Naïve Bayes Classifier for Hand Gestures Recognition

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Abstract: This paper provides recognizing the five gestures of the fingers using Naïve Bayes method. The electromyography signal (EMG) is utilized to recognize the fingers movement. A myo armband is used to obtain the signal. The average success rate of the system is about 90.61%. To verify the results, the outputs of the system are used to control a mobile robot. The results show that the system is able to control the movement of the robot.

1 INTRODUCTION

Every movements of the human generate a signal from the muscles known as Electromyography (EMG) (Eason, Noble, & Sneddon, 1955). Signal of the muscles activities captures using the electrodes placed in the skin of the human. The EMG signals are utilized by the researchers for diverse objectives. In the health applications, one of the purposes of this signal is to known the human muscles condition (Montoya, Henao, Muñoz, 2017). In the engineering applications, EMG signals are used to identify the movement of the human body e.g. the gestures of the hands. One application in robotics is to control robot movement using the recognizing system (Morais, G et al. 2016).for example to control the movement of the robot hand (Andrean, Pamungkas, & Risandriya, 2019). The robot fingers are controlled by the movement of the fingers of the operator. This system enables to help the disabilities people to substitute their hand (Risandriya and Pamungkas, 2018).

To identify the signals of the muscles actions, there are several recognizing algorithm have been used by the researchers. For instance: Neural Network algorithm (Risandriya & Pamungkas, 2018), Fuzzy (Gogić, Miljkovic, & Đurđević, 2016), Adaptive Neuro-Fuzzy Inference System (Caesarendra, Tjahjowidodo, & Pamungkas, 2017), Linear Discriminant Analysis (Zhang, 2012), K-Nearest Neighbor (Kaya & Kumbasar, 2018), etc.

For this study, the Naïve Bayes algorithm is used to recognize the gesture of the fingers of the subjects. The root mean square (RMS) of the EMG signal is used to be processed in this algorithm. Five fingers postures are examined to be identified. These fingers poses are: relax, all fingers are open, all fingers are close, wave out and wave in. These gestures are used to control the mobile robot in the certain track.

To provide a complete explanation, this article is organized as follows: next section objective is to provide an explanation of the method, also Naïve Bayes. Then proceed with the next in section III, which presents experiments on the method proposed to identify hand movements. This is followed by a comparison between the two methods, while the last section is given conclusions obtained from experiments conducted.

2 BACKGROUND

Naïve Bayes classifier is a classifier algorithm based on probability theorem. The Bayesian rule, or known as the conditional probability, is used for this classifier. Equation (1) and equation (2) shows the Bayes rules. To classify the classes, this algorithm calculates the possibility of each of the categories. The group which has the most significant number of probabilities is the event is in that group

$$P(r|q) = P(q|r).P(r)/P(q) \quad (1)$$

And

$$P(r|Q) = (P(q_1|r).P(q_2|r)\dots P(q_n|r)) \quad (2)$$

Where:

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P(a|x) is the probability of posterior class a with attribute x
P(x|a) is the likelihood which the probability of the predictor given class
P(x) is the probability of class x
P(a) is the probability of class a
$X = (x_1, x_2, \ldots, x_n)$

In this classification, all features/values are assumed to be values independent of each other in each class. Because of this condition, even if a value depends on one another, this classification will consider all propositions to be independent so that it gives the probability effect. One of the advantages of Naive Bayes is that only the average value and standard deviation of variables are required to estimate the parameters of the classification. The equation of mean and standard deviation are shown in (3) and (4) respectively.

$$\mu = \frac{1}{n}\sum_{i=1}^{n} q_i \tag{3}$$

$$\sigma = \sqrt{\left|\frac{1}{n-1}\sum_{i=1}^{n}(q_i - \mu)^2\right|} \tag{4}$$

Where:
μ is the mean of the attribute in a class
σ is the variance of the attribute in a class

The decision making rule for classification is to choose one more possibility based on the results of the probability density values such as the Gauss Density equation. [5]

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \tag{5}$$

For the experiments the Root Mean Square (RMS) of the EMG signals is used as signals which will be processed in the Naïve Bayes method. EMG is a method to known electrical signal from the muscle activity e.g. contraction or relaxation. To obtain this signal, the electrodes are used. The Root Mean Square (RMS) value of the EMG has a linear relation and the activity of the muscle (Fukuda, T, Y. et al 2010). The RMS values enable to obtain the effective value of EMG signal. RMS equation (6) as follows:

$$RMS = \sqrt{\sum_{i=1}^{N} \frac{x_i^2}{N}} \tag{6}$$

Where:
x_i^2 = the square of EMG signal amplitude
N = the data from EMG value

3 METHODS AND RESULTS

To establish the ability of Naïve Bayes algorithm the block diagram of the system shown in Figure 1 is made. This system aims are to recognize the gestures of the hand also to drive a mobile robot.

The myo sensors are placed in the upper hand of the subject. For this equipment we used myo armband. A computer with 64 GB RAM and Intel processor i-3 are used for performing Naïve Bayes algorithm. The outcome of the algorithm is used for controlling a custom mobile robot. This robot must be follow in the specified path.

To control the robot hand gestures of the user are used. Fist pose is used to stop the robot (Figure 2 (a)), while the relaxed pose is used to transition from one command to other command, as shown in Figure 2(b). To make robot move forward, open fingers gestures is applied (figure 2 (c)). Figure 2 (c) and Figure 2 (d) are the gesture which are used to control robot to move to the right and turn left respectively.

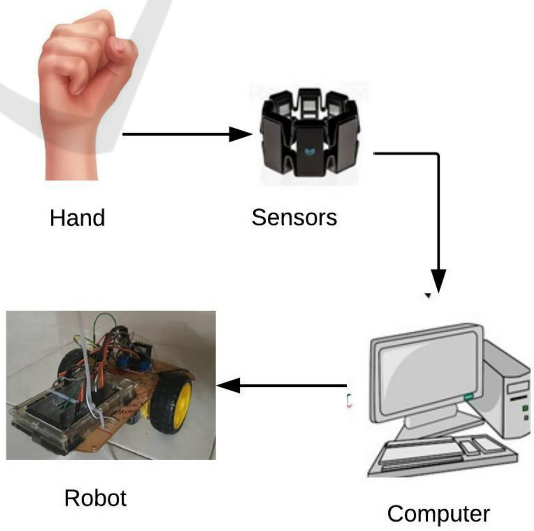

Figure 1: Block diagram of the system.

The algorithm which has a high achievement to recognize the pose of the user's hand is calculated.

Also, the time of the robot for accomplish the mission are measured.

The sensor is used using the surface EMG or known as sEMG. For this system a myo armband is utilized, this device is positioned on the user's arm. Figure 3 shows users who use muscle sensors. This equipment has eight muscle sensors and a position sensor. These eight sensors will be used to obtain signals from the user's muscles when moving their fingers. One subject used for the experiment was a male aged 23 years. The user had never used the myo Armband sensor before.

Before the sensors signal processed in Naïve Bayes and NN algorithm, the information is filtered. Moving average filter is used to reduce the noise. For the retrieval of data for the training phase, subjects performed thirty times for each pose. In the Naïve Bayes method, the mean and the standard deviation of the RMS signal of the training phase are saving in the database of the algorithm.

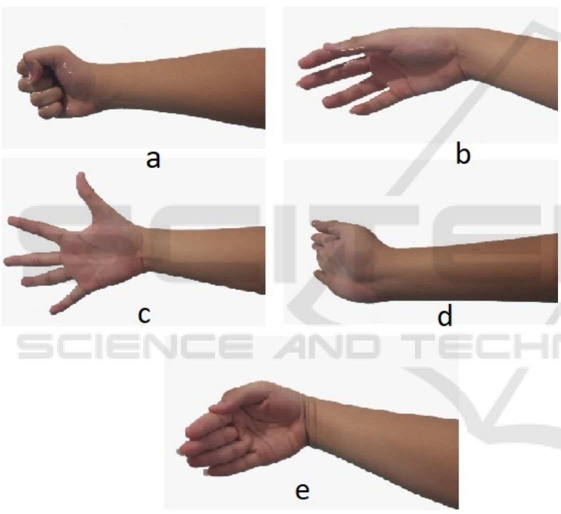

Figure 2: Poses of the hand (a) fist (b) relax (c) open (d) wave right and (e) wave left.

Figure 3: The usage of the armband.

For the application phase, the subject tries the effectiveness of both methods to recognize the pose of the hand. The subject is doing the three times experiment (thirty times per experiment) for each gesture and each method. The results of these experiments are shown in Table 1 for Naïve Bayes. The average for the Naïve Bayes method is 90.61%, success rate. The flow charts of the algorithms are shown in Figure 4.

To prove the success of the system in recognizing finger movement patterns, both algorithms are tested to move a mobile robot. The information from the computer to the robot is transmitted using wireless via Bluetooth connection. This robot is equipped with two dc motors. The dimension of the robot is 10 cm height, a length and width are 20 cm and 15cm respectively. The mobile robot has a free-wheel at the front. An Arduino Uno is used to controlling the robot. Robot figure is shown in Figure 5

The task of the robot is to follow the path, as shown in Figure 6. Before the experiments are performed, the subject is trained how to drive the mobile robot using Naïve Bayes algorithm five times each. For the experiments, every task is measured how much time is needed for mobile robot to accomplish the path for this algorithm. The results can be shown in Table 2.

Table 1: Result the success recognition for Naïve Bayes method.

Pose	Percentage success value (%)			Average
	Trial 1	Trial 2	Trial 3	
Fist	89.26	90.12	90.53	89.97
Relax	91.22	90.37	91.03	90.87
Open	87.61	89.27	86.47	87.78
Wave right	93.6	90.31	92.74	92.22
Wave left	92.92	93.28	90.41	92.20

Table 2: Time to accomplish the path.

Algorithm	Trial (second)			Average (second)
	1	2	3	
Naïve Bayes	7.2	8.5	7.6	7.67

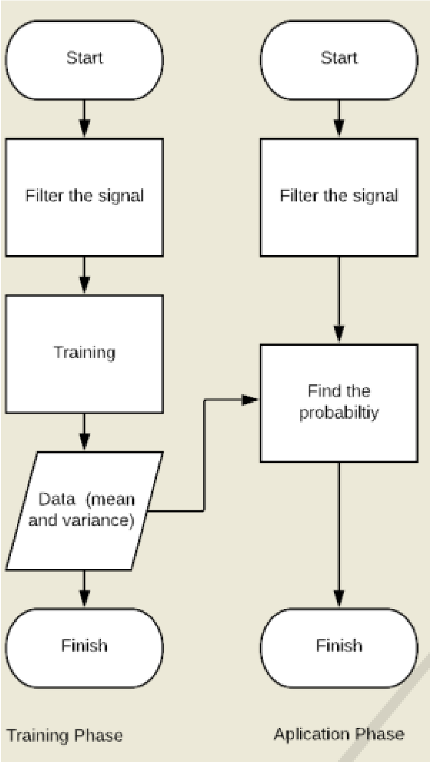

Figure 4: Flow chart of the algorithms.

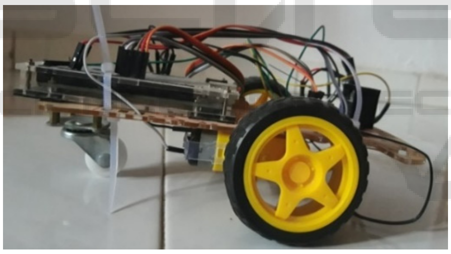

Figure 5: A mobile robot.

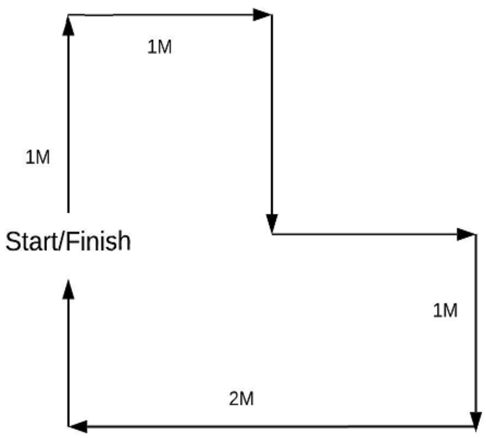

Figure 6: Path of the robot.

4 CONCLUSION

This article shows the ability of a recognize system to identify fingers gesture using Naïve Bayes algorithm. This system consists of a muscle sensor, a computer, a controller, and a mobile robot. Data taken are RMS values in the time domain. This system enables to recognize the gestures around 90.6%. Moreover, this system able to control mobile robot to follow the certain path without any

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