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Design and Simulation of Brain Controlled Electronic Wheelchair for Physically Challenged Person

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Abstract: ***Improving the quality for the life of elders and disabled person and giving proper care at the right time is one of the most important role to be performed as a responsible citizen in the society. This paper is describing about the integration of hardware, software and sensors with the help of Brain Computer Interface (BCI) to develop best generation wheelchair for physical challenged persons. Electronic wheelchair is one of the easiest way for disabled persons to lead an independent life. This smart wheelchair is totally controlled by brain, and here mechatronics plays an important role in safety recovery. By developing these types of wheelchairs it can reduce the usage of human effort and force to drive the wheels of wheelchair. It also provides a better opportunity for physically handicap person to move from one place to another. One of the best method to record brain activities can be done with the help of electroencephalography (EEG) this is also known as brain waves signal, through these EEG signals the BCI interface encode and decode the signals and transfers to ATMEGA 328 microcontroller. This wheelchair with the support of motor drives the movement is designed in such a way to control the commands like moving forward and backward, stop, turn left and right. Intelligent Wheelchair is designed using solid works and implementing into MATLAB using simmechanics is simulated using simscape multibody and the resulting torque is obtained. The aim of this paper is implement mind controlled movements for disabled persons.Keywords: Orthosis, Paraplegia, Rehabilitation, Simulation, Under limb.***

Keywords: Arduino, ATMEGA 328, Brain computer interface, Emotiv EPOC headset, Electroencephalogram (EEG), wheelchair.

I. INTRODUCTION

Wheelchairs are the most important source for many physical handicapped and senior citizen people. Wheelchair is used as topmost assistive devices for enhancing personal mobility for challenged people. It is manually operated or power-driven device which is designed for challenged person. Smart wheelchairs have been the subject of research since 1980s and have been developed on four continents. A Brain Computer Interface (BCI) system provides a better communication between computer and brain and other physical devices by translating different patterns of brain into commands in real time interface[2]. Many designs based on the BCI are designed with the Electroencephalogram (EEG) systems, such as brain controlled wheelchair present in this literature. BCI technology provides a means of communication which allows the persons with severely impaired movement to communicate with assistive devices using the EEG or other brain signals. EEG technique deploys an electrode cap which is placed on the user's scalp for acquisition of EEG signals that are captured and translated into movement commands by Arduino microcontroller which moves the wheelchair[2]. The electrical activity of the brain is monitored in real time interface by using an array of electrodes, which is arranged on the scalp in a process known as EEG, these sensors are most expensive and their use is only for hospitals and laboratories. EEG signal are classified into several bands like alpha, delta, beta, theta and mu suppression, each corresponding to various states of being like relaxing, ranging over 8-14 Hz; concentrating, ranging over 13-30 Hz; deep sleep, from 0-4 Hz; meditating from 4-8 Hz; moving your hands or legs or just by imagining these motion
actions respectively[1]. It is non-invasive in nature, this has an advantage over traditional Body Mass Index (BMI), for not being hazardous to health. With the advance technology, EEG acquisition devices are made more compact, handy and wireless. Using the above mentioned technique, a simple thought brain controlled wheelchair system has been proposed in this paper.

Extensive loss of sensation and they suffer with complete inability to feel anything below the waist.

Predominant cause for paraplegia:

Car & motor cycle accidents, fall, Medical/Surgical Injuries are estimated to be around 72% reasons for the people suffering with paraplegia.

There are many rehabilitation techniques for the people suffering with paraplegia due to Spinal cord injury. At the initial stages of paraplegia, patient rely on a wheelchair for their movement, but using wheelchair for excessive time may lead to medical co-morbidities. Hence rehabilitation devices like Wearable Exoskeletons and orthotic devices are been developing since 40 years. Starting from training a person in virtual reality environment and using a suspended treadmill to over-ground.

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II. OBJECTIVE

Independent mobility is very much necessity to live everyday life for human beings. A person with physically challenged person has restricted mobility. Brain Computing Interface (BCI) provides a better promising solution for challenged person which helps in direct communication between brain and smart electronic wheelchair. Here Electroencephalogram (EEG) signal works as the best method in recording brain signals. By this we can reduce the external human power in controlling the wheelchair. The main objectives in design process is given below:

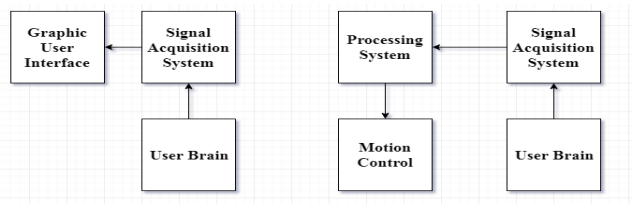
1. To minimize user effort in controlling of the wheelchair.
2. To assure safety when controlling of wheelchair.
3. To maintain safety precautions during the movement of wheelchair.
4. These smart electronic wheelchair using open source software and hardware.
5. The design system should be portable for the challenged persons.

III. METHODODLOGY AND HARDWARE

By taking into the consideration with the existing technology based on number of electrodes which is costly and is used only in the hospitals and laboratories. Mostly this EEG technique is used in hospitals to trace the patient's brain wave conditions. The headset is used on the mind controlled wheelchair is to pick up EEG signals from the brain. These signals are processed through EEG device and to BCI system which analyze and decode the wave signals by microcontroller which takes a decision regarding motion and direction of wheelchair with the help of motor drives and accordingly drives the motor. Modification of manual wheelchair is done by mechanically coupling motors to rear wheels thereby making it an electric wheelchair. In this active rear wheels are rotated by motors to the orientation that matches the current driving direction the system employs differential drive [2]. The proposed device proved to be effective for those people who are suffering from paralysis where the patient loses control over various parts of body and also useful for old age people.

Electronics and Embedded system:

The Electronics and embedded system is about how the emotive headset receives the EEG signals from the brain to the user by using the microcontroller.



(a) (b)

Fig. (1) Conceptual Block diagram (a) Training for wheelchair using GUI (b) Mind controlled wheelchair.

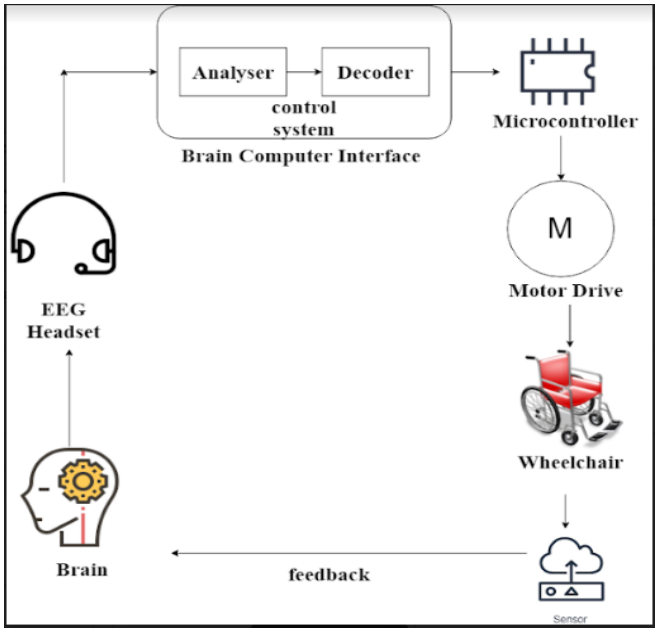


Fig (2) Block diagram of brain wave through EEG headset.

In this flow process brain waves are captured through EEG headset. These signals
are analyzed and decoded and the information extracted is sent to microcontroller. Microcontroller controls the functioning of motors through motor driver.

Emotiv EPOC headset:

Emotiv EPOC headset is one of the EEG device headset which is manufactured by the company Emotiv. This headset is a high resolution portable EEG device and multi-channel for the purpose of BCI system[10]. If consists of 14 electrodes for capturing of EEG signals from brain. The mental command detections like left, right, forward, backward and etc.

Fig (3) Emotiv EPOC Headset.[10]

Arduino Uno:

This Arduino Uno microcontroller is ATMEGA 328P with high frequency of 16MHz for providing high speed control and better processing and having 14 Analog input/output pins of which 6pins can be used as Pulse Width Modulation(PWM)[5]. This microcontroller additionally helps that are provided on the chair like automatic braking, monitoring system and automatic braking.[4]

Fig (4) Arduino Uno Development Board

Different Drive wheelchair:

Basically, one has to select wheelchair according to their needs. In designing and controlling the wheelchairs several points need to be concentrated more like people will be of different heights, cost efficient motors, durability and etc. many wheelchairs are available in the market that can be easily movable from one place to another[7]

Fig (5) Different Drive wheel configuration [7]

Brain waves frequency that detected in EEG:

Table I Characteristics of the Five Basic Brain Waves [9]

Frequency band	Frequency	Brain states
Gamma (γ)	35Hz	Concentration
Beta (β)	12-35Hz	Anxiety dominant, relaxed
Alpha (α)	8-12Hz	Very relaxed
Theta (θ)	4-8Hz	Deeply relaxed
Delta (δ)	0.5-4Hz	Sleep

IV. DEVICES DEVELOPED

In this present society it is very much essential to take care of elders or handicaps. So we can help them by inventing different types of wheelchair at low cost by this the user can afford easily with minimum requirements. Here are some of different types of wheelchairs developed for physically challenged persons to move from one place to another without any external help for the user. By developing these types of wheelchair they can independently do their works, can move from place to place, some of the wheelchair can climb the stair.

I. Manual Wheelchair:

The manual wheelchair is the type of devices to help a person to move him without assistance of battery. There are three types of manual wheelchairs namely self-propelled, attendant propelled, and wheelbased wheelchairs[6]. This wheelchair when we use as a Single-arm drive wheelchair it enables the user to move either left or right and while two-armed drive wheelchair enables user moving in the forward or backward directions on a straight path as shown in Fig(8).

Fig (6) Manual Wheelchair.

II. Stair Climbing Wheelchair:

The stair-climbing wheelchair is very high expensive, when compared to normal wheelchair, it is classified into three categories: - continuous stair climbing wheelchair, auxiliary stair climbing wheelchair and intermittent-stair climbing wheelchair. Continuous stair climbing wheelchair having the best set of supporting device, wheelchair relies on this supporting device for the continuous motions. In this auxiliary stair climbing wheelchair, the attachment depend on the another device which is fitted on wheelchair and this will be needed an assistance to support the functions of climbing stairs. The process of climbing stairs is similar to the people who are climbing from up and down stairs, it is also called as walking stair climbing wheelchair. Intermittent stair climbing wheelchair is one of the top most supporting devices that elevates the wheelchair and other set of supporting systems.

Fig (7) Stair Climbing Wheelchair

III. Manual Pediatric Wheelchairs:

Manual pediatric wheelchair are popular type of wheelchairs used by kids of all ages. In this type of wheelchairs motors do not propel so either the user or caregiver must and should push the chair to move around[6].

Fig (8) Manual Pediatric Wheelchair

IV. Electric Wheelchairs:

This is an electric wheelchair which can be used for someone those who hasn't got the mobility or dexterity due to disabled condition of hands, shoulders or more general conditions. Main advantage of powered wheelchair is it can recline, leg and seat elevations and other necessary functions. It has special seating and arm and leg rest requirements. These wheelchairs will bring independence and freedom to physically handicap persons [6]. Each wheelchair has its own particular handling characteristics.

Fig (9) Electric wheelchair

V. DESIGN OF WHEELCHAIR IN SOLIDWORKS

The Brain control electronic wheelchair is specially designed for physically challenged persons. This wheelchair is especially designed for those who are paralyzed, handicaps, accident persons and born handicaps by birth. It has an Electroencephalogram (EEG) brain sensing device which is placed on the top that senses the brain signals and convert it into movement of wheels with Brain Computer Interface. EEG head rest is a rotary joint which can be easily adjustable for wearer's body. With the help of two servo motors and microcontroller the wheels can be moved. Here are the figures designed in solid works.

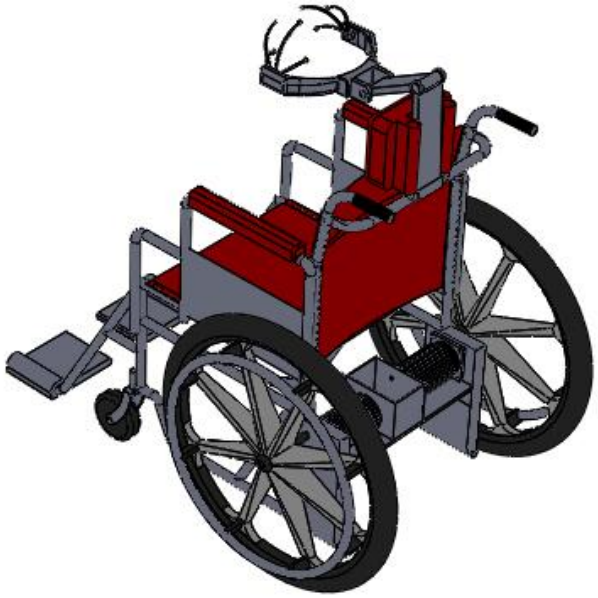


Fig (10) Isometric view for proposed wheelchair.

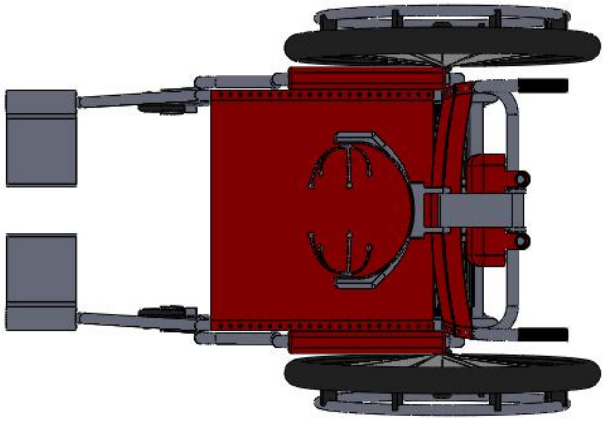


Fig (11) Top view of wheelchair

VI. SIMULATION

This wheelchair is mainly designed in solidworks and simulation is done in MATLAB software. Solidworks design in imported into MATLAB through simmechanics is shown in the Fig[12]. By using simmechanics explorer, we can run the simulation of the device and verify its motion.

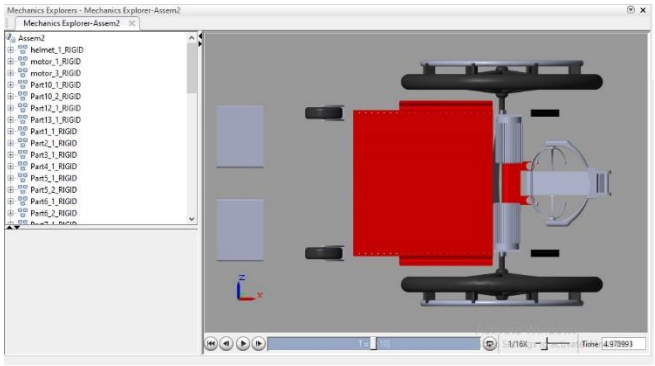


Fig. (12) Simmechanics explorer if the wheelchair design

VII. RESULT

Rotary joint of wheels is provided with sinusoidal input signal in order to calculate the output torque. The same graph for both the wheels of the wheelchair. Motion for the device is provided by the sensors and the torques are set to automatically compute. Output torques are realized and are plotted as shown in the Fig.13. and the signal statistics are shown in the table II.

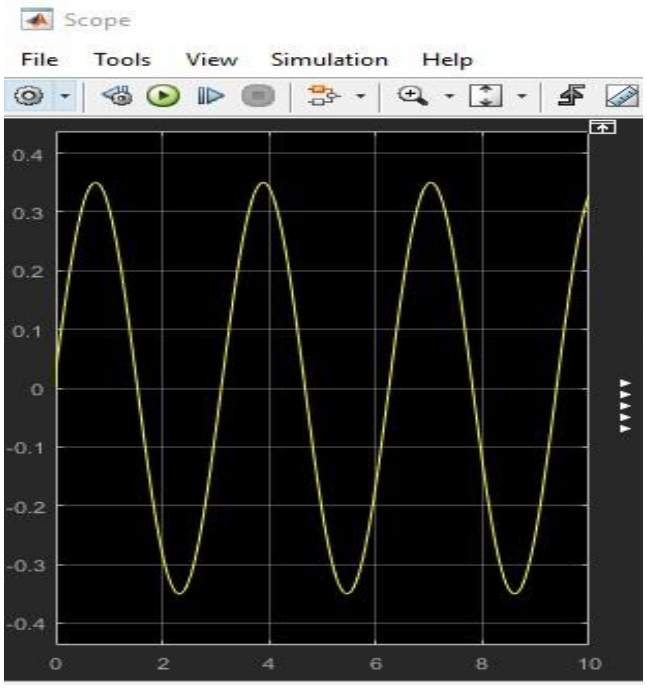


Fig (13) Torque output graph

TABLE II. SIGNAL STATISTICS

	Values	Time
Max	3.502e-01	0.747
Min	-3.502e-01	8.602

Peak to Peak	7.003e-01	
Mean	1.172e-02	
Median	3.841e-02	
RMS	2.533e-01	

ADVANTAGES:

1. Using a portable EEG brainwave headset can be used as dry active sensor technology to read the brain electric activity.
2. It can prove beneficial for any individuals in handling and shifting of the wheelchair.
3. It doesn't require any human support for the movement of wheelchair.
4.

DISADVANTAGES:

1. Fixing of these electrodes must be done before in any other further course.
2. The mental state must be stable in all the time of working in wheelchair.
3. Some basic training must be given to the user before the person use in environmental conditions.
4. Cost of the wheelchair is high.

VIII. FUTURE SCOPE

In this brain control electronic wheelchair is mainly controlled by thoughts. This wheelchair can be modelled in such a way that it can be easily turn into semi sleeper position to avoid long seating position of the user and to have some relaxation[8]. In this we can use previously invented techniques like stairs climbing, etc. These are more can be proposed in the future scope of the wheelchair.

IX. CONCLUSION

Design consideration of EEG signal based Brain control electronic wheelchair for physically challenged persons has been discussed to lead an independent life without any difficulties. Several methods are planned to receive the signals from EEG device for movement of the wheelchair and controlling the operations by using motor or the system using with microcontroller. This wheelchair can assists the human by doing their work by their own without any external user support in moving in their lifestyles. These results can be taken further and can be implemented for making device in real time interface with low cost of the system and to expand the application range.

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