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Human Computer Interaction Using Bio-Signals

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Abstract: Increase in the role of computerized machines in our day-to-day life, Human Computer Interaction (HCI) has become an important part of the human life. HCI controls the effective utilization of the available information flow by the interfaces between the humans and computers. It recognizes the users' body movements and translates them into the machine commands. There is an increasing need for the assistive technology today, to help disabled people to attain some level of autonomy in terms of movement and communication. There are various biomedical signals (bio-signals) that can be used for the neural linkage with the computers, which can be obtained by a specialized tissue, organ, or cellular systems like nervous system. Such as Electroencephalogram (EEG), Electro-oculogram (EOG) and Electromyogram (EMG). Such approaches are extremely valued for specially-abled persons. Many attempts have been made to recognize and use signals from the gestures made, for developing HCI. Signal controller and processing is proceeding in many directions along with the signal development and classification for graphical controller, this enables the especially abled to use word processing program and other personal software and internet. This paper discusses the different types of Bio-medical signals, methodologies and classification for the purpose of interpreting the signals into machine command.

Keywords: HCI, Bio - Medical Signals, Electroencephalogram (EEG), Electro – Oculogram (EOG) and Electromyogram (EMG).

I. INTRODUCTION

Bio Medical signal is a collection of electrical signals which are obtained from any organ that represents a physical variable of interest. These signals are normally a function of time and are described in terms of amplitude, frequency and phase. There are number of individual who are having motor disabilities. It has been estimated that nearly up to 4 lakhs of individuals may be leaving with the limitations imposed by the Spinal dysfunction. The quality of life of these individuals can be improvised by providing them with a practical, reliable means to use standard Personal Computers (PC's).The quality of their life can also be improvised along with those identified by the Assistive technology Act of 1998, and as presented in some of the case studies can come at least in two ways-

- Increased integration to society and communication by communicating and working through the computers, using standard software.
- Increased unassisted control over the environment by a dedicated software or output devices to turn appliances ON/OFF etc.

With the today's Graphical User Interface (GUI) based computer software, most of the human computer interaction is based on the selection operations, even though the limited entry of data, it can be achieved by selection through different approaches, and such as "On-screen keyboard". Selecting requires two basic types of capabilities**:**

- Pointing: Positioning of the cursor at desired location on the screen, over the appropriate area or icon.
- Clicking: Selection of items by moving the mouse up/down function, associated with the icon at the location of the screen cursor.

The Robotic researchers have been trying to combine the robotic techniques into the rehabilitation systems to improve the quality of life of specially abled and elderly persons, To implement HCI acquired and processed signals need to be classified as which is the difficult part of the system. The studies have found that most of the classifications in HCI is based on neural networks. This is because, it has been used very widely in the past and as well as it has numerous advantages in the processing and classification of biomedical signals. In this paper, several types of bio-signal based systems and their applications along with some merits and demerits have been discussed.

II. LITERATURE SURVEY

In this paper we come to know how, Personal computers offer people with disabilities new possibilities for personal autonomy and social integration [1]. Human Computer Interface as an assistive technology helps the people with motor

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disabilities and who can't move their arms. The techniques of Eye tracking can be used for the communication of such people through the movements of eye to control the cursor [2].

Most of the paralysed or physically disabled persons are unable to communicate with others, easily. To minimize this problem, different types of Human-Computer Interface (HCI) systems have been developed, this paper talks about different type of HCI [3]. HCI can be used for the peoples who are paralysed and cannot move their arms to use applications. A new mouse is proposed whose operation is based on the detection of eye blinks and measurements of rotations of the user's head as an input device [4]. This paper presents, the proposed scheme utilizes three EMG signals as inputs for the muscle-computer interface. An EMG based scheme including continuous control simple classifier for an electric-powered wheelchair [5]. We will come to know about some early applications and research on brain-computer interfacing from this paper. The interest in BCI research and medical applications has guided researches and has led to necessary and useful research results [6].

To improve the quality of life of disabled people researchers think on the necessity of simple and natural human-machine control interface. This paper presents an embedded solution for real-time EMG based hand gesture recognition [7]. This paper presents, how EEG dataset with (uncontrolled) natural saccades was used, where subjects looked freely at images on a screen. EEG data was used as an input to neural networks, namely a multi-layer perceptron and a convolutional neural network [8]. BCIs have attracted massive attention, triggered by new scientific progress in understanding brain function and by impressive applications. The systems and methods used in processing of applications, signals, improvements, and current challenges. Finally, BCI possible future trends are discussed in this paper [9].

III. PROPOSED SYSTEM

A. EEG Signal and its approach

Human body exhibits different physical changes and responds physiologically to physical and psychological stimuli. These changes comprise of skin conductance, facial expressions, heartbeat, body temperature, brain signals, pulse rate and many more. The advancement and researches in biomedical technology has given us access and ability to identify even smaller change in physiological parameters.

EEG is a technique which is non-invasive measurement with temporal resolution in milliseconds. From a region of the brain, the synchronized neuronal activity is recorded by an electrode as an oscillating signal which reflects the potential of the group of neurons situated in close proximity to the electrode stimulus-based brain computer-interaction application. This has been resulted in the ability to detect different psychological and physiological phenomenon. The coupling intended functionalities with stimuli signals on the computer screen is used to achieve the user communication with computer screen. The constant focus stimulates the brain for intended commands, as a result in return, the brain releases a response signals.

The brain’s stimulus signals and response signals are identical. Once the signal is successfully identified, the presence of signal patterns which is identical to the one of the alternative stimulus signals it is paired with a command in a user interface and indicates the user’s intention. The signal pattern is unique for every option, users can be simultaneously offered with multiple options. The response signals are weak and are buried inside the EEG signal, which are polluted and includes brain’s natural activities, this is the main challenge of working with stimulus signals.

It is important to identify the types of emotions, these emotions are mapped through physiological measures. There are eight types of basic states of emotions such as fear, anger, disgust, sadness, anticipation, surprise, joy and acceptance. The video stimuli are very effective in electing emotions compared to other types of stimuli such as audio stimuli and picture stimuli. The environment needs to be maintained while collection the data, there should be no external and unwanted stimuli such as light or sound.

Though the proper care is taken during the collection of the raw data, EEG signals are found to be contaminated and polluted by the external noise. Pre-processing is done in order to remove all the external and unwanted elements from the signal. To get an effective data set ten seconds of post and prior data is removed. Electrical noises are removed from the raw signal using Butterworth notch filter which is of 01 to 40 Hz.

HCI using the Electroencephalogram signals is one of the most important technological applications for the people who are paralyzed and suffering from severe neuromuscular disorders, as it potentially provides those peoples with control, communication, or rehabilitation tools this help them to compensate or restore their lost abilities and overcome their disabilities.

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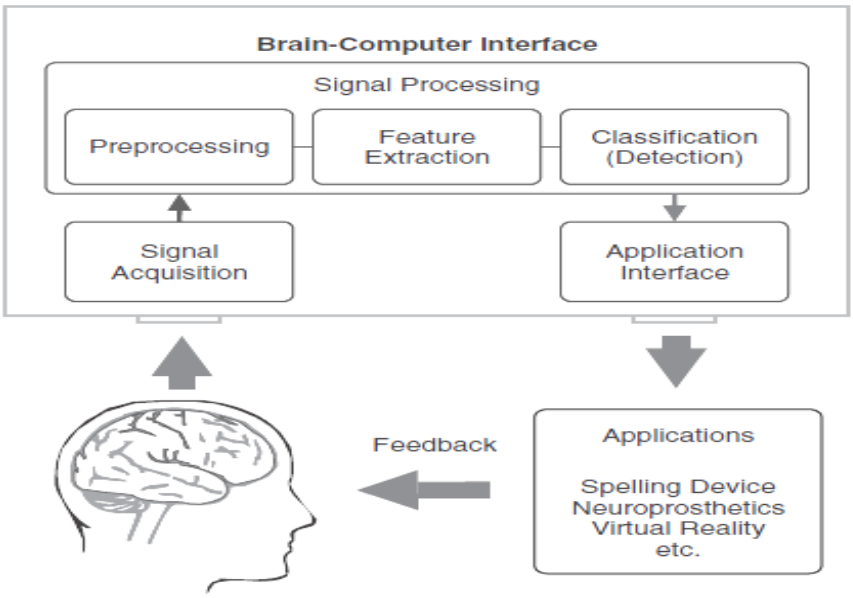

Fig 1. Structural components of Signal processing

B. EOG Signal and its approach

A human eye conveys great information with respect to the movement of the eye. It is a behavior which can be measured and it provides sensitive means of learning about cognitive and visual stimuli. The technique which measures the cornea retinal potential associated with movement of eye is known as Electrooculography. Some of the bio-signals are also been used for the creation of a new communication interface between humans and computers. When compared to other conventional, bio-signals offers many new possibilities mostly like audio visually based HCI. The most frequent of all human movement is eye movements. Eye is one of the main subsystems of our body, since one of the primary senses. The visual information of interest is directly related to the position of the eye. Using the position of the eye it is possible to provide a very intuitive assistive device. We can measure the position optically, mechanically, and electrically.

The EOG is the electrical method of measurement, it is the least invasive method of determining the eye position. EOG signals are considered as one of the easiest way to estimate eye movements. The device used here is the low-cost device which is often utilized for Human- Computer Interaction applications, such as to facilitate moving a mouse, typing on a virtual keyboard, or controlling a wheelchair. The advantage of using EOG signals as an input source of human computer interaction (HCI) is that the movements of can be estimated using low cost devices and it is known that for the complete EOG recording system can be assembled for less cost and the movements of eye can be estimated through Sensors with a precision of up to 1.5° .

An EOG is a signal which changes based on the eye movements, the changes are caused due to the standing potential between the cornea and retina of the eye. This standing potential increases when the cornea approaches towards an electrode, and it decreases when cornea moves in opposite direction or away from the electrode. The frequency of EOG signals between the frontage and backside of the eye ranges in between 0 to 100 Hz.

Eye work as an electrical dipole during this time between the backside and the frontage. There will be changes in direction of the positive and the negative pulse to the dipole based on the eye movements which are measured. The gaze angles is caught during the linear behavior which is between + or - 300 for vertical eye movement and + or - 500 for horizontal eye movement and during each level of eye activity 20 μV changes are seen.

These EOG signals obtained from the movement of the eye is converted into digital signals. The contaminated signals present in the acquired digital signals are further processed and removed. The prominent features are extracted out from the set of band, signals are applied to processing and feature extraction technique. The features are applied individually to neural networks to classify the signals into different eye movement pattern signals. These pattern signals are used to control hardware as control signals applied from graphical user interfaces. There is a lot of well-organized Human Computer Interactions using Electro-oculogram signals has been created for the help of disabled persons. HCI with the help of an EOG has been broadly and efficiently applicable in the development of biomedical signals and devices to fulfill the basic needs.

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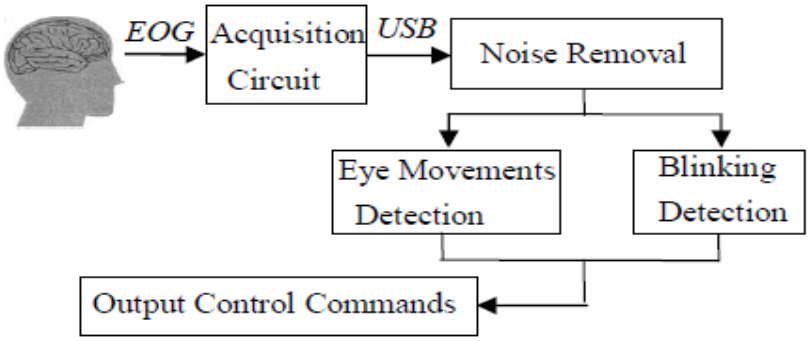

Fig.3 Basic Block Component Diagram of HCI System

Fig 2. Basic Block Component Diagram of HCI

C. EMG Signal and its approach

EMG signals are said to be the source of a new way of HCI, which is EMG signals can be considered as alternative mechanism of input. In fact, developing an input device using EMGs is considered as a natural means of HCI, as the electrical activity generated by the movements of human's arm muscle can be transformed and interpreted as computer's control commands. EMGs can be easily acquired on the human skin surface by conveniently attachable electrodes.

EMG measures the electrical currents that are generated in muscles during the muscle contraction and this represent the neuromuscular activities. In many fields EMG signals can be used, it can be used for variety of applications including HCI, interactive computer gaming and clinical applications. Furthermore, it can also be used for sensing isometric muscular activity which does not translate into movements. This helps EMG signals to classify subtle motionless gestures and control interfaces without being noticed and without disturbing the surrounding environment. On the other hand, due to its noisy characteristics it difficult to analyze the EMG signals. Compared to other bio-signals, EMG signals have complicated types of noise that are caused due to the inherent equipment noise, motion artifacts, interaction of different tissues, and electromagnetic radiation. Thus, the pre-processing is required to filter out the unwanted noises in EMG.

A hand gesture requires relative flexure of fingers of the user and contains the information that is often too abstract to be interpreted by the machine. To improve the quality of life of the deaf or non-vocal persons through hand-gesture to speech system is one of the most important applications of hand gesture recognitions and another major application of the hand gesture recognitions is in rehabilitation engineering and in prosthesis. Some of the commonly used techniques in hand recognition include vision-based system, mechanical sensors, and the use of EMG has an advantage that it is non-invasive and it is easy to record.

Myoelectric activity observed from any muscle site comprises the activity form the nearby muscle as well, referred to as cross-talk, because all these muscles present in the forearm are close to each other. The cross-talk problem is more consequential when muscle activation is comparatively weak (subtle) because comparable signal strength is very low. Due to the low signal to noise ratio extraction of the useful information becomes difficult. EMG activity is hardly discernible from the background activity, at lower level of contraction. There is need to identify components originating from the different muscles, to identify the small movements and gesture of the hand.

The classification and performance of hand and finger movements are dependent significantly on the feature extraction, that is very important and essential to improve the accuracy of classification. They describe the identification procedure that is based on EMG patterns of forearm activity using various different kinds of Neural Networks models

An EMG controlled pointing device using a neural network has developed a prototype system. The prototype system uses the information on the EMG signals for controlling the pointer. The operator's intend the direction of the pointer movement and the velocity are estimated from the EMG signals, and natural interaction can be carried out using this basic information. In the proposed method, several numbers of base directions have been set on the computer display, and the operator's intended direction could also be estimated from the probability that the pointer will move to each base direction. The neural network is used to estimate the probability of the pointer movement to each base direction.

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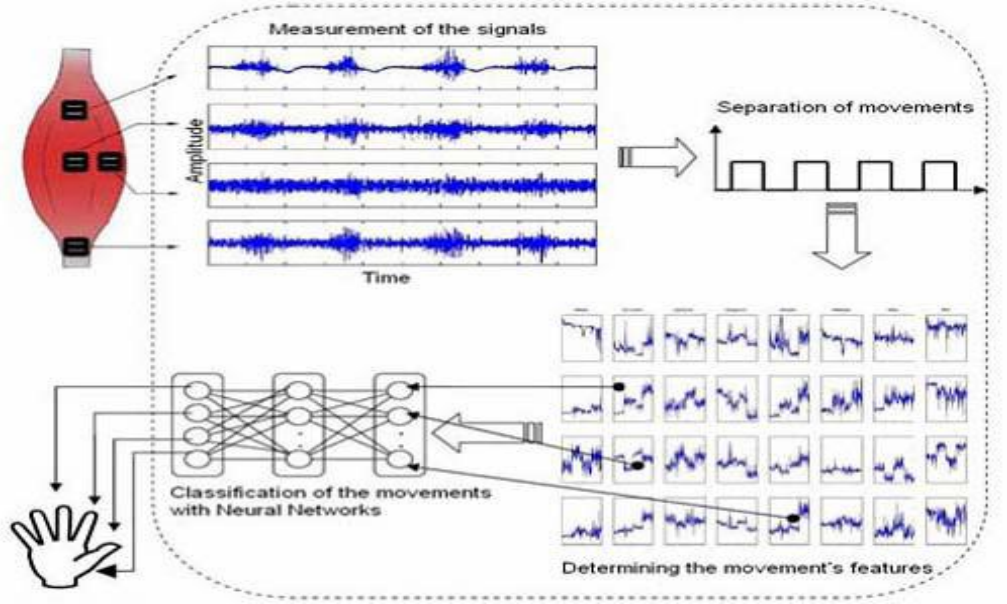

Fig 3. Hand gestures signal processing

Instead of mechanical devices such as keyboards and joysticks, hand gestures are used as interface with a computer. EMG signals which are non-invasive are used to sense from the muscles and to perform these gestures, signals are then interpreted and translated into useful computer commands. The ability of humans to naturally interface with a computer allows manipulating any electrically controlled mechanical system.

EMG signals convey and represent more information than just their average amplitude. In particular, it has been identified and observed that EMG signals that are caused by the contraction of a muscle have a different frequency composition from EMG signals which is caused due to the contraction of another muscle. For the HCI system, it is very much critical to differentiate between the EMG associated with frontals contraction and that resulting from the contraction of a temporalis muscle.

IV. CONCLUSION

Use of standard interface to operate compute technically is very much inappropriate for the persons who are suffering from the severe physical disability. This is because it majorly requires reliable use of hand movements. Developing of HCI by using different bio-signals will ultimately help to improve the Quality Of Life of the disabled persons. This review paper focused on the different bio-medical signals and approaches in the field of HCI. Biological-signal-based systems approaches are distributed widely, along with the distribution of wearable devices, whose range of applications is also wide. Beside this there are several artificial intelligent using of which may yield remarkable humanizing of HCI.

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