WHEELCHAIR FOR PHYSICALLY DIFFERENT-ABLED PEOPLE WITH HAND GESTURES, VOICE AND ULTRASONIC CONTROL

U. V. I. S. Rupasinghe[1], D. P. M. Fernandez[2], J.A.D.C.A.Jayakody [3]

Faculty of Computing, Sri Lanka Institute of Information Technology

[1]isurur93@gmail.com, [2]dulip.joes@gmail.com,[3]anuradha.j@sliit.lk

ABSTRACT

This paper is concerned with the design and development of a voice and gesture recognized wheelchair system to assist disable people to travel safely. The architecture of this wheelchair consists of a main board, sensors and a user panel. Furthermore, it consists of two interfaces "Flex glove mode" and "Voice mode", which enables individuals to use it in different conditions. This exclusive combination allows to operate wheelchair to navigate to destination, and any surrounding dynamic obstacles to be detected with the aid of ultrasonic sensors, during real-time autonomous navigation, minimizing edges and preventing accidental collisions.

Keywords: **Hand Gestures, Ultrasonic Control, Flex glove mode, Voice mode, Wheelchair.**

1. INTRODUCTION

There are many smart technologies available nowadays, are brilliant compared to the technologies used previously. Some of these technologies help differently abled people in various ways in their day to day life, making them feel like they are also same as the people around them. This research work focusses to provide a solution to wheel chair navigation as a disabled person. Moving around in a regular wheelchair is tedious work even for a normal person and becomes much more difficult for people suffering from hand or arm impairments. For example an individual would need to move the wheel with the hands, which requires a person to waste more energy to move around the environment. Thereby regular wheelchair would not satisfy the differently abled people in their daily life due to this tedious worked compared to the new system which is developed. [1]

This document discusses about a Wheelchair for differently abled people with Hand Gestures, Voice and Ultrasonic Control. It is able to identify user commands and gestures and move smoothly according to the user's specified directions. Also, it has an additional feature for obstacle detection where the wheelchair stops when there are obstacles. This kind of autonomous mobility decreases the reliance on caregivers. [1] This wheelchair is designed for the majority of people who are impaired and even people who are weak in eye sight.

The proposed and developed wheelchair is available with two different input types' finger motions and voice recognition. Finger movement is one of the inputs to drive the wheelchair, and it is mainly targeted for individual who has impairments on their legs. Identifying the various gestures created by bending the fingers will be the input necessary to drive the wheelchair. The next method of driving the wheelchair is to obtain human commands through voice. This would be another input type, and it is mainly targeted for individuals who have impairments on their "legs as well as the hands". This method is developed by various movements of the wheelchair which is programmed based on a different voice commands. However, the uniqueness of this new system is to make it more "Generic" from other Wheelchair Systems.

Furthermore, there is another unique feature on this wheelchair, which is "Obstacle detection" this is quite important to individuals who are weak in "Eye Site". The obstacle detection feature takes readings from the ultrasonic sensors and analyze them to see if obstacles are present in the wheelchair's current path. If there are any obstacles in the wheelchair will come to a halt.

2. BACKGROUND REASEARCH

In this topic provides background into the measurement of finger motions and voice commands, the fundamental techniques that are being developed to move the wheelchair with easily to support the differently abled individuals in their daily life.

There are many research projects in this field. As an example is the wheelchair done at the Nagasaki University and Ube Technical College. It uses the existing ceiling lights to identify its current location based on a layout provided to the wheel chair beforehand. One disadvantage of this it is that is limited to indoor environments only. Another very common wheelchair is the "Wheelesley" [6] robotic wheelchair "Wheelesley" consists of a standard powered wheelchair with an on-board computer, sensors and a graphical user interface. Users of this chair will be interfacing with the GUI to move around. With this wheelchair the user has more control in the navigation process. Also another project that is similar is the "NavChair" [7] this has the added capability obstacle detection. This chair is equipped with twelve ultrasonic sensors to detect obstacles and an onboard computer. This chair provides added security as even if the user provides commands to the wheelchair if there are obstacles in the way the wheelchair will not respond to user commands.

The wheelchair designed under this topic comprises many of the features mentioned above and some new added features as well. The proposed system will gather user command in two ways hand gestures and Voice commands. Furthermore the system will have the capability to detect obstacles take necessary action to prevent any collisions.

3. BLOCK DIAGRAM OF THE PROPOSED SYSTEM

Figure.1 depicts the block diagram of the proposed system. The power for all equipment in the wheelchair is obtained from the 02 (24V) batteries mounted on the wheelchair. With the support of a step down power circuits,"24V" coming in from the batteries and using electronic circuits it is reduced to 5V to provide power the "Arduino Mega 2560" evaluation board, the voice recognition module and the flex sensors on the flex glove. A switch is used to select the mode of input whether voice or hand gestures, the inputs are given to the mega board. Based on the inputs received through the Arduino board, will turn on the relevant driver circuits to move the wheelchair in the direction specified by the user. There is also another set of switches, which can be used to cut the power supply to the driver circuits in case of an emergency (commands not being recognized) to avoid collisions.

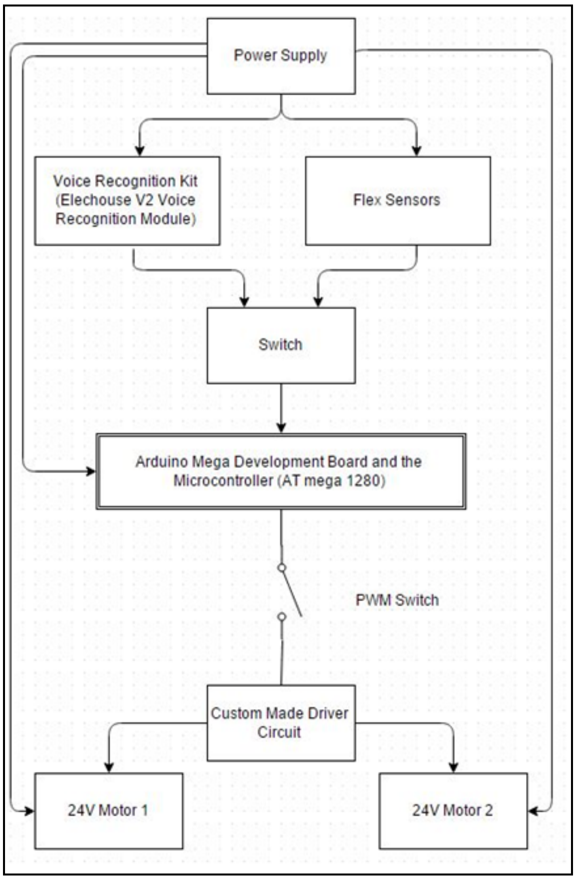

Figure 1: Block Diagram of the Proposed System.

3.1. Hand Gesture Recognition

According to the proposed solution, it is important to recognize the user's hand gestures, so flex sensors are used to gesture subsystems. The flex sensors are passive resistive devices that can be used to detect bending or flexing. The flex sensor decreases its resistance in proportion to the amount it bends in either direction A flex glove was designed by attaching 3 4.2' sensors. Each sensor sends an analog reading based on the bend of the sensor these readings are then mapped to the range of 0- 100. If a reading exceeds the threshold value it detects a gesture. [3]

Table I – Movement of the wheelchair, according to the gestures

Direction	Stored Gesture
Forward	All Fingers bent
Reverse	Little Finger bent
Left	Index Finger bent
Right	Middle Finger bent
Stop	All Fingers relaxed

3.2. Voice Recognition Kit

The wheelchair can be operated by voice commands as well. The voice recognition module used for this purpose is the “ElecHouse V2” Voice recognition module. This module can store 15 commands, however, only compare against 5 any time. First the commands are programmed in (recorded) into the module. The user commands picked up by the microphone, is analyzed and matched against the stored commands and sends a byte corresponding to the command recognized by the “Arduino” board via a serial connection. Based on the byte received the wheelchair will move with the user requested direction. [4]

3.3. Obstacle Detection

To implement the obstacle detection feature ultrasonic sensors were used. Ultrasonic sensors emit a sound wave towards a target, it is reflected at an interface between different materials and an echo is returned. Measuring the time interval between sending the sound wave and receiving the echo will determine the distance to the object. The “Arduino” board can be programmed to stop the wheelchair if the distance to an object or obstacle is near. By positioning sensors facing the forward direction left and right the system will be able to identify obstacles on a much wider scope [5].

3.4. Power Circuit

To provide the power to ultrasonic sensors: the “Arduino” boards and the flex sensors using the 12V battery, hence a separate Power circuit was built. The circuit takes an input of 12V and has the ability to output 7V, 5V, and 3.3V on to three separate rails. The 7V is used to provide power to the two “Arduino” boards, 5V is used to power the ultrasonic sensors and to provide power for the push button switches, and the 3.3V will be used to power the flex sensors placed in the flex glove.

4. WORKING OF PROPOSED SYSTEM

The proposed system consists of a voice recognition module and a flex glove unit. The voice recognition kit has the ability to store 15 commands, but can only match input only to 5 commands. The five commands stored are forward, reverse, left, right stop. The flex glove has 3 flex sensors attached. Based on the values coming in from the sensors according to the bends we can identify different gestures. The system is programmed to identify 4 gestures forward, reverse, left and right, any other gestures will stop the wheelchair ones received from the voice recognition module.

5. METHODOGY

This wheelchair has a structure of a normal electronic joystick operated wheelchair design. Only the framework of the wheelchair is similar to the other wheelchairs and also the two motors. Moreover a special structure at the front was welded into place the sonar sensors. From this point on, work on the circuits and coding began.

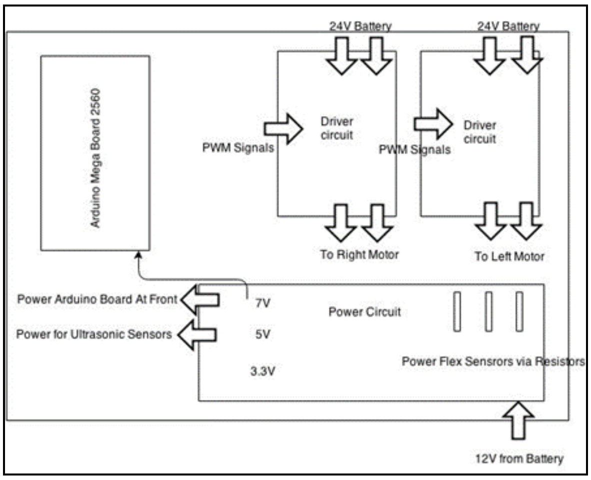

Figure 2: Block Diagram of the Main Control Board

Figure 2 depicts the mechanical design of the proposed wheel chair and voltage levels that required to operate motes and sensors.

5.1. Flow Diagram:

Figure. 3 depicts the sequence of instructions and logic proposed to operate wheel chair with the voice and the hand gesture recognize functions.

It is very important to send commands to operate motors according to the voice and the gesture mode, so flow chart provides the way how the system operates according to the command,

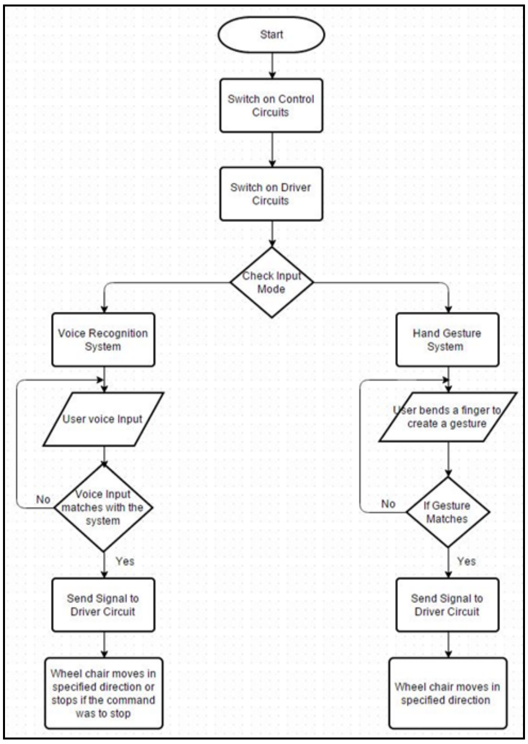

Figure 3: Flow Diagram

6. RESULTS AND DISCUSSIONS

Based on the results of the implemented system, it is observed that the commands received from the flex glove are more accurate than the ones received from the voice recognition module. Note: Any gesture other than forward, reverse, left, the right will stop the wheelchair so thus failure to recognize a gesture will also stop the wheelchair.

Table II – Test Analysis of the wheelchair

Direction	Voice Commands	Hand gestures	No of trials	Accuracy Voice (%)	Accuracy Hand gestures (%)
Forward	40	48	50	80	96
Reverse	42	47	50	84	94
Left	45	45	50	90	90
Right	41	46	50	82	92
Stop	38	-	50	76	10 0

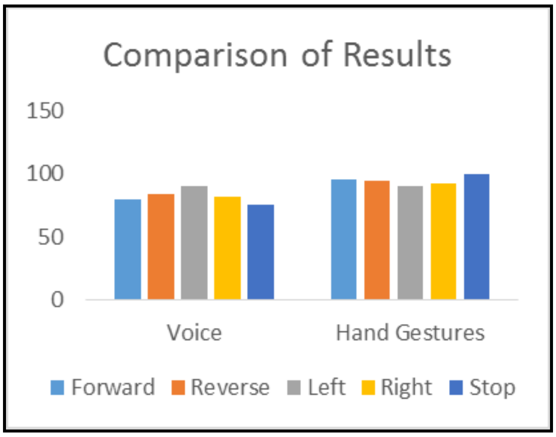

Figure 4: Test Comparison

7. FUTURE DEVEPLOPMENTS

7.1. Wireless obstacle detection:

Currently the distance readings are done by an “Arduino” board placed close to the special structure built to place the ultrasonic sensors, so once an obstacle is detected it the board would set high one pin and this signal is read by the main “Arduino” board. Hence, for this purpose multiple wires need to be connected between the boards running alongside the structure of the wheelchair. These wires can be a hindrance to many users, also the wires are exposed to physical damage. Therefore a wireless solution can be proposed. Bluetooth or Wi-Fi can be used to indicate to the main board that an obstacle has been detected removing the need for the wires. Only the wires to power the board and the common ground would be necessary. Also attenuation that might occur in the wires carrying the digital signals can be avoided as well.

7.2. Use of better sonar sensors:

The current sensors used (SRF 05) cheap and are not very reliable and tend to give bad readings at times. These sensors have to be used because better sensors would cost more and were not available locally also due to the sensors that had been mounted the cost was huge. However, if good sensors can be used a much more reliable obstacle detection setup can be made.

8. CONCLUSION AND FUTURE SCOPE

It has observed from the proposed system that the flex control system has high accuracy when compared to the voice recognition system. The obstacle detection feature also could use some improvement as the system was able to detect obstacles in the forward direction only. The system was unable to detect any obstacles that were present on the left or right of the wheelchair. This could be attributed to the fact that the sensors used were low quality grade and the code used for the obstacle detection system lacked efficiency.

For further improvements in the proposed system, installation of high power ultra-sonic sensors to detect obstacles with a higher accuracy is recommended. Also the use of a high precision voice module to capture user commands much more accurately can be recommended as well. Tweaks done on the code relating to obstacle detection will further improve the efficiency in detecting obstacles and taking the necessary action.

9. ACKNOWLEDGEMENT

This work has been supported by the Sri Lanka Institute of Information Technology, Malabe, Sri Lanka.

10.REFERENCES

1) Richard C. Simpson, PhD, ATP "Smart wheelchairs: A literature review" Dept.
2) Rehabilitation Sci. Tech., Univ. Pittsburgh, Pittsburgh, Tech. Rep. Smart wheelchairs: A literature review, July/August, 2005.

3) G. Pires et al., "Autonomous Wheelchair for Disabled People," in International Symposium on Industrial Electronics. Guimarães., Int. Symp. Ind. Electron. 1997, pp 797-801
4) Instructables (2014). How to Make Bi-Directional Flex Sensors [Online] Available: http://www.instructables.com/id/How-to-Make-Bi-Directional-Flex-Sensors

5) Electroniccaestudio. (2014). Voice Recognition Module V2. [Online] Available: http://www.electronicaestudio.com/docs/SHT-151m.pdf

6) Nihon Dempa kgyo Co. Ltd (2015). Ultrasonic Technology [Online] Available: http://www.ndk.com/en/sensor/ultrasonic/aboutl.html

7) Holly A. Yanco "Wheelesley: A Robotic Wheelchair System: Indoor Navigation and User Interface" MIT AI Lab, Cambridge, MA, Tech Rep. Wheelsley, 1998

8) Richard C. Simpson et al "NavChair: An Assistive Wheelchair Navigation System with Automatic Adaptation" Metrica Corp, Houston TX., Tech. Rep. 50463519511aec617d, 1997.