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# Wheelchair Motion Control Guide Using Eye Movement Based on EEG Signals

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## Abstract

The design and implementation of an Autonomous Movement Robot based on a Wheelchair based on EOG signal is to help a disable or handicapped person. These EOG electrodes are placed at right and left of eye and other pair of electrodes are at top and right of the eye. These electrodes used to response after gazing of one target point for a particular time period. After gazing of point, the wheelchair used to move to a target position. So, it produce delay during eye gaze. To overcome this delay, EEG amplifier are used. These EEG signals are placed to capture brain waves. These brain waves are controlled by microcontroller and it produce analog waves. To convert analog waves to digital output Analog to digital converter is used. Object Sensor is used to avoid obstacles in its path respectively. The main contribution of the work is the combination of several technologies and techniques that came from different areas such as mechanical, electronic engineering. Driver circuit with relay are used to move wheelchair automatically. ZigBee is used for long transmission of wheelchair. Accelerometer and interfacing circuit are done by using head movement. DLOA algorithm used to avoid obstacles while reaching destination point. The target coordinates of the destination place using EEG, to reduce delay for auto navigation process.

**Keywords**: wheelchair, electroencephalography, eye movement, accelerometer, IR Sensor

## Introduction

An embedded system is a combination of hardware and software. It is a computer system used to design specific control function in a large system mostly with real-time applications.

An existing system deals with Electrooculography (EOG) signal. EOG used to record the eye movement so the wheelchair is controlled by eye movement, eye blink an eye gaze. It’s mainly composed of point bug algorithm and it is used to navigate wheelchair automatically at a degree of 0 and 40, it is increment upto 10 degree. The disadvantage of the system is using eye gaze, because of this eye gaze it produce delay during navigation process. To overcome, EEG signals based on dipole movement is used.

The proposed system deals with EEG signals. These Electroencephalography amplifies the signal to reduce delay. Here, Microcontroller used is ATmega 16L. It is used to control all function components. EEG signals used to record the brain waves. During process signal produce an analog signal.

**Paper Scope and Contributions**

An auto-navigation process based on EEG signals with dipole movement. It is a hand-free system for control function of electric power wheelchair using EEG. Many new methods are introduced for controlling method of wheelchair besides manual method. These dipole movement describes how the wheelchair moves in a direction as right, left and bottom direction using pair of electrodes. The movement of wheelchair is based on EEG signal with dipole movement. It consists of relay and it helps the movement of wheelchair in forward and reverse direction. Relay is an electromagnetic switch used for long transmission. EEG mainly used to record the brain waves with BCI. These EEG signal with dipole movement consists of pair of electrodes and these electrode produce output as analog.

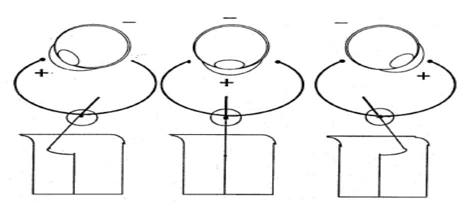


**Fig.1. Dipole Movements**

The data which are acquired used to capture signal and it transmit them to a ZigBee device. An Acquisition is done in real time using microcontroller-based platform. The zigBee device used here is XBee. This module is connected to microcontroller and its command set allow Sensor users to configure network and interface parameters via the microcontroller. ZigBee produce low energy consumption. The analogue signal are converted to digital by microcontroller's internal Analog to Digital Converter (LPC1756, 12-bit resolution, 100–300 Hz sampling frequency adjustable in 10-Hz steps) before being transmitted via ZigBee

## System Architecture

A system describes a pair of electrodes placed near eye in left and right direction. EEG signal amplifies and it produce analog output. To convert analog signal to a digital ADC (Analog to Digital Conversion is used. The transmitter process done by this method and these siganls are controlled by Microcontroller. The EEG values are displaced in LCD. It receives the output to a ZigBee device. It act as transmitter and receiver. It is a type of protocol and works with Indoor and Outdoor application.

These are connected to receiver. The receiver also controlled by Microcontroller and it contains LCD display. Accelerometer is used to accelerate the direction in left, right, forward and reverse direction. Since, it is a multi-axis it works with many directions. Object sensor used to sense the object to avoid collision. Alarm is used to indicate whether obstacle is found during motion. These object sensor is controlled by SCU. Here, wheelchair describe in a robotic model. Power supply used is 5v to 12v.

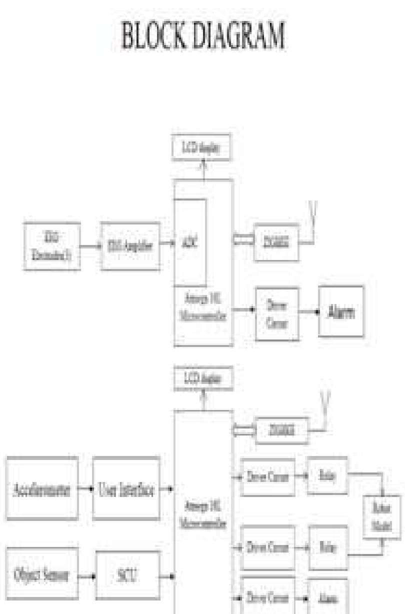



**Fig.2. System Architecture**

In power supply step down transformer is used. It normally provides AC voltage of 230v. To produce DC voltage capacitor is used. The voltage regulation is usually obtained using voltage regulator IC units. For ICs, microcontroller and LCD supports 5v. For alarm, op-amp and relay supports 12v.

## Related Work

### Power Supply

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. When four diodes are connected as shown in figure, the circuit is called as bridge rectifier.

The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B.

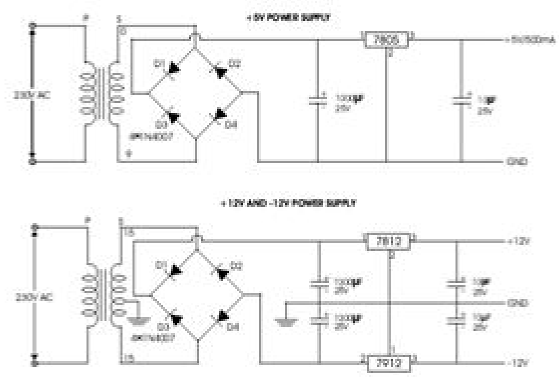



**Fig.3. Power Supply Circuit Diagram**

The positive potential at point A will forward bias D3 and reverse bias D4. The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

### DC Motor with Relay

This circuit is designed to control the motor in the forward and reverse direction. It consists of two relays named as relay1, relay2. The relay ON and OFF is controlled by the pair of switching transistors. A Relay is nothing but electromagnetic switching device which consists of three pins. They are Common, Normally Close (NC) and Normally Open (NO). The common pin of two relay is connected to positive and negative terminal of motor through snubber circuit respectively. The relays are connected in the collector terminal of the transistors T2 and T4.

When high pulse signal is given to either base of the T1 or T3 transistors, the transistor is conducting and shorts the collector and emitter terminal and zero signals is given to base of the T2 or T4 transistor. So the relay is turned OFF state. When low pulse is given to either base of transistor T1 or T3 transistor, the transistor is turned OFF. Now 12v is given to base of T2 or T4 transistor so the transistor is conducting and relay is turn ON. The NO and NC pins of two relays are interconnected so only one relay can be operated at a time. The series combination of resistor and capacitor is called as snubber circuit. When the relay is turn ON and turn OFF continuously, the back emf may fault the relays. So the back EMF is grounded through the snubber circuit.

1. When relay 1 is in the ON state and relay 2 is in the OFF state, the motor is running in the forward direction
2. When relay 2 is in the ON state and relay 1 is in the OFF state, the motor is running in the reverse direction.

**ATmega Microcontroller**

The high-performance, low-power Atmel 8-bit RISC-based microcontroller, an 8-channel 10-bit A/D converter. It combines 16KB of programmable flash memory, 1KB SRAM, 512B EEPROM, and a JTAG interface for on-chip debugging. The device supports throughput of 16 MIPS at 16 MHz and operates between 4.5-5.5 volts.

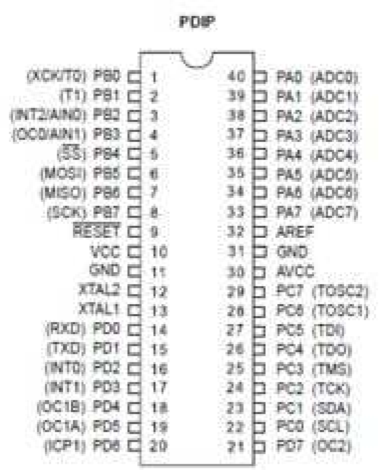



**Fig.4. Pin Diagram**

| Parameter | | Value |
|---|---|---|
| Flash (Kbytes) | : | 16 Kbytes |
| Pin Count | : | 44 |
| Max. Operating Frequency | : | 16 MHz |
| CPU | : | 8-bit AVR |
| Max I/O Pins | : | 32 |
| External Interrupts | : | 3 |

**ZigBee (XBEE SERIES 2 OEM RF MODULE)**

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks [4-5]. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones.

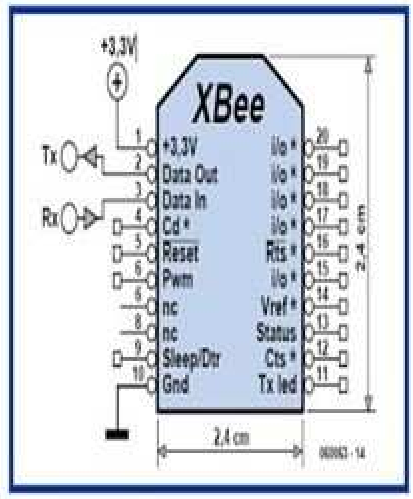



Fig.5. ZigBee Pin Layout

ZigBee is targeted at applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be similar and less expensive than other WPANS such as Bluetooth. This allows ZigBee networks to be formed ad-hoc, with no centralized control or high-power transmitter/receiver able to reach all of the devices. Any ZigBee device can be tasked with running the network.

**XBEE SERIES 2 OEM RF MODULE**:

1. It works within ZigBee protocol.
2. It provides low cost, low power, high performance and easy to use
3. Indoor : up to 133’ (40m)
4. Outdoor : up to 400’ (120m)
5. Transmit power : 2mw
6. RF data rate : 250,000bps

**EEG Amplifier**

EEG can also be used in intensive care units for brain function monitoring:

1. To monitor for non-convulsive seizures/non-convulsive status epilepticus [6-9].
2. To monitor the effect of sedative/anesthesia in patients in medically induced coma (for treatment of refractory seizures or increased intracranial pressure).
3. To monitor for secondary brain damage in conditions such as subarachnoid hemorrhage (currently a research method)

EEG may be used to monitor certain procedures:

1. To monitor the depth of anesthesia.
2. As an indirect indicator of cerebral perfusion in carotid endarterectomy to monitor amobarbital effect during the Wada test.

Electroencephalography used to measure the activity of brain waves. Electrodes are placed in scalps and it used to measure brain waves with BCI. Brain computer interface used to calculate brain waves. A pair of electrodes are placed to see the amplified signal. These signals are converted to digital signals by analog to digit al converter (ADC).

The present study investigated controlling of a power wheelchair by EEG signals. This was an attempt to control direction of wheelchair via brain signals. Each direction (left, forward, right, backward and stop) of the wheelchair corresponds to five mental tasks (movement imagery, trivial multiplication, geometrical figure rotation, non – trivial multiplication and relax). To differentiate five mental tasks, wavelet packet transform was employed for feature extraction and Radial basis function neural network was used for classification. The experimental result showed 100% accuracy. ADC (Analog to Digital Converter) is a conversion of analog waveform that comes from EEG signal converted to digital waveform. When it combine with ATmega microcontroller it consists of 8 channels of ADC, AREF and AVCC [10-14]. It consists of two resistor namely $R_T$ and $R_1$. $R_T$ connected to Vref and $R_1$ connected to Vss and both resistor are connected with REF ADC as a positive voltage connected in between resistor and negative to be ground i.e., Vss.

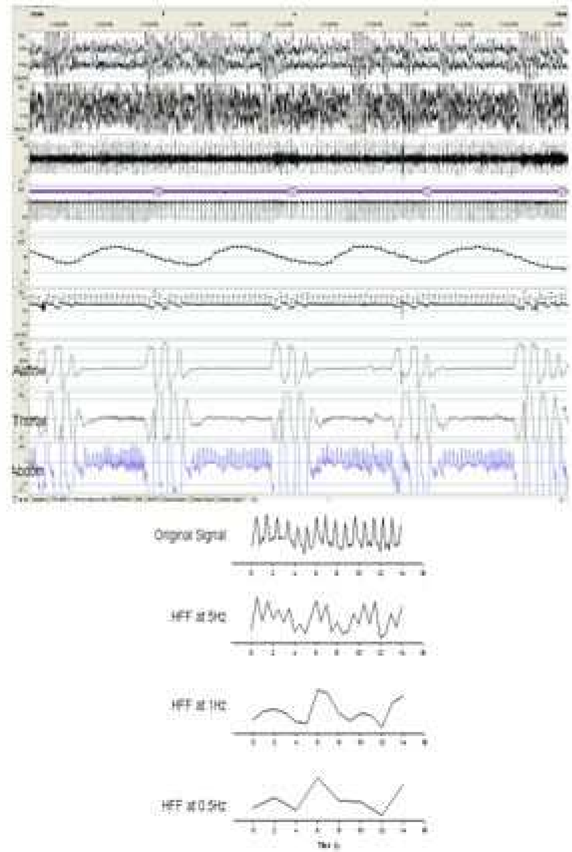



**Fig.6. EEG Waveforms**

**Accelerometer**

An accelerometer is an integrated device which is used to measures proper acceleration. These acceleration experienced with relative to free fall. Single-axis and multi-axis models are available. Here, multi-axis is applied to detect magnitude and direction of the acceleration as a vector quantity. It can be used to sense orientation, acceleration, vibration shock, and falling. These micro machined accelerometers are increasingly present in portable electronic devices and video game controllers, etc. to detect the position of the device. It is a capable of measuring the speed of object how fast it’s changing. It generates an analog voltage as output and it is used as an input to the control system.

**Analog to Digital Converter**

An EEG signal used to produce input signal as analog waves. To convert this ADC (analog to digital converter) is used to produce digital signal.

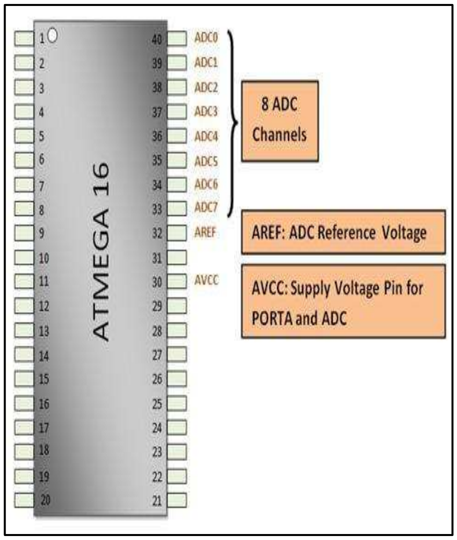
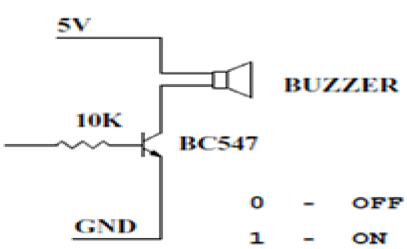



**Fig .7. ADC Pin Diagram**

**Object Sensor and Alarm**

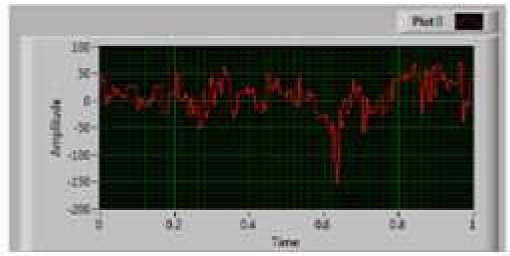
IR sensor used to sense the obstacles during motion of wheelchair. By DLOA method the wheelchair used to rotate all around to find obstacles. If any obstacles are found it produce alarm sound to avoid collision between objects.

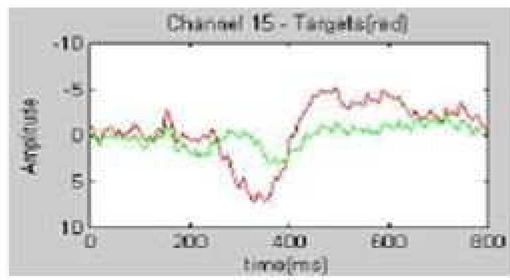



## Discussion

A measurement system of an EEG signal is used to detect brain waves by dipole movements with no errors. All signal waves act as input for controlling the wheelchair. It can be easily distinguish and make it possible to expand selected target points. By this, the brain waves can be easily detected with the EEG measurement system and it consists of different characteristics values. It can be done by different simulation methods.

Many different methods are tested and simulated by same initial points with different goal points, shapes and location of obstacles. In real life, the testing is conducted by wheelchair and it can be integrated with hardware to control the motors by use of microcontroller.






## Conclusion

The paper deals with EEG signal to control wheelchair motion by using brain waves. The main aim is to help handicapped persons, by use of the brain waves and can be easily controlled the wheelchair motion in environment. By this process, the navigation can be done automatically and can be concluded that user can enjoy looking around while navigation done automatically. The result was classified with five different people and it learned to recognize them with overall success rate of 82%.

## Future Work

Future work deals with head Movement and Finger Movement for disabled person (blind) with EEG signals.

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