Brain Computer Interface for Wheelchair Movement using Blink Detection

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Abstract - *Physically disabled often require a third person to move from one place to another. Relying on others put a toll on the person. So, we propose a system in which eye blinks are used to determine the choices made by the person. This requires no additional physical effort. This help to make the person self-reliant. The direction of motion intended by the person is determined by his eye blinks. It wouldn't require much training to use a model like this as all it uses is eye blink activity. The proposed solution is relatively inexpensive. Such a system can be implemented on to motorized wheelchairs to support the disabled.*

Key Words: BCI, Brainwave, EEG, Neurosky Mindwave Mobile, Wheelchair Control, Blink Detection

1. INTRODUCTION

Electroencephalography is at the core of brainwave technology. It is a way of recording and monitoring brain activities with the use of electrodes attached to a person' head. Basically, the electrodes record activity via electrical impulses that the brains' neurons emit to communicate with the rest of our bodies. Up until the last few years, electroencephalography has, for the most part, only been available in hospitals and other medical institutions where technicians use very expensive EEG equipment that can cost thousands of dollars. These are otherwise unavailable to mainstream consumers and developers. However, the past few years have seen the advancement and improvement of more affordable EEG-related products such as Neurosky's Mindwave Mobile - quite possibly the most affordable EEG-sensor and Brain-Computer Interface available to developers in the market today albeit having less features than other super-expensive, similar devices. The widespread availability of affordable EEG sensors has opened the doors to the limitless possibilities in the field of brainwave technology.

The integration of brainwave technology into modern-day wheelchairs will give doctors and patients alike new options in addressing motor-related handicaps.

2. RELATED WORKS

Keerthana, et al. [1] of VIT University developed a way of switching electrical appliances on and off using brainwaves. The project uses a Neurosky Mindwave Mobile for brainwave sensing and transmission. Apart from the switching on and off of the electrical appliance, this project also tested the Mindwave Mobile's accuracy in terms of translating brainwave data into usable ones. A series of tests for varying intensities of Beta and Gamma waves was made and the Mindwave Mobile managed to pass all of them. This project did not use other features of the Mindwave Mobile such as blink detection. Limitations of this project include the max transmission range of Bluetooth and the limited range of brainwave-related data that the Mindwave Mobile can sense.

Manuel Adrian Aclan, et al. [2] at De La Salle University Philippines developed a short messaging system using Emotiv's super-expensive $800 EPOC headset. Emotiv's EPOC headset is able to detect specific facial movements, giving the developer access to a wide range of possible controls. The biggest limitation of this project is its cost. While Emotiv's EPOC headset can detect a larger range of brainwaves and facial movements, it is extremely expensive and therefore inaccessible to most student-developers.

Hector Dominguez [3] developed a Bluetooth remote-controlled RC car for his summer study's final project. His project makes use of a Bluetooth module to send and receive signals to and from the Android application that serves as the remote controller of the RC car.

Roger Achkar, et al. [4] developed a smartphone-controlled wheelchair with an auto-movement feature that allows you to save a predefined path that the wheelchair will take. Limitations of this project include the lack of an obstacle-sensing feature that would make its auto-movement more effective.

3. HARDWAVE DEVELOPMENT

Figure 1 shows the Hardware System Flow. Both the Mindwave Mobile and the HC-06 Bluetooth module will connect to the Android application simultaneously. It starts with the Neurosky Mindwave Mobile, which is worn around the user's head, that picks up brainwave-related data and processes it before wirelessly transmitting it through its own built-in Blue- tooth module to the Android Application. The Android appli- cation acts as a middleman between the Mindwave Mobile and the Arduino, the microcontroller that resides in the minia- ture wheelchair itself. In addition to acting as a middleman, the Android application can also be considered as a safety precaution for the user. Because data from the Mindwave Mobile is not directly transmitted to the Arduino, the Android application can weed out unwanted data, ensuring that only relevant information is sent to the Arduino. By moving most of the processing to the Android application, this will also reduce the amount of processing that the Arduino has to do, thereby making it more efficient. Using Neurosky's Android SDK, the Mindwave Mobile and the Android application will then be interfaced, allowing the transmission and reception of EEG and EOG data. The resulting data received by the Android application will then be wirelessly transmitted to the HC-06 Bluetooth module, which is connected to the Arduino. The Arduino, in turn, passes the data to the L298N motor driver. The L298N Motor driver has 4 DC motors connected to it and is responsible for both its speed and direction-control. Depending on the data passed on by the Arduino, the L298N then sends subsequent commands to the DC motors, allowing the movement of the miniature wheelchair.

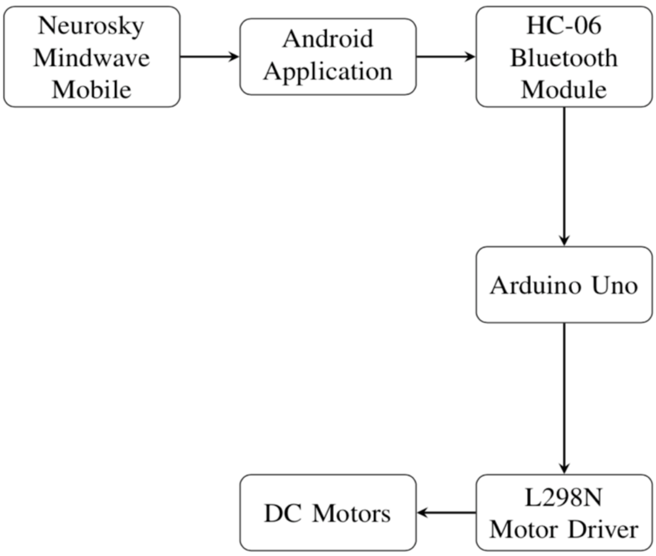

Fig -1: Hardware System Flow

4. SOFTWARE DEVELOPMENT

Figure 2 illustrates the overall flow of the software used in this project.

After both the Mindwave Mobile and the Arduino's Bluetooth module establish connection with the Android application, the Android application begins fetching the signal quality value, which can be not detected, poor, medium, or

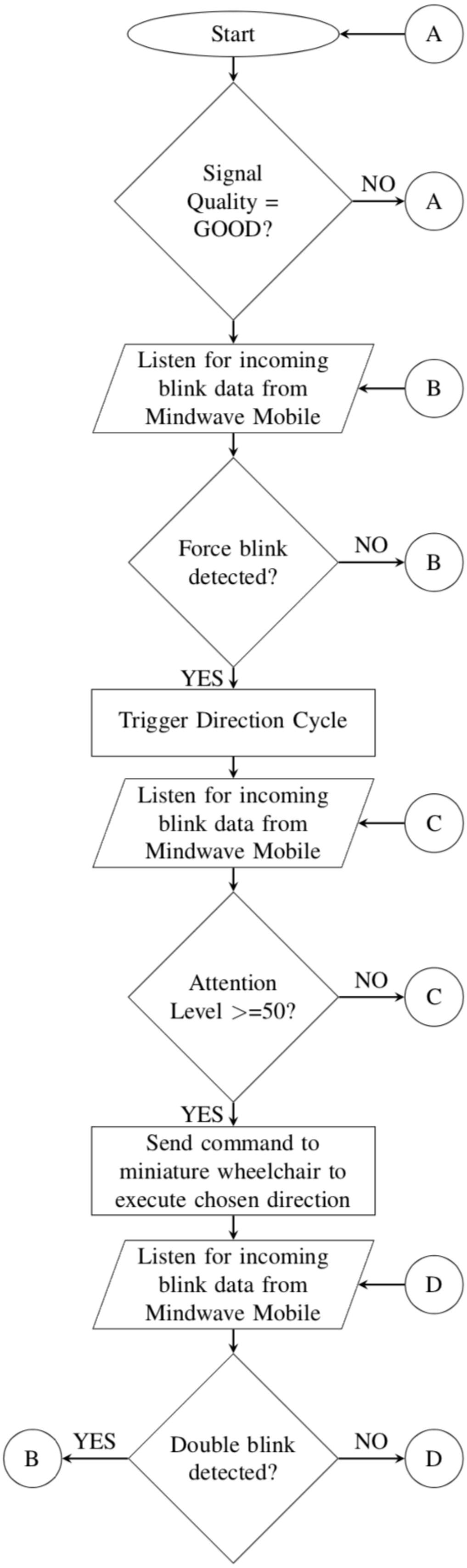

Fig -2: Software System Flow

good. The signal quality will be not detected when the user is is made by the forehead skin with the dry sensor, medium if partial contact is made by the forehead skin with the dry sensor, and good if the dry sensor makes firm contact with the forehead.

Once the signal quality value turns into good, the Android application begins listening for any incoming force blink data from the Mindwave Mobile. When a force blink or a blink whose blink strength value is above the threshold value of 90 is detected, the Android application begins cycling direction values forward, reverse, left, and right for 10 seconds with a 2-second interval in between changing the direction value.

This 10-second direction-cycle window is known as command mode. During command mode, the Android application listens for two consecutive blinks, otherwise known as a double blink event, from the user. When it detects a double blink event, the cycling of directions stops and whatever direction is shown in the cycle at the moment of the double blink event will become the chosen direction.

For blinks to be considered consecutive, the time elapsed between two blink events must be equal to or less than 400 milliseconds. When a direction has been chosen, the Android applications shifts to focus mode where it starts listening to any incoming attention data from the Mindwave Mobile.

Attention values are outputted by the Mindwave Mobile once every 1 second and once it goes to 50 or more, the Android application switches to running mode where it sends a command to the Arduino based on the direction chosen earlier. Each direction has a respective Bluetooth command that will be transmitted to and interpreted by the Arduino residing on the miniature wheelchair.

Outside of focus mode, the attention listener process is set to null to reduce the amount of work the Android application has to do simultaneously. Similar to command mode, the user exits running mode by blinking consecutively to go back to standby mode. From then on, the whole operation loop is repeated should the user want to move the miniature wheelchair once again.

The speed is kept at a constant throughout operation when the miniature wheelchair is running. This is due to accuracy and control-issues that are innate to the brainwave detection in the Mindwave Mobile. Because of this, the constant speed can also be thought of as a safety feature for the user.

5. RESULT

Four different tests where done to check the working of the system.

- Bluetooth Module to Android Application Range Test Table below shows that connection between the HC- 06 Bluetooth Module and the Android application is maintained until 30 meters. Connection range test was done in an open area with no obstacles between the HC- 06 Bluetooth Module and the Android application.

BT Module to Android Application Range Test Results				
Distance	Fwd	Back	Left	Right
10m	✓□	✓□	✓□	✓□
20m	✓□	✓□	✓□	✓□
30m	✓□	✓□	✓□	✓□

- Mindwave Mobile to Android Application Range Test Table below shows that connection between the Mind- wave Mobile and the Android application is maintained until 35 meters. Connection range test was done in an open area with no obstacles between the HC-06 Bluetooth Module and the Android application.

Mindwave Mobile to Android App Range Test Results				
Distance	Fwd	Back	Left	Right
10m	✓□	✓□	✓□	✓□
20m	✓□	✓□	✓□	✓□
30m	✓□	✓□	✓□	✓□
35m	✓□	✓□	✓□	✓□

- Normal Blink Detection Accuracy Test☒Table below is for the testing of the normal blink detection accuracy of the Mindwave Mobile. Normal blinks refer to the involuntary or voluntary rapid closing and opening of the eyes to keep them lubricated and free from irritants.

Normal Blink Detection Test Results												
One Blink…	✓□	✓□	✓□	✗	✓□	✓□	✓□	✗	✓□	✓□	✓□	✓□
Two Blink …	✓□	✓□	✓□	✓□	✗	✓□	✓□	✓□	✗	✓□	✓□	✓□

- Forced Blink Detection Accuracy Test

Table below shows the results of testing of the forced blink detection accuracy of the Mindwave

Mobile. Forced blinks refer to voluntary ones that are hard and forceful.

Forced Blink Detection Test Results												
One Blink...	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓
Two Blink ...	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓

6. CONCLUSIONS

While this project allowed for the movement of the miniature wheelchair prototype, it is by no means perfect. Current EEG and brainwave technology, while effective to a certain extent, is nowhere near perfect. Blink detection is still not 100% accurate, an issue that will most likely be solved as blink detection technology gets better and better. As for brainwave detection, the inconsistencies and fluctuations in brainwave data can mostly be attributed to humans inability to have complete control over their brainwaves. Algorithms that calculate usable values from raw brainwave data can get better, but until human beings learn how to control and manipulate individual brainwave frequencies, complete and absolute control of brainwaves will remain impossible.

Mindwave-Mobile-related issues like hardware bugs that cause it to suddenly stop functioning at times also contribute to the various aforementioned problems that the researchers have no control over. Some of these could be solved using a better advanced headset like the EMOTIV Epoch but it's much more expensive.

This project does hold promise though for the future of EEG and brainwave- related products. Brainwave technology will undoubtedly get better over time and we are very confident that the day will come when they can be effectively integrated into everyday products.

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