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Mouse Cursor Control System based on facial Electromyogram and Mechanomyogram

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***Abstract*—This paper reports the development of a mouse cursor control system as an assistive technology for upper arm amputees. The control is based on facial electromyogram (fEMG) and mechanomyogram (MMG) signals. The fEMG and MMG signals are collected for six words from eight subjects. A reference signal has been simulated based on the mean values of the signals representing the six words. The Euclidian distance between the Cepstral coefficients of the six words from that of the reference signal comprised the feature vector. Classification is through a probabilistic neural network. Six mouse cursor operations: up, down, left, right, left click and right click are reproduced. We have achieved an average classification rate of 91.5% using fEMG and 89.5% using MMG signal. The classification result is mapped into cursor operations through a switch based linear control.**

***Keywords*: facial Electromyogram, Mechanomyogram, Cepstral Coefficients, Probabilistic Neural Network**

I. Introduction

It has been estimated that up to 4,00,000 individuals are living with the limitations imposed by spinal dysfunction [1]. The improvement in their quality of life can be brought by increased unassisted control over their environment through assistive technology (AT) [2]. The advantage of using fEMG and MMG for access devices is that physical movement is unnecessary enabling the user to control the device only when weak volitional muscle activity exists. Furthermore, the switch performance is not compromised as the fEMG and MMG are not susceptible to acoustic random noise as in the case of voice control system [3]. Although most of the work in literature focus in classification of words, very less work is done towards mapping this classification into mouse cursor control. Therefore the development of a fEMG or MMG based mouse cursor control system holds promise.

II. Signal Acquisition and Preprocessing

Eight healthy subjects (four male and four female), of an average age of 25, participated in the experiment. Ag/AgCl surface electrodes were aligned with their axis parallel to the supposed underlying fibers of the facial muscles of interest after cleaning the site with alcohol wetted swabs. The details of the electrode placement are in Figure 1 and Table I.

In line with the work reported in [4], six words: click, creamer, cooler, down, left and looky have been selected. The subjects were asked to pronounce each of the six words,eight times, in a similar manner, with minimal variation in volume and speaking rate. The details of the signal acquisition system are in Table II. To reduce the influence of physical parameters, signals were normalized with maximum volunteer contraction as reference point [5].

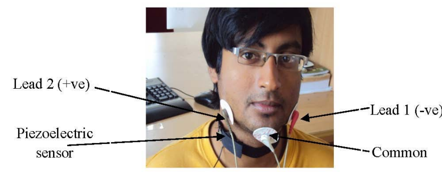

Fig. 1. Electrode placement on the subject

TABLE I
ELECTRODE PLACEMENT ON SUBJECTS

Electrode No	Electrode Lead	Specific Muscles	Muscle's function
1	Lead 1	Masseter	Elevate mandible, close jaw, Principle Principle masticator
1	Lead 2	Risorius	Draws the mouth angles laterally
2	Piezoelectric Sensor	Platysma	Depress mandible Tense neck

TABLE II
SPECIFICATION OF AD INSTRUMENTS DURING SIGNAL ACQUISITION

Electrode No.	Parameter	Value
1	Low pass frequency High pass frequency	20 Hz 500 Hz
2	Low pass frequency High pass frequency	3 Hz 100 Hz
1, 2	Amplification Range	± 5V
1, 2	Common mode rejection ratio (CMRR)	110 dB
1, 2	Notch filter cutoff frequency	50 Hz

III. Feature Extraction

A reference signal representing all the six words is simulated based on the mean values of the fEMG and MMG signals. The simulated reference signals are described as:

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$$fEMG(ref) = (\sum_{i=1}^{6} |fEMG(i)|)/6 \quad (1)$$

$$MMG(ref) = (\sum_{i=1}^{6} |MMG(i)|)/6 \quad (2)$$

where
$fEMG(ref)$ = fEMG reference signal
$fMMG(ref)$ = MMG reference signal
i = 1, 2, ...,6 i.e. Words under experiment (click, creamer, down, left, looky, cooler)
$fEMG(i)$ = fEMG for the i^{th} word and
$MMG(i)$ = MMG for the i^{th} word

Complex cepstrum coefficients of the fEMG/ MMG signals have been calculated using equation 3 [6]. It holds information about both magnitude and phase of the signal spectrum.

$$C_{fEMG(i)/MMG(i)} = 1/(2\pi) \int_{-\pi}^{\pi} log|(fEMG(i)/MMG(i)).(e^{j.\omega})|e^{jn\omega} d\omega \quad (3)$$

The Euclidian distance between the cepstral coefficients of the reference signal and each word is the feature vector used for classification. It is calculated using equation 4.

$$d_{fEMG/MMG} = \sqrt{\sum (C_{(fEMG(ref)/MMG(ref))} - C_{(fEMG(i)/MMG(i))})^2} \quad (4)$$

where, $d_{fEMG/MMG}$ represents the Euclidean distance between the reference, $fEMG(ref)/MMG(ref)$ and $fEMG(i)/MMG(i)$.

IV. Proposed Architecture

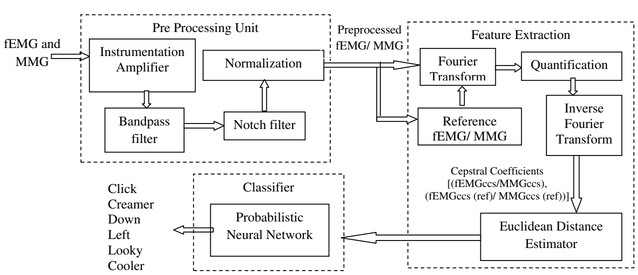

Fig. 2. Proposed Classification Architecture

Figure 2 shows the schematic of the proposed classification architecture. The σ value in the range of 0 to 16 generates minimum error during training. σ value is set at six. Figure 3 and 4 shows the output clusters of the classifiers based on the fEMG and MMG signals. An average classification rate of 91.6% and 89.5% is achieved based on fEMG / MMG signals.

On classification, the type of input word is mapped into six operations of the mouse cursor (Left Click, Up, Down, Left, Right, Right Click). Four pulse width modulated signals

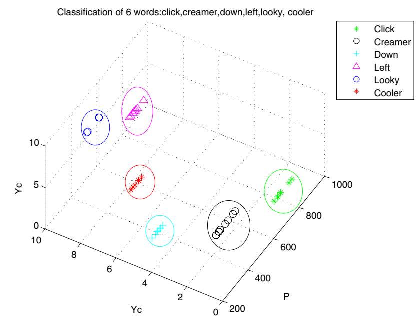

Fig. 3. Classification based on fEMG. Y_c = Target values, P = Input Features

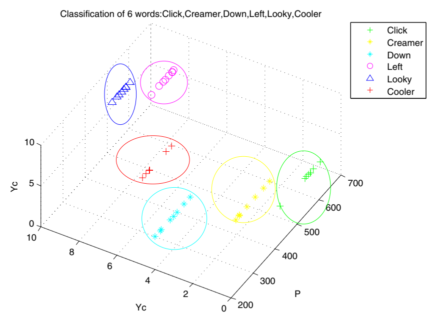

Fig. 4. Classification based on MMG. Y_c = Target values, P = Input Features

generated at the data pins of parallel port move the cursor right, left, up and down and two single pulsed signals are generated for executing the right and left click operations.

V. Final Remarks

Although work in literature has shown classification of words based on EMG signals, most of them are either limited to lower classification accuracy or for lesser number of words or control is through voice signals. fEMG and MMG based system do not compromise with the switch performance as they are not susceptible to acoustic noises as in the case of voice control system. Therefore the development of a fEMG/ MMG based mouse cursor control system holds promise.

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