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Design of Multipurpose Smart Wireless Controlled Wheelchair

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Abstract-- In the whole world,some people are born with certain disabilities and some are disabled due to sudden accidents, etc. In order to overcome the problems of disabled persons, the design of multipurpose smart wireless controlled wheelchair system is presented in this paper. This system consists of brain computer interface (BCI) which uses brain signals for controlling the movementof wheelchair. It helps the disabled personsnot only for moving one place to anotherbut also communicate with other persons without any external assistance. So,this paperis focussed to designa multipurpose wheelchair which helps the disabled personsfor leading their life independently.The purpose of this paper is four-folded: (i) introduce up-to-date works; (ii) classify and review state-of-the-art techniques; (iii) propose a multipurpose wheelchair idea; and (iv) predict potential research directions in the future. This paperalso serve as a good reference for researchers in the areas of smart brain controlled wheelchair for navigation in familiar environments.

Keywords-- Smart Wheelchair, Bain Computer Interface, Electroencephalography, Artificial Intelligence

1. Introduction

According to the survey of United Nations Disability Program(UNDP), the annual disability status report states that about 80%of disabled population live in developing countries.World bank report estimates that 20% of world's poorest population have some kind of disability,out of which aged population is more[1]. In general, aging is closely associated with disability prevalence.The survey made by United Nations Statistics Division(UNSD) revealed that as per 2011 census the total disability in persons was 26.8 millionout of which 2.1 million population was suffering from multiple disabilities which was around 7.8% with reference to the total disability. Around 2.04 million population suffering from disability were children and in that also about 0.15 million children were suffering with multiple disabilities which was around 7% with respect to total number of children suffering from disability. Population suffering from SpasticityQuadriplegic Cerebral Palsy(SQCP)a type of motor neuron disability is also under consideration. Stallings et al. [2] stated that for every 70% out of all suffering from cerebral palsy seen with SQCP disabilityeffects all the limbs, vocal chords, hearing, and in some cases eyes also. Most of the effected are around the age of 2-18 years of age and its effect lasts throughout the life making them immobile without assistance. Assistance is one of the important part in their life like they get help from family, friends, and even neighbours. This assistance is normally for personal and household activities. Even though, some of them think that receiving assistance is a troublesome process and on the other hand, some think it is necessary for those who are suffering from severe disability. It weaken elderly aged people's independence. Sometimes, these disabilities makes the people burden to other.In fact, in some cases irrespective of the situation their family members feel burden to serve them. Even communication is also a major issue in case of the individualsuffering with severe disability. By taking these conditions into consideration, an idea of introducing technology is proposed for their voluntary movement and easy communication with anyone. There are several innovations made to assist these types of conditions with different technologies as the technology always hikes at every point of time which makes its usage feasible to explore and implement new ideas. Out of these,braincomputer interface(BCI)[3] is the developing technology. With this an idea emerged out to use this technology to assist the elderly aged as well as a category of paralysed population. This paper proposes anidea of using aBCIsmart wheelchair which is self-assistive, works with the usage of Electroencephalography(EEG) technique. This is a human-machine interaction technology which directs the user to connect with the system to control with brain generated minute electrical signals as commands. This system also includes a human-human interaction system which is helpful to the user to communicate with anyone through brain with the help of the machine.

Majorly this idea originated due to some facts published by some journals as the current disability status of elderly aged populationand the future problems to be faced. Saikia et al. [4] surveyed that as per 2011 census number of population aged 60 years were 103.8 million and population aged 80 years were 11.3 million. According to UN forecast by 2050, there will be 323 million population over 60 years of age in India. Several studies and applications were done with different technologies to assist the disability but mostly worked with wheelchair units on considering the people with multiple disabilities. **Fig.1**shows that several works were done to improve the ease of accessing and controlling the wheelchair through voice commands, eye tracking, joystick, breath controlled, head gestures, hand gestures, Electrocardiography (ECG), EEG, etc. But, these technologies are being efficiently controlled by completely healthy people. The breath- and joystick-controlled systems are bit complex while using them like if we are in tension or if we are in very happy mood, we may not be able to control our breath.In case of joystick-controlled wheelchair for a quick turn of joystick leads to more complexity in controlling the wheelchair. To overcome these types of issues a technology known as BCIcame into existence which controls an external device with brain pulses[3].

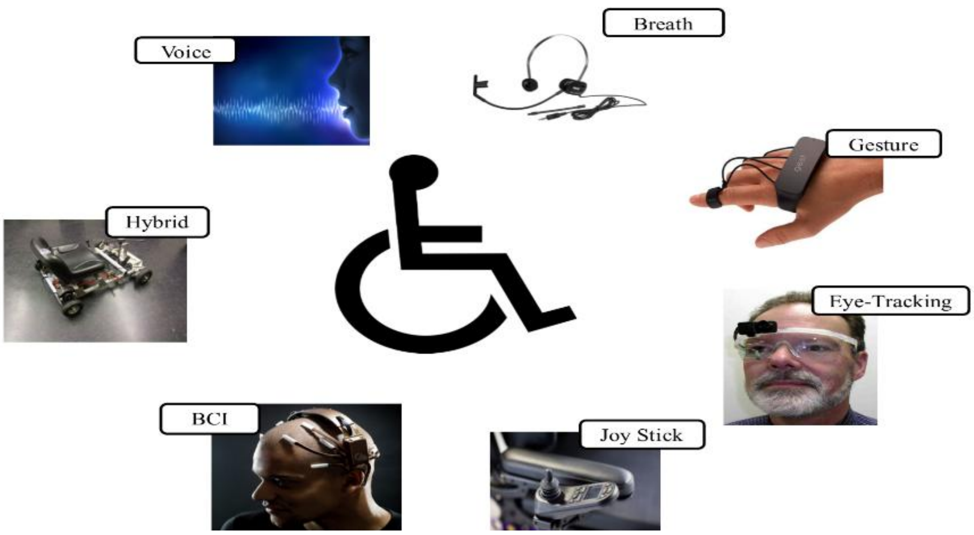

Fig. 1: Different wheelchair controlling methods

2. Literature Review

Technologies with which researchers have proposed different assisting devices are: Simpson et al. [5]used the technology of controlling the wheelchair using voice commands through which the respective movement and direction of the wheelchair is controlled. Thissystem is limited toits control that it can help the people havingdisability with their limbs only and

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makes these individuals to move voluntarily. There is a great scope in the future to develop these types of projects integratedwith the present technologies. Tanaka et al.[6] formulated the idea of implementing semi-automated wheelchair unit fitted with a computer vision-based equipment which involves in automatic driving the device and direction can be controlled by using EEG signals only and as an alternative, this system included a joystick for manual driving as well and this might be the first EEG controlled wheelchair. The total demonstration of the experiment was made to achieve the respective goals of reaching the wheelchair to its destination using EEG signals only. The limitation isthe large number of steps required to reach a destination with these two systems might exhaust the subjects.Iturrate et al. [7] reported that it took 11 minutes and nine decision steps to realise a 40-m-long path with this system.Kulkarni et al. [8] proposed a histogram technique for gesture identification through image processing which involves in finger spelling gestures of static American sign language(ASL)which results as text on screen and also implemented its reverse techniques of text to sign language. Here the limitation of the system is mainly the recognition of gestures by the camera which can be poor in case of non-uniform background. The proposed system cannot be able to design the system for dynamic gestures. This system is not always suitable because there are many kinds of gestures which indicatesame thing by different people.

Rebollar et al.[9]discussed novel approach in translating isolated gestures of ASLinto both speech as well as text. This technology can offer one of the ways of augmented communication between the deaf and the hearing communities through gesture recognition techniques with components integrated electronic Accelegloves and two-link arm skeleton with the usage of Hidden Markov Model (HMM) technique. This system is particularly for the people who are mostly dumb and deaf as well as partially paralysed.Lin et al. [10] stated that the observation of EEG signals was made through an experiment and classified that the response to the signal generatedremains same irrespective of our consciousness. There is a limitation that the system used Bayes quadratic process in EEG classification. EEG signals can be non-linear whereas Bayes process can only classify linear classified signals. Limitation is that P300 potential mainly rely on external stimuli which may be ineffective for some disabled persons.Ahmed et al. [11] and Lin et al. [12] suggested an idea of controlling the wheelchair movement with just blinking of an eye through EEG technique.The system response was estimated to be 20 seconds for a session by allotting four commands of 5 seconds each. The limitation of this suggestion is that the command generation depends on the eye blink strength and EEG sensor integrated with one electrodecaptures the electric pulses from brain while blinking of an eye. Secondly, the sensor can capture only a single type of signal repetitively.

Li et al. [13]proposed a design of an EEG controlled wheelchair having good performance and suggested that there is a potential perspective of applying the designed system to people with disability in daily life, which would strengthen independence of their daily living. The limitations associated with this type of system is that it needs a heavy training to be attentive while using and also it cannot serve all the disabled people. Li et al. [14] proposed a method to control the 2-D cursor on the screen of a monitor with the generation of Mu/Beta brain waves which indicates the state of reacting to the spontaneous actions with which the response time would decrease. This generated signal is used for moving the cursor whereas a neurology concept of brain signal P300runs about 300ms after the occurrence of desired output.The satisfactory accuracy of this 2-D cursor control listed is 80%. The overall control of cursor can be done with the combination of P300 and motor imagery. The main limitation is that the P300 potential rely on external stimuli. Liet al. [15] suggested a solution for asynchronous control of a wheelchair using hybrid P300 potential and steady-

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state visual evoked potential (SSVEP) of BCI system and stated a rectification of a key problem of distinguishing control and idle state based on EEG signal by simultaneously controlling the system with hybrid P300 and SSVEP. The limitation of this system is that it is difficult to produce a stop command because P300 mostly rely on external stimuli.

Rebsamen et al. [16] proposed a controlling system using P300 potential in BCI to control wheelchair to navigate in familiar environment which is quite easy to control. But the major limitation of this P300 used system is that it produce a long delay result which could be about 300ms and also it almost impossible to design a stop command with it. The authors used Mu/Beta waves for accurate stop command which needs lot of training. Kim et al. [17] proposed a simple way to control a device movement with a technique called imagery techniquewhich monitors the state of brain and depending on the situation of the brain the electrodes get detected and following command applies to perform certain action. It is limited to people who are mentally attentive in making their own decisions and also the brain stimulation takes place even if we think about things other than controlling of wheelchair which may result in false commanding to the system.Wang et al. [18] proposed a simple way to control a device movement with a technique called brain imagery technique in whichleft/right turning operation was performed using left/right-hand brief motor imagery, and stopping was determined by both left and right hands brief motor imagery. Even though, this wheelchair controlling needs less training but mostly the limitation was overcome by Platz et al. [19]. Platz et al. [19] suggested that Mu event-related desynchronization (ERD) response may be altered after stroke and therefore may limit the potential for patients who havea stroke to engage in MI-BCI training.Fitriet al. [20] proposed that this paper mainly concerned about the safety in using the wheelchair because mobility of the system always provides the people’s quality of life. So, using computer-vision based obstacle detection technology through a LASER line instrument and a camera mounted on a wheelchair unit works as per the program in order to avoid collision between the obstacles.Suresh et al. [21] proposed an idea of controlling wheelchair through BCI controlling mechanism and monitor the user conditions through E-senses algorithm completely through wireless medium.This system uses completely generated basic signals which requires lot of concentration to communicate with the wheelchair unit and control it. One of the limitations is thatit requires more timefor a session of transmission and acquired signal for complete controlling of the system.

Ghulyani et al. [22] proposed an idea of differentiating and field of interfacing of invasive and non-invasive brain waves capturing units and their usethrough this proposal. The authors also gives distinguished explanation on Electrocorticography (ECoG) and EEG. It also mentioned to implement different technologies in different ways to make people out from their disability. This idea of implementation is mostly to help physically challenged to be as a normal in the society without any discrimination. Chaudhari et al. [23] suggested an experimental idea of approach to perceive drowsiness during driving which converts the system to automatic driving mode to avoid accidents and this is being monitored using only neuro sky remote which captures and analysis the brain situation. These types of systems are limited to some prototypical practises becausethe delay is longto grasp the signal, process and then analyse the system control to convert them to automatic controlling system until the person retain his/her consciousness.Jones et al. [24] developed a method to observe the consumption of time for controlling a cursor through BCI-interface by dividing it into two forms flickering and non-flickering. The whole system was being initiated using a hand-held switch to activate. In this method, the results were amazing90% more efficient than other devices, but this system is limited topeople with particular disability only. Zhenxin et al. [25] proposed an experimental approach of controlling and capturing the EEG signal and display

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the image results as 3-D display through EEG signalling technique and image simulation done on MATLAB for better and almost precise result display. This system is limited to forward and stop controlling purpose and this system faced a problem due to noise interference, it results low performance in controlling left/right directions. Huang et al. [26] proposed a simulation to control a 2-D virtual wheelchair system based on ERD technique in EEG for direction changing. This simulation took 59 seconds to reach the target with best set to 39 seconds. These types of systems are well controlled as simulator but have limitations that it can be used by only partially paralysed individuals because mostly for ERD, the authors used P300 for spelling or graphical user interface (GUI) selection purpose which rely on external stimuli for its activation. Mirza et al. [27] proposed a method to control the movement and direction of wheelchair unit with neuro signals generated using EEG sensor, with attention and meditation i.e. depending on the type of brain signal generated respective control command is send to the wheelchair to perform an action that is programmed using Arduino microcontroller integrated with the EEG sensor. This project proposal is limited to controlling only if the user is elderly aged, havinganydisabilityand people facing problem in communication.

Orhan et al. [28] proposed a method in fusion with language model to improve spelling activity through event related potentials (ERP) corresponding to stimulus EEG signal using rapid serial visual presentation(RSVP) technique which tries to perform mental target to match with the symbol corresponding sequence which performs with relatively high speed. Its analysis supports the hypothesis using a language model to support ERP classification in BCI-speller performance. The results suggested that for first letters of words the BCI system could switch to multi-trial mode, while for subsequent letterssingle-trial EEG evaluation with high-order language model could be beneficial. Reduction in the number of repetitions is a direct multiplier factor for reduction in time to type a given length text. Future scope of this work is to use fusion technology which can reduce the span to get the result. Swee et al. [29] formulated and designed a smart wheelchair system with fast Fourier transform(FFT) and EEG classification techniques.By using FFT, the complicated brain wave generated into simpler EEG signals which are used as command signals for controlling the wheelchair unit. These techniques useda base of 14-channel Emotive EPOC EEG (i.e. official EEG device manufactured by Emotive Inc.) headset for capturing the signals to analyse and perform respective action through programming. Here, this system achieved 90% efficient EEG signal with minimal noise. His proposal is limited to the people who are aged and some who are suffering from multiple disability. This project has very good future scope for its performanceon integrating it with some other technologies for further assistance for completely disabled. Middendorf et al. [30] suggested a technique to implement SSVEP for better response and accuracy in each of the target with less time which gave 92% average accuracy in selecting right option with an average response time 2.1 second. The three white LED chessboards with programmable flicker frequencies are used to induce various SSVEPs as stimulation. The Fourier transformation of the EEG signal's autocorrelation is used for feature extraction.In future, the success demonstrationwill implement BCI system. To achieve this, the author need SSVEP technique for natural response signal acquisition and compared it with the standard computer mouse using Fitts law to evaluate the paradigm to evaluate the speed and accuracy in achieving the right target.

Maksud et al. [31] and Jayabhavani et al. [32] designed a low-cost EEG signal acquisition based smart wheelchair controlled and programmed using both raspberry pi and Arduino mega. This project includes two controlling consoles which are mostly alternative to each other. They controlled wheelchair through brain waves and through joystick controller in case of any malfunctioned situation. EEG acquisition is done through eye blinking, thereby

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respective command send to wheelchair unit and it works.But this method also has limitation with the usage of ultrasonic sensors which detects the obstacle, but rarely thiswill not detect the obstacle by loss of safety. Further improvement will be made on using image processingto provide more safety.Long et al. [33] proposed a hybrid combination of motor imagery and P300 to control the wheelchair in both real and simulated condition which gave good result.Using of P300 whichindividually rely on external stimuli andmotor imagery needs training to concentrate enough to be attentive to this type of systems. It is also difficult to generate a stop command using P300 potential. In order to avoid this, we use motor imagery to imagine foot for stop command. The future scope depends on using this system with SSVEP for better performance with in less time.

He et al. [34] and Ferreira et al. [35] suggested a P300-based threshold-free brain switched system to control the wheelchair system.This brain switch was used to create a start/stop command for a smart wheelchair with an autonomous navigation system performing the left, right, forward, andbackward functions. Inthis project, P300 is used to select the commands over GUI to control the movement and direction control of wheelchair unit with two support vector machine (SVM) used to know the state of wheelchair to perform respective operation depends on the state of system. Mostly whenever the authors used P300 potential simultaneously with Mu/Beta rhythm waves to produce a stop command through imagining,then the respective signal generated stops the system. It needs to have an alternative manual controlling system, otherwise it is limited to its usage as only experimental approach.Kaufmann et al. [36] proposed a brain-computer interface based wheelchair control utilizing tactually-evoked event-related potentials. This proposed system can generate signals through motor nerves which are responsible for movement and direction control of wheelchair system. This needs little training to get familiar in using limbs and body parts to perform actions. These types of systems are limited to the persons who are disabled due to accidents and aged people but it is not useful for paralysed individuals. Jiang et al. [37] proposed an EEG controlled system in which braincommunicate with the wheelchair unit via iPhone. The developed systemcontrol the wheelchair through threshold to process the user’s attention can produce two signals which are yes/no for a particular command to execute. This system is designed to help people with spinal cord injuries (SCI) and amyotrophic lateral sclerosis (ALS) due to the inability to move limbs and body caused by nerve cell death.These types of systems are feasible in making but coming to controlling we need to be always attentive and focus on GUI which is one of the drawback because it may lead to inappropriate control. For future scope, it might not be feasible to implement instead we can go for commanding the system through EEG using SSVEP.

Leishman et al. [38] proposed a BCI-controlled smart wheelchair deictic control method that monitors and manages human-computer system control as well as analyses the cognitive requirements of driving tasks such as attention and performance during driving processes and also includes traditional manual driving.These types of assistive systems are more likely limited to people who are mentally active and can operatethrough brain-controlled interface systems.Iturrate et al. [39] presented an automated navigating synchronous EEG brain-actuated system which relies on a P300 neurophysiological protocol which is of automated with pre-defined route for automated navigation and obstacle detection using LASER scanners which resulted in 94% accuracy for the BCI. This system movement is repetitivelike a robot. This system is only limited to repetitive works which involves no decision making by the user. Yang et al. [40] proposed a method to transform textual information in the form of Chinese language for deaf-people in consideration with the modern day communicating ways like email sending, chatting etc., with hashing technique process. Chinese textual language is also more feasible and Chinese phrases is made word by word. This system completed a sign

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language conversion word by word which would be a limitation to this system because it needs a long duration to complete a sentence.Kouremenosa et al. [41] proposed a prototypical concept for Greek text to Greek sign language conversion system using machine translation technique and sign language synthesis using web 3-D and Perl programming applications. This system is limited for some symbols translation using a designed 3-D avatar because the avatar representation of sign language is not clear and mostly due to unnatural movement of the GUI based designed avatar.

There were several researches done to improve the living style of a disabled person, aged person, etc. But till now, there is no evidence of a system which involves all these technologies integrated together to make a hybrid system which can assist the completely paralysed or aged people.This proposal article mainly consider the aged population and people suffering from various disabilities/diseases like Epilepsy, Cerebral Palsy involves in restrict the mobility as well as the problem of being dumb anddeaf also. So, to make them connected to the real-world an introduction of EEG based multipurpose wheelchair system which includes the control of direction and movement via brain signals through EEG sensor and also associated in two-way communication with any type of people using this EEG technology ofBCI system. Here, an explanation for the existing technology gives a brief idea of this proposal. The idea of two-way communication is transforming language of understanding in different ways like from brain signals to text and text to speech as well as sign language. In EEG signalling for efficient way of communication and controlling of the wheelchair system, a preferable usage of P300 and SSVEP is needed where P300 is efficient enough for typing text through brain and SSVEP is natural brain signal generates to operate mostly in closed-loop as a feedback system for efficient results. This basic idea of simulated implementation isdone using MATLAB, which is user friendly and easy to access and program it. Here is an explanation for the existing technology of thought-controlled wheelchair, which includes speech synthesiser and generates the Hawking's directive electronic voice for the text generated with the thoughts using tablet computer along with an IR sensor for decision making while using the tablet for typing text by using brain signals. This system includes universal remote controller to control TV, music, lights, doors, etc., with maximum efficiency of 95% for normal user but while coming to the Hawking due to his defect the recognition signal strength was very weak so, the efficiency reduced to 50%. The whole system was controlled using a power supply through battery useful to control wheelchair movement.The thought-controlled wheelchair system includes electrodes attached to the vocal cordsby controlling the wheelchair through brain generated electric pulse which can be as small as possible but efficiently effective to control the wheelchair. The current existing technology of wheelchair based on Stephen Hawking scientist is shown in **Fig. 2**.

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Fig.2: Current existing technology of wheelchair [42]

3. Problem Identification

Nowadays,the technology is increased and there are several innovations proposed by various researchers. Wheelchair is one of the great invention which was madeby John Dawson in 1783, a huge revolution in helping the aged as well as disabled people [43]. The increase of technology leads to development of wheelchair with integration of different technologies to control its movement and not only in the developing the wheelchairs but also several technologies are invented to assist the disabled persons like deaf and dumb, blind, even prosthetic technology also developed.There are several limitations to their invented technologies based on the performance of the systems on which they implemented their projectbecause every technological implementation deals with only a particular disability which is always raising a challenge to face and further to help the disabled in different ways. Further, working on these technologies, there would always be a great scope in the future only for specific disability.But,there are many cases where elderly aged people as well as people suffering from disability with diseases like cerebral palsy and epilepsy are not able to move their limbs. It shows effect in hearing, talking etc., and these people always rely on others even in doing their personal works. For assisting these types of people, there are some inventions in automating the technologies of wheel chair made by various researchers. Even though there were many technological improvements in this field but still it is not useful to fulfil all the needs of the disabled persons. The need of the hour is to make a hybrid system which can assist the disabled to most extent. Till date, several researchers were already worked on this area butthere is no evidence of work done on integrating these technologies to make the system smarter than the existing systems which can serve maximum needs of the aged people or the people suffering from multiple disability.So,there is a need is tointegrate all these technologies to make a smart system which can assist aged as well as completely paralysed individuals thatfurther connects the real world with brain computer interface technology. This proposed idea is mainly for those people who are quiet as well as more creative and also for those people whoare suffering from Spasticity Cerebral Palsy disorder between the age of 2-18 years. The proposed wheelchair system is mainly controlled by brain through EEG technology andmakes two-way conversation with anyone. The users also find difficulty to drive these wheelchairs that are developed by the new technologies due to lack of knowledge. So, there must be a clear demonstration givento each user about thelatest technologies which are used in the wheelchair.

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The objective of this paper is to make a wheelchair controlling system that helps the disabled persons in living their life independently. The various challenges faced by the researchers to implement this system are as follows:

i) Reduce the complexity in controlling the system.
ii) Minimize the error probability chances.
iii) In addition to this an integration of the communicating system with the existing brain controlling system to make it more feasible for the user.

4.Methodology

In this paper, the comprehensive literature review of multipurpose wheelchair controlling system in the past few years is presented. Many researchers did a lots of works on autonomous wheelchair for disability, diseased as well as old aged peoples. According to literature survey, there is no single unified wheelchair controlled system which is used to fulfil all the requirements of disabled persons. All the wheelchair designed methods have their own advantages and disadvantages. So, there is a need to propose an efficient and effective idea for designing the autonomous wheelchair which works well for all kinds of applications.

4.1Proposed Method for designing a Multipurpose Wheelchair Controlling System

This paper proposes an idea for designing a multipurpose wheelchair which automatically controls all the applicationsfor leading the daily life of paralysed persons. The proposed system is also helpful to dumb and deaf peoples as well as paralysed persons.**Fig.3**shows the flowchart of wireless wheelchair control through EEG module. In the EEG module, brain wave sensor is used to control the system. This sensor is used to sense the brain signals and perform the operations for which it is specifically designed.

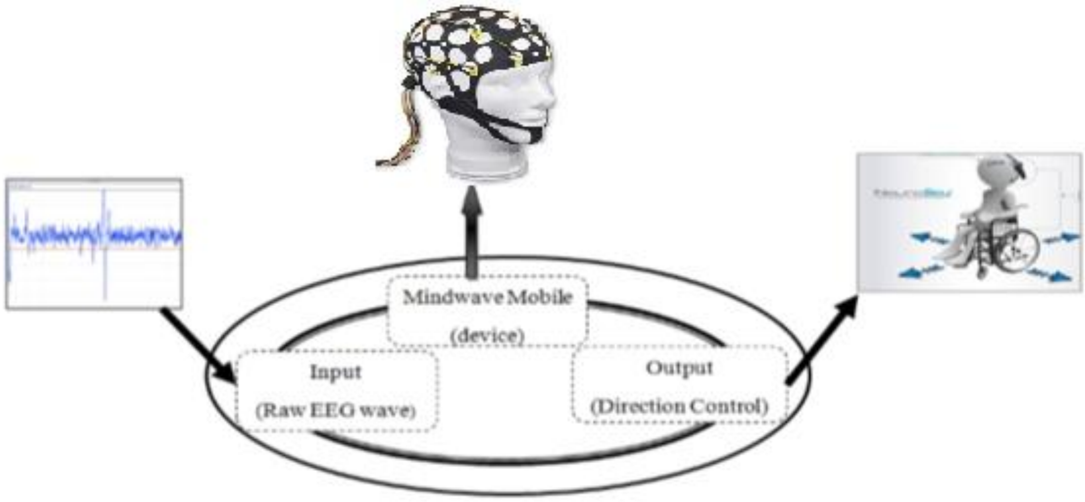

Fig. 3: Overview of wireless wheelchair control through EEG module [44]

Several researchers implemented various technologies that can assist the disabled persons. But, in this paper an idea of introducing a hybrid smart wheelchair system is implemented which is controlled by brain via EEG sensor. While in the process of communication the user can be able to communicate with others in different ways like the generation of text using brain signals into either speech or sign language and vice-versa. In these, the generated EEG signals are of two types: (i) raw signal to respective voltage conversion which is used to control the movement of wheelchair; and (ii) digitised signals which are used for

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communication between two people. It is just like if the person using wheelchair is dumb can communicate through machine by just thinkingand this is being processed and displayed on the monitor-1 in three ways:

i) Textual understanding (Prints on the screen that the user thinks what to speak)
ii) Sign language (printed text translates to sign language)
iii) Transform text to voice with text to speech processor

The person who is communicating with the disabled (wheelchair user) can make conversation by using two ways:

i) Sign language (Signs will get captured by the camera through image processing)
ii) Speech conversation (While talking depends on type of disability, this is being processed as voice to sign language or voice to text)

The proposed wireless controlled wheelchair modelisshown in **Fig.4**.

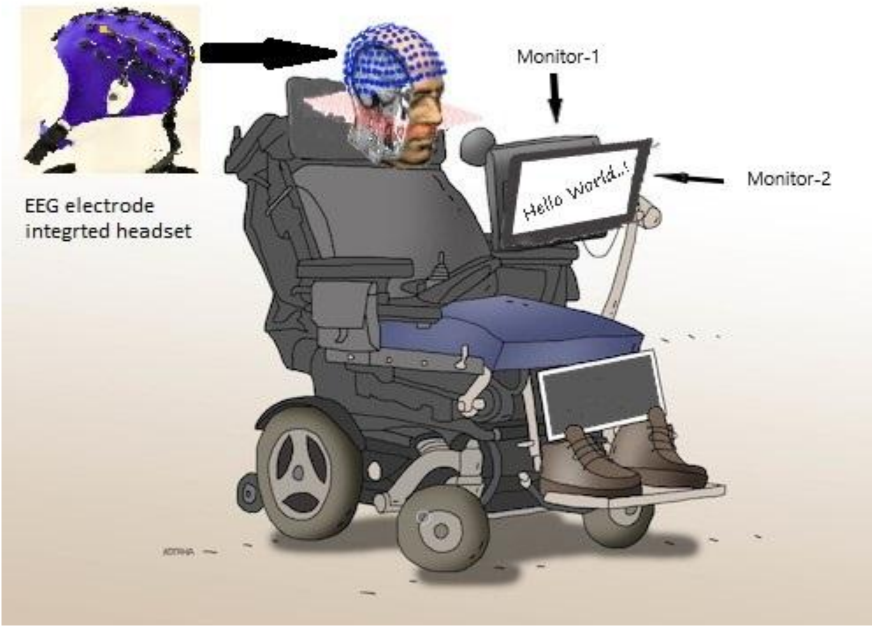

Fig. 4: Proposed model wireless controlled wheelchair

In this wireless multipurpose wheelchair controlling concept, an idea of introducing different controlling modules like embedded signal processing module, image processing and speech processing modules, wireless physiological signal acquisition modules which would be complicated and this makesthe system efficient enough to serve the disabled person.

For the acquisition of EEG signal, the dry passive EEG electrodes attached to a helmet and feed into the brain wave sensor. Brain wave sensor sense the signals generated by the user. The EEG signals generated are given as the inputs to the brain signal processor and further to the data processing unit through wired medium. This wired transmission is not only used to reduce the errors but also it can reduce the delay of processing the information. The processed data is given as command instructions to the wheelchair unit through wired medium and afterwards to the microcontroller for performing the tasks like movement and making conversations. Ultrasonic sensor is used for obstacle detection by giving an alert about the obstacle. IR-sensor which is also used just above the front wheels to avoid any small obstacles which may stop the wheelchair. The block diagram of the proposed system is shown in **Fig.5**. The various list of features incorporated to this system are:

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i) Brain wave sensor (sense different signal from different parts of brain)
ii) Thought controlled direction movement system
iii) Manual operation facility in wheelchair system
iv) Master operated facility (in case of emergency the one who is monitoring the system will have an authority to control it from the monitoring centre via internet using IoT technology)
v) Two monitors (Monitor-1 is for wheelchair user purpose and Monitor-2 is for communicating the user with second person)
vi) Thought controlled text generating facility
vii) Speech to Sign language conversion technology and vice versa (i.e., to provide a communication medium with any type of people with this proposed technology)
viii) Sign language to voice or text to voice conversion

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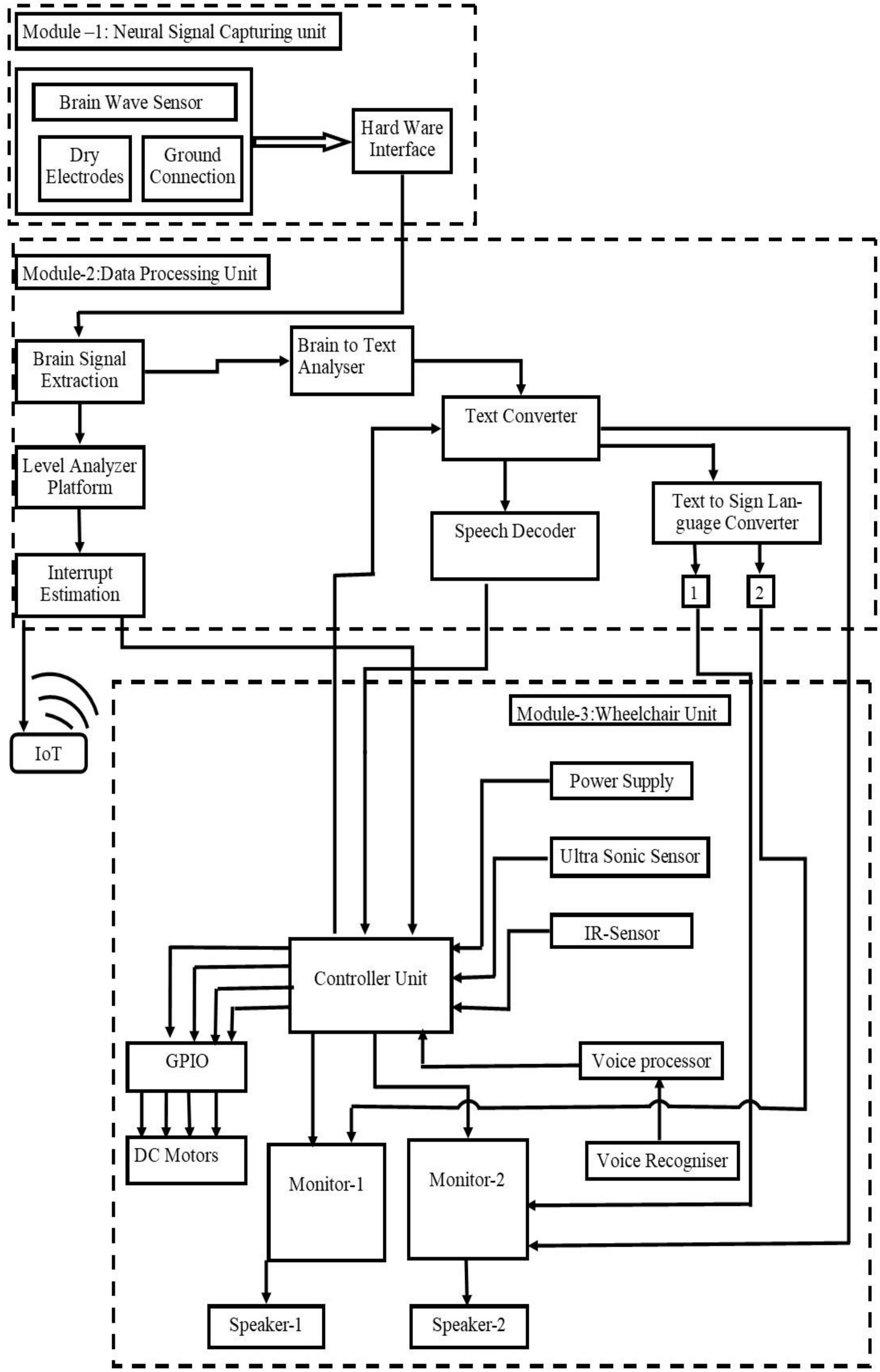

Fig. 5: Block diagram of multipurpose smart wireless controlled wheelchair

4.2 Module description

The multipurpose smart wireless controlled wheelchair is divided into threemodules: (i) Neural signal capturing unit; (ii) Data processing unit; and (iii) Wheelchair unit. These modules are used to control the wheelchair unit by giving commands to the brain.

4.2.1Neural signal capturing unit

In neural signal capturing unit**,** the signal generated by the brain is being captured and measured using EEG sensor through electrodes attached on scalp for signal acquisition. Then, the captured signal is used for controlling the movement of wheelchair as well as it is also responsible for man to man communication usingmachine as medium of communication. The passive electrodes are used for capturing the EEG signal through the EEG signal capturing helmet as shown in **Fig. 6**. The acquired signal is feed into the data processing unit where analysis of signal can be done.

Fig.6: Acquisition of EEG signal[45]

4.2.2 Data Processing Unit

The artifacts and noise developed in the wireless controlled wheelchair controlling system can be removed by using Fast Fourier Transform (FFT)method. The attention and blink strength signal levels can be classified separately with the help of the level analyser technique. The brain wave sensor can be interfaced with level analyser fortransferring the EEG signals efficiently. For visualizing the brain signals, the brain wave visualizer software and the MATLAB softwareis used. The processed signals as commands are further given to the wheelchair unit for controlling various operations.

4.2.3 Wheelchair Unit

The wheelchair unit is basically act as control unit which is used for communication. It consist of filters and analysers for converting the signal to textthen text to either sign language or speech. This conversion can be visible on the monitors which is fitted on the wheelchair as communication unitas shown in **Fig. 7**, **Fig. 8** and **Fig. 9** gives us the information about how the signal is used for processing the text as well as for controlling the whole wheelchair.

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Fig.7: Communication unit fixed to the wheelchair system

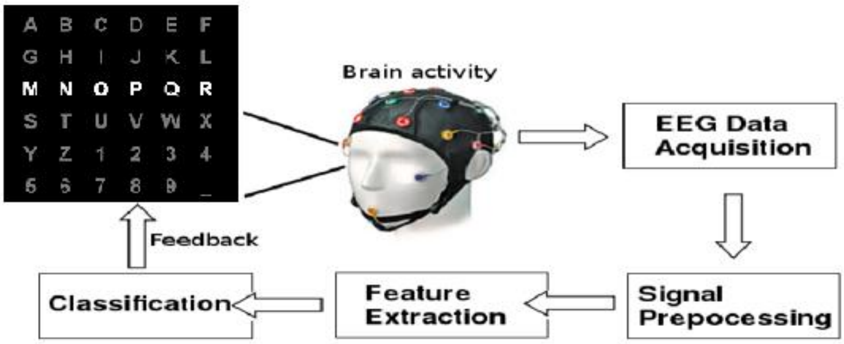

Fig.8: Processing of EEG signal [46]

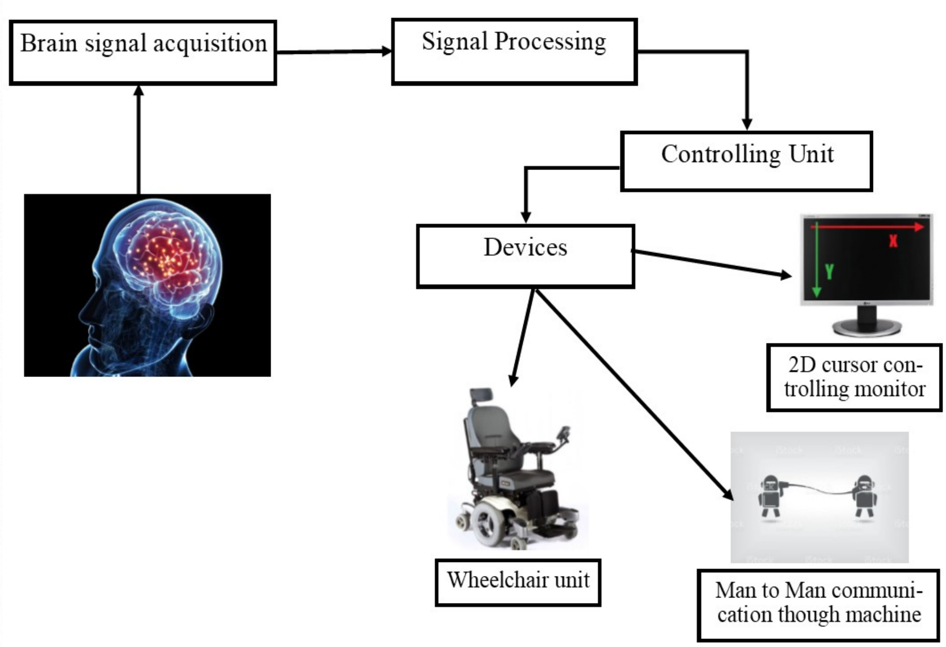

Fig.9: Block diagram for controlling the wheelchair by the user

Fig. 10 gives the brief idea about the conversion of text from our thoughts into speech signal. Thisspeechsignal is used as voice coming out form the speaker which is helpful for dumb and deaf people. and **Fig.11**shows the technology product called "UNI" from an American based company named "Motion savvy", this technology gives an idea that how we can convert a sign language to speech and speech to text on optional basis and vice versa [47]. Further, the system is also used for controlling the direction of wheelchair, typing the text as well as to

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halt the process. Sign language output for letter 'B', letter 'Y' and letter 'L' through sign language is shown in **Fig. 12**.

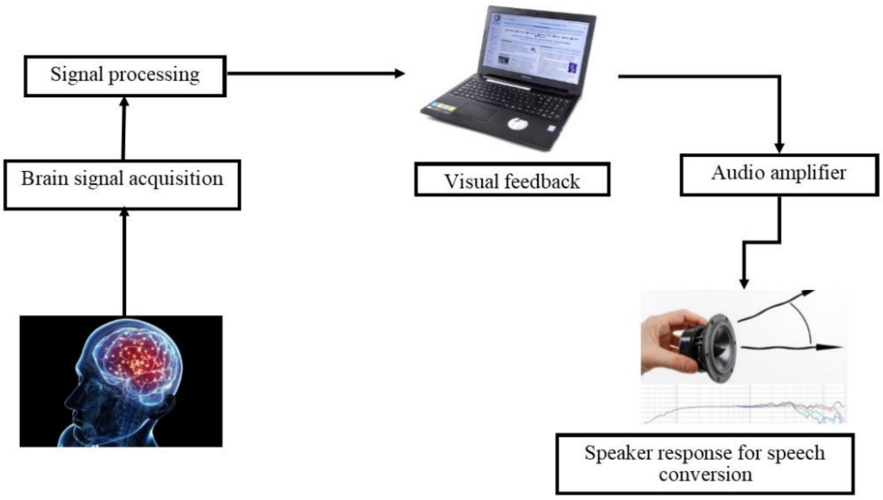

Fig.10: Text to speechconversion (audio)

Fig.11: Sign to speech and speech to text conversion [47]

(a) (b) (c)

Fig. 12: Sign language output for:(a) letter 'B'; (b) letter 'Y'; and (c) letter 'L'

5. Conclusions

In this paper, the conceptual way of designing multipurpose smart wireless controlled wheelchair is proposed. Theproposed approach can be controlled by EEG signal which commands from the front lobe of the brain. The speech signal is mostly generated from the

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side lobes of the brain i.e.,left brain and right brain. It act as a lifeline to the disabled or the paralysed person who are intending to move independently and able to connect with the world solely. Theproposed idea needs to be implemented in such a waythat it not onlyminimise the limitations of existing wheelchair systems by giving better performance but also respond with less time having maximum efficiency.

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