Human Eye Mouse

Mr.Avinash P. Gavali[1], Mr. Rohit V. Bhuran[2]
(Ast.prof. of sahyadri poly.,sawarde)
India

ABSTRACT

The paper presents a novel idea to control computer mouse cursor movement with human eyes. In this paper, a working of the product has been described as to how it helps the special people share their knowledge with the world. Number of traditional techniques such as Head and Eye Movement Tracking Systems etc. exist for cursor control by making use of image processing in which light is the primary source. Electro-oculography (EOG) is a new technology to sense eye signals with which IR combinational sensor are used to control the mouse cursor. The signals captured using sensors (electrode), are first amplified, then noise is removed and then digitized, before being transferred to PC for software interfacing. So it is successfully implemented and demonstrated. The final application consisted of: An eye controlled cursor providing control over left, right, up and down.

Keywords— *EOG(ElectroOculooGraphy), Human Computer Interaction, Real-Time System, Ag/AgCl electrodes.*

I. INTRODUCTION

PEOPLE with physical disabilities face a lot of problems in communication with their fellow human beings. In this paper, the design of an eye-controlled mouse system with an emphasis on the *Human-Computer-Interface* (HCI) based on *Electro-oculography* (EOG) has been presented. Computers can be used by persons with disabilities for communication, environmental control, source of information and entertainment

There are a lot of head and eye movement tracking systems for cursor control. Some of them are equipped with sophisticatedly designed systems using complicated concepts or using high quality devices such as high cost 3-D graphical hardware.

Head Movement Tracking System is a device that transmits a signal from top of the computer monitor and tracks a reflector spot placed on the user's forehead or eyeglasses. Using only the movement of the user’s head, the movement of the cursor can be controlled, allowing ‘The Head Mouse’ to be used as an ordinary computer mouse. But problem with this technique is that some disabled people cannot even move their head comfortably, also the system becomes inaccurate if user’s forehead is not facing the camera.

Eye tracking is a technology in which a camera or imaging system visually tracks some features of the eye and then a computer determines where the user is looking at Eye tracking technology can be divided into two areas; firstly a remote computer-mounted device, in which an IR camera is mounted on a computer screen, and secondly a head-mounted device, in which an IR camera is placed on user’s head. This technique is accurate but expensive.

Electro-oculography (EOG) is a new technology of placing electrodes on user’s forehead around the eyes to record eye movements. EOG is a very small electrical potential that can be detected using electrodes. The majority of the people using this setup may have severe cerebral palsy or been born with a congenital brain disorder or suffered traumatic brain injury, for example from automobile or drowning accidents. This technique is adapted because it is inexpensive and accurate.

The anatomy of the eye is shown in the Fig. 1. The light entering the pupil, is focused, inverted by the cornea and lens and projected onto the back of the eye (fovea). The fovea defines the center of the retina with the region of highest visual acuity. The retina houses seven layers of alternating cells and processes which convert a light signal into a neural signal (transduction). The actual photoreceptors are the rods and cones, but the cells that transmit to the brain are the ganglion cells. Cones provide the focus on fine detail and distinguish color. They require relatively high levels of illumination to operate. Rods, on the other hand, are much more sensitive to light, providing superior capability to detect movement in low levels of illumination. The axons of the ganglion cells make up the optic nerve, the single route by which information leaves the eye.

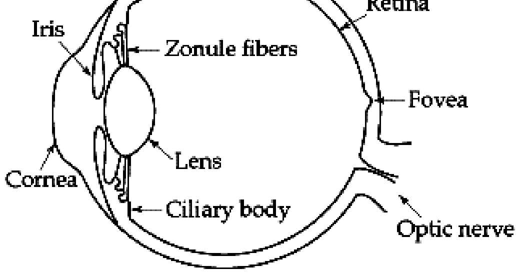

Fig. 1 The anatomy of the eye [3]

A. Sensing Eye Signals

Due to the higher metabolic rate at the retina compared to the cornea, the eye maintains a voltage of +10 to +30 millivolts with respect to the retina. This corneoretinal potential, which is roughly aligned with the optic axis and hence rotates with the direction of gaze, can be measured by surface electrodes placed on the skin around the eyes, (see Fig. 2). The actual recorded potentials are smaller in the range of *15 to 200 microvolts* and are usually amplified before processing [4]. With proper calibration, the orientation of the electric dipole can be used to specify the angular position of the eyeball to within 2 degrees vertically and 1.5 degrees horizontally [4]–[5].

Independent measurements can be obtained from the two eyes, but as the two eyes move in conjunction in the vertical direction, it is sufficient to measure the vertical motion of only one eye together with the horizontal motion of both eyes. To detect vertical motion, one electrode is placed 2cm above where as another electrode is placed 1cm below the left eye. To detect horizontal motion, an electrode is placed on outer side of each eye with 2cm distance from the eye (see Fig. 2). *Ag/AgCl electrodes* are chosen as their half cell potential is closer to zero.

When the eyes look straight ahead, a steady dipole is created between the two electrodes. When the gaze is shifted to the left, the positive cornea becomes closer to the left electrode, which becomes more positive [6], with zero potential at the right electrode, and vice versa. The EOG signal is a result of a number of factors, including *eyeball and eyelid movement, different sources of artifact such as EEG, electrodes placement, head movement and influence of the luminance, etc*. For this reason, it is necessary to eliminate the shifting resting potential (mean value) because this value changes [7]. To avoid this problem, it is necessary to have *ac differential amplifier* that will take the difference of the two opposite electrodes.

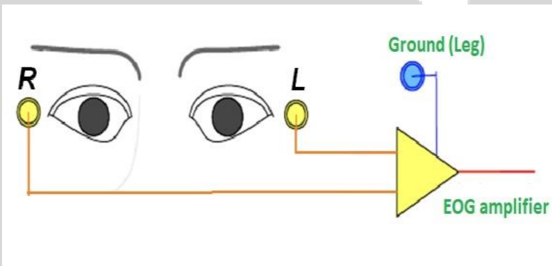

Fig. 2 Correct positions of five electrodes [8]

B. Signal Amplification

EOG amplifier is used to amplify the acquired EOG signal.
The acquired signal is having amplitude in millivolt. It cannot be used to process the microcontroller operations. Hence we amplify it using a 1000 gain amplifier and will get the signal in terms of volt.

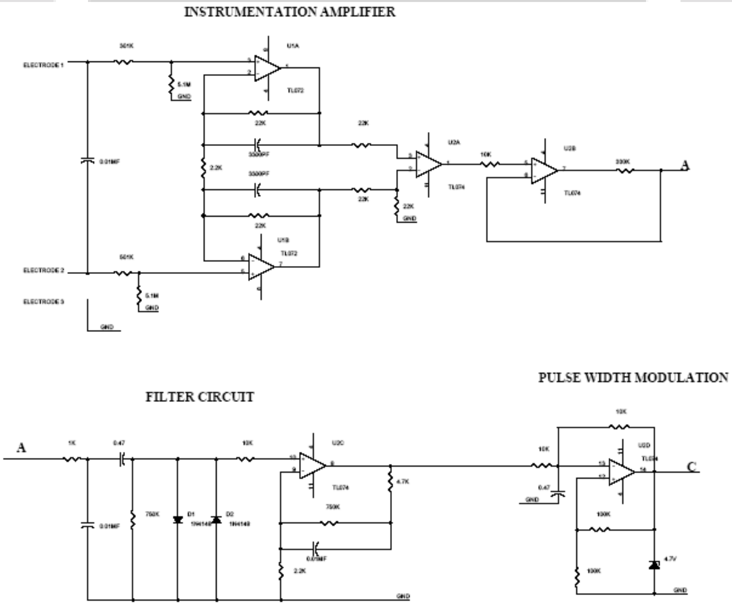

Fig.6 Amplifier and filter circuit

A. Filter selection

Modern EOG monitors offer multiple filters for signal processing. The most common settings are monitor mode and diagnostic mode. In monitor mode, the low frequency filter (also called the *high-pass filter* because signals above the threshold are allowed to pass) is set at either 0.5 Hz or 1 Hz and the high frequency filter (also called the *low-pass filter* because signals below the threshold are allowed to pass) is set at 40 Hz. This limits artifact for routine cardiac rhythm monitoring. The low frequency (high-pass) filter helps reduce wandering baseline and the high frequency (low pass) filter helps reduce 60 Hz power line noise. In diagnostic mode, the low frequency (high pass) filter is set at 0.05 Hz, which allows accurate ST segments to be recorded. The high frequency (low pass) filter is set to 40, 100, or 150 Hz. Consequently, the monitor mode EOG display is more filtered than diagnostic mode, because its band pass is narrower.

B. Limb Leads

Leads I, II and III are the so-called limb leads because at one time, the subjects of electrooculography had to literally place near the eyes. They form the basis of acquiring of EOG signal. Eventually, electrodes were invented that could be placed directly on the patient's skin.

- Lead I is a dipole with the electrode on the right eye
- Lead II is a dipole with the electrode on the left eye.
- Lead III is a dipole with the electrode on hand or leg.

C. Circuit Description

In this circuit there are three electrodes is used to measure the EOG waves in which two electrodesare fixed with left and right hand another one electrode is fixed in the right leg which acts as reference ground electrode. Electrode 1 and Electrode 2 pick up the EOG waves from the both hands. Then the EOG waves are given to instrumentation amplifier section.

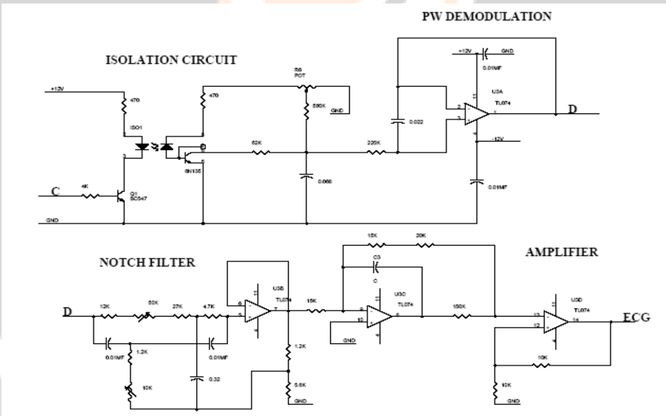

Fig.7 Circuit diagram

The instrumentation amplifier is constructed by the TL 072 operational amplifier. The TL072 are high speed J-FET input dual operational amplifier incorporating well matched, high voltage J-FET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset current and low offset voltage temperature coefficient.

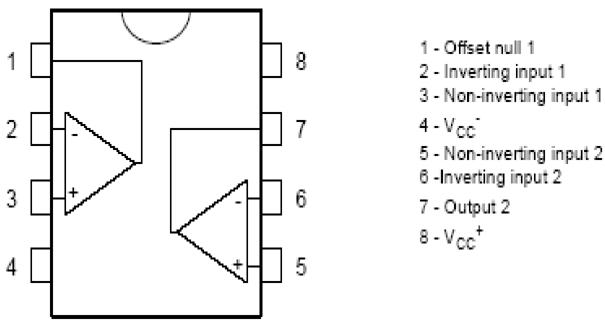

Fig.8 amplifier IC

The instrumentation amplifier amplifies the differential signal from the both electrode. This amplified EOG waves contains the line frequency, high frequency and low frequency noise signals. So the EOG wave is fed to filter section. The filter section consists of high pass filter and low pass filter which is used to remove the high frequency and low frequency noise signal. After the filtration the EOG wave is given to pulse width modulation unit. In this section the EOG wave convert to pulse format in order to perform the isolation. The isolation is made possible by the by the opto-coupler. The isolation is necessary to isolate the human body and monitoring equipment such as CRO, PC etc.

The EOG pulse format wave is then given to the PWM demodulation unit in which the pulse format is reconstruct to original wave. Then the wave is fed to notch filter section in order to remove the line frequency noise signal. A notch filter is a band-stop filter with a narrow stop band (high Q factor). Notch filters are used in live sound reproduction (Public Address systems, also known as PA systems) and in instrument amplifier (especially amplifiers or preamplifiers for acoustic instruments such as acoustic guitar, mandolin, bass instrument amplifier, etc.) to reduce or prevent feedback, while having little noticeable effect on the rest of the frequency spectrum. Other names include 'band limit filter', 'T-notch filter', 'band-elimination filter', and 'band-rejection filter'. Typically, the width of the stop band is less than 1 to 2 decades (that is, the highest frequency attenuated is less than 10 to 100 times the lowest frequency attenuated). In the audio band, a notch filter uses high and low frequencies that may be only semitones apart. Here the notch filter is constructed by the operational amplifier TL074. Finally noise free EOG wave is given to amplifier. Then the amplified signal is given to monitored device such as CRO, PC etc.

D. IR sensors

Infrared transmitter is one type of LED which emits infrared rays generally called as IR Transmitter. Similarly IR Receiver is used to receive the IR rays transmitted by the IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other.

The transmitted signal is given to IR transmitter whenever the signal is high, the IR transmitter LED is conducting it passes the IR rays to the receiver. The IR receiver is connected with comparator. The comparator is constructed with LM 358 operational amplifier. In the comparator circuit the reference voltage is given to non inverting input terminal. The inverting input terminal is connected IR receiver. When interrupt the IR rays between the IR transmitter and receiver, the IR receiver is not conducting. So the comparator non inverting input terminal voltage is higher than inverting input. Now the comparator output is in the range of +5V. This voltage is given to microcontroller or PC and led so led will glow. When IR transmitter passes the rays to receiver, the IR receiver is conducting due to that non inverting input voltage is lower than inverting input. Now the comparator output is GND so the output is given to microcontroller or PC.

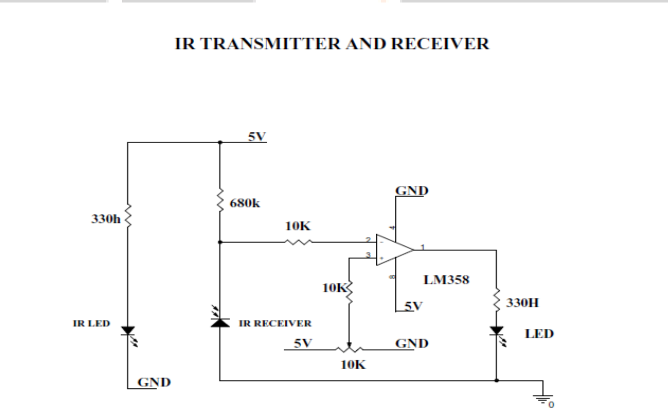

Fig.9 IR sensor

E. Microcontroller

The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

The output signal is given from PIC Microcontroller to the VB driver. The VB window is used for moment of the cursor on the screen.

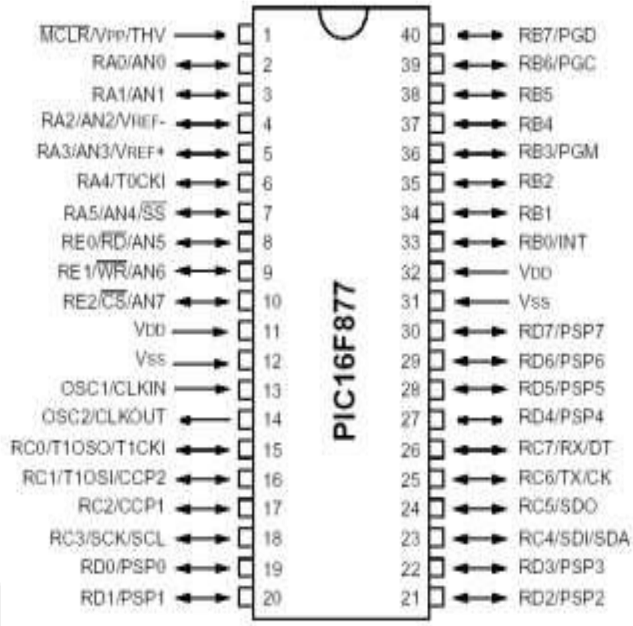

Fig.10 PIC Microcontroller

IV. FUTURE DIRECTIONS

Human Computer Interfaces have an enormous scope in near future. There are four aspects as far as future enhancements are concerned.

- Making of Sophisticated Software by which one can paint, chat and play virtual games.
- Use of other areas of scalp for EOG acquisition.
- Make a sophisticated product that can be implemented in fighter jets. Pilot just has to point the target with the eyes and press the trigger when target becomes under the range. It will be highly appreciated since the eye movement is more fast and accurate than just the hand movement.

REFERENCES

[1] Jee Hoon Yoo, Jin Young Kim. 2003, “Eye-movement communication technology for the physically disabled”, unpublished.
[2] Lukander, K. “Mobile usability - Measuring gaze point on handheld devices”, In Proc. CHI 2004, April 24-29, Austria.
[3] “Eye and Retina”, http://thalamus.wustl.edu/course/eyeret.html
[4] Bernard D. Shaviv. 1993, “The design and improvement of an eyecontrolled interface”, unpublished http://www.cs.sunysb.edu/~vislab/projects/eye/Reports/report/report.pdf
[5] Young and Sheena, "Survey of eye movement recording methods", behavior research methods and instrumentation, Vol. 7 (5), 1975, unpublished.
[6] Vinodh Kumar. R, Naveen. R, Sriram. L, “Computer mouse controlled by eye”, 2004, unpublished.
[7] Rafael Barea, Luciano Boquete, Manuel Mazo, Elena López, “System for assisted mobility using eye movements based on electrooculography”, IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol. 10, No. 4, December 2002.
[8] Yingxi Chen, “Design and evaluation of a human-computer interface based on electro-oculography”, 2003, unpublished. URL: vorlon.case.edu/~wsn/theses/yingxichen_thesis.pdf
[9] Charles Kitchin and Lew Counts, “A designer’s guide to instrumentation amplifier”, pp. 34-36.