Design of electric wheelchair controller based on brainwaves spectrum EEG sensor

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Abstract. The purpose of this study was to design of electric wheelchair. A wheelchair is a tool for people with disability. In general, a wheelchair is still controlled by hand or using a Joystick electrically, so users with a disorder can perform activities without any help. The research was designed to help disabilities who do not have hands and feet. So there needs to be wheelchair control without the use of hand or foot muscles. Therefore, it is designed an electric wheelchair that can be controlled based on brain wave activity using EEG sensors. EEG sensor is a device that can detect the activity of human brainwaves, this sensor can be used for control on a movement direction of a wheelchair, based on the parameters Blink detection and Attention. The laptop device is used as a LabVIEW-based programming control center that is associated with the Arduino as a communication between input and output components. As well as the ultrasonic distance sensor HCSR-04 is used as a wheelchair safety. Wheelchair movement can be controlled automatically, with the movement forward, backward, turn right and turn left, with an average success rate of 80%. This is because there is instability in detecting brain signals. Wheelchair ability in bringing user load is less than 130 kg.

1. Introduction
Technological advances in this decade are a great achievement in the development of mankind. Through science and technology, various devices have been created as a tool to facilitate human life, especially for people with special needs, they have limitations in performing their daily activities special need. The utility of a wheelchair, in general, is to help patients who have temporary or permanent disturbances in the motor system on their feet. With the Brain computer Interface (BCI) people with disabilities can certainly control their own wheelchairs through brain waves of EEG signals. The greatest advantage of EEG signals is that the complex pattern of neural activity can be recorded in a split second after the stimulus is given [1]. Utilization of EEG signals can usually be used to determine brain function, anesthesia, know oxygen levels in the brain, detect certain neurological diseases as in epilepsy [1]. But in this study the use of brain waves will be utilized to be able to control a wheelchair, which is expected to be used for the disability.

The research on brain waves has been done, such as the following studies. Research on electroencephalogram (EEG) signals based on existing computer interfaces only controls the movement of the wheelchair forward, right, left, or backward [2]. And there is also a proposed BCI platform design to command the electric wheelchair simulator [3]. In terms of Brain-computer interfaces (BCIs) technology can offer promising new interaction modalities, that is, using direct brain activity [4].
Previous research has not yet implemented a security system in their wheelchairs. Therefore, in this study, designing wheelchair controllers with EEG signals is equipped with a security system, making it easy for users. Therefore, in this study, designing wheelchair controller with EEG signal equipped with the safety system, so as to provide convenience for the user.

2. Method design of wheelchair system

Design is an important stage in this research, a series of activities to realize a system that can work well and systematically. The following is a block diagram of the wheelchair control system based on the brain wave spectrum of the EEG sensor (Electroencephalogram), as shown in Figure 1.

![Figure 1](image1.png)

**Figure 1.** Diagram block of wheelchair system.

In this study using neurosky as an EEG sensor because it offers convenience compared to the technology using which EEG-based system consists of many electrodes [5,6]. Design of wheelchair construction was built by utilizing conventional wheelchairs selected because it has a robust construction, easy to obtain at affordable prices and of course expected to be used by the subject of disabled patients. In this wheelchair also added some major components in order to be operated electrically, as in Figure 2.

![Figure 2](image2.png)

**Figure 2.** The Design of wheelchairs.
3. Result and discussion

EEG Sensor testing and analysis

This EEG sensor is the main component to drive wheelchair control, using EEG NeuroSky Mindwave Mobile sensor. This sensor is enabled to detect 2 times eye-blinking pulses and 3 times eye-blinking pulses done by the user. The experimental results confirm that control by using attention and eye-blinking signals offer a convenient way to control an electric wheelchair [7].

| Action                        | Extracted Signals |
|-------------------------------|-------------------|
| 2 times eye-blinking pulse    | ![Waveform]       |
| 3 times eye-blinking pulse    | ![Waveform]       |

Table 1. EEG sensor testing.

Testing of movement response to wall blocks

The difficulty of a wheelchair navigation system is to avoid obstacles, move between obstacles and provide a sense of security [8]. This test is carried out by moving the electric wheelchair from 2.5 meters distance to the barrier wall, and the wheelchair will stop moving if the distance between the wheelchair with the wall is less than or equal to 50 cm, this condition is applied to the front and rear distance sensor. This aims to avoid the wheelchair does not hit a wall or object that is in front of it.

Table 2. Test the movement of a wheelchair so as not to hit a wall or objects in front of it.

| Sensor            | Tests | Set the stopping distance (cm) on the program | The stop point against the wall or object that is in front (cm) |
|-------------------|-------|-----------------------------------------------|---------------------------------------------------------------|
| Ultrasonic Sensor | 1     | 50                                            | 47.2                                                          |
| (front)           | 2     | 50                                            | 46.7                                                          |
|                   | 3     | 50                                            | 44.5                                                          |
|                   | 4     | 50                                            | 44.8                                                          |
|                   | 5     | 50                                            | 45.7                                                          |
| Ultrasonic Sensor | 1     | 50                                            | 46.8                                                          |
| (behind)          | 2     | 50                                            | 45.5                                                          |
|                   | 3     | 50                                            | 43.7                                                          |
|                   | 4     | 50                                            | 46.8                                                          |
|                   | 5     | 50                                            | 44.3                                                          |

Tests on LabVIEW Programming

This test is aimed to test whether the overall algorithm built on LabVIEW programming is appropriate and can be applied to an electric wheelchair system. In Figure 3 which is the data processing interface of the EEG sensor, it has been known to work well and can communicate with the Arduino in
exchanging data accurately to input and output components. Below is the data of the trial results of the movement of the value of the attention of the sensors EEG Neurosky Mindwave. Based on eSense Attention meter indicates the level of attention or focus of a person range from 0 to 100. The "neutral" period scale is at a value between 40 and 60 at a given moment [9]. The setpoint attention selected in this test is at 60, this refers to a value between 40 and 60 at any given moment in the "neutral" period.

![Design of Electric Wheelchair Controller Based on Brainwaves Spectrum EEG Sensor](image)

**Figure 3.** Display of overall testing interface on LabVIEW.

**Table 3.** Test result on movement on attention values.

| Mode         | Tests | Setpoint Attention | Attention Value | Movement Wheelchair | Percentage of Success (%) |
|--------------|-------|--------------------|-----------------|---------------------|---------------------------|
| Forward      | 1     | 60                 | 74              | Forward             |                           |
|              | 2     | 60                 | 64              | Forward             |                           |
|              | 3     | 60                 | 60              | Forward             | 100                       |
|              | 4     | 60                 | 66              | Forward             |                           |
|              | 5     | 60                 | 70              | Forward             |                           |
| Turn Right   | 1     | 60                 | 68              | Turn Right          |                           |
|              | 2     | 60                 | 62              | Turn Right          |                           |
|              | 3     | 60                 | 50              | Not Moving          | 80                        |
|              | 4     | 60                 | 78              | Turn Right          |                           |
|              | 5     | 60                 | 64              | Turn Right          |                           |
| Turn Left    | 1     | 60                 | 82              | Turn Left           |                           |
|              | 2     | 60                 | 62              | Turn Left           |                           |
|              | 3     | 60                 | 66              | Turn Left           | 80                        |
|              | 4     | 60                 | 58              | Not Moving          |                           |
|              | 5     | 60                 | 66              | Turn Left           |                           |
| Backward     | 1     | 60                 | 68              | Backwards           |                           |
|              | 2     | 60                 | 52              | Not Moving          |                           |
|              | 3     | 60                 | 70              | Backwards           | 60                        |
|              | 4     | 60                 | 54              | Not Moving          |                           |
|              | 5     | 60                 | 62              | Backwards           |                           |
The experimental results in Table 3, it can be seen that the tool will move if the Attention value exceeds or equal to Set Point value. Where Set Point value can be arranged according to subject concentration condition. Success rate based on the test of each movement got an average percentage value of 80%. This is influenced by Attention values that do not reach the setpoint.

3.1. Charge power test load chairs
The purpose of this test is to know the ability of the wheelchair to the load carrying capacity of the user's subject, as in Table 4.

| Experiment | Loads tested (kg) | Distance achieved (m) | Time reached (sec) | Speed (m/sec) | Wheelchair Action |
|------------|------------------|-----------------------|--------------------|---------------|------------------|
| 1          | 40-60            | 1                     | 6,25               | 0,16          | Move             |
| 2          | 61-80            | 1                     | 7,62               | 0,13          | Move             |
| 3          | 81-110           | 1                     | 8,87               | 0,11          | Move             |
| 4          | 111-130          | 1                     | 10,31              | 0,09          | Move             |
| 5          | >130             | 1                     | -                  | -             | Not Moving       |

It can be concluded that the wheelchair capability when the load is transported less than or equal 130 kg can still move, but with the speed of slowing down, and when tested by giving a load of greater than 130 kg wheelchair does not move. This is because of the limitations on the DC motor gearbox torque used in this study. In addition to the ability to carry the load, there are several features that must be considered from the electric wheelchair that is the ability to navigate and can adapt automatically through the interface with the user [10][11].

4. Conclusion
Based on the result of "Design of Electric Wheelchair Control Based on Spectrum of EEG Sensor Brain Sensor" can be obtained with some conclusions, among others.
- Electric wheelchair design has been completed, with using EEG Neurosky Mindwave sensor.
- The safety system works well, in which the electric wheelchair will stop if it detects front and rear obstacles at a distance of ≤ 50 cm.
- The average success rate of the control signal EEG reach 80%, this is because there is instability in detecting brain signals.
- Based on the test, the load that can be carried by a wheelchair is a load that is less than or equal to 130 kg, more than that the wheelchair can not run.

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