ISSN: 2278-0181
ACMEE - 2016 Conference Proceedings

Mobility Assistance using Neck Semg Signal

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***Abstract*— Immobility is a serious issue for people suffering with high level of paralysis mostly due to injury in the higher levels of spinal cord (mostly C1-C7). Since this immobility cannot be cured with drugs, this paper describes a very feasible method of using sEMG signals obtained from the neck muscles as an input signal for a human wheelchair. Active electrodes were used on the neck muscles to obtain raw EMG signals. These signals were processed and classified using Neural Network tool (ANN) to separate each of the six different neck movements. This method of controlling a wheelchair can be used as a substitute for the conventional joystick control which will be helpful mainly for people suffering with severe paralysis.**

Keywords*— *EMG, mobility assistance, sternocleidomastoid, trapezius

I. INTRODUCTION

Immobility in patients with severe paralysis can cause emotional instability in them which can hamper their self-confidence. The conventional joystick control mechanism of wheelchair can be helpful only if the patient is able to move its hands. In cases where patients cannot even move their hands this mechanism cannot be used [1]. The voice based control is another option but it has its limitation of not being accurate in noisy environment. In such cases the EMG based control is a very feasible and reliable method for mobility assistance. EMG gives the electrical activity associated with the muscles. Surface EMG gives a non-invasive, low cost and yet accurate measurement of electrical activity for this purpose [2]. We sampled sEMG signals from the neck muscles which are mainly responsible for the rotation and lateral movements of the neck. We identified these muscles as the sternocleidomastoid and the trapezius muscle. The raw EMG signals were obtained using proper filtering techniques. The electrical activity is shown by the skeletal muscles when contracted. This activity can be measured using the active electrodes placed on the neck of the subject [3]. The movement of the neck in leftward or rightward is natural indication of direction. This principle can be used to programme a microcontroller which in turn will control the motor governing the motion of the wheelchair. The various steps involved in the implementation of the above said goal are shown in Fig.1

II. MATERIALS AND METHODS

The movement of the neck can be divided in to rotation, lateral flexion, flexion and hyperextension. Rotation can be left rotation (L) or right rotation (R). Flexion is forward movement (F), hyperextension is when the head goes backwards (B), other can be lateral left (LL) and lateral right (LR). The EMG obtained from the sternocleidomastoid muscle is used to decide the direction for movement of the wheelchair [4]. When the head is rotated towards left, the amplitude and frequency of the potential obtained from the right sternocleidomastoid is clearly higher than that obtained from left sternocleidomastoid. Similarly when the head is rotated towards right the potential obtained from left sternocleidomastoid is higher than right sternocleidomastoid [5]. The remaining movements comprising of lateral flexion, flexion and hyperextension can be distinguished using the inputs from the trapezius muscle. For acquiring the signal subjects in the age 18-27 were selected [6]. The electrodes were placed on the left and right trapezius for this purpose. The location of the muscles is as shown in Fig.2. Each of the movement is repeated on every subject for 15 sessions. The electrode placement for subjects is shown in Fig.3. [7]

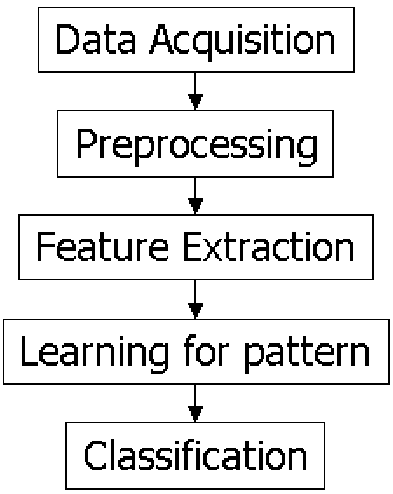

Fig.1: EMG pattern classification procedure

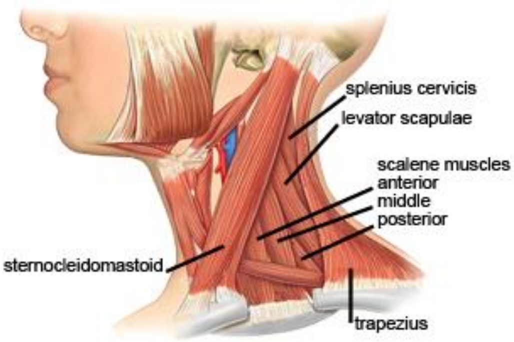

Fig.2: Musculature of human neck

Fig.3: Electrode placement on different muscles

III. EMG ACQUISITION SYSTEM

The system used for recording EMG is a 2channel data acquisition system, BIOPAC MP100. Using this system, two recordings can be taken simultaneously. The recordings were taken for a time window length of 5 seconds. The sampling rate was setup at 1000Hz. The electrode output is fed to an amplifier whose gain is setup at 2000. The low pass filter cut-off frequency is 500Hz and high pass filter cut-off frequency is 100Hz [8].

When a movement occurs in neck it causes the muscles to show some electrical activity. This electrical activity can be recorded using EMG. The EMG for this experiment has been recorded using Ag-Cl surface electrodes. The acquired signals are shown in Fig 4(a)-4(f). After acquiring the EMG signal from the above mentioned muscles for 15 sessions, some features are chosen with good separability between different movements for feature extraction. In this case mean absolute value (MAV), Root mean square (RMS), Maximum value (MAX), Minimum value (MIN), Difference of maximum and minimum values (DIFF), Standard deviation (STD) can be used as a suitable choice [9]. MAV is closely related to the magnitude of the signal whereas MAX, MIN and DIFF show the maximum signal change within one duration of period. STD gives an estimate of the noise power in the signal. The pattern classification for the experiment was done using Neural Networks in MATLAB [10].

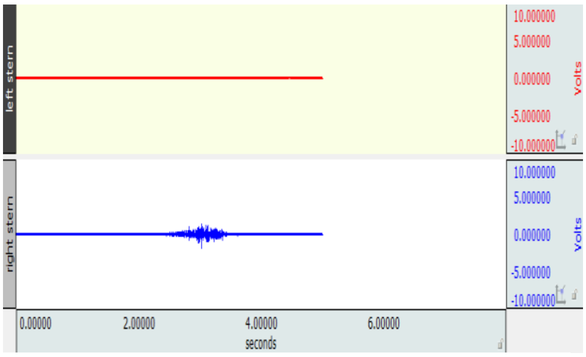

Fig.4 (a): Sternocleidomastoid (left movement)

For classification ANN pattern recognition tool was used. All the 6 movements were separately classified on the 2 muscles. The classification process was started with 2 movements and then the no. of movements was gradually increased to 6. The results of the classification process are shown in Table1 and Table2.

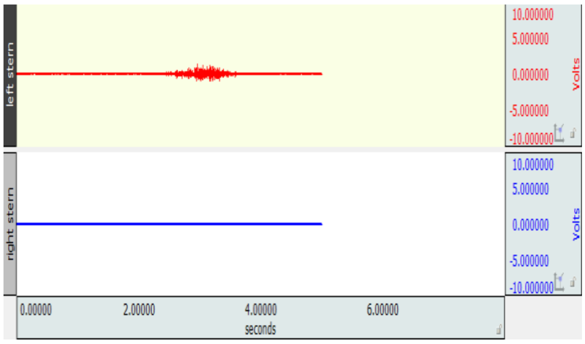

Fig.4 (b): Sternocleidomastoid (right movement)

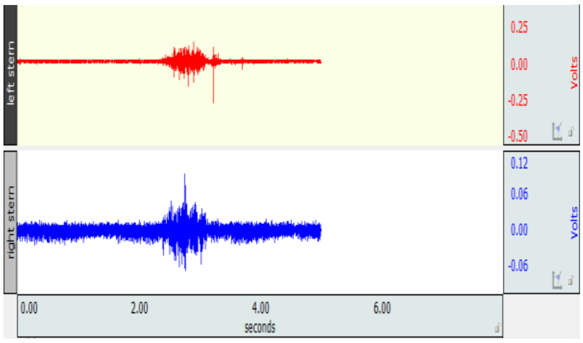

Fig.4 (c): Sternocleidomastoid (Flexion)

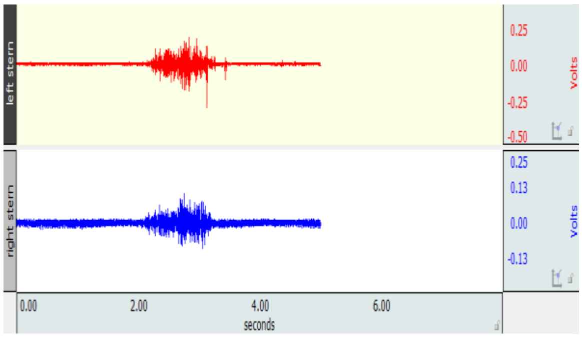

Fig.4 (d): Sternocleidomastoid (Hyper-extension)

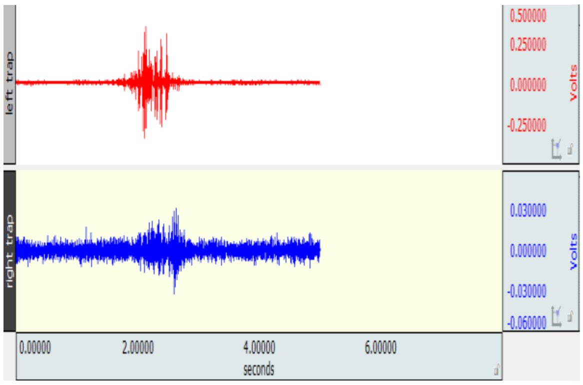

Fig.4 (e): Trapezius (Lateral Left)

As can be seen from Table1 accuracy decreases to 89.02% when 3 movements are classified. So, up to 3 movements can be classified using Sternocleidomastoid muscle. The accuracy levels in case of Trapezius muscle are on the lower side and hence are ignored. When classifying 4 movements by the Sternocleidomastoid muscle the accuracy level drops to 72.32%, as a solution to this problem, a new technique of thresholding is suggested. In this method, every channel is assigned a threshold value. If the amplitude of that channel at any moment exceeds this threshold value, the corresponding channel is assigned a value of 1, otherwise 0. This procedure is applied to all the channels namely, Left Sternocleidomastoid, Right Sternocleidomastoid, Left Trapezius and Right Trapezius. The process is depicted in the form of a flowchart in Fig5.

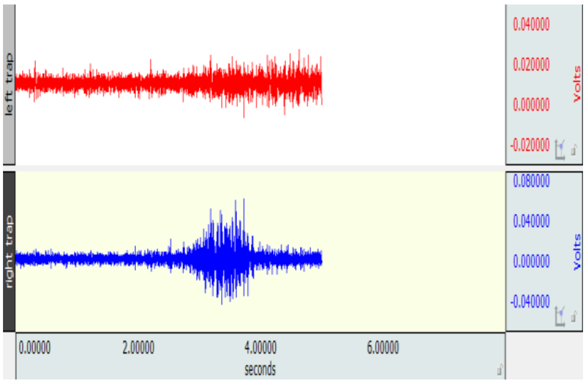

Fig.4 (f): Trapezius (Lateral Right)

Table1. Classification for different no. of movements (Sternocleidomastoid)

SUBJECTS	NO. OF MOVEMENTS				
	2 MOV	3 MOV	4 MOV	5 MOV	6 MOV
SUB 1	95	95.6	80.8	66.7	55
SUB 2	95	80	70	62	47.2
SUB 3	96.7	93.9	63.3	68	46.1
SUB 4	85	78.9	67.5	54.7	55
SUB 5	100	96.7	80	74.7	49.4
AVERAGE	94.34	89.02	72.32	65.22	50.54

Table2. Classification for different no. of movements (Trapezius)

SUBJECTS	NO. OF MOVEMENTS				
	2 MOV	3 MOV	4 MOV	5 MOV	6 MOV
SUB 1	83.3	70	60.8	44.7	45
SUB 2	93.3	86.7	91.7	78.7	62.2
SUB 3	78.3	54.4	43.3	40.7	33.3
SUB 4	83.3	78.9	73.3	56	43.3
SUB 5	88.3	86.7	89.2	76.7	77.2
AVERAGE	84.3	75.34	71.66	59.36	52.2

A program is written in MATLAB to implement the above algorithm. The process is implemented for Subject 1 for the 15 sessions of EMG recording for different movements. The code generated is in the format (ch1 ch2 ch3 ch4). As there is no muscle activation for the REST case it allotted a code of (0000). The result of the code generated for all the 15 sessions for subject1 is shown in Table3 below.

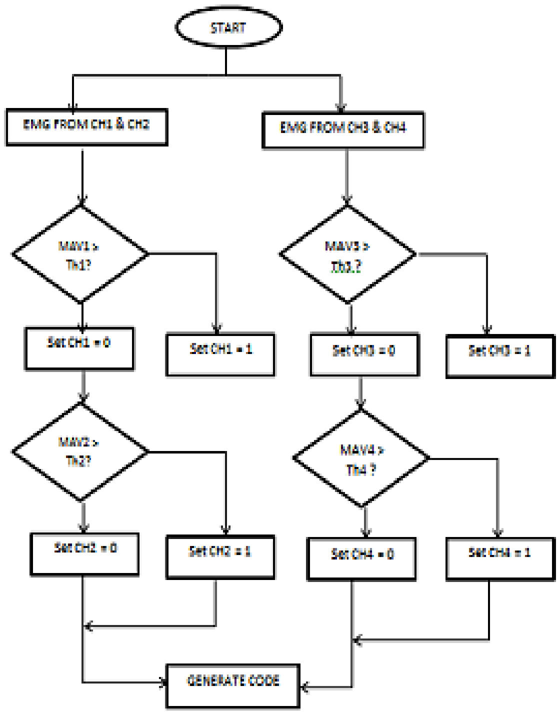

Fig.5: Flowchart for Thresholding

Table3. Codes generated for different movements

LEFT	RIGHT	FLEXION	LATERAL RIGHT
0111	1011	0011	0101
0111	1011	0011	0111
0111	0011	0011	0111
0111	1011	0011	0101
0111	1011	0011	0101
0111	1011	0011	0101
0111	1011	0011	0101
0111	1011	0011	0111
0111	1001	0011	0101
0111	1101	0011	0101
0111	1011	0011	0101
0111	1011	0011	0101
0111	1011	0011	0101
0111	1011	0011	0101
100%	80%	100%	80%

For the 15 sessions 100% accuracy was achieved for left rotation, 80% for right movement, 100% for Flexion and 80% for Lateral right movement. Out of the total 60 codes generated for the 4 movements 54 were correct which gave this method an overall accuracy of 90%. This is found to be much better than 72.32% in case of Sternocleidomastoid muscle using ANN. By applying this technique and from the results obtained Left rotation, Right rotation, Flexion and Lateral Right movement were allotted codes 0111, 1011, 0011 and 0101 respectively. Also, this technique is simple for implementation purpose.

IV. RESULTS AND DISCUSSIONS

The filtered EMG signals were obtained independently and non-invasively using surface electrodes from the sternocleidomastoid and trapezius muscles of the neck. The amplitude of right Sternocleidomastoid is higher when head is rotated left and the amplitude of left Sternocleidomastoid is higher when head is rotated left. Amplitude of left trapezius is higher when head is rotated laterally towards left. Similarly, the amplitude of right trapezius is higher when head is rotated laterally towards right. The left and right trapezius show similar patterns during flexion. The accuracy achieved for classification went on decreasing as the no. of movements were increased. The accuracy achieved for 3 movement classification using Sternocleidomastoid muscle was 89.02%. To increase this accuracy thresholding was used to obtain binary codes for different neck movements. Using this technique, 4 movements were classified namely left rotation, right rotation, flexion and Lateral right. The codes obtained were 0111, 1011, 0011 and 0101 respectively. The individual accuracies for these movements were 100%, 80%, 100% and 80% respectively. This method gave an overall accuracy of 90%.

V. CONCLUSION

The above process provides a reliable and low-cost method of classifying neck movements which can be used to control a human wheelchair. In the future attempts can be made to classify more no. of movements. Other classification techniques such as SVM, Fuzzy Logic can also be used for the classification purpose. This process will be very helpful for people suffering with high level of paralysis who cannot even move their fingers conventionally used in joystick control. Additionally this method can be superior to voice control methods in noisy environments.

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