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Development of Motorized Board of Wheelchair Using Arduino Controller

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Abstract: In the present world, there a lot of robots that been used to make human life easier as it plays an important role not even in the industry but also in our personal lives. This idea was applied in healthcare industries as its responsibility to improve the quality of cares and saving patient lives. This paper presents an overview of the Development of Motorized Board of Wheelchair Using Arduino Controller. This project aims to make an automated wheelchair in the market becomes noticeable and widely use to help patients with current technologies. It also gives freedom for those that have difficulty in using a manual wheelchair with suitable technology and design in term of comfortability, accessibility, functionality and affordability. This project was designed by using SolidWorks 2016 for the body hardware and Fritzing software for the circuit. This project used two DC power window motor to drive the wheels and by using triple-axis accelerometer breakout ADXL335 as the controller to steer the movement of the wheelchair. This project also equipped with wireless communication between the receiver and transmitter by using the HC-12 UART as the interfaces. Additionally, the user is free to choose a suitable chair according to their situation of sickness and comfortability. As a result, the dimension of this prototype chassis is 800 mm (length) x 600 mm (width) x 710 mm (height) with 9 kg of weight, and the average maximum speed is 1.98 km/h without load.

Keywords: Arduino, Wheelchair

1. Introduction

A wheelchair is a combination of chair and wheel that widely used as the transportation but in this project, the wheelchair was a focus on medical options that are designed for disabling and injury or illness person. Using 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 as it requires great effort and the help of other people [1].

A Development of Motorized Board of Wheelchair Using Arduino Controller is an automated wheelchair that using a control system to replace and easily control for the user. The purpose is to reduce

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or eliminate the user' while driving a wheelchair. Usually, a smart wheelchair controlled via a computer or electronic device sensor, which has a suite of sensors and applies techniques in mobile robotics. In this project, it was a combination of the current technology and wheelchair, but the design was focus on user requirements so that the wheelchair is comfortable to use. This may include specialized on the control, constructions and the design of the project. Besides, the controls are designed to facilitate the wheelchair control compared with the current wheelchair on the market and this project also suitably used for an indoor or outdoor environment which nowadays these options are an important suit with their personal needs. Their general conclusion is that improvements should be made to the control interfaces and monitoring technologies for automatic navigation [2].

Miller DP, Slack MG 1995 [3], they made a series of smart wheelchair prototypes based on power wheelchairs which the original prototype used mechanical interface to wheelchair joystick, but subsequent prototypes integrated into control electronics of wheelchairs and they provide collision avoidance and autonomous navigation. On the other hand, David Bell claimed that even in straight travel, variations in wheel diameter due to load shifts cause angular accuracy to be an order of magnitude worse than in most mobile robots [4].

This project was focusing on designing the board in which the chair of this board depends on the user to determine the suitable chair to make it's more comfortable. This wheelchair consists of a frame, seat and a linkage mechanism. The frame consists of a chassis with DC motorized units and a battery pack. The movement of this board is depending on the motor control and drive system which consists of Arduino and motor driver. The movement of the board will be controlled manually by the user. The user just needs to move their gesture controller with the direction they want, then through the data received, the receiver circuit will give an address to the receiver circuit and the wheel will move to the direction of the designated destination. A gesture recognition system which identifies the gesture is then interfaced to the wheelchair control system to move it to the desired location [5]. The simple package will be used with very affordable price electronics part that would not complicate the wheelchair appearances and with high efficiency of the controller that could achieve to 80.0 % of recognition rate, is used to build an effective hand movement-controlled of this smart wheelchair.

In this era of technology, as well as in the wheelchair technology is not left behind which is progressively marketed. Unfortunately, the price of automated wheelchair technology currently sold in the market is too high and only certain groups that able to have it. Most of the currently automated wheelchair has a very heavyweight and high in maintenance which it is a major factor why consumer prefers classic wheelchairs rather than the modern ones. Besides that, due to the size, weight, and maintenance, the automated wheelchair in the market becomes noticeable, especially at a young age. Consideration of that problem, this project has a special thread on designing the board and tires for a possible solution of a current problem. The objectives of this project are (1) to characterize and investigate the appropriate hardware such as wheels, DC motor and power supply to make it operate for a long period during the day, (2) to design and construct the electric board to reduce the difficulties experienced by the user using a wheelchair with their daily life and environment, and (3) to determine and evaluate the performance of the wheelchair in term of comfortability, accessibility, functionality and affordability.

Table 1 illustrates the literature research in which several methods of previous research being taken and become a guideline for this project.

Table 1: A literature review from the previous project

No	Title of the project	Implementation	Comments
1	Wheelchair project report [6]	▪ Contain several questionnaires of individual and clinicians about how to make or design a desired	▪ This report contains information about consumer needs and several improvements that can be

		and ideal wheelchair compare with the current wheelchair.	added to make an ideal wheelchair. ▪ It also contains the advantages and disadvantages of wheelchair maintenance mean that we are encouraged to focus on how easier the user to get the spare parts maintenance to choose the hardware that been used for the automated wheelchair.
2	The Power Wheelchair [7]	This report explains: ▪ The use of a power wheelchair. ▪ Why needs a power wheelchair. ▪ Basic components of the power wheelchair.	▪ The report explains the importance of choosing the right wheelchair depends on consumer need. ▪ It explains the type of seating, positioning and the type of wheel drive and its control effect the user. ▪ In conclusion, a different person needs a different type of wheelchair according to their comfort and treatment or medical health care that needs to be provided.
3	A Control System for Robots and Wheelchairs: Its Application for People with Severe Motor Disability [8]	Hardware requirement: ▪ Optical sensor ▪ Vibration sensor ▪ Wireless interface ▪ Driver ▪ Encoder	▪ The control is quite difficult to understand the circuit and function each of the component in the circuit. ▪ But I can use the idea of how they adapt the design robot to be implemented with the surveillance system.
4	Mobile robot control using Bluetooth Low Energy [9]	▪ Control robot using Bluetooth Hardware requirement: ▪ SumoBot Board with surface-mounted BS2 ▪ QTI Sensor ▪ Parallax Screwdriver ▪ Chassis, SumoBot ▪ Front Scoop, SumoBot" ▪ Wheel, Plastic, 2.58 Dia, .3 W ▪ Rubber Band Tire ▪ Battery holder, 4cell, AA, leads ▪ SumoBot Manual ▪ Res, CF, 5%, 1/4W, 470 Ohm ▪ LED-GREEN-T ¾ ▪ LED-Infrared - T1 ¾ ▪ LED-Red - T1 ¾ ▪ IR Receiver ▪ LED Stand ▪ LED Light Shield ▪ Serial Cable ▪ 3 inch Jumper Wires ▪ Servo Extension Cable (10 inches) ▪ Piezo Sound Generators ▪ Continuous Rotation Servo (Futaba)	▪ This project is about to build a robot and control it using Bluetooth which the concept can be implemented in my project. ▪ But its use to many sensors which for me it's not necessary for the user of the wheelchair.
5	Final Report: EyeMove [10]	Hardware requirement: ▪ The microprocessor (MSP430) ▪ Pressure sensor	▪ Easy for the consumer to control ▪ The technologies are high in cost where its state they use $384.10

		▪ Sonar sensor ▪ Motor ▪ Motor drivers Software requirement: ▪ Eye-tracking algorithm ▪ Controller	and when we convert to Ringgit it's become around RM1,705.60 because of its use a lot of sensor and camera to detect the motion of the eye. ▪ The stabilized helmet fixture is too big, not comfortable and difficult the movement of a user.
6	Automatic wheelchair for physically disabled persons [11]	Software requirement: ▪ KEIL µVision4 ▪ Eagle Hardware requirement: ▪ MAX232 ▪ HM2007 ▪ ARM7 ▪ L293D ▪ Accelerometer ADXL 335 ▪ Ultrasonic sensor	▪ This project creates 3 different modes of controlling the wheelchair: - Joystick - Accelerometer - Voice recognition ▪ This project also uses 2 types of sensor to increase the accuracy of the sensor ▪ This project model also much lower compared to other systems. ▪ But they use the 2 software that is not familiar for me and it takes a lot of times to an expert with the software compared to Arduino.
7	Automated Innovative Wheelchair [12]	Hardware requirement: ▪ Neck movement sensor ▪ Encoder (HT12E) ▪ Transmitter ▪ Decoder (HT12D) ▪ Pothole detector ▪ Obstacle detector ▪ Chair status detector ▪ Control unit ▪ Motor Driver (H Bridge) Motor	▪ Control using neck movement ▪ Motors: For moving the wheelchair DC motor MY1016Z2 is used which is DC Brush Gear Motor which is not suitable for my project because this motor expensive. ▪ Using Microcontroller 89V51RD2 which in my project I prefer using Arduino because its program is easier and easier to obtain.
8	Design of Motorised Wheelchair [13]	▪ Stair climbing wheelchair. ▪ Customers requirement: - A stable seating base - A vehicle that is easy to manoeuvre - A stable vehicle - Freedom of travel - A vehicle that is easy to transport - A vehicle that meets the assistant's needs Hardware requirement: ▪ 750-watt gear motor ▪ Clustered wheel concept ▪ Frame; aluminium, stainless steel, cold-rolled steel, flat steel, tubular steel, or steel frames.	▪ The author uses hand drawing to design the wheelchair which now has software that more advance that is solid Work which it's easier to design and assembly.
9	Mobile Controlled Wheelchair [14]	Hardware requirement: ▪ Basic manual wheelchair ▪ DC motor (scooter motor) ▪ Arduino ▪ Router ▪ IP camera ▪ Smartphone	▪ This project focus on build control for a standard wheelchair. ▪ It is more on an innovative idea. ▪ Use the android application to complete the control circuit.

		▪ Relay	▪ The IP camera only helps the user to visualize the path. ▪ I can use the Arduino as nowadays it's very familiar and easier to write the program compare to others.
10	Automated Wheelchair using Android Technology [15]	Hardware requirement: ▪ Arduino UNO ▪ Bluetooth Module ▪ L298D Motor driver ▪ Battery 13volts ▪ 2 DC Motors ▪ Android phone Software Requirement: ▪ Android Studio ▪ Arduino programming	▪ Referring to the block diagram of Androwheel. The proposed system uses touch-screen ▪ That link or connect with the android mobile to control the wheelchair. They create an application of android to develop this purpose. ▪ This android mobile is connected to microcontroller fitted inside wheelchair via Bluetooth controller.
11	Smart Electronic Wheelchair Using Arduino and Bluetooth Module [16]	Hardware requirement: ▪ voice recognition kit ▪ Bluetooth module ▪ Arduino Uno ▪ ultrasonic sensor ▪ motor driver ▪ 2 DC motor	▪ This project focuses on controlling the wheelchair using the voice command. ▪ Rereferring to project no 1 this wheelchair is one of the solutions to increase the ability of a user to control the wheelchair. ▪ In my opinion, this technology is not suitable for the users that have a problem with their voice and weak.
12	Design and Fabrication of a Voice Controlled Wheelchair for Physically Disabled People [17]	Hardware requirement: ▪ Wheel ▪ Caster wheel ▪ DC Motor ▪ Axle ▪ Bearing ▪ Lead-acid battery ▪ Relay ▪ Microcontroller ▪ PIC microcontroller	▪ This project has the same type of controller like project no 10 which is using voice command. ▪ According to the resulting picture, they made the same design for this wheelchair which is only designing the board. ▪ But these project does not mention that the user can use various type of chair with this board means that the chair for this project can't be changed.

Arduino Studio and Programming were chosen because this software has a lot of advantages compared to others such as Microprocessor (MSP430), Microcontroller 89V51RD which complex to program. Besides, the price of Microcontroller Arduino more affordable and easier to get in the current market. Referring to Jonathan DelRosario [10], the accelerometer will be used as the controller for this project as its more comfortable and friendly use for the user and if the user has disabilities in wrist movements, they can use other parts of the body such as legs, or other parts of hands to control the wheelchair.

Besides that, the concept of accelerometer mode also helps this project easier to be controlled by others if the users need helps. Referring to [12], this concept is suitable since the chair is depending on the user comfort and it can be changed anytime and anywhere. It is suitable for both condition outdoor and indoor so that it can be used and suitable on any surface. SolidWorks software will be used to design and assemble all the hardware in this project. Replacing our batteries with lithium batteries, which are

very light in weight and very small in size with higher efficiency than the used ones, will improve the functionality of the motor and will speed up the process of wheelchair movement [18] but in this project lead-acid battery was used because of comparison of prices is more affordable compare to lead batteries.

2. Materials and Methods

2.1 Block Diagram of Motorized Board of Wheelchair

In order to make this wheelchair can be controlled with automatic technology, the accelerometer will be used as the controller for this project. Figure 1 shows the overall block diagram which consists of Arduino as the controller which are acts as the interface for hardware and software component. The motor driver will use as the main function to take low current control signal from the controller and turn into a high current signal to drive the DC motor.

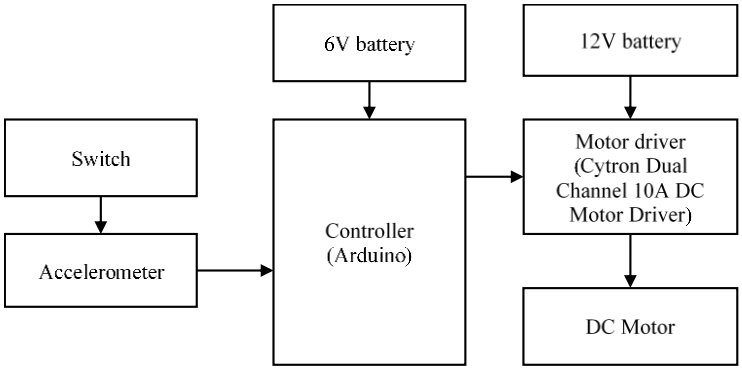

Figure 1: Block diagram motorized board of wheelchair

2.2 Block Diagram of Control System

Figure 2 shows the block diagram of the control system. This system consists of a receiver and transmitter. The receiver and transmitter will be connected by using a wireless connection.

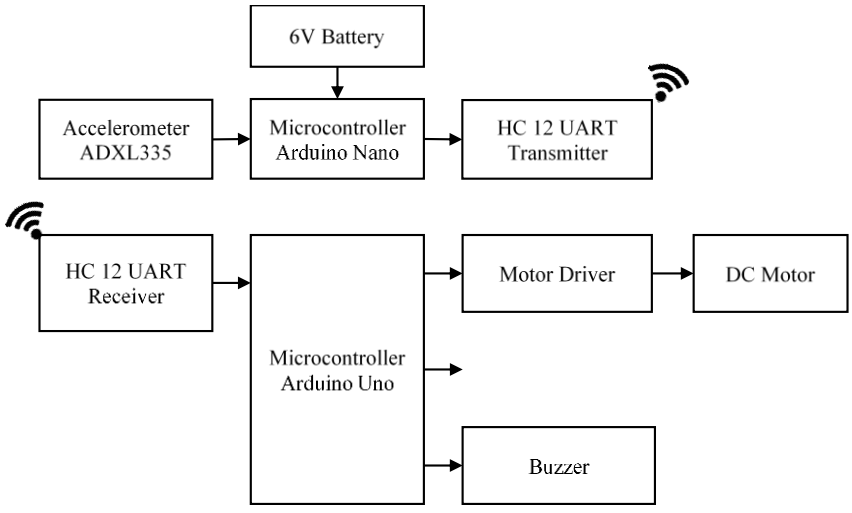

Figure 2: Block diagram of control system

2.3 Programming Development Method

In order to manage the program so that it always runs well, by following the Program Development Cycle which learns in subject Computer Programming that the procedure requires the programmer to properly develop the programming software as stated that the coding must follow the flowchart creates. After that, the programmer can begin to write the program according to the flowchart. Figure 3 shows

the flowchart of the wheelchair control system. It illustrates the message used from the transmitter to the receiver which the receiver takes the data from the accelerometer and send the data to the transmitter to control the movement of the motor. This flowchart also shows how the ultrasonic sensor and buzzer in detecting the obstacles.

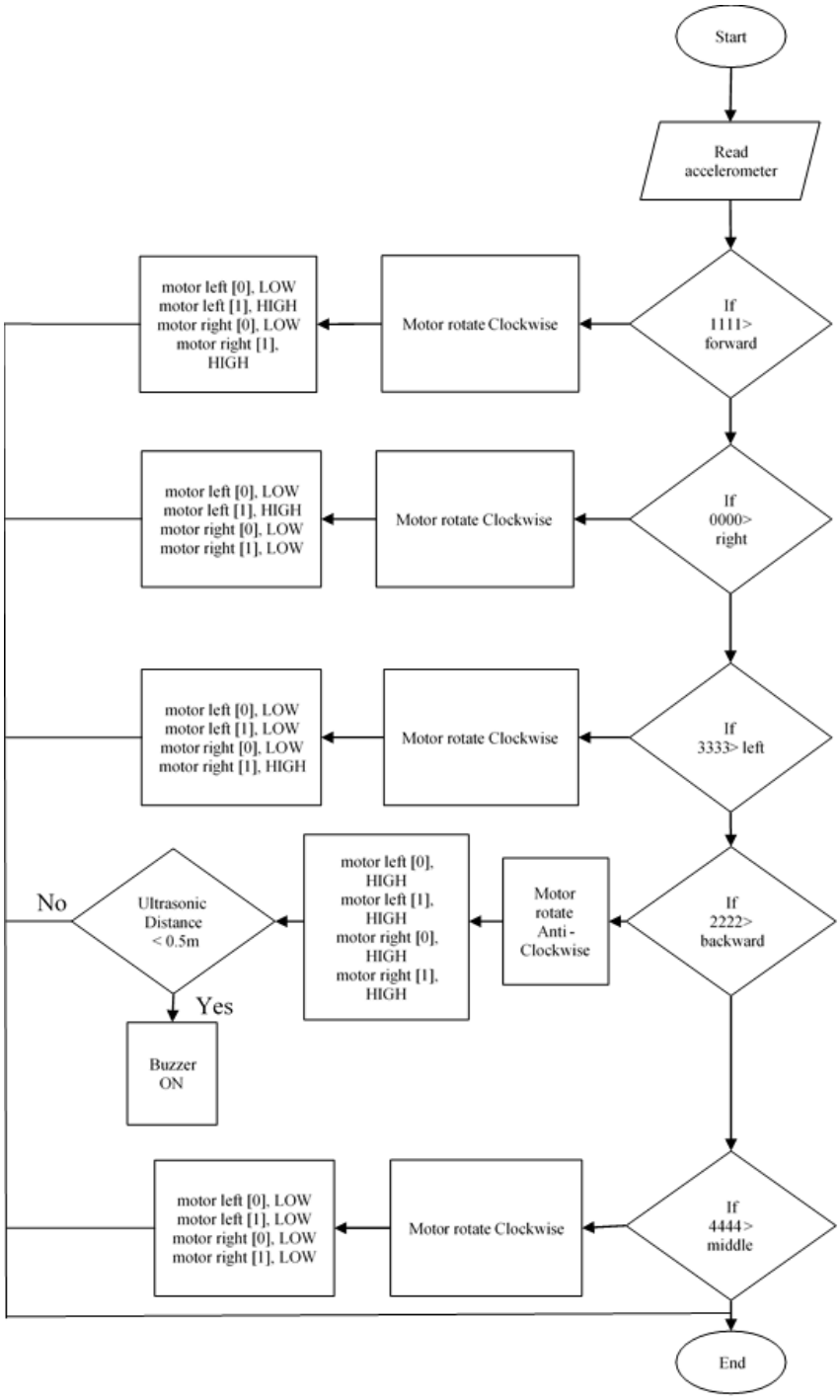

Figure 3: Flowchart of the wheelchair control system

3. Results and Discussion

3.1 Developed Prototype

Figure 4 shows the fully assembled Smart Board Wheelchair. Its total weight is 9 kg and Table 2 briefly shows the technical parameter and the material used.

Figure 4: Block diagram of the control system

Table 2: Example of presenting data using a table

Item	Description
Dimension	800 mm (width) x 600 mm (length) x 710 mm (height)
Weight	9 kg
Max load	Power Window max load = 100 kg Max load = 100 kg – 9 kg ± 20 % max load power window = 71 kg
Voltage consumption	12 V
Sensor	1-unit accelerometer ADXL335 1-unit ultrasonic sensor
Power Window DC motor	1-unit
Material (body)	Wooden planks, aluminium, iron (chair bracket and motor bracket)
Tire	2-unit silicon back tire (diameter = 4 inches) 2-unit freewheel silicon front tire (diameter = 3 inches) 2-unit silicon tire (diameter =1.5 inches)

An experiment is conducted to determine the direction of the motor according to accelerometer and speed produced by the smartboard. Before beginning the testing, the motor driver needs to check either its functioning well and the power supply 12 VDC is connected to the motor driver circuit with correct positive and negative terminal to avoid from damaging the motor driver. Then, the speed is calculated by using the formula according to the time taken and distance travel by the smartboard. Table 3 shows the currently available in the market that the dimension is suited to the prototype. As mentioned before, user free to choose their chair that comfortable for them to use daily but user need to identify the chair dimension compare to the technical dimension size of this project. It is seen that the dimension is suitable accordingly with most currently chair sold in the market.

Table 3: Variable type of chair in the current market

Item	Description
	▪ Name: GTE Foldable Toilet Commode Toilet Chair Medical Chair Medical Toilet Chair Children Adult With Bucket - Fulfilled by GTE SHOP ▪ Weight: 7.5 kg ▪ Colour: Black ▪ Dimension of Chair: 41 cm (L) x 45.5 cm (W) ▪ Dimension of Hole: 34.5 cm (L) x 18.5 cm (W) ▪ Maximum user's weight: 130 kg ▪ Properties: Rehabilitation Therapy Supplies ▪ Material: Metal
	▪ Name: New Aluminium folding transport commode toilet bathroom shower mobile potty chair ▪ Material: Stainless Steel, PC ▪ Colour: Silver ▪ Maximum Load: 150 kg ▪ Size: 57 cm (L) x 50 cm (W) x 80 cm (H)
	▪ Name: 150 kg Static Load Capacity multi-colour Plastic Chair ▪ Dimension: 43 cm (L) x 38 cm (W) x 80 cm (H)

3.2 Time Travel and Speed Testing

The speed produce by this project can be determined with the distance and time travel taken during the trial (n=3) and Table 4 shows the complete data of the trial result.

Table 4: Result time is taken versus distance

Load (kg)	Distance (m)	Time Taken (s)
No-load	10	18.33
43	10	19.33
63	10	20.33

The average time of time taken for these 3 trials is 18.33 s for distance 10 m without load. The total speed of this project is 1.98 km/h. The important aspect of the wheelchair system is to find its velocity. While this automatic wheelchair moving in a straight line, the distance and time are noted for velocity. The velocity of the wheelchair has experimented under two conditions. First, the velocity is observed in an unloaded condition. This board wheelchair was made to move in a straight line and the velocity is found 0.55 m/s. Secondly, with 63 kg loads was allowed for this board wheelchair to carried and the velocity was 0.49 m/s. Finally, a person weighing 43 kg was seated at this board wheelchair. The wheelchair was allowed to move in a straight line. The velocity of this board wheelchair with this load is 0.52 m/s. Based on the above result; the velocity wheelchair is affected by the load. It is observed that the velocity of the system will decrease proportionally to the load carried by the system.

3.3 Comparison Between Power Window and Mechanical Sensor for Motor Output

Table 5 shows the movement of overall result which shows the operation of the complete circuit.

Table 5: Movement result

Accelerometer	HC-12 UART	Motor Direction
(y>=290, y<=350) & (x>=335, x<=415)	1111	Clockwise
(x>=430, x<=570) & (y>=360, y<=415)	0000	Clockwise
(x>=290, x<=350) & (y>=300, y<=415))	3333	Clockwise
(y>=410, y<=460) & (x>=360, x<=430)	2222	Counter-clockwise

Mechanical sensor The ADXL335 uses a single structure for sensing the X, Y, and Z axes. As a result, the three axes' sense directions are highly orthogonal and have little cross-axis sensitivity. Mechanical misalignment of the sensor die to the package is the chief source of cross-axis sensitivity. Mechanical misalignment can, of course, be calibrated out at the system level. After implementing and testing the functionality of the project it was found that the motor driver and mechanical sensor give the desired orders for the motors to function. After testing, the auto movement of the wheelchair upon a pre-saved path with the axes from the user and seem the application revealed an excellent functionality in all directions. The HC-12 wireless serial communication transmitter is functioning as well, sending the data to the receiver, as tested and confirmed.

4. Conclusion

As a conclusion, many factors need to be a concern to build up this project to avoid a fault and to make it accepted by society. As decided, this project using Arduino Uno and Nano as the microcontroller and according to the project objective to characterize the suitable wheels and DC motor to make it last for a long period during the day which this project use DC power window motor because of its torque to carry a load. Other than that, by using an accelerometer as the controller to control the locomotion of the board and easy to interface with the Arduino but need to add a suitable motor driver with DC power window motor for the wheelchair which MDD10A was used as the motor driver from Cytron Technologies as its max current load is 30A. To make sure the accuracy while transferring the data from the transmitter to receiver more accurate, RF 433 HC-12 UART is used compare to others interface such as RF 433 MHz as its more affordable and easier to program. The project activities are done as planned and this provides a lot of information and mechanism that need to be considered for this project as its main characters are comfortable, easier to remote and affordable.

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