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SMART Wheelchair by using EMG & EOG

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Abstract- *This paper presents a eye pupil control system for an supply powered wheelchair, based on EMG (Electromyography) signals recorded from eye pupil and muscle voltage levels. One-dimensional continuous EMG signals are obtained, amplified, filtered and translated with 32-bit microcontroller into number of control commands like forward, backward, left, right, for the wheelchair that supports multi-directional control and EOG signals detected from eye pupils are used to adjust rotation or speed of the motor. The system works under switching basis to choose either control state or non-control state so that a user are easily do any muscle activity related to eye within non control state. The proposed system is reliable, easy to set up, easy to use and less costly as compared to earlier systems.*
Keywords - *EMG, EOG, Hands free.*

I. Introduction

Earlier wheelchairs are normally controlled by users via joysticks [1], which cannot satisfy the needs of elderly and disabled users, who have restricted hand movements caused by some diseases. Nowadays, many alternative control methods have been developed, voice operated control [2], head gesture control [3], face image detection based control [4]. Although EOG eye tracking control provide a more natural mode of interaction between a man and a machine, operator are not allowed to look around the surrounding environment for safety during running condition. The population of people with disabilities has risen markedly during the past century. As the data come from the National Health Interview Survey (NHIS)[5], two distinct trends have contributed to the increasing overall prevalence of disability aging population, as well as a rapid increase due to health impairments and accidents. Many individuals have problems to use a conventional wheelchair. A recent clinical survey indicated that 9-10% of patients who received power wheelchair training found it extremely difficult or impossible to use it for their activities of daily living, and 40% of patients found the steering and maneuvering tasks difficult or impossible[6][7]. In this paper, we propose hands-free wheelchair control system that uses muscle signals for change the direction and eye pupil signals for controlling speed of the motor for an electric wheelchair muscular and eye based signals are acquired by using a system, and are used to produce control commands. The proposed system is a very simple but the signals detection from the eye & muscle was very difficult task.

II. Basics Of System

The proposed system is based on two techniques of Electromyogram and Electrooculogram.

2.1 Electromyogram

The EMG is an electrical signal that can be used to observe muscle contraction. It is measured either by using surface electrodes on the skin (surface EMG) or by invasive needle electrodes which are inserted directly into the muscle fibre (the invasive, needle or indwelling EMG). As mentioned already, a muscle fibre contracts when it receives an action potential. The electromyogram observed is the sum of all the action potentials that occur around the electrode site. In almost all cases, muscle contraction causes an increase in the overall amplitude of the EMG. Thus it is possible to determine when a muscle is contracting by monitoring the EMG amplitude. The EMG is a stochastic signal with most of its usable energy in the 0-500Hz frequency spectrum, with its dominant energy in the 50-150Hz range as shown in figure 1. The amplitude of the signal varies from 0-10mV (peak-to-peak) or 0-1.5mV (rms). The EMG has been used as a control signal for assistive technologies for a number of years. It is usually used for prosthesis control and is often described by the term myoelectric control [8].

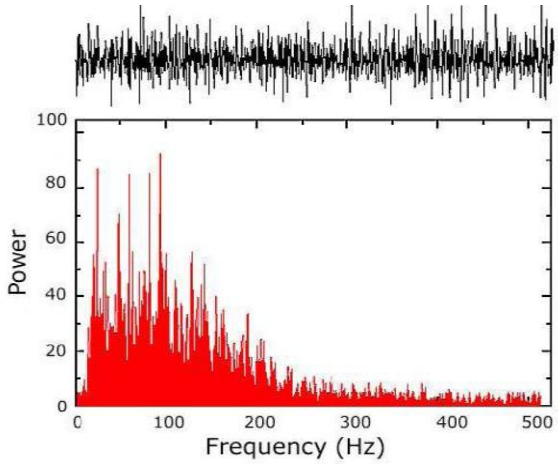

Fig. 1 EMG and frequency spectrum

2.2 The Electrooculogram

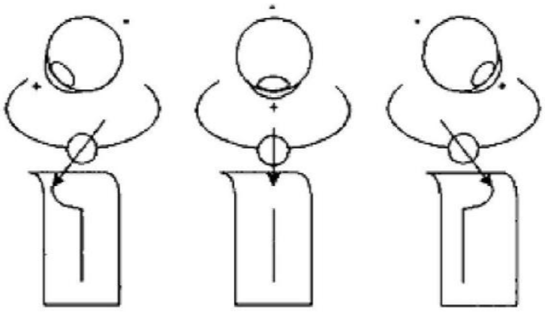

Fig. 2 : The electric field in the tissues surrounding the eye and the effect of rotation of the eye.

III. System Design

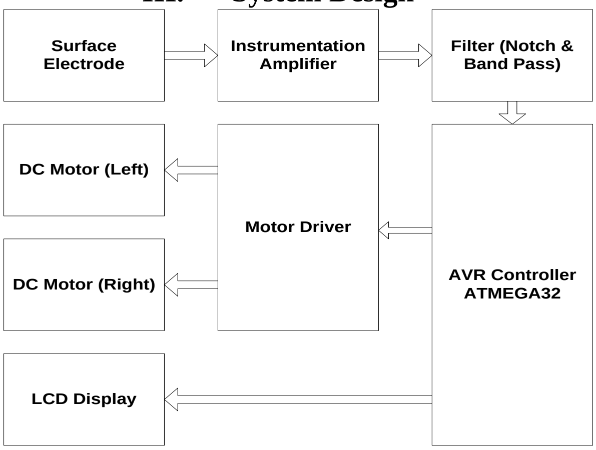

Fig. 3 Block Schematic of Proposed System

This signal is a biopotential measurable around the eye - either between the top and bottom of the eye (the vertical EOG), or between the two sides of the eye (the horizontal EOG). The EOG amplitude varies as the eyeball rotates within the head, and thus can be used to determine horizontal and vertical eye movements as shown in figure 2. These movements can then be harnessed as a control signal for applications, as will be discussed. A method for control based on the electrical conductance of the skin is described. The conductance of the skin may be controlled by consciously relaxing or tensing the body, thus activating or relaxing the sweat glands. This method is constrained by the length of time taken to elicit a response, but it may be applicable in cases of very severe disability[9]. A method for measurement of the firing rate of the sympathetic nervous system based on measurement of the skin conductance is also presented[10].

The EMG signal from the muscle is picked up by the surface electrode, the signal obtained from electrodes are of low magnitude (i.e. 0-5mV) and analog in nature it is therefore necessary to amplify these signals by instrumentation amplifier into a range (0-3V) suitable for the A to D converter to convert analog signal into suitable digital signal. The circuit are required to design a system are Instrumentation amplifier, bandpass filter and notch filter. Three op-amp circuit the gain of 1000 is to be designed for better amplification as the signal strength is very weak. In order to remove the noise signal notch filters are designed i.e. Twin-T notch filter is design. After that one band pass filter is designed to select the range of that signal (10Hz-10KHz). As compare to other microcontrollers the AVR are best suited for this application due to their features:

a) AVR is 32-bit Controller with real-time emulation that combines the microcontroller with 32 KB embedded high-speed flash memory.
b) A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at max clock.
c) It has a blend of serial communication interfaces ranging from multiple UARTs makes these devices very well suited for communication.
d) It has 32-bit and 16-bit timers,
e) ADC features.
f) With nine edge or level sensitive external interrupt pins.
g) Due to their tiny size and low power consumption.
h) AVR controller has a conversion time as low as 3usec.

The recording and the processing of EMG signal is done by AVR microcontroller. In this paper the signal from the sensor is obtained at a interval of 5sec it is digitized. This data is stored in the memory. The signal is given to motor driver circuit (L293D) and according to program it will control the actions like forward, Back, Left & Right. LCD display (LM041L) 16x4 alphanumeric display is used to show the step rotation of motor.

IV. Simulation & Results

Simulation is carried out using proteus simulation tool. The results are shown in figure 4 & figure 5 in the form of animation of the motor to rotate in forward & reverse direction as per the rotation of the eye & LCD display showing the values of rotation of wheel in step. Based on the successful simulation results, the same work will be carried out for practical implementation.

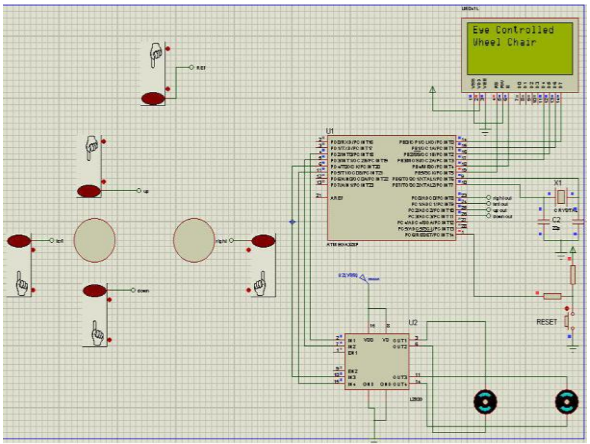

Fig. 4 Simulation Circuit

As shown in figure 6 left 52 indicates the signal received from left eye and it is more than reference signal. The reference value decided in code is 50 so, if user will start to give the input from eye pupils the input signal is compared with set reference signal and input signal is greater than reference value then left side motor will start to rotate and the multimeter connected across the motor shows the supply voltage (10V) which is used to drive the motor.

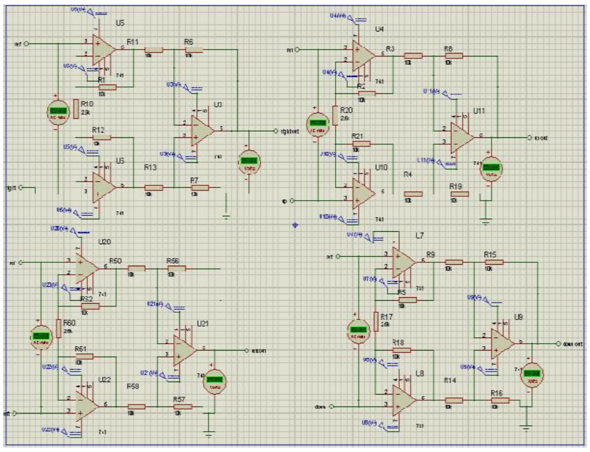

Fig. 5 Simulation Circuit

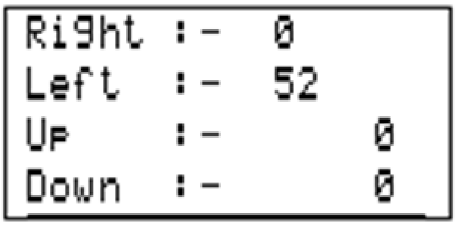

Figure 6 LCD display shows input value

Lai [4] presented visual based hands-free control of intelligent wheelchair. The stored images compare with webcam images and generate control commands. To test the comparison webcam needed and dedicated pc installed onto the system so, the system requires more power to operate and costlier as compared to proposed system. Chun [12] developed the hands-free wheelchair control using DSP TMS320LF2407. In this design the author was not shown any signal processing related task so no need of costlier DSP processor. In our system we take care of cost as well as ease of setup, and minimum circuit complexity.

V. Conclusion

In this paper, a pristine hands-free control system based on EMG and EOG signals is proposed for controlling an electric powered wheelchair. The system is low cost, easy to setup, and easy to use. A new user might require about half an hour of practice with a simulator in order to control the system at will, before using the actual wheelchair. Although the control is not as natural as head gesture or EOG eye tracking systems, our system allows users to look around the surrounding environment freely while the wheelchair is moving. This is practically important for route planning, and backward movement for an obvious reason. The EOG to detect eye movements would be an important safety feature if the system was to be used in an outdoor or non structured environment.

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