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Voice Controlled Intelligent Wheelchair using Raspberry Pi

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Abstract— **An intelligent wheelchair is designed to help physically disabled patients by using speech recognition system to control the movement of wheelchair in different directions. Automatic obstacle detection is done using an ultrasonic sonar system which helps the patient to apply a momentary brake in case any obstacle suddenly comes in the way of the wheelchair and also vocally inform patient about obstacle distance from wheelchair. The intelligent wheelchair is designed in such a way that it can be controlled easily with minimum effort from the patient and also provides protection from obstacle collision if any voice mistake happens. The extra features like voice search and news listening mode is also available. The leading improvement is the low cost design and more features which allows more number of patients to use this wheelchair.**

Keywords- Intelligent; Obstacles detection; Ultrasonic sensor; Voice recognition; Speech synthesis; Wheelchair.

I. INTRODUCTION

There are patients who have lost control of both arms and legs, as a result of higher level spinal cord injury or brain and nervous system there are patients that have lost their legs in an accident use the standard wheelchair. These wheelchairs are propelled by the use of hands of the patient sitting on it or by some other person by applying external force. There is a complexity in the use of these wheelchairs because it requires some physical effort. A joystick controlled wheelchair is a replacement of standard wheelchair. These wheelchairs are powered by the eclectic current and the direction of wheelchair controlled by use of joysticks. It removes the effort of the patient or some other person for propelling the wheelchair. A new advancement in the development of the wheelchair is voice controlled wheelchair. Voice recognition depends on converting a particular spoken word to an electrical signal which is further digitized in order to be processed by a computer or microcontroller. [1] The voice recognition not works very well in all conditions due to the noise of environment and incorrect accent. [2]

Uvais Qidwai et al. (2010), presented an idea for controlling the wheelchair by giving some fuzzy logics by using voice commands. This controlling system is called Fuzzy Inference system (FIS). This FIS is implemented on the MATLAB software as speech processor. But there is some limitations for using this system because it not works well in noisy environment. [3] S-.Y. Cho et al. (2009), presented an idea to control the movement of the wheelchair by using is a direct communication pathway between the brain and an external device. This controlling method is called direct neural interface (DNI). Wheelchair is controlled through a skid steering method. The mechanical part including the conventional steering can be eliminated. It also uses differential speed that controls the propulsion and turning. The system is neat, low cost and high dynamic performance; it can be used for stoke patent or disabled patents. [4]

Rini Akmeliawati et al. (2011), Replacement of the popular joystick stick controlled wheelchair with a hand-glove control system for easier movement by bending the fingers of the user. Wheelchair is controlled by wearing an instrumented glove that is fitted with the bend sensors that are used for movement and direction of the wheelchair. One way communication is performed between the instrumented gloves and the controller and it is kept at the lower portion of the wheelchair by placing a sheet in between the wheelchair wheels and the seat. It can be used by a wide variety of users. [5].This method is not useful for the patient who has amputee or paralyzed arm.

A. Al-Haddad et al. (2012), Eye movement controlled wheelchair is a new approach in the field of wheelchair development. The wheelchair is guided by the Electro-Echography (EOG) The control unit uses the gaze angle of the wheelchair user to obtain the desired position of the wheelchair. The wheelchair is guided automatically by the use of Bug algorithm. The Bug algorithm utilized to navigate the wheelchair. [6]

M. Mace et al. (2010), it is a controlling of a robot by the implementation of tongue-movement ear pressure (TMEP). Signals is presented, alongside results from a series of simulated control tasks. This scheme utilizes the discrete cosine transform to extract the frequency features from the time domain information, a univariate Gaussian maximum likelihood classifier and a two phase cross-validation procedure for feature selection and extraction. [7]

The presented work is more innovative in the sense, it uses speech recognition system to provide direction movement control of the wheelchair. In this wheelchair no separate speech recognition circuit is used because it is done by Raspberry Pi using Speech recognition algorithms. The ultrasonic Sonar senor is used to detect obstacle within range of 6.45 meters. This will offers emergency breaks for protection to the patient .Speech Synthesis (Text to Speech TTS) is used to provide vocal alarm to user e.g. “Obstacle detected 7.5 ft. ahead”. Google voice search is also available to get any kind of information by just a single voice command. E.g. “Capital of Pakistan” wheelchair system uses google to search answer and eSpeak (Speech Synthesizer) [8] to provide vocal response. Wheelchair has also an interesting feature of News Reading just say “News” and listen News.

II. Methodology

The block diagram shown in Fig.1 includes all the components of wheelchair. Microphone is used to converts voice commands from sound wave to electrical signal Raspberry Pi is next unit which use google API/CMU Sphnix (Speech to Text) for speech recognition Google API (Speech to Text) converts this voice command to text.

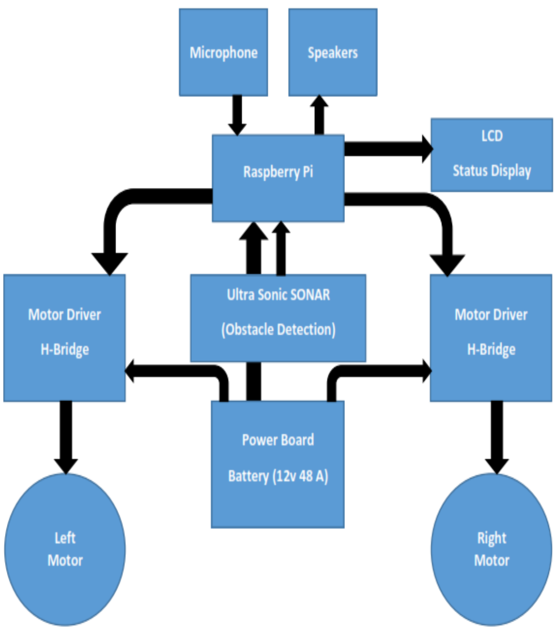

Fig. 1. Block Diagram of Wheelchair

Now on biases of this text command Raspberry Pi decide what user wants to do e.g. “Move forward/Move Back/Move Left/Move Right or Stop”. In case of any command from users except “stop” Raspberry always check distance using SONAR. If SONAR has clear distance more than 2ft. Raspberry Pi is used as controller and can be programmed in C#, Python, PHP, Java, Go, Pascal and Scratch etc. Power Board has 12v48A battery to provide voltage.

A. Raspberry Pi

Raspberry Pi is on board computer that is capable of doing everything that you expect from a desktop computer. Like Internet, playing videos game and many interesting things. This credit card size computer has CPU of 700MHz with 512 MB RAM with 2 USB Ports, Ethernet, Wi-Fi , Audio output and HDMI Display. [9] Speech Recognition, Speech Synthesis and Obstacle detection is done by using Raspberry Pi. Speech recognition can be achieved in many ways like CMU Pocket Sphinx [10], Siri and Google API.

Fig. 2. Raspberry Pi Model B

We used Google API (Speech to text) for voice recognition. Speech Synthesis is used for vocal response from Raspberry Pi. There are many ways to achieve synthesis facility like eSpeak, Festival, Pico Speak to Text and Google Text to Speech. We used eSpeak as Synthesizer for vocal response by wheelchair. Raspberry Pi’s GPIO are connected to SONAR and H-Bridge to measure distance and drive motors respectively. LCD is connected to GPIO for monitoring the status of wheelchair state. Fig. 2 shows Raspberry Pi Model B.

B. Ultrasonic Sensor (SONAR)

MaxSONAR EZ0 is used for obstacle detection which has 6.45meter range to detect any static object as shown in Fig. 1. This SONAR has three output options Analog, PWM and Serial. This 42 KHz ultra-sonic sonar require 2.5-5.0 volts and 2.0mA. [11] PWM output of SOANAR is connected to Raspberry Pi GPIO to measure distance from detected obstacle. SONAR is mounted on a servo motor if any obstacle detected servo motor moves SONAR to left or right side to get clear sight and wheelcahair moves in that direction.

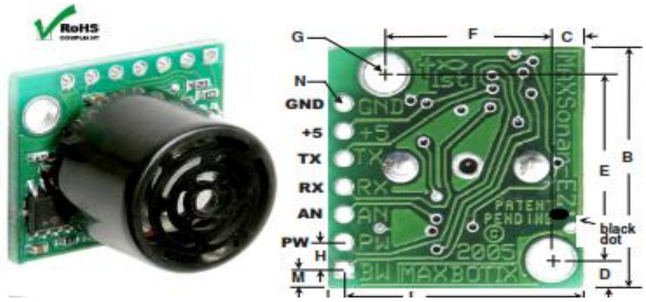

Fig. 3. Max SONAR EZ0

C. Status Indicator LCD

A small LCD is used to display the status of wheelchair. LCD displays the patient commands and their response by wheelchair. A 16x2 blue backlight LCD is shown in Fig.4.

e.g. "Ready to Listen Command"
"Obstacle detected 6.2fts ahead"
"Moving Forward"
"You asked: Capital of Pakistan?"

Fig. 4. Status Indicator LCD

D. Motor Driver (H Bridge)

H-Bridge is used to control the direction wheelchair motors. Fig. 5 shows the dual motor driver circuit that has max current rating of 14A continuously with 5.5-16 volts with max PWM Frequency of 20 KHz. [12] H-Bridge is connected to Raspberry PI GPIO through Opto-coupler circuit (4N35 Opto-Coupler IC) for sake of protection of Raspberry Pi. In case patient command is "Move Forward" Raspberry Pi GPIO provide PWM signal and 1, 0 to PWM (A), 1IN (A) and 2IN (A) pins of H-Bridge respectively.

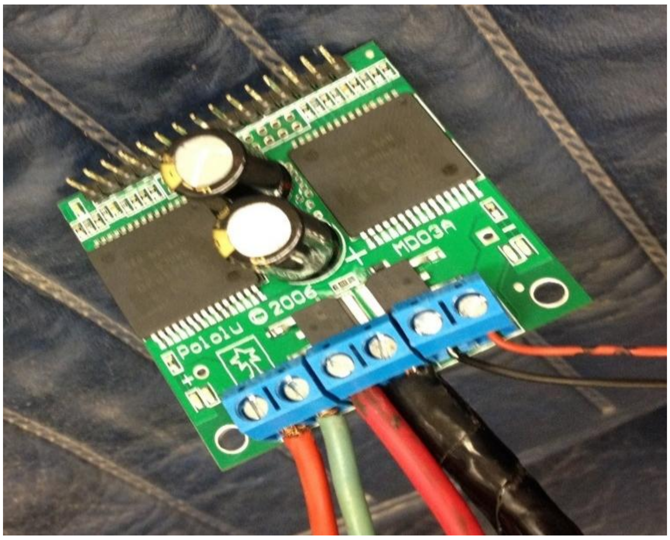

Fig. 5. Motor Driver

Voice commands and motor driver inputs and outputs:
1IN (A) and **1IN (B)** for direction control and **1PWM** for speed control pins **Output (A)** same for channel 2.

User says: *move forward*

1IN (A) = 1 1IN (B) = 0
1PWM (90% Duty cycle, 20 KHz Frequency)
Output (1) Motor rotates clockwise

2IN (A) = 1 2IN (B) = 0
1PWM (90% Duty cycle, 20 KHz Frequency)
Output (2) Motor rotates clockwise

E. DC Motors

Three D.C motors used in this wheelchair. Two of them used with left and right tires and third is used for direction control. Each motor can handle weight of 55-60kg so total 110-120kg can held by wheelchair. The operating voltage of motor is 12-24V, no load current is 7Amps and full load current is 13Amps each. The directional motor rating is 12v and 2.5Amps

III. Work Description

A Complete master board is shown in Fig. 6 that contains all required circuits of wheelchair. The board includes Raspberry Pi (Model B), Power Board, TP Link for wireless Internet connectivity (used by Google Voice Search), H-Bridge, SONAR and LCD directly connected to GPIO's of Raspberry Pi and Headset is plugged in USB. Headset and TP Link connected to Raspberry Pi via Powered HUB. Raspberry Pi receive voice command from patient and then translate it into text to understand that what patient wants to do. Google API has N-gram probability and use HMM to search the best possible results of user command. HMM is composite of two stochastic processes and provide very unambiguous and flexible speech recognition. Once Raspberry Pi has command word (except “Stop”) the next task is check clear distance for movement of wheelchair SONAR pins +5, GND and PWM directly connected to Raspberry Pi GPIO 5V, ground and GPIO14 respectively. The GPIO14 is declared as Input to measure the PWM to calculate distance of detected obstacle. If obstacle distance is more than 2feets wheelchair moves according to command. The response of wheelchair along with distance of obstacle from wheelchair displayed on status indicator LCD also vocally informed to patient using speech synthesis.

E.g. patient says “Move Forward” sonar check clear distance let an obstacle detected at 6feets. LCD and Speaker response “Moving Forward with clear distance of 6feets”

Power board is used to provide required voltage to all circuits including motor driver. Raspberry Pi is programmed in python language and working well according to the patient commands. Using speech synthesizer we achieved vocal response from wheelchair. Patient can also listen news by just saying “News” and Raspberry Pi start reading news from newspaper this also achieved by speech synthesizer. The most interesting feature of this wheelchair is google voice search. This provides extraordinary facility to patient to search about anything or ask some question. Google voice search gives best possible answer to questions of patient. E.g. To use this feature patient required to say “Google Search” Raspberry Pi response “Yes Sir” now you can ask for questions, e.g. “what is the speed of light”. Raspberry Pi search for answer and respond as “the speed of light is = 299792458 m/s”.

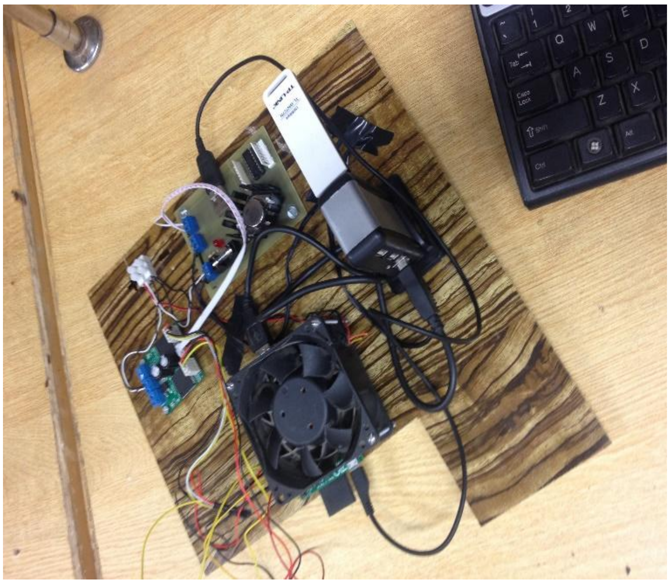

Fig. 6. Master Board

IV. Results

The Wheelchair is tested with voice commands using both speech recognition methods. CMU Sphinx has very poor accuracy to recognize correct word. In noisy environment its accuracy is about 50% and in noise less environment maximum 60% accuracy be achieved. Because of its poor accuracy we switch our recognition method to Google Speech to Text.

Google STT has excellent results in both condition as discussed above with 85-90% accuracy. Wheelchair response in two ways to patient, LCD display and Headphone Speaker (Speech Synthesizer). SONAR was tested with different objects like ‘walls, chairs and tables’ etc. and results were perfect within range of 6meters.We can use another SONAR at back side of wheelchair to prevent form obstacles in backward drive. We can add robotic arm with wheelchair for pick and place as paralyzed person can’t hold things with comfort. E.g. cup of coffee or want to pick something from ground like their glasses from table or any household item.

V. Conclusion

In this paper, Voice Controlled Intelligent wheelchair, with voice control, obstacle detection, speech synthesizer, news reading and google voice search is developed. The wheelchair we developed is more useful for the patient who paralyzed from waist down and even can’t move their finger. This wheelchair can be controlled in many languages with any prior training and there is not limitation of number of commands. Most interesting thing of this wheelchair is google voice search. Aim behind this product is to develop a cost effective and user friendly wheelchair so maximum patient can use this and make their life easy.

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