121-CP-2@: Design and Fabrication of a Voice Controlled Wheelchair for Physically Disabled People

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Design and Fabrication of a Voice Controlled Wheelchair for Physically Disabled People

G Azam and M T Islam*

[1]*Department of Mechanical Engineering, CUET, Chittagong-4349, Bangladesh*

*Corresponding author: tazul2003@yahoo.com

Abstract:

Many disabled people usually depend on others in their daily life especially in moving from one place to another. For the wheelchair users, they need continuously someone to help them in getting the wheelchair moving. By having a wheelchair control system they become more independent. The aim of this research project is to design and fabricate a voice controlled wheelchair for physically disabled people. The wheelchair control system which employs a voice recognition system for triggering and controlling all its movements. It integrates a microcontroller, microphone, voice recognition processor, motor control interface board to move the wheelchair. By using the system, the users are able to operate the wheelchair by simply speaking to the wheelchair microphone. The basic movement functions includes forward and reverse direction, left and right turns and stop. The spoken words are linked to the voice recognition processor via a microphone attached closed to the user's mouth. It utilizes a PIC controller manufactured by Microchip Technology to control the system operations. It communicates with the voice recognition processor to detect word spoken and then determines the corresponding output command to drive the left and right motors. To accomplish this task, an assembly language program is written and stored in the controller's memory. The voice controlled wheelchair runs successfully with a speed 1.21ft/s for 30kg load.

Keywords: *Disable, wheelchair, microcontroller, microchip and PIC*

1. INTRODUCTION

The rapid growing and advancement of modern technology has yield to the developments and inventions of modem equipments and machineries. These inventions have eased human significantly in all aspects of their daily lives. One of these inventions that give great impacts and implications to the lifestyles of disabled and handicapped people is the implementation of motorized wheelchair. Nowadays, there are many kinds of motorized wheelchair available in the market, for instance wheelchair that utilizes the analogue joysticks, touch activated switches and LCD, sip and puff switches, chin-controlled switches, head-controlled switches, tongue-touch pad switches, eye gazed switches, predetermined lines and routes, and two points autonomous navigation that uses LRF technology.

This paper concentrates and focuses on the implementation of a voice-controlled motorized wheelchair. With all the available methods in the ongoing researches, definitely, the daily lifestyle of the disabled people will be improved. The introduction of the motorized wheelchair increases their independency and mobility in performing their daily social life activities. Different researches on wheelchair were done by worldwide renowned universities and researchers are discussed below:

National University of Singapore, in 2002 uses dead reckoning to keep wheelchair on prescribed path. User can leave path to avoid obstacles, and controls speed of wheelchair along path. Path can be defined with GUI or by walkthrough. Torque sensors in push rims sense user input. Small motorized wheels apply force to regular manual wheelchair wheels.[1]

University of Notre Dame, U.S. in 1994–2000 made a wheelchair where user can automatically reproduce routes taught to system by manually driving wheelchair from starting point to goal point. Uses machine vision to identify landmarks in environment. No obstacle avoidance mode.[2]

Osaka University, Japan, 1998-2003 have produced Intelligent wheelchair system which has two cameras, one facing toward user, second facing forward. User provides input to system with head gestures, interpreted by inward-facing camera. Outward-facing camera tracks targets and allows user to control wheelchair with gestures when out of wheelchair. Shares navigation with user (obstacle avoidance).[3]

MAid RIAKP, Germany 1998–2003 made a wheelchair which has two operating modes: Narrow-Area Navigation (NAN) and Wide-Area Navigation (WAN). In NAN, system knows starting position and orientation and navigates to goal position and orientation. In WAN, system moves to goal destination but also identifies (and avoids) moving objects in environment. Later addition was the ability to follow moving objects.[4]

University of Alcala, Spain, 1999–2003 was fabricated a wheelchair where they used a test bed for various input methods (voice, face/head gestures, EOG). Provides obstacle avoidance. Uses machine vision to interpret user's gaze for control of wheelchair and to identify landmarks. Uses both laser and IR to detect drop-offs. Uses modular architecture based on commercially available building automation hardware. Allows chair to interact wirelessly with hardware nodes in environment.[5]

University of Pennsylvania, U.S. 2002–2003. They designed a Smart Chair which provides several modes of operation, including "travel to target" mode that uses a deictic interface, hallway navigation, door passage, three-point-turn, and collision avoidance. Machine vision and laser range finder fused to calculate depth information.[6]

Tin Man KIPR, U.S. 1994–1999 they made series of smart wheelchair prototypes based on power wheelchairs. Original prototype used mechanical interface to wheelchair joystick, but subsequent proto- types integrated into control electronics of wheelchairs. Provides collision avoidance and autonomous navigation. [7]

The objectives of this research project are- to equip the present motorized wheelchair control system with a voice command system. By having this features, disabled people especially with a severe disabilities that is unable to move their hand or other parts of a body, are able to move their wheelchair around independently.

2. MATERIALS AND METHOD

To fabricate a realistic voice controlled wheelchair, various kinds of equipment are necessary**.** At first wheelchair is made mechanically or by the installation of mechanical equipment/parts. Secondly, electrical equipments/components are designed for using in the wheelchair and after installing these in the mechanical wheelchair, the mechanical wheelchair now is turned to an electrical wheelchair. Here some brief idea about the equipments/components used to construct the wheelchair and their installation.

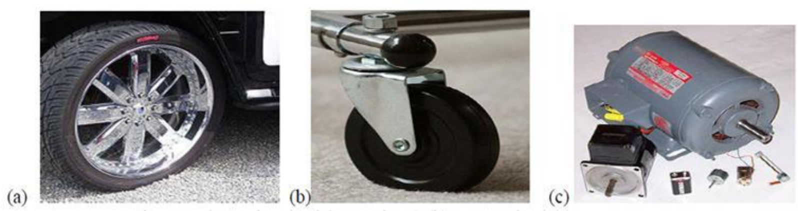


Fig.1 (a) Main wheel (b) Caster wheel (c) DC Motor. [3]

Wheel: As shown in the Fig.1(a) a wheel is a circular component that is intended to rotate on an axial bearing. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines.

Caster Wheel: As shown in the Fig.1(b) a caster (or castor) is an unproven, single, double, or compound wheel that is designed to be mounted to the bottom of a larger object (the "vehicle") so as to enable that object to be easily moved. They are available in various sizes, and are commonly made of rubber, plastic, nylon, aluminum, or stainless steel. Casters are found in numerous applications, including shopping carts, office chairs, and material handling equipment. Generally, casters operate well on smooth and flat surfaces.

DC Motor: As shown in Fig.1(c) a dc motor is an electric machine that converts electrical energy into mechanical energy. The reverse conversion of mechanical energy into electrical energy is done by an electric generator. In normal motoring mode, most electric motors operate through the interaction between an electric Motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy.

Axle: As shown in Fig.2(a) an axle is a central shaft for a rotating wheel or gear. On wheeled vehicles, the axle may be fixed to the wheels, rotating with them, or fixed to the vehicle, with the wheels rotating around the axle. In the former case, bearings or bushings are provided at the mounting points where the axle is supported. In the latter case, a bearing or bushing sits inside a central hole in the wheel to allow the wheel or gear to rotate around the axle. Sometimes, especially on bicycles, the latter type axle is referred to as a spindle.

Fig.2 (a) Axle, (b) Ball bearing, (c) 12V lead acid battery.

Bearing: As shown in the Fig.2(b) a bearing is a machine element that constrains relative motion and reduces friction between moving parts to only the desired motion. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Many bearings also facilitate the desired motion as much as possible, such as by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

Lead-Acid Battery: As shown in the Fig.2(c)the lead–acid battery was invented in 1859 by French physicist Gaston Planet and is the oldest type of rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, makes it attractive for use in motor vehicles to provide the high current required by automobile starter motors.

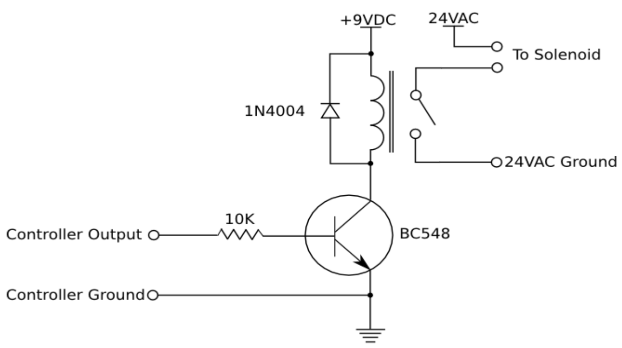


Fig.3(a) Relay Circuit

Relay: A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations. A circuit diagram of the relay is shown in Fig.3(a)

Microcontroller: A microcontroller (sometimes abbreviated µC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems.

PIC microcontroller: PIC is a family of modified Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller" now it is "PIC" only. PIC 16F73 microcontroller pin diagram is shown in the Fig.4

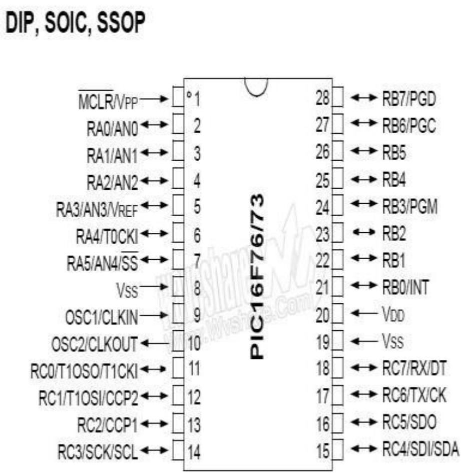


Fig.4 PIC 16F73 microcontroller pin diagram.

Design Method: The design and development of the system involves the implementation of both hardware and software. These approaches must be well implemented so that it will produce satisfactory outcome of the system which is to produce the correct wheelchair movement upon receiving the voice input command.

System Block Diagram: The wheelchair movement control system block diagram is shown in Fig.5 which can be divided into four different blocks: 1. Microphone unit. 2. Voice recognition module. 3. Main control system block. and 4. Power Supply Block.

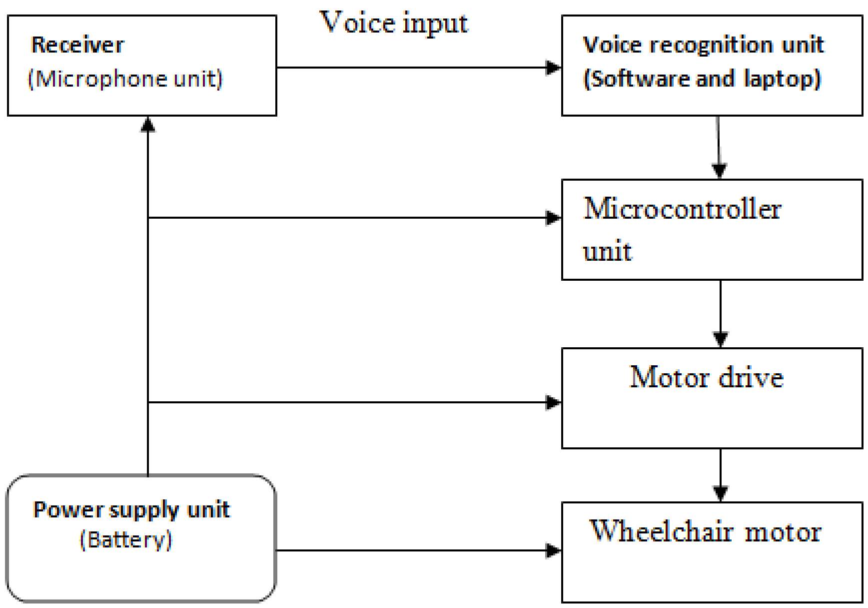


Fig.5: Wheelchair control system block diagram.

Theory of System Operation: Fig.5 shows the system block diagram showing the interconnections between each block or module. All the modules are mounted onboard as to ease the wheelchair movement. This includes a microphone which is located nearest to the user so as to make it handy and easy to use.

Generally, the input voice level affects the recognition accuracy result. For best recognition result, the microphone should be mounted or attached as closed as possible to the user's mouth. Principally, the system is triggered by the voice command word produced by the user through the use of this microphone. The user commands' for the wheelchair movement by producing words which have been stored previously in the SRAM memory. This SRAM resides in the voice recognition processor. To keep the system as simple as possible, the words are kept short and the quantity is kept to minimum quantity. The quantity of words can be added and upgraded later on for future development and improvement. The five basic command words are chosen and they are shown in Table-1 :

Table-1: Command words and its operations

Command words	**Operations**
SAMNE	Moving forward
DANE	Moving right
BAME	Moving left
THAM	Stop moving

The voice from the user is picked up by a microphone and the analog output of the receiver is then fed to the voice recognition module. In this module, the signal is then compared and matched to the data previously stored in its memory to determine the corresponding output command. Then it latches data which is in binary-coded decimal to input port A and port D of the PIC microcontroller. This BCD signal is then processed by the PIC and the output is sent to port C which is connected to the motor interface unit. These signals will drive the motors and make the wheelchair moves.

When the user speaks the word 'forward' to the microphone, the wheelchair moves in forward direction. The word 'back' means it moves in backward or reverse direction. Meanwhile the word 'left' causes the wheelchair to turn to the left, and 'right' makes the wheelchair to turn to the right direction. The wheelchair will continue.

moving in the direction according to the word received until the user speak out the word 'stop'. When the user pronounces the word "stop", a number " 05 " is displayed on the seven-segment display (if the display board is connected) which means that it has received a "stop" command from the user. Then the motors stop immediately by using the electrical braking method. These movement paths are illustrated in Fig.6

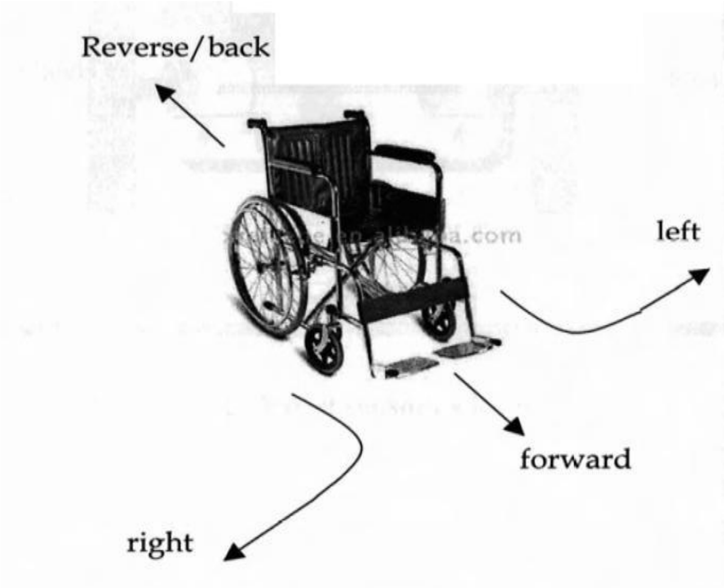


Fig.6: Wheelchair movement paths. [2]

Voice Controlled Wheelchair Fabrication: The manual wheelchair is modified into an electrical wheelchair which is controlled using voice command. The important part is to upgrade the manual wheelchair into an electrical wheelchair. Thus, the parts like motors, pulleys, belts and a battery are needed. With the combination of these mechanical and electrical parts, the manual wheelchair now is turned to be an electrical wheelchair. There are a number of possible driving wheel configurations (front wheel drive, rear wheel drive and mid wheel drive) which affect the characteristics of the chair in different situations, with turning while driving being the most complex. Further features can be added to assist the user such as lights, actuators and wireless links. The heart and brains of the powered wheelchair is in the controller as it provides both a conduit for the power to the motors and controls the overall system. The wheel which is connected with the motor is considered as the main wheel. The main wheel is 6” in diameter. Fig.1(a) shows the main wheel that has a single bore at the centre. This bore is connected to the motor. A caster (or castor) wheel shown in Fig.1(b) is an un driven, single, double, or compound wheel that is designed to be mounted to the bottom of a larger object (the "vehicle") so as to enable that object to be easily moved. This section mainly deals with the electrical components used in controlling the wheelchair. A DC motor shown in Fig.1(c) is an electric motor that runs on direct current (DC) electricity. DC motors can operate directly from rechargeable batteries, providing the motive Fig.7:

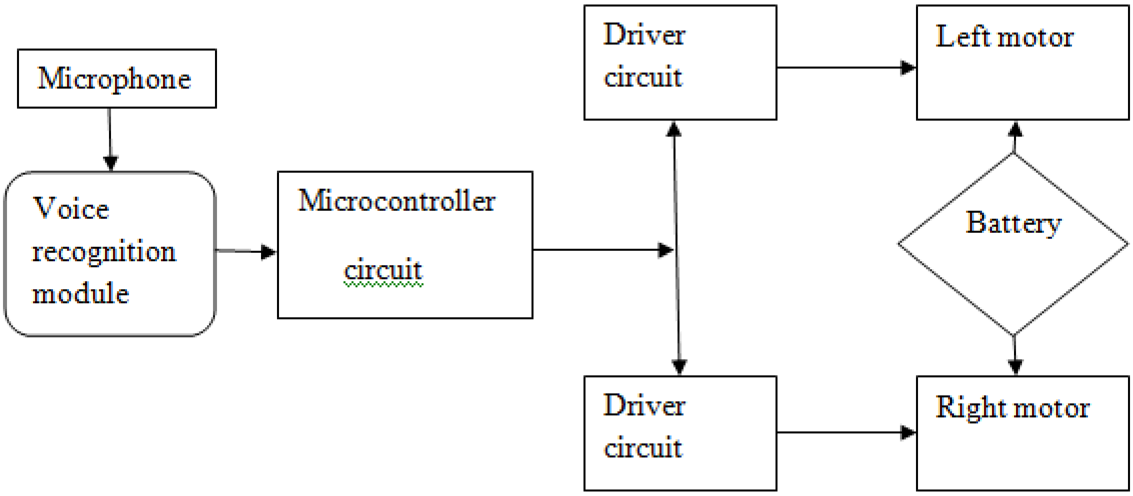


Fig.7: Basic Components of Wheelchair

power for the vehicles. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Also step-down transformer, filter capacitors, rectifiers, transmitter-receivers are used in the system design. Fig.7 shows the basic components used in the design of the voice controlled wheel chair.

Interfacing external circuits: This Fg.8 shows how a circuit can be interfaced through the data bus of speech recognition circuit. It will show messages and error codes on LCD. It will also operate four relays as per data from speech circuit. Fig.9(a) The Main or Brain circuit used in the Wheelchair which take input command from laptop and send output to relay. Fig 9(b): The Relay or motor control circuit used in the wheelchair. It takes input from brain circuit and output is to control motor according to command. Fig.10 shows the complete assembled voce controlled wheel chair

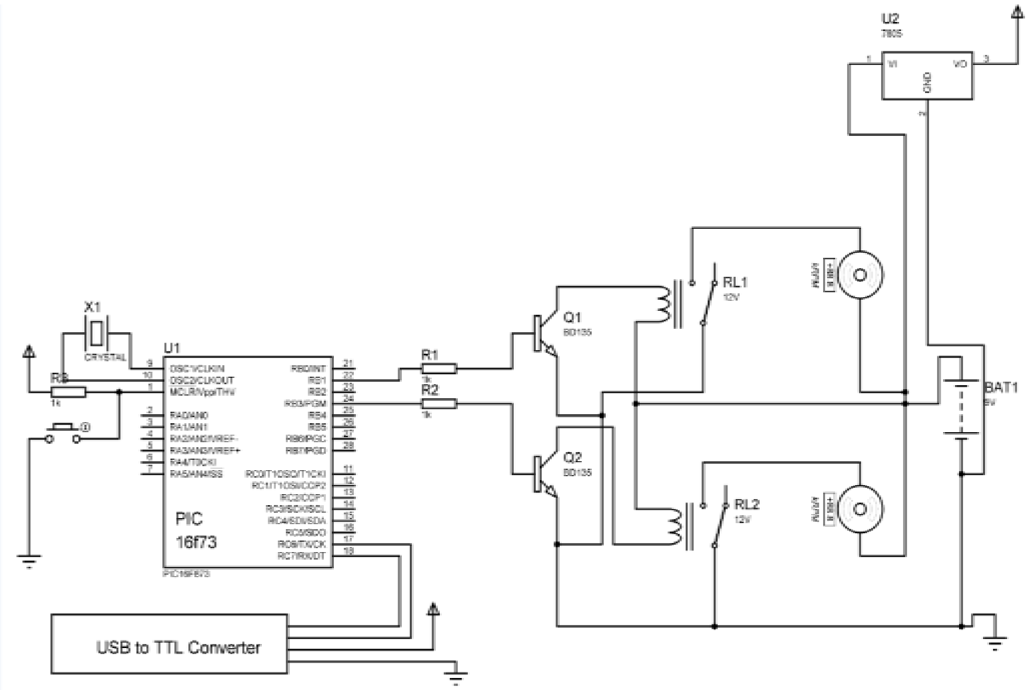
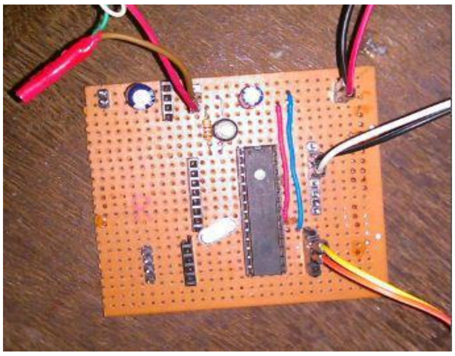


Fig.8: Implemented interfacing circuit diagram.



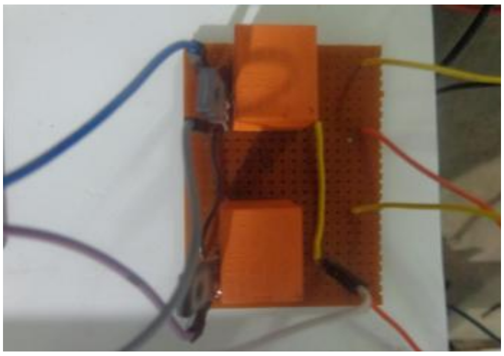


Fig.9(a) Main or Brain circuit and (b) Relay or motor control circuit

Fig.10 The complete wheelchair.

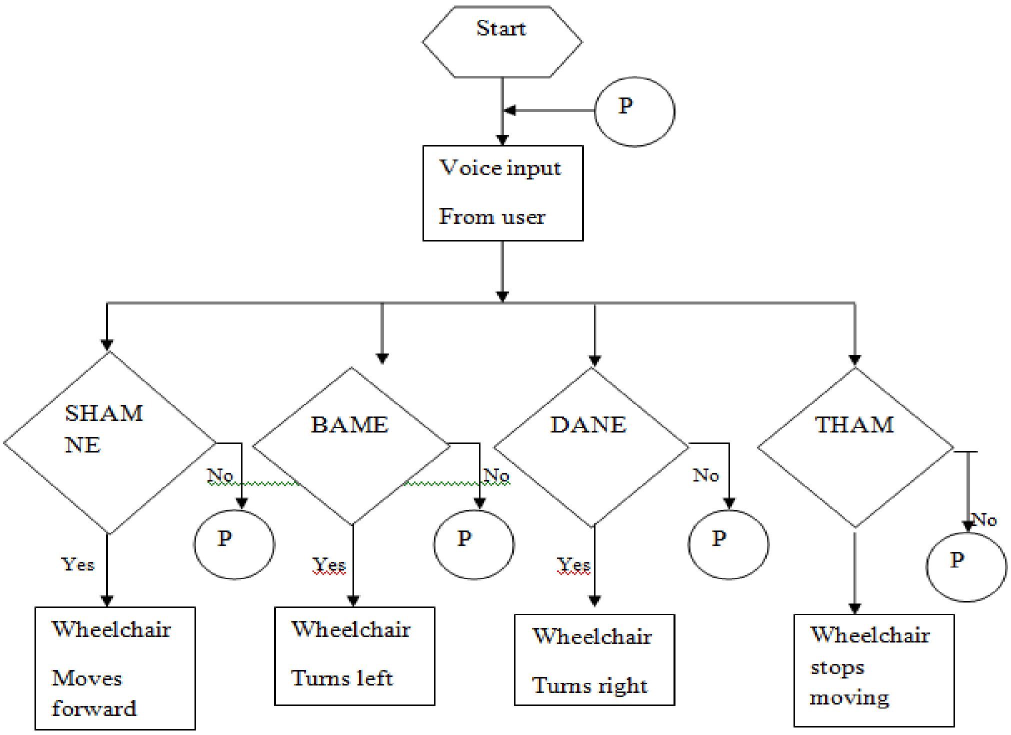


Fig.11: Voice controlled motion of the wheelchair.

Operation of the Wheelchair: A complete new designed voice controlled wheel chair for disable person is shown in the Fig.10. In this system some advanced voice commands are designed so that the user can choose the speed. The user can select the speed in two levels, either slow or fast speed to move. For example if the user need only to move in a short distance or to approach object, he should use the slow speed. This speed selection is important for safety and extra maneuverability of the user. The main part of the design is to control the motion of the wheelchair. Fig.11 shows the working principle of the wheel chair based on the voice recognition. There are four types of motions considered, moving forward, moving in reverse direction, moving to the left and moving to the right. For the speed, the user may use slow or fast speed. Slow speed is important as the user want to move in short distance or approaching an object. The system starts by applying the supply voltage to the speech recognition circuit. The system will be in stand by condition in which the LED on circuit recognition board will be turned on.

The system can be controlled in two speed conditions, fast and slow. For fast condition the system will supply higher current to the motors. If the user does not want the wheelchair to move in high speed, the slow speed can be set by applying low current supply to the motors. The direction and speed of the wheelchair depends on the user. For the forward command the wheelchair moves in forward direction. For the reverse direction the oppositemovement of wheel rotation will occur. The left command will make right wheel moves forward and left wheel moves backward. The right command makes left wheel moves forward and right wheel rotate backward. In this system, by assigning the word command stop the rotation of both motors will stop. The wheelchair system will go back to the stand by condition or end the whole system by turning off the power supply of the speech recognition board.

3. RESULTS AND DISCUSSION

After the design and development of the wheel chair with respective interfacing circuits, the technology will be tested for the motion of the wheel chair using trained voice. The proposed design was implemented using modern concept. This would be implemented for disabled people after having the smoothly furnished design of the wheel chair.

Results: The important aspect of the wheelchair system is to find its velocity. While the voice controlled wheelchair moving in a straight line, the distance and time is noted for velocity. The velocity of the wheel chair needs to be experimented under two conditions. First the velocity is observed in unloaded condition. The wheelchair was made to move in a straight line and the velocity is found 1.53ft/s. Secondly, with 15kg loads was allowed the wheelchair to carry the load and the velocity was found 1.24ft/s. Finally a person weighing 30kg was seated at the wheelchair. The voice controlled wheelchair was allowed to move in a straight line. The velocity of the wheel chair with this load is 1.21ft/s. Based on the above result, the velocity of voice controlled wheelchair is affected by the load. It is observed that the velocity of the wheelchair system will decrease proportional to the load that is carried by the system.

Discussion: This proposed system contributes to the self dependency of physically challenged and older people. It reduces the manual effort for acquiring and distinguishing the command for controlling the motion of a wheelchair. The speed and direction of the wheelchair now can be selected using the specified commands. Thus the only thing needed to ride the wheelchair is to have a trained voice. Besides that, the development of this project is done with less cost and affordable. However this system requires some improvements to make it more reliable. This design could be improved by implementing wireless communication, using sensors to detect obstacle in the wheel chair. By improving this system, we directly enhance the life style of the disabled people in the community. Lastly, we hope that this kind of system could contribute to the evolution of the wheelchair technology.

4. CONCLUSION

The aim of this research was to design and fabricated a voice controlled wheelchair for disabled people usually depend on others in their daily life especially in getting from one place to another. From the above results and discussions following conclusion can be drawn. The voice controlled wheel chair runs successfully with a speed 1.21ft/s for 30kg load. The wheelchair responds to the voice command from its user to perform any movements functions. The basic movement functions includes forward direction, left and right turns and stop. In order to recognize the spoken words, the voice recognition processor must be trained with the word spoken out by the user who is going to operate the wheelchair.

The motor drive and control system of the intelligent wheelchair has been presented. The proposed microcontroller based voice operated intelligent wheelchair would bring more convenience for the disabled people. The technology can also enhance safety for users who use ordinary joystick-controlled powered wheelchairs, by preventing collisions with walls, fixed objects, furniture and other people.

5. REFERENCES

1. Ms. S. D. Suryawanshi, Mr. J. S. Chitode and Ms. S. S. Pethakar: **“**Voice Operated Intelligent Wheelchair”, IJARCSSE,May-2013.
2. J.B.A Ghani,“Wireless speed control with voice for wheelchair application”, UNIVERSITI TEKNOLOGI MALAYASIA, May-2007.
3. R. Puviarasi, MrithaRamalingam and ElanchezhianChinnavan : “Low Cost Self-assistive Voice Controlled Technology for Disabled People”, IJMER, August-2013.
4. S Tellex: “Relational Interface for a Voice Controlled Wheelchair”, May 17, 2005.
5. O.Babri, S. Malik, T. Ibrahim and Z. Ahmed:” VOICE CONTROLLED MOTORIZED WHEELCHAIR WITH REAL TIME OBSTACLE AVOIDANCE”, University of Engineering and Technology, Lahore
6. G. Pires, N. Honório, C. Lopes, U. Nunes, A. T Almeida: “Autonomous Wheelchair for Disabled People”, University of Coimbra, Portugal.
7. M.Nishimori, T.Saitoh and R. Konishi: “Voice Controlled Intelligent Wheelchair”, Kagawa University, Japan, Sept-2007.