

Voice and Gesture Controlled D.C. Motor Fan's Rotational Speed and Direction

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ABSTRACT

Physically challenged people in Kenya and the rest of the developing countries in the world; encounter difficulties, when controlling most of the motor driven devices in industries and domestic areas of work. In this research paper, a system that utilizes voice and gesture commands to control the rotational speed and direction of a d.c. (direct current) motor fan is developed. Arduino board is used for providing a link and developing the system hardware parts. The software part is accomplished in Arduino IDE (Integrated Development Environment) using embedded C language. Hardware is then carefully constructed and software porting is done successfully. Outcomes obtained after actual implementation and testing showed that through the use of voice and hand gesture commands speed and direction of a d.c. motor fan can easily be manipulated.

Keywords: d.c. motor fan, microcontroller, sensor, wireless communication technology.

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1. INTRODUCTION

1.1. Background of the Study

The world today is rapidly changing in terms of technological advancements. Developing countries in Africa and other third world countries in the world are also gradually embracing new changes in technological developments. Nowadays, various electronic devices have been developed and many of them are operated by the use of microcontrollers, electronic sensors, and smartphones among other devices. For instance, with the increasingly widespread applications of microcontrollers, sensors, and smartphones, various efforts for designing and developing microcontroller based systems and devices have been made: [1]–[21].

Similarly, electric fans are equally important devices that can help in making life more comfortable. They can be used in air conditioning areas, regulating room temperature and concentration of gases, among other uses. Their usage can be applied in domestic, factory, and industrial areas. For that reason, the mechanism of controlling them, especially their rotational speed and direction is an important concern.

Generally, the speed of a d.c motor fan is given by (1) below;

$$N = k \left(\frac{V - I_a R_a}{\phi} \right) \text{r.p.m.}, \quad (1)$$

where N is the speed in rate per minute (rpm) and K is a constant equal to A/PZ . A is the number of parallel paths through the armature, P is the number of poles whereas Z is the number of conductors in the armature. V , R_a , I_a , and ϕ are: terminal voltage, armature resistance, armature current, and useful flux per pole respectively.

There are various ways in which the speed and direction of a d.c. motor fan can be controlled. They include the application of traditional methods such as the flux control method, adjustment of resistance connected to the armature circuit, and adjustment of armature terminal voltage, and some modern methods such as application of room temperature conditions and pulse width modulation techniques.

1.2. Statement of the Problem

The use of traditional methods in controlling the speed of a d.c. motor fan requires a skilled and physically fit operator. Moreover, the speed of the temperature controlled d.c. motor fan can be regulated depending on room temperature conditions. For this reason, physically challenged people find it difficult to operate d.c. motor fan devices whose rotational speed and direction are controlled by application of the mentioned methods.



2. LITERATURE REVIEW

Traditionally, the speed of a d.c. motor fan can be controlled by applying the following methods: flux control, adjustment of resistance connected to the armature circuit, and adjustment of the armature terminal voltage (pulse width modulation). With the flux control method, the shunt field current and hence the speed of the d.c motor fan can be adjusted by connecting a variable resistance in series with the shunt field.

The armature circuit resistance method for controlling the speed of a d.c. motor fan is achieved by connecting an external series resistance in the armature circuit whereas armature terminal voltage control method is achieved by using a power electronic inverter system like a H-bridge inverter. This method takes advantage of the fact that since the voltage drop across armature resistance is quite small, then a change in armature terminal voltage of a shunt motor will be accompanied by a proportional equal change in speed of the d.c motor fan (direct current motor fan).

However, in the modern era and with developments in technology, more advanced ways of controlling the rotational speed and direction of the d.c. motor fan have been invented.

There are various recent efforts that have been made as far as controlling the rotational speed and direction of the d.c motor fans is concerned: [22]–[31]. Pulse width modulation technique has also been applied in designing the speed and direction control of a d.c. motor fan and accordingly, some efforts have been made over the same; [32], [33].

In this research paper, however, an electric d.c. motor fan that can be operated by use of voice and gesture commands is developed. With the system, fans can be put on and off and their rotational speed and direction can also be controlled using voice and gesture commands. Voice and gestures are wireless communication technologies employed in this article and they are intended not only to provide convenience to the users but also to give an opportunity to those who are physically challenged to easily operate and run the system. For instance, Voice as an essential communication component part of this project helps those who are physically challenged to operate the system using their speech.

Interestingly again, the gesture technology applied in this project provides an opportunity for those who are physically challenged to easily run the system both in domestic and industrial areas and wherever it can be applied through by use of their hand gesture signs.

3. METHODOLOGY

3.1. Construction Requirements

The following parts are necessary for the construction of the system:

3.1.1. Arduino UNO Microcontroller

It is a single-board computer. It has fourteen digital input/output pins, six analog inputs, sixteen Megahertz (MHZ) ceramic resonators, Universal Serial Bus (USB) connection, In-Circuit Serial Programming (ICSP) header,

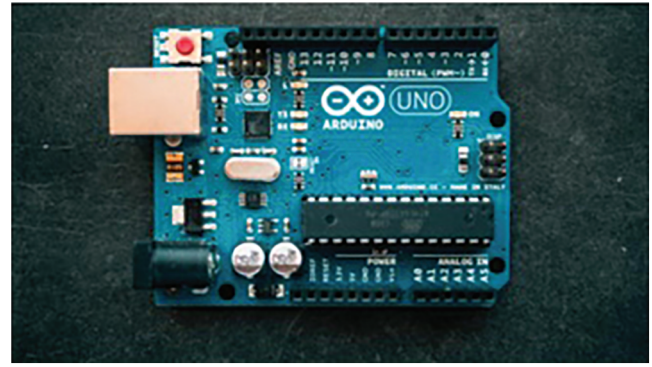


Fig. 1. Arduino UNO microcontroller.

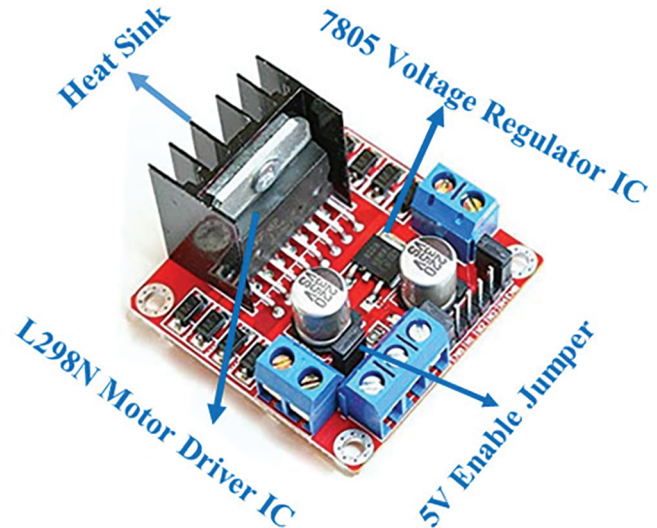


Fig. 2. L298N motor driver.

a power jack, and a reset button. It can simply be linked with a USB cable to a laptop. To start it, it must first be powered through an Alternating Current (AC) to Direct Current (DC) adapter or a battery. The Integrated Development Environment (IDE) of the microcontroller is Java written application that is able to compile and upload programs with a single click to the board.

The diagram of Arduino is shown in Fig. 1.

3.1.2. Motor Driver

It is one of the important parts of the fabrication of the project. It controls the rotation of d.c. motors to where the fans are attached thus also controlling the rotation of the fans. The operational voltage of L298N bridge motor driver used in this project ranges between 5–35 V. Fig. 2 shows the diagram of L298N motor driver.

3.1.3. Gesture Sensor

It captures signs and transmits them to the microcontroller in a text form for further processing.

Accordingly, its diagram is shown in Fig. 3 below.

3.1.4. D.C Motor

It is an electrical machine that converts electrical energy into kinetic energy. Motors are basic components that can be found in most home and industrial appliances. Real examples where applications include motors are automobiles, electric fans, refrigerators, food blenders,

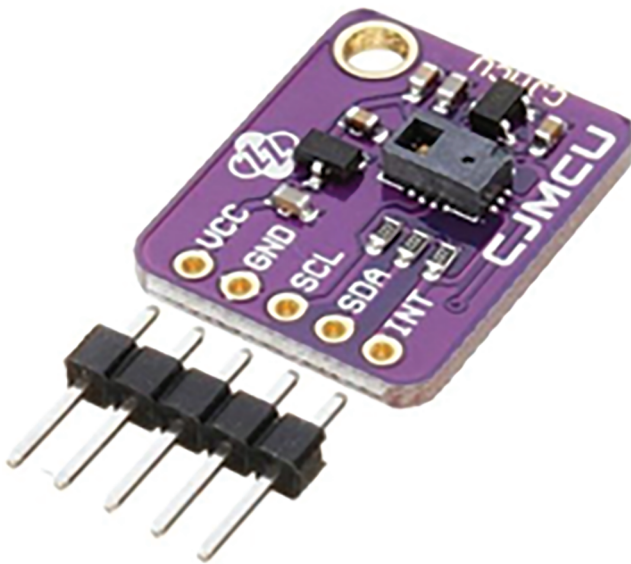


Fig. 3. PAJ7620 gesture sensor.

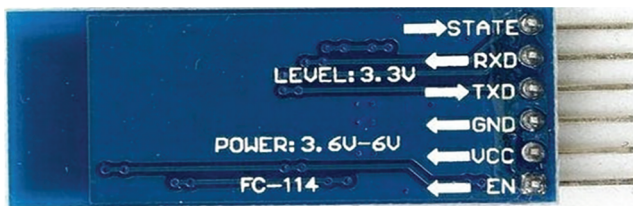


Fig. 4. HC-05 Bluetooth module.

hydroelectric generators, water pumps, and many more. For demonstration purposes, this system uses d.c motors of the Digital Video Disc (DVD) player, with 1.5–12 V range and 2750 rpm.

3.1.5. Bluetooth Sensor

It is connected to the microcontroller and its function is to receive the voice commands in the form of a text from the transmitter component before sending them to the microcontroller for further processing. Currently, we have HC 05 and HC 06 Bluetooth modules. This system uses HC 05 Bluetooth module and its diagram is shown in Fig. 4.

3.1.6. Power Source

The Arduino Uno microcontroller requires to be powered with a 12 v d.c battery for it to work efficiently. However, an AC to DC power adapter with voltage ranges between 1.5–12 V can also be used.

3.2. Implementation

The following are steps for implementing the project;

Carefully connect various components of the system like the motor driver, motors fans, Bluetooth module, gesture sensor, and Liquid Crystal Display (L.C.D) among other parts to the Arduino microcontroller as shown in Fig. 5. Fig. 6 shows, a block diagram representation of the system whereas Fig. 7 shows a detailed circuit diagram of the system.

Connect Arduino microcontroller to a power source and upload the voice code program of the project into

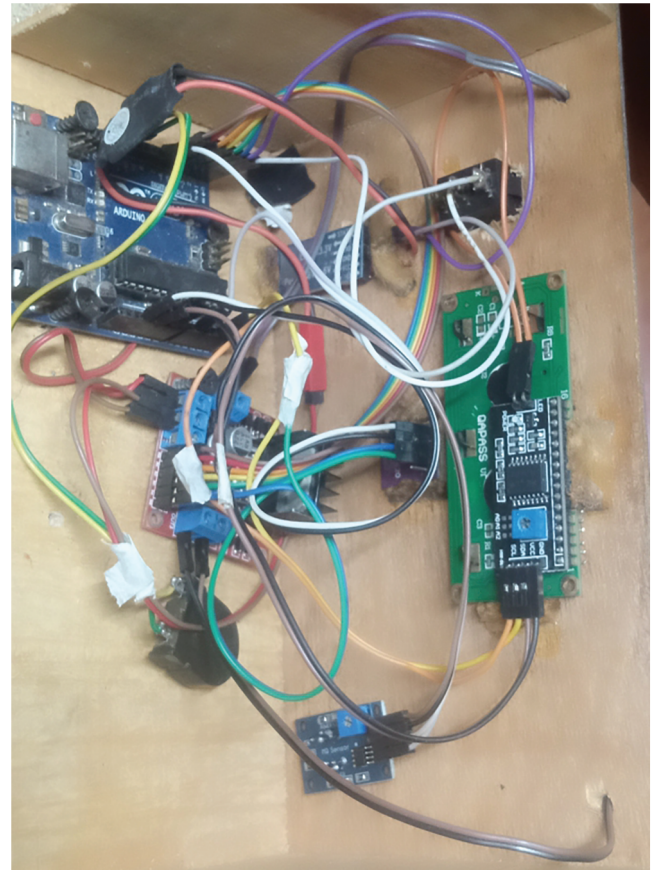


Fig. 5. Arduino microcontroller and other parts of the system.

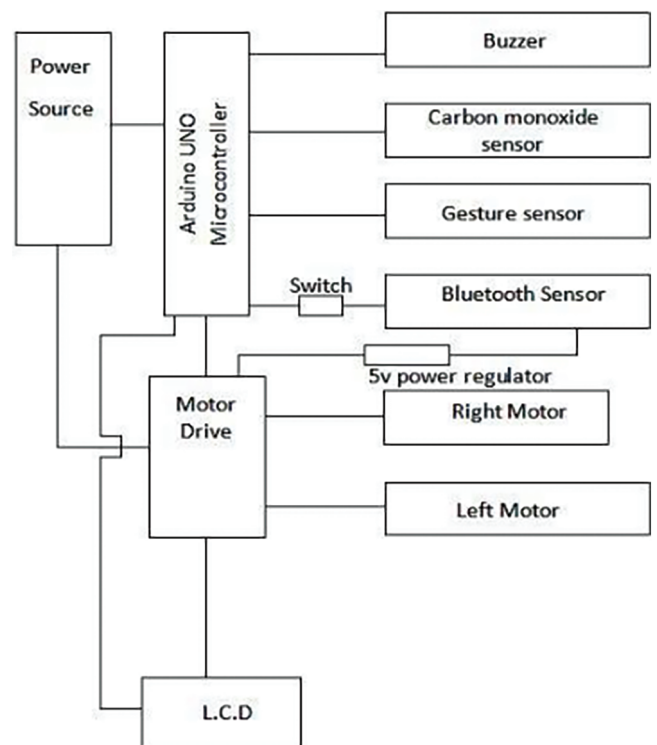


Fig. 6. Block diagram representation of the system.

the microcontroller. Download Arduino Bluetooth control application from google play store and make sure HC-05 has been paired to your smartphone using a password “1234”. HC-05 is a Bluetooth Serial Port Protocol (SSP)

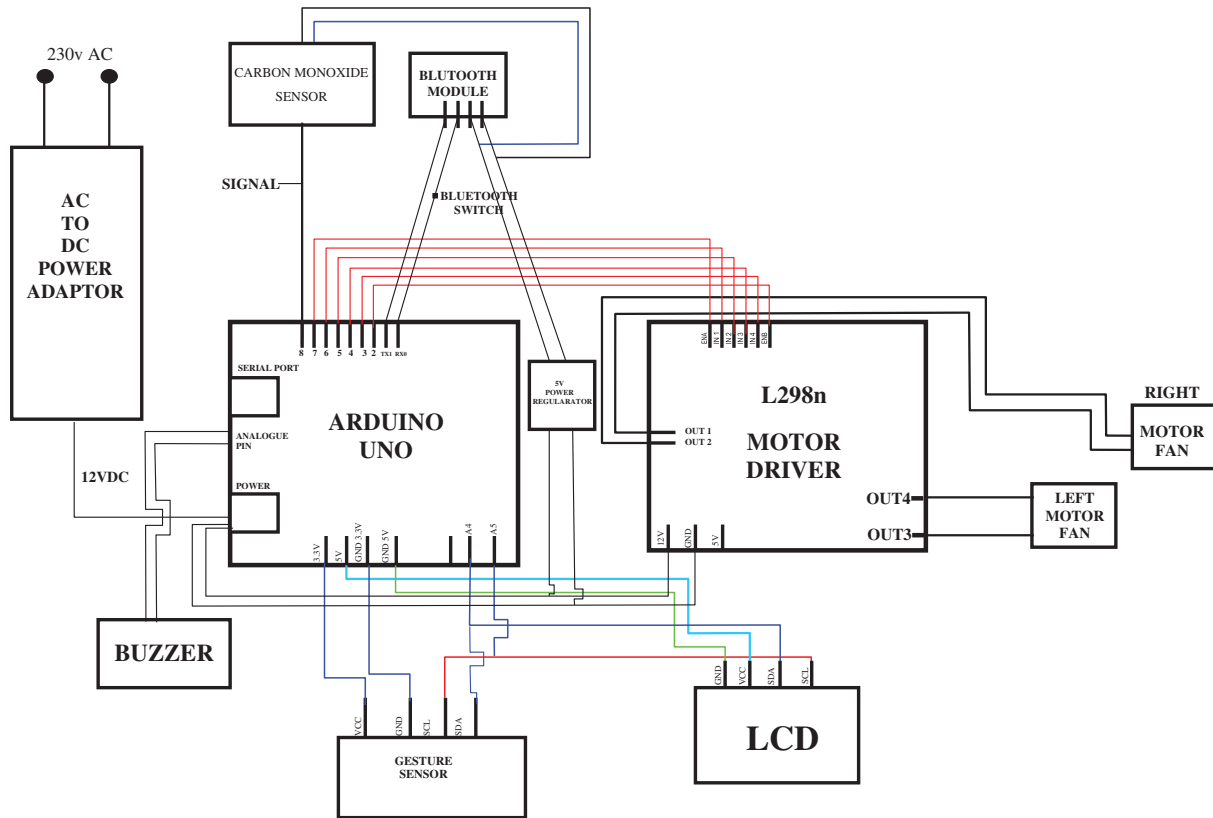


Fig. 7. Circuit diagram of the system.

which means it can communicate serially with Arduino Uno. On clicking the voice Bluetooth control application, one will be directed to articulate a certain command for running motors or a particular motor in the system.

The following voice commands are used in running of motors in the system:

Turn right on,
Turn right off,
Turn all devices on,
Intervals,
Turn left on,
Turn left off,
Turn all devices off,
Devices quick,
Devices down,
Clockwise,
Anticlockwise.

On speaking any of the listed commands above, there will be an effect on the rotational speed of the d.c. motor fan(s). The outcome is discussed in the results section of this paper.

Now turn on the gesture part by uploading its program code and disconnecting the voice part using the Bluetooth serial switch. Bring the hand closer to the gesture sensor and move it to the right direction and then to the left direction over the sensor. Again raise your hand up over the sensor and observe its effect on the rotation of the motors. Move the fingers of your hand in a clockwise direction and then anticlockwise direction, over the sensor and observe its effect on the rotation of the fans. You can also press the hand forward directly towards the sensor and then withdraw it backwards and carefully observe the changes

to the rotational speed of the motors. Finally, lower your hand down while being closer to the sensor.

4. RESULTS

On connecting various components and doing proper wiring on them, the project was found to be working as expected thereby controlling the rotational speed and direction of the D.C. motor fans.

As already mentioned, the system uses voice and gesture technologies in its operation. When applying voice commands, the spoken command gets converted into text through a speech-to-text converter application installed in the Android software before being sent to the microcontroller for further processing through Bluetooth connectivity. After the text has been received by the microcontroller, it controls the rotation of d.c. motor fan accordingly.

On the other hand, when applying gesture commands, a hand sign gets captured and processed into text form by the gesture sensor. It is then sent to the microcontroller for further processing. The microcontroller again controls the rotation of the d.c. motor fan accordingly. Arduino program code usually called a sketch, for executing the commands associated with each of the mentioned technologies, has to be uploaded first into the microcontroller.

For the case of the voice component of this system, on articulating the command “turn left on” the left motor starts rotating with a speed of say 200 pwm (pulse width modulation) frequency. On the other hand, when one speaks the command “turn right on”, the right motor fan immediately starts rotating with a maximum speed of

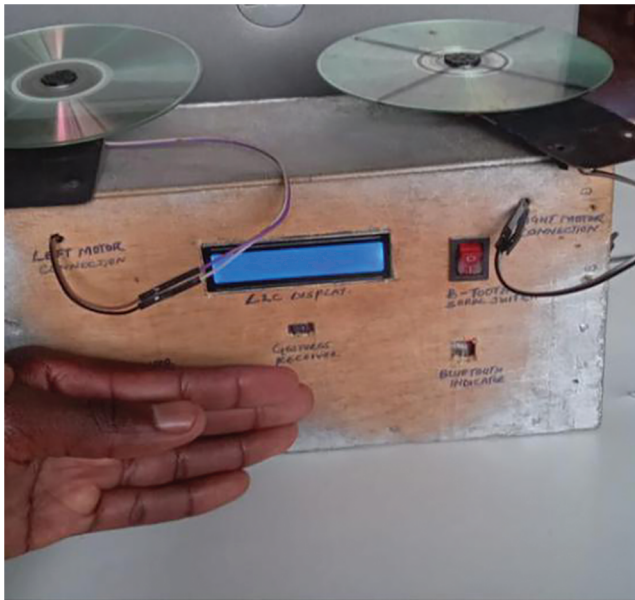


Fig. 8. Hand gesture results.

255 pwm frequency, thereby putting off the rotation of the left motor fan. The commands “turn right off” and “turn left off” put off right and left motor fans respectively.

The command “turn all devices on” puts on right and left motor fans simultaneously and sets them rotating at 200 pwm frequency; whereas, articulation of the command “turn all devices off” put off the rotation of right and left motor fans simultaneously. Articulation of the command “devices quick” makes left and right motor fans rotate with a maximum speed of 255 pwm frequency; whereas, speaking the command “devices down” reduces the rotational speed of right and left motor fans to 150 pwm frequency. Articulation of the command “intervals” makes right and left motor fans rotate with an interval speed of 160 pwm frequency.

The command “clockwise” makes left and right motor fans rotate in a clockwise direction with a speed of 250 pwm and 200 pwm frequencies respectively, whilst speaking of the command “anticlockwise” left and right motor fans rotate in an anticlockwise direction with a speed of 200 pwm and 250 pwm frequencies, respectively.

On the other hand, in the case of the gesture component of this system, when a hand is moved towards the right direction over the gesture sensor, the right motor fan starts rotating with a speed of say 155 pwm frequency and when it is moved towards left direction over the sensor, the left motor fan immediately starts rotating with a speed of say 200 pwm frequency, thereby putting off the rotation of the right motor fan.

When the hand is pressed forward directly towards the sensor, right and left motor fans rotate with an increased maximum speed of 255 pwm frequency and when it is withdrawn backward directly away from the sensor, motor fans rotate with a relatively low speed of 155 pwm frequency. Moving the fingers of a hand in a clockwise direction over the sensor, makes right and left motor fans rotate in a clockwise direction with a speed of 255 pwm and 150 pwm frequencies respectively, whereas, moving them in an anticlockwise direction makes right and left motors

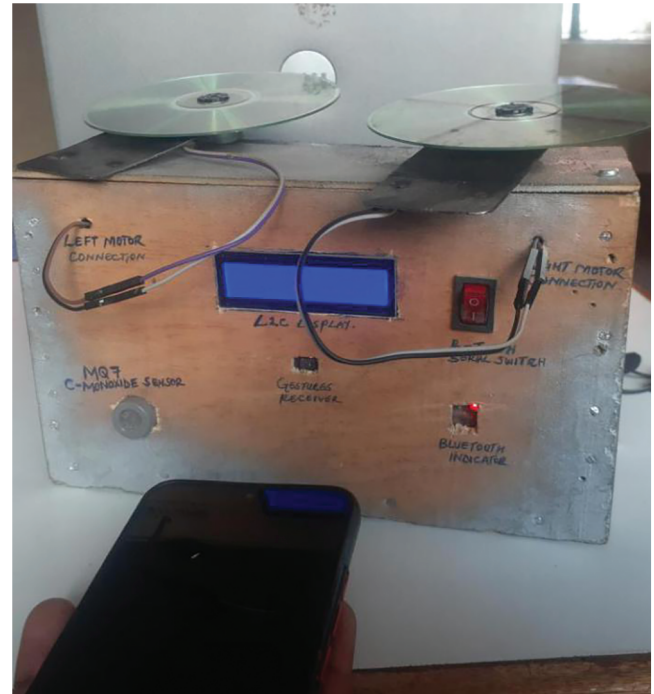


Fig. 9. Motor fans controlled by voice commands spoken through an android device.

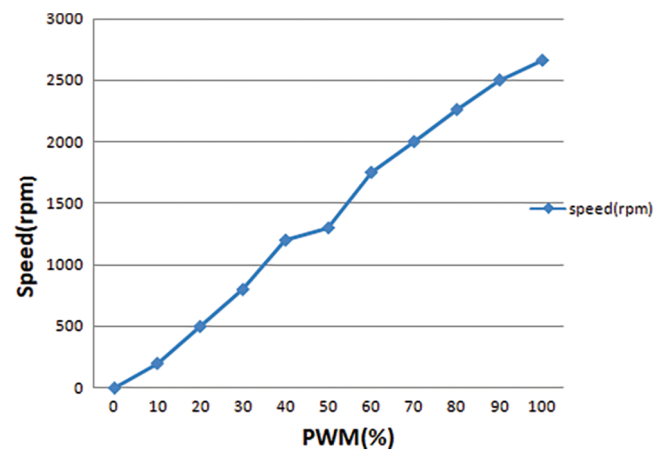


Fig. 10. Sketch of graph when rpm of motor used is plotted against pwm (%).

to rotate in an anticlockwise direction with a speed of 150 pwm and 255 pwm frequencies, respectively.

Raising the hand while being closer to the sensor puts on all motors simultaneously and sets them revolving at a speed of 255 pwm frequency, whereas, lowering it down while still being closer to the sensor, simultaneously puts off the rotation of all motor fans instantly. Figs. 8 and 9 show the results of using hand gesture and voice commands respectively to control the speed and rotational direction of a d.c. motor fan.

It is worth important to note that, in this research article, maximum and minimum speeds are set at 255 pwm and 150 pwm frequencies respectively. For a motor fan running with a relatively higher pwm, its rate per minute is higher than the one rotating with a relatively lower pwm. As part of the results obtained, Fig. 10 is a sketch of the graph when rpm is plotted against the applied commands and pwm frequencies. For instance the command “devices down”, makes the right and left motor fans rotate with

an approximate speed of 1618 rpm where the duty cycle is 59%, whereas moving the hand towards the left direction over the gesture sensor, makes left the motor to run with an approximate speed of 2156 rpm where the duty cycle is 78%. A digital tachometer was used to measure rpm of the motors.

5. CONCLUSIONS

By using voice and hand gesture commands one can easily control the speed and direction of a d.c. electric fan conveniently and wirelessly.

The system can help those people who are physically challenged and are working in domestic areas or in industries. By use of their voices or hand gestures, they will be able to control rotational speed and direction of the d.c. motor fans when used in regulating environmental or workshop room conditions such as concentration of hot exhaust gases, smoke and dust particles, and even room temperature conditions.

Apart from the d.c. motor fan, more electronic devices that can be operated and controlled by voice and gesture commands are in the process of being discovered.

Despite, a few challenges like reliability to a stable power supply, the system proved to be effective in its operation. Once stabilized, the system does not have any delays and thus it reduces the computational time involved in its operation. Suggestions for further improvements to the system where possible, may also be made in the future.

DECLARATION OF COMPETING INTEREST

The authors declare no conflict of interest.

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