AI Based Brain controlled Wheel Chair

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Abstract:

Around the world, there are almost 6 million population who are born disable or facing disabilities diseases that made them dependent on external help, they always need other's assistance for their mobility. Diseases such as **Strokes** that deactivates the nerves or parts of the body and stroke patients can only move certain parts of their body such as (eyes, tongue and brain). **ALS-** Amyotrophic lateral sclerosis is a progressive nervous system disease that affects nerve cells in the brain and spinal cord, causing loss of muscle control. **Locked-In Syndrome** is a severe neurological disorder characterized by complete paralysis of voluntary muscles, except the control of jaws and eyes. Locked-in syndrome Patients are conscious and can think and reason, but are unable to speak or move. They can only use jaw and eyes movement for communication. They always need external help from other person for their mobility which makes them dependent. They always dependent on nutritional and physical therapies and comfort care to live a healthy life. EEG-based brain computer interfaces have been proposed as a method to facilitate the interaction of disable patients with the external world. In this thesis, we present system of **Artificial Intelligence (AI)** based brain controlled wheelchair that will be efficient and reliable for Locked-In Syndrome patients to live a healthy and better life. Our designed wheelchair will work on jaw movement that would generate four commands as an output of wheelchair: Forward, Left, Right, Stop. AI based brain controlled wheelchair will include data acquisition using an EEG headset, signal processing, machine learning algorithms and different AI models. The wheelchair is controlled by motor imagery (MI) and jaw clench for its movement.

Keywords—Locked-In Syndrome, Machine Learning, Artificial Intelligence, Filters, Brainlink Mindwave EEG Headset. Wheelchair.

Introduction:

Looking through the advancements in the technology and brain controlled devices being implemented, a new invention was made in field of medical for purpose of helping paralyzed patients in their mobility by inventing a mind controlled wheel chair. A mind-controlled wheelchair is a mind-machine interfacing device that uses thought (neural impulses) to command the motorised wheelchair's motion. The first such device to reach production was designed by Diwakar Vaish,[Singhdeo, Saswat] (2016-03-31) [3]. Head of Robotics and Research at A-SET Training

& Research Institutes [4][6]. This brain controlled wheel working with an electroencephalogram (EEG) worn on the user's forehead detects neural impulses that reach the scalp allowing the micro-controller on board to detect the user's thought process, interpret it, and control the wheelchair's movement. The wheelchair is of great importance to patients suffering from locked-in syndrome (LIS), in which a patient is aware but cannot move or communicate verbally due to complete paralysis of nearly all voluntary muscles in the body except the eyes. Such wheelchairs can also be used in case of muscular dystrophy, a disease that weakens the musculoskeletal system and hampers locomotion (walking or moving).

We learnt how to use machine learning for interfacing brain and Computer and help this advancement of technology in medical field such as brain controlled wheel chair through use of different parts of body has been made. Each time advancement in this field helps disable and paralyzed patients to tackle the problem of their dependency for their mobility. The advanced way of controlling wheel chair through machine learning and non-brain source signals are used, such as eye-blinking, teeth clenching, jaw squeezing, and other movements. Thus, paralyzed patients have been much benefited through this invention. Especially people with ALS and Locked-In syndrome are much more in ease and are feeling independent through this invention for their mobility.

In the paper "T. Carlson, R. Leeb, R. Chavarriaga and J. del R. Mill´an with the Chair in Non–Invasive Brain–Machine Interface "[8] , they have used BCI with proficiency based on imaginations of movements and then recording the electrical activity of brain using EEG from which features are extracted, interpreted and classified using machine learning techniques and actions for moving left or right are being decided and then implemented on brain controlled wheelchair helping the user in their mobility.

Seeing advancement in technology in contrast to medical field, we thought to work on designing a brain controlled wheel chair which will be working on Artificial Intelligence and helping Locked-In Syndrome, ALS and Paralyzed patientis in their mobility.

Methodology:

Our project is divided in four main modules and then implemented it one by one. Those four modules are shown below in block diagram of project:

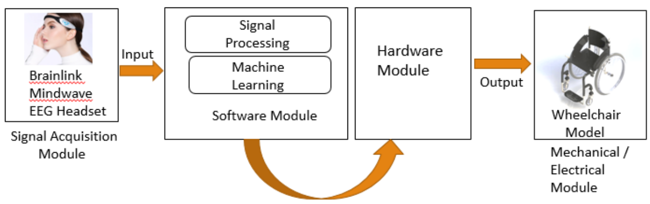

Figure 1 : Block Diagram Of Brain Controlled Wheelchair

Above shown modules are implemented one by one in a sequence. Firstly, signal acquisition module is implemented using Brainlink mindwave EEG headset. Brainlink Mindwave EEG headset is used to detect and record brain waves caused by jaw movement of a person. For software module, in first part signal processing is performed on brain waves obtained from EEG headset using different filters to acquire Alpha waves. Alpha waves (8-13Hz) are the core component of our project. For machine learning part, different offline raw datasets are used for training a model and checking validity of the data acquired from brain waves in form of Alpha waves. Different Artificial Intelligence based Models are used to train model in Jupyter. In jupyter, MacroML library performed the main part of converting trained model on Python script in to C code which was further combined with c-code on Arduino IDE according to requirement of running wheelchair in four output movement : left, right, forward and rest.

This code is then burnt on Arduino Uno to run designed wheelchair in Hardware Module. For Hardware Module, Arduino Uno, l298n motor driver, battery, servo motor, and Bluetooth HC-06 module are combined together on a chases according to the requirements of working wheelchair. Thus, following the above described procedure, we were able to design a AI based brain controlled wheelchair prototype model.

Data Acquisition and Signal Processing:

We used Brainlink Mindwave EEG Headset for acquisistion that will be further use for processing and training model to run our wheelchair prototype, but due to its incompatibility with PC windows we had to use External Bluetooth for data acquisition.

Figure : BrainLink Mindwave EEG Headset with External Bluetooth HC-06 Module And Battery

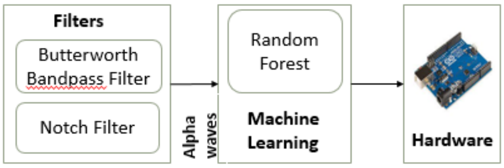

Figure : Signal Processing Module

Our designated frequency range is the alpha waves (7-13 Hz) [when the subjects moves their jaw . To handle real-time data, we tested at 60 Hz with a frequency of two seconds. The signal was first notched-filtered at 30 Hz and 13 Hz to eliminate power-line commotion utilizing a Butterworth channel. After information pre-handling, we utilized Power Spectral Density (PSD) to remove the some extra power of the band.

MicroML Library for C-code Conversion:

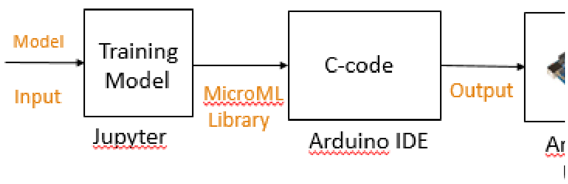

Figure 2 : ML to C-code Implementation

Main work after training a model is done here. This library is used in python code to convert to c-code which will be help us to run our trained model on Arduino IDE Sofware and later burning it on Arduino UNO.

C-Code in Arduino IDE software:

For running wheelchair using Arduino Uno, we burnt c-code on Arduino IDE software. C-code script is written in a way that it integrates the c-code converted from Python using MicroML library with c-code written that has to be used for movement of wheelchair in left, right, backward and forward directions or rest/stop mode.

Hardware Implementation:

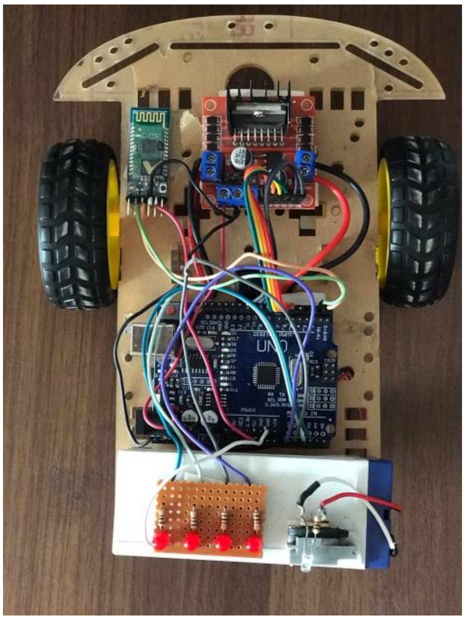

Figure : Wheelchair Prototype Model

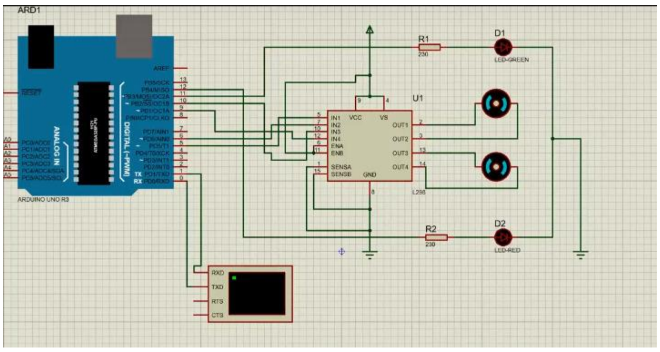

Figure : Hardware Working Diagram of Project

Hardware Implementation:

To determine the wheelchair movement using headset, the easiest way is by processing brain electrical signal which is result of jaw clench. The processed data were classified into 5 types of movement signal consist of moving forward, moving backward, turning left, turning left, and default. In the classification of wheelchair moving data, we used imagery motor method and jaw motion, for imagery motor we used features in Brainlink mindwave headset, and for the jaws motion we processed high alpha signal recorded by the headset. We took data for imagery motor, thus the data results could be references for controlling. Brainlink mindwave headset feature has scale range from 1 to 30Hz. At a normal condition the scale is between 8 to 30Hz, and the scale can be increased up to 40 by jaw clenching and focusing the attention and meditation concentration. The classification that we have done is summarized as follows:

a. Moving forward : Both Jaw Clench
b. Turning left : Left Jaw Clench
c. Turning right : Right Jaw Clench
d. Stop : Relax

Subjects for data exercise were taken from normal people since getting the post-stroke patient or LIS patients was quite challenging. The criteria for a good subject were not under pressure, not in pain (especially headache and under stress). This is because the concentration of the subject using jaw clench becomes the basic determinant so that the wheelchair can be used by everyone. In addition, for data exercise we used 3 minutes exercise duration for each classification class, and break was carried out for 5 minutes, because we did not want to impose pressure on the subject's brain to keep the jaw clench or concentrate.

Result and Discussion:

```
================================================================================
Running RandomForest classifier...
Accuracy: 0.8441

Confusion Matrix
[[114  25]
 [ 16 108]]

Classification Report
              precision    recall  f1-score   support

       False       0.88      0.82      0.85       139
        True       0.81      0.87      0.84       124

    accuracy                           0.84       263
   macro avg       0.84      0.85      0.84       263
weighted avg       0.85      0.84      0.84       263
================================================================================
```

Figure : Datasets Accuracy

At first, reason of poor result was invalidity of signals due to a lot of noise presence in signals as we were acquiring signals using serial communication of Bluetooth having slave and master relationship with EEG headset. Anyhow, acquired signals from EEG headset on IPhone and PC were then processed and filtered to meet the required output. The offline datasets was trained using random forest classifier. The accuracy at end of all dataset we get was 84% as a result. Model was trained using machine learning AI Model and supervised ML algorithm i.e. Random Forest Classifier which was further implemented with c-code to be burnt on Arduino UNO. C-code was used to perform motor functions of wheelchair prototype model.

Conclusion:

We implemented data acquired from Brainlink Mindwave EEG headset but the main issue we faced was interfacing the brainlink mindwave headset with Windows PC as this headset tend to be compatible with only IOS devices, we tried to connect to PC directly using Bluetooth HC-06 module but it was not possible and not working so we used master- slave serial communication between EEG headset, our designed AI based brain controlled prototype and Windows PC to acquire signal but due to poor connectivity we faced severe issues in data acquisition. We used raw datasets for jaw movement to run our prototype wheelchair. This wheelchair was made by using Arduino Uno, DC motors, L298N motor driver, 12V Battery and chases. We did data acquisition at real time for shorter interval when the connectivity was possible, using that acquired signals, we did the signal processing using filters and then detected alpha waves which were required to run the wheelchair model. We did perform Artificial Intelligence model of random forest for classification and regression. RF also known as supervised ML algorithm. This method is the machine learning algorithms or AI models that was further used to trained our model on Jupyter Notebook software. After training the model, MicroML library was used to convert model into C-code which was then used as a header file in C-code written to run the wheelchair. The c-code written on Arduino IDE was then compiled and the burnt on Arduino Uno which as a result used to drive the wheelchair prototype in left, right, forward, backward directions and for rest.

Recommendations and Future Work:

1. Our hardware is made up of cheap module like low cost brain wave Brainlink Mindwave EEG headset which will make it accessible to everyone within reasonable cost as well as portable.

2. Our project can be implemented with advanced technology in future to give more advanced results having more accuracy and good sensitivity.

3. The current algorithm we used was improved version of thresholding linear regression i.e. Random Forest in Artificial Intelligence Models and also known as supervised Machine Learning Algorithm. It is resultant of converging different machine learning algorithms.

4. It was a little achievement to detect alpha waves using jaw movement and applying machine learning algorithms on it to run a model prototype of wheelchair. Whereas we were succeeded in our goal at the level of proficiency but not with 100% results we want but we did our best to get an output where we detected brain's electrical activity using low cost EEG headset and then interfaced it with Arduino UNO using different AI and ML techniques in contrast of C-code. Using different machine learning algorithms, we were able to run the wheelchair prototype model. Whereas in future more work can be merged with more advanced techniques in AI and ML so that our work can provide advanced results with more precise and accurate details.

5. Our work can also be combined with other features for the enhancement of working of wheelchair like location tracker and heartbeat tracker.

6. After converging AI and ML techniques with our work and introducing more features, wheelchair can be introduced at market level and can also be introduced in to medical field at reasonable costs.

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