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Mind Controlled Wheelchair

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***Abstract**: The paper deals with engineering an electric wheelchair from a common wheelchair and then developing a Brain Computer Interface (BCI) between the electric wheelchair and the human brain. A portable EEG headset and firmware signal processing together facilitate the movement of the wheelchair integrating mind activity and frequency of eye blinks of the patient sitting on the wheelchair with the help of Microcontroller Unit (MCU). The target population for the mind controlled wheelchair is the patients who are paralyzed below the neck and are unable to use conventional wheelchair interfaces. This project aims at creating a cost efficient solution, later intended to be distributed as an add-on conversion unit for a common manual wheelchair. A Neurosky mind wave headset is used to pick up EEG signals from the brain. This is a commercialized version of the Open-EEG Project. The signal obtained from EEG sensor is processed by the ARM microcontroller FRDM KL-25Z, a Freescale board. The microcontroller takes decision for determining the direction of motion of wheelchair based on floor detection and obstacle avoidance sensors mounted on wheelchair's footplate. The MCU shows real time information on a color LCD interfaced to it. Joystick control of the wheelchair is also provided as an additional interface option that can be chosen from the menu system of the project.*
***Keywords**: Electric wheelchair, Brain Computer Interface (BCI), Open Eelectroencephalography (EEG) Headset, Signal processing, Microcontroller Unit (MCU), ARM FRDM KL-25Z, Firmware Menu System.*

I. Introduction

Millions of people around the world suffer from mobility impairments [1]. People having mobility impairments need new devices with sophisticated technologies to help them for comfortable mobility. Wheelchair users having mobility impairments experience a high level of movement and functional limitation. Many patients are unable to control the powered wheelchair using conventional interface and also they are deemed incapable of driving safely [1]. Brain controlled wheelchair is being developed to provide mobility to the individuals who find it impossible to use a powered wheelchair due to motor, sensory, perceptual, or cognitive impairments [1]. Advancements in robotics, sensor technology and artificial intelligence promises enormous scope for developing an advanced wheelchair. Brain computer interfaces (BCI) are systems that communicate between human brain and physical devices by translating different patterns of the brain activity into commands in real time [2]. The electrical activity of the brain is monitored in real time using an array of electrodes, which are placed on the scalp in a process known as electroencephalography (EEG) [1]. Traditional EEG sensors are expensive and their use is limited only to hospitals and laboratories. The electrodes of EEG sensors require conductive gel on skin in order to facilitate reading signals [2]. The advantage of using a portable EEG brainwave headset is that it uses a dry active sensor technology to read brain electric activity. Traditional gel based EEGs can take up to 30 minutes to start acquiring data while the Neurosky headsets are ready to go in seconds. For this reason, headset based on Neurosky technology is cost- effective and easy to handle. The on board Think Gear IC processes raw signals, filters the noise and digitizes the signal [2-5]. The control system design for the wheelchair using various methods of BCI as well as speech and gesture recognition are discussed [2- 8], but the actual implementations are not shown. The multipurpose manual wheelchair is designed to serve various purposes of the patient as well as elderly people [9]. A wheelchair is designed which is controlled through Electro-oculography. The movement of the wheelchair direction is restricted to particular direction based on horizontal and vertical movements of the eye. But practically, eye will also have some oblique movements for which the wheelchair is not satisfactorily responding for the movement in particular direction [10]. The proposed work deals with engineering an interface between the human brain and an electric wheelchair using a portable EEG brainwave headset and firmware signal processing and filtering. The project eliminates the drawbacks of conventional EEG by using a dry sensor technology to pick up EEG signals instead of using a conductive gel and reducing the time it takes to setup. This project aims at creating a cost efficient solution, later intended to be distributed as an add-on conversion unit for a normal wheelchair. Doing so would be of noble and of importance to 'brain-active-body-paralyzed' patients providing them the independence of mobility. The research gaps of the previous versions [1-10] addressed in this project are:

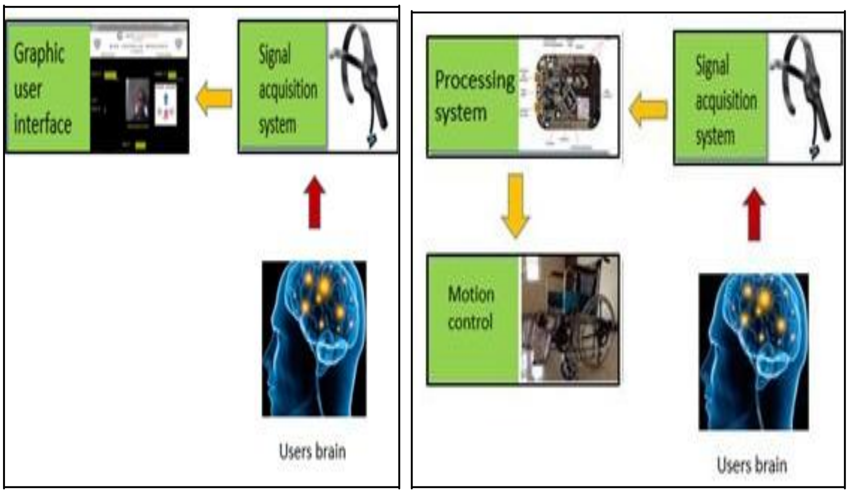
- The reduction in cost by making the design as a conversion kit for a regular wheelchair; the project doesn't reinvent the wheel, it instead builds on top of an existing framework and brings together the best of things. The mechanical modifications are narrowed down to a level where they can be reproduced easily and put on other manual wheelchairs.
- The project uses a mind wave headset instead of traditional EEG to acquire brain signals thereby reducing the set up time.
- The wheelchair's embedded subsystem uses a menu based GUI, this allows the wheelchair to be either mind wave controlled or joystick controlled; the two modes of operation make it possible for this system to be useful for a wide range of disabilities in people.

II. Methodology

The Mind controlled wheelchair controls the direction and motion of wheelchair based on the decision taken by the user. The mind wave headset is used in the mind controlled wheelchair to pick up EEG signals from the brain. These signals are processed by a microcontroller which in turn takes a decision regarding the motion and direction of wheelchair and accordingly drives the motor. Manual wheelchairs are driven with the help of man power as the source of energy for moving the chair. The manual wheelchairs are driven by the user by using the rear wheels with additional rims called the "Push Ring" for movement by rotating forward or backward [9]. The modification of manual wheelchair is done by mechanically coupling motors to rear wheels thereby making it an electric wheelchair. The active rear wheels are rotated by motors to the orientation that matches the current driving direction; the system employs differential drive. The proposed device proved to be effective for people suffering from paralysis where the patient loses control over various parts of body and also useful for the old age people. It is a cost efficient solution compared to the expensive powered wheelchairs used in most of the existing products by electrical and mechanical modification. The conceptual block diagram of mind controlled wheel chair is depicted in figure 1. The various components interfaced with the microcontroller to control the wheel chair are shown in Fig. 2.

A. Electronics and embedded subsystem

The electronics and embedded subsystem comprises of the Neurosky's Mindwave Headset which is a portable EEG mobile headset used to pick up EEG signals from the brain of the user and transmit them to the microcontroller unit via Bluetooth. The Bluetooth module used for receiving the signals transmitted by headset is BlueSMiRF(RN-42) that is interfaced with the microcontroller used over USART. Figure 3 shows the algorithm for data acquisition by RN-42 (BlueSMiRF) from the mind wave.



(a) (b)

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

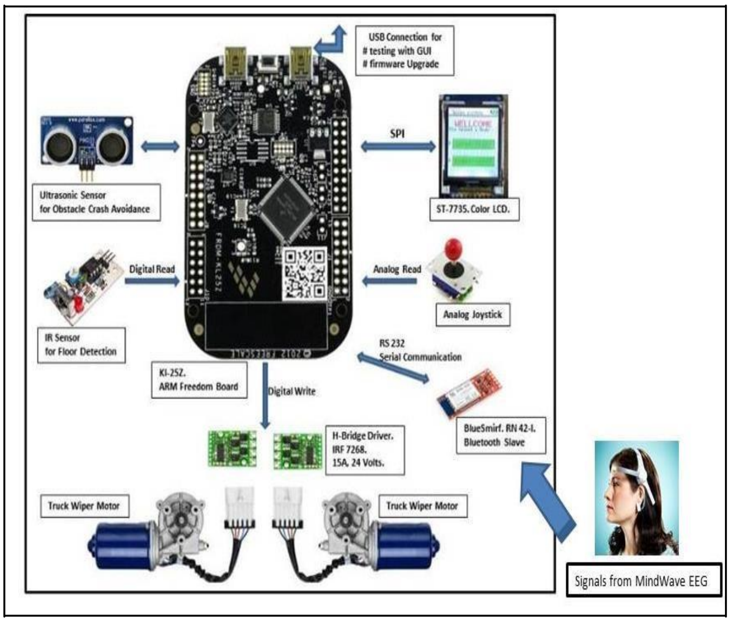
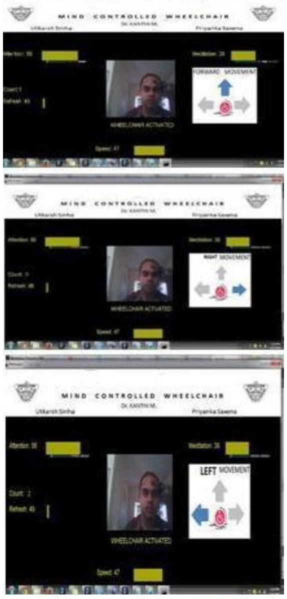


Fig. 2 Sensory, processing and actuation systems



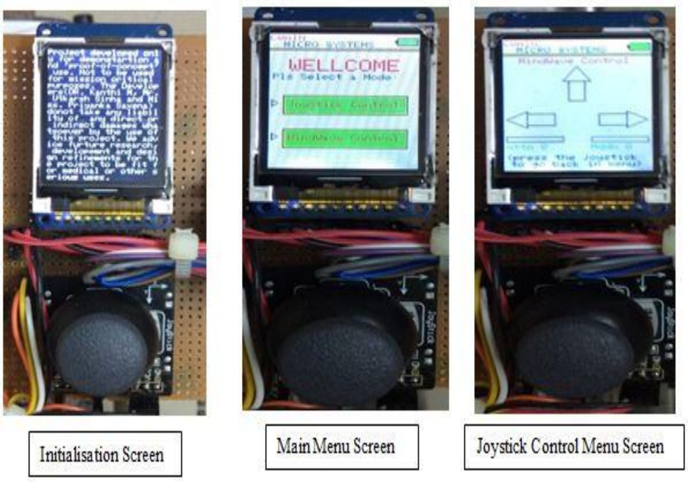


Figure 3. GUI development using Java **Figure 4**. GUI on wheelchair

The microcontroller used is FRDM-KL25Z which is a Freescale Freedom Development Platform microcontroller board assembly. It features a Kinetis L series microcontroller built on ARM Cortex M0+ core

[11]. H-Bridge MOSFET drivers are used to drive motors. The microcontroller forms an essential part of the processing system. The microcontroller in response to the signals picked up by EEG sensors compute the direction of motion. The microcontroller outputs the processed data to the user interface and motion control systems.

B. Software and data processing subsystem

Graphic user development is needed to provide Neuro feedback to individual in the form of visual stimulus using which they can control their brainwave output more easily and enable a more efficient control system [2], [4], [12]. Prior to letting the subject use the wheelchair, a training program to control the direction and speed of the wheelchair is formulated. Custom software is developed using Java. This software simulates a wheelchair environment on the PC screen. Figure 4 describes the algorithm of the Java program. Right, Left, Forward and Stop commands given by the user.

III. Results

The need for graphic user development is to provide neuro feedback to individual in the form of visual stimulus so that they can control their brainwave output more easily and enable a more efficient control system [5], [9], [11]. Figure 5 shows the graphical user interface results for forward, right and left movement respectively.
The hardware GUI on the wheelchair is shown in Figure 6.

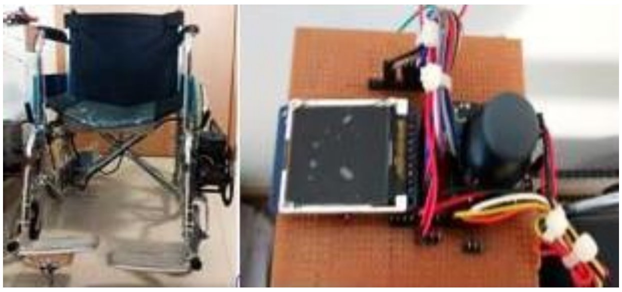


Figure 5. Mind controlled wheelchair

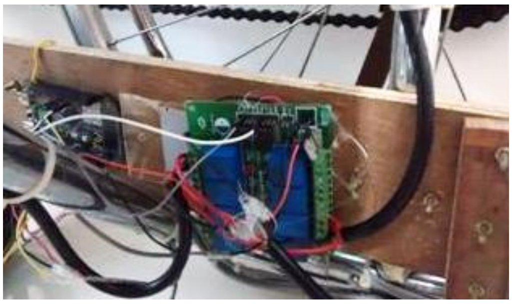


Figure 6. Hardware GUI on the wheelchair

IV. Conclusion and Future Scope

The mind wave headset records the electric activity of the brain and the wheelchair moves according to the mind attention or meditation level. This project deals with engineering an interface between the human brain and an electric wheelchair using a portable EEG brainwave headset and firmware signal processing and filtering. This project aims at creating a cost efficient solution, later intended to be distributed as an add-on conversion unit for a normal wheelchair.

Advances have been made in the technology of “Mind controlled wheelchairs”. Performance of mind controlled wheelchairs has demonstrated its potential as an effective approach to providing independent mobility to a wide range of users who cannot independently operate a powered wheelchair system. The future work is projected into two different directions. First integrate the developed system with databases that can be made available through a wireless network and access to the internet. The user can download maps describing buildings and streets, and the on board sensors (cameras, laser range finder, GPS) must allow the user to designate destinations at the highest navigation level. Second one is pursuing feedback from potential users and working toward the next design with a view of developing a more practical, aesthetically appealing prototype.

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