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A System Design Approach to Control a Wheelchair Using EOG Signal

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***Abstract* - In this paper a practical miniature model of the wheelchair system has been implemented. The system has been verified using test signal which has been provided by potentiometer.The movement of the human eye signal is used as a control signal for the wheel chair movement, called human-machine interface (HMI) system. The goal is to design a sophisticated HMI based system which can be helpful for a physically handicapped person.**

***Keywords* - EOG signals, HMI system, physically handicapped.**

I. INTRODUCTION

Development of interfaces adapted to the user physical skills is necessary in some situations where users have different diseases. In most cases, some residual user movements are used to interact with these interfaces. Bio-signals are useful to detect these movements, such as electrooculography (EOG) or electromyography (EMG) where the aim is to handle a computer through event and a virtual keyboard. Also the EOG signal has been used to handle a wheelchair.

However, the first step of acquiring signals starts with positioning of electrodes followed byfiltering and amplifying units respectively.The placement of electrodes is important for acquiring a goodsignal form the eyes. The overall placement of the electrodes can be represented as shown in Fig.1.For the detection of horizontal discrimination, electrode is placed to the left of the left eye and one to the right of the right eye.

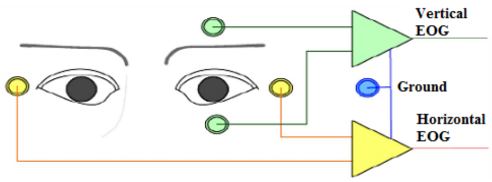

Fig.1 Electrodes placement for EOG signal

It is important to keep the electrodesequidistant from the centre of the face for the EOG to be properly centred. In a similar fashion, an electrode is placed above the eyebrow and below the eye for both the left and right eyes. These four electrodes are used for vertical detection. Although it is possible to detect vertical motionwith just two electrodes, greater sensitivity is here achievedusing four electrodes, thus providing for moreaccurate detection due to the greater dipole induced.

In this paper, the experimental setup has been constructed to apply the EOG signals for controlling the movement of the wheel. A miniature working model of the wheel chair is developed and also verified with virtual test signal using potentiometer as an input. The remaining part of this paper is organized as follows: Section II presents the work details and complete structure of the system. The working of experimental setup is described in Section III. Section IV contains with experimental results and discussions and Section V is ended up with conclusions.

II. COMPLETE STRUCTURE OF THE SYSTEM

An Electrooculogram or EOG is the resulting signal of the potential difference caused by eye movements. The voltage difference is measured between the cornea and the retina. The resting potential ranges from 0.4mV to 1mV and a pair of electrodes are commonly used to detect this signal, but the voltage difference when there's an eye movement can be as small as just some microvolts. Depending on the eye's position, an electrode is more positive or negative with respect to the ground electrode. Therefore, the recorded signal is either negative or positive when moving the eyes. The system relies mostly in three important factors: the differential voltage from the electrodes, noise, and offset. In electronics, these three "power sources" can be summed in order to estimate the output voltage. However in this work, a prototype one wheel base has been designed to control the wheel chair movement. It has been tested using a test signal. A microcontroller is used to provide the control signals.

The complete structure of the system is depicted in Fig.[2]. Since the strength of the voltage signal is very low and noise sensitive, an amplification circuit with proper filter has to be designed to acquire the signal for the process. Generally instrumentation amplifier and low pass filter or sometimes band pass filter are used to amplify the signal and remove the noise from the signal

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respectively.

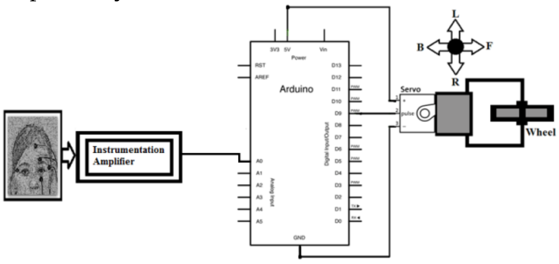


Fig.2. Complete structure of the system

Instrumentation amplifiers (in-amps) are precision gain blocks that have a differential input and an output that may be differential, or single-ended with respect to a reference terminal. These devices amplify the difference between two input signal voltages while rejecting any signals that are common to both inputs. General purpose instrumentation amplifier such as a low power INA118, offers excellent accuracy due to its versatile 3-op amp design and small size for the respective work objective.

III. Experimental Set-Up

The experimental set-up consists of a dc motor, a servo motor and a microcontroller as shown in Fig.2 and Fig.3.

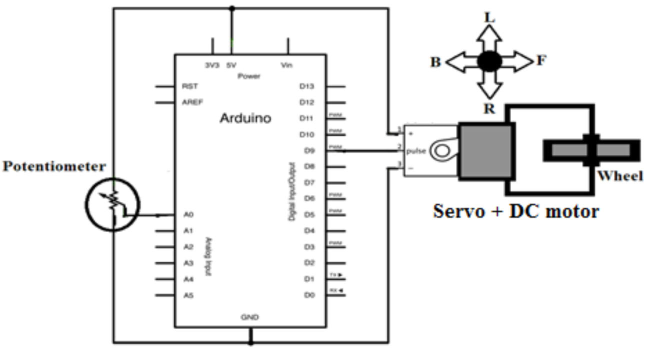


Fig.3. Experimental setup block diagram.

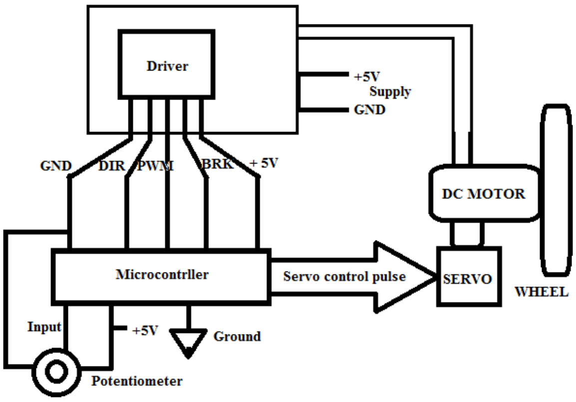


Fig.4. Experimental setup

A motor driver is used to drive the dc motor in either forward or backward directions. The servo motor is used to drive the complete dc motor in either left or right directions as per control pulses. The specifications are given in Table1.

Table 1

Name of the components	Quantity	Specifications
Microcontroller kit	1	Arduino Uno
DC motor with wheel	1 set	5V, 1.8W
Servo motor	1	Hitec, HS-55
Resistance	1 box	¼ W
Capacitor	1 box	16 V

Motor driver: It is a simple TTL/CMOS based interface that can connect directly to the I/Os of an MCU. It has a breaking feature that can guarantee immediate halt on the shaft of motors in most high power applications and also includes protection circuitry to avoid any electrical fluctuations affecting the normal operation of an MCU. Fig.4 shows the motor driver pin configurations.

Fig.5. Motor driver [Robokits.com]

Connection Information:
V(+) 24Vmax and GND(-): Power Supply input to driver (Input Voltage)
Motor: Two Terminals of the DC motor
Control I/O Description
GND – connect to GND on controlling board
DIR – Pulled down to GND Forward by default and Backward when 5V (logic high)
PWM – Pulse Width Modulation input to control speed of motor (recommended freq 20Hz to 400Hz)
BRK – breaking input to halt the motor in operations when 5V (logic high)
5V – regulated 5V output from motor driver board (maximum 50mA supply).

Microcontroller logic: There are 5 pins available in the motor driver to operate the dc motor which holds the wheel. The servo motor has 3 pins: ground (black),5V (red) and control pulse (yellow). A digital logic has been implemented using microcontroller kit- Arduino UNO.
In this work, the 5 pins of motor driver are controlled using microcontroller I/Os. Pin 10 (Output_A) and Pin 9 (Output_B) are assigned as outputs for motor running respectively. Pin 7 (Switch_dir) is assigned to reverse the speed of the motor as a switch. Pin 7 is connected to the DIR pin of the driver to reverse the speed of the wheel. The PWM pin and the BRK pin is kept at active high and active low respectively. Ground (GND) must be connected for the protection of the circuits and board. Pin 11 (LRdir) is a PWM pulse for controlling the servo direction. The connection diagram of the driver with microcontroller is given in the Fig. [4]. A potentiometer

is used to change the duty ratio of PWM pulse. Instead of real EOG signal, the potentiometer is regulated to verify the base model operation.

IV. Experimental Results and Discussions

A. *RESULTS*

Initially, suppose the wheel is moving in the forward direction and PWM is fixed at a particular duty ratio as shown in Fig. 6. Now if the switch is changed to the opposite direction, the outputs at the pin 10 and 9 are also changed the voltage level as shown in Fig. 7.By changing the duty ratio of the PWM pulse using potentiometer, the direction is controlled using servo operation which is shown in Fig. 8 and Fig. 9.

Fig. 6. (1) PWM (2) Output A (3) Output B

Fig. 7. (1) PWM (2) Output A (3) Output B

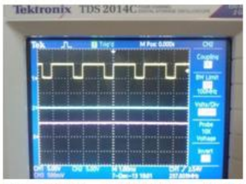


Fig.8(1) PWM duty change-a

Fig. 9(1) PWM duty change-b

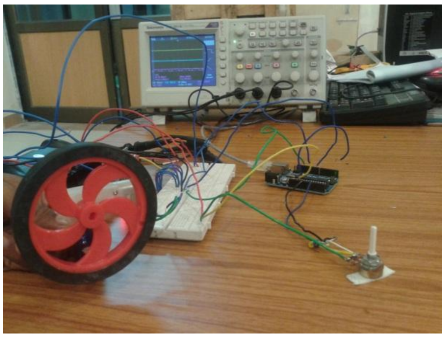
B. *DISCUSSIONS*

By changing the duty ratio of the PWM, the left-right direction of the wheel can be controlled. More than 50% of +5V move the wheel in the right hand direction where less than 50% of the +5V changes the motor in the left direction, shown in Fig. 8.and Fig. 9. The switch enables the wheel in the forward direction and in the backward for active high and active low respectively. The overall results are satisfactory.

V. Conclusion

Using test signal, the system provides satisfactory results. Using various experimental results, the miniature version of the system has proved that it can provide satisfactory outcomes under all possible circumstances. In future instead of test signal, EOG signal will be used to reach the objective as expected.

VI. Appendix



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