Controlling Power-assisted Wheelchair Movements by using LDA Classifier

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Abstract *— The main aim of this paper is to present a controlling method for the movements of the wheelchair in a different direction: forward, backward, right side, left side, and stop condition. This method depended on the electrical signals of the muscles that are collected from the masseter and buccinators muscles by using the Electromyogram (EMG). After recorded the EMG signals from the muscles extracted the features of autoregressive model (AR model) and classify it by using Linear Discriminant Analysis (LDA) classifier then used it as a control signals for controlling the movements of the wheelchair, where the maximum rate accuracy of classification was 87.75.*

Keywords — *Autoregressive model, Electromyogram, Masseter Muscles, Buccinators Muscles, Linear Discriminant Analysis.*

I. INTRODUCTION

There are many elderly and paralyzed people suffering from the difficulties in moving their lower and upper limbs, also there are many people who are lacking the ability of controlling their limbs, where the wheelchair is very important for these people to help them in moving from place to another in daily live [1].

At the last years the controlling method of the wheelchair was by using joystick but this method is very difficult for these people, therefore must be using another controlling methods that be easy for the elderly and paralyzed people. However in recent years has been used many methods for controlling on the movements of the wheelchair such as: voice recognition [2] eye moment [3] head gesture [4] and bio-potential signals interface [5-8]. Where the bio-potential that are used in the controlling movements of the wheelchair include the signals of the electroencephalographic (EEG), electromyogram (EMG), and electromyogram (EMG) [9] [10].

The EMG signals is very easy to collect it from the muscles, and be more reliable, stable, little interference compared with the others signals of the EEG and EOG, for this reason the EMG signals become widely use in the controlling method in these days.

In this research focuses on how to collect the EMG signals from the masseter and buccinators muscles and how to process it to extract the features of AR model from it, then classify the features by using the LDA classifier and used it as a control signals on the movements of the wheelchair in a different directions: forward, backward, right side, left side, and stop condition.

II. METHODOLOGY

The EMG signals are collected from the masseter and buccinators muscles then processing it and extracted the features of AR model, where the order of AR model that has been used in this research start from one to five order to choose the best order after classify it by using the LDA classifier, then apply the result of classification on the wheelchair.

In this research work has been used two channels for collecting the EMG signals of the buccinators and masseter muscles. The first two electrodes is fixed on the buccinators muscles skin's, the second two electrodes is fixed on the masseter muscles skins, and the last electrodes has been used as a ground body. In Fig. 1 the electrode placement of the buccinators muscles

Fig. 1 Schematic drawing showing the three landmarks (A, B, and C) demarcated on a hermi-face for location of the buccinators muscle.

In Fig. 1, Point A denoted to the angle of the eye, Point B denoted to the labial angle, and Point C

denoted to the outer point that be parallel to the major point of the buccinators muscle. The two plane has be determined, the first plane was vertical, passes through the point A and point C. The second plane was vertical, passes through the point C and Point B. The first electrode will be fixed on the point C, and the second electrode will placed beside the first electrode toward point B [11].

For the second channel. The first electrode is placed on the specific point is determined in this way: along an imaginary line extending from the gonion to the exocanthion, in other words compute 2cm from the gonnion bone then draw imaginary line towards the eye of the subject then fixe the first electrode. For the second electrode is fixed 1 cm superior the first electrode [12], as showing in Fig. 2.

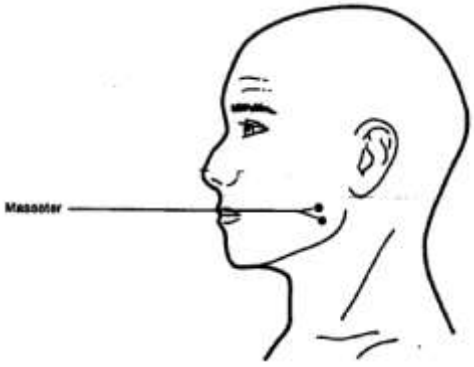

Fig. 2 Schematic drawing showing the location electrode of the masseter muscle.

After fixed the surface electrodes on the skin of buccinators and masseter muscles, collecting the EMG signals.

The signals that are collected from the masseter muscles represented the signals of single clenching and double clenching. The signals that are collected from the buccinators muscles represented the signals of single and double blowing. For the signal of masseter muscles, at first the subject made single movement same clench movement (represent the signals of single clenching movement), then the subject made double movement same clench movement (represent the signals of double clenching movements). For the signal of buccinators muscles, at first the subject made single movement same blow movement (represent the signals of single blowing movement), then the subject made double movement same blow movement (represent the signals of double blowing movements). The EMG signals of masseter and buccinators muscles recorded from fifteen subject, each subject make ten trail for each movement. After collected all the EMG signals has been used band pass filter for removing the noise and to reduce the interference.

III.FEATURE EXTRACTION

The features of AR model extracted from the signals of masseter and buccinators muscles in frequency domain, where extracted in a five type of order: AR first order, AR second order, AR third order, AR fourth order, and AR five order. The purpose of using different order of AR model is to choose the better order that give high accuracy with the classifier, where the coefficient of AR model that getting by using the Levinson-Durbin algorithm (L-D algorithm), will feed directly to the LDA classifier. In the following formula the equation of AR model:

$$x(n) = -\sum_{k=1}^{p} ak\ x(n-k) + w(n)$$

Where, *x(n):* the sampling value of the EMG signals, *w(n):* the incentive value, *p:* the order of the model, *ak:* the coefficient of the AR model, *k: 1,2,3..... k-1*, and *n: 1,2,3..... n-1*.

The meaning of above formula is that the $x(n)$ is produced by combination of the several past values $x(n-k)$ and the current incentive value $w(n)$ [13]. The following formula represent the model functions:

$$H(z) = \frac{1}{1+\sum_{k=1}^{p} ak\, z^{-k}}$$

The order of AR model directly different according to the order that be selected, where if the order of the AR was high, directly it will produce vibration and dramatic change, while if the order of AR model was low, same high order curve fitted with a low order curve, the result will be smooth. Where the selection of AR order is very critical for the AR model.

The model of AR is different if the order that selected be different, where if the order is too low, such as a high-order curve fitted with a low-order curve, it will produce smooth result, and if the order is too high, such as a low-order curve fitted with a high-order curve, it will produce the dramatic change and vibration. The coefficients of AR model features will be stored in columns. In Fig 3 sample of AR model feature 4-order for one subject.

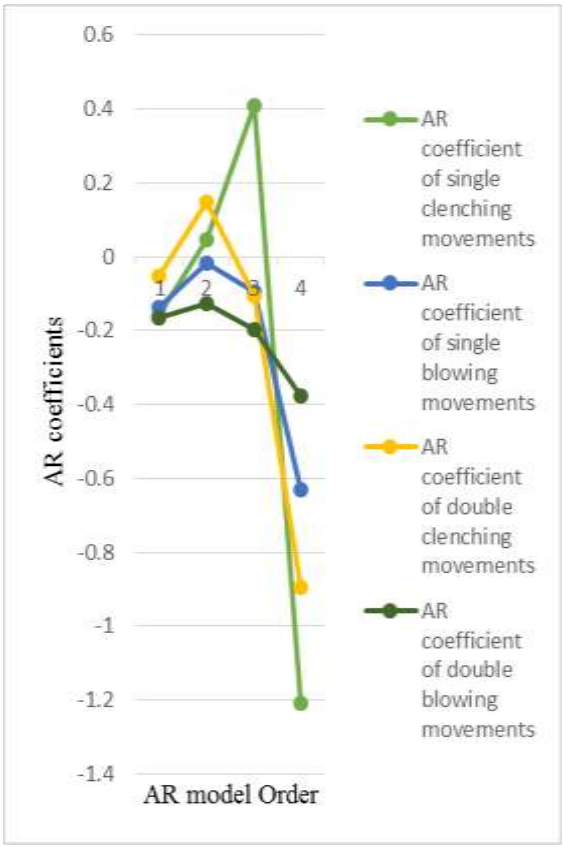

Fig. 3 AR model features 4-order

From Fig 3 it can be observed that, the coefficients of AR model 4-order of each class different from class to another, that lead to high accuracy in the process of classification.

IV. CLASSIFICATION

The classification of the EMG signals is very important with the pattern recognition to use it as a control signals on the movements of the wheelchair, where in this research work has been used the LDA classifier for classification the EMG signals for using it in the controlling method, where after extracted the features of AR model has been used it as an input to the LDA classifier then apply the result of classification on the wheelchair, however the LDA classifier is widely used in classification the EMG, where it is take little time during the process of classification [14].

In the process of classification has been used 70% of the total signals of the EMG for the training group and 30% of the total signals used for testing group. The LDA classifier estimating which movement's mean feature set used the maximum value for the function of discriminant covering the recorded covariance matrix. However the LDA classifier reduce the distance among the vectors belonging to the same class of the EMG signals and maximizes the distance among the center of EMG data class. The result of classification EMG signals by using the LDA classifier shown in Fig 4.

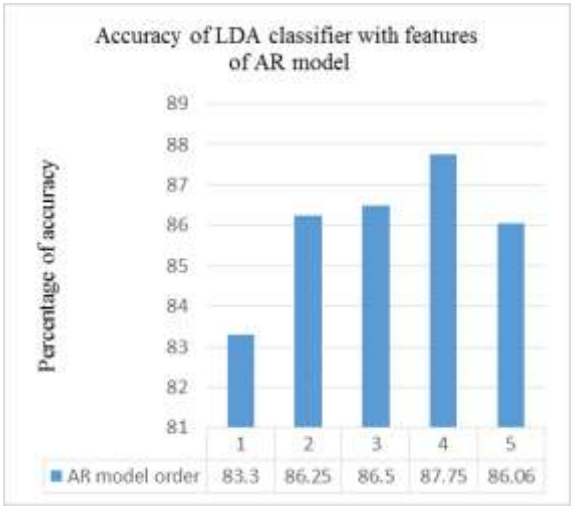

Fig. 4 The accuracy of LDA classifier with AR model features.

From the Fig .4 noticed maximum rate of the accuracy of LDA was 87.75 when the order of AR model was four compared with the other result, therefore has been used this order in the controlling method of the wheelchair movements. The coefficient of AR model 4- order was as: A = [*a*1, *a*2, *a*3, *a*4], where the letter A represented the combination of fourth coefficient for the AR 4-order, these coefficients feed directly to the LDA classifier.

In Table 1. Shows the accuracy of LDA classifier for each class when the AR model order was four.

TABLE 1: THE ACCURACY OF LDA CLASSIFIER WITH AR MODEL FEATURE 4-ORDER

Movements type	Accuracy of LDA classifier with AR model 4-order
Single Clenching	92.03
Double Clenching	86.67
Single Blowing	86.70
Double Blowing	85.60

V. CONCLUSIONS

The classification of EMG signals is very important in the methods of controlling, where the extracted features of AR model from the signals of masseter and buccinators muscles has been used as a control signals of the wheelchair movements, where the signals of single clenching used for forward and backward direction and its accuracy was 92.03,

signals of double clenching used for stop condition and its accuracy was 86.67, signals of single blowing used for turn right and its accuracy was 86.7 , and the signals of double blowing used for turn left and its accuracy was 85.6. However this method is very easy for the elderly people, where there are many researches collected the signals from the lower and upper limbs and used as a control signals on the movements of the wheelchair, but these method is very difficult for the elderly and paralyzed peoples because them lacking the ability of controlling their upper or lower limbs.

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