A Written Report

On

Integration of Brainwaves Technology with Modern Days Wheelchair

For

Affordable & Effective Assistive Device for the Physically Challenged

By

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**Aim:** Affordable & effective assistive device for the physically challenged.

**Introduction:**

This project is a cost effective, practical, ecofriendly and the safest way to assistance to the physically challenged, especially person with mobility impairment. It clearly tackles the problem that faced by physically challenged i.e. mobility of person, by using the advanced technology. According to the Survey 0f 2016, almost large % of PwDs. (Person with Disability) are mobility impaired. As the person with this type of disability faced huge problem while transporting, as it required number of people for task and this makes them feel depended, thus downgrading there moral values. As this project provide effective assistance and handle there transportation to an extent & also it became very effective for person that has upper limb loss/impairments or for the person suffering from acute paralysis.

Wheelchairs have been around for a very long time. The earliest record of wheeled furnishings dates way back to 5th century BCE China. Early Chinese models used wheelbarrows to transport both heavy objects and disabled people. Over time, the design and functionality of wheelchairs have improved with the invention of the first lightweight, collapsible and mass-produced wheelchair in 1933 by Harry Jennings and Herbert Everest serving as the introduction of the modern-day wheelchair. Further, the wheelchair has evolved with the growth and development of technology. In addition to the traditional manpower-driven wheelchairs, electric and battery-powered wheelchairs are now also available. Moreover, wheelchairs can still be taken a step further with the power of brainwaves.

As this aims to build device, basically a smart wheelchair based on Micro-controller & Neuro-Control. Both of these are advance technology, result of years of research & development. The Smart Wheelchair uses micro-controller as its processor and it is controlled by using brain-waves that is sensed by Brain-wave Sensor i.e. based on Neuro-Control Technology. By using this approach of controlling the wheelchair, it allows person with disability in upper limb or suffering from acute paralysis, can easily handle there transportation problem their own, as it require brainwave for control which is major advantage of it over the traditional Man-powered or Joystick/Button Controlled Wheelchairs.

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. 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.

**Statement of the Problem:**

This project aimed to help solve the following issues:

1. Complete dependency of people with no limbs or those with motor-related diseases with similar effects;

2. Partial paralysis that only leaves the affected access to only the most basic of motor movements such as eye-blinking; and,

3. Inability of people with motor-related handicaps but with fully-functioning brains to independently move around.

**Significance of the Study:**

This project is aimed towards quadriplegics, paraplegics, people involved in freak accidents that have left them without an extremity or any for that matter and people with motor conditions severe enough to impair movement of the extremities; it will give them an alternative way of controlling traditional wheelchairs. The completion of this project will benefit the following people/institutions:

1. Partially or completely disabled people motor-wise;

2. People with fully-functioning brains whose motor movements are impaired; and,

3. Medical companies, which will now have an alternative for people with mobility impairments.

**Novelty & Technology Stack:**

The project is mainly based on two technologies, Micro-Controller (comprising of all necessary sensor modules) & Neuro-Control. Both of these are advanced multi-purpose technology and consider as the key future of all development. The micro-controller is small on-board computer which has few kb of memory. It uses less amount of energy (electric) & are very cost efficient. The Neuro-Control uses EEG that stands for Electroencephalography, is the physiological method of choice to electrical activity generated by the brain. And all of we know that brain works by generating some amount of electricity in form of brainwaves, which capture by EEG headband.The terms discussed below are some of the more technical terms that the layman may not know:

**Brain-Computer Interface (BCI)** A brain-computer interface is a communication pathway between the brain and an external electronic device. A brain-computer interface allows users to directly control an external using only brain signals. The Neurosky Mindwave Mobile is an example of a brain-computer interface.

**Electroencephalography (EEG)** Electroencephalography or EEG is a method of recording the brain’s electrical activity. EEG is done by placing electrodes on the subject’s scalp. It measures voltage fluctuations within the neurons of the brain. EEG used to be confined to medical institutions, but the development of cheaper, more consumer-friendly EEG devices have put it in the mainstream market. **Electrooculography** Electrooculography or EOG is a technique for recording movements of the eye. EOG uses the electrical changes due to muscle-related movements in the ocular region to detect events such as blinks.

**Bluetooth** Bluetooth is a global wireless communication standard for connected devices wirelessly over a certain distance. At present, there are about 8.2 billion Bluetooth devices in use worldwide. Bluetooth devices, depending on the class, can transmit up to 100m. However, the most common transmission distance for Bluetooth devices is 10m. **HC-06 Bluetooth Module** the HC-06 Bluetooth module is one of the most common Bluetooth modules used by hobbyists and professionals alike. It is a serial port protocol Bluetooth module that only acts as a slave. HC-06 modules can transmit up to 10m.

**Microcontroller** A microcontroller is a very small computer on a single integrated circuit. It has a processor, a memory module and programmable input and output ports. Microcontrollers are typically used in embedded systems that have specific and dedicated functions. **Arduino Uno.** The Arduino Uno is one of the most, if not the most, popular microcontrollers around. It is based on the ATmega238p. The Uno has fourteen digital input/output pins with six of those doubling as PWM outputs. **L298N Motor Driver** the L298N Motor Driver enables the control of DC motors by amplifying the low-current signal from the Arduino into a higher-current signal suitable for motor control.

**Neurosky Mindwave Mobile** Neurosky’s Mindwave Mobile is an Electroencephalography or EEG headset that measures and transmits brainwave data via Bluetooth. It can monitor attention and meditation levels as well as detect blinks. The Mindwave Mobile is one of the most affordable Brain-Computer Interfaces available. **Attention eSense Meter** a value based on the user’s beta brainwaves that are calculated by Neurosky’s proprietary algorithm. Attention is associated with the focusing of a single thought by the user. **Meditation eSense Meter** a value based on the user’s alpha brainwaves that are calculated by Neurosky’s proprietary algorithm. Meditation indicates the level of mental calmness and relaxation.

**Idea & Approach Details:**

**Design Objectives** The primary goal of this project is to develop a miniature wheelchair prototype that is controlled via the user’s blinks and brainwave data. Other goals are the following:

1. Translate brainwave data and blinks into wheelchair movements;

2. Develop an Android application that will serve as a data receptor for the Mindwave Mobile and a data transmitter for the miniature wheelchair;

3. Receive attention and blink strength levels wirelessly via Bluetooth from the Mindwave Mobile via Neurosky’s Android SDK; and,

4. Develop an algorithm based on the Mindwave Mobile’s blink detection to effectively detect forced and involuntary blinks for wheelchair control.

Figure 1, shown below, illustrates the overall system flow of the project. The major components of this project are as follows: the Neurosky Mindwave Mobile for brainwave and blink detection, an HC-06 Bluetooth module for wireless transmission of data, an Android application that acts as a data receptor and transmitter, an Arduino microcontroller to process data from the Android application into wheelchair movements, and a motor driver module to operate the miniature wheelchair’s motors. The devices mentioned work together to give a person control over his wheelchair using only his mind and with his blinks.



**Hardware Development** 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 Bluetooth module to the Android Application. The Android application acts as a middleman between the Mindwave Mobile and the Arduino, the microcontroller that resides in the miniature 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.

**Software Development** The software was created with the goal of creating a way to operate the minature wheelchair that is as simple and straightforward for the user while staying within the boundaries of the very limited controls the Mindwave Mobile affords us. The researchers came up with a sequential operation loop composed of four different modes, each representing a state of the wheelchair. The modes are as follows: standby, command, focus, and running.

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 good. The signal quality will be not detected when the user is not wearing the Mindwave Mobile, poor if almost no contact 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. The signal quality has a value from 0-255 with 0 being the best and 255 being the worst. The range of values that each signal quality value is based upon has not been revealed by Neurosky. As an added safety precaution, when the signal quality value is not good, a stop command will be sent to the miniature wheelchair, preventing any unwanted motion. Once the signal quality value turns into good, the Android application begins listening for any incoming force blink data from the Mindwave Mobile. At this point, normal blinks or blinks whose blink strength values are below the threshold value of 90 are discarded.

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.

**Recommendations & Dependencies:**

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.

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.

**Recommendations**

1. The use of Lithium-Polymer batteries instead of ordinary AA batteries. Lithium-Polymer batteries are more suited for applications such as this and provide tremendous performance advantage over regular batteries. The researchers originally planned to use Lithium-Polymer batteries instead of AA ones; however, such batteries were - and still are - banned from being shipped via air;

2. Addition of an obstacle-sensing and obstacle-avoiding feature;

3. Use of a better EEG headset such as Emotiv’s EPOC headset; and,

4. Use of GPS & Compass Sensor for Autonomous Navigation.

**Scope and Limitation**

While this project is aimed towards disabled people in general, it does have some limitations, specifically in who can or cannot use this project and the hardware-related ones. The aforementioned limitations are the following:

1. Due to financial constraints, only a miniature wheelchair prototype will be created;

2. Transmission range between this project’s components is limited to their respective Bluetooth devices;

3. The miniature wheelchair can only go in one direction at a time: forward, reverse, left, or right;

4. Quality of transmission signal may be affected by interference from other devices;

5. Due to the nature of brainwaves, complete and absolute control over them is impossible;

6. Blink detection focus levels are not 100% accurate;

7. People with blink disorders are not allowed to use this product;

8. People with epilepsy and similar disorders are not allowed to use this product;

9. People who are prone to seizures are not allowed to use this product;

10. The EEG sensor cannot identify a human being’s specific thoughts;

11. The EEG sensor can only use attention and blink strength levels as methods of control; and,

12. For quadriplegics or people with no limbs, assistance is still required in the operation of this project, particularly in the turning on and off of the components.

**Cost Estimation**

The table below contains the estimated prices of the materials used in this project:

Table 1

*Estimated Prices of Materials*

|  |  |  |  |
| --- | --- | --- | --- |
| Part Name | Quantity | Unit | Sub Total |
|  |  |  |  |
| 1. EEG Headset | 1 | 6700 | ₹6700 |
| 1. Arduino | 1 | 300 | ₹300 |
| 1. HC-05 Bluetooth Module | 1 | 250 | ₹250 |
| 1. L298N Motor Driver | 1 | 250 | ₹250 |
| 1. Motorized Wheel Chair | 1 | 10500 | ₹10500 |
| 1. Miscellaneous |  | 1000 | ₹1000 |
|  |  |  |  |
| Total |  |  | ₹19000 |

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