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# Motorcycle Start-stop System based on Intelligent Biometric Voice Recognition

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**Abstract.** Current mechanical key in the motorcycle is prone to bulgary, being stolen or misplaced. Intelligent biometric voice recognition as means to replace this mechanism is proposed as an alternative. The proposed system will decide whether the voice is belong to the user or not and the word utter by the user is 'On' or 'Off'. The decision voice will be sent to Arduino in order to start or stop the engine. The recorded voice is processed in order to get some features which later be used as input to the proposed system. The Mel-Frequency Ceptral Coefficient (MFCC) is adopted as a feature extraction technique. The extracted feature is the used as input to the SVM-based identifier. Experimental results confirm the effectiveness of the proposed intelligent voice recognition and word recognition system. It show that the proposed method produces a good training and testing accuracy, 99.31% and 99.43%, respectively. Moreover, the proposed system shows the performance of false rejection rate (*FRR*) and false acceptance rate (*FAR*) accuracy of 0.18% and 17.58%, respectively. In the intelligent word recognition shows that the training and testing accuracy are 100% and 96.3%, respectively.

## 1. Introduction

Modern internal combustion engines in motorcycle typically lack the ability to self start, it need additional mechanism to crank the engine. One of the oldest form of manual mechanism to crank the engine usually employs a kickstart lever. Current commercial motorcycle starting engine system can both employ the kickstart lever and a starter motor which is activated by a mechanical switch in a form of pushing a button after turning on an ignition key. The key is also used to turn off the engine simply by turning the key to the off position to cut the electricity supply to the ignition coil. Also, a kill switch or idle stop button sometimes available to disrupt the process of combustion engine and engineered to close it in the fastest way possible. The key is designed to limit the access of the vehicle for unauthorized user. However, this mechanical key is prone to forcible bulgary access, being stolen, misplaced, lost or duplicated. In Indonesia itself, motorcycle theft tends to increase from year 2012 as many as 41,816 cases to 42,508 cases in 2013[1].

Limitations of the key as conventional security system urge some researcher to consider biometric verification process. Biometrics methods used for personal authorization utilize some features such as the face, voice, hand shape, finger print and iris[2]. Finger print pattern recognition is one of an example of biometric technique that can be applied in vehicle ignition authentication where a person



finger print is matched with the database where if the recognition is not valid then the control will not ignite the vehicle[3]. Each of biometric method has its own advantages and disadvantages in their application[4]. Voice as one of biometric characteristic is increasingly popular to be used as it is a natural signal which is fast, simple and convenient to produce and not easy to be stolen. Therefore, the ability to access the system should always remain with the user wherever they go, increasing the easiness and safety of the user.

This paper introduces a start-stop system based on intelligent biometric voice recognition. The proposed system is based on the performance biometric which offers an ability to provide positive verification of identity from an individual's voice characteristics to access the start-stop engine mechanism. The proposed system features are extracted from the person voice data and then Support Vector Machines (SVMs) is used to develop models of the voice persons based on the feature extracted from the authorized person voices.

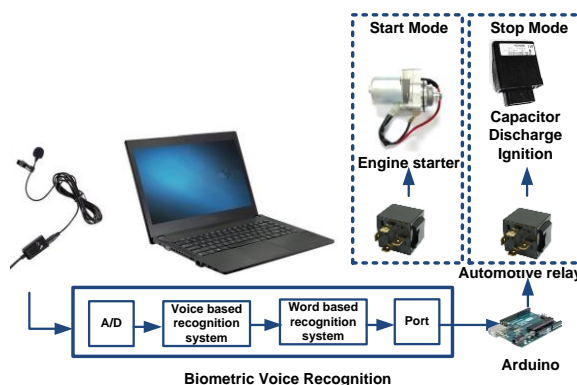
First, the prototype of the voice based automation starting engine control is described. Next, the voice based model used in the proposed system is discussed in detail. Finally, the performance of the proposed intelligent biometric voice recognition for engine start-stop access control is evaluated experimentally.

## 2. Proposed System

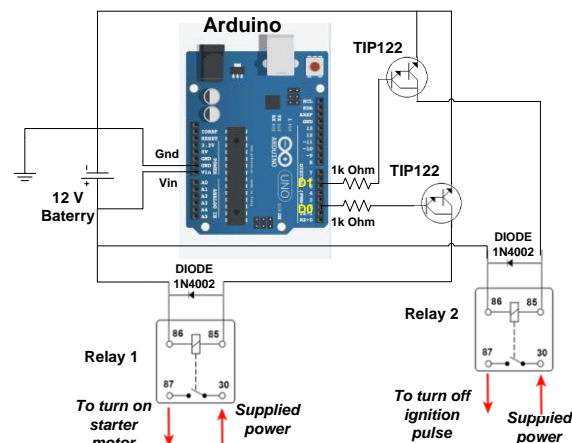
### 2.1. Proposed System Description

Figure 1 show the proposed system description, the system basically consists of five main components, namely voice recording, voice based recognition system, word based recognition system, Arduino, and two automotive relay. 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 hand phone microphone used as a voice sensor to record the person voice. The recorded voice then processed in an intelligent voice recognition system which will recognize the person identity based on his/her voice. Once the person is identify then the system will recognize the word utter by the recognize person with an intelligent word recognition system. Recognized word is then used as an input to the Arduino which will activate the automotive relay to activate the engine's starter or turn off ignition pulse.

A personal computer (PC) of 2.1 MHz Intel Core i3 processor equipped with a sound card is used for voice recognition system implementation. The sound card records the voice data based on the sampling frequency of 44 kHz. In this system, all of the voice data processing and speaker recognition algorithms are implemented in the PC using MATLAB and its toolbox. As a result of the intelligent voice and word recognition, 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 relay. The automotive relay works on 12 volts DC power supply and it is set in normally open (NO) condition.

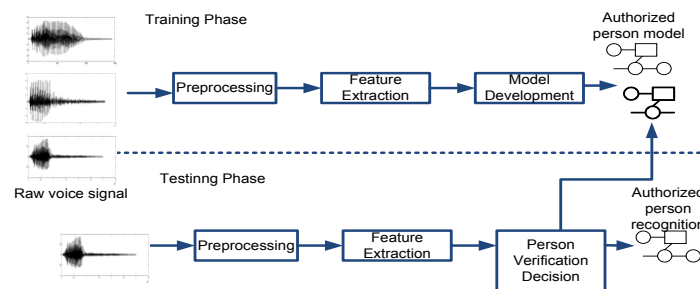


**Figure 1.** Proposed intelligent biometric voice recognition for motorcycle start-stop system.



**Figure 2.** Arduino and relay circuit [5]

In the case a person is recognized by the intelligent voice recognition as an authorized user, the access is granted [6]. In sequence, the word utter by the authorized user is detected by the word recognition system whether it is in 'On' or 'Off'. In case the word is 'On', Arduino sends a signal to the automatic relay no 1 so that the automotive relay is demagnetized. As a result the starter motor is activated to turn the engine on by that authorized person. In case the word is 'Off', Arduino sends a signal to the automatic relay no 2 so that the automotive relay is demagnetized and turn off the ignition pulse which in that case turning the engine off. The system diagram is shown in Figure 2. Therefore, without an 'On' command signal from the intelligent biometric voice recognition system, the circuit for starter motor will always remain at an off condition which means the engine also remains off. Similarly, without an 'Off' command signal from the recognition system, the circuit for ignition pulse will always remain on during engine running.



**Figure 3.** Intelligent biometric voice recognition system

The overall process of the proposed system for intelligent biometric voice recognition is shown in Figure 3. There are two important parts of the voice recognition, namely person identification and speech recognition. On the person identification part, the system will authorize the person. The system will decide whether the person is the authorized person or not. Once the person is authorized by the system, then the system will recognize the word uttered by the authorized person.

## 2.2. Feature Extraction

As shown in Figure 3, feature extraction is an important process in the proposed system. Features are some quantities, which are extracted from preprocessed voice and can be used to represent the voice signal. In this work, the MFCC technique is applied to the system. The MFCC takes advantages of several well-known properties of the auditory system, since provide relatively good performance and straightforward to be implemented[7]. Furthermore, the MFCC process is explain detail on the other work [8].

## 2.3. Support vector machine (SVMs) classification

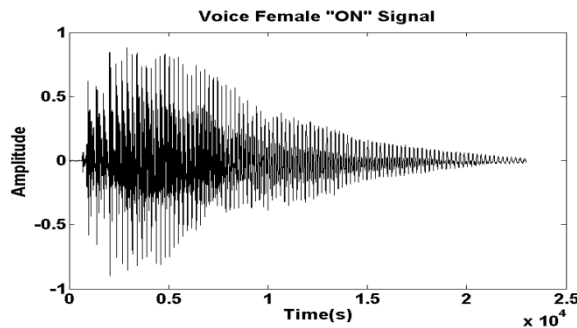
SVMs classification is implemented as pattern classification. The basic idea of SVM is the mapping of non-linearly training data into higher-dimensional feature space through the kernel function. There are three important aspects of SVM, namely discrimination (optimal) hyperplane, optimization via Lagrange multipliers and kernel functions [9][10]. The discussion detail of the SVM was explain in the previous work [8].

# 3. Results

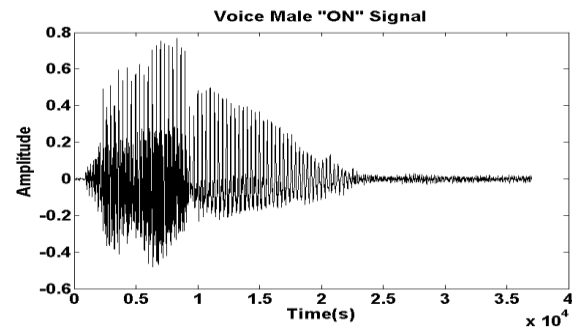
## 3.1. Experimental setup

In order to evaluate the effectiveness of the proposed intelligent biometric voice recognition for motorcycle start-stop system, the proposed system is installed in Intelligent Control System Laboratory, Binus-Aso School of Engineering. The voice of 10 (ten) speakers is used in the experiment. Each of the speakers has to utter the word 'On' and 'Off' for 10 times, as shown in Figure

4 and 5. There are three series of experiments. Firstly, speaker recognition experiment, this experiment is used to determine the accuracy of the proposed voice recognition system. In this experiment the



**Figure 4.** Female ‘On’ voice sample.



**Figure 5.** Male ‘On’ voice sample.

system determines the speaker identity. This experiment consists of two phases, training phase and testing phase. In the training phase, the system is trained with the data in order to develop the model of the recognize speaker, seven (7) speakers are used to train the system and the other three (3) speakers are used to test the system. Therefore, the training data and testing data are contained of 70 words and 30 words of ‘On’ and ‘Off’ words, respectively.

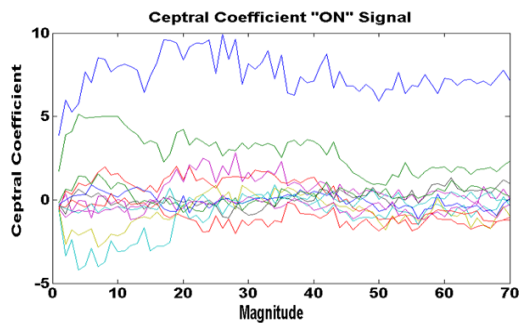
The second experiment is the access control system, this experiment is implemented to determine the authorize person in the system. In general, this experiment has four possible decisions; the authorized person is accepted, the authorized person is rejected, the unauthorized person (an impostor) is accepted and the unauthorized person (an impostor) is rejected[3]. The accuracy of the access control system is then specified based on the rate in which the system makes the decision to reject the authorized person and to accept the unauthorized person. The quantities to measure the rate of the access control accuracy to reject the authorized person is then called as a false rejection rate (*FRR*) and that to measure the rate of access control to accept the unauthorized person is called to as a false acceptance rate (*FAR*). Mathematically, both rates are expressed as a percentage using the following simple calculations:

$$FRR = \frac{NFR}{NFA} \times 100\% \quad (1)$$

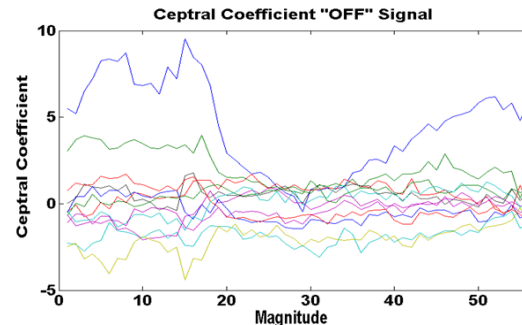
$$FAR = \frac{NAA}{NIA} \times 100\% \quad (2)$$

where *NFR* is the numbers of false rejections and *NFA* is the number of false acceptance. *NAA* is the number of the authorized person attempts and *NIA* is the number of impostor person attempts. In order to achieve the high security of the proposed system, it is expected that the proposed system will have both low *FRR* and low *FAR*. Furthermore, in the second experiment, one (1) speaker is considered as the authorized person to access the motorcycle and the other three (3) speakers are assumed as outside impostors. Finally, the third experiment is applied to recognize the word uttered by the authorize speaker. Each speaker, who is assumed as authorized person, has to say the word ‘On’ for 10 times where 5 voice data are used as training data and the other 5 voice data are used as a testing data for each person. This means the text-dependent speaker verification system is used in the proposed system.

In the third experiments, the data is extracted with MFCC feature extraction technique. The MFCC coefficients, the 12 Cepstral coefficients are used. These filters are simulated by integrating the FFT spectrum of 20-ms Hamming-window speech segments in which the frame rate is 10-ms. Figure 6 and 7 shown the 12 MFCC Cepstral coefficient extracted from the voice signal for ‘On’ and ‘Off’, respectively. The extracted data, are then become an input to the classification system. The SVMs based multi-class classification is applied to perform classification process using one-against-one method. The RBF kernel function is used. The effectiveness of the proposed method is evaluated based upon the training phase and the testing phased, respectively.



**Figure 6.** Cepstra Coefficient of the 'On' signal.



**Figure 7.** Cepstra Coefficient of the 'Off' signal.

### 3.2. Experimental Results

In the first experiment, the extracted process resulting 1732 data are extracted from the word 'On' for the training data and 759 data resulting from the extracting process of the testing data in order to evaluate the proposed system. The SVM-base multiclass classification one against one is applied, the Gaussian kernel with a degree of 11 is used.

The training accuracy and testing accuracy of the proposed system achieved 99.31 and 99.43%, respectively as shown in Table 1. Person 3 have the highest testing accuracy of 100%, and person five have the lower testing accuracy of 98.38%.

The second experiment, consist of one authorize person and other three are unauthorized person. The extracted process resulting 128 data are extracted from the word 'On' and 'Off' are used to train the system and 759 data resulting from the extracting process of the testing data in order to evaluate the proposed system. The evaluation result is shown in Table 2. The result shows that the average of *FRR* and *FAR* accuracy are 0.18% and 17.58%, respectively. The result shows that the access control system convenient for the authorized person.

The third experiment, the system recognizes the word utter by the authorize person. The system will decide whether the authorize person speaks the word 'On' and 'Off'. 359 data are used to train the system and 540 data resulting from the extracting process of the testing data in order to evaluate the proposed system. The evaluation result is shown in table 3. The average training and testing accuracy of the proposed system achieved 100% and 96.3%, respectively, as shown in table 3. The accuracy of the testing data consists of accuracy of the word 'On' and 'Off', which accuracy of 95.31% and 97.3 %, respectively.

**Table 1.** Experiment I results.

Model	Authorized Person	Training Classification Rate (%)	Testing Classification Rate (%)
SVM-Multiclass Classification One-Against-One Kernel=Gaussian; Kernel option=11; c = 1000; lambda = 1e-7;	Person 1	99.31	99.71
	Person 2		99.75
	Person 3		100.00
	Person 4		99.66
	Person 5		98.38
	Person 6		99.43
	Person 7		99.52
average		99.31	99.43

**Table 2.** Experiment II results.

Authorized person	FRR(%)	Close set FAR(%)	Open Set FAR(%)
Person 1	0.29	0	32.7
Person 2	0.25	0	8.8
Person 3	0	0	11.24

**Table 3.** Experiment III results.

Model	Authorized Person	Training Classification Rate (%)	Testing Classification Rate (%)	
			‘On’	‘Off’
SVM-Multiclass Cl. One-Against-One Kernel=Gaussian; Kernel option=11; c = 1000; lambda = 1e-7;	Person 1	100	95.31	97.3

#### 4. Conclusions

This study has documented the development of intelligent biometric voice recognition for motorcycle start-stop engine access control. The proposed system adopted Mel-Frequency Cepstral Coefficient (MFCC) coefficients as the feature of the person voice and used Support Vector Machines to develop authorized voice models based on their words. Experimental results showed that the proposed system produced a good performance, especially it gave a good training and testing accuracy. The system be able to start and stop the motorcycle based on the authorize person voice.

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