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A New Detection Control System for Disabled People's Wheelchair

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Abstract

Disability is a state of physical or cognitive impairment experienced by people of different age groups. It results in difficulty adapting to the periphery of people with disabilities because of their inability to move hands, feet or both, delays in learning and response, difficulty to engage in daily activities and difficulty to identifying their feelings, such as being in a relaxed, meditation, fatigue or active state. In this paper, an intelligent control detection system is proposed to help people with disabilities. However, it is characterized by its ability to make emotion identifying easier with people with disabilities. In addition, the proposed system is heavily based on artificial intelligence to become more adapted with disable people. Emotions people are revealed by electroencephalography (EEG) signals of the mindware a Neurosky product that is measured by a sensor placed on the forehead, then it was suggested that a deep neural network be used to classify four types of brain waves so that will can to identify their emotions. The proposed system was tested and the results of the test of the intelligent system for persons with disabilities were positive.

Keywords: *Artificial intelligence; electroencephalography; deep neural network; brain waves.*

1. Introduction

Recent studies by the World Health Survey (WHS) reveal estimates of the number of people with disabilities by about 110 million people and there received a lot of controversy over the fact that there are many ways of diagnosing disability [1]. Disability is a defect in the work of a member of the human body, for example, the inability to identify the emotions. As a result of this, a person is unable to express his emotions to other people. To solve this problem, we try to use the interaction with the machine to better recognize their emotions using intelligent systems. The researchers suggested a system to classify four waves of brain waves to read the feeling of disabled people. The system is mainly based on using the mindware headset produced by Neurosky to read waves of the human mind and then invest them to build an intelligent system helps to classification these bran waves describe feeling because every type of these waves is responsible for a specific feeling like relaxing, active, fatigue or meditation. The system seeks to build consists of the headphones of the mindware which is worn by the disabled.

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Then the brain waves are read and stored after processing in the form of a data set and investing the features for it, and then using the MATLAB program to build a deep artificial network and thus the feeling of the disabled people is determined. However, each type of the four brain waves, is responsible for a specific feeling, for example, the alpha wave is responsible for feeling relaxed, theta wave is responsible for the feeling of meditation, and the delta wave is responsible for feeling fatigue, while the beta wave is responsible for feeling active. Figure 1 describes the main idea of the proposed research.

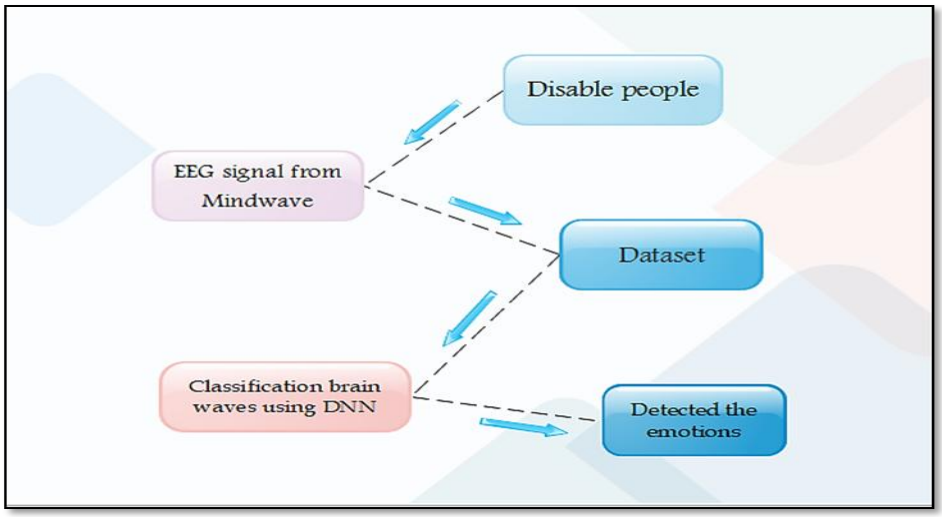

Figure 1. describe the main idea of the proposed research

The problem for people with disabilities, which led researchers to submit this research is the difficulty of knowing their feelings and even the difficulty of understanding their feelings due to their inability to express their feelings as a result of a disability and there are not smart systems that enable them to clarify what they feel. Moreover, the researchers need to find solutions to help them that can be easier to use, more efficient as well as cheap so that they are available to all layers of the people. This research aims to raise the standard of living for people with disabilities to enable them to easily describe their feelings. Because the team that provided the researchers took advantage of modern technology and invested it in helping people and give them appropriate care by designing an intelligent system that allows them to easily describe their emotions by investing brainwaves (Alpha, Beta, Gamma, Theta) produced by mindware device. However, the main important objectives are as following:

1. Employing EEG signals generated by the mindware.
2. Employing artificial intelligence technology (deep neural network) to classify brain waves using MATLAB.
3. Employing brain waves to describe the emotions of disabled people.

This research has contributed to providing an advanced smart system that invests the waves of the mind, giving them the ability to express their emotions to others easily and efficiently.

2. Literature Survey

In this section, some significant previous works are presented related to this work. Utkarsh et al. have developed a custom program in Java. This program

simulates the wheelchair environment on your computer screen [2]. The purpose of this development in graphical user interfaces was to provide individual neurological observations in the form of an optical stimulus so that they could control their brain wave output more easily and enable a more efficient control system.

In [3], authors focused on using an Android-based application for this project to control the movement of an electric wheelchair where they developed an algorithm capable of reading and manipulating EEG data from a Neurosky headset and a mind wave headset in a mental matter. After processing the data, this program sends a signal to the connected HC-06 on the board of the wheelchair controller where the electric wheelchair is able to move as desired by the user using this application.

Kara et al. adopted the use of EmotivEpoc Neuroheadset headset low cost and easy to use and is able to measure the brain activity of the wearer using 14 sensors [4]. In addition, there are gyroscopic sensors in the headset that can detect the direction of the headset. Charles et al. relied on wheelchair movement control using the wireless network, designed to provide timely support to patients with disabilities as well as to Cheap price [5]. The movement is done immediately based on the patient's brain wave values using this setting.

Utama et al. have been improved the fact that people with wheelchairs can achieve optimal safety settings by using distance sense which means the wheelchair avoids hitting a wall or object in front of it [6]. In [7], researchers have sought to make use of modern and low-cost technological devices at the same time to make a special interaction with the wheelchair in order to help people with disabilities. The eye blinked and then processed to control the movement of the wheelchair automatically.

Keong et al. have been focused on assessing the extent to which the EEG headset Neurosky-mindware can classify brain waves when the numbers of electrodes that we are needed reducing [8]. This means using cheaper EEG headphones that allows a wide range of people to diagnose a mental condition in an affordable and easy to use way.

Girase et al. demonstrated how to control a wheelchair using EEG signals obtained from the human brain [9]. As a result, the wheelchair is controlled using brainwaves measured using the mindware. In [10], researchers intend to help people with disabilities and make them more independent. By developing the mechanism of using human waves to control the robot based on the Brain-Computer Interface (BCI) and using lad view to analyze brain waves and invest them to move the wheelchair. In [11], the researchers aimed at this project to show a way to control a robotic car using Neurosky mindware by connecting the robotic car with Neurosky mindware and the computer wirelessly.

Selva et al. modified the wheelchair-driven propulsion mode one [12], where they managed to control the wheelchair through laptops by developing remote control unit. They also added two webcams, a display screen, and 10 sonar sensors. In [13], authors proposed a wheelchair control via Bluetooth with mindware headphones, as it is an ideal way to use it for the elderly and people with disabilities to increase their activity and job performance. Being the slide used for wheelchairs.

In [14], the researchers aim through this research the possibility of controlling the car to help people with disabilities or who suffer from movement syndrome. That by investing readable brain waves using the mindware device so that after collecting the EEG signal, they are going to using artificial intelligence technology known as the artificial neural network to control the direction the car is going or Stop this car.

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In [15], authors in their research suggested using and investing EEG signals to be able to distinguish human emotions and then classify them using the many Kohonen neural networks that are modified for human emotions. In [16], Salih et al. have been proposed a control system to makes possible use of the keyboard by physically disabled people by using EEG signals that are read by the mindware device. Where the keyboard key can be chosen in conjunction with the flash of the eye.

In this paper, an intelligent system is proposed that determines the feelings of people with disabilities by classifying brain waves. However, people with disabilities wear in their heads a mind wave device that has a sensor placed on the forehead and through this device brain waves are read and then we include artificial intelligence and invest the deep neural network to classify brain waves using the MATLAB program so that we can then determine to feel disabled people.

3. Neurosky Technology

Neurosky technologies represent vitality sensors. The basis for the work of these sensors is based on the analysis of biometric data, which was not previously added in any product or technology provided. These technologies are one of the wearable devices and are easy to move from one place to another without discomfort. These technologies are invested in many research institutions, where the effectiveness and quality of this technology have been demonstrated by these research institutions. There are four products of mindware Neurosky namely declared as following:

- Mind wave.
- Mind wave mobile.
- Mind wave mobile plus.
- Mind wave mobile two. -

Figure 2 displays four products of mindware Neurosky. Computer games and many research programs and applications can be designed using Neurosky mindware headphones. As for Mind wave, mobile has invested in improving motion control or attention for low-attention children.

Figure 2. mindware device types [17]

Mind wave is one of the Neurosky product that is the most suitable device to be utilized for the process of reading the brainwaves and to benefit from any change in the process of implementation of any other effectiveness. Mind wave describes the mental state of the person wearing it in the form of Neurosky proprietary Attention {Attention

measurement refers to the intensity of the user's focus}and Meditation {Meditation measurement refers to relaxation} eSense algorithms. Mind waves interact with the brainwaves of the person wearing the device through Sensor touching the forehead called ThinkGear, a technology found in all Neurosky products. By the Think Gear chip, we can calculate the brainwaves and also the eSense {Attention and Meditation}. The values calculated by the ThinkGear chip, via headphones, are extracted to a computer. Components of mind wave device are mentioned below [18]:

- Adjustable Head Band
- Sensor Tip/Arm
- Ear Clip
- Power switch
- Battery Area
- Flexible Ear Arm

Electroencephalogram (EEG) is reading the signals of the brain and these EEG signals are measured by the electrodes that are placed on the scalp. In most cases, wet electrodes are used due to their low cost, but they need time when used and they are considered to be permanently unwanted given that they need to raise the outer skin layer. So that, it has been Later developed to dry electric poles that are becoming more used and more desire and there is no need any gel material is placed between poles and scalp and also do not need to lift the outer skin layer of the head. Due to these posts provided by EEG, they have been invested in the mindware device to help in reading the human brain activity.

Esense is an algorithm that describes a person's state of mind. This algorithm belongs to a company Neurosky. The basis of its work depends on amplifying the brain wave signal and then using this algorithm on the remaining signal after removing noise and muscle movement and this ensures better results for the user. Neurosky products contain two types of esense (meditation esense and attention esense) algorithm. Attention esense represents the intensity of the user's level of concentration and its value is between 0 to 100 and this value may be less in cases where the concentration level is low. The meditation esense algorithm represents the level of meditation and relaxation of the user and its value is limited between 0-100 and the level of meditation can be in cases of anxiety less value.

4. Brain Waves

They are electrical waves divided into several frequency bands. Each of these areas is concerned with representing a particular type of mental activity. This means that depending on the mental activity of the human being and the sensations. However, high-frequency waves represent a state of high concentration and high activity, while low-frequency brain waves represent fatigue, relaxation, and sleep. This leads us to say that brain waves represent many things depending on where they appear in the brain. Hertz is the unit used to measure the frequency of brain waves. Brain waves are classified according to frequency bands into four types as follows [19]:

1- Delta waves: The frequency ranges from 0 Hz to 4Hz where it represents the slowest brain waves. During meditation, stress, and deep sleep, this type of wave is created.

2- Theta waves: their frequency ranges between 4Hz-8Hz. This type of brain wave is responsible for dreams and in most cases these waves appear during sleep (but not deep sleep) and in most cases appear in cases of long Meditation.
3- Alpha waves: the frequency between 8Hz-12Hz These waves represent quiet mental activities, which means that the brain is aware of what is going on around it, but it is ineffective. This can be likened to the STAND BY status of the computer where the computer does not perform any action that needs the processor but is ready to receive any alert.
4- Beta waves:12HZ-40HZ Beta waves appear when we act, think, and listen. These waves are in the turn divided into three beams:

- Low beta waves: 13Hz-15Hz.
- Beta waves: 15Hz-22Hz.
- Normal beta waves: 22Hz-30Hz.

5- Gamma waves:40Hz-100HZ Gamma waves represent the highest values of frequencies and thus are the fastest waves where they represent the cases of focused and orderly thinking. Figure (4) display the brain wave types.

However, figure 3 displays brain wave types. that the human brain is made up of five types of waves, and each of these waves has a special frequency band and several activities.

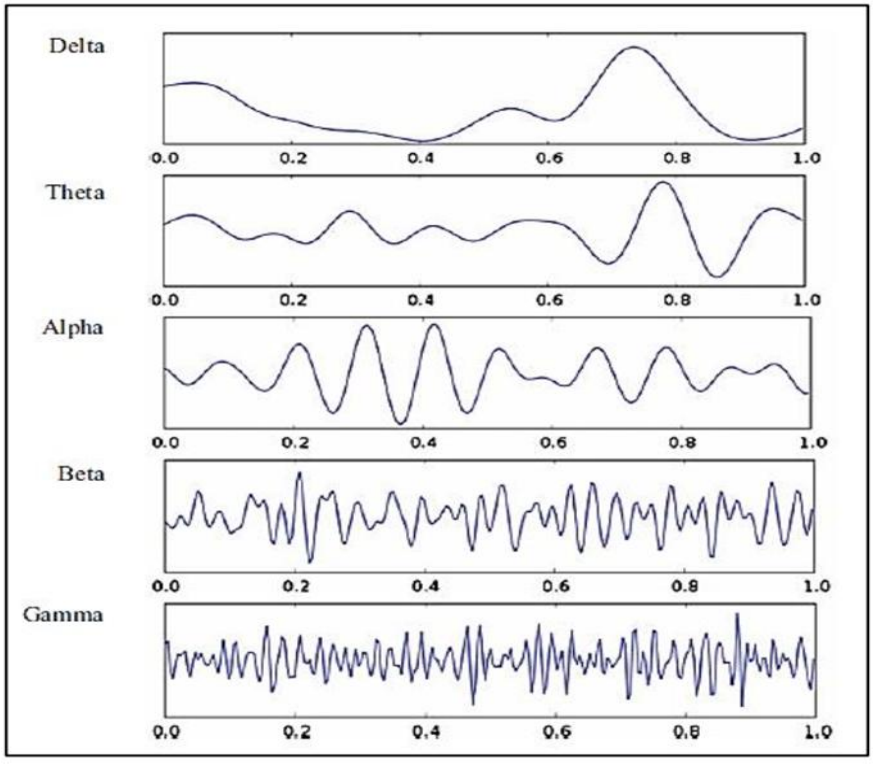

Figure 3. display the brain waves types [20]

5. Device Configuration

Mind wave that utilized in this paper is required basic components and/or some requirements to ensure proper use of the device and also obtain correct results. However,

below is an explanation of these requirements that must be considered when connecting a mindware device to a regular computer or a MAC device because the mindware device is configured to communicate with any kind of it, as follows:

a. Operating system: For PC Windows 7/XP. As for Mac devices, it required Mac OS X 10.5.8 or previous versions.
b. Processor: For both PC and MAC required to have Intel Core Duo.
c. Memory: There is required to have at least 1GB for PC and MAC.
d. Hard disk: The PC or MAC should have 1GB disk space.
e. USB: Should there is a USB port in PC and MAC and is available.

Battery: Running mindware requires 1AAA batteries to operate. Therefore, you should pay attention to changing the batteries whenever required. And to find out if the battery is low or not, we operate the device by pressing the play button, and if the light when operating blinks this indicates that the device battery is low and must be replaced.

Using mindware: Before we start using the device, we need to make sure that we are wearing the device properly in order to ensure that we benefit from the features and functions that the device provides.

- We have to rotate the sensor arm approximately 90 degrees to be more comfortable and convenient when using it.
- Make sure to touch the front sensor arm of the forehead, as the device must be removed and reset to make it touch the forehead.
- After that, we remove the ear hook behind the left ear and fasten it to it. The metal part of the ear hook should be in contact with the earlobe and jewelry should be worn in the ear to ensure provide appropriate contact with the skin of the ear.
- To ensure a clean signal, you must make sure that the forehead sensor touches the forehead, as well as you must remove makeup and keep hair away to avoid interference with the connection.

However, Figure 4 displays the correct way to wear the mindware device.

Figure 4. displays the correct way to wear the mindware device.

6. Dataset

Word "Dataset" is comprising of two words (Data + set). It means a set of data. So, by data word [21], we mean the set of facts and information that are relevant to the problem that is being to find solutions to them, and thus the data, whether (physical or digital), it represents the cornerstone that contributed to the progress of different technology and science. The dataset that is used in different scientific fields to conduct research and different experiments has been able to analyze, classify, and record observations. This means that the dataset adds to the research enhancement and makes it more developed.

But, to ensure that the desired results are obtained from conducting the research when using the dataset, researchers must consider using a dataset with data that is sufficient to lead to achieving access to all the desired search results. This means that the use of a dataset in the research requires that the researcher be fully aware of how to choose a suitable dataset for use in the research to reach the desired results.

7. Methodology

In this paper, a new intelligent system is proposed to help disabled people. However, it is composed of the following stages namely:

1. Generate Mindware Signal:
   Firstly, the brain signals are read by a mindware device, and then these signals are collected, processed, and stored as a dataset, and take advantage of the features of these signals to be able to classify these signals using artificial intelligence technology DNN.

2. EEG Signal – Mind wave:
   Using brain signals is easier and more effective to detect the different emotions when the mindware device is used because in this case. It depends on brain waves to detect the emotions and thus it is appropriate even for cases where the person is disabled and which is difficult for him to describe the emotion. In an environment far from noise, brain waves are calculated. When the brain waves are less than 4*Hz*, this represents the delta brain wave, and when the frequency is more than 4*Hz* and less than 8Hz, the current brain wave means theta, and so on for the alpha brain wave whose frequency ranges between eight to 12*Hz* and the beta wave, whose frequencies range from 12 to 40*Hz*.

3. Employing Artificial Intelligence (AI) on this signal dataset:
   The intelligent system was built using an Intel Core i5 (8th Gen) processor with 8GB of RAM and using the MATLAB version R2018a. Human brain waves are classified using the Artificial Intelligence Network (DNN), a mathematical technique designed to simulate the way the human mind performs a certain task. It consists of more than one layer of the artificial network and also consists of more than one hidden layer. However, the classification of brain waves means that when the type of brain wave is within the alpha range, the system is trained to detect a particular emotion and when the type of brain waves is in the beta, delta, or theta range, then the system is trained to detect another specific emotion. of the data for dataset 1 and data for the dataset, 25% were used during the training phase.

4. Test the proposed system to make sure the target is reached by classifying the control system using DNN technology to achieve relaxation, meditation, fatigue, or active emotions for disabled people. However, all the phases of the control system are designed and showed in the order through the following flowchart. Figure 5 shows the phases of the proposed control system.

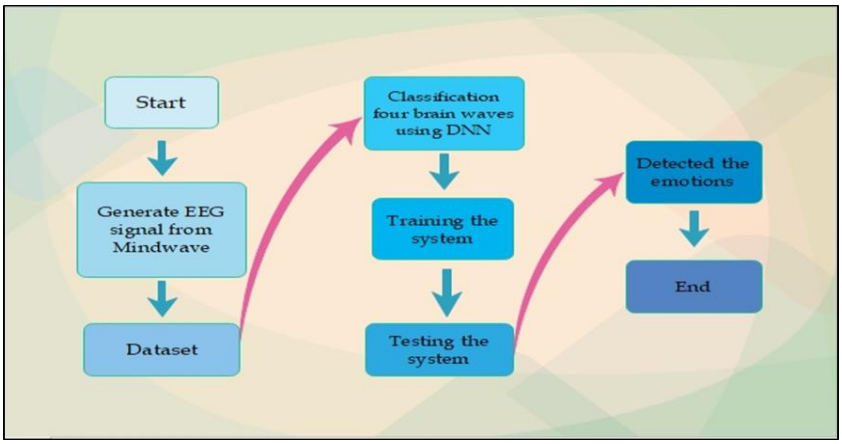

Figure 5. the phases of the proposed control system

8. Experimental Results and Discussion

Through the course of the experiment that was applied for people with disabilities, the following data were taken data for Alfa, Beta, Delta, and Theta for the patient from the to make the emotions depending on the signal that comes from the brain. Feelings of people with disabilities are categorized using DNN, and 25% of data from both datasets 1 and dataset 2 are used for the training process, as well as the use of another 25% during the validation stage. The following figures illustrate the results that we reached from intelligent system training with an explanation of the change that occurs in the results that we get when the hidden layers of the network change in each round where the system was trained using two datasets and each dataset have values of different data and then the system was tested by comparing the results obtained from the training of dataaset1 and between the results of the data training of datalet2.

Figures 6 shows the error graph, which is calculated after training the neural network, as this graph shows errors between the target values and the expected values after training the network. The y-axis in the graph displays the number of data used from the dataset. The bins that are included in the charts in the table mean the number of these vertical bars in the charts that show the variance of the network error and the error range is divided into 20 boxes and each box has a width.

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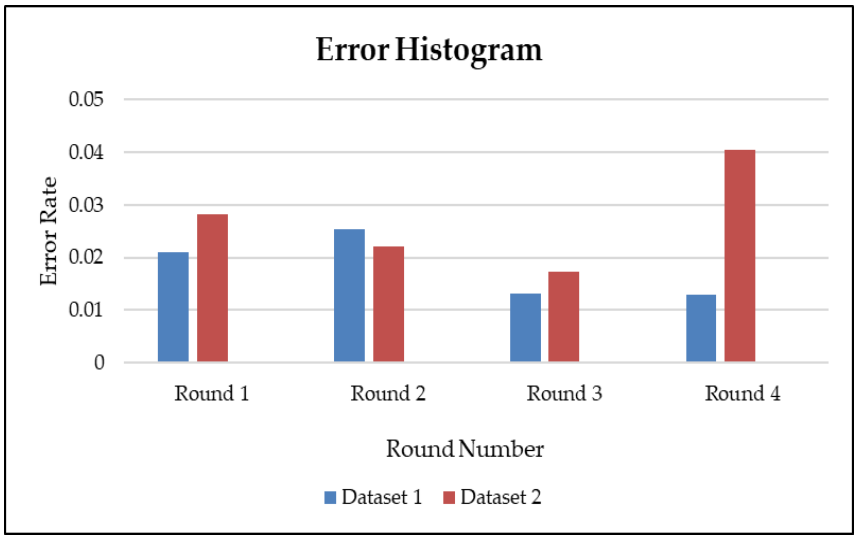

Figure 6. The change of error histogram in each round and dataset

However, Table 1 displays the performance of the network. Therefore, through this table, we explain to what degree the training process has reached the network, and the training line in the drawings represents the state of network training it has arrived.

Table 1. The change of performance in each round and dataset

Round	Performance	Subset_1	Subset_2
Round 1	At Epoch	11	8
	Best validation performance	0.541%	0.568%
	Accuracy	99.3%	96%
	Hidden layer	4	6
Round 2	At Epoch	16	14
	Best validation performance	0.529%	0.538%
	Accuracy	98.2%	99.1%
	Hidden layer	10	12
Round 3	At Epoch	16	11
	Best validation performance	0.569%	0.548%
	Accuracy	98.75%	99.2%
	Hidden layer	14	16
Round 4	At Epoch	23	17
	Bes validation performance	0.528%	0.560%

	Accuracy	99.3%	99.13%
	Hidden layer	18	20

The confusion matrix rate is shown in Figure 7 with various samples of datasets. These matrixes enable us to predict how the classification algorithm will perform or what is problems that have [22]. This matrix shows the types of errors committed by the classification model and also shows the number of valid predictions and the number of incorrect predictions and their division according to the categories to which they belong.

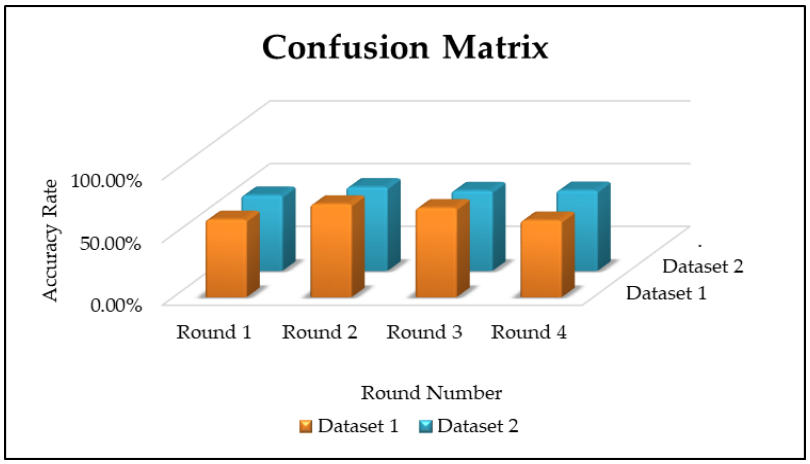

Figure 7. display the confusion matrix of using two datasets

By comparing the results obtained in this research to determine the feeling of persons with disabilities using the Deep neural network (DNN) with the results obtained by the research presented by Hemanth [15], which depends on the use of Kohonen Neural Networks (KNN) to determine the feeling of people, the results of the proposed methods indicate All of these methods give good results when used to determine emotions.

9. Conclusions

In this research, an intelligent system is proposed to describe the feeling of people with disabilities, and in this way, it helps in identifying the emotions by classifying four types of brainwaves that read from the mindware device that the disabled people wear to enable them to describe their emotions. In any case, this system gets much data and determines the feeling. The data obtained from the dataset is trained using the deep neural network and using the MATLAB program, after which the trained data is verified and then tested and this is an effective way to help disabled people. This system gives effective results as it can be used easily and is characterized by low cost.

In the future works, an intelligent system proposed in this research contributed wonderfully in providing a system that enables us to understand the feelings of people with disabilities and we aim in the future to use devices such as Arduino to expand the benefit of reading brain waves from mindware device to contribute to moving the wheelchair for the disabled people by building an intelligent control system.

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