Multi-faceted Wheelchair control Interface

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Abstract - *As the population of the elderly and the disabled grows, so does the demand for care and support equipment to enhance their quality of life. The most popular mobility aid for people with limited mobility for the past 20 years has been the electric powered wheelchair (EPW), and more recently, the intelligent EPW, also known as an intelligent wheelchair (IW), has attracted significant attention as a new technology to meet users' varied needs. Elderly people and disabled people face a lot of difficulties in performing the simplest day to day tasks. Many of them rely on others or utilizing conventional technologies such as wheelchairs to accomplish tasks. With the help of modern technology and the advent of voice-enabled applications and devices we can build tools to help them interact with society and smooth their mobility during everyday activities. A major problem that they face is to reach the wheelchair, hence, to curb this issue we propose a mobile application that enables the user to locate and navigate the wheelchair towards themselves whenever they need it. The primary goal of the interactive user operated wheelchair system project is to provide a user- friendly interface by employing two ways of interaction with the wheelchair that is entering choice of direction through touch screen (haptic) and voice recognition input using speech recognition module to operate a wheelchair.*

Key Words: Support; Intelligent wheelchair; Mobile application; Interact; Voice-recognition; Haptic;

1. INTRODUCTION

The project on using technology with wheelchair is an assistive technology that includes this initiative to make life more independent, fruitful, and joyful for dependent and disabled people. The primary goal of the interactive user operated wheelchair system project is to provide a user-friendly interface by employing two ways of interaction with the wheelchair that is entering choice of direction through touch screen (haptic) and voice recognition input using speech recognition module to operate a wheelchair. The device is made to allow a person to operate a wheelchair with their voice. This project aims to facilitate the movement of older persons who are unable to move well and disabled or handicapped people. It is hoped that this approach will enable certain folks to move around less frequently as a daily necessity. A crucial piece of technology that will enable new forms of human-machine connection is speech recognition. Therefore, by applying speech recognition technology for the movement of a wheelchair, the issues they confront can be resolved. The employment of the smart phone as a middleman or interface can actualize and maximize this. To create a program that can detect speech, control chair movement, and handle or manage graphical commands, interfaces have been built for this project. The wheelchair with a motor that can be moved using vocal commands. It is crucial for a motorized wheelchair to be able to avoid obstacles automatically and in real time, so it can go quickly. Through research and design wise, the wheelchair to control development along safe and effective use of the provision independence and self-use mobility.

2. Literature Review

Numerous studies have found that all impaired people can benefit from independent mobility or movement, which includes powered wheelchairs, manual wheelchairs, and walkers. Independent mobility improves educational and employment prospects, lessens dependency on group members, and fosters sentiments of independence. Independent mobility is crucial in laying the groundwork for a lot of young children's early learning. [1] A cycle of deprivation and lack of drive that develops learned helplessness is frequently the result of a lack of exploration and control. Independent movement is a crucial component of self-esteem for older individuals and aids in "ageing in place." Due to the necessity of movement for many of these activities, mobility issues contributed to the issue of activities of daily living (ADL) and instrumental ADL limitations. [2] Reduced socialization chances as a result of mobility issues frequently cause social isolation and a variety of mental health issues. While traditional manual or self-automated wheelchairs can often meet the needs of people with impairments, certain members of the disabled community find it difficult or impossible to utilize wheelchairs independently. In paper [3], they describe a smart wheelchair navigation system through multiple inputs hence the users with different types of disabilities can also use the same system. Simple and low cost ATMega32L of AVR microcontroller family is used for processing purpose.

Microcontroller will compare those values with saved threshold values. When it gets below the threshold value, it will transmit stop command to the H-bridge motor driver circuit to avoid the possibility of collision. Controller will get navigational commands from android phone, which are connected through Bluetooth. User can give voice commands to the android device which will be compared with saved commands and its value will be passed to controller.

In paper [4], they describe a design showing the movement and voice-controlled wheelchair that can guide the paraplegic to head towards their will and wish with the help of the voice command wheelchair. It has provided a design that is efficient in helping the handicapped people without putting their strengths and efforts to pull the wheelchair, by commanding it on their voice with a facility to control the speed of the wheelchair. The brain of the proposed system is Microcontroller. Voice to text app is used to get the voice input from the handicapped person and it is given to the Microcontroller via Bluetooth EGBT45ML.The voice gets converted to the machine code which will be given to the motor driver to control the movement of wheelchairs.

This paper [5], presents an automatic wheel chair using voice recognition. A voice-controlled wheelchair makes it easy for physically disabled person who cannot control their movements of hands. The powered wheel chair depends on motors for locomotion and voice recognition for command. The circuit comprises of an Arduino, HM2007 Voice recognition module and Motors. The voice recognition module recognizes the command by the user and provides the corresponding coded data stored in the memory to Arduino Microcontroller. Arduino Microcontroller controls the locomotion accordingly. They are using HM2007 voice recognition module which correlates commands to do speech processing and give the result to Arduino which is further programmed with respective locomotion commands. The locomotion is controlled using L293D and Relay which control the motors. The software is coded in Arduino and the hardware components parse the voice commands and translate it to the motors.

This paper [6], describes the wheelchair system with user friendly touch screen interface. This device helps the disables to have automatic advancement to their destination through predefined paths in the indoor system. Use of touch-screen enables less muscle movement and less muscular pressure than the self propelled wheelchairs which are being used from ages. The ability to choose between manual operating mode and predefined operating mode uniquely presents capacity of the wheelchair to operate in multiple environments. Obstacle avoidance facility enables to drive safely in unknown as well as dynamic environments.

In paper [7], a wheel chair ROBOT model contains an in-built Micro Controller And Eye Ball Sensing system, which does the functions like right, left, forward and reverse operations. The wheel chair is designed in such a way that it can move freely without external support or dependency. Through this feature the patients can enable movements of their wheelchair as per their desire.

In paper [8], the design of an automated wheelchair for people suffering from total or partial paralysis is presented. This wheelchair design allows self-control using an Infrared Sensor and a microcontroller (Arduino Uno) based circuitry with emergency message transmitting systems. This design will not only prevent stress on the body during movement in all four directions but will also be accessible by low income households.

Robotic wheelchairs have enhanced the manual wheelchairs by introducing locomotion controls. These devices can ease the lives of many disabled people, particularly those with severe impairments by increasing their range of mobility[9].These robotic enhancement will provide benefit people who cannot use hands and legs. In this project we have developed a voice controlled wheelchair which aim to counter the above problems. The wheelchair can be controlled using joystick as well as using voice commands. He/She just needs to say the direction or move the button for that direction and the wheelchair moves in the desired direction. In hardware development, we are using HM2007 voice recognition module which correlates commands to do speech processing and give the result to Arduino which is further programmed with respective locomotion commands[10].

3. Gap analysis

Prior to this, researchers have designed wheelchairs that require high hardware configuration using heavy and complex models such as 2-axis joystick, huge brakes and tires etc. All these components combinedly contribute to difficulty in mobility for the patient using the wheelchair. With the use of dedicated hardware peripherals, the elderly and disabled people require maximum physical efforts for motion . Also, even though they are heavy and complicated, they provide a similar performance to other light-weight software-based models. Most of the papers described, lack the concept of integrating software into the hardware for efficient mobility. With the use of software, not only we can design light weight and minimalistic wheel-chair , but also we can embed various technologies like artificial intelligence for including latest features like autopilot into the wheelchair. Hence, the majority of the proposed models were not performing as efficiently as they were supposed to .

4. Proposed system

4.1 Flowcharts

Wheelchairs can be controlled in two ways: utilizing the user's voice and an Android app.

The first flowchart demonstrates how voice instructions can be used to operate a wheelchair. First, a Bluetooth connection is made between the wheelchair and the user voice application. The user is then expected to utilize the application to utter particular commands. The word is then validated and converted to text using the Google voice service. The text format is then analysed by the controller, who then verifies that the input is correct before providing the motor drivers with precise instructions for the movement in the directions of left, right, straight, backward, or stop.

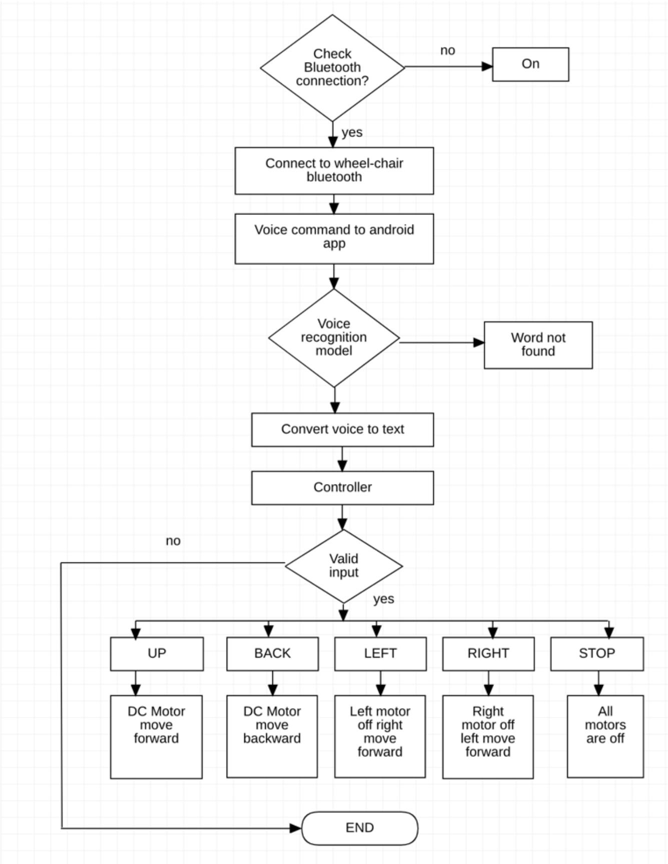


Fig 1: Flowchart for User Voice Command

The user will utilize an Android device with a GUI app in the second part of our project to send commands by clicking on a certain button, and the wheelchair will respond as instructed. The wheelchair will move as a result of the commands. The internet or Wi-Fi connection is a must for this module. The microcontroller first verifies that the input is genuine before giving the motor drivers specific instructions for moving left, right, straight, backward, or stopping altogether.

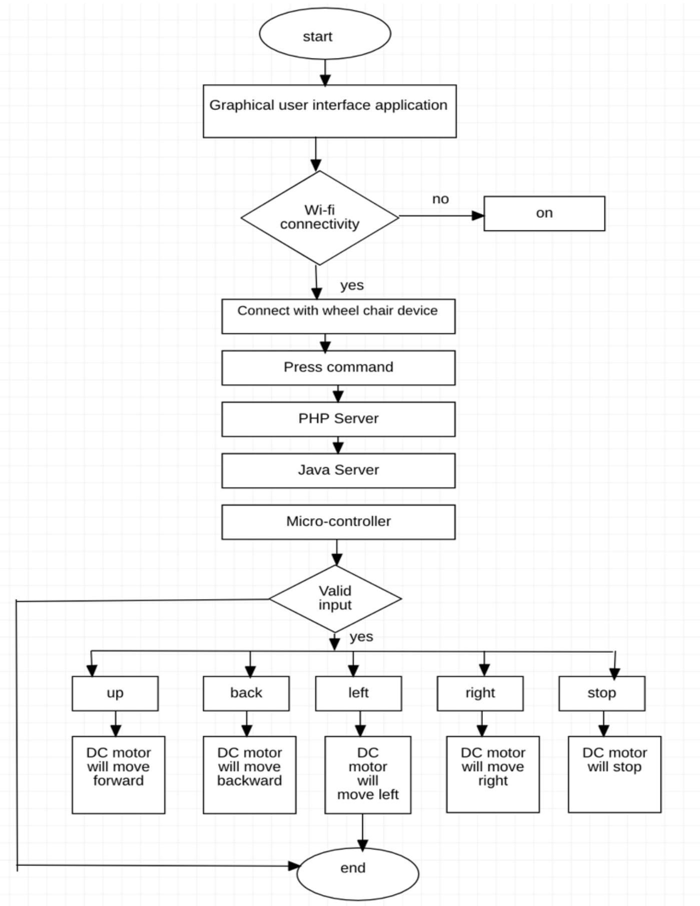


Fig 2: Flowchart for GUI Command

4.2 Block Diagram and explanation

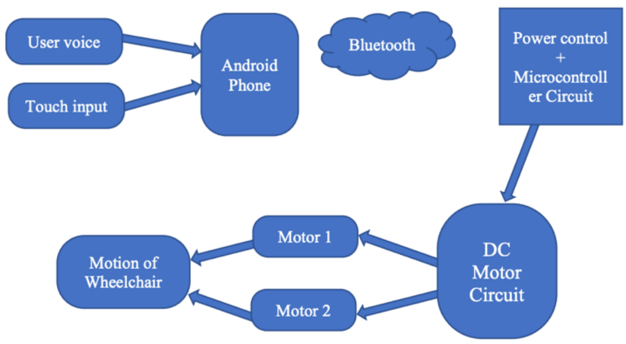


Fig 3 :- Block diagram for the proposed model

It is an application to run on the android device with the GUI app for sending command by clicking on the specific button and the wheelchair will behave accordingly as per the command. The commands will produce the movement of wheelchair. The Bluetooth connection is used to transmit instructions to the actuators in the wheelchair. Microcontroller checks for the valid input and then gives specific instruction to the motor drivers for its movement towards left, right, straight, backward otherwise stop.

Android will act as middleware. Android will offer connectivity through Bluetooth and will send wireless data over the connection. Android will have a voice recognition app to receive voice commands. The voice recognition app will first decode the sets of instructions from the voice commands and then later send it to the Bluetooth serial module. The microcontroller will receive the set of instructions; it will compare the instructions with the predefined conditions that are set as base. If the condition is satisfied, then the signal will be sent to the driver circuit which in turn will convert output pulse signal from microcontroller to electrical signal to drive the wheel or to give the mechanical instructions to the wheel's DC motors. There is also one other way to give directions and other controls, by pressing a finger against the various quadrants on the app which is programmed with different values for different directions.

4.3 UI Interface

The user-interface is designed in compliance with the Sneiderman's 8 golden rules, fitts' law and Neilsen's 10 heuristics for UI Design. We have used a simple interface where we prioritize the arrow buttons for direction and thus making them of bigger size. Thus, according to Fitts' formula the time to acquire the direction buttons for the user is reduced as it is inversely proportional to the width of the buttons. The direction options in the user interface are provided according to real-world directions for ease of use and the voice option makes the process immensely simple for users that might have less or no vision. The standard settings and positions for buttons have been used so the user needs least or no adaptation to the interface.

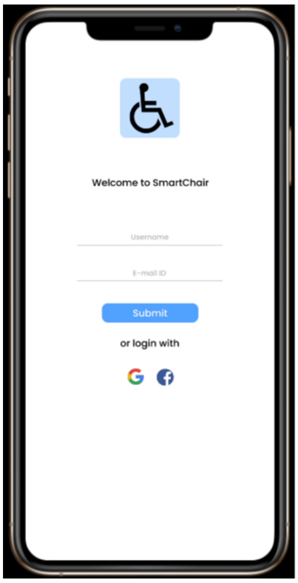


Fig 4: Login screen

Fig 5: Home page

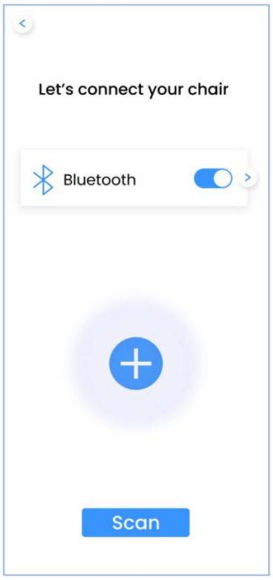


Fig 6: Bluetooth Connection

Fig 7: Battery info

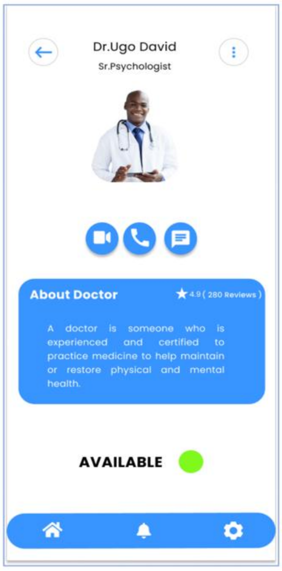


Fig 8: Emergency contact

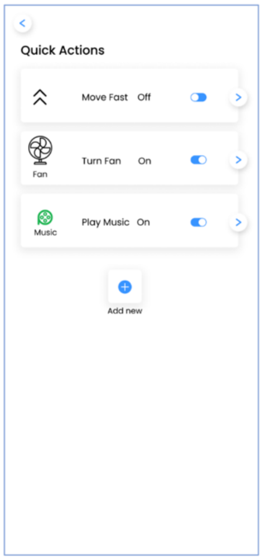
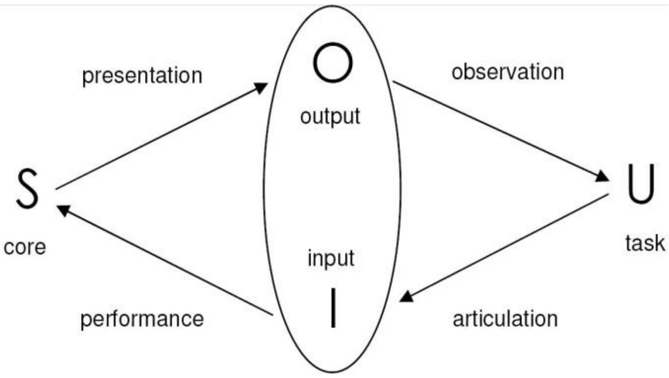


Fig 9: Quick Actions

The user can immediately stop the wheelchair at any point during their journey by speaking or clicking. A user could run into an error for example if the voice enabled system is unable to recognize the command. When this happens, the system reads out the 5 commands that the user can use LEFT, RIGHT, FORWARD, BACKWARD, AND STOP. The user-interface implements recognition over recall by providing interface where directions are already given and not asked to be entered by user so the user can just recognize and select. The user-interface is flexible to various types of handicap or disabled people by taking input in multiple ways.

4.4 Interaction Model

Abowd & Beale's Model is used as interaction framework.



Abowd and Beale's interaction framework identifies system and user components which communicate via the input and output components of an interface. Similar cyclical processes are taken in this communication from the user's task formulation to the system's execution and presentation of the task to the user's observation of the task's outcomes, from which the user can then design new tasks.

In the proposed system, user is the person using the wheelchair application interface on their phone. Input is via touchscreen (Haptic input) input through smartphone or voice-enabled input. The system takes in as input commands from the user to either move in a certain direction or stop the movement of the wheelchair. Using the Arduino IDE, we can convert the commands to actual actions performed by the wheels through motor. The output is required movement of the wheelchair.

4.5 Testing the model

Unit testing method was employed for generating the test cases . Unit testing involves isolating different sections of the code to check for bugs and errors for different possible inputs to the application. Various output were observed for different inputs as a result of the test.

5.Result and discussion

Testcase	Result
Haptic input: Left	Success
Haptic input: Right	Success
Haptic input: Forward	Success
Haptic input: Backward	Success
Haptic input: Stop	Success
Haptic input: Multiple keys	Failed
Audio input: Left	Success
Audio input: Right	Success
Audio input: Forward	Success
Audio input: Backward	Success
Audio input: Stop	Success
Audio input: Noise	Failed
Audio input: "Great day"	Failed

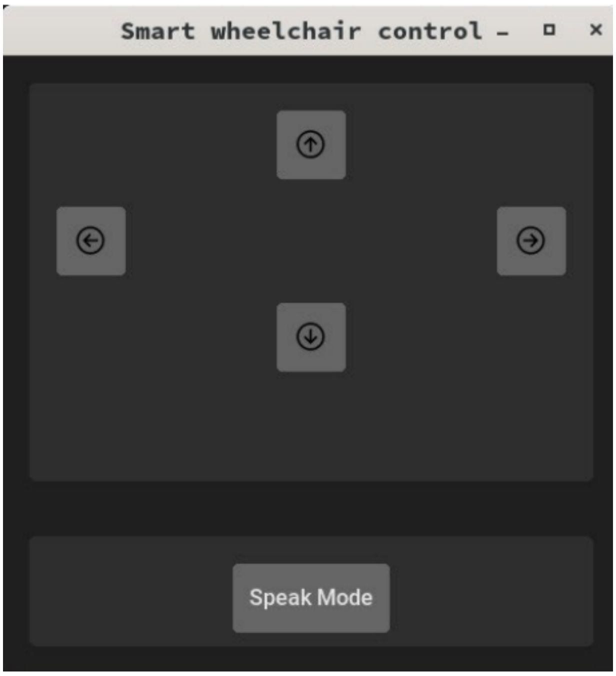


Fig 10 : Tkinter GUI Panel for voice recognition

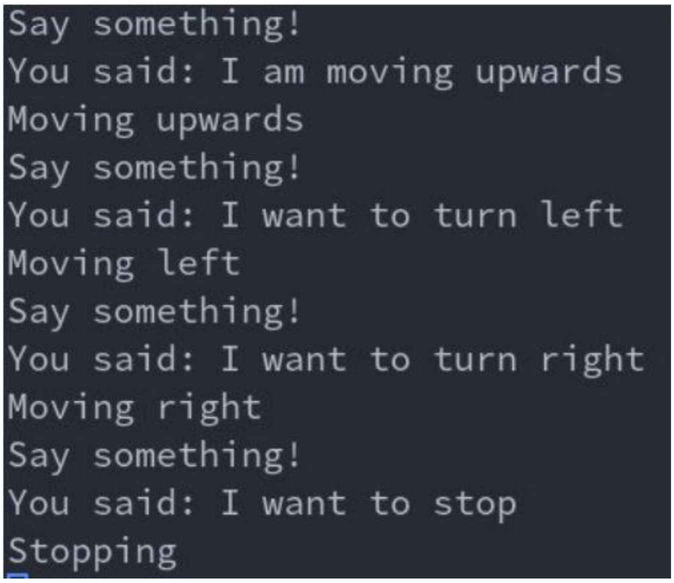


Fig 11: Sample output for commands from buttons and voice

The project was tested for parsing and transmission of user input. Haptic input enables the user to hold down the buttons and transmit the movement signal via bluetooth as long the button is held. The signal ceases when the button is released. This design is quite convenient and intuitive for people to work with. Voice recognition functionality allows the user to toggle the movement state by saying key voice-activation words like ‘forward’, ‘stop’ etc. Once the voice command is recognized, the corresponding movement signal is transmitted continuously until interrupted by another user input. The voice recognition performance was found to be dependent on the phone’s microphone quality and varied from phone to phone. Usage of earphone and headphone mics improved command recognition. The noise tolerance of the system was tested in a room by playing music and having multiple audio sources. It was found to be quite sensitive to noise as it attempted to parse and recognize words from surrounding sound and failed to recognize commands when the music loudness levels were similar to the testers voice. The system had satisfactory performance in lightly noisy environments and when the microphone was held close when speaking.

6. Conclusion and Future work

In this project we developed a user-friendly graphical user interface to perform operations on a wheelchair from instructions given through a smartphone device. We integrated a simplistic and minimalistic user-interface with voice recognition feature that enables movement by of the chair by just speaking the command. In the future we can try to collaborate with mechanical experts to build a fully functional voice-enabled wheelchair. Another one of our main goals is to expand the functionality of our software and include more functionality such as speed control or AI-powered obstacle detection using the phone’s built in camera. We also seek NGOs that support the cause of providing easy movement to elders and handicap people. An implementation of the final product can help disabled people live an easier and better life.

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