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Control of Robotic Wheel Chair using EMG Signals for Paralysed Persons

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Abstract

Aim: In recent years, physically challenged people faces more constraint in day to-day movements. In this work, an EMG based hands-free control system for a wheelchair is proposed. **Methods:** Trapezium EMG signals are acquired, analyzed and then processed into a controlled movements (forward, left, right, etc.) using an embedded circuits for the wheelchair. **Results:** The system allows the patient to choose a smooth independent movement in the control state or non-control state. The movements depend upon the strength of the EMG signals acquired. **Conclusion**: The entire system consists of EMG electrodes, a microcontroller and a DC motor for the operation of the wheelchair. The control system is incorporated with muscle processing circuits which give an independent and safe movement to the paraplegic patients.

Keywords: EMG, Microcontrollers, Trapezium Muscle, Wheelchair

1. Introduction

In general, 1 in 50 people are affected with some form of paralysis which may be temporary or permanent according to a recent statistics. The paralyzed and semi paralyzed people struggle for mobility. So, the necessity of wheel chair for disabilities will increase in future[1]. Hence in order to overcome such problems, an automated wheelchair based on EMG signal has been developed[2–4]. Conventionally the joystick[5] based wheelchairs are operated by users, which cannot be affordable for elder one's and disabled users as their limb movements constrained with diseases such as Parkinson's disease and quadriplegics. Inceptionally, the need for the wheelchair was designed to favor those kinds of patients to act independently with their own needs, such as carrying items from one place to another. Several other methods have been developed[6–9]. Similarly, EOG signal controlled[10,11] and EMG signal controlled[12,13] studies are documented for this bio-signal controlled wheelchair. Robotic wheelchair is a novel technique, in which we have incorporated an on-board PIC Microcontroller incorporated for motion control of two differentiation driven wheels. The proposed system does not require any human assistance; moreover the system is furnished with an RF transceiver which is used to detect the obstacles in the path and it regulates the patient by an alarm and the brakes are immediately applied.

2. Materials and Methods

2.1 Electrode Placement

Three Ag-Agcl surface electrodes were placed on different muscles. For signal acquisition two electrodes were placed on the upper trapezium muscles. To obtain a reference point (the point with respect to that the potentials are being measured) a third electrode is placed. Any movement of the muscle, especially contraction will generate an EMG signal which is sensed and acquired through electrodes placed on the upper trapezium muscles.

2.2 Signal Acquisition

A signal acquisition system is developed to acquire the EMG signal due to the movement of head. Using an Ag-AgCl

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electrode the trapezium EMG signals are analyzed and processed[14,15] into control movements (i.e. forward, left, right, etc.) which are fed into a PIC microcontroller. For navigating, the wheel chair two types of rotation of neck muscle are considered-flexion and lateral rotation. From the rotational movements, four types of control commands are identified to control the DC motor.

3. Methodology

Myoelectric signals are produced during muscle contraction when ions flow in and out of muscle cells.

When a nerve sends the signal to initiate muscle contraction, a potential is developed across the muscle due to the movements of electrolytes. The complete process is described in the block diagram as shown in Figure 1. The contracting muscles ionic current is converted into electronic current using Ag-AgCl surface electrodes. A typical EMG signal has an amplitude level of 0-5mV with a frequency range of 0–500Hz where the dominating frequency lies in the range of 50–150Hz. Generally the noise components are in the frequency range of 0–10Hz (low frequency motion artifacts) and 500Hz (movement between electrodes and skin surface). By using a HPF and a LPF unwanted noises are filtered out. A 0-5V input is required for operation of a microcontroller and hence a precision rectifier along with an amplifier with adjustable gain is introduced to convert the bipolar EMG into unipolar signal. Finally a comparator with its threshold voltage level of 3V is used to distinguish between the two different head movements as both the electrode (right/left) would produce some voltages during lateral rotation. But the muscle of a particular side will be more contracted if it is the side at which the head has been moved and then the voltage generated by the electrode of that side would be higher compared to the other one. Hence the comparator will produce an output voltage high if the corresponding electrode along with its amplifier generates a voltage greater than the obtained voltage. It can also incorporate with F-V converter which has a feedback compartment to validate the input acquired EMG signal. This signal of frequency acquired, converted into corresponding voltage. Also fed into the PIC microcontroller in order to authenticate input has been acquired.

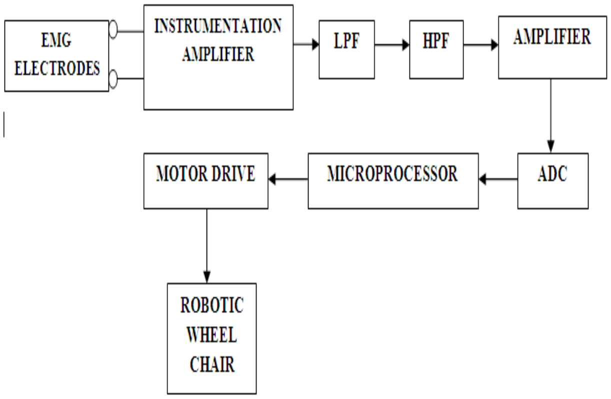

Figure 1. Block diagram of the proposed wheel chair system.

4. Results and Discussions

The prototype of the robotic wheel chair is shown in the Figure 2. The practical usefulness, testing and evaluation of the prototype is carried out in a 15 ft long indoor room. The prototype was tested to complete the task as early as possible for 'n' times. The averaged trial values of the EMG signals are shown in Table 1. The values show that there are no disturbances experienced by the developed Prototype for the "forward" direction during the testing.

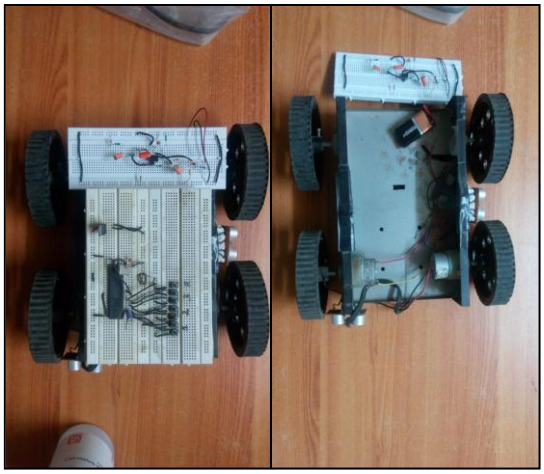

Figure 2. Prototype of the proposed robotic wheel chair.

Table 1. Strength of the EMG signal vs time

Trial no	Forward Direction (sec)	EMG Amplitude (mV)
1	124	30
2	133	26
3	147	20
4	129	28
5	142	23

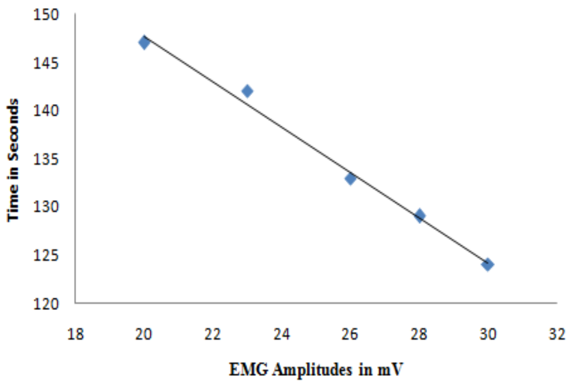

Figure 3. EMG amplitue vs time taken by the system to reach the objective.

For the "right or left" evaluation the turning has to be improved more efficient in the case of sharp precise turn.

The turn constraint issue has to be eliminated for which many no of trials and driving has to be formulated with efficient comparators.

The graph plotted between the muscle strength and time taken by the prototype model to reach the objective is shown in Figure 3. It is noted from the above trials that muscle activity contraction increases, measured in amplitude shows less time taken by the model.

5. Conclusion

The proposed EMG controlled wheelchair provides the required frequency stability in the forward direction depending upon the EMG strength of the subject carried out. However, the system needs to be improved in the right and left turn for a better independent movement for the paraplegic's patient.

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