Brain Controlled Car using Deep Neural Network

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Abstract - Brain Computer Interface (BCI) is the modern technology which uses the brain neural activity to control the machines, robots, etc. This paper focuses on processing of the signals received from the Electroencephalography (EEG) headset into directions using Artificial Neural Network. The main aim is to control a car using Neurosky Mindwave Mobile headset. The goal is to help people suffering from disabilities and motion syndrome. The EEG headset is placed on the head of the user and signals like Alpha1, Alpha2, attention level, meditation level, blink and raw signals are recorded. The pre-processed signal and feed-forward Artificial Neural Network are used for classification. ANN is developed in 3 layers: input, hidden and output. The six signals received from Neurosky Mindwave headset is given as input to ANN. This will identify the direction of the car to move forward, backward, left, right or stop.

Keywords - Brain Computer Interface, Electroencephalography, Neurosky Mindwave, Artificial Neural Network.

I. INTRODUCTION

Neurons are the basic unit of a human brain and these billions of neurons are interconnected to perform different body activities. Human emotional states and thoughts affects the interaction of neurons. Interaction between the neurons creates electric discharge which cannot be measured individually but can be aggregated into waves which will be measured using EEG technology. Brain activity can be monitored for Brain Computer Interaction using several measurements like electric field and magnetic field. EEG is the most used technique for BCI due to its low cost, less technical complexities

and it is non invasive in nature. In this paper, Neurosky Mindwave Mobile headset is used to measure the brain activities. The benefit of using Neurosky Mindwave headset is that it has TGAM as a primary brainwave sensor which processes and output EEG frequency spectrum. Due to dry electrodes, this module can be used in toys, video games and wellness devices because of its low power consumption which is suitable for portable battery driven applications [3].

The dry electrode is placed on the head of the user to record the EEG signal. The AM digital chip which is embedded inside the EEG headset extracts the raw EEG and convert it into normalized data. This data are categorized into its own frequency ranges types such as delta, theta, alpha, beta and gamma.

TABLE 1.FREQUENCY COMPONENTS OF BRAIN WAVES [10]

Brain Wave Type	Frequency Spectrum (Hz)	Amplitude (μV)	Significance
Delta	0,1-0,3	100-200	• deepest, dreamless sleep • unconscious state • cognitive tasks by frontal lobe
Theta	4,0-7,5	<30	• REM sleep, dreaming • physiological at the age of 1-6 • cognitive task by frontal lobe (Fourier analysis) • Intuitivity, creativity
Alpha	8,0-12,0	30-50	• the "basic" wave of the brain • when stimulated high frequency rhythm occurs (alpha block) • relaxed, but non-sleepy state
Beta	13,0-30,0	<20	• sensory and emotional influences • harmonic, wide awake, excited, conscious state
Gamma	30,0-50,0	<10	• high mental activity

These value received from the Neurosky Mindwave is applied to the Artificial Neural Network. Neural Network has three layers: input layer, hidden layer and output layer. The ANN can be used to train the machine using Back Propagation algorithm. Back Propagation algorithm is much faster than the other ANN algorithms.

A. Motivation

BCI seems to be focused narrowly on medical applications but boarder applicability of BCI exists other than medical use. Due to advancement in deep learning and new algorithms and techniques are explored related to pattern recognition has created a new way to analyze the brain waves received from the EEG headset. This can be used for a person who is suffering from disabilities to carry out their everyday activities.

B. Scope

This work combines both software and hardware components in order to control the car through reading and interpreting EEG waves from brain. The final functionality is to run the software application and control the car without any human interaction with the car.

C. Objective

1. The main objective is to practically manipulate the physical objects through human brain.
2. To develop an application which will act as a interface between the Neurosky Mindwave headset and Micro-controller.
3. To navigate the car using a headset through obstacle course.

II. LITERATURE SURVEY

Ref No.	Problem Addressed	Summary of Solution
[1]	Detecting movement intention for people suffering with Quadriplegia	1. This paper used feed forward neural network with gradient conjugate training and resolve it's performance with receiver operating characteristics. 2. The neural network classify data into two main groups stop and forward which are supervised algorithm.
[2]	Monitoring brain activity with the	1. This paper presented robot control using brain

	help of EEG and Artificial neural network.	activity by utilizing self organizing maps and neural network to recognize thought patterns. 2.The presented method was implemented using low cost commercial consumer grade EEG device. 3. The experimental results showed in improvement of 8 % over ANN based classification.
[3]	Evaluating the brain wave data collected from the neurosky headset and processing it.	This study proposes Universal measuring data collection, preprocessing and visualizing how brain wave signals are measured with EEG Headset. 2. A windows forms application was developed to evaluate and visualize the brain wave data of EEG headset , program was written in c# and developed in visual studio which can also display the signals by a column chart and a time chart.
[4]	Automating the home based on auditory steady state response based on obtaining users EEG signal from auditory stimulus .	1. This paper proposed a system which used auditory signals received from user . Two voice control devices were used in the implementation (smart bulb and smart fan) with accuracy above 90 % for both devices. 2. The experimental result showed that the home automation devices can be operated efficiently and effectively using an individual Auditory steady state response(ASSR).
[5]	Human robot interaction through tele-operation by brain electrical activity	1. This paper presented Human robot interaction by Brains electrical activity in real time with two prototype based on the neurosky system and the Emotiv EPOC headset system. 2. Neurosky prototype was used to sample calm, normal and concentrated states from five users and was visualized with the help of a chart. 3. Emotiv prototype was not only to detect brain signals but also facial expressions. The application was developed in java and Emotiv development kit was used to train a new user profile.
[6]	Classification of Left/Right Hand movement EEG signals using event-	1. EEG data were preprocessed with MATLAB and then was epoched and movement related cortical

	related potential(ERP) and artificial neural network.	potential. Classification was accurate about 65 % for the hand movement and result is acceptable for BCI implementation with little more improvement.
[7]	Classify the facial expression from EEG signals using wavelet packet transform and SVM classifier.	This paper proposed the system using classification of EEG data on wavelet packet transform to classify expression namely: 1. smile 2. Neutral 3. clench 4. Head shake 5. blink 6. Eyebrow rays using a support vector machine
[8]	Actuating a robotic arm with the help of device command receiving from EEG signal.	1. This project develop prosthetic link for amputee. That can help them to do their daily task by a robotic arm by extracting and processing their brain wave . 2. Translational algorithm generates device command from process EEG signals which carry out uses intent if it exceeds specified threshold. 3. The hyper terminal which is a interfacing software takes the output from processed signal and translational algorithm that is the virtual reality of robotic arm.

III. PROPOSED SYSTEM

We propose a system to control a car through EEG signals. EEG Signals received from the Neurosky Mindwave Headset along with other parameters are applied to a neural network as an input. The trained neural network will predict direction in which the car should move which is sent to Raspberry Pi through bluetooth module and DC motor will be used to physically move the car in desired direction.

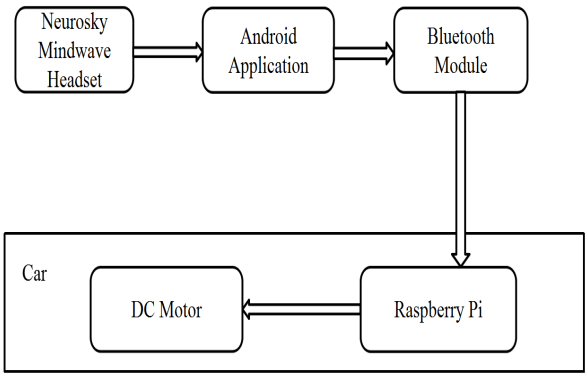

Fig 1: Architecture of the Proposed Model

Neurosky Mindwave headset- The Neurosky MindWave headset measures and output the EEG power spectrum (alpha, beta, gamma, theta and delta waves). The device consists of a headset, an ear-clip, and a sensor arm. It is battery powered and uses the TGAM module .It consists of bluetooth with BT/BLE dual mode module (10 meters range) with Sampling rate at 512Hz . We will use this headset to collect the signal from brain of subject wearing headset.

Android Application-Signal captured from a headset will be transmitted to android application through bluetooth where the signal received is filtered and processed.

Neural network-Signals obtained from EEG headset will be fed to a neural network which will first be trained on a workstation using backpropagation algorithm. We plan on using TensorFlow[12] framework to accomplish this. Pre-trained network can be used with TensorFlow and with the help of transfer learning, model can be trained.

Now the generated model is converted into a file format which TensorFlow Lite understands. Interpreter is fed with TensorFlow Lite model, The interpreter then executes the model using a set of operators. If there is a hardware acceleration present then it can be executed on the accelerated hardware which gives high performance otherwise this can be executed directly on the CPU as well.

Bluetooth module - Bluetooth is a global wireless communication standard to connect

wireless devices. Bluetooth devices, depending on the class, can transmit up to 100m. However, the most common transmission distance for Bluetooth devices is 10m[11]. Bluetooth module will be used to transmit the output of neural network to Raspberry Pi.

Car and DC motor- This paper proposes to use Pulse Width modulation signals to drive a DC motors on the car. TheAndroid application utilized Android Bluetooth API. A Battery will be powered to operate the car. The main components of the car will be Raspberry pi, a motor controller, DCmotors, a regulator, batteries and a plastic car chassis. The car will be able to move forward, backward, left and right. The car will be controlled based on the direction received from android application.

IV. METHODOLOGY ADOPTED

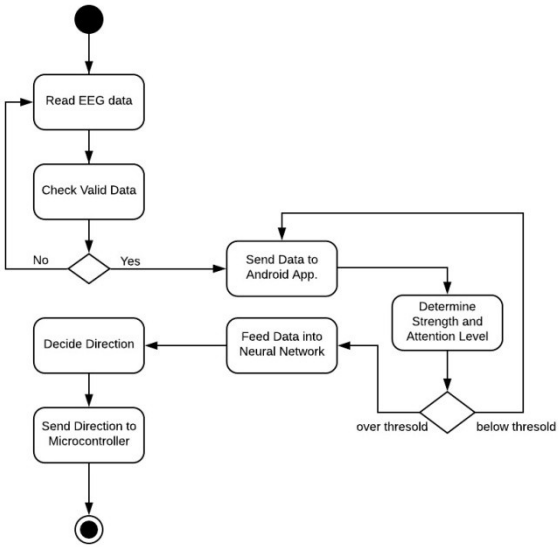

Fig 2: Basic Flow of Proposed System

The EEG signals which are received from the Neurosky Mindwave headset worn by the user are checked if its valid. It is sent to application where if the strength and attention level are above threshold then it is given as an input to the ANN. ANN is pre-trained on the values received from the headset. From the output value of the ANN, the direction is predicted which is sent to the micro controller and the car is moved in that direction.

IV. CONCLUSION

The proposed system will enable the use of brain waves to manipulate the physical object without human intervention. The advantage of this proposed system is to use the EEG signal acquisition headset to collect EEG signal, and then transmits signal by Bluetooth communication to realize the system automation with EEG signal. This model can be further extended to use it for a wheel chair. It will help the person with disability to help carry out everyday activities.

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