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Development of Wheelchair Gesture Control

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Abstract:

The needs of disabled individuals in mobility can be satisfied through wheelchair. But some of them may face a hard time to maneuver the wheelchair using their arms. This study will cover the development of wheelchair gesture control and describe a wheelchair for individual with physical disability. The wheelchair can be easily maneuvered and change directions according to the gestures made by the user. The aim of this project is to develop an enhanced system of a wheelchair in recognition of gestures. To achieve this aim, research has been made throughout the process of the project to understand the system of accelerometer to improvise and innovate the existing manual wheelchair. Problem statement: Long-term wheelchair user often faced shoulder pain. This problem seems to be related with the excessive use of arms as the users rely on their arms for their mobility and transfers. Therefore, the user may face rapid fatigue, loss of endurance, decreased speed and much more. Besides, quadriplegic patient cannot move their body to maneuver the wheelchair. Thus, the idea of Wheelchair Gesture Control came up to solve this issue. Wheelchair users will not depend on their arms anymore as they can easily control the movement of the wheelchair just by tilting the transmitter.

Keywords: *wheelchair, accelerometer, right-hand rule.*

I. INTRODUCTION

The technology of wheelchair is becoming more sophisticated days by days. Research and development of wheelchairs are required to make them widely available, safer and more effective as there is a massive need for wheelchairs. Utilization of assistive innovation is a progressive basic method of adapting to a disability. The contribution of engineers has been shown since the advent of advanced mobility devices. Hence, this contributes to the improvement of mobility impairments for people with disabilities or elderly people.

This project is an approach of an innovative wheelchair, which turn the physical gesture into electrical signals. Some patients have a hard time to "drive" their wheelchair with their arms due to old age, lack of strength and lack of force or psycho-motor problems. Some think that joystick-based maneuvering wheelchair could be the key to solve this issue, still, it is also impractical in some extent. Therefore, this wheelchair is going to bring a fundamental change between man and machine.

II. MATERIALS AND METHODS

Block diagram was structured to identify the system. It described a slight brief about the analogy of the system based on this project. Furthermore, the objective of block diagram is to provide the processes and workflows of hardware and software. Before identifying the system, components needed in this project, inputs and outputs must be defined. Therefore, there are three essential parts of a block diagram; input, process and output.

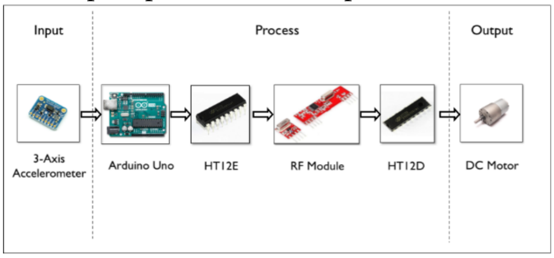


Fig. 1. Block diagram

Based on Fig. 1, the sensor that will be used for this project is 3-axis accelerometer. This project requires a 3-axis accelerometer because this sensor can recognize the analog signal (in this case, gestures signal) made by the user. Next, the Arduino UNO ATMega328 microcontroller will be used to process the data. The microcontroller is programmable, and the program of the wheelchair controls the output. The encoder, HT12E will encode and convert the analog signal to digital signal. Then, 433 MHz Radio Frequency (RF) Transmitter transmits the encoded data to the 433 MHz RF Receiver. The signal received is then decoded back into an analog signal by the HT12D decoder. After the signal have been decoded, the DC Motor will move according to the command.

In every study, the process of a system must be in a particular order to make the process more structured. Besides, to understand more of a process, the relationships of the system must be defined. Hence, a flowchart in graphic representation must be structured to visualize the actual process of this project. Based on Fig. 2, the process and decision making of the wheelchair have been included to track the workflow of the project.

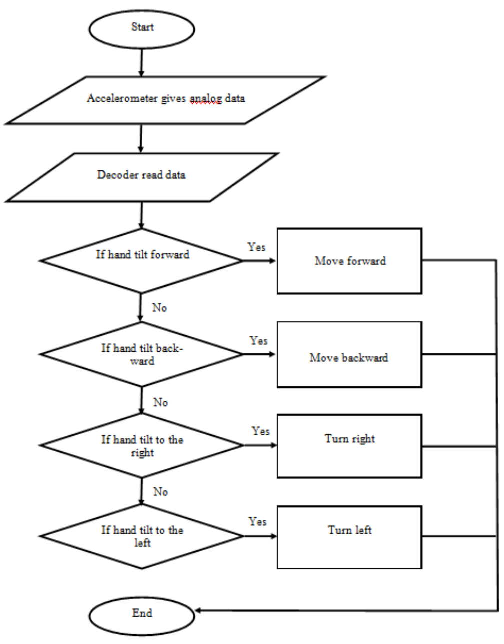


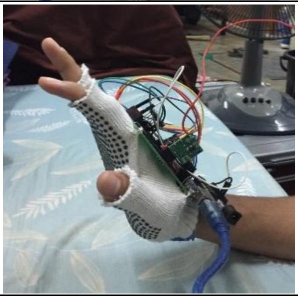
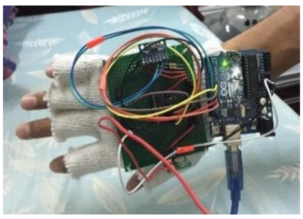
Fig. 2. Flowchart

The sequences of this project have been shown in Fig. 2. To maneuver the wheelchair, the user must direct the wheelchair to the desired direction by gestures. Then, the accelerometer will translate the gesture made by the user. The encoder will convert the given signal from analog to digital signal. This process is important because the signal must be readable by the microprocessor, hence converting the motion signal into an electrical signal. Next, the decoder will read and translate the digital signal back to an analog signal.

The movement direction of the motor will be according to the gestures. If the gesture is in the forward direction, the motor will move forward. If the gesture is in backward direction, the motor will move backward. If the gesture is in the left direction, the motor will go left. If the gesture is in the right direction, the motor will go right.

III. RESULTS

TABLE 1RANGE OF AXIS OF ADXL345 IN DIFFERENT HAND GESTURES.

Hand Gesture	Direction of the Wheelchair	Range of axis of ADXL345
	Forward	16<=x<=84 6<=y<=95
	Backward	x<=15
	Right	y<=5
	Left	y>=96

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Based on TABLE 1, sets of hand gestures have been shown to indicate the direction of the wheelchair. This project used an ADXL345 Accelerometer sensor to navigate the wheelchair. Basically, an accelerometer can measure the acceleration due to gravity by measuring the capacitance differences between the capacitor inside accelerometer. Therefore, this sensor can provide and measure the data for the gestures made by hand. The data are necessary because it can provide the range of the three-axis; x-axis, y-axis and z-axis, in which the range is then can be coordinated into specific ranges, so that the wheelchair will move accordingly (z-axis was excluded as the wheelchair only needs the range of x-axis and y-axis for its mobility).

TABLE 2OUTPUT VOLTAGE OF LEFT AND RIGHT DC MOTOR ACCORDING TO THE GESTURES MADE.

Direction of the Wheelchair	Output Voltage of Left DC Motor (V)	Output Voltage of Right DC Motor (V)
Forward	+5.56	+5.53
Backward	-5.54	-5.52
Right	+5.50	-5.47
Left	-5.47	+5.53

The output voltages of left and right DC Motor have been shown based on TABLE 2. In a forward direction, both motors give positive readings, which is +5.56V for left DC motor and +5.53V for the right DC motor. This is because the current is injected into the positive terminal of both DC motors, which resulting for both DC motor to be rotating in a forward direction.

In a backward direction, both motors give negative readings, which is -5.54V for left DC motor and -5.52V for the right DC motor. This is because the current is injected into the negative terminal of both DC motors, which resulting for both DC motor to be rotating in a backward direction.

In a right direction, right DC motor gives a positive reading, +5.50V while left DC motor gives a negative reading, -5.47V. This is because the current is injected into the positive terminal of the right DC motor and negative terminal of the left DC motor, which resulting the wheelchair to be navigated to the right direction.

In a left direction, right DC motor gives a negative reading, -5.47V while left DC motor gives a positive reading, +5.53V. This is because the current is injected into the negative terminal of the right DC motor and the positive terminal of the left DC motor, which resulting the wheelchair to be navigated to the left direction.

IV. DISCUSSION

Three-dimensional space was formed by orienting all three axes perpendicular to each other. These three axes are typically known and labelled as x, y and z. Positive x-axis pointing out of the page, positive y-axis pointing to the right and the positive z-axis pointing up. The point where the three axes transverse to each other is called the origin. The three axes can be oriented in any way, as long as all three axes are perpendicular to each other and can be 'measured' with what is called right hand rule.

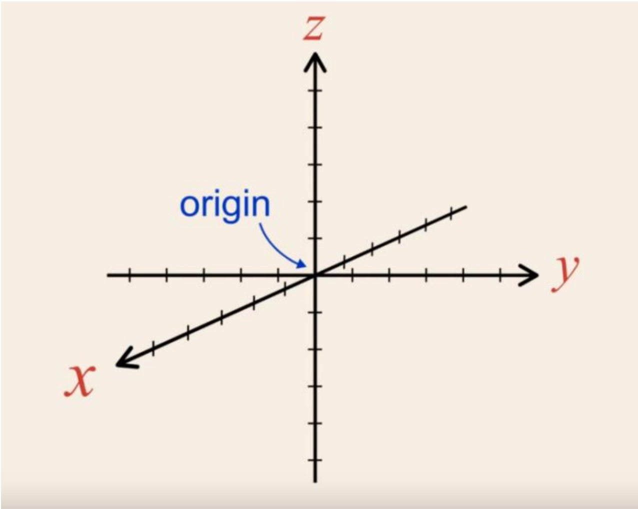

Fig. 3 Cartesian Plane coordinate system (three dimensions).

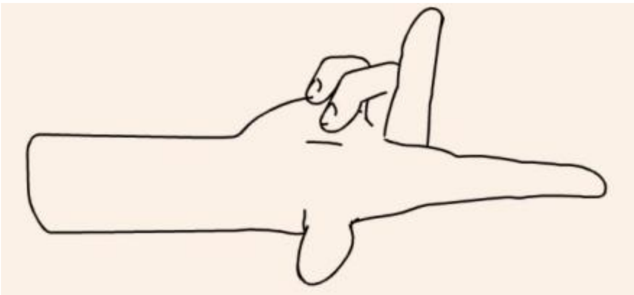

Fig. 4 Right-hand rule.

Based on Fig. 4, the right-hand thumb is pointing to the positive direction of the x-axis. The index finger is pointing to the positive direction of the y-axis and the middle finger is pointing to the positive direction of the z-axis.

By implementing the rule, the data was then measured and studied to see the relationship between incline angle towards gestures made and

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the value of the three-axis, which x, y and z. The rule was then implemented and shown as follows.

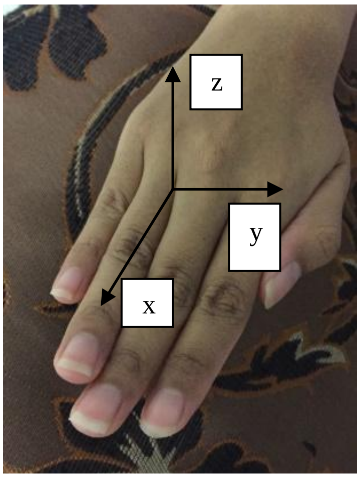

Fig. 5Implementation of the right-hand rule.

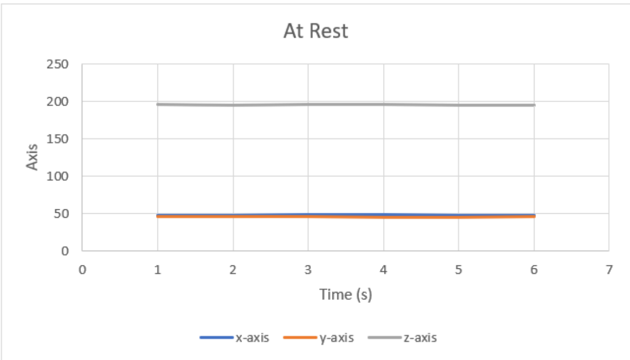

Fig. 6Accelerometer without any gestures in representation of graphical diagram.

TABLE 3X-AXIS, Y-AXIS AND Z-AXIS WITH RESPECT TO INCLINE ANGLE

Time (s)	x-axis	y-axis	z-axis
1	48	46	196
2	48	46	195
3	49	46	196
4	49	45	196
5	48	45	195
6	48	46	195

Based on TABLE 3, the axis of the x-axis increases while z-axis decreases as the inclination angle towards forward direction increases. By applying the right-hand rule, the thumb finger (x-axis) pointing towards a positive direction while the middle finger (z-axis) pointing towards a negative direction.

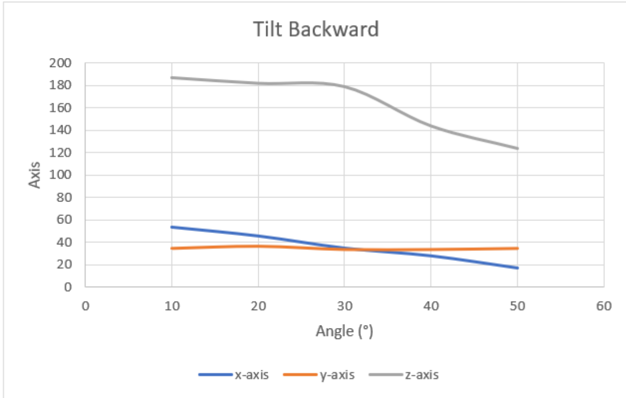

Fig. 7Accelerometer tilted towards the backward direction in the representation of graphical diagram.

TABLE 4 X-AXIS, Y-AXIS AND Z-AXIS WITH RESPECT TO INCLINE ANGLE.

Incline angle towards the backward direction (°)	x-axis	y-axis	z-axis
10	54	35	187
20	46	37	182
30	35	34	179
40	28	34	144
50	17	35	124

Based on TABLE 4, the axis of the x-axis and z-axis decreases as the inclination angle towards backward increases. By applying the right-hand rule, the thumb finger (x-axis) while the middle finger (z-axis) pointing towards a negative direction.

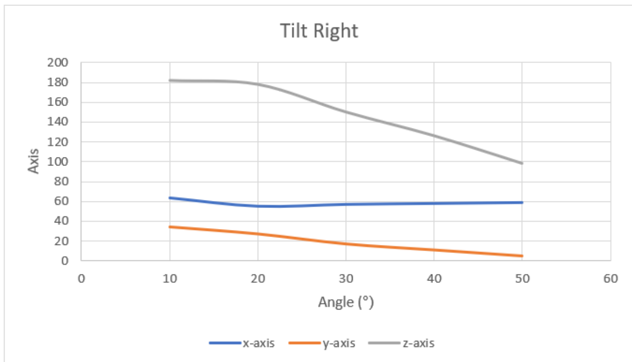

Fig. 8Accelerometer tilted towards the right direction in the representation of graphical diagram.

TABLE 5X-AXIS, Y-AXIS AND Z-AXIS WITH RESPECT TO INCLINE ANGLE.

Incline angle towards the right direction (°)	x-axis	y-axis	z-axis
10	64	34	182

20	55	27	178
30	57	17	150
40	58	11	126
50	59	5	98

Based on TABLE 5, the axis of the y-axis and z-axis decreases as the inclination angle towards right direction increases. By applying the right-hand rule, the index finger (y-axis) and middle finger (z-axis) pointing towards a negative direction.

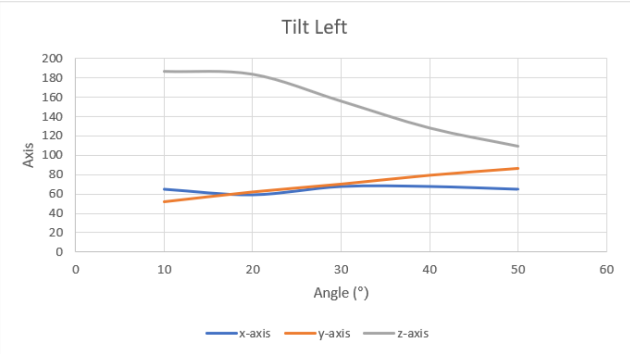

Fig. 9Accelerometer tilted towards the left direction in the representation of graphical diagram.

TABLE6: X-AXIS, Y-AXIS AND Z-AXIS WITH RESPECT TO INCLINE ANGLE.

Incline angle towards the left direction (°)	x-axis	y-axis	z-axis
10	65	52	187
20	59	62	184
30	68	70	156
40	68	79	128
50	65	86	109

Based on TABLE 6, the axis of the y-axis increases while z-axis decreases as the inclination angle towards left direction increases. By applying the right-hand rule, the index finger (y-axis) pointing towards a positive direction while the middle finger (z-axis) pointing towards a negative direction.

V. CONCLUSIONS

To conclude, the milestone of this project is to develop a convenience wheelchair which will solve the common problems faced by manual wheelchair users. Besides that, this project aims to ease the users to maneuver the wheelchair for their mobility. There is no denying the fact that there are flaws in this project, but the problems will be fixed and improved now and again.

An innovative gesture-based wheelchair was developed and tested throughout this research. Before the development of the wheelchair, several literatures have been reviewed in order to identify the problems that lead to the development of the project. There are many technicalities that need to be considered to manufacture a wheelchair, including the vehicle mechanics and wheelchair designs for different duration. Past researches on the developed wheelchair gesture control have also been reviewed to improve the researches.

In a future development, a mind-control wheelchair would be very useful for patients who suffer from full-body paralyze. The wheelchair that combines artificial intelligence and brain control are an approach for the patients to gain new movability, in which it converts the brain signals into expected commands towards the wheelchair.

Besides that, if the users are living in an apartment, or they are happened to be in a shopping mall, it is impossible for them to climb up the staircase or staircase escalator. Hence, the development of wheelchair with Galileo Wheels can be developed to ease their mobility. The wheels will give more grip, besides giving more stability to the wheelchair.

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