Wireless Gesture Controlled Wheelchair

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***Abstract*— In this research work, we present a Bluetooth-based wheelchair which can be controlled by finger or hand gesture using an Android application developed by us installed in smart gadget. The device helps those deprived of motion in their day to day activities. Even though there is a tremendous leap in this field, there are no facilities for the user to control the wheelchair with less strain on their hands. So this prototype will be a great help for the differently abled users as they can control the wheelchair by just moving their fingers or hands on the touchscreen. The prototype can be varied between touch and swipe. In some cases, the differently abled might not be able to control their fingers. In such cases, since Bluetooth is used, a second person can control the motion rather than pushing it.**

***Index Terms*—Wheelchair, Bluetooth, Android application.**

I.INTRODUCTION

The objective of this research work is to develop a wireless control system using hand gesture with the help of electronic gadgets like smartphones or tablet using the Android application developed by us. The success of a technological product depends not only on its efficiency but also on the way it interacts with the end users. The end users are usually unaware of the undergoing processes that are essential for the system to work efficiently. So the interface should be as user-friendly by black boxing as many processes as possible. So the Android platform is chosen as it provides various open tools for this task. The Arduino outputs control signals to the motor drivers, a master-slave configuration is used to connect the Android app with Arduino board, the smartphone acts as a master and the HC-05 Bluetooth module acts as a slave.

As per the studies were done by WHO (World Health Organization), it is estimated that out of 650 million peoples with disabilities 10% of them need wheelchairs for their day to day locomotion. The most commonly available control method is the joystick control for powered wheelchair navigation. But all users cannot be comfortable with a joystick as it requires strength and power to hold the joystick and move. Due to varied strengths in hands all users including elders, physically challenged, partially paralyzed patients, quadriplegics, stroke patients, spinal cord injury patients etc. cannot use the joystick. Alternative control methods are available at huge cost and are not affordable by people of developing nations.

II.MOTIVATION

According to the 2011 statistics of India, 20.3% of the differently abled people have mobility issues. Their disability makes it impossible for them to have a normal life. For some differently abled, movement can be a complex issue. But, technology can make it simple, even for them. 98% of the powered wheelchairs are joystick based which is not suitable for all, some people might not have enough strength and may have difficulty while operating them. In addition, customized wheelchairs are sold at high prices.

Android's open platform makes it possible to build apps meeting specific needs and distribute them free of cost. Since 64.8% of the smartphones in India are Android based, it has a wide range when marketing the product is concerned. The app can be shared among a selected group of people beforehand and can easily get connected to the slave Bluetooth to control the wheelchair. This flexibility is a huge benefit when the user is unable to afford a caretaker dedicated completely to him/her. Also, the pairing of the master and the slave requires a password which makes it difficult for unauthorized people with the app to control the wheelchair. So the product is affordable and secure.

III.RELATED WORKS

Since the conventional controlled wheelchair lacks universality, many customized wheelchairs with novel ideas had been developed to address a specific section of differently abled. In the research paper [1], the Authors uses bend sensors to control the wheelchair. The bend sensor is basically a voltage divider circuit. The bent fingers control the speed and the direction of motion. It makes the control process very easy with little practice. But it might be difficult for a person other than the user to operate it when such an emergency arises. In the research paper [2], the Authors proposes an EMG based signal processing system where predefined hand gestures are used for controlling the wheelchair. But it takes some time for the user to get used to the system. The Authors in the research paper [3], proposes a voice based system. But these systems are not cost effective and their efficiency is not on par with the other solutions when tested outside laboratory conditions.

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The research paper [4], emphasizes the need to use non-conventional energy like solar energy for powering the wheelchair. The system, as the author admits, has some portability issues. They may be addressed by the future technologies by reducing the size and weight of solar panels. In the present day market, it is not cost effective either. The authors of research paper [5] developed a simulator to navigate the wheelchair, based on Dijkstra algorithm, between predefined locations. The system can auto-navigate avoiding static and dynamic obstacles relieving the users a lot. But, it needs an explicit map of the surroundings of the user beforehand. The research paper [6] proposes a mechanical model using only 2 wheels instead of the usual 4. The system aims to solve the problem of navigating through narrow passages for which the 4 wheeled chair needs a lot of maneuverings. As already mentioned the problem is a complex one and needs a completely different solution when the situation changes with the generally used 4 wheeled wheelchairs it is impossible for the elderly and differently abled to go upstairs unless there is pavement to the top The authors of research paper [7] proposes a novel stair climbing wheelchair proposing systems to help elderly and differently abled to climb stairs.

IV.SYSTEM ARCHITECTURE

Arduino Uno, a single board microcontroller is used since the programming of Arduino is quite easy. It has inbuilt RX and TX pins which make the interaction between the microcontroller and the Bluetooth modules easy. Also, it provides a user-friendly terminal to check the values that are going to be sent to the slave Bluetooth. Bluetooth, a secure protocol, is perfect for short range wireless communication because of its low power and cost efficiency. HC05, perfect for slave configuration is used in the system. It can be configured as slave using AT commands. When it is in slave mode, HC05 can accept but cannot initiate connections. The Android device (mostly prefer tablet than mobile) acts as a master.

The user can place his/her palm on the tablet and move according to where they want to go. The tablet display must be bigger so that the entire palm fits on the tablet. The touchpad of the tablet will recognize the movement of the palm and correspond to each movement, the tablet will send some data to the Bluetooth transmitter and it will transmit the data through Bluetooth. At the receiver side, the Bluetooth receiver receives the data and passes the data into the microcontroller. The function of the microcontroller is to receive the incoming data and check if it is a control data or a PWM data. According to the data received the microcontroller will decode the data and output will be produced accordingly. The output is given to two motor drivers. The motor drivers have two digital inputs and one Analog PWM input. The microcontroller can give various combinations of 0 and 1 to drive the motor. The motor works only when a polarity exists. As there are 2 control inputs there can be 4 combinations that can occur. When the input is 01 or 10 the motor will rotate clockwise or counter clockwise. When the control input in 00 the motor will be in off state and when it is 11 the motor is in high impedance off state. When one wheel is rotating clockwise and other is rotating counter-clockwise, then the wheelchair moves linearly. If the wheels are rotating in the same direction the wheelchair will turn left or right.

Android-based Bluetooth wheelchair, as the name suggests, works with the help of an Android app created with MIT app inventor and Bluetooth. MIT app inventor 2 it is a platform where you can create an app very easily by placing each and every component on the screen and assign the functions by dragging and dropping the functions given for each of the components. As shown in Figure 1, the system uses Arduino to control the motor.

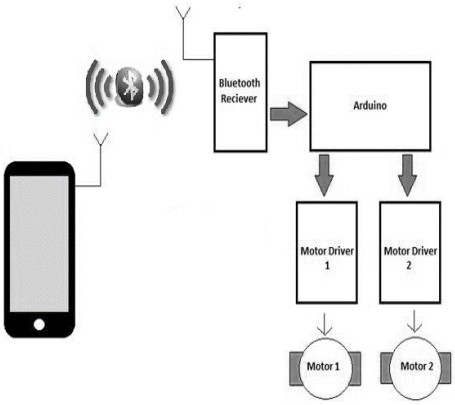

Figure 1. Wheelchair basic function.

V.IMPLEMENTATION

The first version of the app was such that the user can control the wheelchair by touching the buttons which are present in the Android application. But it had some demerits. It couldn't allow the user to connect to the Bluetooth devices when the app is open and the app lacked speed control. Since it was found inconvenient to operate, the second version of the app was made.

In the second version, since it is a little bit difficult to press the button for a long time, the button was replaced by a ball. So that the user can control the wheelchair by dragging his fingers on the top of the ball. The latest version of the app is designed in a way that a ball is occupied in the center of the screen and it can be moved to all the 4 directions. Also, a slider is given at the top of the screen so that the user can set the speed by changing the slider. If the user wants to stop the app he can press the exit button and the user can disconnect the Bluetooth connection. When the user opens the app a screen, as shown in Figure 2, Screen1 is displayed.

Figure 2. Android application Screen1.

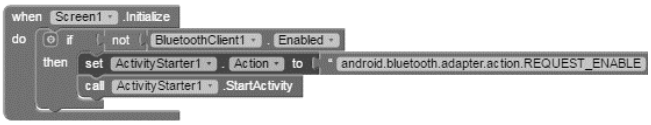

Figure 3. Blocks for Bluetooth initialization.

Since our app doesn't work without Bluetooth, we need to make sure if it is enabled or not. If not, we need to enable the Bluetooth from the app. As shown in Figure 3, when the screen "Screen 1" is started, the app checks if the Bluetooth is enabled or not. If not the app calls an activity called Bluetooth adapter enable request which is executed with the help of an inbuilt function called "Activity Starter". It will show a notification like below.

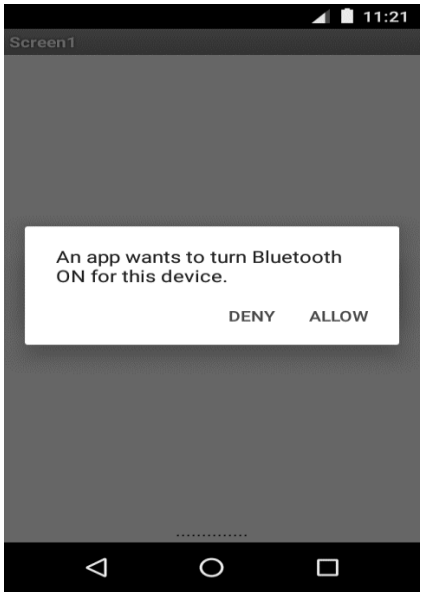

Figure 4. Notification for enabling Bluetooth.

As shown in Figure 4, if we press the ALLOW, the app will enable the Bluetooth and shows the first screen where we can select which Bluetooth devices we need to connect. Otherwise, the app will stop working and close the screen.

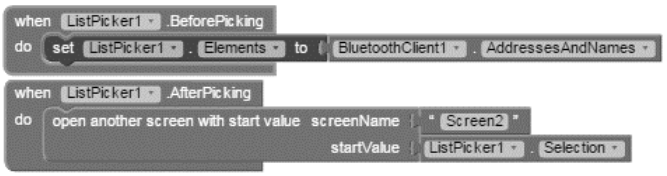

Figure 5. Blocks for Bluetooth connection.

These are the two components of a function called "List Picker" as shown in Figure 5 when it is pressed it will show the list of Bluetooth devices which are previously connected to the master device. When we pick any one from the list it will set the start value as the one we picked and with that value, it will change the screen from "Screen1" to "Screen2". In Screen2, the start value is taken as the address of the Bluetooth to connect.

The user will be directed to screen 2, as shown in Figure 6, will be displayed whenever the user changes the position of the ball that is when he drags the ball on the screen, the app will send certain alphanumeric values to the slave Bluetooth from the Bluetooth of the smartphone. If he moves the slider that is placed in the top of the screen the app will send an integer value between 30 and 100 to the slave Bluetooth module. When he presses the exit button, the app will ask the user whether he wants to disconnect the app or not. On the other side, the signal from the smartphone will be received by the slave Bluetooth module and is given to the Arduino. In Arduino according to the values given by the Bluetooth the controls will be set, that is if the value is for the change of direction, the required signals are sent to the motor driver and the motor driver will control the motor. If the value is for the speed, a control signal is directly sent to the Arduino and is sent to the PWM pin of the motor driver thus the speed of the motor is controlled.

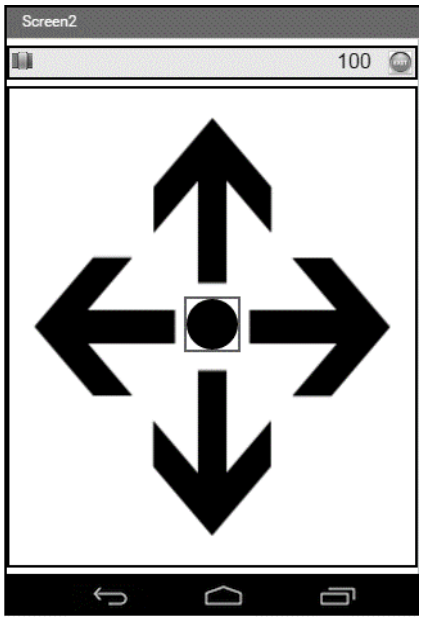

Figure 6. Android application Screen2.

Figure 7. Blocks for sending.

Figure 7 shows a timer which is a component of the function "Clock". This will execute whatever inside the timer every time the clock resets. For our app, we have used a global variable named "global name" which will contain the data to be sent after each function is executed. We have used the "Bluetooth Client" function to send the data to the slave board. Since the data is in character format we are using "send text" feature of the Bluetooth Client to send the data.

VI.EXPERIMENTS AND RESULTS

As the part of experimentation, we made an app as shown in Figure 8, which can control the motor with Arduino through Bluetooth. This app includes 5 switches. We made a circuit which consists of Arduino and 2 motors. Whenever the buttons in the app are pressed the signals are sent to the Arduino through Bluetooth and motors are rotated. The rotation of motors is controlled by changing the signals from the application. That is each button sends different signals to the Arduino.

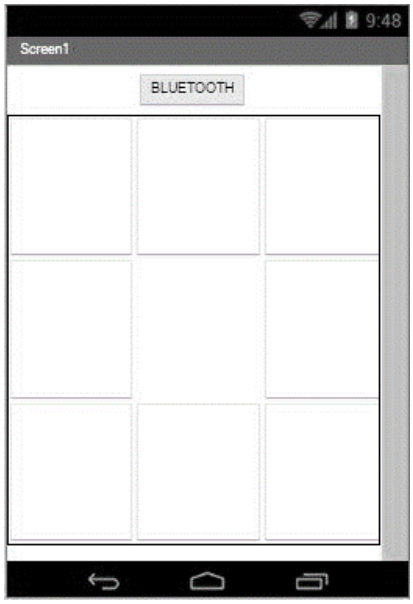

Figure 8. The primary version of the app.

As shown in Figure 9, in the second app that we made, the switches are converted to a single circle. The app can send the signals when the user swipes his/her finger over the circle. Instead of pressing switches we are swiping on the screen and whenever the user removes his/her finger from the screen the motors will stop. The user can vary between using a single finger or hand gesture depending on their strength to control the wheelchair as shown in Figure 10.

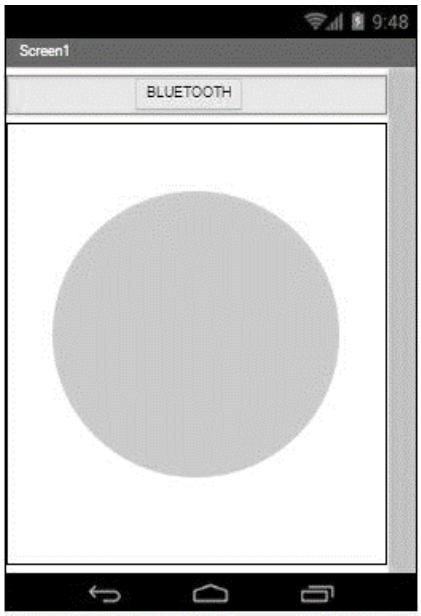

Figure 9. The latest version of the app.

Figure 10.1

Figure 10.2

Figure 10. Prototype used.

Later the app was changed in a way that it enables the user to choose the speed of the motors. We tested our prototype using different smart devices. Pairing time, the time taken for the smart device to connect with the Bluetooth module is calculated 100 times and the average for different devices is shown in the Table1. We have checked motion in each direction 100 times and it gave and 98% success rate for the forward direction. In the reverse direction, it was 100% and in right it was 99% and left it was 98%. Thus from this, it gave a result of nearly 99%.

We also noted down the time taken for the system to react to the command given by the user as shown in table2. The prototype showed a varied response time for different directions.

TABLE I. PAIRING TIME (AVERAGE OF 100 READINGS)

	Android devices		
	Mobile 1	***Mobile2***	***Tablet***
Pairing time (sec)	2.02	2.2	2.05

TABLE II. RESPONSE TIME (AVERAGE OF 100 READINGS)

Response time (milliseconds)	**Android devices**		
	Mobile 1	***Mobile2***	***Tablet***
Forward	28.33	28.67	27.33
Backward	38.66	38	34
Left	38.33	25.5	38
Right	30	22.50	33

V.CONCLUSION

Thus, an effective wireless controlled wheelchair is developed for the differently abled which does not take much effort to operate and uses immensely popular Android platform. The open platform also allows further developments. The system can be programmed to be controlled by palm movements rather than fingers. It can be made to auto navigate or use google maps to move between pre-calibrated positions.

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