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Research paper

Intelligent Wheelchair Control Prototype Using Voice Recognition System for Disabled Patients

Nik Nur Zuliyana Mohd Rajdi[1]*, Naechitra Jothi [2]

[1,2]Faculty of Engineering & Information Technology, MAHSA University, Bandar Saujana Putra, 42610 Jenjarom, Selangor, Malaysia
**Corresponding author E-mail: zuliyana@mahsa.edu.my*

Abstract

One of the very common disabilities that requires aid is the mobility impairments. Thus, to transport themselves, these individuals will begin to solely depend on an assistive devices, commonly on a traditional wheelchair. In order, to ease the movement of a disabled patient, a technologically advanced wheelchair prototype is developed. The prototype is made up of acrylic plastic and wood and consists of a Voice Recognition System, ultrasonic sensors, LCD display and an emergency brake and it is fabricated in such a way that it is user friendly and safe for the user. The system is programmed in such a way that, the wheelchair prototype moves accordingly to the main five commands which are “Forward”, “Back”, “Left”, “Right” and “Stop”. Besides that, the ultrasonic sensors are embedded at the back and front of the wheelchair prototype, displays alert through the LCD screen which is placed on the hand rest when it senses obstacles. The calculated mean value of all the commands also denotes the accuracy level of the whole wheelchair system which is 95.40%. The value of standard deviation that is obtained through the IBM SPSS Statistics is 2.881 which by means this system is reliable and is accurate.

Keywords: *Intelligent wheelchair; Voice recognition system; LCD screen; Ultrasonic sensor; microphone*

1. Introduction

Disability is just not a mental and physical condition that limits an individual’s impairments, limitations and participations. It is a complex phenomenon that reflects the interaction between the individual’s body features and the features of the society the individual lives in [1]. Thus, an individual with any types of mobility impairments will begin to solely depend on wheelchair to move or transport themselves around. According to researchers, it is a difficult task to drive a wheelchair for a normal person in a domestic environment because the wheelchair is controlled manually by rotating the wheels and even extremely difficult for people who are disabled [2]. Therefore it is crucial for the disabled to begin using sophisticated artificial locomotion, taking advantages on the evolution of technology. The main functions developing smart wheelchairs is to create an interaction between the locomotion of the wheelchair and the user and to provide autonomous navigation which comes with flexibility and robust obstacles avoidance [3]. About 15% of the world’s population suffers from disability and of between 110 million and 190 million adults has serious form of disabilities whereby certain part of their body do not function anymore [1]. The disabled people in the United States has increased from 11.9% in 2010 to 12.6% in 2013, 2014 and 2015 and as year 2015, 51.1% disabled people are working in the range of 18-64 years while 41.2% are of age 65 and above [4]. In Malaysia, according to the Social Welfare Department, the number of disa-bled people from the year 2012 to 2014 rose from 445,006 people to 531,962 people and up to 22,845 people are mobility impaired [5]. In this research, the four main components that is used to produce an intelligent wheelchair are the Voice Recognition Module, Ultrasonic Sensor, LCD Display and Arduino UNO as shown in the Figure 1 illustration. A voice recognition module is easy to be used since it utilizes programmable speech recognition which requires simple voice commands through microphone and operates in an independent speech recognition mode [2]. The ultrasonic sensor is able to measure distances up to a few meters [6]. Thus, the embedded ultrasonic sensor is programmed to alert the user when there is an obstacle at a distance from the back and front. As of for Arduino UNO, it is an open-source electronic based platform which can be used for both hardware and software [7].

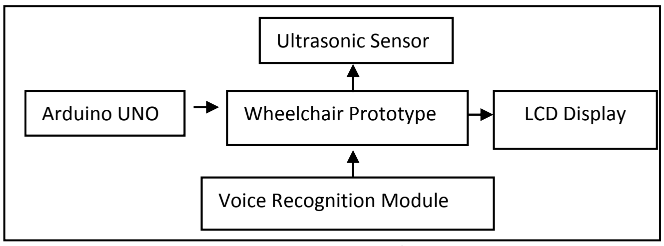

Fig. 1: Illustration of research prototype.

2. Methodology

An automatic wheelchair that uses Speech Recognition System as its control and this wheelchair is designed to help any individuals and patients with mobility impairment to loco mate themselves with ease.

2.1 Wheelchair Designing

This prototype wheelchair has to be developed in such a way that it mimics the stability of the traditional wheelchair and it needs to be user friendly and safe. The dimension of this prototype wheelchair is 0.21m x 0.27m x 0.40m (Length x Width x Height) and the materials used to build this prototype are transparent acrylic plastic as the base, and polyethylene as the chair. The design of the wheelchair is drawn using Sketch-up Pro 2016 software as shown in Figure 2.

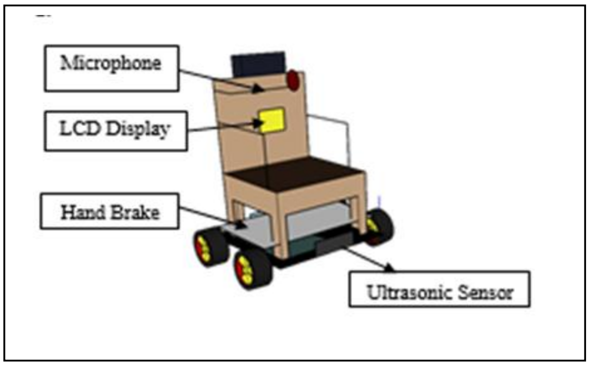

Fig. 2: The front-side view, of the wheelchair prototype

2.2 Circuit Stimulation

The circuit of this prototype wheelchair consists of Arduino UNO, DC drive gear motors, Voice Recognition Module V3 with microphone, ultrasonic sensor, buzzer, LCD Display with i2C, bread board, jumpers, L298N H-Bridge Stepper motor drive module and 24V battery. The circuit of this prototype was stimulated as shown in Figure 3.

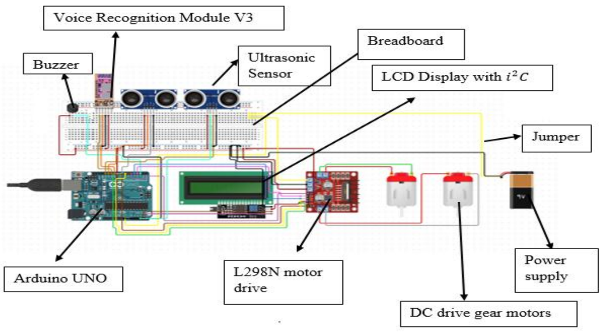

Fig. 3: Proteus 8.1 stimulated circuit diagram.

2.3. Voice recognition system installation

To train commands using the Voice Recognition Module V3, the voice recognition, vr_sample_train is uploaded to Arduino UNO and under the settings (accessible through the serial monitor) of the Elechouse Voice Recognition V3 Module Train Sample, the baud rate is set to 115200. The recognizer is first cleared and the commands (forward, back, left, right and stop) are trained through the instruction given by the system as shown in Figure 4.

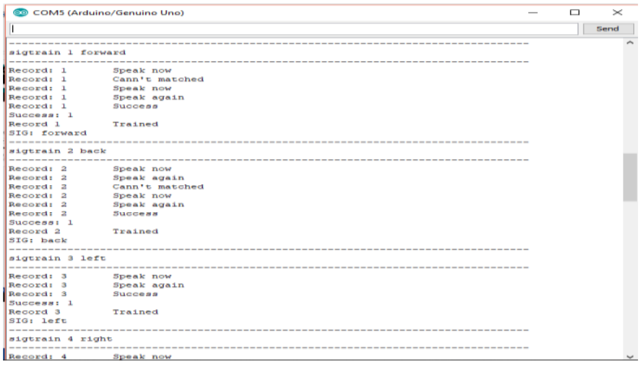

Fig. 4: The record status of the commands: forward, back and left which is 'Trained'.

The commands: forward, back, left, right and stop are trained as such shown in Table 1 and when a command is successfully trained through the system's instructions, the system denotes the record number and the signature of the record.

Table 1: The commands and voice recognition system format

Commands	Voice Recognition System Format	Signature	Record Number
Forward	Sigtrain 1 Forward	Forward	1
Back	Sigtrain 2 Back	Back	2
Left	Sigtrain 3 Left	Left	3
Right	Sigtrain 4 Right	Right	4
Stop	Sigtrain 5 Stop	Stop	5

When the commands are loaded into the voice recognition system, the serial monitor displays the status of the commands as shown in Figure 5.

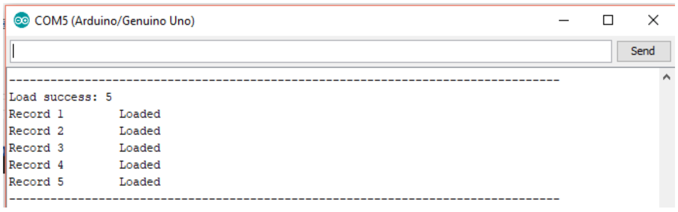

Fig. 5: The status of the commands in the voice recognition system

2.4. Fabrication of prototype

After the installation of the voice recognition system, then wheelchair prototype is fabricated. This prototype wheelchair is fabricated in such a way that, this prototype is user friendly and is safe. This wheelchair prototype is made up of trans-parent acrylic plastic as the base and polyethylene as the chair. As for the circuit of the wheelchair, it is embedded onto the base of the wheelchair prototype which is on the transparent acrylic plastic by using long and short nuts. The circuit connections are carefully connected and sealed with glue to pre-vent loose connection. The hand rest of the wheelchair is made up from plywood. The brake platform is made up of acrylic plastic which is attached 0.03 meters away from the base using two springs on both sides as shown in Figure 6. The wheelchair prototype was then fabricated completely with black and red flint sheet as shown in Figure 7 to mimic the look of a wheelchair.

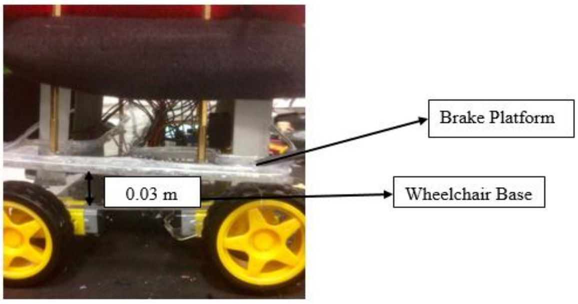

Fig. 6: The brake platform

Fig. 7: The complete fabricated wheelchair prototype

2.5 Testing of voice recognition system

The voice recognition system was tested with 25 individuals with different age range and gender. When the samples train their voice through the microphone, the commands get loaded into the voice recognition system. The sample tests their voice and the results appears on the serial monitor Arduino UNO as shown in Figure 8 and also on the LCD screen as shown in Figure 9.

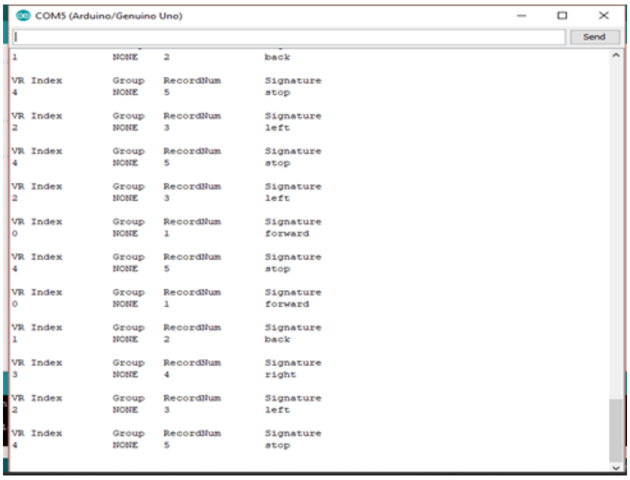

Fig. 8: The results of the sample tests

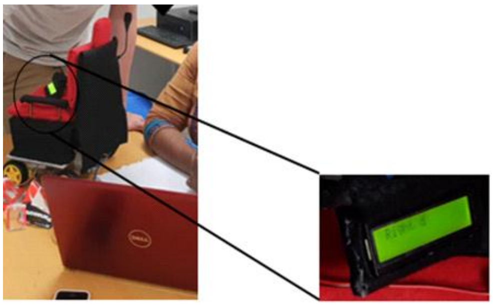

Fig. 9: The LCD Display result of 'Right' command.

3. Testing of ultrasonic sensor

The ultrasonic sensors that are attached at the front and at the back of the wheelchair prototype is programmed to detect and obstacles that 0.15 meters away from the wheelchair. When an object is detected at the front of the wheelchair, the LCD screen displays "Object F-B" which means an object is detected at the front as shown in Figure 10, thus the user should command "Back". When an object is detected at the back of the wheelchair, the LCD screen displays "Object B-F" which by means an object is detected at the back as shown in Figure 11, thus the user should command "Forward". The testing is conducted on a flat surface with an object placed 0.15 meters away from the front of the wheelchair prototype and with an object placed 0.15 meters away from the back of the wheelchair prototype. Figure12 shows the location of the object from the ultrasonic sensor.

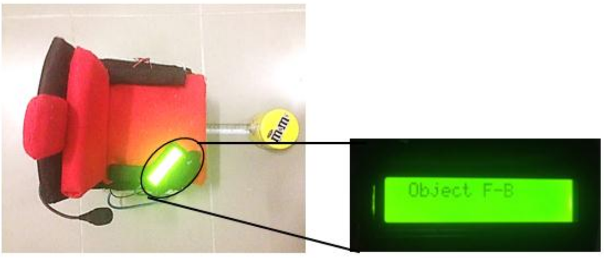

Fig. 10: LCD screen displays "Object F-B"

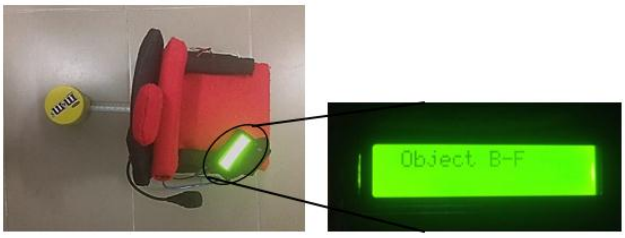

Fig. 11: LCD screen displays "Object B-F"

Fig. 12: Placement of the object from the ultrasonic sensor

4. Testing of voice recognition system

The testing was conducted with 20 person with different gender and age range in a discreet place. The results of the test, with five trials of a sample is as shown in Table 2. After the commands are successfully trained into the Voice Recognition System, when the prototype wheelchair moves accordingly to the sample's command is it denoted as "1"- successful. When the prototype wheelchair fails to move accordingly to the sample's command it is denoted as "0"-unsuccesful. The total sum values of the five trials of each samples for every commands were also calculated and recorded. The total of five trials for each commands is in the range of 0-5, whereby any sum which is more than zero is denoted as successful.

Table 2: Results obtained from five trials by Sample 1

Sample No	Gender	Age	Commands	Trials					
				Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Total Trials Value
1	Male	18	Forward	1	1	1	1	1	5
			Back	1	1	1	1	1	5
			Left	1	1	1	1	1	5
			Right	1	1	1	1	1	5
			Stop	1	1	1	1	1	5

5. Analysis of voice recognition system testing

The result of the Voice Recognition System testing is analysed based on the number of successful command, 1 and unsuccessful command, 0 of the five trials for each commands of all the 20 samples. The sum of five trials for each commands is in the range of 0-5 whereby any sum which is more than zero is denoted as successful. The total value of the sum of five trials of 20 samples are added and denoted as "Total Successful Trials" as shown in Table 3. Since every samples' number of trials is five for each command, thus the total number of trials by 20 samples for each command is 100.

From the values obtained, as shown in Table 3, the accuracy level for each commands are calculated and the graph of percentage of accuracy for each commands is plotted as shown in Figure 13. The graph is generated using the IBM SPSS Statistics. Since the total number of trials by 20 samples for each command is 100, thus the percentage of accuracy for each commands is given by;

Accuracy of a Command in Percentage =

$$\frac{Total\ Sucessful\ Trials\ of\ a\ command}{100} \times 100 \qquad (1)$$

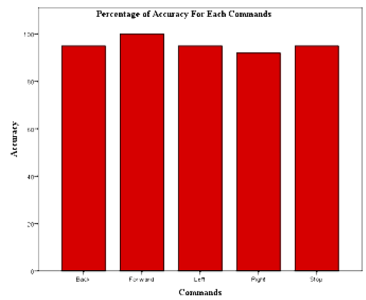

Fig. 13: Graph of percentage of accuracy for each commands

Table 3: The total value of the sum of five trials of 20 samples

Sample No	Commands (Sum of Five Trials)				
	Forward	Back	Left	Right	Stop
Sample 1	5	5	5	5	5
Sample 2	5	4	5	4	4
Sample 3	5	5	4	5	5
Sample 4	5	5	5	4	4
Sample 5	5	5	4	5	5
Sample 6	5	5	4	4	5
Sample 7	5	5	5	5	4
Sample 8	5	5	5	5	5
Sample 9	5	5	4	4	5
Sample 10	5	4	5	4	5
Sample 11	5	4	5	4	4
Sample 12	5	5	5	5	5
Sample 13	5	4	5	5	5
Sample 14	5	5	5	5	5
Sample 15	5	5	5	4	5
Sample 16	5	5	5	5	5
Sample 17	5	4	5	5	5
Sample 18	5	5	5	4	4
Sample 19	5	5	5	5	5
Sample 20	5	5	4	5	5
Total Successful Trials	**100**	**95**	**95**	**92**	**95**

The mean (in percentage), $\bar{x}$ and standard deviation of the total successful trials of all the commands were calculated to identify the level of accuracy of the whole prototype wheelchair system. To formula used to calculate the mean is:

$$Mean, \bar{x}\,(in\ percentage) = \frac{(\sum x_i)}{n} \times 100 \quad (2)$$

By using the IBM SPSS Statistics, the mean of the total successful trials of all the commands is 95.40% as shown in Table 4.

Table 4: The mean value obtained is 95.40

	Accuracy	Commands
Valid	5	5
Missing	0	0
Std Deviation	95.4	

From the standard deviation value, the spread out from the mean can be identified. To calculate the standard deviation of the total successful trials of all the commands, the standard deviation, σ is given by the formula:

$$\sigma = \sqrt{\frac{\sum(x-\bar{x})^2}{n}} \quad (3)$$

The standard deviation obtained using the IBM SPSS Statistics is 2.881 as shown in Table 5.

Table 5: Standard Deviation obtained is 2.881.

	Accuracy	Commands
Valid	5	5
Missing	0	0
Std Deviation	2.881	

The level of accuracy of the whole prototype wheelchair system is 95.40% and it is expressed in a bar graph as shown in Figure 14.

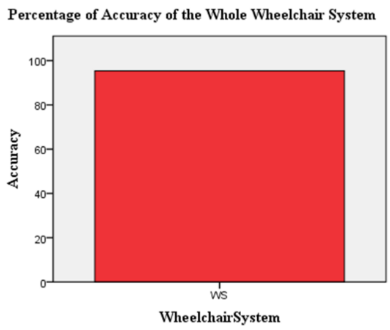

Fig. 14: Percentage of accuracy of the whole prototype wheelchair system is 95.40%

6. Interpretation of analysis

The "Right" command has total successful trials of 92% which is less than the calculated mean value of the whole system, 95.40. One of the reasons why the "Right" command has a lower total successful trials compared to other commands is because of the pronunciation of the sample is vague. Besides that, few of the samples did not speak right onto the microphone as briefed which is also a reason to be implied on other command's unsuccessful trial. The other occurrence that can affect the accuracy of the commands is the inaudibility of the environment. When the environment is quiet, commands received by the voice recognition system is more accurate. The value of standard deviation that is obtained through the IBM SPSS Statistics is 2.881 which by means this system is reliable and is accurate. he cost of developing the prototype wheelchair is affordable despite with the presence of a complete Voice Recognition System embedded to the wheelchair and also with the presence of two ultrasonic sensors. The prototype wheelchair is also developed as a user-friendly and as a safe locomotion option for the disabled patients. Furthermore, a manual brake is connected directly to the hand rest of the prototype wheelchair. In case of an emergency, the user can always use a small force to push the hand rest down to stop the wheelchair.

7. Conclusion

With the data obtained from the testing of Voice Recognition System 3 or VR 3, it is made certain that all objectives are achieved completely. The wheelchair prototype can be developed in a simple and affordable manner by using low-cost tools and electronic equipment. The wheelchair prototype is technologically advanced for disabled patients to ease their locomotion in abode areas such as Intensive Care Unit, ICU and Operation Theater, OT in hospitals. As mentioned earlier, this wheelchair prototype benefits the user by providing an easy locomotion option instead of using the manual traditional wheelchair which requires force to move. Besides that, the prototype is embedded with ultrasonic sensors at the back and front of the wheelchair to alert the users when any obstacles are sensed.

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References

[1] WHO, "Disabilities," 2017. [Online]. Available: http://www.who.int/topics/disabilities/en/.
[2] M Prathyusha, K Roy, and M Shaik (2013), "Voice and touch screen based direction and speed control of wheel chair for physically challenged using arduino," Int J Eng Trends Technol, Vol. 4, No. April, pp. 1242–1244.
[3] R A M Braga, M Petry, A P Moreira, and L P Reis (2008), "Intellwheels - A development platform for intelligent wheelchairs for disabled people," ICINCO 2008 - Proc. 5th Int. Conf. Informatics Control. Autom. Robot., Vol. 1 RA, No. January, pp. 115–121.
[4] L. Kraus, "2016 Disability Statistics Annual Report," Univeristy New Hampsh., 2015.
[5] Department of Social Welfare Malaysia, "Measure Disability Through Censuses : Malaysian Experience," no. July (2016).
[6] A. Carullo and M. Parvis (2001), "An Ultrasonic Sensor for Distance Measurement in Automotive Applications," IEEE Sens. J., vol. 1, no. 2.
[7] Arduino, "What is Arduino? / Why Arduino?," 2016. [Online]. Available: https://www.arduino.cc/en/Guide/Introduction.