INTELLIGENT AUTOMATIC RIGHT-LEFT SIGN LAMP BASED ON BRAIN SIGNAL RECOGNITION SYSTEM

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Abstract. Comfort as a part of the human factor, plays important roles in nowadays advanced automotive technology. Many of the current technologies go in the direction of automotive driver assistance features. However, many of the driver assistance features still require physical movement by human to enable the features. In this work, the proposed method is used in order to make certain feature to be functioning without any physical movement, instead human just need to think about it in their mind. In this work, brain signal is recorded and processed in order to be used as input to the recognition system. Right-Left sign lamp based on the brain signal recognition system can potentially replace the button or switch of the specific device in order to make the lamp work. The system then will decide whether the signal is ‘Right’ or ‘Left’. The decision of the Right-Left side of brain signal recognition will be sent to a processing board in order to activate the automotive relay, which will be used to activate the sign lamp. Furthermore, the intelligent system approach is used to develop authorized model based on the brain signal. Particularly Support Vector Machines (SVMs)-based classification system is used in the proposed system to recognize the Left-Right of the brain signal. Experimental results confirm the effectiveness of the proposed intelligent Automatic brain signal-based Right-Left sign lamp access control system. The signal is processed by Linear Prediction Coefficient (LPC) and Support Vector Machines (SVMs), and the resulting experiment shows the training and testing accuracy of 100% and 80%, respectively.

Keyword: human factor, brain signal, Linear Prediction Coding (LPC), Support Vector Machines (SVMs)

1. Introduction

Many of the current innovation in the automotive technology are in the development of automation related to the powertrain system, data communication intra and inter vehicles in relation to the driver assist technology, and the design technology inside the vehicle[1]. However nowadays, comfort as a part of the Human-Factor plays an important role in the real life, especially in the advanced technology era. However, many of the current technologies which support the driver assist technologies are the drivenless technology still require human physical movement to operate the
specific function in the car [2], [3], which sometimes are not comfortable for the driver and distract the concentration of the driver. Therefore, in this work the automated Right-Left sign lamp based on brain signal recognition system is develop. The proposed method is used in order to make certain feature to be functioning without any physical movement, by just thinking about it in our mind.

Current commercial right-left sign lamp system uses a mechanical switch, which is operated by bumping the switch up or/and down, or sliding the peripheral near the driver operation area. This method does not provide safety to avoid unauthorized person to be able to operate it. Moreover, the switch is also prone to faulty operation. Apply the brain signal as biometric characteristic is one of the potential solution, since it is natural signal that is readily available, easy apply as output, which cannot be stolen. One of the possibilities to be applied to the system always, embedded to with the user. Therefore, its increase the ease and safety of the user. Machine interface based on brain signal recognition is attracting attention, mainly because it solves issues of common problem of the driver in performing multitasking operation.

Brain signal is recorded using Electroencephalograph (EEG). It was invented by Berger, by externally attaching some electrodes around human skull [4]. This peripheral produces signal that is related to the physiological function of the brain. Brain signal is consisted of five different waves which have certain frequencies, the Delta waves lie within the range of 0.5 to 4 Hz, the Theta waves lie within the range of 4 to 7 Hz with amplitude greater then 20µV, the Alpha waves with the rate of change lies between 8 and 13 Hz and amplitude between 30 and 50 Hz is usually active when thinking, and the Gamma wave lies between 5-30µV [5]. There are four important steps in the brain signal processing, namely preprocessing, feature extraction and classification. Preprocessing is a process of filtering the signal in order to improve the signal-to-noise-ratio. Feature extraction is a process to extract the signal into the feature vector that can be used as input to the classification system. The last step is classification system, which classify the data.

In this work the brain signal recognition system is used to develop the whole system. As a future of development of the features which have hands-free operation enables the driver to access the feature on the move and in a real driving environment such as start the engine, switch on-off of the left-right lamp and etc. This work introduces an intelligent automatic starting right-left sign lamp based on the brain signal recognition system. The proposed system performance of signal biometric which offers an ability to provide positive recognition from an individual’s brain signal characteristics to access the on-off left-right lamp in automotive. The Linear Predictive Coefficient (LPC) is applied in order to extract the brain signal data. Then, the machine learning, Support Vector Machines (SVMs), is used to develop models of the brain signal [6]. First, the prototype of the brain signal based automation starting right-left sign lamp described. Next, the signal is extracted and modelled based on LPC technique, and then recognized based on machine learning method SVMs used in the proposed system discusses in detail. Finally, the performance of the proposed intelligent automatic brain signal-based turn on-off left-right sign in lamp.

2. Proposed System

2.1 Proposed System Description
The proposed system consists of four main systems, namely brain signal recognition system, Arduino, simulation of the automatic Right-left sign lamp. One relay is to turn on a Right-Left sign lamp, that will be connected to the Arduino. EEG used as a brain sensor to record the person brain signal. The recorded signal, then processed in an intelligent brain signal recognition system which will recognize the person thinking based on their mind. Once the mind of the person is identified, then the system will recognize the mind thinking by the person with an intelligent brain signal recognition system. The
identified mind is then used as an input to the Arduino which will activate the automotive relay to activate the right or left lamp.

Figure 1. Proposed intelligent automatic brain signal based of lift-right sign lamp[7], [8].

A personal computer (PC) of 2.1 MHz Intel Core i3 processor is used in this experiment. In this system, all of the right-left brain data processing and recognizing in the PC using MATLAB and its toolbox. As a result of the intelligent brain signal recognition, a decision signal which will switch right or left the sign lamp is sent through the parallel port of the PC to the Arduino. This decision signal is sent from Arduino to the automotive relay, as shown in Figure 2. The automotive relay works on 12 volts DC power supply and it is set in normally open (NO) condition, as shown in Figure 3. In the case of Right-Left sign lamp, person mind is recognized by the intelligent brain signal recognition, the access is granted. Furthermore, the brain signal is determine whether it is in ‘left’ or ‘right’. In case the signal is ‘left’, Arduino sends a signal to the automatic relay so that the automotive relay is demagnetized. As a result the left sign lamp is activated. In case the word is ‘right’, Arduino sends a signal to the automatic relay so that the automotive relay is demagnetized and turn on the right lamp, as shown in Figure 4[6].

Figure 2. Electromagnetic automotive relay [9]

Figure 3. Arduino and the automotive relay [9]
Figure 4. Proposed complete intelligent automatic brain signal based on lift-right sign lamp.

The proposed system for the brain signal recognition system as shown in Figure 5. The brain signal passes through a preprocessing stage. In this process, the signal is used to spectrally flatten the signal. After preprocessing, the signal is then used as input to the feature extraction steps. In this process, the preprocessing signal is then extracted into the feature vector which will be used as input for the classification system. Classification system consists of two important processes: training and testing process. Training process is the process of develop the model of brain signal, the system is trained to develop the model of right/left brain signal model. The model is then saved in the database. In the testing phase, the input data will match with the model in order to recognize the mind of thingking left/right[10].

Figure 5. Voice recognition system

2.2 Feature Extraction

Figure 5 shows the feature extraction process. This process consist of some quantities, that extracted from preprocessed signal and can be used to represent the brain signal. In this work, the Linear Predictive Coding (LPC) technique is applied to the system. Levinson-Durbin Algorithm[11] is applied as method to estimate the LPC coefficient. This algorithm is applied based on the experimental work that results in the smallest error.

LPC as one of the autoregressive (AR) model that considers the output signal $y(n)$ as linear combination of $p$ previous outputs $y(n-1), y(n-2), ..., y(n-p)$, where $p$ is the model order. The equation is given as follow [12]:

$$\hat{y}(n) = - \sum_{k=1}^{p} a(k)y(n-k)$$

(1)

The residual error $e(n)$ between the actual and the predicted samples is given:
where $\hat{y}(n)$ is the predicted signal and $a(k)$ are the linear prediction coefficients. The coefficients

The order of the LPC model obtained is 11 as shown in Figure 7 where the first non-increasing declining point is at 11th order.

2.3 Support Vector Machines (SVMs)

SVM is a learning system that used hypothesis space of nonlinear data that mapping the data into higher-dimensional feature space through the kernel function. The two important concepts of SVMs, firstly are linear separable cases, this case happens in ideal condition of data, and non linear separable data which introduced misclassification data as shown in Figure 6 and Figure 7, respectively.

![Figure 6. SVMs with linearly separable data.](image1)

![Figure 7. SVMs with non-linear separable data.](image2)

3. Experimental Result

In order to evaluate the effectiveness of the proposed intelligent automatic sign left-right lamp based on the brain signal recognition system. The proposed system is installed at simulation system equipment. In this proposes system the brain signal of thinking left and right signal is considered, the person has to think the left and right site exchangeable and the signal was recorded. The brain signal is then processed in a computer in order to have the characteristic each of the right and left brain signal thinking. The signal of thinking left and right are used in the experiment. Figure 8 and Figure 9, are the example of ‘left’ and ‘Right’ thinking, respectively.

The data were taken from Swartz Center for Computational Neuroscience (CCN) [14], the data record the signal of the brain while thingking of left and right. The data consists of right and left brain signal data with each of the data consists 19 data with the size 64300 samples/sec, as shown in Figure 8 and Figure 9, for right and left brain signal, respectively. In this experiment 10 brain signal data were thinking of left and 10 signal data while the brain thinking of right is implemented. The recorded brain signal are then processed of feature extraction technique. In this stage, the LPC methods is then applied in order to obtain 12 ceptrals coefficient which determined the characteristic feature each of the signals. The feature characteristic is then applied as a metric coefficient form, which will be used as input to the recognition system.

The feature characteristic of the processing signal is then applied as input to the recognition stages. In this stages, the feature signal is used as input to the recognition system. This stages will develop the signal left and right models and save in the data based. The system work in order to compare the signal model that save in the data based and the signal which coming as input to the system and identifying them.
The brain signal data are then processed using Matlab® which will be resulting in the recognizing system for right and left signal, respectively. The recognizing signal, is then processed in Arduino which connected to relay and continuing to the Right-Left sign lamp.

Figure 8. Raw signal of brain thinking of Right-side

Figure 9. Raw signal of brain thinking of Left-side

Figure 10. Cepstral Coefficient of the signal of thinking right

Figure 11. Cepstral Coefficient of the signal of thinking left

LPC coefficients, 12 Cepstral coefficients are applied. Figure 10 and Figure 11 shown that 12 LPC Cepstral coefficient extracted from the brain signal while thinking of ‘left’ and ‘right’, respectively. Each of the signal builds to 12 Cepstral coefficients which will sign as the significant characteristic of the signal. The significant characteristics are then applied as input to the recognition system. The SVMs classification method is then applied as recognition system. In this system the feature data are used as input to the system. The method will determine the most important data which lies on the Hyperplane as shown in Figure 6. The important data are then saved in the database. This data will be used as a reference data. The next data will apply as input to the system and will compare with the reference data to be identified.

There are two important stages in the recognition system, they are training classification and testing classification. In the training classification, the data applied as input to the system, and the system will acknowledge the most important data to be classified. Once the data are classified the data is then applied as reference data, which save in the data based. The training classification is a stage that data is test based on the data which are applied to the training data. In the testing data, the system is tested with the new data that not applied to train the system.

The effectiveness of the proposed method in the training process is based upon training classification rate. The training accuracy and testing accuracy of the proposed system achieved 100% and 80%, respectively. The result is then used as input to the Arduino, and the output from the Arduino is applied to be activated the automotive lamp simulation which will simulate the sign lam on the car, as shown in the experiment result in the Figure 12 and 13, for the left and right sign lamp, respectively.
For the future development of the integrated device of lighting sign lamp of right-life sided will build in the integrated stand alone system. This device allowed humans to use conveniently, since it will keep it simple and functional. This device will anticipate for suddenly break or late to switch sign lamp. The driver will be able to activate the sign lamp by just thinking the direction of the sign lamp, which are left and right sided.

4. Conclusion

This work the intelligent automation brain signal based on right-left sign lamp had been developed. The proposed system adopted Linear Predictive Coding (LPC) coefficients as the feature of the person’s mind and Support Vector Machines to develop the brain signal recognition system. Experimental results showed that the proposed system produced a good performance, especially it gave a good training and testing accuracy.

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