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Communication Device for Locked-in Syndrome Patients

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Abstract: Here a Brain Computer Interface (BCI) technology to analyze the brain waves along with controlling a device as well as analysis of the EEG signals BCIs are interfaced through the humanoid brain signals along with gadgets by decoding brain activity in real-time action commands. The project will be implemented using ML [machine learning] and IoT[Internet Of Things].

Keywords: EEG, IOT, BCI, IoT, ML, EPOC.

I. INTRODUCTION

Attachment of bio-sensors on the head surface electrical signal frequencies may be determined. Interfacing human mind with the system where people suffering from the so-called locked-in syndrome can communicate some predefined messages. Head surface is being attached with metal electrodes, as well as conductive media, being a measurement of electrical activity is defined as the electroencephalogram (EEG). Brain wave patterns are unique to individuals. To obtain the basic brain signal patterns from the individuals, they should be relaxed with eye closing state. Brain wave patterns consist of RAW EEG Signal, Attention, Meditation, Eye Blink and Fundamental frequencies. Brainwave sensing devices are sending the analogue electrical signals, digitizing as well as amplifying them. Brain sensing module decoded brain signals as well as connecting with the computer to observe our brain activities.

II. RELATED WORK

Here we introduce each paper based on the technologies used in the EEG based systems.
This paper [1] is about a brain-controlled wheelchair based on EEG-SSVEP Signals classified by Nonlinear Adaptive Filter. This paper is about to help people who are severely disabled who cannot control a normal electric wheelchair. Here, the project based on electroencephalogram based steady-state visual evoked potential (EEG-SSVEP) is the most important tool used for the measurement of cognitive function in both research and medical fields. The method used in this paper is firstly a Data Acquisition by participating nine people aged between 24 and 26 who have different levels of experience in BCI studies. Secondly, the feature is extracted by eliminating noise interfering with the signals by identifying a non-linear model between the immeasurable interference and the noise source. Finding a good model structure and estimating parameters from these in a linear and non-linear signal processing is a general problem. This is a working and viable tool that is also helpful for other projects.
The aim of the paper [2] is to create a wheelchair that can be used by patients who are experiencing locked-in syndrome to control a wheelchair using their eyes. For this the eyes of the user is tracked at all times using face detection. Then the training is done on what kind of eye movement should occur when what type of movement occurs with the eye. This is then coupled with EEG signals to help achieve the most accurate output that will make the experience of the user even more comfortable.
The aim of this paper [3] is to make a brain-controlled wheelchair with combined EEG and EOG signals.NeuroSky Mindwave headset is used for acquiring brain signals. The classification of both EEG and EOG signals is done using Principal Component Analysis Algorithm. The movement of the wheelchair is paired to different brain signals after the classification. In this paper classification accuracy is about 93%.In the future, by using multi-electrodes a good tolerance with respect to noise and artifact can be acquired.
The aim of this paper [4] is to make a brain-controlled wheelchair with EEG signals and voice cues. In this paper, EEG signals are captured using a Neurosky ThinkGear module. The captured EEG signals are classified using Independent Component Analysis Algorithm. The output of classification is interpreted as commands for different movements of the wheelchair. This system shows a classification accuracy of about 93%.In future scopes,multi-electrodes can be used to extract the EEG signals.

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The aim of this paper [5] is to develop a brain-controlled wheelchair for completely paralyzed people. In this paper, EEG signals are used to control a wheelchair. In this paper, a mind wave mobile is used to capture EEG signals and send them to the corresponding processor module. Here an STM32 microcontroller is used for the detection of EEG signals. During the detection of blink signals, an approximate threshold is set. The different blink responses are used for different movements of the wheelchair.EEG is not fully utilized in this paper. Adaptive Threshold Setting can be used in future projects.

This paper [6] writes about the brain-computer interface which is implemented in the internet of things. Our body is connected with the brain and it gives the command to them, Brain-Computer Interface(BCI) is the method of interaction of the brain with a computer. There were a lot of sci-fi movies released based on BCI in the '90s and '20s. The science behind the brain is that the commands given to our body by the brain are subconsciously done. So as part of the research, the signals to the body by the brain neurons are found to be electrical signals. As a result, the idea of BCI came such a way that if we take this electrical signal and identify we can also control our other equipment using the brain. Polygraph and Stress, Functional Magnetic Resonance Imaging (fMRI), Reconstructing Visuals, Identifying Thoughts and Intentions can be done through reading the brain. Electroencephalography(EEG) helps to read the brain waves easily. There are two types of EEG invasive and non-invasive methods. The invasive method is such that EEG electrodes are surgically implanted in the brain. The non-invasive method is that various electrodes are placed around the head to read the brain signals. There are various consumer EEG devices such as NeuroSky's MindWave, Interaxon's Muse, OpenBCI, Emotiv EPOC, and Insight. BCI is a vast field having so much researches and it is an evolving technology. Connecting the brain with IoT brings a vast area to open the picture of our brain and possibilities of what humans can do just by thinking.

This paper [7] presents the method of invasive electroencephalography monitoring. For many instances like extratemporal lobe epilepsy or non-lesional temporal lobe epilepsy, Routine scalp EEG recording is not sufficient. For this, we need precise electrographic localization of the seizures where Electroencephalography(EEG) can be a good replacement for the precise localization of the seizures. So in order to achieve this, we need to use the invasive method of EEG rather than the non-invasive method by placing EEG electrodes around the surface of the brain by implanting those electrodes into the brain. These electrodes are called invasive electroencephalography (iEEG). It can be also used to find the important functional areas of the cortex. Subdural grid electrodes or Depth electrodes are mainly used as iEEG. There may occur various complications for iEEG, such that superficial infection, intracranial hemorrhage, cerebral infections, and elevated intracranial pressure. While planning for EEG we need an excellent neurosurgeon and an epileptologist who can know the location of electrode placement, type of the electrodes to use, choice of arrays, length of recording, mapping of the eloquent cortex, and surgical planning and decisions. iEEG requires expertise in many things and also it is very helpful in the surgical management of epilepsy.

This paper [8] proposes the security to protect the property of the people using smart home automation system containing GSM security systems. Smart homes are a widely researched area and the people for the last decade have shown very interest in this topic. In this project, a microcontroller device embedded on an Arduino board is used in the system design. It is based on an R3 Board ATmega32 corresponded with an R3 Ethernet Shield and this IDE can be programmed using Arduino software in which C language is used. A GSM Shield is used to send messages and also to receive messages where it is operated using a SIM card so that the user who uses this can get access to the network. The microcontroller can access the internet through an ethernet shield which gives the network stack having UDP and TCP. If a photo is taken using the camera in the house it can be sent to the database through the secured connection of ethernet and it can be received by the user so that he can see his property full and well if he is far away from home. Through SMS communication, the changes in operation modes, any attacks, etc can be informed to the user.

This paper [9] proposes the noise level classification that occurred in EEG signals using Hidden Markov Model. The communication between the neurons in the brain is using the electrical spikes between them. And all the information needed for the function of various properties is contained in each of these spikes. In order to read these electrical spikes, EEG is used. Mainly EEG signals are used in order to examine the diseases. Most of the signals contain noises which decrease the clarity of data present in the signals. There can be a higher amount of noises or lower. Here, in order to detect the noise in the signals, an automated measurement is used and the features are extracted using the Mel-Frequency Cepstrum Coefficient (MFCC) and are clustered into different groups. The short-term power spectrum of a signal is represented by MFCC. The recognition of voice, speech are done through MFCC widely. The MFCC is calculated by, firstly, the data signal is read and recorded in separate files and they are split into frames having a length between 20 to 40ms. On the next hand, these data frames are quantized and then a complex Discrete Fourier Transform calculation is done. After that, a Periodogram-based Power Spectral calculation is done and the Mel-spaced filterbank is applied. As an outcome, 26 numbers are occurred and a log magnitude calculation is done for these 26 energies. Discrete Cosine Transform calculation is applied to these which gives us 26 cepstral coefficients and called Mel-Frequency Cepstral Coefficients. A Hidden Markov model is applied for 20 signals from each cluster and the data are classified.

The work of this paper [10] is to communicate/automate home appliances based on the human brain's neural activity. The method used for interacting with the human brain and the digital computer is called Brain-Computer Interface(BCI). There are two methods for this. Invasive and Non-invasive. Here, a Non-invasive method is used for this work and used

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to use external devices without touching them. This project helps the elders, decibel people, and also the people who cannot move their normal muscular parts in order to use the peripheral devices. The property which comes under the Non-invasive method, Human Attention Level is used here to measure the brain signals using a NeuroSky Headset. The Attention measures are measured between one and a hundred. When the person controlling the home uses intense concentration and directed, stable mental activity kind of mental focus to control and this level of the user's mental focus is called attention. So, in order to obtain attention values, the person should focus on the device which has to be controlled. When the NeuroSky headset acquires the signal and the signal is sent to a personal computer using Bluetooth where the personal computer is a medium between headset and device to be controlled. Here an ARM7 processor is used. If the condition for the device is satisfied the position of the device changes. ie, for example, if a fan is on and condition satisfies the position changes from on to off and vice versa.

This paper [11] discusses RGB - D SLAM (simultaneous localization and mapping) systems. It uses the banishing point and door plates in a corridor environment simultaneously for navigation. The vanishing point and door plates are utilized as landmarks for extended kalman filters - based SLAM to increase the stability of the SLAM process. In data association process , the vanishing point act as a semi - global unique feature usually observed in the corridor frontage and the door plate has a strong signature information (ie, the room number). The details include localization and path planning of an unknown environment is the important task for the mobile robots in the navigation field. The SLAM scheme for a corridor environment that uses a vanishing point and door plates will provide a great help for the robots in the localization and path planning process. The reliable SLAM can be performed for a corridor environment due to the combination of vanishing point and door plates.

These paper [12] focus on the main drawback off to-class brain-computer interface system. That is the law bandwidth of the communication channel.The BCI system has tov output comments,left hand motor imagery (MI) or right hand/foot MI. For every trail entering control, assistive devices require multiple motion comments. This paper discusses a real time implementation of a novel iAUI design for a mobile robot control task.The user-centric design that presents all the control options to the BCI user at all time is the major advantage of iAUI design.

This paper [13] discusses a new human computer interaction technique called BCI (Brain - Computer Interface) Which Provides a good communication pathway between human brain and electro equipment. It is mainly used for the people who are suffering from spinal cord Injuries or ALS. BCI is used instead of peripheral nerve muscle tissues and it provides a complete interaction. The development of BCI technology is due to the great advancement occurring in the field of computer technology and bio - signal processing technology. But these designs have some problems; Bulky acquisition devices, Cumbersome to use, Expensive and difficult to communicate. To address these problems we need portable control devices in some situations such as wearable artificial limbs and battlefield equipment. For using portable control devices a portable brain control system is designed based on the principle of applicability, practicality and cost. This control system has a portable EEG acquisition module, microprocessor, micro drive module, Bluetooth module and the control program accuracy rate of the system is related to 86.41 +or- 3.92%. The advantages of these designs are high reliability and practical value.

This paper [14] discusses a walking assistant robot in complex indoor environments. Nowadays there are so many elderly people suffering from walking due to various knee or leg muscle problems. This design of walking assistant robots can help these types of people. Due to the help of these robots, the elderly people can easily do their daily needs without other's help. This novel shared - control design is the combination of active robot navigation and passive mobility. The walking assistant robot can move by adapting the user's motion commands. This motion is done due to the passive behaviour of the robots. The speed of the robots can be controlled by an active navigation method. Currently, these designs can be operated as if on a horizontal plane.

This paper [15] describes the combination of P300 detector and BCI technology.BCI technology can provide a direct communication path between the human brain and external devices. The external devices are the computers by analysing the brain measurements. The P300 detector can detect the signals that come from the brain through electroencephalogram. This technique is based on convolution neural network (CNN) methods. This method helps the people have severe motor disabilities like spinal cord injuries or like amyotrophic lateral sclerosis. The EEG helmet can be fixed on the head part of the body and these helmets can direct the neural signals that come from the brain. These signals can be converted into electro signals by EEG. The P300 speller can accept these electro signals and process it through three ways. First is record the EEG signal in the form of P300 waves, second is direct the each characters in the form of flashlight and last recognize the characters.

This work [16] is focused on EEG signal analysis for BCI interface by trying to extract the features from the EEG signal to give out the most accurate output possible. It is understood that EG signals will vary for different users who might still have the same command but it is always in the same range but different values. From this paper it is understood that for making any device that is using EEG signals it should be trained specifically for the user. The feature extraction takes place by using the visual representation of the EEG signal.

The paper [17] a prosthetic arm is created to help the patients who are currently in their rehabilitation phase of their injured arm. The prosthetic arm is trained to give support to the actions of the user's arm, so that a quicker recovery can be obtained and also keep a positive attitude towards rehabilitation. Here the user has to train how the arm should work

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using the EEG signals that are being emitted. After the training is done the user will be able to control the arm in such a way that the arm will help with movement of the hand but will not completely do the task for them. This will help with the muscles movement and the brain signals synching up as well.

The paper [18] is focused on creating a training system that will be easy for the user to train the data. In this method an EMOTIV training interface is used which is a visual training method which is easier than traditional methods. Here a 3D cube can be controlled by the user using the EEG signals that are being received via the EEG headset. These signals will create an appropriate movement within the interface hence this is a visual training system. This can be used in various different types of applications where the user input is to map anything from the brain signals that are obtained from the user.

This paper [19] deals with creating a smart prosthetic arm which can be useful for patients who have their arms amputated. The main focus of this paper is to provide an alternative to the more expensive and difficult method of operation. Here EEG signals are taken from the user using an EEG headset which is placed over their head. Using machine learning we can train the arm to do what the user has in mind. The addition of smart sensors can also help the user in having a very interactive use of the arm with the surrounding around them. This is an easy to implement and highly accurate method.

This paper [20] deals with classifying the different emotions from the EEG signals that are obtained from the user using the EEG headset which is placed over the head of the user. The emotions are calculated by plotting a graph based on the valence and arousal that is calculated from the EEG signal that has been received by the user. To trigger different emotions, images are used and the EEG signal is mapped to the emotion that would be felt by the user while viewing that image. These two signals are then classified using openBCI.

III. PROPOSED SYSTEM

Attachment of bio-sensors on the head surface electrical signal frequencies may be determined. Interfacing the human mind with the system where people suffering from the so-called locked-in syndrome can communicate some predefined messages. Head surface is being attached with metal electrodes, as well as conductive media, being a measurement of electrical activity is defined as the electroencephalogram (EEG). Brain wave patterns are unique to individuals. To obtain the basic brain signal patterns from the individuals, they should be relaxed with eye closing state. Brain wave patterns consist of RAW EEG Signal, Attention, Meditation, Eye Blink and Fundamental frequencies. Brainwave sensing devices are sending the analogue electrical signals, digitizing as well as amplifying them. Brain sensing module decoded brain signals as well as connecting with the computer to observe our brain activities.

IV. CONCLUSION

These papers will create a device where people who are suffering from locked-in syndrome can communicate about some of their basic needs. This system will provide a new world of interactivity especially to the people suffering from the so-called locked-in syndrome, but cognitively intact and alert.

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