Mobility assistance for patients with Quadriplegia

A Veerubhotla*, S Kumar, S Bachhal and A Kumar

Biomedical Instrumentation Division
CSIR-Central Scientific Instruments Organisation, Chandigarh, India

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Immobility often causes psychological and social effects on the person. Since immobility cannot be cured even by using drugs in most cases, it is essential that such people be given a means of mobility which does not let their immobility hinder their day to day life. This paper describes a very feasible mobility solution for the physically impaired people especially those who are suffering from spinal cord injury in the higher levels of C1-C7. Independent Electromyogram (EMG) signals obtained from the neck muscles of the patient using active EMG electrodes have been used to control the direction of movement of the wheelchair. The direction and degree of movement of the neck governs the speed and motion of the motor powered wheelchair. Ultrasonic sensors placed on the wheelchair have been used for obstacle avoidance. Experimental results have shown that the designed solution is very feasible, cost effective and requires very less training of the user.

Keywords: Active electrode, Cerebralpacly quadriplegia, Electromyogram (EMG), mobility assistance, motor powered wheelchair, Sternocleidomastoid muscle, trapezius muscle

Introduction

The ability to move in one's environment with ease and without restriction is very much needed for the emotional stability of any person. Research at the SH HO centre for Gerontology and Geriatrics, has proven that movement disorders and illnesses where the symptoms cause abnormal movement have an enormous impact on people’s personal and professional lives causing a major loss of mobility and independent living. Among the many movement disorders are ataxia, dystonia, Parkinson’s disease, Multiple Sclerosis, Myasthenia gravis, neuromuscular disorders and quadriplegia. Quadriplegia or tetraplegia is caused due to an injury to the spinal cord, resulting in the partial or total loss of use of all limbs and torso of a person. Since quadriplegia limits the mobility of patients, they are forced to depend extensively on others. This may even cause emotional stress to the patient. As an alternative to the joystick control, various input interfaces such as a sip and puff, chin controller, ultrasonic non-contact head controller, head movement and voice controller have been developed to improve manipulability, safety and comfortableness.1-7 Some of these require computer interfaces or robotic interfaces which increases their cost while those controlled by voice cannot be used in noisy environments. Movement of the head and neck is a natural gesture to indicate direction. EMG may be obtained from the neck muscles of a severely paralyzed person too. EMG is the electrical activity produced by the skeletal muscles when contracted. The surface EMG of the neck muscles can be easily acquired by using active electrodes. This paper presents an EMG based wheelchair for severely paralyzed people.

Materials and Methods

According to exercise prescription (ExRx.net), the motion of the neck can be divided into rotation (looking side to side), lateral flexion (ear to shoulder), flexion (chin to sternum) and hyperextension (looking up). Many muscles are involved in moving the head and neck. Of these muscles, independent EMG signals have been obtained from the Trapezius and the Sternocleidomastoid muscles. The obtained EMG signals in the right Sternocleidomastoid muscle when the neck is moved towards left and EMG in the left Sternocleidomastoid muscle when the neck is moved towards right. The trapezius muscle is activated when its corresponding shoulder is moved. The acquired EMG from the neck muscles using jelly less active EMG electrodes. The independent signals obtained from the left and right Sternocleidomastoid muscle

*Author for correspondence
E-mail: virdi205@gmail.com
and any of the trapezius muscle is amplified and fed to an analog to digital converter. The digital output is further fed to the controller where the logic for the motor driven wheelchair is stored. The Fig. 1 shows the block diagram of the process.

Results and Discussion

During the acquisition of the EMG it was observed that independent signals were obtained from the left and right Sternocleidomastoid muscles. When the head was rotated to the right, the left Sternocleidomastoid muscle potential could be recorded and when the head was rotated left, the potential from the right Sternocleidomastoid muscle was recorded. When the head was moved in a particular direction, EMG was observed only in one muscle (either the left or the right) while EMG in the other muscle is negligible. The active muscle can be easily distinguished from its amplitude and frequency which are quite high when compared to the inactive muscle. Thereby, the direction of movement of the head of a person can be deciphered just by observing the EMG of both the muscles. The wheelchair is programmed to move in same direction as the head.

Relationship between Muscle Contraction and Wheelchair Movement

The motor powered wheelchair is programmed such that the wheelchair moves left when the head is moved left and the wheelchair moves right when the head is moved right. The wheelchair moves forward when the head is moved up and when no input is given, the wheelchair continues to be in its previous state. The wheelchair starts and stops only when an input from the Trapezius muscle is obtained. The signal flow diagram of the motor powered wheelchair is shown in Fig. 2. Though intended for use by quadriplegics, the wheelchair has not yet been tested on them.

Conclusion

This paper describes an EMG controlled motor powered wheelchair which has been developed for the disabled. It has been found that EMG signal is one of the most reliable signals produced naturally by the user. In cases where the EMG signal may have less strength due to any muscular problem of a person, it can still be compensated by amplifying it further. The use of ultrasonic sensors, gives the user the added advantage of obstacle avoidance. The developed wheelchair has low cost too and hence will be affordable even by the lay man. Furthermore it requires very less training of the user. Since it does not require mobility in the hands, patients having disability in their four limbs may also use it. The EMG signal is not affected by external noise. Further, external electrical or magnetic interference does not disturb EMG signal. Energy required to move the neck in any specific direction is very much less than that required for the sip and puff mechanism. The patient automatically gets adapted to its usage, since initial training required is minimal. It may further be summarised that the developed design overcomes the shortcomings of most existing wheelchairs and hence can be used effectively by all those who have varied degrees of movement disability.
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References