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Design and Development of Line Following Tour Guide Robot

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Abstract: The aim of this research project is to develop a Tour Guide Robot showing sufficient intelligence to work as a tour-guide in different environments. In doing so, both a software and a hardware architecture are proposed, the different modules of which, such as a sensor, speaker, amplifier, motor(dc), and display, among others, control the different components of the robot. Those components are in turn used by other modules designed for navigation and interaction. A sensor fusion for the purposes of localization is implemented by means of an Arduino Uno Board, which is one of the control module components, together with the other sensors needed for path following. A speaker and amplifier system that controls the voice modules also forms part of this architecture for assisting interaction. Finally, all the modules are controlled with an Arduino Uno Board and programming language. The modules are optimized for immediate execution to achieve navigation and human-machine interaction. The interaction with visitors will be achieved through video display on an android tablet placed on top of the robot. The tour guide robot will display the video about the place it visits when the visitors press the video play button on the android tablet screen.

Keywords: Sensor, Arduino Uno, speaker, amplifier system, programming languages.

I. INTRODUCTION

In the era of rapid technological advancements, robotics and automation have become pivotal in shaping the way industries and logistics operate. Today, robots are no longer a thing of science fiction movies. From cleaning robots to clinical robots, they are inescapable and are becoming a basic part of people's lives, as robots anticipate an ever-increasing number of parts in people's step by-step lives, their impact on society continues to create. The project mentioned in this research focuses on creating an autonomous indoor robot that can be used for campus visits as tour guides. For example, this tour guide robot can be used during University Open House or registration of new students.



Figure 1: Line following Tour Guide AGV

The purpose of this project is to provide tourists with an automated, reliable, and optimized experience of touring. The proposed tour guide robot makes use of an android tablet for video display and ultrasonic sensor and infrared sensor for obstacle avoidance and path following, it also uses a text to speech recognition system to speak. This technology application is widely used due to its low price and small size. The Infrared sensor helps the robot to move in a straight line and follow a certain assigned path. This kind of robot is suitable to be used in educational environment because it can help students or visitors understand about engineering. A tourist guide robot that brings visitors around the faculty of Zeal College of Engineering and Research is one such innovative solution. It will provide an interesting example of what education can produce at the university. This paper presents the development and implementation of a tour guide robot for Robotics and Automation faculty. The tour guide robot will guide visitors around the faculty of electrical engineering and show videos on various areas visited by the robot

II. DESIGNING OF THE ROBOT

The prototype design of the robot is developed on the software Fusion 360 by Autodesk. It is designed according to the parameters and accurate measurements taken to develop the robot and its application.

A. Designing the Prototype using FUSION 360

Fusion 360 is a powerful CAD (Computer-Aided Design) software developed by Autodesk that allows users to design 3D models, simulate functionality, and generate manufacturing documentation. Designing a prototype using Fusion 360 involves several steps:

- 1) *Sketching*: Begin by creating a new design file in Fusion 360. Start by sketching the basic outlines or profiles for prototype's components. Using tools like lines, arcs, circles, rectangles, and splines to create 2D sketches on different planes to complete the prototype design of the AGV.
- 2) *Extrusion and Revolve*: Once the 2D sketches ready, the shapes like wheels, agv base and upper body can be extrude or revolve them to create 3D shapes. Select the sketch for to extrude or revolve, then use the corresponding tool to specify the direction and distance for extrusion of angle for revolution.
- 3) *Materials and Appearances*: Assign materials and appearances to your prototype to make it look more realistic. Fusion 360 comes with a library of predefined materials, assign the materials according to feasibility of the design and strength and initiate the final design and simulate it.

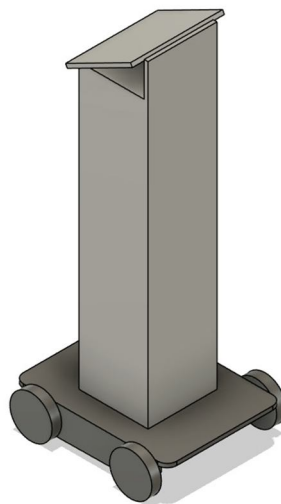


Figure 2: AutoCAD Design of prototype

III. CALCULATING STRAIN AND STRESS USING FUSION 360

The Fusion 360 allows us to perform stress and strain analysis using the built-in simulation workspace. This allows us to evaluate how your design will behave under various loads and conditions, helping you optimize its performance and durability. to calculate stress and strain using Fusion 360 involves steps:

- 1) **Preparing Model:** Start by ensuring that the 3D model is fully defined and ready for analysis in Fusion 360. Make sure all components are properly assembled if the design involves multiple parts. Assign appropriate materials to your model. Fusion 360 offers a library of materials with predefined properties, or you can create custom materials if needed.
- 2) **Access the Simulation Workspace:** Switch to the Simulation workspace in Fusion 360 by clicking on the "Simulation" icon in the toolbar. This will open up the simulation environment where you can set up and run analyses.
- 3) **Set Up the Study:** Click on the "New Study" button to create a new simulation study. Choose the type of analysis you want to perform, such as static stress, modal frequency, thermal, or nonlinear analysis. For stress and strain analysis, select the "Static Stress" study type.
- 4) **Apply Loads and Constraints:** Define the loads and boundary conditions that your design will experience in real-world conditions. Common loads include forces, pressures, torques, and gravitational loads. Apply constraints to restrict the movement of certain parts or fix them in place.
- 5) **Run the Analysis:** Once you have set up the study and defined all the necessary parameters, run the analysis. Fusion 360 will solve the equations and calculate the stress and strain distribution throughout model.
- 6) **Review Results:** After the analysis is complete, you can review the results to understand how your design behaves under the applied loads. Fusion 360 provides visualizations of stress, strain, displacement, factor of safety, and other relevant parameters. Examine the results by viewing contour plots, graphs, and animations. The analysis also shows the shear stress and shear strain developed in the design of the robot's base.

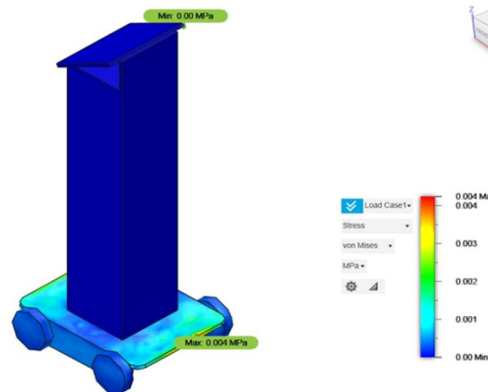


Figure 3: Stress and strain analysis of robot

IV. HARDWARE

The components selected for the project are taken from the study of research papers in literature review, internet, and other video sources. The components included in our projects are as follows:

A. Arduino Uno

The Arduino Uno is one of the most popular microcontroller boards in the Arduino family. It is widely used in electronics and robotics projects due to its versatility, ease of use, and a large community of developers and resources. The board is based on the Atmega328P microcontroller and is known for its simplicity, making it an excellent choice for beginners and experienced makers alike.

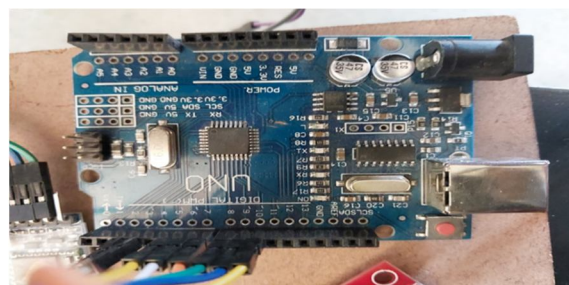


Figure 3: Arduino Uno board.

The Arduino Uno board is a versatile microcontroller platform designed for easy programming and interaction with a wide range of electronic components. Its simplicity and extensive community support make it an excellent choice for both beginners and experienced.

B. Motor Driver

L298N Motor Driver Module is a high-power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit. 78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller. The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through 5V terminal to power the internal circuitry. ENA & ENB pins are speed control pins for Motor A and Motor B while IN1 & IN2 and IN3 & IN4 are direction control pins for Motor A and Motor B.

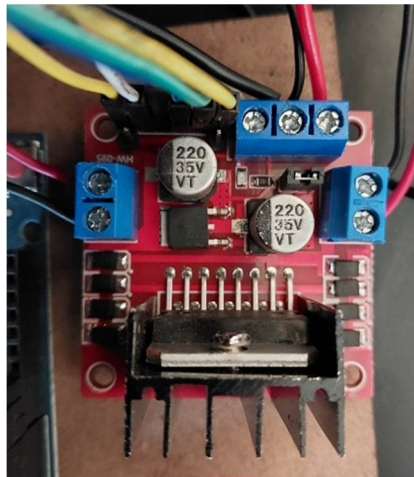


Figure 4: L298N Motor driver

C. IR Sensor

IR sensors are electronic devices that can detect the presence or proximity of objects by emitting and receiving infrared light. They are commonly used in applications such as line following, obstacle detection, and proximity sensing in robotics. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode. Photodiode is sensitive to IR light of the same wavelength which is emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received.



Figure 5: IR Sensor

D. Bluetooth Module

These small electronic devices enable seamless connectivity between various devices, making them an integral part of numerous applications and industries.

It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard, and many more consumer applications. It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions.

It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air.

HC-05 is a Bluetooth module which is designed for wireless communication. This module can be used in a master or slave configuration.

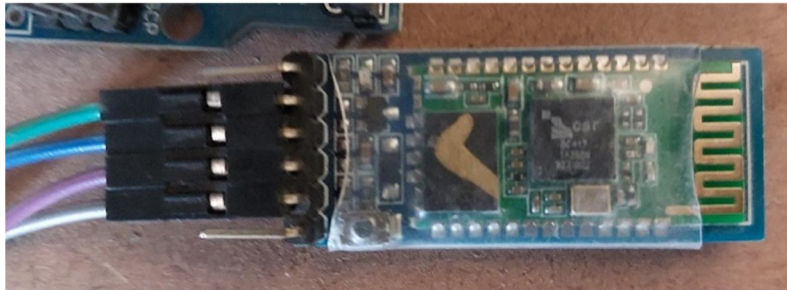


Figure 6: Bluetooth Module HC-05

V. ELECTRICAL CONNECTION CIRCUIT

The connection of the hardware used in the robot for line following is shown below. The circuit consists of the following components like Arduino Uno, Bluetooth module, Motor Driver, IR sensors and Gear motors of 12 volt each.

The below circuit is created by the help of Tinker Cad software which is a basic line following circuit which also has an App based control over the robot.

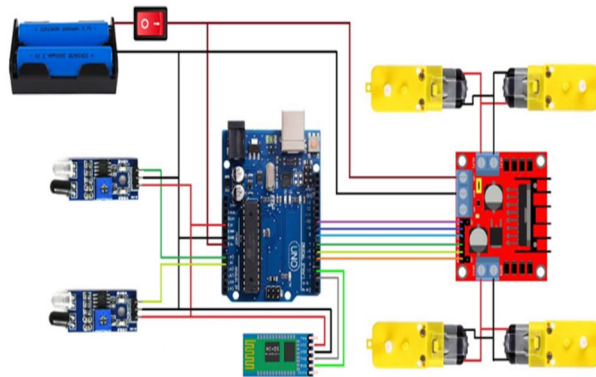


Figure 7: Line following circuit

VI. SOFTWARE ARCHITECTURE

The software architecture includes App interface for the moment control and GUI interface for interactive user interface.

A. App Interface

The Interface developed for the robot is developed through use of MIT App Inventor which is a free platform to develop the applications. The app is developed in failure cases if occurred when the robot is not working, or we want to operate the robot manually. The App is developed on the platform i.e. MIT APP Inventor which is an open and free source to develop and create the app.

The below image shows the app developed for the operating the movement of the robot.

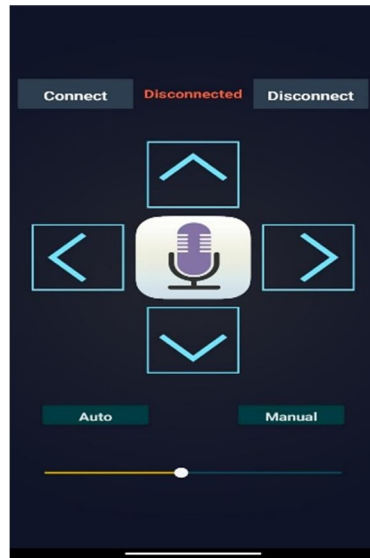


Figure 8: App Interface

The buttons which are seen in the above image of App Interface are basically forward, reverse, and left and right turn. We have also interfaced it with Google Voice Control button which also helps in guiding the operator to operate the robot. It also has the Two modes which are Auto and Manual mode. The Auto mode which is used when the robot is used for line following application. The Manual mode is used for manual movement application or when the guide wants to skip the station and go to the other station.

A. GUI Interface

The GUI Interface that we have developed is a website-based GUI interface which helps the tourer to understand about the station on the screen and voice over text.

The GUI has the following contents: -

- 1) HOME PAGE
- 2) ABOUT US
- 3) COMPONENTS
- 4) STATION PAGE
- 5) STATION 1
- 6) STATION 2

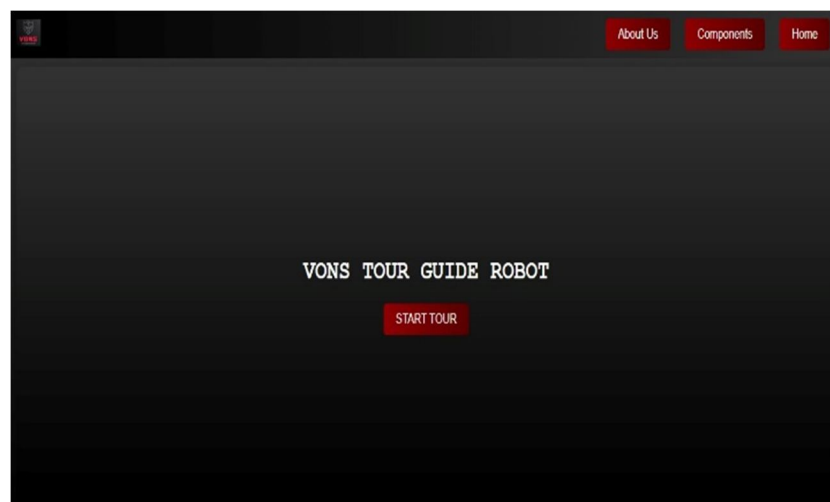


Figure 9: Home Page of GUI

The Home Page contains the Buttons like START TOUR, ABOUT US, COMPONENTS, HOME. The START TOUR button is used for Starting the tour. After clicking on START TOUR the voice over interface speaks and welcomes the person and tells the tourer to select the station.

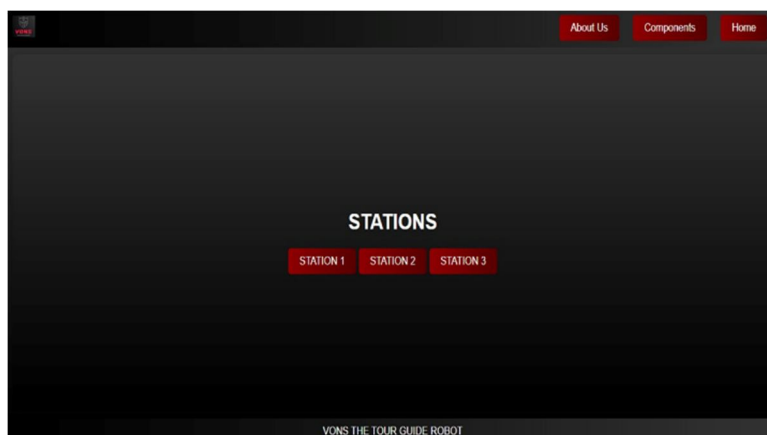


Figure 10: Station Page of GUI

The above image Station page describes or helps the tourer to select the station by a voice over narration like “Please select your station.”

There are mainly three stations that are described as

STATION 1

STATION 2

STATION 3

After clicking on Station 1 the individual window of the station 1 will open.

The Above-mentioned information and the images are the glimpse of the GUI interface which makes the robot to interact with the persons and the students and give them the needy information about the Robotics and Automation Department.

VII. CONCLUSION

The "Tour Guide Robot" project stands as a testament to the collaborative potential of cutting-edge technologies in the realm of robotics. It demonstrates the adaptability of automation systems in navigating and responding to dynamic environments, a capability that is increasingly vital in today's Tourism industry.

Looking forward, the impact of this project extends beyond its current scope. It opens doors to further exploration, including scalability, real-world application, and continuous refinement. As technology advances and automation becomes more integral to various industries, this project represents a noteworthy stride in the direction of optimizing efficiency, precision, and adaptability.

In conclusion, the successful execution of this project underscores the transformative potential of integrating sensors, and robotics. It is a stepping stone toward a future where automated systems are not just tools but adaptable, intelligent partners in day-to-day life of a human being.

From the overall experimentation and testing we have concluded that the line following tour guide robot successfully runs and interacts with following key achievements of this project can be summarized as follows:

- 1) Line Following: We have developed a robust AGV platform equipped with Infrared (IR) sensors that adeptly follows predefined paths. This line-following capability is essential for the reliable and efficient movement of the AGV within its environment.
- 2) Seamless Communication: The establishment of seamless communication between the Robot and the human allows for efficient coordination. This enables the robot to request assistance when the communication is needed.
- 3) Enhanced Efficiency: The successful execution of this project showcases the potential for enhanced efficiency in Tourism industry. The integration of these technologies not only streamlines communication tasks but also improves the overall performance of the Robot's system.



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