Performance Analysis of Speed Control System using Voice Command and Ultra Sonic Sensor Based Approaches

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***Abstract*—This paper represents an experimental comparison of controlling the speed of the DC motor using voice commands and ultrasonic sensor-based control. The aim of the experiment was to compare the performance of both control methods in terms of speed control, distance measurement, and precision. An Arduino microcontroller, a DC motor, a microphone, and an ultrasonic sensor were used in the experiment. The Arduino was programmed to recognize certain keywords from the voice commands and adjust the speed of DC motor accordingly, in the case of voice command-based control. Regarding the ultrasonic sensor-based control, the Arduino was programmed to gauge the distance to an object using the ultrasonic sensor, and then modify the speed of the DC motor accordingly. The outcomes demonstrated that although both control methods could handle the DC motor's velocity, the ultrasonic sensor-based control performed better in terms of precision and distance measurement. However, the voice command-based control had the advantage of being more user-friendly and intuitive. The paper includes a detailed comparison of the performance of voice command-based control and ultrasonic sensor-based controlling of speed control of DC motor. It highlights the advantages and disadvantages of each method, and it can be used as a reference for selecting the appropriate control method for a specific application.**

Keywords: DC motor, ultrasonic sensor, Arduino, Microphone, speed control

I. INTRODUCTION

Controlling speed of a DC motor is a crucial aspect in various applications such as robotics, automation, and mechatronics. The ability to control the speed of a DC motor allows for fine-tuned adjustments in the operation of a device or system, which can improve efficiency, accuracy, and overall performance[1]. There are various methods to control the speed of a DC motor, including traditional methods such as potentiometer-based control and more advanced methods such as digital control using microcontrollers. In this work,the focus is given on two modern control methods: speed control of a DC motor by voice command and speed control of a DC motor by ultrasonic sensor-based control.

Both voice command and ultrasonic sensor-based control are relatively new methods of speed control that offer unique advantages over traditional methods. Voice command-based control allows for hands-free operation and control using natural language commands. This can be particularly useful in situations where manual control is difficult or dangerous, such as in industrial settings[2]. Ultrasonic sensor-based control, on the other hand, uses a physical sensor to measure the distance to an object and adjust the speed of the motor accordingly. This can be useful in applications that require precise distance measurement, such as in robotics and automation[3].

This paper starts with an overview of the technical principles involved in both voice command and ultrasonic sensor-based controlling speed of DC motors. Then compares the performance of both control methods using an Arduino microcontroller, a DC motor, a microphone, and an ultrasonic sensor. The experiment measure the speed of the DC motor using a tachometer and collect data for analysis. Later the paper discusses the advantages and disadvantages of each control method and provides a comparison of the performance of both methods.

Finally, the paper conclude with a discussion on the potential applications of both voice command and ultrasonic sensor-based controlling for speed of DC motors. The future possibilities of these control methods and how they may be used in conjunction with other advanced technologies to improve the performance of DC motor-based systems has also been discussed. The goal of this work is to provide a comprehensive understanding of the capabilities and limitations of both voice command and ultrasonic sensor-based control for speed control of DC motors, and to help readers make informed decisions when choosing a control method for their specific application.

II. System Description

The speed control system using a microcontroller, motor driver, and sensor is an effective and low-cost solution for regulating the speed of a motor. This system is highly adaptable and can be tailored and expanded to fulfill various demands, rendering it a versatile instrument for automation and control objectives. The sensor provides the input to the microcontroller [4]. The microcontroller is the brain of the system, which reads the sensed signal, calculates the motor speed, and generates a control signal for the motor driver. The motor driver is used to control the speed of the motor. A Pulse Width Modulation (PWM) based motor driver is used in this project, which can vary the duty cycle of the control signal to regulate the speed of the motor [5].

Fig.1. represents the block diagram representation of the system.

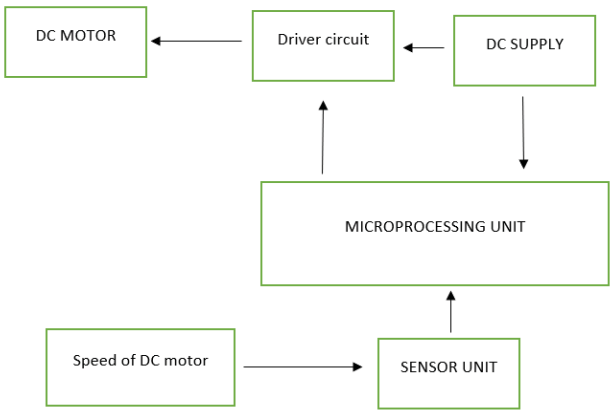

Fig. 1. Block diagram

III. Methodology

The experiment to compare the speed control of a DC motor by voice command and ultrasonic sensor-based control was conducted using an Arduino microcontroller, a DC motor, a microphone, and an ultrasonic sensor. The following is a detailed description of the methodology used in the experiment.

A. Hardware:

DC motor: A small-sized DC motor was used in the experiment. The voltage and current ratings of the motor were 12V and 0.5A, respectively.

Arduino microcontroller: An Arduino Uno was used as the microcontroller for the experiment. It was programmed using the Arduino IDE.

Microphone: A standard electret microphone was used to capture voice commands.

Ultrasonic sensor: A HC-SR04 ultrasonic sensor was used to measure the distance to an object.

Tachometer: A digital tachometer was used to measure the speed of the DC motor.

Bluetooth module

B. Software:

Voice recognition library: The Arduino Voice Recognition library was used to process the voice commands.

Ultrasonic sensor library: The New Ping library was used to interface with the ultrasonic sensor.

C. Experimental setup:

Voice command-based control: The microphone was connected to the Arduino and the Voice Recognition library was used to process the voice commands. The Arduino was programmed to recognize certain keywords, such as "increase speed" and "decrease speed" and adjust the speed of the DC motor accordingly.

Ultrasonic sensor-based control: The ultrasonic sensor was connected to the Arduino and the New Ping library was used to interface with the sensor. The Arduino was programmed to measure the distance to an object and adjust the speed of the DC motor accordingly.

D. Data collection:

The speed of the DC motor was measured using the tachometer and recorded for analysis.

The distance to an object was measured using the ultrasonic sensor and recorded for analysis.

E. Data analysis:

The collected data was analyzed to compare the performance of both control methods. The data was analyzed for the following parameters: speed of the DC motor, distance to an object, and precision of control.

To reduce the impact of external factors on the outcome, the experiment was carried out under controlled conditions. The speed of the DC motor was varied by adjusting the voltage applied to the motor using the Arduino PWM output pins. The voltage was varied from 0V to 12V in increments of 2V, and the speed of the motor was measured at each voltage level. The experiment was repeated for both voice command and ultrasonic sensor-based control to gather data for comparison.

The above methodology allowed to compare the performance of voice command-based control and ultrasonic sensor-based control in terms of speed control of DC motor, and it also helped to understand the advantages and disadvantages of each method.

IV. Controlling Speed Using Ultrasonic Sensor

When controlling a motor's speed with an ultrasonic sensor, the distance between the sensor and an object is measured with the sensor, and the result is used to change the motor's speed.

Ultrasonic signal from the sensor are sent out, reflected by the object, and then returned to the sensor. Using the time it takes for the pulses to return, the sensor can then determine how far away the object is. The motor's speed can then be managed using this distance measurement, for instance by modifying the voltage or PWM signal sent to the motor.

A. Working principle

The ultrasonic sensor sends out a series of ultrasonic(sound) waves, which bounce off of an object and return to the sensor. The Arduino board receives the distance measurement from the sensor and uses it to calculate the desired motor speed. The Arduino board then uses PWM

(pulse-width modulation) to control the speed of the motor. PWM involves rapidly switching the power to the motor on and off, with the duty cycle (the proportion of time that the power is on) determining the average power delivered to the motor and hence its speed. The distance measurement from the sensor is continuously monitored, and the motor speed is adjusted accordingly. The Arduino board uses a control algorithm to adjust the duty cycle of the PWM signal applied to the motor in order to control the speed of the motor. The sensor, Arduino board and the motor are connected to each other. The sensor sends the distance measurement to the Arduino board which process it and give the command to the motor. The motor speed is adjusted according to the command given by the Arduino board.

B. *Flow chart to analyse stepwise algorithm*

The Arduino board, ultrasonic sensor, and motor driver are initialized and calibrated. The ultrasonic sensor continuously measures the distance to an object. The Arduino board uses the distance measurement to calculate the desired speed of the motor. The Arduino board uses PWM to control the speed of the motor based on the calculated speed. If the ultrasonic sensor detects an obstacle, the Arduino board adjusts the motor speed to avoid it. The Arduino board continuously monitors the distance measurement and the motor speed and adjusts as necessary to ensure that the motor is operating at the desired speed. It shows the distance measurement and the current speed of the motor on the LCD. The flowchart is shown in Fig.2.

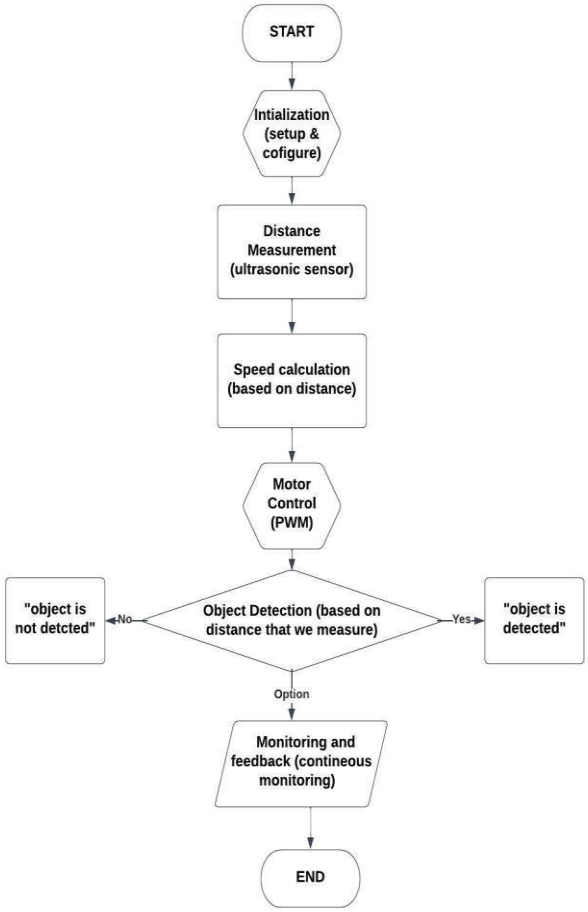

Fig. 2. Flow chart for speed control using ultra sonic sensor.

C. *Hardware set up*

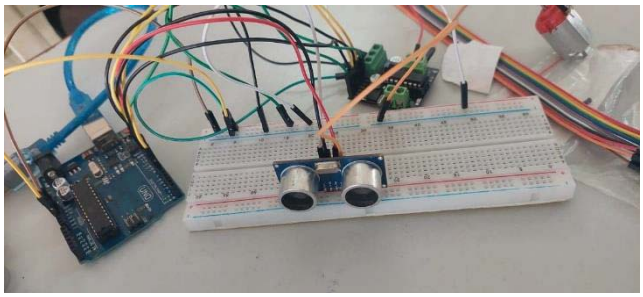

Fig. 3. Hardware set up for distance-based speed control of dc motor

Fig.3 represents the hardware set up.

D. *Testing:-*

The system is designed in such a way that the speed of the DC motor changes with respect to the proximity of the object kept. If the range is more the speed will be more and if the range is less, speed is reduced.

In Fig.4, it can be observed that speed will be updated as per change in value of distance.

Case 1: when object is far to the sensing unit: Let us assume a scenario where distance is > 5cm, then the speed will be updated to 2 where 2 is the level of speed indicating a higher value of speed compared to the speed level of 1 which is lower speed.

Case 2: when object is near to sensing unit: If distance is < 5cm, then the speed will be changed to level 1.

Fig. 4. Serial monitor for distance-based speed-controlled dc motor

V. Speed Control Through Voice

Here the main aim is to control the speed of a DC motor using voice commands through a Bluetooth module and an Arduino microcontroller. The use of voice commands allows for a more convenient and user-friendly interface for controlling the motor as opposed to traditional methods such as using buttons or potentiometers. The Arduino processes the incoming voice commands from the Bluetooth module and adjusts the speed of the motor accordingly[7]. The project demonstrates the ability to control the motor speed wirelessly through voice commands and the use of Arduino's PWM capabilities. Fig 5 represents the flow chart for the speed control with voice control method.

A. Working Principle

The user sends a voice command through a smartphone or computer connected to the Bluetooth module (HC-05). The voice command is transmitted via a serial communication protocol.

The Bluetooth module receives the voice command and sends it to the Arduino through the RX and TX pins.

The Arduino microcontroller processes the incoming command and checks if it is a valid command for controlling the speed of the motor[8]. This is done by using an if-else loop which checks for specific keywords in the received data.If the command is valid, the Arduino adjusts the duty cycle of the PWM signal on the PWM pin connected to the motor driver (L293D). The duty cycle of the PWM signal is proportional to the speed of the motor.

The motor driver amplifies the PWM signal and provides the necessary current to the DC motor, thus changing its speed. The motor driver also has the ability to change the direction of the motor based on the input from the Arduino.

The user can give different voice commands to change the speed of the motor in different increments. For example, the user can say "increase speed" to increase the speed of the motor or "decrease speed" to decrease the speed of the motor. The Arduino continuously monitors the serial communication for new commands, allowing the user to change the speed of the motor at any time[9].

B. Flowchart

Fig. 5 represents the flow chart for voice control method of speed control. The corresponding algorithm is shown below.

- Initialize serial communication at 9600 bits per second for Bluetooth and regular serial communication.
- Initialize the pin modes for M_Enable, M_IN_1, and M_IN_3 as OUTPUT
- Set the initial value of cmd to 49, duty_cycle to 50, and set to 0
- In the loop function, set the duty cycle using analogWrite and the direction using digitalWrite for M_IN_1 and M_IN_3
- Check if there is any available data from the Bluetooth serial communication.
- If there is, read the data and assign it to the variable cmd
- Use an if-else statement to check the value of cmd and set the duty cycle and print out a message accordingly.
- Delay the loop by 50 milliseconds.

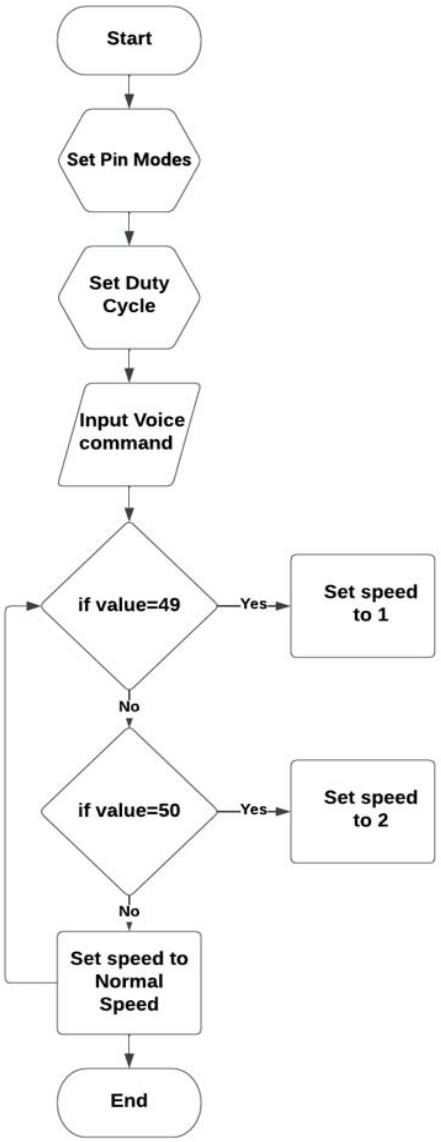

Fig. 5. flow chart for voice control method of speed control

C. Hardware set up:

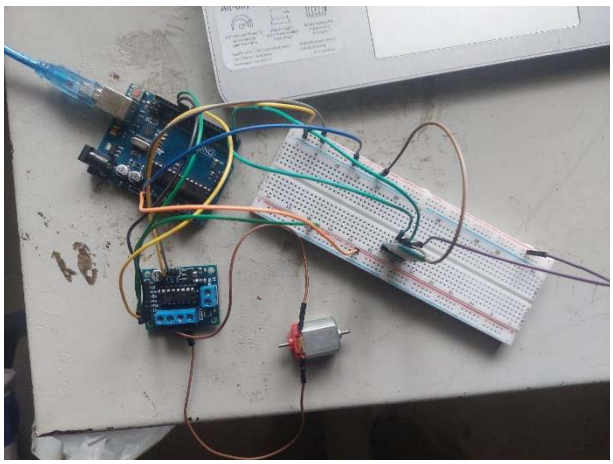

Fig. 6. Hardware setup for voice-based speed-controlled dc motor

Fig.6.shows the hardware setup for voice-based speed-control method of dc motor.

D. Testing:-

The project was tested by connecting the circuit to a power supply and connecting the Bluetooth module to a smartphone. Voice commands were given through the smartphone to control the speed of the motor, and the motor's speed was observed to change accordingly [10]. The motor was able to reach different speeds depending on the voice command given.

In Fig.7, it is seen that when the command 0 is given the dc motor is rotating at a normal standard speed. Next, it is observed that when the voice command 1 is given, the motor rotates at a different speed by varying the duty cycle [11].

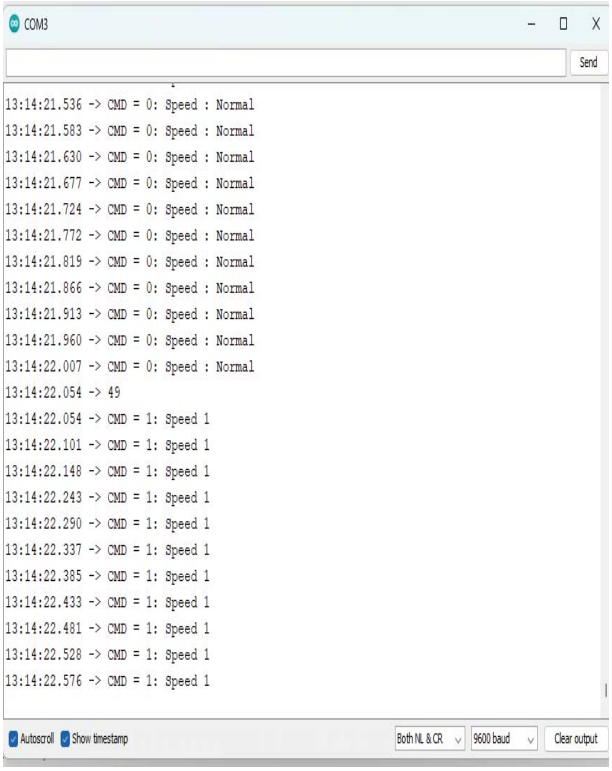

Fig. 7. Serial monitor for voice-based speed-controlled dc motor

VI. COMPARISON

The Table I provides a detailed comparison of the speed control of a DC motor using an ultrasonic sensor and using voice control:

Speed control of a DC motor can be achieved using various methods, such as using an ultrasonic sensor or using voice control. Both methods have their own advantages and disadvantages.

Ultrasonic sensor-based speed control utilizes distance measurement to control the speed of the motor. The control range of this method is generally limited by the range of the sensor, which typically ranges from a few centimetres to several meters [12]. The precision of this method is quite high as the distance measurement is typically very accurate. Ultrasonic sensors are also not affected by ambient noise, making them highly immune to noise. The complexity of the setup is moderate as ultrasonic sensors are typically easy to install and set up but may require additional hardware such as a microcontroller or motor driver to control the motor. However, the flexibility of ultrasonic sensor-based speed control is limited as the ultrasonic sensor is typically only able to control the speed of the motor based on distance measurements.

TABLE I. COMPARISON

Feature	Ultrasonic Sensor	Voice control
Control method	Distance measurement	Distance measurement
Control range	Depends on the range of the sensor, typically a few centimetres to several meters	Depends on the sensitivity and quality of the microphone and speech recognition software, typically a few feet to several yards
Precision	High, as the distance measurement is typically very accurate. Depending on the sensor the threshold range can be different.	Moderate, as the speech recognition software may have difficulty understanding certain accents or speech patterns, and background noise can interfere with the accuracy of the recognition
Immunity to noise	High, as the ultrasonic sensor is not affected by ambient noise	Low, as background noise can interfere with the accuracy of speech recognition
Complexity of setup	Moderate, as ultrasonic sensors are typically easy to install and set up, but may require additional hardware such as a microcontroller or motor driver to control the motor	High, as speech recognition software and hardware can be complex to set up and may require additional programming or machine learning expertise
Flexibility	Low, as the ultrasonic sensor is typically only able to control the speed of the motor based on distance measurements. In some cases directions can also be incorporated	High, as speech recognition software can be trained to respond to a wide variety of commands and can be integrated with other controls or devices
Applications	Suitable for applications where precise distance-based speed control is required, such as robotics, automation, or obstacle avoidance	Suitable for applications where voice-based control is desired, such as home automation, smart devices, or accessibility for users with physical limitations

On the other hand, voice control-based speed control utilizes speech recognition to control the speed of the motor. The control range of this method is generally limited by the sensitivity and quality of the microphone and speech recognition software, which typically ranges from a few feet to several yards. The precision of this method is moderate, as the speech recognition software may have difficulty understanding certain accents or speech patterns, and background noise can interfere with the accuracy of the recognition. Voice control is less immune to noise as background noise can interfere with the accuracy of speech recognition. The complexity of the setup is high as speech recognition software and hardware can be complex to set up and may require additional programming or machine learning expertise. However, voice control is highly flexible as speech recognition software can be trained to respond to a wide variety of commands and can be integrated with other controls or devices.

In conclusion, controlling speed of a DC motor using an ultrasonic sensor is generally more precise, has higher immunity to noise, and is simpler to set up compared to using voice control. However, voice control is more flexible and can be integrated with other control systems or devices. The choice between these two methods will depend on the specific requirements and limitations of the application.

VII. Conclusion And Future Scope

This paper presents an experimental comparison of speed control of a DC motor using voice commands and ultrasonic sensor-based control. The aim of the experiment was to compare the performance of both control methods in terms of speed control, distance measurement, and precision. The results showed that both control methods were able to control the speed of the DC motor, but with different advantages and disadvantages. The ultrasonic sensor-based control performed better in terms of precision and distance measurement, while the voice command-based control was more user-friendly and intuitive. In the ultrasonic sensor-based control, the Arduino was programmed to measure the distance to an object using the ultrasonic sensor and adjust the speed of the DC motor accordingly. The experiment was conducted in a controlled environment and the results showed that the ultrasonic sensor-based control provided precise control over the speed of the DC motor. The ultrasonic sensor was able to accurately measure the distance to an object, and the DC motor was able to respond quickly to changes in the distance. In the voice command-based control, the Arduino was programmed to recognize certain keywords from the voice commands and adjust the speed of the DC motor accordingly. The findings indicated that the voice command-driven control could successfully regulate the speed of the DC motor, albeit with less accuracy when compared to the ultrasonic sensor-based control. Nonetheless, the voice command-based control provided the benefit of being more user-friendly and instinctive since the user could easily manage the motor speed by speaking into a microphone. In conclusion, both control methods have their own advantages and disadvantages, and the choice of control method will depend on the specific requirements of the application. For applications where precise control and accurate distance measurement are important, ultrasonic sensor-based control may be a better option. For applications where user-friendliness and intuitive operation are more important, voice command-based control may be a better choice. Overall, this paper provides a comprehensive comparison of the performance of voice command-based control and ultrasonic sensor-based control for speed control of DC motors. The report highlights the strengths and weaknesses of each method, and it can be used as a reference for selecting the appropriate control method for a specific application.

The experimental setup helps in understanding the pros and cons of both the approaches – sensor based as well as voice command-based control schemes. The analysis enables the user to adopt these schemes in various embedded system / IoT based applications like robotics, precision farming, healthcare etc. In all these applications, mobility is a crucial aspect and speed control is essential. Based on the context, an appropriate speed control scheme can be chosen for the application.

References

[1] V. K. Singh, A. Sahu, A. Beg, B. Khan and S. Kumar, "Speed & Direction Control of DC Motor through Bluetooth HC-05 Using Arduino," 2018 International Conference on Advanced Computation and Telecommunication (ICACAT), Bhopal, India, 2018, pp. 1-3.

[2] Chandini K, Priyanka M K, Shalini S, Sushma P. “Voice Integrated Speed and Direction Control of DC Motor", International Journal of Emerging Technologies and Innovative Research (www.jetir.org | UGC and issn Approved), ISSN:2349-5162, Vol.7, Issue 10, page no. pp90-93, October-2020J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] S. Arun Prakash, Aravind Mohan R., Rahul M. Warrier, Arun Krishna R., Sooraj Bhaskar A, and Aswathy K. Nair, “Real Time Automatic Speed Control Unit for Vehicles”, in 2018 2nd International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)

[4] H. Priya U., P., J., S., P. V. V. S., K. Deepa, and Anjana Jain, “Energy Conservation Strategy for DC Motor Load Applications”, in Recent Trends and Advances in Artificial Intelligence and Internet of Things, V. E. Balas, Kumar, R., and Srivastava, R., Eds. Cham: Springer International Publishing, 2020, pp. 177–186.

[5] B. Sahithi, P. V. Manitha and S. Lekshmi, "Design and Simulation of Washing Machine Equipped with Universal Motor," 2022 International Conference on Intelligent Innovations in Engineering and Technology (ICIIET), Coimbatore, India, 2022, pp. 111-117, doi: 10.1109/ICIIET55458.2022.9967608

[6] A. Mohanty, P. V. Manitha and S. Lekshmi, "Simulation of Electric Vehicles Using Permanent Magnet DC Motor," 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT),2022,pp.1020-1025,2022.

[7] Sai, T.Mathurri & Kumar, S.Keerthi. (2016). “Speed control of DC gmotor using voice commands”, 2016 International Conference on Computation of Power, Energy Information and Commuincation (ICCPEIC).

[8] Ajay,Pranav Venugopal,Chaithanya S,Lkeshmi R Chandran,Dheeraj Krishna V” Sensor less Speed Control Method for Brushless DC Motors Using Back EMF Method”, 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT-2018)

[9] V. K. Singh, A. Sahu, A. Beg, B. Khan and S. Kumar, "Speed & Direction Control of DC Motor through Bluetooth HC-05 Using Arduino," 2018 International Conference on Advanced Computation and Telecommunication (ICACAT), Bhopal, India, 2018, pp. 1-3.

[10] A. Bhattacharjee, G. Ghosh, V. Kumar Tayal and P. Choudekar, "Speed control of BLDC motor through mobile application via secured Bluetooth," 2017 Recent Developments in Control, Automation & Power Engineering (RDCAPE), Noida, India, 2017, pp. 203-206.

[11] Sai, Talpa and Supradeep K. Kumar. “Speed control of DC motor using voice commands.” 2016 International Conference on Computation of Power, Energy Information and Commuincation (ICCPEIC) (2016): 800-803.

[12] D. Rama and T. Ananthan, "FPGA Based Emulator Design of a DC Motor," 2019 International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2019, pp. 1739-1743, doi: 10.1109/ICCES45898.2019.9002133.