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Application of Artificial Neural Networks in Modeling Direction Wheelchairs Using Neurosky Mindset Mobile (EEG) Device

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Abstract

The implementation of Artificial Neural Network in prediction the direction of electric wheelchair from brain signal input for physical mobility impairment.. The control of the wheelchair as an effort in improving disabled person life quality. The interaction from disabled person is helping in relation to social life with others. Because of the mobility impairment, the wheelchair with brain signal input is made. This wheel chair is purposed to help the disabled person and elderly for their daily activity. ANN helps to develop the mapping from input to target. ANN is developed in 3 level: input level, one hidden level, and output level (6-2-1). There are 6 signal from Neurosky Mindset sensor output, Alpha1, Alpha2, Raw signal, Total time signal, Attention Signal, and Meditation signal. The purpose of this research is to find out the output value from ANN: value in turning right, turning left, and forward. From those outputs, we can prove the relevance to the target. One of the main problem that interfering with success is the problem of proper neural network training. Arduino uno is chosen to implement the learning program algorithm because it is a popular microcontroller that is economic and efficient. The training of artificial neural network in this research uses 21 data package from raw data, Alpha1, Aplha2, Meditation data, Attention data, total time data. At the time of the test there is a value of Mean square Error(MSE) at the end of training amounted to 0.92495 at epoch 9958, value a correlation coefficient of 0.92804 shows that accuracy the results of the training process good.

Keywords: Navigation, Neural network, Real-time training, Arduino

1. INTRODUCTION

Human brain is the fattest organ in the body. Brain has 60% fat of the whole brain. The brain weighs 2 percent of the overall body weight. The brain has estimated 100 billion microscopic cell called neuron. Brain never ceased functioning even when the host is sleeping. Neuron can transfer

information in speed of 240 km/hour through the spinal cord. The brain along the neural system accommodate the mechanism to control conscious movement such as moving and thinking. Subconscious activity such as digesting and breathing. These activities can be monitored through equipment called EEG. Electroencephalogram(EEG) is a measurement of voltage fluctuation that is detected from electrode attached to the scalp.
In the invasive BCI system sensor by inserting the sensor into the brain tissue in the outer layer of the cortex or under the scalp or inserted in the inner cerebral cortex (intracortical). Meanwhile, BCI systems are categorized as non-invasive sensors that are not inserted in brain tissue such as BCI-based EEG, fMRI, MEG, and PET. The signal provided by BCI can reveal various information such as brain activity, facial expression, or user's excitement. Electroencephalography (EEG) is the most studied non-invasive interface, primarily due to its smooth temporal resolution, ease of use, portability and low installation cost. But it also has flaws such as vulnerable to noise, another substantial obstacle in using the EEG as a brain-computer interface is the extensive training required before the user can use it properly. The neurons in the cerebral cortex emit very small voltages (mV) electrical waves, which are then passed through an EEG machine to be amplified in order to allow sufficient size electroencelogram to be captured by the reader's eye as an EEG Alpha, Beta, Theta, Attention, Meditation and so on.

That bad recorded brain signals will mislead the process of diagnosis. This process of brainwave measurement and recording is called Electroencephalography, while the tools used to monitor electrical activity in the human brain are known as electroencephalogram (EEG). Electroencephalography (EEG) can assess brain activity during the movement of the body but head movement can cause faint electrocortex signals. Electrodes on EEG are usually made of conductive materials, such as gold or silver chloride, with a diameter of 1 cm. There are two types of BCI systems that are invasive and non-invasive in the process of obtaining brain signals.

Implementation of artificial neural networks greatly simplifies the modeling methodology. It is not necessary to have the function of input and output parameters in real form. If only such a function it will be formed through the network during the training process and will be written as the weight of individual neurons. However it is important that this function exists and has an ordinary and unique character. The implementation of ANN (artificial neural network) in predicting wheelchair direction from invisible voltage inputs makes it very attractive to designers and manufacturing engineers because they can use predictions as part of their design. The prediction using ANN is more complicated by addressing all the stages involved in the simulation process, such as looking into neuron-predictive ANN models, and presenting the results and conclusions from the predictions presented in this work. Controlling a robot or wheelchair through a neural signal is a very interesting idea because there are human limitations in doing a certain job. The control of artificial neural networks is increasingly popular in everyday life such as home automation, healthcare, industry and transportation systems. Those mentioned before are examples of applicable field of ANN.

Because artificial neural networks are a gentle computational mechanism, the proposed approach can be implemented on an electronic prototype platform, for example the Arduino microcontroller program, which receives multiple inputs and can influence its surroundings by controlling the actuator. The Neural Network approach has been presented to develop appropriate stabilization methods. ANN aims to study the behavior of the user or the driver of the wheelchair, by providing a smoother steering and controling the wheelchair's direction like general driver. To improve understanding of nerve signals and how they can be used to control an actuator, this study intends to build a wheelchair control system through nerve signals.

2. RELATED WORKS

This research is similar to that research conducted by Mustafa Ahmned Yousef and Mustafa Ezz EL-din Mohamed [5]. In their research, researchers used Neurosky Mindset as a brain signaling sensor and controlled the speed with PWM in RC cars. Other studies conducted by Tom Carlson and Jos'e del R. Mill'an [9] differed in tools for reading brain signals using Monopolar EEG using 16 electrodes. Other than that, researcher also used P300 method and Canonical Variate Analyis (CVA). Camera in the research of Tom Carlson and Jos'e del R. Mill'an is used as sensors to determine the wheelchair position.
Furthermore, in the study of Vijay khare, Jayashree Santhosh and Sneh Anand Manvir Bhatia [8] has the subject of processing data signal processing with Wavelet Packet Transform and using Radial Basis Function Neural Network (RBFNN). Subsequent research is by Ki-Hong Kim, Hong Kee Kim, Jong-Sung Kim, Wookho Son, and Soo-Young Lee [10]. In their study, they controlled wheelchairs with EEG and EMG. Methods were performed with Linear Prediction Coefficients (LPCs).

The research will be conducted using Neurosky Mindset as the brain signal reader with ANN method and the combination of Alpha, Gamma, Tetha, Delta, Beta, Meditation, Attention, Raw, Total time. Many studies of invasive electrodes have helped to understand the elements of the brain phenomenon. A previous study was able to identify signals from neurosky mindsets for control in a game computer. This has been achieved by using EEG equipment such as NeuroSky which only displays one electrode on the forehead and the other electrode in the earlobe. The user's EEG signal is sent to the computer via Bluetooth to control the played game.
This section is;
1) Obtain an EEG signal
2) Process and classify EEG signals and
3) Use signal classification to control the features in the game.

The solution method uses the NeuroSky mindset for part 1, Fourier transformation and artificial neural networks to classify brain wave patterns in Section 2, and the Snake game uses the classification results to control the characters in Section 3. The signals are then processed. The wave band power is calculated using Fourier transformation. This information is used as input to artificial neural networks that are trained to classify three different mental tasks. Then this classification is used to control the movement of characters in custom-built PC games, and it works.

3. ORIGINALITY

In this research has the originality from a signal obtained from the NeuroSky mindset, which is used to predict & adjust the direction of the wheelchair position; turn right, turn left, and forward using the ANN method. ANN method used in this research helps engineers and designers in the company to plan outputs in the production process or the desired control with easy ANN process on the computer or microcontroller.

Indicates that the developed ANN-based model can predict the induced voltage with high accuracy. The signal is then processed and the wave power is calculated using the Fourier transform. This information is used as input to artificial neural networks that are trained to classify three different mental tasks. Then this classification is used to control the movement (turn left, turn right and forward) of the character in the electric wheelchair.

4. NEUROSKY MINDSET MOBILE DEVICE

4.1 EEG Function

Figure 1. Mindset NeuroSky
Source: Instruction Manual Neurosky Mindset

Sensor NeuroSkyMindset is commonly used in a computer game. The design of NeuroSky headset is light enough and fits in the ear with a probe located on the forehead. This equipment will capture the wave of brain signals and project them into motion games. During that time, the computer will detect the size of the wave generated in a certain scale and then adjust the sensitivity so that the computer game can run. The NeuroSky mindset measures electrical activity in the human brain through electrodes attached to the forehead and earlobe.

The Output from the mindset sensor NeuroSky's:

1.Attention

The measurement of attention indicates the level of user intensity of "focus" or "attention". The value ranges from 0 to 100. The level of attention increases as the user focuses on one thought or external object, and decreases when disturbed.

2. Blink Detection / Heartbeat

The detection algorithm blinks / blinks whenever the user gives an indication of blinking. A higher number indicates "strong" flashing, while smaller numbers show "lightness" or "weak" blinking.

3. Signal quality

Shows the quality of brain wave signals captured good or bad. Based on this the user can decide whether the brain wave signal can be used or not.

4. Meditation

The meditation size shows the mental level of "quietness" of the user or "relaxation". The value ranges from 0 to 100. The level of Meditation increases as the user relaxes his mind and decreases as he or she fears anxiety or stress.

5. Sensor on / off contact

This sensor determines whether the headset is in use, whether the sensor detects and gives a conductive surface clue, such as in the skin or scalp.

The main output of the NeuroSky mindset sensor signal that will be used is the attention signal. In addition, other signals are also used such as meditation signal, alpha signal, raw signal, total time signal. The attention signal will be used as input to ANN to predict wheelchair direction by controlling the DC motor rotation.

4.2 EEG sensor layout

EEG device that is easy to be used, it is a wearable device like regular headphones. This tool has one dry sensor that can be placed on the forehead, the left side, and 3 dry sensors on the left ear for reference. It has a microchip that pre-processes the EEG signal, and transmits the data via Bluetooth. The output data is presented in Table 1. The processing algorithm is not an open protocol, but the FFT on the signal that gives the band strength. However, these strengths are scaled and filtered to connect to one another. In addition, Neurosky mindset has speakers, such as headsets, and microphones, so it can be used for many tasks such as listening to music and order through speaking

4.3 Aligning the Neurosky mindset sensor to Arduino

The EEG / neurosky mindset sensor must be adjusted to work with the Arduino microcontroller. Arduino can only read the input value between 0V and 5V, while the sensor produces an output value between ± 5V.

Table 1. Brain Signal Type

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1 – 3 hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4 - 7 Hz	Intuitive, creative,recall, fantasy, imaginary, dream
Alpha	8 - 12 Hz	Relaxed, but not drowsy,tranquil, conscious
Low Beta	12 -15 Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16 -20 Hz	Thinking, aware of self & surroundings
High Beta	21 - 30 Hz	Alertness, agitation

Source: Instruction Manual Neurosky Mindset

Figure 2. Arduino Uno

From the ANN output the value that has been obtained then distributed to the Arduino microcontroller to control the direction of the wheelchair of the user. The disadvantage of the ANN process is high computation time, so that the decision has to wait for a while to produce a definite output. The architecture has 6 input units that fully connected to the hidden layer of up to 2 units, which is also fully connected with 1 units on the output layer.

5. SYSTEM DESIGN

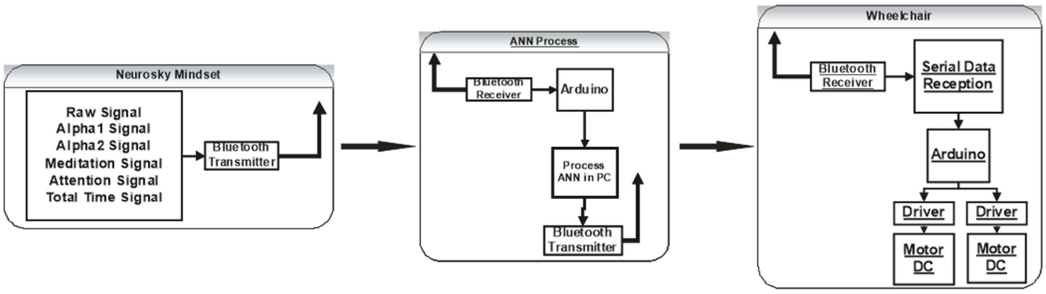

Figure 3: Diagram of Research

From the sensor block system above, the NeuroSky sensor acts as the main sensor that will get the brain signal data in packet data format. The data packet consists of Alfa / α data signals, Beta / β, Tetha / θ, Gamma / δ, attention, and meditation. These headphones will capture signals through brainwave technology devices with electroencephalograms (EEGs) in these headphones. From captured brain waves, the device will recognize the waveform that will be inserted into an Arduino microcontroller. These headphones use Bluetooth connectivity to be integrated with other hardware. In the use of certain NeuroSky mindset sensors, there are four electrodes attached to the appropriate position, to get the right brain signal input. Then the data packet is sent to the microcontroller with Bluetooth modem module.

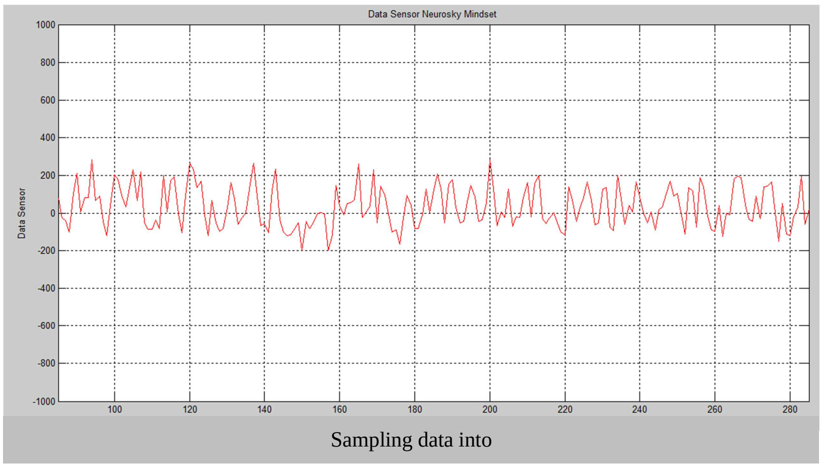

Figure 4: Raw Signal

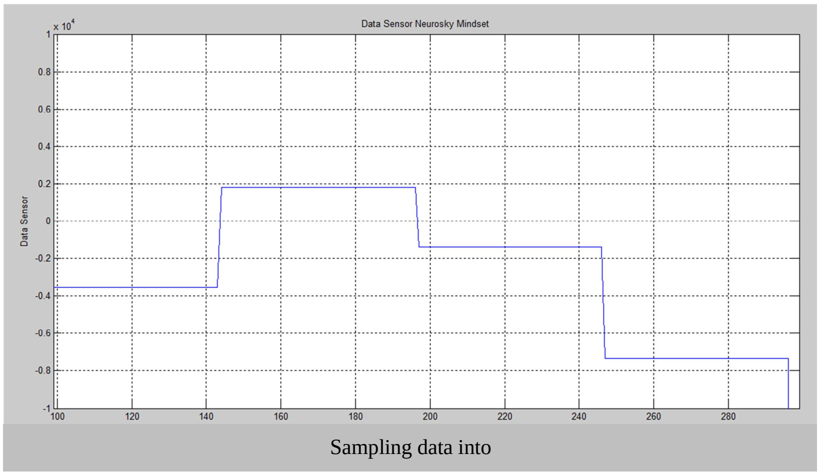

Figure 5: Alpha1 Signal

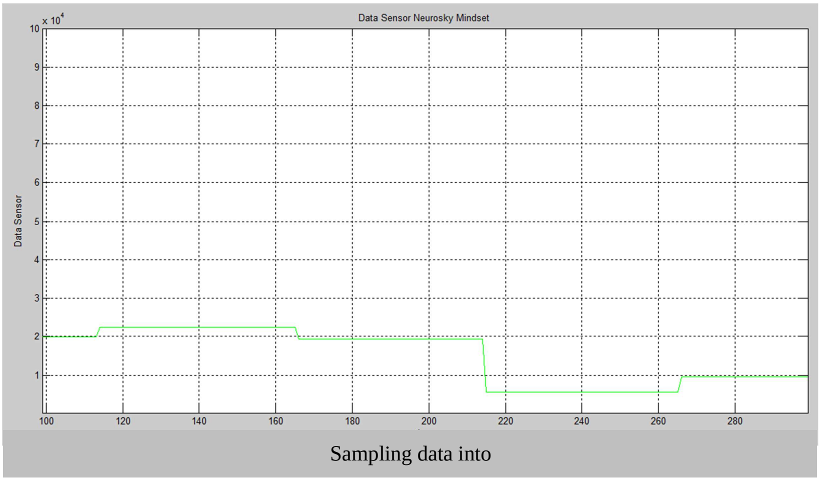

Figure 6: Alpha2 Signal

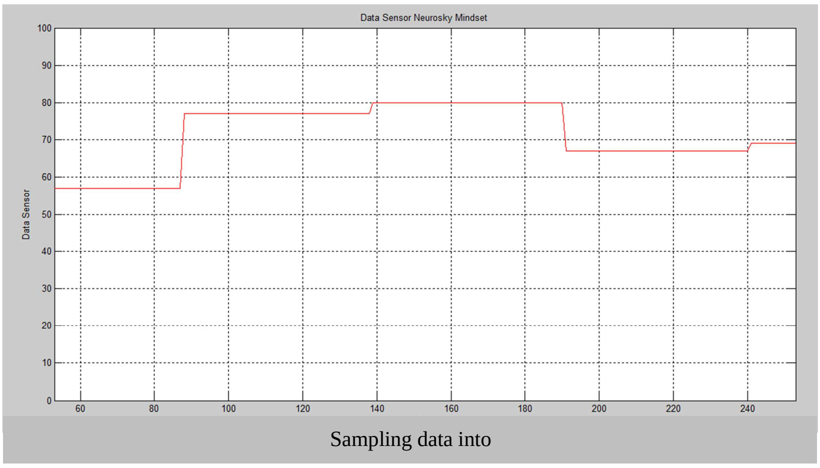

Figure 7: Meditation Signal

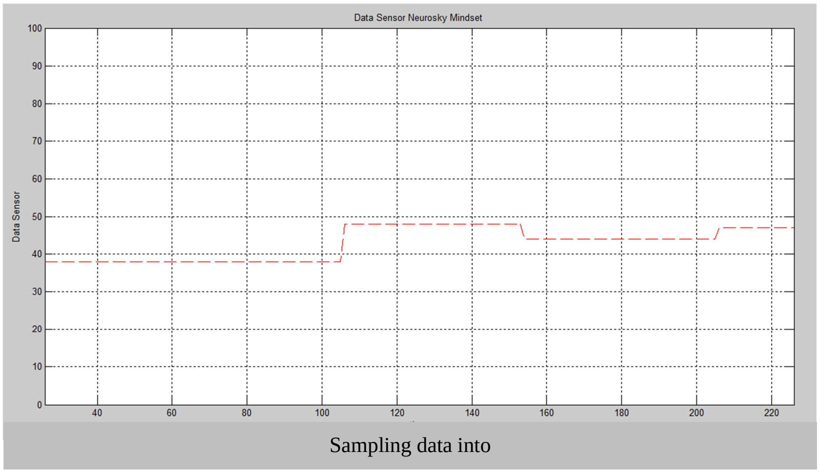

Figure 8: Attention Signal

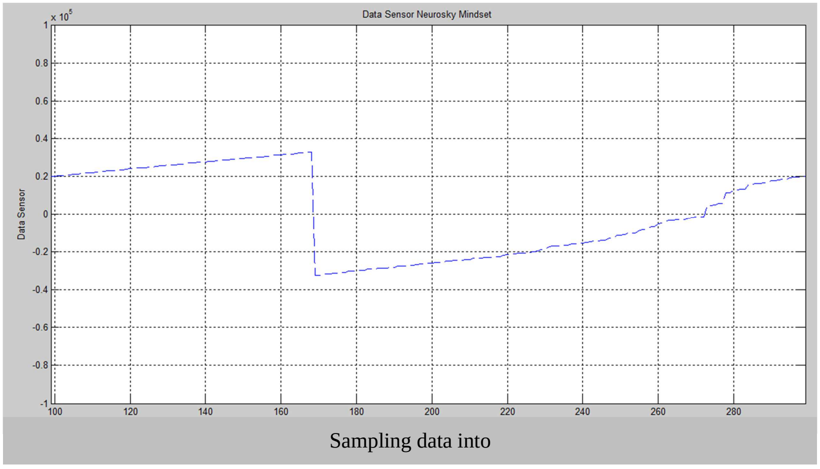

Figure 9: Total time Signal

This bluetooth modem works in serial communication (RX / TX). Because it is wireless, the devices can reach 100 meters' distance from other's devices. By default, each BlueSMiRF module is shipped with a 9600BPS band rate, then adjusts to the Neurosky mindset to communicate with a speed of 115200BPS. Connect BlueSmirf to Arduino in serial way as:

- VCC on bluetooth modem connected to 3.3V arduino
- GND bluetooth modem is connected to GND arduino
- TX-O bluetooth modem is connected to RX-I arduino
- RX-I bluetooth modem is connected to TX-O Arduino

In the back propagation neural network algorithm is used binary sigmoid activation function in which this function is worth between 0 to 1. However, the binary sigmoid function actually never reached the number 0 or 1. Signal from neurosky mindset sensor output is in the form of data packet, this data packet can be read in Arduino monitor series, the value of the various output signals generated by the neurosky mindset sensor are varies in data types.

For Example, the value of attention signal and meditation signal have an interval of 0-100, the value of Alpha signal have integer data type of 0 until 65535. Then raw signal value has long data type so it requires a process of data normalization to reduce large computation calculation. Normalization of data into the range 0.1 to 0.9 is using the following equation:

$$X' = \frac{0,8\,(X-b)}{(a-b)} + 0,1 \tag{1}$$

Where:
X '= normalization result data
X = original data / initial data
a = maximum value of original data
b = minimum value of original data

Table2. Initial data sensor

Data Retrival	Raw	Alpha2	Alpha1	Meditation	Attention	Total time	Target
1	4500	37.5	287.5	76.25	93.75	500	TURN LEFT
2	10875	112.5	337.5	76.25	82.5	3625	TURN RIGHT
3	3125	25	362.5	75	43.75	6750	FORWARD
4	6662.5	25	287.5	75	82.5	1750	TURN LEFT
5	5375	62.5	275	73.75	70	5250	TURN RIGHT
6	3062.5	25	350	75	45	3000	FORWARD
7	375	25	325	76.25	71.25	1500	TURN LEFT
8	11000	25	400	75	83.75	2750	TURN RIGHT
9	7150	87.5	362.5	75	56.25	5500	FORWARD
10	587.5	25	350	37.5	106.25	2125	TURN LEFT
11	1725	87.5	312.5	75	68.75	1750	TURN RIGHT
12	525	25	425	75	51.25	4250	FORWARD
13	8500	37.5	287.5	75	81.25	1750	TURN LEFT
14	3000	25	350	87.5	93.75	3500	TURN RIGHT
15	10125	37.5	412.5	75	32.5	3500	FORWARD
16	4750	25	387.5	73.75	80	625	TURN LEFT
17	1750	75	412.5	72.5	92.5	3000	TURN RIGHT
18	10750	25	437.5	73.75	46.25	6125	FORWARD
19	3125	25	187.5	76.25	83.75	1750	TURN LEFT
20	10625	112.5	287.5	76.25	82.5	1750	TURN RIGHT
21	6500	25	387.5	76.25	47.5	1500	FORWARD

Table3. Data Sensor after normalization

Data Retrival	Raw	Alpha2	Alpha1	Meditation	Attention	Total time	Target
1	0.46	0.13	0.33	0.71	0.85	0.14	TURN LEFT
2	0.97	0.19	0.37	0.71	0.76	0.39	TURN RIGHT
3	0.35	0.12	0.39	0.7	0.45	0.64	FORWARD
4	0.633	0.12	0.33	0.7	0.76	0.24	TURN LEFT
5	0.53	0.15	0.32	0.69	0.66	0.52	TURN RIGHT
6	0.345	0.12	0.38	0.7	0.46	0.34	FORWARD
7	0.13	0.12	0.36	0.71	0.67	0.22	TURN LEFT
8	0.98	0.12	0.42	0.7	0.77	0.32	TURN RIGHT
9	0.672	0.17	0.39	0.7	0.55	0.54	FORWARD
10	0.147	0.12	0.38	0.4	0.95	0.27	TURN LEFT
11	0.238	0.17	0.35	0.7	0.65	0.24	TURN RIGHT
12	0.142	0.12	0.44	0.7	0.51	0.44	FORWARD
13	0.78	0.13	0.33	0.7	0.75	0.24	TURN LEFT
14	0.34	0.12	0.38	0.8	0.85	0.38	TURN RIGHT
15	0.91	0.13	0.43	0.7	0.36	0.38	FORWARD
16	0.48	0.12	0.41	0.69	0.74	0.15	TURN LEFT
17	0.24	0.16	0.43	0.68	0.84	0.34	TURN RIGHT
18	0.96	0.12	0.45	0.69	0.47	0.59	FORWARD
19	0.35	0.12	0.25	0.71	0.77	0.24	TURN LEFT
20	0.95	0.19	0.33	0.71	0.76	0.24	TURN RIGHT
21	0.62	0.12	0.41	0.71	0.48	0.22	FORWARD

Arduino is used as wheelchair direction controller to turn right, turn left or forward. An Arduino board consists of an 8-bit AVM Atmel microcontroller with complementary components that facilitate programming and merging into other circuits. An important aspect of Arduino is in its standard connector, which lets users connect CPU boards to a variety of interchangeable add-on modules known as shields. Some shields communicate with the Arduino board directly on the Arduino board and connected to multiple pins, but many shields can be individually addressed via the I^2C serial bus so that many shields can be stacked and used in parallel. Most boards include a 5-volt voltage regulator and a 16 MHz crystal oscillator (or ceramic resonator in several variants). The Arduino microcontroller has also been programmed with a boot loader that simplifies program uploading to on-chip flash memory, compared to other devices that usually require an external programmer. This makes the Arduino more straightforward by allowing the use of ordinary computers as programmers. Process the data signal in the form of the attention signal value and then give the motor output to 3 conditions.

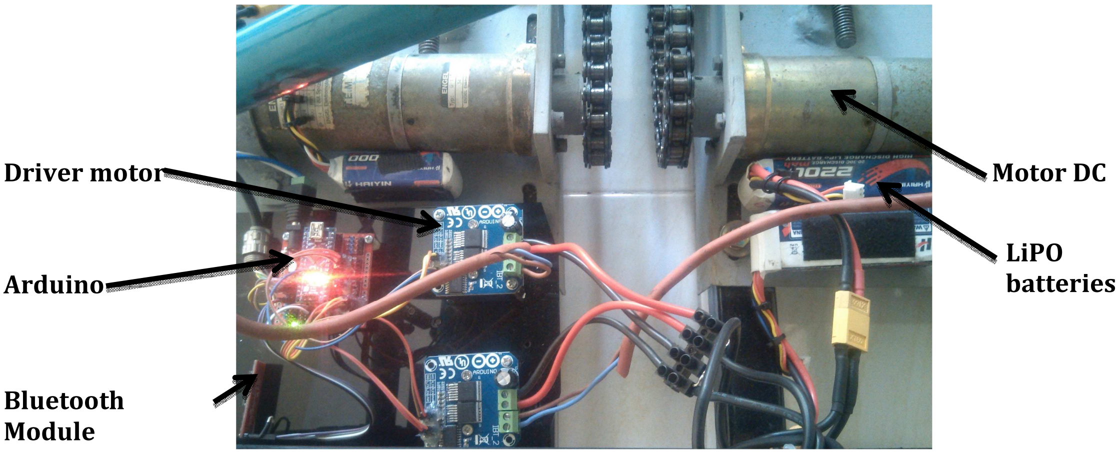

Figure 10: Electronic circuit wheelchair

Table 4. Specifications of dc motor

No	Description	Value
1	Rated voltage	24 V DC
2	Rated Current	5000 mA
3	Maximum Speed	200 RPM
4	Torque	80 gm-cm
5	Weight	700 g

5.1 Artificial Neural Networks Modeling

Backpropagation Algorithm

Involved Algorithm in Backpropagation

1. Initialization: this is usually done before the training. Weight and bias should be initialized. Initialization means adjusting network weight and bias towards its original value. The MATLAB 'init' function takes the network object as input and returns the network object with all initialized weights and biases.
2. Training: training and learning function is a mathematical procedure used to adjust network weights and biases automatically. While the former determines the global algorithm that affects the weight and bias of the given network, the latter can be applied to individual weights and biases within the network. The ANN training basically consists of determining network parameters such as weights and others, which enable the achievement of desired goals based on the existing training set. Typically, multilayer artificial neural networks that are trained, supervised in accordance with back propagation algorithms. The training stops when performance has been minimized to the goal, the performance gradient is below the minimum gradient, the maximum number of moments reached, or the maximum amount of time has been executed.
3. Preprocessing and Post-processing: Nerve network training can be done more efficiently if certain processing steps are performed on input and

network targets (preprocessing). It is often useful to measure inputs and targets before training so that it is always within the specified range. With this approach, the data that are recorded incorrectly and abnormal data are identified and discarded or adjusted using statistical methods to avoid contamination of the model.
4. Simulation: The function of sim simulation 'sim' is to simulate the network. It takes network input and network objects, and then returns the network output. By using a trained nerve network, the estimation results are simulated using input parameters.

5.3 Analysis and Design

A network architecture will determine the success of the achieved target because not all problems can be solved with the same architecture.
The network architecture that will be used to predict changes in wheel direction turn right, turn left, and straight is a network with multiple layers. This model is a network with multiple layers and has one or more hidden layers that are between the input layer and the output layer.
The network architecture can be shown in Figure 11:

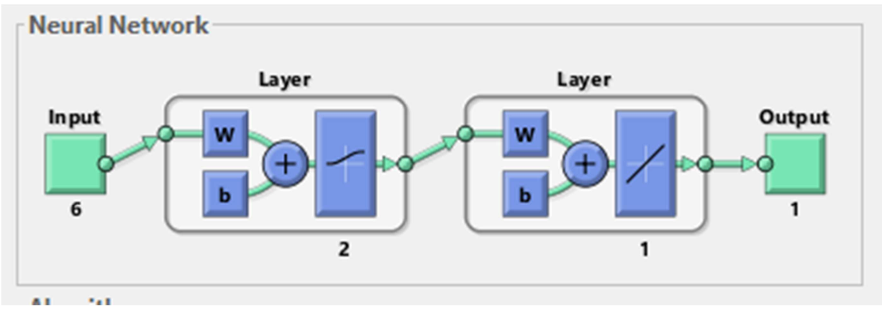

Figure 11: Neural network architecture 1: 6 input nodes, 10 hidden nodes, and 3 output node

The number of neurons in the hidden layer is determined by trial & error. Number of neurons, number of hidden layers, type of activation function, type of training function, target error, epoch number, learning rate, and momentum can be used as research variables in designing artificial neural network architecture.
Weight initialization are randomly assigned because we do not know how the best weight can generate output values near the target weights are initialized with small random numbers consisting of positive and negative numbers.
Trainlm is a training function with Levenberg-Marquardt backpropagation algorithm. It is the fastest algorithm in updating weight and biases compared to other algorithms but requires the bigger memory than others.
From the network architecture, it can be formulated layers and variables used.

1. The input or input layer (X) is a variable affecting the output (Y) with a layer consisting of six (6): Baku, Alpha 1, Alpha 2, Meditation, Attention, Total Time.
2. The hidden layer (z) consists of 10 vertices. To get more precise results, the number of nodes can be changed again and again by entering the number of different nodes.
3. Output layer or output variable (y) with layer 3 (three) nodes is to predict the direction of the wheelchair.
The expected output of the output detects the value to predict the direction of the wheelchair. While the results are as follows:
1. Turn left 90 degrees
2. Turn right 90 degrees
3. Straight ahead
Add the number of Neurons in the Hidden Layer. According to research in journals, the optimal hidden layer is only one, keep in mind, the more hidden layer, the process becomes very slow and sometimes the computer cannot process it and displayed "Out of Memory"
Data table below has been on scale to facilitate the process of data processing by ANN.

Tabel 5. Training data of brain signal prediction change

Data Retrival	Raw	Alpha2	Alpha1	Meditation	Attention	Total time	Target
1	0.46	0.13	0.33	0.71	0.85	0.14	TURN LEFT
2	0.97	0.19	0.37	0.71	0.76	0.39	TURN RIGHT
3	0.35	0.12	0.39	0.7	0.45	0.64	FORWARD
4	0.633	0.12	0.33	0.7	0.76	0.24	TURN LEFT
5	0.53	0.15	0.32	0.69	0.66	0.52	TURN RIGHT
6	0.345	0.12	0.38	0.7	0.46	0.34	FORWARD
7	0.13	0.12	0.36	0.71	0.67	0.22	TURN LEFT
8	0.98	0.12	0.42	0.7	0.77	0.32	TURN RIGHT
9	0.672	0.17	0.39	0.7	0.55	0.54	FORWARD
10	0.147	0.12	0.38	0.4	0.95	0.27	TURN LEFT
11	0.238	0.17	0.35	0.7	0.65	0.24	TURN RIGHT
12	0.142	0.12	0.44	0.7	0.51	0.44	FORWARD
13	0.78	0.13	0.33	0.7	0.75	0.24	TURN LEFT
14	0.34	0.12	0.38	0.8	0.85	0.38	TURN RIGHT
15	0.91	0.13	0.43	0.7	0.36	0.38	FORWARD
16	0.48	0.12	0.41	0.69	0.74	0.15	TURN LEFT
17	0.24	0.16	0.43	0.68	0.84	0.34	TURN RIGHT
18	0.96	0.12	0.45	0.69	0.47	0.59	FORWARD
19	0.35	0.12	0.25	0.71	0.77	0.24	TURN LEFT
20	0.95	0.19	0.33	0.71	0.76	0.24	TURN RIGHT
21	0.62	0.12	0.41	0.71	0.48	0.22	FORWARD

Training begins by initializing the initial weights and bias from artificial neural network backpropagation. The input in the backpropagation neural network model consists of a layer of 6 input layers, 2 layers of hidden layer and 1 layers of output.
While the sample data for testing is as follows:

Tabel 6. Test data of brain signal prediction change

Data Retrival	Raw	Alpha2	Alpha1	Meditation	Attention	Total time	Target
1	0.50	0.15	0.37	0.41	0.85	0.24	TURN LEFT
2	0.87	0.21	0.47	0.51	0.56	0.39	TURN RIGHT
3	0.35	0.12	0.39	0.63	0.75	0.64	FORWARD

The next step is to arrange the trainer data along with the target practice in accordance with the format of ANN programming in Matlab. The training data is arranged to be a 6 x 21 matrix as follows:

Tabel 7. Training data matrix 6x21

0.46	0.97	0.35	0.633	0.53	0.345	0.13	0.98	0.672	0.147	0.238	0.142	0.78	0.34	0.91	0.48	0.24	0.96	0.35	0.95	0.62
0.13	0.19	0.12	0.12	0.15	0.12	0.12	0.12	0.17	0.12	0.17	0.12	0.13	0.12	0.13	0.12	0.16	0.12	0.12	0.19	0.12
0.33	0.37	0.39	0.33	0.32	0.38	0.36	0.42	0.39	0.38	0.35	0.44	0.33	0.38	0.43	0.41	0.43	0.45	0.25	0.33	0.41
0.71	0.71	0.7	0.7	0.69	0.7	0.71	0.7	0.7	0.4	0.7	0.7	0.7	0.8	0.7	0.69	0.68	0.69	0.71	0.71	0.71
0.85	0.76	0.45	0.76	0.66	0.46	0.67	0.77	0.55	0.95	0.65	0.51	0.75	0.85	0.36	0.74	0.84	0.47	0.77	0.76	0.48
0.14	0.39	0.64	0.24	0.52	0.34	0.22	0.32	0.54	0.27	0.24	0.44	0.24	0.38	0.38	0.15	0.34	0.59	0.24	0.24	0.22

Tabel 8. The training target is organized into a 1 x 21 matrix

1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3

Training begins by initializing the initial weights and bias of artificial neural network backpropagation. In the backpropagation training the artificial neural network model used consists of 6 input layer, 2 hidden layer and 1 output layers.

6. EXPERIMENT AND ANALYSIS

The experiment was conducted in a closed room, away from noise or environmental disturbance.
Experiment steps:
1. Experiment with the initial condition of wheelchair user sitting on a wheelchair using a neurosky mindset sensor.
2. Then the neurosky mindset sensor user is given image trigger 1

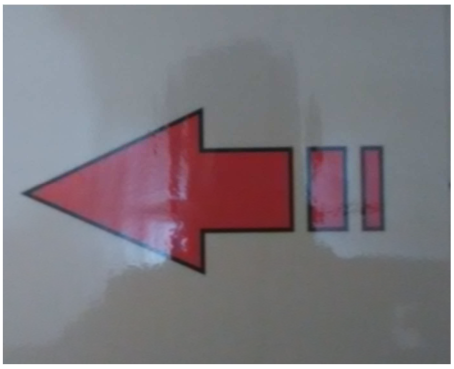

Figure 12: Image Trigger 1

The user is required to view the image and focus on the image with a distance of 2 meters, then the neurosky mindset sensor issues data packets to be processed by ANN then the result from ANN is sent to Arduino to give command to rotate CCW (counter clock wise) to the motor which will change the direction of turn Left 90 degrees from initial condition.

3. Then the neurosky mindset sensor user is given image trigger 2

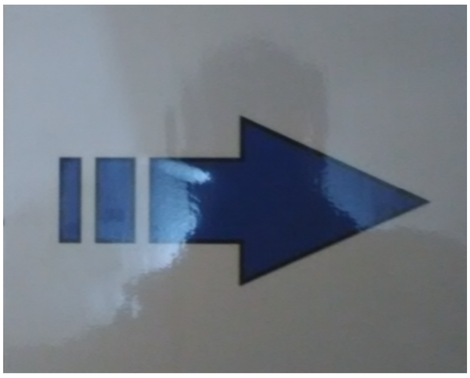

Figure 13: Image Trigger 2

The user is required to view the image and focus on the image at a distance of 2 meters, so that the neurosky mindset sensor outputs the data packet which will be processed by ANN then the result from ANN is sent to the Arduino to give the CW (clock wise) rotating command to the motor that will change the direction to right turn 90 degrees from initial condition.

4. Then the neurosky mindset sensor user is given image trigger 3

Figure 14: Image Trigger 3

The user is required to view the image and focus on the image at a distance of 2 meters, so that the neurosky mindset sensor outputs the data packet which will be processed by ANN then the result from ANN is sent to the Arduino to give the straight forward command to the motor that will change the direction to straight forward from initial condition.
This approach will follow an empirical trial and error model. Uncertainty about what will work with respect to EEG classification, in a real-time environment this approach makes sense. It also makes it difficult to break the goal into easy-to-follow steps, before experimenting. Researcher questions will be a priority, but any interesting findings and experiences should be investigated further and reported. Thus, this research will be a floating process from start to finish, and background information will be incorporated as to be relevant and found; Not only in Chapters 3 and 4. This is done to improve readability. The following figure shows the experimental results of our work.

Figure 15: Experiment Application to wheelchair.

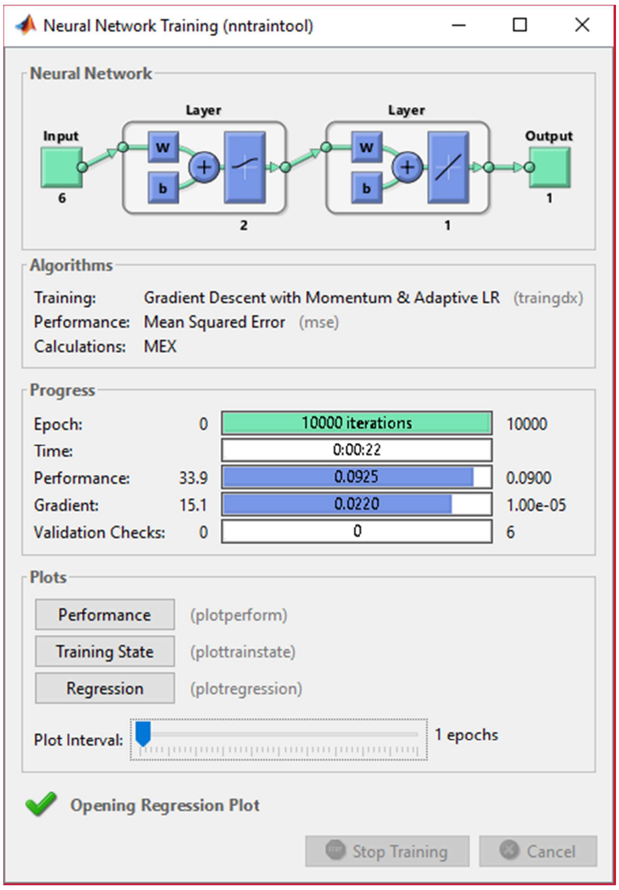

Figure 16: Regression simulation results.

The output of the target by ANN versus output and error is calculated for a review of each iteration course. Then deploy Back Into Neural Network errors and used to review notes and adjusted, thus minimizing the mean squared error output of the between Training Network and its actual output.
Regression Analysis is done once a collection of data is collected, it is always important to determine the relationship between the dependent and independent variables. Regression analysis makes it possible to understand how the value of the dependent variable (or 'criterion variable') changes when there is one independent variable that varies, while the other independent variable is held constant. It's widely used to predict, forecast, and analyze data sets. It can also be used to understand which of the independent variables are associated with the dependent variable. Regression analysis uses different models to predict the value of the dependent variable. This model includes linear regression and simple polynomial. Simple linear regression estimates the value of dependent variables that are linearly related to one independent variable. While the polynomial model is used to estimate the possibility of polynomial relationship between variables. The least squares method approach is used to estimate the best fitting line and model used.

In supplying the voltage, the source is using two LiPO 12v 2200MaH batteries due to high energy density and it is available in stores nearby. The test is done by wheelchair moving both DC motors at full speed and with the collection of constant neurosky mindset sensor data. This produces about 15 minutes of battery life.

Based on the results of the table above, it can be seen that the network recognizes the pattern in slow fashion. From the results, we obtained the best network architecture is 50.1 with the learning rate = 0.03 and momentum = 0.6, and the results of MSE = and percentage = 81.8181%. In this training the error goal (MSE) of 0.092495 is achieved in the 9958 epoch as shown in the figure below:

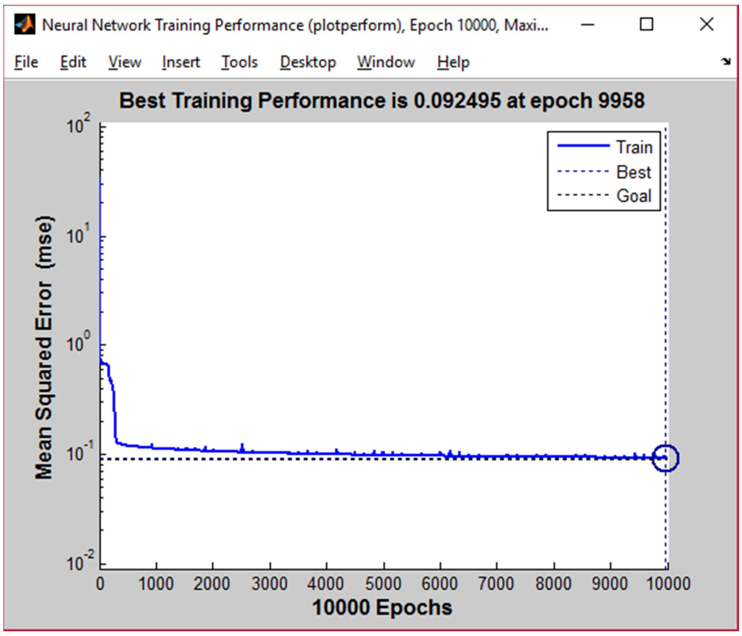

Figure 17: Error MSE and performance

While the resulting correlation coefficient R is 0.98886 as shown in the following figure:

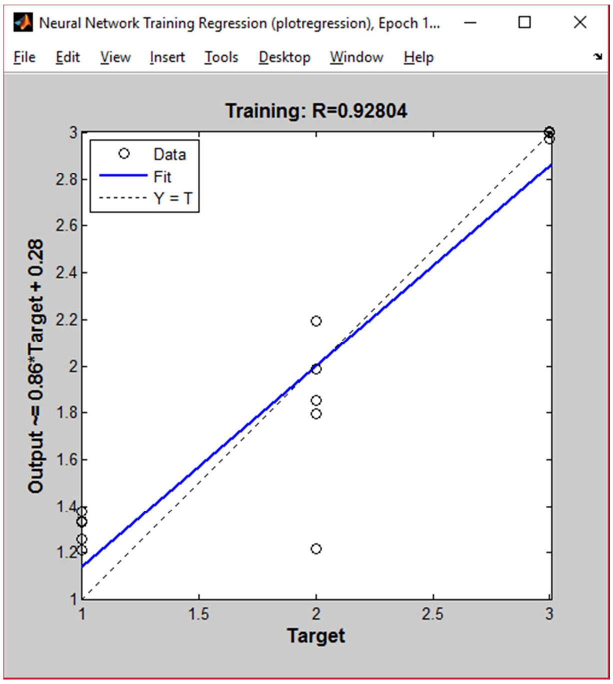

Figure 18: Regression simulation results.

So the results obtained in the command window as follows: 1 3 1

Based on the value of correlation coefficient and the value of MSE (Mean Square Error) obtained in the training process, it can be concluded that ANN can predict wheelchair direction good.
The value of the correlation coefficient and the resulting MSE value in the test process shows that the back propagation neural network is good enough to predict the direction of the wheelchair. Both values can be improved by enriching the training data and changing parameters that affects network performance such as error goal, epoch number, network architecture, activation function type, etc.

7. CONCLUSION

The results of the analysis and design as well translation of the test can be summarized as follows:

1. Artificial neural networks with backpropagation algorithms are able to predict rapid response techniques and high data approximation quality compared to mathematical solutions that have been demonstrated and simulation results are very promising. Backpropagation nerve network is an information processing system that aims to train a network to gain equilibrium between the network's ability to recognize patterns used during training and the ability of the network to respond appropriately to similar (but not the same) pattern of inputs to the pattern used during the training.

2. Close loop wheelchair control is developed using Atmega 168 Arduino microcontroller. The ANN control was successfully implemented on the Arduino microcontroller and tested on the wheelchair control system. The output of the system also matches the theoretical results that indicate better system accuracy. ANN controls can be used for machine control mechanisms with complex load patterns.

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