ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

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www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN 2454-9940

www.ijasem.org

Vol 17, Issue 3, 2023

https://zenodo.org/records/14505555

A Case Study on the Electronic Wheelchair Control Capability of a Smartphone with a Speaker-Independent Recognition Engine

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Abstract—*A voice commanded electronic-wheelchair controlling system was constructed to be controlled remotely by voice commands, which consisted of three parts: a smart phone, a wheelchair controlling module and two brushless motors. The smart phone was programmed with a Google's speaker independent recognition engine and a google map, which can be used as a remote controller for seven voice commands: left, right, forward, backward, faster, slower, stop. Those commands were used with a word "command" to increase the recognition accuracy. Information of the location and the moved distance of the chair were shown on the google map. The command recognition time of the smart phone for each one of the seven commands was measured by changing of the number of several voice commands. The recognition time for each one of the seven commands were measured. A wheelchair controlling module was built on the electric circuit board with a ATMEGA's 89C2081 microcontroller. And the response time between the phone and the wheelchair control module was measured. Even though it was convenient to use voice commands for some functions, the voice recognizing engine had caused a lot of errors and stability problems in recognizing voice commands.*

Index Terms— android program application, Bluetooth communication, electrical wheelchair, remote smart phone controller, remote voice controller I.

INTRODUCTION

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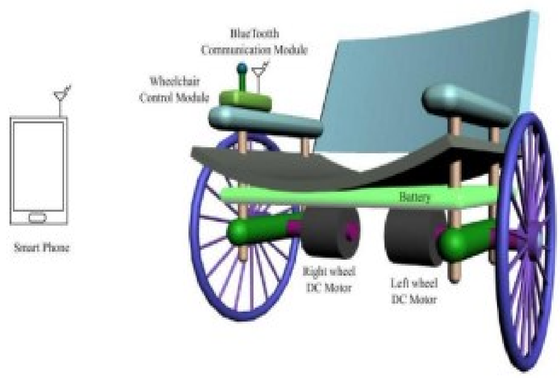
BODY OF PAPER

In this paper, an electronic wheelchair controlling system was developed and controlled by several voice commands. And, a microcontroller was used in building the wheelchair controlling module. The voice recognition time of the smart phone was measured for a number of voice commands. To make simple, only seven commands were used to control the wheel chair: left, right, forward, backward, slower, faster, and stop. These commands were used with a word "command" to avoid unwanted operation by accidental response to normal conversation, because sometimes unwanted spoken word causes the chair operated to the just normal conversation instead of the commands. Fig. 1 shows an electronic wheelchair using a smart phone as a voice controller. The chair was equipped with a wheelchair controlling module, a battery, a right wheel DC motor, a left wheel DC motor, and a manually controlling joystick. The communication specification between the Smart phone and the wheelchair control module was in 9600 bps Bluetooth communication.



ISSN 2454-9940
www.ijasem.org
Vol 17, Issue 3, 2023
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Fig. 1. An electronic wheelchair using a smart phone as a voice controller.

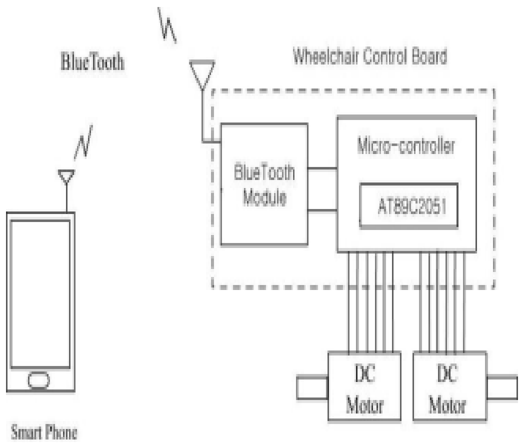

Fig. 2. Detailed system connection of a wheel chair controlling module and a smart phone remote controller.

The smart phone was used as a remote voice controller along with a manually controlling joystick installed on the arm of the chair. After receiving voice commands for the wheelchair, the phone sent the controlling signal to the wheel chair control module. The phone showed the information of the location and the moved trace of the chair on the Google map.

Fig. 2 shows the detailed system connection of a wheelchair controlling board and a smart phone remote controller. The control board consisted of a Bluetooth module and a Micro-controller. The board was built on an electric circuit board with AT89C2051 microcontroller. As for the motors of the wheel chair in experiment, two DC motors made by CARELINE, model number EC82L245545CLGBR, were used. The DC motor was a DC 24 Voltage driven, and had the rotation of 5,500 rpm. According to the command signals received from the smart phone, the controller board emitted two fairs of electric voltages to the motors. Each motor was operated by the controller voltage.

Fig. 3 shows the screen of a smart phone including a Google map as a background image. The map showed the information of the location and the moved trace of the chair on the Google map. And the phone drew the map around the area of the phone location. By checking the battery status, it

Fig. 3. The screen of a smart phone with a Google map.

drew a circle at the center of the location which is the possible traveling distance with the current battery charge. Fig. 4 shows the diagram of the program blocks of the constructed system. The remote controller smart phone was a Samsung's Galaxy of which model Number was SHW-M130K. The android build number was Gingerbread, and Firmware version 2.3.6. After the program of the smart phone started, the phone was connected in Bluetooth to the communication program of the wheelchair control board. Then, the smart phone program waited for a voice command. When a voice command was announced, the phone sent the chair control board a control signal which was included in a protocol. The command decoding program of the control board retrieved the command from the protocol after performing CRC error check and command decoding process. The motor control board including an AT89C2051 microprocessor outputted the control voltage to a selected motor, and sent back to the smart phone an "ACK" protocol for receiving the command successfully.

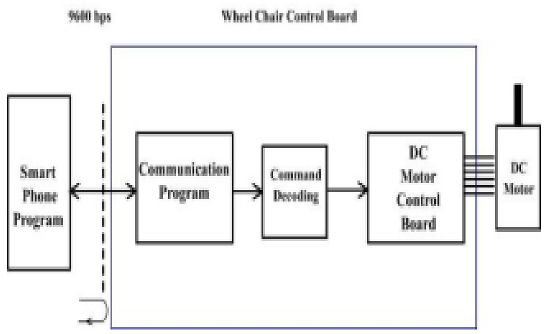

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Fig. 4. Diagram of the program blocks of the constructed system.

Protocol Start	Portocol Type	Receiver Address	DATA	Check Sum

Fig. 5. The structure of a communication protocol.

The smart phone and the wheelchair control board were communicating in the Polling process, so there were two kinds of stations, a primary one and a secondary one. The smart phone was the primary station and the control board the secondary. The smart phone broadcasted in half duplex the “Ready to receive” protocol, and awaited the “ACK (acknowledgement)” protocol from the board as the same as the Stop-and-Wait process. The RTR protocol contained the control signal of the voice command. When there was a voice command, the smart phone program sent the “Ready to receive” protocol with the wheel chair control signal corresponding to the command. Then, the program checked the ACK protocol from the wheelchair control board for the successful communication. The response delay time of this polling process between the smart phone and the control board was measured to be about 100 milliseconds. Fig. 5 shows the structure of the protocol for the communication between the phone and the control board.

The protocol consisted of characters in 8 bits. It begins with “STF:” characters which mean the start of the protocol, following is “RTR:” characters for "ready to receive", an “ADDR” character for the receive-side PLC address, a "DATA" character for the port 0’s output data of the ATMEL microprocessor, and "CS" as the check sum for some error detection. Therefore, the "Ready to receive" frame was as follows "Ready to receive" frame:

"STF" +":"+ "RTR" + ":" + "ADDR" + ":" + "DATA"+ ":" + "CS"

Here,

“STF” : 3Bytes for a frame start,

“RTR” : 3 Bytes for the Ready-to-receive,

“:” : 1 Byte for data separator,

“ADDR” : 1 Byte for the receiver PLC address,

“DATA” : 1 Byte for the data of the port 0,

“CS” : 1 Byte for the check sum.

The responding ACK protocol had the same structure as the "Ready to receive", except using “ACK” instead of “RTR”.

Therefore, the "ACK” protocol was as follows;

"STF" +":"+ "ACK" + ":" + "ADDR" + ":" + "DATA"+ ":" + "CS"

The "DATA" part consisted of two nibbles. The first one was for the output control signal and the last one for the input of the devices’ statuses if available. The microprocessor's two ports (P0.4, P0.5) was used as outputs for the DC motor control signal. Table-I shows the output port's Data. The “on” state of the port P0.4 was 1110(&HE) in the first part of the byte of "DATA”, the “on” state of the P0.5 was 1011(&HB). The connection of the receive-side AT89C2051 ports was as follows, Port of the microcontroller Electric Wheelchair Motors AT89C2051

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P0.4	Left Motor
P0.5	Right Motor

TABLE I
OUTPUT PORT'S DATA

Receive-side PLC address	"DATA" part of the protocol: Check Sum	output port
0x01	0xEF:0x43	P0.4 On
0x01	0x7F:0xB3	P0.5 On

The response time of the loopback test, which is between the smart phone and the wheelchair control board, was measured.

CONCLUSION

In this paper, a voice controlling electronic wheelchair system was constructed with the Google voice recognition technology and controlled remotely with an android smart phone. The system consisted of a smart phone, a wheelchair controlling module, and step motors. The smart phone was programmed in Android to recognize seven voice commands, and to send the proper signal to the wheelchair control module in Bluetooth communication of 9600 bps data rate. The wheelchair control module was built on an electrical circuit board with ATMEGA 89C2051 microprocessor.

The smart phone was programmed to show all the information of the location and the travelled trace on the screen. As a remote-control smart phone, Samsung Galaxy SHW-M130K model was used. And an android program was developed on the Gingerbread version for the phone to be used as a remote monitoring and controlling device. And, system test was conducted by measuring the response time of all over the system in 9600 bps Bluetooth communication between the phone and the wheelchair control module. The recognition time of the smart phone was quite difficult to measure and varied unreliable. Even though it was convenient to use voice command for some functions, the voice recognizing engine had caused a lot of errors and stability problems in recognizing voice commands.

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