Electric Wheelchair Controlled by Joystick and Android/iOS Smartphone

(Pengendalian Kerusi Roda Elektrik Menggunakan Kayu Bedik dan Telefon Pintar (Android/iOS))

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Abstract

A wheelchair is used by people who are difficult to walk because of having physical problems, injuries, or disabilities. There are many options and different types of wheelchairs such as manual wheelchairs, electric wheelchairs, and scooters depending on the patient's financial ability, physical limits, and strength. Not all people with movement disabilities have enough strength especially elders. Moreover, there is no wheelchair controlled by smartphones currently available in the market and even custom-made electric wheelchairs are very expensive. Therefore, the main objective of this project is to provide a solution to this matter by modifying an existing manual wheelchair that would use smartphones (android/iOS) and joystick to control its movement. So, the rationale of this project is it can help patients with movement difficulty to move easily with significantly at a lower cost. Implementation of this project will be using System Development (SDLC) Life Cycle methodology that divide the complex task into several phases of development. This project will be divided into two parts, namely the implementation of hardware and software. The main hardware of this system consists of Arduino microcontrollers and motors that can be controlled using a smartphone via Bluetooth module and joystick. Ultrasonic sensors are located on the rear of this wheelchair to detect objects or obstacles and buzz the buzzer so that the person who uses it can be acknowledged when there are objects behind during reverse movement. The software part will consist of Arduino programming using Arduino Integrated Development Environment (IDE) software and mobile apps programming using Massachusetts Institute of Technology (MIT) App Inventor software. In the end, the implementation of this project can be used in universities, companies, hospitals, and at home as well to facilitate someone's movement without having to rely too much on help from others. In conclusion, this project is expected can help the disability and elder to move freely and control the electric wheelchair by themselves independently.

Keywords: Electric Wheelchair, Smartphone, Arduino, Joystick

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INTRODUCTION

BACKGROUND

A wheelchair is a tool that was built to make disabled people easier to move and it is also used by people who are difficult to walk because of having physical problems, injuries, or lack of physical stamina. Therefore, the wheelchair can be classified as a type of medical equipment to improve access for people with mobility problems. The most common wheelchair can be controlled by the user in a sitting situation by moving the wheel using their hands. However, this wheelchair also has the handling at the back for others to help to move it. Nowadays there are many options and different types of wheelchairs such as manual wheelchairs, electric wheelchairs, and scooters, but they are classified as either manually or electrically.

PROBLEM STATEMENT

Nowadays, there are many types of helping tools available in the market. Helping tools for movement usually depending on the users, such as their physical limits and stamina. Not all people with movement disabilities have enough strength especially elders. So, it is hard for elders to find a suitable tool to help them move around. Therefore, we want to modify an existing wheelchair that would use the Android/iOS app and joystick to control its movement. People with disabilities will feel easy to use these wheelchairs because this wheelchair using only a smartphone app and a joystick to control it. Moreover, there is no wheelchair controlled by smartphones currently available at the market. Other than that, the most custom-made electric wheelchair is expensive.

OBJECTIVE

This study embarks on the following objectives:

i. To modify the normal/manual wheelchair and allows it to be controlled using a joystick for those who have problems with movement.
ii. To modify the normal/manual wheelchair that can be controlled using a smartphone.
iii. To detect obstacles using an ultrasonic sensor to prevent accidents.
iv. To test the maximum inclines, angle, and load of the proposed system.

LITERATURE REVIEW

A wheelchair is a tool that was built to make people with disabilities easier to move. While we call the wheelchair a "modern invention," its history can be traced back through thousands of years (PA Healthcare, 2016). Today, there are several different wheelchair design models, but they are basically classified as either manual or electrical (Ahmad Muhaimin, 2012).

The use of an electrical wheelchair leads to a large amount of independence for persons with a physical disability who can neither walk nor operate a mechanical wheelchair alone (Lodhi et al., 2016). There are previous projects/products regarding electrical wheelchair that has been carried out such as voice-controlled wheelchair (Lodhi et al., 2016; Jamuna, Kumar, & Karthikeyan 2015) and wheelchair with gesture recognition (Vishal, V.P et al, 2014), Based on the review that has been done, a few disadvantages have been identified for the previous project.

Based on the review for the voice-controlled wheelchair (Lodhi et al., 2016; Jamuna et al., 2015), it has been identified that it is only suitable for indoor use. Since the project used voice to give the command to the microcontroller, it is difficult to detect the voice command if there are many humans or ambient voices. A review on the electrical

wheelchair with gesture recognition (Vishal et al., 2014) identifies that even it has very high maneuverability, it is significantly high cost.

A study on the theory of components, circuits, and past projects that have been carried out reveals that we can use newer technology to control the wheelchair. The latest technology that can be used is using the smartphone app to control the wheelchair movement via Bluetooth connection. As we know that almost every one of us can afford to have at least one smartphone. This is the main advantage of this project which is upgrading and improving the capability in controlling the motor using smartphones combining with the joystick as another option to control the movement.

METHODOLOGY

The system is developed using the System Development Life Cycle (SDLC) methodology as shown in Figure 1 below. This life cycle is to divide the work of a complex system into several phases of development. It allows complex work more easily understood and controlled. Each phase in the SDLC has different properties and each contains a unique work development. This life cycle methodology can help illustrate important management processes and procedures for achieving unparalleled decisions in development applications.

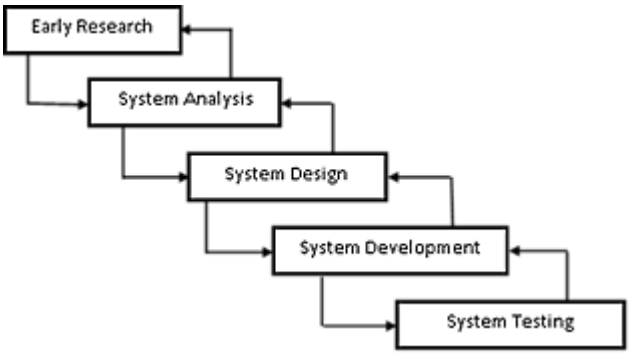

Figure 1. Project Development Methodology

RESULT & ANALYSIS

MODEL DESIGN

The wheelchair is designed by modifying the existing wheelchair currently available in the market. The design consists of two 24 Volt DC wiper motors attached to both rears wheels to control the movement of the wheelchair. The joystick is put in the right arm frame but can easily move to the left arm frame in case left-hand users are using it. Smartphone holders are put beside the wheelchair frame which can be easily moved up in front of the user chair. The circuit and battery case are put behind the electric wheelchair to give more balance and easy for maintenance purposes such as for recharging or changing the battery and troubleshooting the circuit. Battery capacity required is about 24V, 14.4Ah, and power needed for motors is about 450W. The total setup weighs approximately 50kg and its weight capacity is within 100 –120kg. The design concept of the wheelchair is shown in Figure 2.

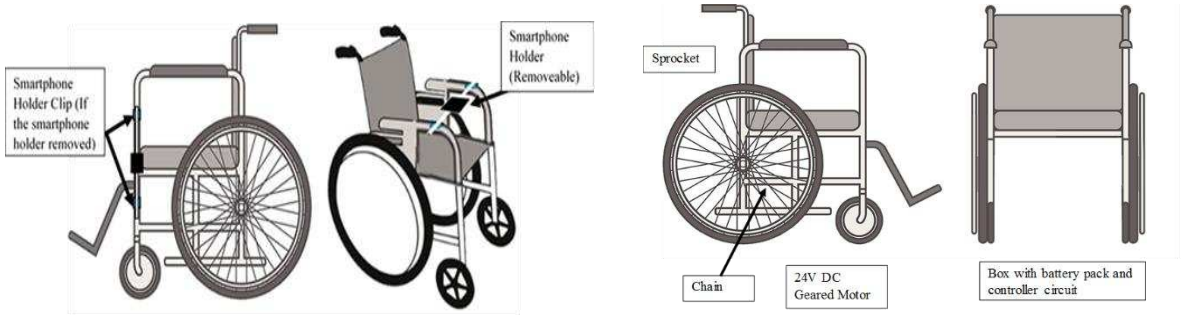

Figure 2. Design Concept

CONTROL SYSTEM

The main controller for this project is using Arduino. Arduino device is paired with a Bluetooth module that communicates with a smartphone to move the wheelchair-using android/iOS app. The same concept applies to control the wheelchair movement through Joystick, where Arduino devices are paired with the Joystick through Bluetooth connection. Bluetooth module also relates to Arduino devices and relay module to control the motor movement and makes both left and right motors functional. The relay module and Bluetooth module connections are connected through the Arduino development board. Arduino also uses to control the output for the buzzer, where the signal input is taken from the ultrasonic sensor. An overview of the component's connections is shown in Figure 3.

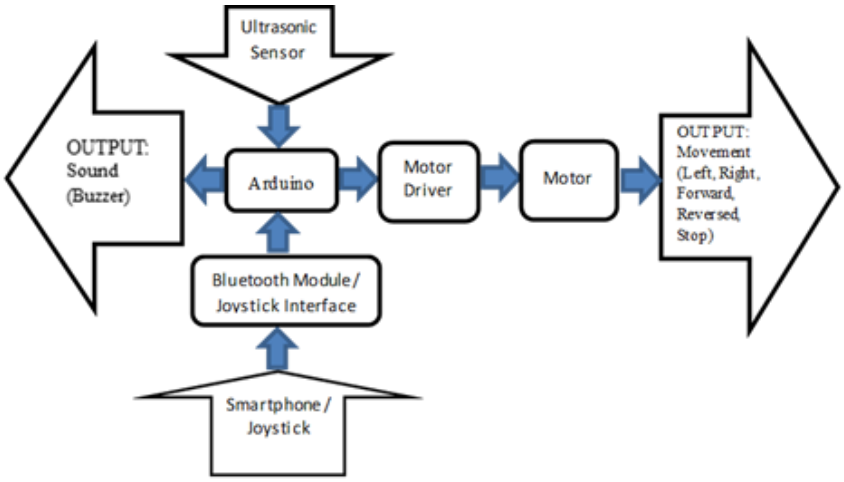

Figure 3. Design concept

MOBILE APP INTERFACE

The android/iOS application is build using the Massachusetts Institute of Technology (MIT) App Inventor. It is an online intuitive, visual programming environment that allows everyone to build fully functional apps for smartphones and tablets. The mobile interface is divided into 3 sections. The first section shows the institution logo, second section the Bluetooth connection button, and the third section the control button area. For the control button area, it has button-up, button-down, button left, button right, and stop button as shown in Figure 4. The Electric wheelchair can be controlled just by pressing the interface control area button through the smartphone. Each button serves to control the movement of the wheelchair in its respective direction. The smartphone is connected to a wheelchair through Bluetooth technology with a maximum range of about 15m. An additional interface that shows the info for the developer is also available.

Figure 4. Mobile app interface

ANALYSIS

The testing performance including "Weight Vs Speed" to analyze the capability of the motor to carry users according to their weight at full speed and the capability of the motor to carry users through a steep environment. However, for safety purposes, we limit the motor full speed to 40% only from its maximum actual speed. To test the effectiveness of the prototype, volunteers were asked to become a part of the testing of the prototype. Each volunteer with different weight was asked to ride the Electric Wheelchair at the full speed. The result then is plotting on the Graph. Motor output "Weight vs. Speed" graph is shown in Figure 5.

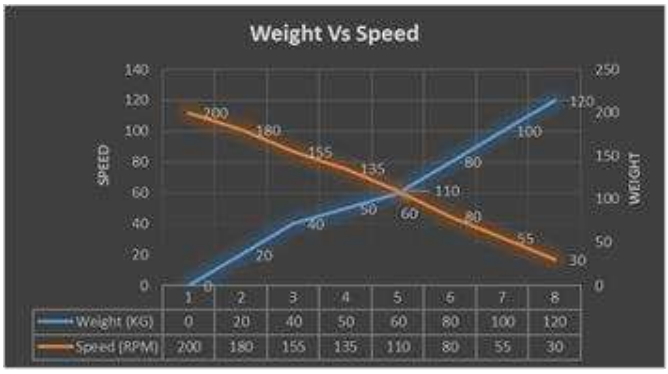

Figure 5. Mobile app interface

The second test is to test the capability of the Electric wheelchair to carry the user moving through a steep road, and the maximum load it can carry. From this test, this "Electric Wheelchair" can carry user through 25°- 30° steep, with an average weight 80kg without any real problem. The maximum load for this wheelchair is limited to 100kg for safety purposes even though it can reach to 120kg load.

Figure 6. Incline Testing

Cost analysis is needed to ensure this project is within the budget. The total cost is shown in Table 1. Based on the survey, this is one of the low-cost Electric wheelchairs that currently available at the market.

Table 1. Cost analysis table

	Component	Cost (RM)
1	Wheelchair Frame	250
2	Motor	600
3	Crank	56
4	Chain	36
5	Custom Joystick	20
6	Arduino MEGA	230
7	Motor Driver	250
8	Box	30
9	Battery Charger	220
10	Battery	186.8
11	Control Cable	15
12	Power Cable	60
13	Switch	11
14	2 Way plug socket kit (Male & Female)	36
15	DC to DC converter	39
16	Terminal connector	20
17	Material (aluminum bar, pipe, rubber gasket, bold and nut, etc.)	250
18	Other electric & electronics part	50
	Total	2359.8

FUTURE RECOMMENDATION

After testing this project there are several suggestions that can be made. The suggestions are:

i. To make a safety belt in this wheelchair for safety purposes.
ii. If the sensor detects obstacles, the buzzer will buzz, and the wheelchair will also automatically stop.
iii. Further improvement on the Breaking system to make it is more efficient.
iv. To add speed control both on the joystick and smartphone app.

CONCLUSION

The proposed electric wheelchair concept will benefit the disabled as well as the elderly to help their movement more easily. The technology used is the latest technology, simple and the cost required is also quite affordable. It is hoped that the studies of this electric wheelchair will open more space and opportunities for us to explore further the latest technology to help those in need.

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