Computer Assist for Paralyzed using EEG

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***Abstract*— Computers have made life easier for the general population, however a technology is not fulfilling its purpose unless it is accessible by everyone. Namely the paralytics (hemiplegia, quadriplegia) who have a hard time with technology because it is designed for an average person. This is why we decided to make a hardware interface for desktop computers which would allow these patients to use a computer with ease. Various combination of non-invasive Brain-Computer Interface (BCI) have been promising in helping such patients by giving interactive solutions. A combination of 3 electrode EEG and an Arduino Leonardo, on basis of P300 waves which play crucial role in decision making process in brain will be used to make this hardware interface. This hardware interface aims to mimic a mouse and keyboard in operation and also its speed of use as much as possible for the concerned patient.**

***Index Terms*—EEG, P300, Brain Computer Interface, Paralysis.**

I. Introduction

A large number of people suffer with diseases related to impairment and nervous system related breakdown causing paralysis. Hemiplegia and Quadriplegia are two such types of paralysis. Hemiplegia is a medical condition where in the patient loses voluntary control over one half of the body due to improper functioning of peripheral neural system[12]. On the other hand quadriplegia is a more serious form of paralysis where the patient is not able to voluntarily move any of the limbs. This disables such patients from usage of computer due to limited or no mobility. The system we propose is intended to solve this problem with use of non-invasive BCI techniques. BCI has the ability to eliminate the limitations caused due to nervous system breakdowns(that does not affect working of brain)[15].

The decision making process is based on the impulses generated in the brain. Electroencephalography(EEG) is a technique where in these impulses are traced to map Attention, concentration and Eye blinks of any given user[11]. These mapped waves can then be used as parameters for decision making by a computer device.

We here propose to use these parameters from EEG for decision making processes related to computer operations such as mouse clicks and an external accelerometer shall be used to map mouse movements onto the computer depending on neck movement of the patient[13]. These two parameter when combined with a application where easy typing interfaces and smart application access is provided shall make the usage of computer easier for patients suffering from above two types of paralysis[5].

II. Proposed Architecture

The proposed system will implement only mouse functions in hardware because mouse as a pointing device unlike a physical keyboard is versatile and simple. So not only will it be easier to use but also simpler to implement. The keyboard function will be accomplished using on-screen application based keyboard and a quick access bar for opening applications from anywhere. The system is divided into three major modules:

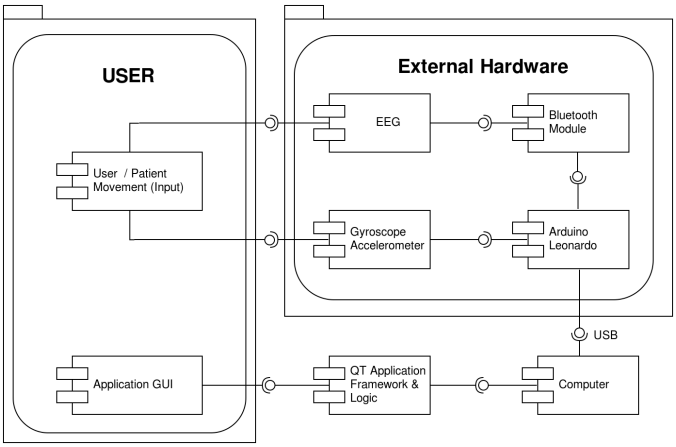

Fig. 1. Proposed System Architecture

A. Module 1: Mouse pointer movement

The mouse pointer movement is done using combination of Arduino Leonardo and Accelerometer. Supposing the unit is attached to the patients head, the movement of the head will make the acceleration in X and Y axis change. If the change is detected the mouse pointer on the computer screen is moved according to the head movement in sync. Thus using the accelerometer 2D values in X and Y axis we move the mouse pointer on the screen[1].

B. Module 2: Mouse click function using EEG

The mouse click function is done using EEG headset, Bluetooth HC-05 module and Arduino Leonardo. Whenever there is a voluntary hard blink from the user or patient there is a change in the blink strength which is calculated from the raw value from the brain waves[4][14]. If the change detected is above minimum threshold it triggers the mouse click function on the Arduino Leonardo which does a mouse left click on

the computer screen wherever the mouse pointer is currently focused on.

C. Module 3: Keyboard Application

The keyboard application is developed using Qt and consists of text area and a 9 key based keyboard layout for numbers and letters. This helps the user in typing better as the keyboard is very compact than the traditional keyboard and does not require the user to move the mouse pointer to reach every letter. Also contained in the application are common function key combinations used by the average user such as cut, copy, paste, enter, delete, clear text area. The application will also have a list of shortcuts of applications installed on the computer and helps the user in quickly opening the application he/she wishes to[3].

III. System Requirements

A. Hardware Requirements

- EEG Headset
- Bluetooth Module
- Accelerometer Module
- Arduino Leonardo

B. Software Requirements

- Qt
- Arduino IDE

IV. System Design

The overall system design is as follows.

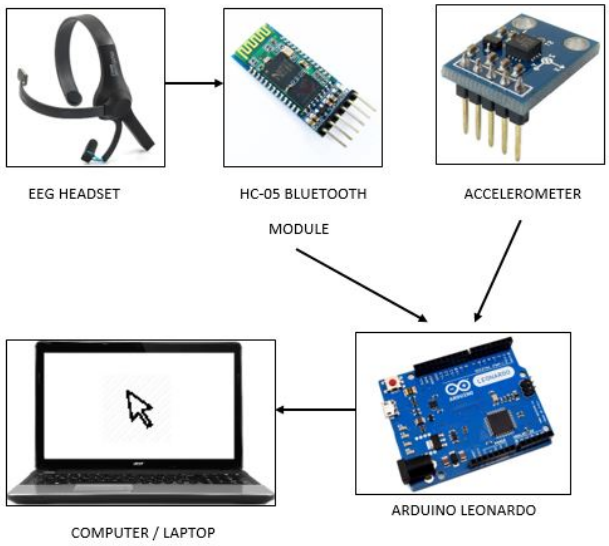

Fig. 2. Proposed System Design

The overall system design is as follows. The EEG headset is connected to the Bluetooth module and sends data to it which is then transferred to the Arduino Leonardo to which it is connected to. The Accelerometer is connected directly to the Arduino and takes the sensor values on the analog pins of the Arduino.

The accelerometer is responsible for the mouse pointer movements while the EEG headset is responsible for the mouse clicks. The Arduino Leonardo is directly connected to the computer or laptop using micro-a USB cable. The Arduino Leonardo is used for the mouse emulation and it works on the inputs by accelerometer and the EEG headset. Thus it can directly send commands to the computer for the mouse cursor and click functions.

V. Methodology

The project development has 2 key parts for development, namely mouse emulation and keyboard application control based on the QT application.

A. Mouse Emulation

The emulation is process to map the sensor readings of accelerometer to mouse movement on the computer. Accelerometer is planned to be setup on top of the head and hence any movement on 3D plane shall be mapped as mouse pointer movement. Hence it is essential that the patient shall be able to have relatively free neck movement ability. A special Arduino-Arduino Leonardo shall be deployed for this emulation process. The Arduino leonardo has keyboard and mouse primitives which makes it more easier for emulation process.Arduino shall be connected to the Laptop using a USB connector. The calibrations can then made according to patient's requirements.

The possible bottlenecks to this approach could be the problems related to calibration of the system for every individual. Also the fact that blinks and deliberate blinks need to be distinctly evaluated in order to make correct decisions regarding mouse clicks[6]. Also the accuracy of accelerometer for movement of mouse pointer is posing some challenges. Firstly the accelerometer based mouse lacks the precision of a conventional mouse. In that the cursor tends to easily overshoot the target because the head has to be brought to a perfect vertical alignment for cursor to be stopped. This can be mitigated by increasing the tolerance for the vertical alignment, now the head wont have to be perfectly vertical however this would increase the threshold for triggering cursor movement. This means that a balance has to be reached between the tolerance and triggering tilt angle. Alternatively a nonlinear mapping of sensor to mouse cursor speed could get us to that balance point.

B. Keyboard Application

Keyboard application is a key aspect of the application to be developed. The keyboard we will use shall be a custom made layout, being very similar to T9 keyboard[2]. The typing shall be done with use of eye blinks. These eye blinks shall be detected using EEG headset[17]. The headset gives a numerical value which when goes beyond a threshold value depicts deliberate eye blinks. These eyeblinks values are transmitted to arduino leonardo using bluetooth for which HC-05 bluetooth

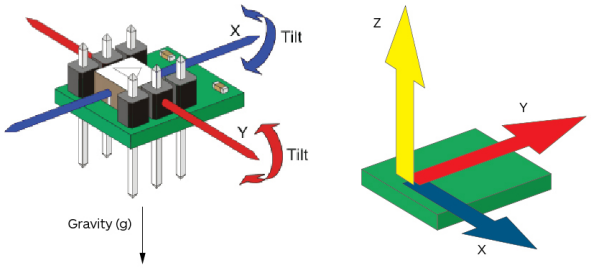

Fig. 3. Illustration of 3-Axis Accelerometer

module. The mouse movement and keyboard clicks(using blinks) shall enable the user to type on the application and also use the added functions of cut, copy and paste to transfer between applications .There are a few possible bottlenecks for this approach too, The layout of the keyboard might be new to most users and the typing speed initially might be slow, but user will get used to the system with time.

Fig. 4. GUI of Qt Keyboard Application

C. Application Usage

The application to be build shall be built using QT framework. The application should consist of easy access application bars which shall provide easy access to more used applications . The keyboard layout as specified will be made using QT . The UI shall also have some commonly used soft keys such as cut.copy,paste. The easy access application will include web browser, office application setup pages. The application will also show whether the device is connected or not and transmitting signals. The application will be self-sufficient in the sense that it will be enabled to detect circuit breakdowns in the system and shall notify the module where the problem lies for easy debugging.

VI. Workflow

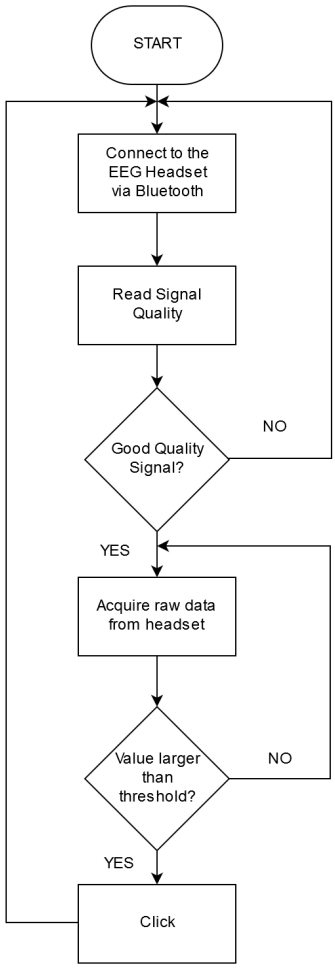

Fig. 5. Flowchart for Mouse Click

The mouse click program works on the following steps:

- Connects to the EEG headset using HC-05 Bluetooth module
- After the connection is established the EEG headset gets the brain wave signals and sends it to the Bluetooth module
- The Arduino connected to the Bluetooth module receives the data and parses the payload data
- If the checksum of the packet and the generated checksum matches this means that the signal is unaltered and of good quality
- The raw data is obtained from the payload and the blink strength is calculated

- If the blink strength crosses a set minimum threshold it can be registered when the user does a hard blink on purpose voluntarily
- This is passed as a mouse click activity to the computer and also to indicate the led on the pin 13 of the Arduino glows.

VII. Conclusion

This system helps the paralyzed patients use the computer with ease. The System proposed to be developed is feasible as a solution to current problems related to the system namely cost and ease of usage. It can be further enhanced by using a much better EEG headset to detect brain activity more accurately with the help of more number of electrodes. This can be also used to control more number of devices such as mobile phones, tablets or even home appliances connected to the network of Internet of Things (IOT). The bottlenecks mentioned above need to worked for possible solutions and its effectiveness.

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