TITLE: EYE INTERFACE TECHNOLOGY

ELECTRO OCULOGRAPHY — Control computer with eyes

A PAPER UNDER BIOMETRICS

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ABSTRACT:

Today the use of computers is extended to every field. Many sophisticated devices like touch screen, track ball, digitizers etc made interaction with computer ease from novice to professional.

But physically disabled individuals are deterred from using computers due to their inability to control mouse. However, if directional discrimination of an icon can be achieved, quadriplegics can take the function of a mouse without the use of hand.

In this paper I come before with a new model of based on Electro-Oculography which uses Electro-oculogram Bio potential amplified signal to control computer. I also discuss its implementation details, including software and hardware design.

As my contribution to this paper I introduce a new keyboard design, some modifications in design to overcome the drawbacks in existing model.

In single statement my paper deals with controlling, operating computer with the aid of eyes. And this was the project which I am doing under the precise guidance of Indian institute of technology madras (IITM) in which a live working model costs around 10 lakhs is being built by our team members. The all rights of this project strictly belong to iit madras and our team members.

In this paper I provide the following details:
1. Introduction
2. Electro Oculography: Principle
Introduction:

Computer is used in every field now. Mice and touch screens are a nice improvement over keyboard for some tasks but it can’t be useful for quadriplegics. Although several hardware and software interfaces have been devised for the handicapped computer user, there are no inexpensive systems that deliver the true power and ease of today's computers.

It is estimated 150,00 severely disabled persons able to control only the muscles of their eyes without any problem.

This encompasses the construction of the eye-tracking hardware and its fine-tuning in software.

II. Electro-Oculography

Through the six extra-ocular muscles by,

Absolute eye position

Speed of movement, or through the levator palpebrae (eyelid) and other peri orbital muscles as unilateral or bilateral blinking and blink duration. Most eye-tracking systems have chiefly addressed the need to measure eye position and/or movement, treating blinks merely as artifact to be discarded. This would be a serious mistake in a practical interface as will be discussed later; but fortunately, almost all systems can easily be extended to process blink data.

One eye-tracking method in which blink (and in fact all eye movement) data is particularly simple to collect and analyze, even with very modest equipment, is electro-Oculography.

Higher metabolic rate at retina maintains a voltage of +0.40 to +1.0 this corneoretinal potential is measured by surface electrodes placed on the skin around the eyes. The actual recorded potentials are smaller, in the range of 15 to 200 micro volts, and are usually amplified before processing. The potential across two electrodes placed posteriolaterally to the outer canthi is measured relative to a ground lead strapped around the wrist or clipped to the auricle, and the resulting voltage amplified and sent though a custom-built, 8-bit analog to digital converter filtered to remove high-frequency electrical noise. The converter fits into an IBM PC expansion slot, and transmits the digitized data through the PC serial port to a SUN workstation for display.

On the positive side, the
equipment is cheap, readily available, and can be used with glasses or contact lenses, unlike some reflection methods.

**III. Design considerations**

Eye muscles cannot be operated directly as that of muscles present in the foot and hand. Hands are only the extension of the eye i.e., they select the computer screen as selected by the look. So if we delete the intermediate steps & if we directly control by look it is helpful for both handicapped & non handicapped.

![Block Diagram of the Design considerations](image)

The Erica workstation, or eye-gaze response interface computer aid, is an example worthy of study. Erica is based on a standard personal computer specially adapted with imaging hardware and software. Through near-infrared reflectometry, the Erica workstation can be used to control a computer with eye movements.

**Monitor Geometry:**

Take a 19 inch monochrome display with typical pixel configuration 1024x768 at 72 dpi, for an active display area of 14.22x10.67 inches. When centrally viewed from a distance of 2 feet, this region subtends an angle of 25 degrees vertically, and 33 degrees horizontally.

Maximum EOG or reflectometry resolution is about 1-2 degrees; with menu boxes generously separated by 3 degrees, the 19 inch display still has sufficient room for a 10x4 matrix of directly selectable keys - leaving the entire bottom half of the screen available for a text display area and other controls. Better keyboard implementations should definitely be possible. Fukuda and Yamada is the other selection method. Distinguish between routine eye function and intentional selection actions are necessary. Perhaps the most significant item in this entire project, inexplicably absent from any other eye-controlled system, is the proposed use of a unilateral blink as that selection action. Blinking normally occurs every few seconds, either consciously or unconsciously - but always bilaterally. Blinks are easily detected by EOG as sharp, strong pulses in the vertical channel; since vertical eye movement is always conjugate, a pulse in only one vertical channel is unequivocally a unilateral wink.

**Actual Method:** With a 19 inch monitor as described above, a two level keyboard could be laid out in a 10x4 menu box matrix; the bottom half of the screen could
display about 25
Complete lines of text, and still
have additional file, paging, or
main menu controls off to the side.
The first level of the keyboard
would contain all the alphabetic
characters, common punctuation,
and cursor keys; selecting a
special "shift" key would display
the second level of the keyboard,
with the numbers and less
commonly used symbols or
editing functions.

IV. Electro-Oculography:
Principles and Practice
EOG is based on electrical
measurement of the potential
difference between the cornea and
the retina. This is about 1 my
under normal circumstances.

Figure 1: Placement of Transducer
Pickups to Measure Eye
Movements

Figure: Child with the EOG
Electrodes

The Corneo-retinal potential
creates an electrical field in the
front of the head. This field
changes in orientation as the
eyeballs rotate. The electrical
changes can be detected by
electrodes placed near the eyes.

Figure: The child drawn a
image using EOG
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Figure: The image drawn by the child using EOG

It is possible to obtain independent measurements from the two eyes. However, the two eyes move in conjunction in the vertical direction. Hence it is sufficient to measure the vertical motion of only one eye together with the horizontal motion of both eyes. This gives rise to the three channel recording system shown in Figure. Our eyes need to move in order to keep the image of whatever we are interested in at the central part (called the fovea) of the retina. Thus there are four types of eye movements, called vestibular, optokinetic, saccadic, and pursuit. The first two have to do with the largely involuntary head motion. The saccadic movement is used to "jump" from one object of interest to another.

The orientation of the eyes is measured by triangulation. The accuracy of the location determination depends on the accuracy with which the eye orientation is determined. Some of the noise patterns such as the 60 Hz line frequency can be easily removed, using a notch filter. Other noise artifacts are by the turning of an electrical switch on/off in the vicinity of the electrodes, contraction of the facial or neck muscles, slippage of the electrode due to sweat and eye blinking. Eye blinking is considered noise in ENG. However, the signals produced by eye blinks are, in fact, quite regular. This makes it easy to recognize and eliminate them.

V. System Design for Location Specification using EOG

The work related to the proposed system involves both hardware and software design and development. The system architecture is shown in Figure 2.

The hardware part of the system is fairly straightforward. We have completed the design of the amplifier and filter sections and assembled a crude circuit for testing and data collection. Our overall design philosophy has been to keep the actual add-on hardware (i.e., in addition to the computing hardware) as simple as possible. Thus we have chosen to do most of the filtering and noise
removal in software. The actual hardware fabricated amplifies the voltage picked up by the transducer, removes the electrical line frequency (60 Hz notch filter), and removes high frequency noise (120 Hz low pass stage). Subsequently, the analog signal is converted to digital form and the data samples are sorted in an IBM PC and finally transferred to a UNIX based workstation, where all the software processing will take place.

**Interaction of the System with User:**

The graphics displays in these two modes are

![Mode 1](image1) ![Mode 2](image2)

In the synchronizing mode, the system displays a moving cursor and the user is asked to follow the cursor. The cursor follows a fixed path and the user's eye movements are analyzed to verify that the pattern of movement and the cursor motion is the same.

The second interaction mode is the command mode, where the cursor is moved by the system to track the user's gaze. In our example interface, shown in Figure 3, we show four command "buttons." The cursor is at the center of display (the cross).

Imagine that this command system controls a machine, whose speed can be changed. So when the user looks at the start button the cursor follows his or her gaze. Then the command is activated by the user winking twice - i.e., the machine is started. The natural blink & valid blink must be distinguished another technique is for transmitting commands. This too should be fairly easy to distinguish from natural eye blinks. When the head is turned away from the screen, the system will be able to detect this because the fixated distance changes from the "norm" recorded during calibration. This will cause the system to disengage and freeze the cursor on the screen. To re-engage the user should perform a gesture such as fixating on the cursor and winking twice.

**Removal of Noise:**

1. Signal smoothing and filtering to eliminate noise.
2. Calculation of Quantitative Parameters from the signal channels (two for horizontal movements, one for each eye, and one for vertical movement of the eyes). These parameters are angular positions, Angular velocities and angular accelerations of the eyes.

**VI. Current Eye Track System**

Our objective in this project was
to build a 2D point-of-regard controlled spatial locator system and demonstrate its feasibility in a computer graphics environment. The system block diagram is shown in Figure 2 and discussed in Section 5. We acquire data using an IBM compatible PC and perform software development on a SUN workstation. This decision was based on convenience. Hardware prototyping is inexpensive and quick on the PC bus because of the wide availability of components and printed circuit boards available in the market specifically for this purpose. On the other hand, the window based user interface software (based on X windows) is at present better supported on the SUN and other UNIX based workstations. We chose X as our window environment because it is rapidly evolving into an industry standard. In the future, production systems based on our research can easily be wholly resident in the PC, since X products for the PC have already appeared in the market, and we expect such products to dominate window system development within the next few years. The initial work involved hardware equipment setup so that real time signal acquisition could take place. This involved assembling the electrodes, constructing the analog and A/D circuits on a PC form factor board, and interfacing and installing it on the PC bus. The PC was then linked to the SUN via a serial (19.2 Kb) line. Routine software has been developed to enable a program running on the SUN to access the eye movement data captured on the PC and transmitted on the serial line.

**Software Discussion:**
The above discussed software is a 3 x 2 boxed menu driven eye selected interface. This menu has two levels, thus enabling a choice of any letter in the alphabet, as well as some additional punctuation characters. When the program is run, there are several parameters which need to be defined to give the software the ability to make a correct choice (number of calibration repetitions, number of data samples necessary for absolute choice determination, different thresholds, etc.). The above parameters can be set manually, or "automatically", by an auto-calibration mode. Once the parameters are set, a second calibration mechanism is invoked. The user follows a box which horizontally moves back and forth on the screen, until calibrated. This mechanism is invoked at this experimental stage every time before the software is ready to attempt a menu selection determination.

**VII. Possible Near Future Improvements**
The first and most important change needed by the above described system is a new board. The experimental board contributes to wrong box selection due to erroneous signals resulting from wire wrapping. A new board which is being designed now will
have better isolation and more importantly four channels (two per eye) instead of two. This will enable the software performance improvement, as well as some additional features which will be added (e.g. processing of a one eyed wink). This improved board will eventually drive to finer resolution on the screen. The software is being revised to enable better results as well. This will take form in the way of defining optimal parameter choices for the various thresholds and sampling rates, as well as some other minor software improvements. Also needed is a better input device. Attaching electrodes to the skin one by one is cumbersome and annoying for the user. What we need is some device which can be put on by the user himself with ease.

VIII. Conclusion
There are many ways to measure eye movement, some far more accurate than EOG, but these are expensive. Furthermore, the eye tracking method is just a means, one in which pinpoint accuracy is not really necessary; the provided service and ease of use of the eye-controlled interface is the true goal. We aim to improve the existing eye-tracking system; will attempt to resolve the current faults and weaknesses, and implement the eye-tracking device in the most user friendly and efficient interface we can devise.

Bibliography
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