Implementation of Voice Controlled Automated Wheelchair on NI myRIO Platform using NI Lab View

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Abstract: The demand for low-cost, safe, easy-to-operate, automated wheel chair has always been the expectation from the physically challenged & quadriplegic persons. An attempt is made in this regard with an exclusive support of voice control, resulting in more simpler & easy to operate system for quadriplegic, tetraplegia users. The proposal describes the implementation of the highly responsive system using NI LabVIEW, on the NI myRIO platform, collects the voice commands from disabled persons to control the operation of DC motors, thus controlling the wheelchair movement. With a concern of proactive safety, an IR sensor is used to detect the obstacle in the path of wheel chair, avoiding the collision of wheel chair and an ultrasonic sensor to halt the wheelchair upon sensing the staircase, pot-holes. This voice controlled wheel chair is designed to offer the handicapped persons, the required independence for indoor/outdoor movement.

Keywords: Automated Wheelchair, NI LabVIEW, NI myRIO, Voice Commands, Shared Variable, Windows Speech Recognition.

I. INTRODUCTION

The population of people with disabilities has increased in the recent years. A recent clinical survey indicated that 9%-10% of patients who received power wheelchair training found it extremely difficult to use it for their activities of their daily living, and 40% of patients found the steering and movement of the wheelchair difficult, so the patients are always dependent on others to push them[1]. They often feel powerless and out of control. Users with severe motor handicaps such as tetraplegia and general muscle degeneration are unable to steer their own wheelchair through a conventional joystick, often depending on other persons[3]. A wheelchair is a wheeled mobility device in which the user sits. The device is maneuvered either manually or via various automated systems. Wheelchairs for physically challenged persons are considered not only a means of transportation but also as a way to allow users to express their individuality. Wheelchairs have been around for hundreds of years, but early wheelchairs were intended only to help a disabled individual to move from point to point. As society progressed and disabled individuals became more integrated, the role of the wheelchair began to change as well. Deprived of mobility, these people find it difficult to go to school, to find a job, to travel to the market and to meet their friends. With the freedom of mobility, these physically challenged people develop self confidence, have the abilities to lead near normal lives and will gain the potential to become contributive members in their family.

This proposal intends to give a new life to each of those physically challenged or quadriplegic persons who have been rundown of the basic privilege of mobility. The proposed system is implemented on NI myRIO platform, uses an application program developed using the NI LabVIEW (Laboratory Virtual Instrument Engineering Workbench). The NI LabVIEW is a system-design platform and development environment for a visual programming language from National Instruments [2]. LabVIEW being one among the powerful graphical programming language offers the extensive support for accessing instrumentation hardware, the different drivers and abstraction layers for many different types of instruments and buses are pre-included. Thus the application developer can focus more on application development aspects rather than getting into the low level driver details, saving both time and money. The NI myRIO-1900 is a portable reconfigurable I/O (RIO) device that can be used to design control, robotics, and mechatronics systems [2].

The myRIO consists of various analog input (AI), analog output (AO), digital input and output (DIO), audio, UART, Accelerometer, FPGA and an a dual-core ARM Cortex-A9 real time processor (Xilinx Zynq system on a chip (SOC) running a Linux real-time OS) in a compact embedded device. The myRIO has the ability to connect to a host computer over standard USB and wireless 802.11b,g,n on the ISM 2.4 GHz, with a channel bandwidth of 20MHz [4]. The system at first receives the voice commands from the user, processes the commands in comparison with the pre-stored vocal commands, these commands under the supervision of the processor are converted into electrical signals and are delivered to the left or right DC motor on either wired standard USB or on the above mentioned wireless interfaces, thus controlling wheelchair movements.
Also, as a precautionary measure, an IR sensor is used to detect the obstacle in the path of wheel chair, avoiding the collision of wheel chair and an ultrasonic sensor to halt the wheelchair upon sensing the staircase, pot-holes. This voice controlled wheel chair system is designed to offer the required independence for indoor/outdoor movement.

II. THE SYSTEM MODEL

The Fig.1 shows the block diagram of Voice Controlled Automated Wheelchair consisting of electronic and electrical components namely, the IR and Ultrasonic sensors to sense the surrounding environment, DC motors to steer the wheelchair and the power supply. All these components are interfaced with NI myRIO and the LabVIEW software. LabVIEW takes various inputs from connected sensors, voice recognition system and processes it according to defined program and then provides the output to the DC Motor for steering the wheelchair.

![Fig.1. Block Diagram of Voice Controlled Automated Wheelchair.](image)

III. THE SYSTEM IMPLEMENTATION

The overall implementation of the voice controlled wheelchair system is described under the two sections as follows:

A. Software Section

The software part plays vital role in controlling the hardware according to the user commands, having the hardware alone cannot help in accomplishing the intended task. Such an imperative task is carried out with the aid of the application program developed using the NI LabVIEW software. The input to the wheelchair is given by user’s voice which is converted to commands using speech recognition system present in Windows OS, these commands are taken by the host program and writes to the shared variable between the host program and the code running on the NI myRIO. Using the Wi-Fi hosting capability of the NI myRIO, it has been possible for the host device to communicate wirelessly over a WLAN network. The code on the myRIO continuously monitors the value updates on the shared variable and executes the appropriate cases in the case structure. The LabVIEW Integrated Development Environment consists of two windows- the front panel and the block diagram. Front panel is the window through which the user interacts with the program and the block diagram holds graphical source code of LabVIEW. The entire system code is placed inside four concurrently executing while loops as shown in the fig.2. The following sections explain briefly about the working of the graphical code.

![Fig.2. LabVIEW code of voice controlled wheelchair.](image)

**DC Motors Loop:** First loop being the motor control of the wheelchair; the wheels are rotated using the dc motors. DC motors has two wires, by changing the polarity of the supply over these wires the direction of rotation also changes. The input to the loop is shared variable (command) according to its value appropriate case is executed. The command can be left, right, straight, back and stop. The wheels move in appropriate direction depending upon the command. Considering the user had given “straight” as the command input, the right motor is connected to pin no’s 5 and 6, and the left motor to the pins 4 and 2 of NI myRIO. Now, the host program updates the ‘command’ to the shared variable with the “straight” command and the code running on the myRIO reads it over Wi-Fi and it invokes the case called ‘straight’ in the case structure, where a high signal (+5V) over pins 5 and 2 is applied, and low signal (0V) over pins 6 and 4 which makes the wheelchair to propel in forward direction, the code for which as shown in the fig.3.

![Fig.3. “Straight” command execution.](image)

Considering the user’s “left” command input, the right motor is connected to pin no’s 5 and 6, and the left motor to the pins 4 and 2 of NI myRIO. Now, the host program...
updates the ‘command’ shared variable with the ‘left’ command and the code running on the myRIO reads it over Wi-Fi and it invokes the case called ‘left’ in the case structure, where a high signal over pin 5, low signal over pins 6, 2 and 4 is applied, causing the wheelchair to propel in left direction, the code for which is shown in fig.4.

Considering the user’s “right” as the command input, the right motor is connected to pin no’s 5 and 6, and the left motor to the pins 4 and 2 of NI myRIO. Now, the host program updates the ‘command’ shared variable with the ‘right’ command and the code running on the myRIO reads it over Wi-Fi and it invokes the case called ‘right’ in the case structure, where a high signal over pin 2, low signal over pins 5, 6 and 4 is applied, which makes the wheelchair to move in the right direction, the code for which is shown in the fig.5.

Consider the user had given stop as input, the right motor is connected to pin no’s 5 and 6, and the left motor to the pins 4 and 2 of NI myRIO. Now, the host program updates the “command” shared variable with the “stop” command and the code running on the myRIO reads it over Wi-Fi and it invokes the case called ‘default’ in the case structure, where a low signal over pins 5, 6, 4 and 2 which makes the wheelchair to stop. Even if the user gives some other commands other than mentioned above the default case will be invoked, as is shown in fig.7.

**IR Sensor Loop:** The IR sensor enables continuous monitoring and detection of the obstacles in the direction of the wheelchair movement. Whenever an obstacle is sensed, the sensor produces a +5V signal on its output pin else a low or 0V signal is produced. The sensor output is connected to pin no. 0 of NI myRIO. If high signal is detected the true case is executed in case structure, in turn executes “back” command code, by giving a pseudo command “back” string
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into the ‘command’ shared variable which in turn makes the wheelchair to move in backward direction. If 0V is detected from IR sensor then the false case is invoked in the case structure and the wheelchair will be in its previous state of motion. This loop is shown in fig.8.

**Fig.8.** LabVIEW code for the IR Sensor upon obstacle detected/ undetected.

**Ultrasonic Sensor Loop:** The final two loops are related to the ultrasonic sensor, one sends the triggering signal and other is for reading the echo signal from the ultrasonic sensor. The ultrasonic sensor has four pins VCC, ground, trigger and echo. The triggering signal is sent by transmitting the TTL signal over pin no. 7 of NI myRIO. TTL signal is generated by continuously sending a high and a low signal at certain time interval. The trigger loop is shown in fig.9.

**Fig.9.** Generation of the Ultrasonic Trigger pulses.

The signals transmitted by ultrasonic sensor gets reflected back when it hits an object. This time of flight is encoded into the pulse width of the TTL signal transmitted over echo pin. Greater the time of flight greater will be the pulse width. So, for calculating the distance between the object and ultrasonic sensor it is essential to know the time of flight, and the time of flight is determined by calculated the time for which the signal on the echo line was high. For this purpose the value of the timer is taken at the beginning of the high signal and transmitted over shift register for next iteration, and at next iteration the value of timer is taken at the beginning of the low signal. The two timer values are subtracted which gives the time of flight value for the waves to travel back to the sensor, and dividing the time of flight value with 58 gives the object distance from the sensor. So, whenever the depth is more than 10 or 15cms the true case of the case structure is invoked, in which the pseudo "back" string is written into the ‘command’ shared variable, then wheelchair will move backward, avoiding any harm to the physically challenged person. If distance measured is below 10cm then false case is invoked in the case structure due to which the wheelchair will be in its previous state of motion. The graphical code for this is enclosed inside the while loop, is shown in fig.10.

**Fig.10.** Code that gets executed upon Ultrasonic Sensor receives the echo.

B. Hardware Section
The implement the system prototype the following hardware devices/ components have been used:

- NI myRIO
- IR Sensor
- Ultrasonic Sensor HC-SR04
- 12V Motor Driver & 12V DC Motors

**NI myRIO:** The NI myRIO-1900 provides several analog inputs (AI), analog outputs (AO), digital inputs and outputs (DIO), audio, and power output in a compact embedded

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device. The NI myRIO-1900 connects to a host computer over USB and wireless 802.11b,g,n. The fig.11 shows the arrangement of NI myRIO-1900 components [4].

Fig.11. Hardware Overview of NI MyRIO.

IR Sensor: The circuit has two stages, a transmitter unit as shown in fig.12 and a receiver unit as shown in fig.13 respectively. The transmitter unit consists of an infrared LED and its associated circuitry. The IR LED emitting infrared light is put on in the transmitting unit. To generate IR signal, 555 IC based Astable multivibrator is used. Infrared LED is driven through transistor BC 548. IC 555 is used to construct an astable multivibrator which has two quasi-stable states. It generates a square wave of frequency 38 kHz and amplitude 5V. It is required to switch ‘ON’ the IR LED. The IR receiver circuit consists of the following components: TSOP1738 (sensor), IC 555, Resistors, Capacitors. In receiver section, the first part is a sensor which detects IR pulses transmitted by IR-LED.

Fig.12. IR Transmitter

Whenever a train crosses the sensor momentarily transmits through a low state. As a result the monostable is triggered and a short pulse is applied to the port pin of the 8051 microcontroller. On receiving a pulse from the sensor circuit, the controller activates the circuitry required for closing and opening of the gates and for the track switching.

Ultrasonic Sensor: Ultrasonic transducers convert ultrasound waves to electrical signals or vice versa. Those that both transmit and receive may also be called ultrasound transceivers; many ultrasound sensors besides being sensors are indeed transceivers because they can both sense and transmit as shown in fig.14. As Ultrasonic spread velocity is 340m / s in the air, based on the timer record t, and is possible to calculate the distance (s) between the obstacle and transmitter, using: \( s = \frac{340t}{2} \), which is so-called time difference distance measurement principle. The principle of ultrasonic distance measurement used the already-known air spreading velocity, measuring the time from launch to reflection when it encountered obstacle, and then calculate the distance between the transmitter and the obstacle according to the time and the velocity. Thus, the principle of ultrasonic distance measurement is the same with radar. Distance Measurement formula is expressed as: \( L = C \times T \). In the formula, \( L \) is the measured distance, and \( C \) is the ultrasonic spreading velocity in air, also, \( T \) represents time (T is half the time value from transmitting to receiving).

Fig.13. IR Receiver.

Motor Driver and DC Motors: This board allows control up to two 12V DC motors individually as shown in fig.15. Each motor can be driven at a maximum of 750mA offering a decent driving current for the motors. It supports both

Fig.14. The Ultrasonic sensor HC-SR04.
clock-wise and anti-clockwise rotation and speed control. It can easily be interfaced with a microcontroller such as Arduino, 8051 or with any DAQ. A DC motor is any of a class of electrical machines that converts direct current electrical power into a mechanical rotation as shown in Fig. 16.

When the IR sensor detects an obstacle in its set range, causes both the DC Motors to stop. When the ultrasonic sensor senses a pot-hole or a step more than 15cms or to any other adjustable range, causes the motors to stop & will execute the “back” command automatically.

V. CONCLUSION AND FUTURE SCOPE

The proposed system tries to contribute the physically challenged persons in their day-to-day mobility activities, by offering them the required independent mobility and with increased safety. The usage of NI products has not only eased the development of the system, but has also increased the system response in navigation and accuracy of obstacle detection. The wheelchair can be powered by finding a way to automatically charge the battery with the help of motion of the wheelchair or by using solar panel and also addition of various sensors to increase wheelchair safety might be the considerations for the future extension.

VI. REFERENCES