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# Neuro-Wheelchair

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***Abstract***

***Medical electronics has always been a very popular field for innovations, regardless of the medical advances that have happened. This paper presents the prospect of developing a neuro-processing wheelchair, an incredibly useful accessory for the quadriplegic, the deaf and dumb, who have lost the use of their limbs. To develop this prototype, we a technology knows as Brain-Computer Interface (BCI) [15][16], a medium through which a direct communication pathway between a human/animal brain and the outside world is established. The prototype consists of a wheelchair, which is controlled using EEG signals obtained from the human brain. The Neuro sky product i.e. mind wave device headset is used to measure the human brainwave signals. The signals are then mapped and compared with the reference values of attention and meditation levels along with blinking eye signals. The wheelchair moves in different directions and can be controlled effectively using the precise thoughts of the individual. So, a human's ability to concentrate is used effectively to control the given wheelchair. An IMU is used to control the wheelchair in slope positions and GPS, GSM to identify the particular location and movement of a person.***

***Keywords: BrainComputerInterface(BCI); InertialMotionUnit (IMU); electroencephalography (EEG); GlobalSystem for Mobile Communications(GSM); Global Positioning Systems(GPS).***

## 1. INTRODUCTION

Medical electronics has been a field of continuous evolvement and innovations. Even with these continuous innovations, there is always room for more. Hence, we have chosen this field as our area of concentration for innovative development. Our idea is to develop a thought processing wheelchair, a perfectly reliable and highly independent wheelchair for the quadriplegic, deaf and mute and blind. This project mainly focuses on developing a neuro -processing wheelchair, which can be explained in simple terms as a wheelchair which reads the thoughts of the patient sitting on it. More clearly, if the patient is a quadriplegic, he wouldn't be able to push the wheelchair on his own. So, he would require the help of a second person to do it. If the patient was a deaf or mute, he wouldn't be able to tell the second person pushing the wheelchair as to which direction he needs to go. To overcome these disadvantages, we've come up with the aforementioned idea of neuro -processing wheelchair. The patient just needs to think on which direction he needs to go and the wheelchair will move in that direction, without the help of any second person, thereby giving the user, reliability.

Human brain consists of in finiteinter connections of neurons. They communicate with each

other by sending some electrical pulses, with varying electrical potential (in micro-volts). This micro-voltage can be sensed by the sensor and electrodes. The sensor or electrode is place on the forehead of the wearer's scalp, based on the standard configuration (10/20 electrode system). These signals are known as Electroencephalography (EEG). Electroencephalographic NeuroSky Mind wave mobile is an EEG device used to record the human brain's electrical activity (Attention and meditation levels). The human brain's all electrical activity is recorded at particular positions on the surface of the scalp.

## 2. Experimental Details

The wheelchair [1] we develop will be able to move based on brain activity. The mental state of the wearer is determined by the Mind Wave sensor in the form of proprietary attention and meditation e-Sense algorithms of the NeuroSky cap (NeuroSky algorithm), with the brainwave frequency bands' data in addition. The NeuroSky cap uses electrodes which are placed on the wearer's scalp on the active region where five types can be recorded. The five types of waves are ***theta, alpha, beta, gamma and delta*** [17][18]**.** The frequency range of Alpha Waves is 8-12 hertz and these waves occur when the brain is calm yet alert. The frequency range of Beta Waves is 12-40 hertz and the waves occur when the brain is active and cognitive. The frequency range of Gamma waves is more than 40 hertz and these waves occur when the brain is in hyperactive state. The frequency range of Theta waves is less than 4-8 hertz and these waves occur when the brain is in hypnotic state. Delta waves have a frequency of 0-4 hertz and occur when the brain is in REM state. We make use of beta waves to get an EEG reading (EEG data acquisition).**[2]**

This data is then transferred to the embedded controller via Bluetooth. The embedded controller used here is Arduino Nano. For controlling the wheelchair in sloppy [3] areas, we make use of accelerometer and gyroscopic sensors. It is a system that controls the leaning positions of the wheels, making it secure for mobility in curvy areas, giving the patient a sense of security. We use GPS and GSM for global positioning which helps in giving the exact location of the patient, in case he gets lost. Also, we can use the module to go to a particular place, when the patient doesn't know the route and energy conservation for backup power using solar energy.

**Description of block diagram:**
This prototype will be mainly able to provide a means of transport and communication for the quadriplegic and deaf and dumb. The EEG acquisition reads the brain waves produced and they are converted to data by the Bluetooth module, which reads the data and gives its specifics such as frequency and then converts the analog signals to binary signals, wirelessly. This analog to binary data conversion is done through Arduino Nano. This data is given to the motor driver, which is an actuator, hence, requiring the analog signal. It rotates in clockwise direction and the wheelchair moves. The wheels of the chair are fitted with the MPU 6065 which contains the accelerometer and gyroscopic meter which give slope control to the chair during the curvy areas. The wheelchair also contains a GPS module for location trackingfor security and GSM module for emergency purposes, if and when the patient gets into an accident. It'll call a friend. The solar panels are an extra feature to provide back-up power in case of batteries emptying in the middle of movement.

## 3. RESULTS AND DISCUSSION

**EEG Acquisition:**
The module we've proposed encompasses three primary steps - data preprocessing, feature extraction and classification. Once we've collected the data, data pre-processing is the primary step, which is added with noise reduction and filtering conducted by the EEG device, Neuro Sky Mind wave Mobile which is employed for data acquisition [4]. The step followed is feature extraction, wherein we extricate features of statistics comprising of mean, standard deviation and maximum and minimum difference of the pre-processed data. The ultimate step comprises of categorization of the extracted features through an apt classifier for the acquired set of real time

data. The Neuro Sky, which consists of two electrodes each of which is placed on the subject's forehead and his/her earlobe, captures the electrical impulses of the human brain, through an electrode which is placed on the human brain. The pre-processor in the mind wave sensor obtains the raw data from the subject's brain [14]. As per our research, 10/20 placement system defines the electrode that is placed on the forehead as fp1 and earlobe electrode as a1. The acquisition of the data is through non-invasive method as we use Mind wave Mobile sensor [6] which consists of a single electrode, single channel as stated above. The electrode on the forehead records the human brain activity. Human brain, in general, consists of infinite interconnections of neurons which carry electrical impulses. In layman's terms, they relay the messages from the brain to the different parts of human body. These electrical impulses of the neurons create an electric force. This creates an electric field with varying electric potential. According to the 10/20 placement system, the sensors are placed and there the electrical potential of some micro-voltage of the brain is read here, when the electrodes are placed according to the 10/20 standard configuration on the scalp, specific measurements of varying potential is given out and this is known as electroencephalography. This entire process is data acquisition. The fp1 and a1 position determines tandem states of mind, via attention and meditation and these are noted through Mind wave sensor. Also, the eye blink states can be recorded, along with low Alpha, low Beta, high alpha, high beta, low gamma, high gamma, high Beta, low Beta, Delta and Theta waves. These signals refer to the various states of concentration and meditation of the human brain. The next step is signal acquisition where signals are acquired from the brain in the form of analog waves and then transformed to digital values. The collected signals are then pre-processed to filter out noise. These digital values depend on the high concentration and attention values of the subject's brain. A synchronous BCI system corresponds at a particular period of time whereas in an asynchronous BCI system, also called as "self-placed", the correspondence takes place at any period of time. This data is given to a Bluetooth module by some established methods.

**Bluetooth:**

Bluetooth is a short-range, radio link designed to replace the cable connecting portable or fixed electronic devices. Prominent features are simplicity of usage, robustness, low cost and less power. There can only be 2-8 Bluetooth devices connected to each other. This is known as piconet. Our prototype contains 2 Bluetooth devices, one as a master and the other as a slave. NeuroSky transmitter is the master and the wheelchair are the slave. The digital values [9] extracted are stored in the payload of the NeuroSky transmitter. This data is shared to the payload of the slave's Bluetooth. This is then transferred to the wheelchair unit as an encoded sequence. Here, there'll be another access code, header and payload of the above-mentioned wheelchair control unit. This encoded sequence is again decoded by the Bluetooth module and stored in the payload. This sequence is divided into packets and stored in the payload of the wheelchair control unit's Bluetooth and transferred to the Arduino [5] through SPI (Serial Peripheral Interface) protocol. Arduino [10][11][12] analyses the data coming from the Bluetooth [13] module and then sends the data in digital format to the motor drivers, which are essentially commands. The driver circuit consists of 4 pins: IN1, IN2, IN3, and IN4. If IN1 and IN3 are high, the wheelchair moves forward. If IN2 and IN4 are high, the wheelchair takes a right turn and then a left turn. The motor driver is powered by 8x1.5v battery. The motor driver is connected to a motor with an rpm of 300 and an operating voltage of 3-12v. Motor driver also acts an H-bridge circuit and it is used to control motor directions and speed.

**GSM and GPS unit :**

GSM system was developed using time division multiple access (TDMA) technique with an intention of communication. GSM [7] technology is employed to communicate with mobile phones. GSM stands for Global System for Mobile communication. We have interfaced GSM module with Arduino board. Overall, we use GSM and GPS technology as a means of location tracking of the patient if and when he travels to unfamiliar geographical areas and loses his way to the destination. We get Geo location coordinates via the GPS system through satellite communication and these values are forwarded to the GSM module through Serial Peripheral

Interface (SPI) Protocol. GSM uses 2G network to send the GPS location to care taker's phone. This also helps in reaching the patient if there is an abrupt degradation in his health.

**Energy conservation unit:**

This is used as back up batteries in case of the primary batteries running out of power. The construction of the solar panels [8] is described more clearly in this section. One photovoltaic cell generates an "Open Circuit Voltage" (VOC) of about 0.5 to 0.6 volts at 25ºC (usually around 0.58V) regardless of their size. This cell voltage remains satisfactorily constant only until there is adequate irradiant light from dull to bright sunlight. Here, we incorporated solar panels of 70mmx70mmx03mm which is of 4.97 V of output power. We use this output power to recharge our Arduino Nano.

No of cells in solar panel =9 cells
Standard value of single cell output =0.65
Total output voltage = no of cells * signal cell output, that is approximately equal to 6v
Total input voltage for Arduino = 0 .65x9=5.85V ~6V

**Results**

We design the wheel chair model graphically in Solid Edge. We use some of projection methods to design the model.We used a thick fiber sheet glass to design model. We designed according to accurate measurements. Two square planes of length =25cm, thickness =2cm and height =8cm for gap between two planes. We used fiber as model material with some hand tools as shown in figure 6.

The below images in figure 7 show the results acquired during EEG acquisition. The first image consists of the brain data obtained from the person wearing the NeuroSky Mind wave Sensor. The images in figure 8 show the control unit of our prototype, which mainly explain how the wheelchair moves forward. Based on the concentration levels of the user, the wheelchair either moves forward or turns to the sides. With high level of concentration and meditation levels, the wheelchair moves forward.

The images in figure 9 below consist of the GPS GSM unit. They show the location tracking and the relaying of live geographical location information of the wheelchair user's caretaker's cell-phone. The images in figure 10 below show solar panels which are used as battery backup in case of the primary batteries running out of power.

**ALL FIGURES**

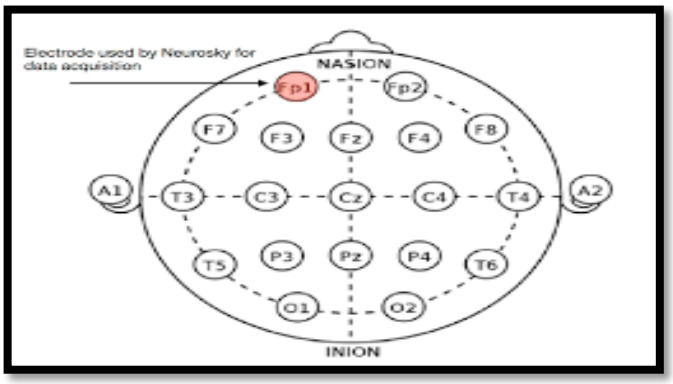



**Figure 1. Schematicofthe10-20electrodesystem**

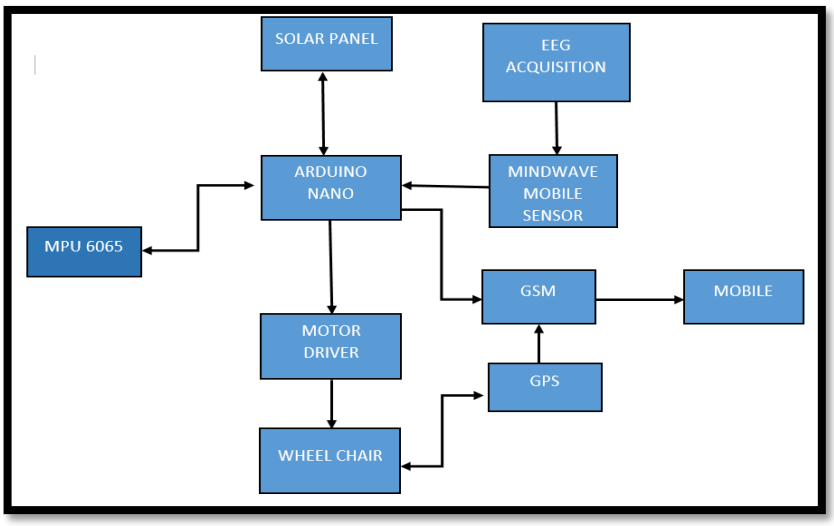



**Figure2..Block Diagram**

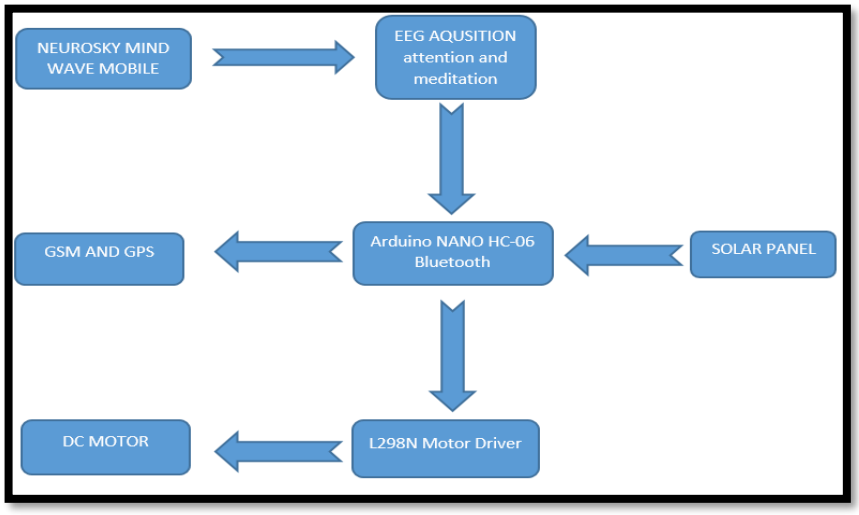



**Figure 3.** Control flow

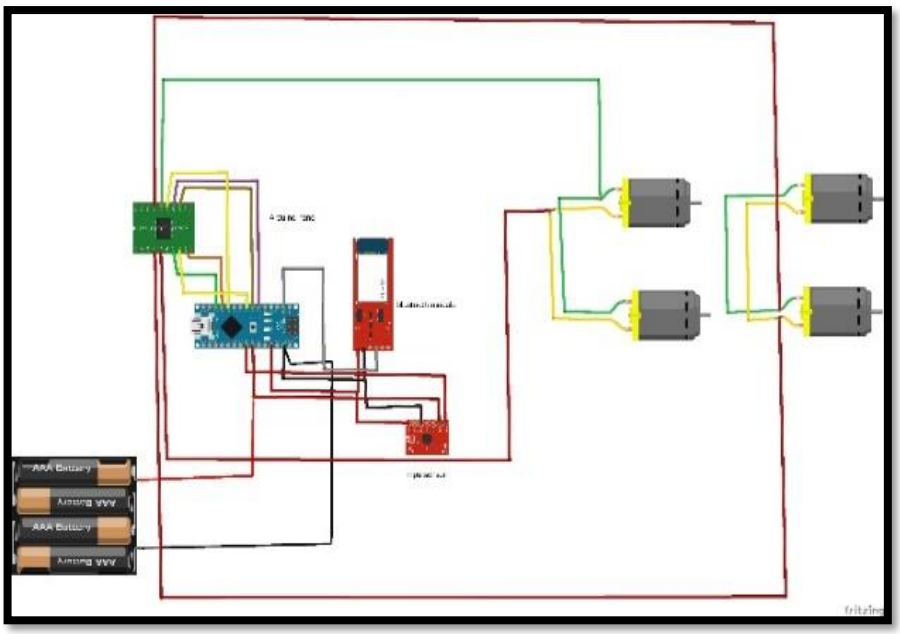


**Figure4**.Circuit design of wheel chair controller unit

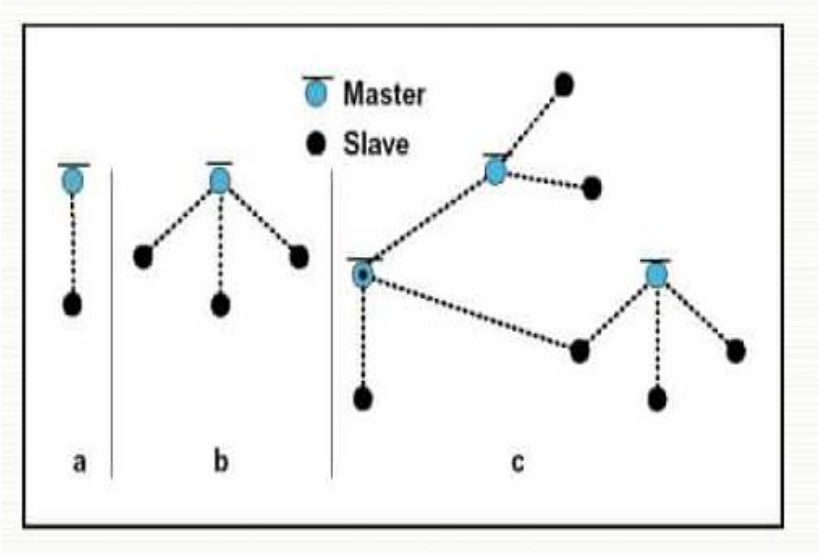
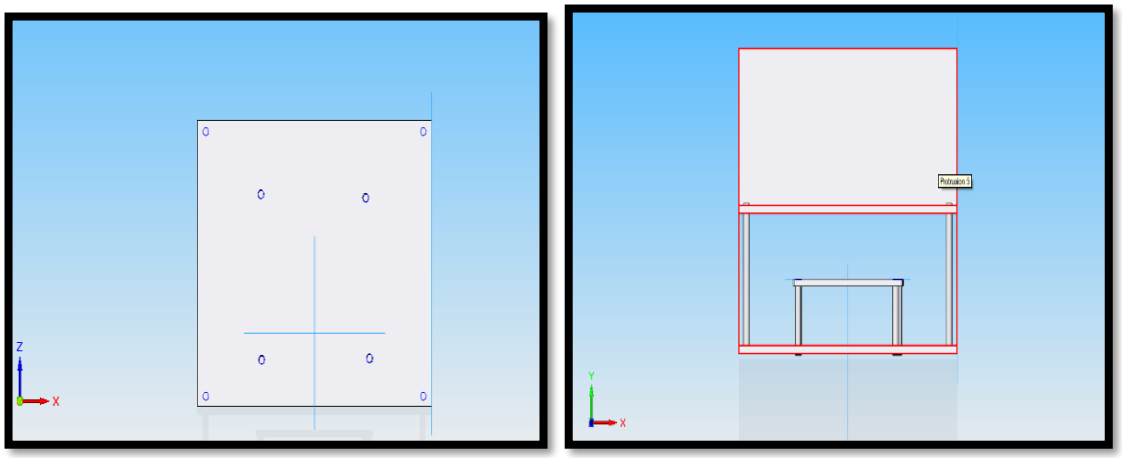



**Figure 5**. Master and Slave for Bluetooth module



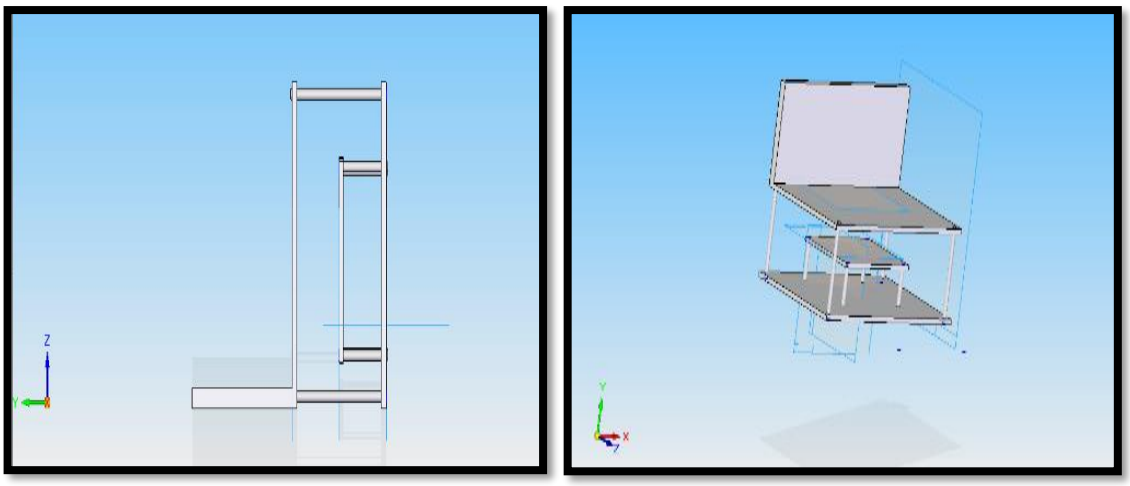


**Figure 6.** CAD design and hardware implementation

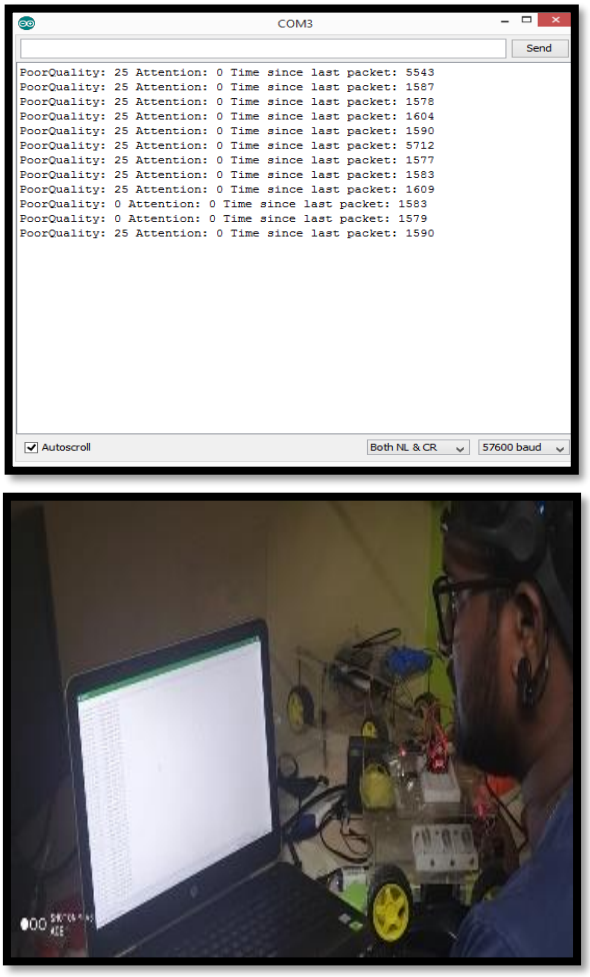
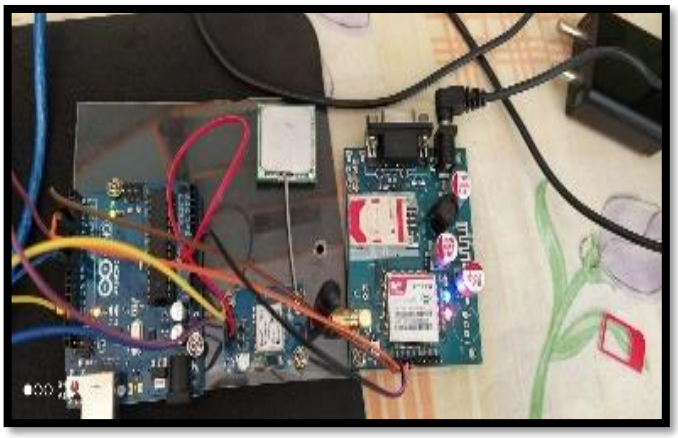



**Figure 7.** EEG values

**Figure 8.** Moment control unit



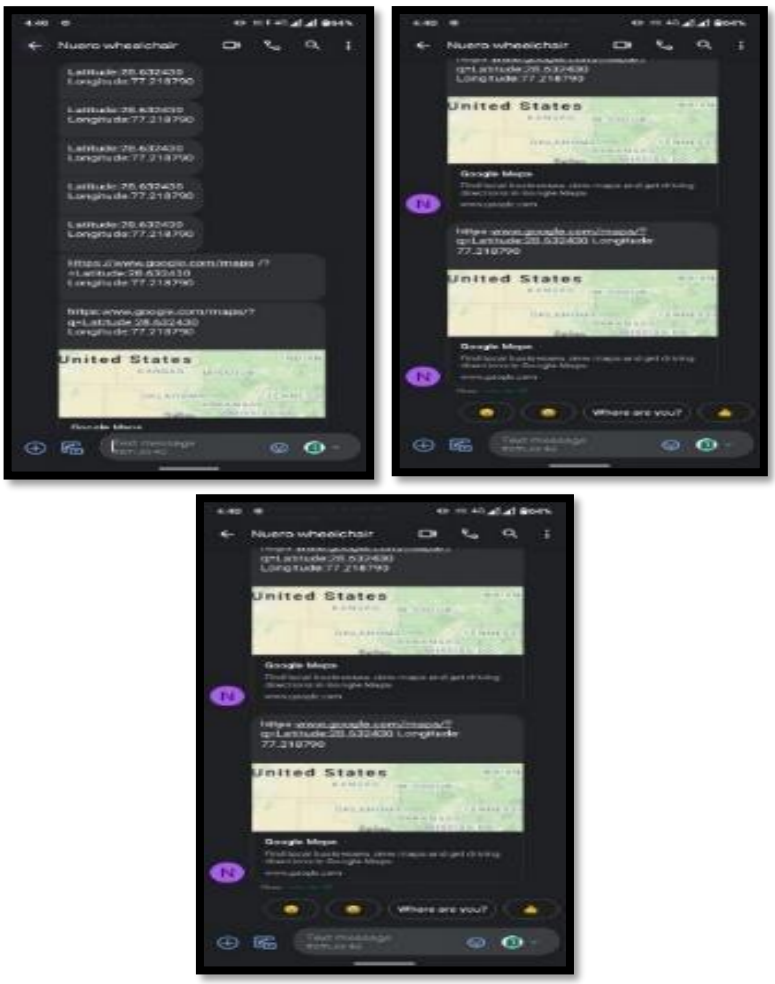



**Figure 9.** GSM and GPS unit

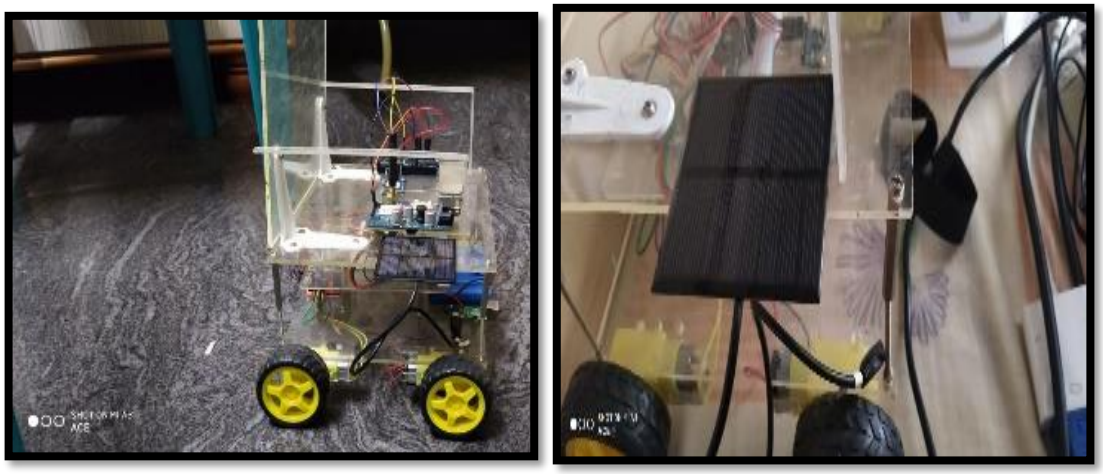


**Figure 10.** Solar panels

**Table I.**

| Name | Frequency | Activity |
|---|---|---|
| Delta | 0.5 - 4 Hz | Deep,dreamsleep |
| Theta | 4 - 7 Hz | Mediation,mentalimagery |

| | | |
|---|---|---|
| Alpha | 7 - 13 Hz | Relaxed calm,not thinking |
| Beta | Above 13 Hz | Alert,normal, awake |

## 4. CONCLUSIONS

The main point to this paper is to help the quadriplegic, the deaf and the mute. The prototype proposed will help the patient to move anywhere he wants to without having to rely on someone to push him. Also, the prototype is equipped with the GPS GSM module to help with location tracking to avoid losing the location of the patient if and when he goes to unfamiliar geographical areas. The prototype is also backed up either solar panels for back up battery. There are further enhancements that can be added to the prototype for further development. It can be further enhanced with a text-to-speech feature for additional support. It can also be enhanced with emotion-to-text feature as a support for mute quadriplegics. The prototype can be introduced with different wheelchair mechanisms to assist on moving on ramps and slopes. An external mechanism of an umbrella sort can be added as a cover to protect the patient from rain or snow.

### Future Enhancements

There are further enhancements that can be added to the prototype for further development.

- It can be further enhanced with a brain signal-to-speech feature for additional support.
- It can also be enhanced with emotion-to-text feature as a support for mute quadriplegics.
- The prototype can be introduced with different wheelchair mechanisms to assist on moving on ramps and slopes.
- An external mechanism of an umbrella sort can be added as a cover to protect the patient from rain or snow

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