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Access Computer Using Electrooculography Signals of Human with Different Directions

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ABSTRACT: Electrooculography (EOG) signals are used to control human-computer interface system. It has the ability to extract the signals so that the users can overcome physical limitations. It provides information about the human eye activity by detecting the changes in eye position. At present there is no effective multi-directional classification method to monitor eye movements. A wireless EOG-based HCI device to detect eye movements in four directions. This includes wet electrodes, an EOG signal classification algorithm which extracts the electrical signals which corresponds to four directions of eye movement (up, down, left and right) and blinking. It is also used to study eye-function in real-life conditions later. Eye movements can be used as signals to transfer information from users to HCI systems. A user can select a response by staring on it for certain amount of time without the need for keyboard entry or manual mouse. This reduces the time to generate a command.

KEYWORDS: multi-directional classification method, human-computer interface, Electrooculography.

I. INTRODUCTION

Recently, many researches are underway to enable disabled and elderly persons to communicate with a machine or computer effectively. Because, communication with the outside world is mandatory for disabled persons too. Depending on the capabilities of the users, different types of interfaces have been developed like speech recognition, vision-based multiple gesture movement, tooth-click controller, Brain-computer interface (BRI), Infrared and ultrasonic non-contact head controllers. There are many limitations of interfaces in speech recognition and vision-based head gesture while operating in outdoor and noisy environment. Patients affected by motor paralysis and impaired speech can't give input in the above mentioned methods. However their eye movement is the only resource of communication which remains intact. Eye movements can be used as signals to transfer information from users to HCI systems. In a feedback system, a user can select a response by staring on it certain amount of time without the need of manual mouse or entry through keyboard. This reduces the time to generate a command.

There are many HCI systems which utilizes the eye movements already like Infrared oculography(IROG),dual-purkinjee image(DPI), Scleral search coils(SCs).These are useful for patients but they are limited by their bulky designs which makes it heavy to transport and restricts the mobility of patients. Electrooculography (EOG) is a technique to measure the corneo-retinal standing potential which exists between the front and back of the human eye potential is due to the presence of electrically active nerves in the retina. The eye acts as a dipole.EOG is used to detect changes in eye position. It is used because they are easier to detect. The potential difference ranges from 15-200 microvolt's and their relationship is linear. An EOG based system can be used for controlling television, wheelchair and keyboard. Fuzzy distinction rule is used in many applications including gaming control and eye tests.

But it is based on pattern recognition so it has several limitations like implementation complexity and increased computation time. But it has difficulty in deciding the bases for Fuzzy rules. It also has wire limitations.

A wireless EOG-based HCI device is used to detect eye movements in four directions. It consists of wet electrodes, a wireless acquisition device and an algorithm to categorize the EOG signals. Wet electrodes are used for providing sufficient electrical conductivity for receiving EOG signals. The advantages of this method are high accuracy, simple design and short computation time. The proposed system is used for controlling a wheel, direct a robotic arm to carry heavy weight and to surf internet without the need of mouse or keyboard entry.

II. RELATED WORK

The amplitude of EOG signals produced by each is unique, even if every blinking of a person is different. To avoid this problem of signal variability, a threshold method is employed to transfer the EOG pulses into square pulse for further administrating. Small fluctuations on EOG waveform may cause some troubles in EOG pulse normalisation which can be encountered by using dynamic threshold instead of fixed threshold. The action is counted as blinking if DIF is smaller than 1500.The blinking action and the number of pulses are cleared [1].

If the graphical interface is vision-controlled, the cursor is directed by eye movements and validation is performed by ocular action such as blinking. “Midas touch” is a drawback of this interface since human eye is always active. Therefore, validation shouldn’t be performed involuntarily. To avoid such problem, eye movement codification is used. The goal of this technique is to develop control strategies based upon certain eye movements and they are interpreted as commands. Direct access technique is used because it is most natural, fastest and comfortable. It allows the system to add large number of commands without the need to memorize complex ocular action. The selected command is validated by two consecutive blinks with a predetermined time limit. It achieves success rate of 92%.But errors are produced with increase in time due to lack of concentration of the user and increased tiredness [2].

The EOG signals are used widely in bio-medical engineering too. Many efficient HCI was developed including computer animation application, home automation, and hospital alarms system. In Pattern recognition, qualities are abstracted and discriminated by a suitable categorizer. Neural networks and support vector machines are used. But, computation time and implementation complexity is a major limitation especially while implementing microcontroller devices. So non-pattern recognition is used to increase the performance due to its simplified structure and its reduced computation time [3].

III. PROPOSED WORK

The components of the proposed device include wet electrodes, a wireless acquisition device and location for placement of electrodes. The EOG signals are measured by wet electrodes which are connected to the EOG acquisition device by wires.

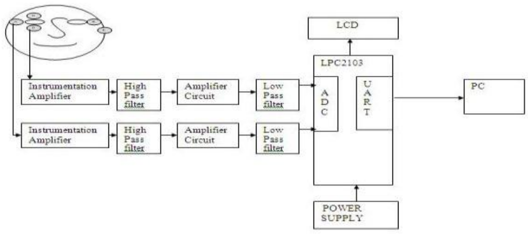

Fig. 1 Project implementation

An instrumentation amplifier is used to improve stability, accuracy of the circuit .The EOG signals are in the frequency range of 0-40 Hz. The cut-off frequency of HPF is set so that it can allow the frequency ranges which are higher than 0 Hz. Also the cut-off frequency of LPF is set such that it would allow the frequency lesser than or equal to 40 Hz. These signals pass through amplifier, filter and ADC in LPC2103.The digital output is communicated to the PC through UART (Universal Asynchronous receiver/Transmitter) terminal.

A. EOG Acquisition Device:

The amplitudes of EOG signals range from 15-200 microvolt. The EOG signals are measured through electrodes placed around the eyes which also get high noise levels. But this is unessential to the experiment as in electromyography (EMG).The EOG acquisition device was designed to measure four channels of EOG signals using wet electrodes which consist of three major units like 1) a wireless unit 2) preamplifier and filter unit 3) a microcontroller unit.

A Bluetooth module is used for transmitting EOG signals wirelessly. The preamplifier amplifies the voltage difference between the reference signals and EOG electrodes while rejecting the common mode noise simultaneously.

$$gain = A0 + \frac{Rinner}{Rg+C} \dashrightarrow \text{(a)}$$

Equation (a) describes the transfer function of the preamplifier circuit. Rinner=80KΩ, Rg=160KΩ.The frequency of EOG signals ranges from 0-40Hz. Instrumentation amplifier is used for extremely high impedance and high common mode rejection ratio. The gain of preamplifier was set to 5.5v.The microcontroller was used to digitize the EOG with the sampling rate of 256 Hz.

B. Human –Computer Interface:

Before using the proposed system, physiological parameters must be recorded since they are used for adjusting the threshold value in the categorization algorithm. The administrated EOG signals are transformed into eye movement; the results are displayed on the screen.

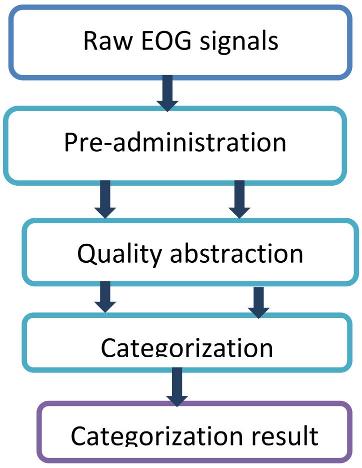

Fig. 2 Flowchart of the proposed EOG signal categorization algorithm.

C. EOG Signal Categorization Algorithm:

The EOG signal analysing method was built by three parts. They are pre-administration, Quality abstraction and categorization. The EOG signals are administrated and they are separated into vertical and horizontal signals. These qualities are abstracted and the signals are transformed into a series of qualities called quality chain. Finally the results are displayed on the screen.

1) Normalization Factor Calibration:

The wireless EOG acquisition device was used to measure the eye movement activity of each user. All of the EOG qualities differed between each user. Factor calibration measures the bio-potential values for those four qualities, the threshold setting can be optimized in the program automatically. The calibration function was made to resolve the inter subject variation problem.

2) EOG Signal Pre-Administration:

The EOG signals include both horizontal and vertical signals which are recorded by the EOG acquisition device. In addition to eye movements, EMG signals are also collected from face and it is used for compensating common mode noise. The disturbance caused by EMG signals is expressed as d (t), where t represents time in seconds. It is assumed that noise is independent of the electrodes and actual EOG signals are expressed as a combination of vertical signal v(t) and horizontal EOG signal h(t).The signals are recorded by the proposed acquisition device which is expressed as X1(t) and X2(t).

These parameters can be related using following equations,

$X1(t)= v(t)+d(t)$----->(1).

$X2(t)= h(t)+d(t)$---->(2).

Common mode noise was removed by subtracting (2) from (1),

$X1(t)-X2(t)=v(t)+d(t)-h(t)-d(t)$.

$X1(t)-X2(t)=v(t) – h(t)$----->(3).

Eqn(3) describes the EOG signals obtained after removing EMG noise. The redundant signals are removed by moving average.

3) Quality abstraction:

After pre-administration, the eye movement qualities are abstracted from the EOG signals. The pre-administrated EOG signals are down sampled from 256 to 51.2 Hz for reducing the complexity in computation. The signals are encoded individually with values ranges from -2 to +2.Th1 and Th2 are used to digitize the potential voltage. When the potential measured is greater than Th2, it would be set to a digital value of 2.The EOG quality sequence was sent to categorizer.

4) EOG Signal Categorizers:

EOG signal qualities contain both vertical and horizontal quality chains. They are administrated separately by checking different detection unit. The program searches to conform target eye movement pattern in the database (up, down, left and right).If there is no match in the database, the output would be null signal.

D. Implementation:

It is used to control the devices through the microcontroller using Eletrooculogram (EOG) data from eye movements of a person.

1) Description:

Five electrodes will be placed on the face of the user. For the horizontal detection two electrodes is placed one to the left of the left eye and right of the right eye. For vertical direction, two electrodes are placed above the eyebrow and below the eyes.

Fig. 3 Placement of electrodes

Reference electrode is placed on the forehead. These electrodes are used to detect the physiological properties about movement of the eyes. The electrode will transmit the data to the amplifier. The data from the amplifier is analog. So it is given to the ADC of the microcontroller. Then the data is converted into digital. Depending upon the data from the controller, cursor movement of Pc is controlled.

IV. SIMULATION RESULT

ARM 7 microcontrollers are used. Button 1 is used to detect the change in right and left movement. Likewise button 2 is used to detect the changes in up and down movement. A photo resistor is varied. When it is in initial position there is small voltage across LDR. When the photo resistor is varied, large amount of light falls on the LDR (Light dependant resistor) and it decreases the resistance value, so current is passed through the channel. Based on the range the direction is displayed in the virtual terminal via UART.

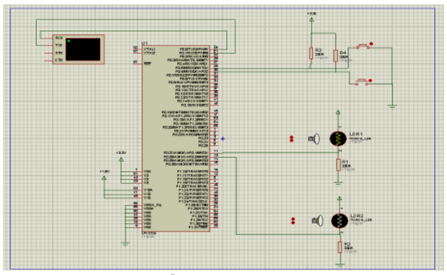

Fig. 4 Simulation output setup

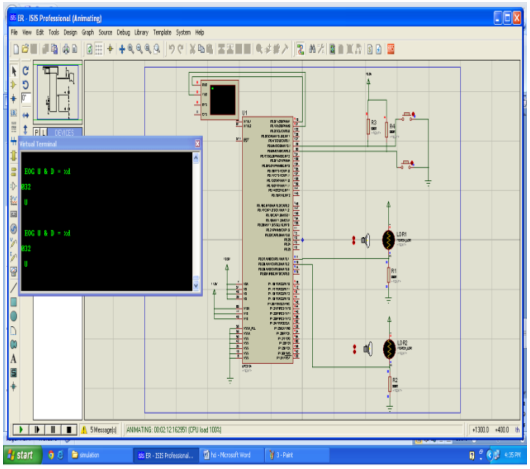

Fig. 5 The output of virtual terminal reads up.

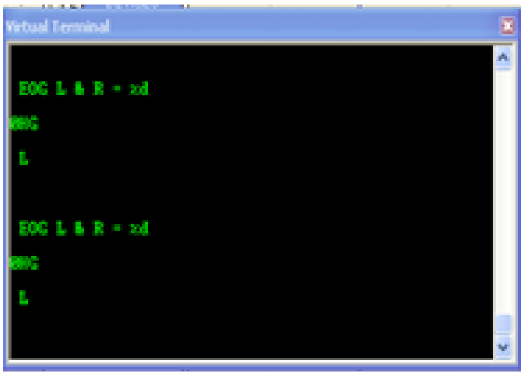

Fig. 6 Virtual terminal detecting left movement.

Button 1 is closed which detects the changes in horizontal direction. The output value falls within the range of left.

Fig. 7 Virtual terminal detecting right position.

Button 1 is closed. The output falls within the range for right.

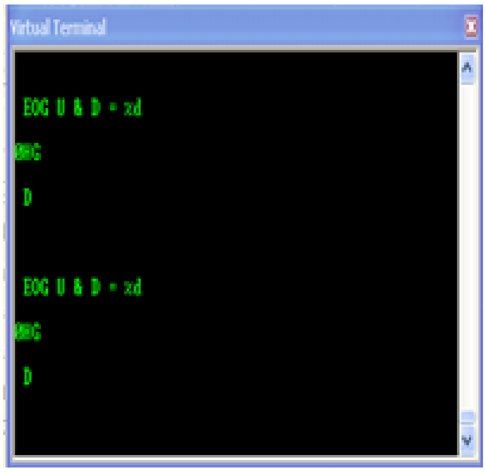

Fig. 8 Virtual terminal detecting down movement

Button 2 is closed which detects the changes in vertical direction.

The output falls within the range of down.

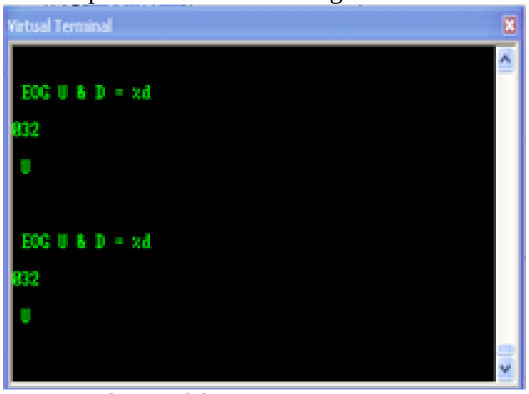

Fig. 9 Virtual terminal detecting up movement.

*Butt*on 2 is closed. The output falls within the range for up.

V. ANALYSIS AND COMPARISON

E. Procedure:

Two sets of measurements were taken. One for training and the other for four direction eye movement experiment. Once the experiment starts, there is nothing on the screen. After 1s, a red dot appears on the centre of the screen**.** The user has to look at this dot. After 2s, another red dot appears on the screen and the user has to stare on it. The position of the new dot is determined by the eye movement task which is being tested (up, down, left and right).The order of each event can be randomized. Both the dot disappears after another 2s and a new trial begins.

1) Performance of Eye Movement Qualities and Categorization of Movement:

The EOG acquisition device is used to measure EOG signals from five electrodes. Let us consider four different types EOG signals. The action if looking up and down corresponds to vertical movement. Therefore, vertical signals are more pronounced than the horizontal signals.

Looking up generates positive peak and negative peak. The negative peak is generated while returning to the centre of the screen. The action of looking down generates a negative peak which is accompanied by positive peak. High pass and low pass filters are used to reduce the electromagnetic interference and EMG signals.

2) Error of Movements in Diagonal Directions:

The accuracy of diagonal eye movement detection is generally lower than the normal (up, down, left, right). When a user is directed to look at down-left direction, the user may move down and the left or vice versa. These errors are caused due to personal habits.

3) Eye Movements in Vertical Direction:

The EOG signals measure also includes EMG signals. For vertical EOG signals, the blink EMG signals are generated by vertical eye movements are identical. It is important to reduce the inconvenienced due to blinking and it has to be nullified.

VI.CONCLUSION AND FUTURE WORK

A wireless EOG-based HCI device is used to detect eye movement in four directions. Even the information can be sent to the computer wirelessly and the results are displayed to the users.

Compared with other eye movement detection methods like IROG, video based eye trackers and SC, the proposed device can measure EOG signals easily. Wet electrodes remain secure in the place of the skin. In future, eye movements can be used to check mail too.

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