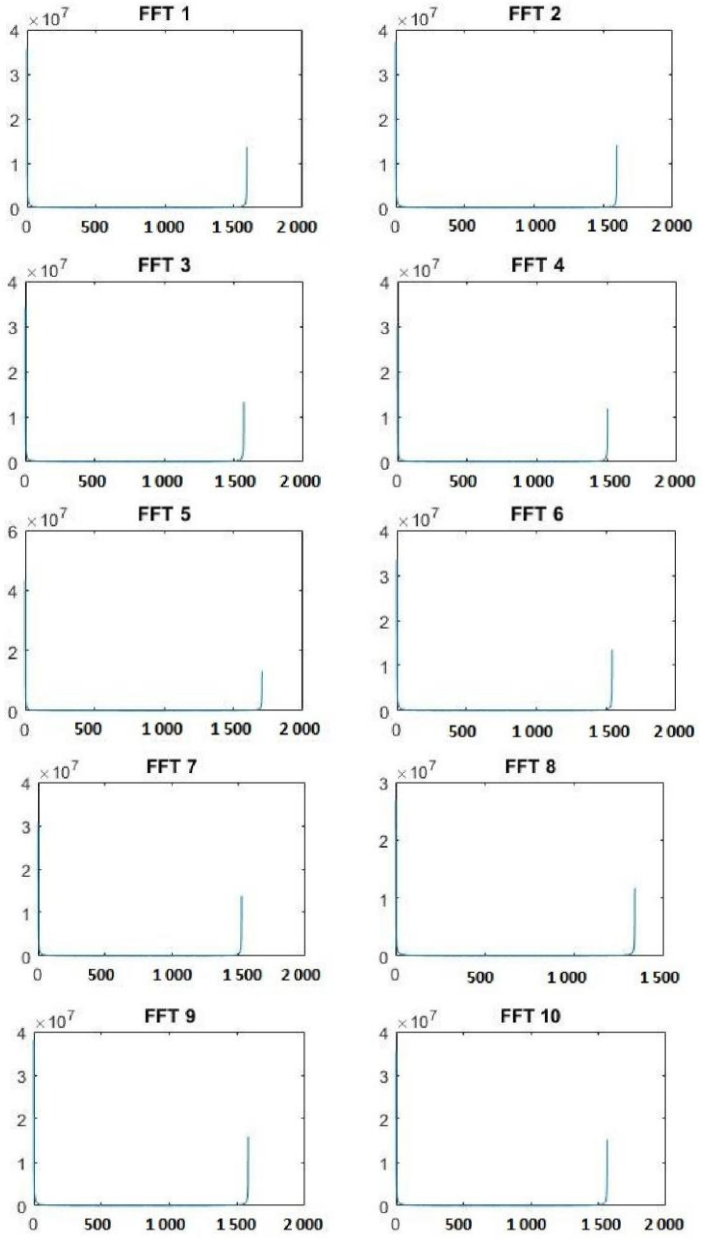
Images Classification	Training (%)	Testing (%)
Sample 1		
Images 1	100	100
Images 2	100	100
Images 3	100	100
Images 4	100	100
Images 5	100	100
Sample 2		
Images 1	100	100
Images 2	100	100
Images 3	100	100
Images 4	100	100
Images 5	100	100

4.3 Experiment analysis

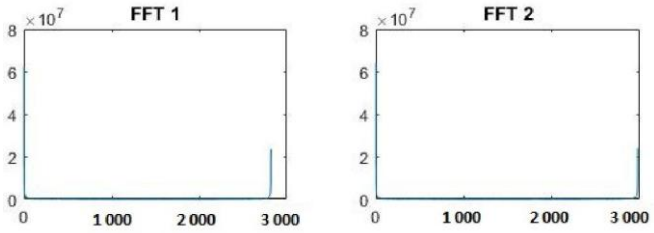
Overall evaluation of the proposed face recognition system has been presented in this chapter. The face recognition system which composes of face detection, segmentation, feature extraction, and face recognition. The result of face recognition system that if the person is recognized, the engine will start.

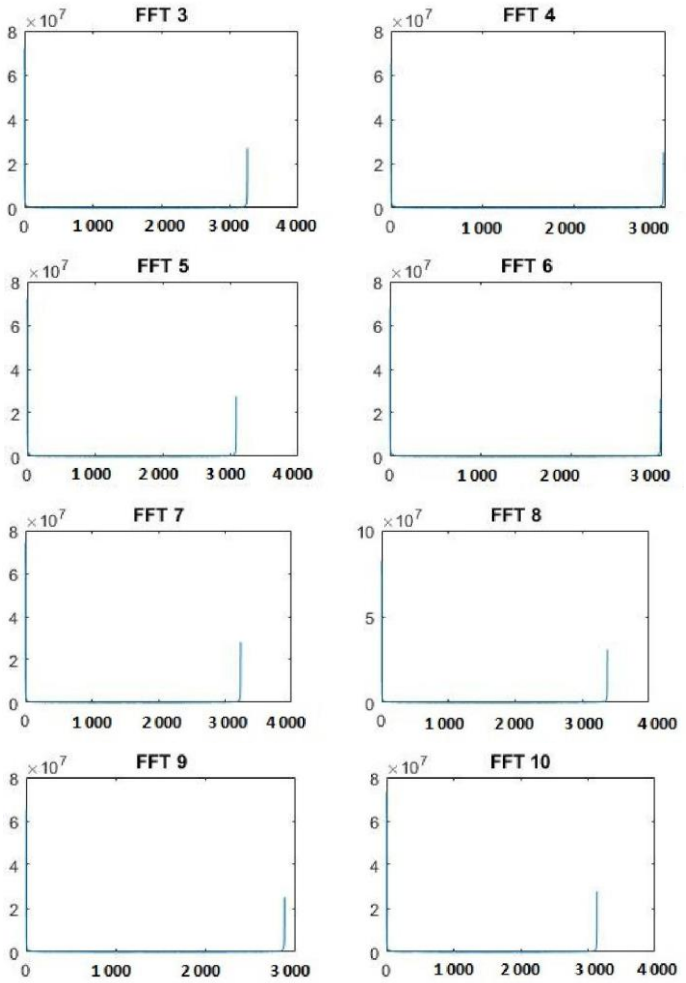
The experiment involving two people, which one of them considered as authorize persons, and the other one consider as unauthorized person. The data sample of the image consists 10 sample data with two different persons. Based on the training and the testing phase accuracy, resulting in 100 % accuracy of both phases (Table 1).

From the experiment, it can be concluded that the system if reliable to recognize the authorize person and which means also the system can be implemented for security system on the vehicle. The face recognition system is then installed in Hardware which consists of Arduino®, relay, and the engine. So, the experiment so that the security system based on biometric method can be implemented.



(a) Peak amplitude Fast Fourier Transform sample 1





(b) Peak amplitude Fast Fourier Transform sample 2

Fig. 8. (a)-(b) The FFT result of the two samples.

5. Conclusion

Safety and comfort as a part of human factor play important role in nowadays advance automotive technology. Security system on a vehicle, as one of the safety aspects, is susceptible from an unidentified person. The conventional security system has potential to be lost, stolen or duplicated by someone. Due to that reason, biometric method can be one of the solution the authentication for driver by using their face is one of the potential solutions. The detected face is then processed in the system which will recognize the face of the authorize person.

The experiment shows the system reliable to recognize the authorize person, since it has good training and testing accuracy, respectively. The face recognition system is then installed in Hardware which consists of Arduino®, relay, and the engine, the result shows that the system is a success to be implemented .

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