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Line Follower Robotics

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ABSTRACT

This paper details the design, development, and evaluation of an autonomous line-following robot using an Arduino Uno microcontroller. The robot navigates a predefined path marked by a line, employing infrared (IR) sensors for detection and a Proportional-Integral-Derivative (PID) control algorithm for motor control. The hardware setup includes an Arduino Uno, IR sensors, DC motors, and an L298N motor driver mounted on a compact chassis. The software, developed using the Arduino IDE, processes sensor data to compute the error between the desired path and the robot's actual position, which is minimized using a PID control algorithm.

Keywords—Autonomous Navigation, Embedded System, Sensor Data Processing, Path Tracking.

1. INTRODUCTION

Line-following robots are pivotal in robotics, finding applications in industrial automation, warehouse logistics, and educational environments. These robots navigate autonomously by following a path marked by a visible or invisible line on the ground. Precision in line following is essential for tasks like automated guided vehicles (AGVs) in manufacturing and service robots in structured environments. The objective of this project is to design and develop a highly efficient line-following robot using the Arduino Uno microcontroller. Chosen for its versatility and strong community support, the Arduino Uno, paired with infrared (IR) sensors and a motor driver, forms the core of the robot's hardware setup. In this project, IR sensors detect the line, while a Proportional-Integral- Derivative (PID) control algorithm adjusts motor speed for accurate path tracking. The PID controller balances simplicity and effectiveness, ensuring smooth navigation. This paper outlines the complete development process, from hardware assembly to software programming, and presents experimental results demonstrating the robot's performance across various track configurations. This research aims to enhance robotics by showcasing a reliable line- following robot design, setting the stage for future innovations in autonomous navigation For this study secondary data has been collected. From the website of KSE the monthly stock prices for the sample firms are obtained from Jan 2010 to Dec 2014. And from the website of SBP the data for the macroeconomic variables are collected for the period of five years.

2. LITERATURE REVIEW

Traditional Threshold-Based Methods Traditional line-following robots employ threshold-based methods for line detection, where sensors detect changes in reflectivity and trigger predefined responses when certain thresholds are crossed. These methods are simple to implement, with the robot adjusting its movement based on predefined thresholds. However, they often struggle with accuracy and reliability, especially in environments with varying lighting conditions and surface textures. The binary nature of threshold-based decision- making can lead to erratic behaviour, causing the robot to deviate from the desired path frequently. As a result, these methods are limited in their applicability to more complex paths and environments.

Recent advancements in line-following robot design have explored advanced control strategies such as fuzzy logic and neural networks. Fuzzy logic systems emulate human decision-making processes by allowing for imprecise inputs and outputs, enabling robots to navigate more dynamically through uncertain environments. Neural networks, on the other hand, use machine learning algorithms to adapt and improve performance over time based on experience. These advanced control strategies offer superior performance and adaptability compared to traditional methods. However, they require extensive tuning and computational resources, making them challenging to implement without specialized expertise and significant computational power.

The pid (proportional-integral-derivative) control approach is a widely used method for line following robots. It operates by continuously calculating an error signal based on the difference between the desired path and the robot's actual position. The pid controller then adjusts the robot's movement by applying proportional, integral, and derivative control actions to minimise this error. Pid control offers a balanced approach, providing smooth and accurate movement while remaining relatively simple to implement and tune. It can efficiently handle variations in line detection and environmental conditions, making it suitable for real time applications like line-following robots. Additionally, pid control provides stability.

3. METHODOLOGY

3.1 Hardware Design

1. Microcontroller (Arduino Uno) The Arduino Uno serves as the brain of the robot, processing sensor data and controlling motor movement based on predefined algorithms.

2. Infrared (IR) Sensors IR sensors are strategically positioned on the robot to detect the line on the ground. These sensors emit infrared light and measure the intensity of reflected light to determine the presence and position of the line

3. DC Motors DC motors provide the driving force for the robot's movement. The rotation of the motors allows the robot to manoeuvre along the detected line.

4. Motor Driver (L298N) The motor driver acts as an interface between the Arduino Uno and the DC motors. It provides the necessary power and control signals to regulate motor speed and direction.

5. Chassis The chassis serves as the structural framework that supports and protects the internal components of the robot. It is typically made of durable materials such as plastic or aluminium and is designed to withstand the rigours of robotic movement

6. Wheels Wheels are attached to the DC motors and provide traction and stability for the robot as it moves along the line. The size and type of wheels may vary depending on the terrain and intended use of the robot.

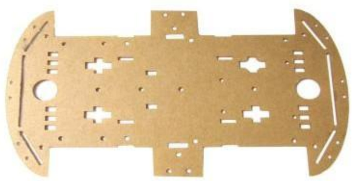
7. Power Supply A power supply, such as a battery pack or external power adapter, provides the necessary electrical energy to operate the microcontroller, sensors, motors, and other electronic components

8. Mounting Hardware Screws, nuts, and spacers are used to securely attach components to the chassis and ensure proper alignment and stability of the robot.

4. COMPONENTS REQUIRED

1. N20 Metal Gear Motor: Motors are like the legs of the robot. Motors will make the robot be able to move around. N20 Metal Gear Motors, shown in Figure (2.5), are being used because of their small size and high speed. The motor operates at a speed of 20,000 RPM (unreduced) but with a gearbox reduction ratio of 100:1 it operates at a speed of 200 RPM. It generally runs on 6v but for this robot it will run on**.**

2. Chassis - The chassis of the robot is 3D designed and shown in Figure (2.1) and Figure (2.2). It has been optimized for maximum performance. A longer chassis will be better than a shorter chassis since there will be more deviation of the IR sensor array resulting in a faster robot.



3. N20 Caster Wheel: This will be used to support the front part of the robot. Without it, the front part would scrape ground as it moves.

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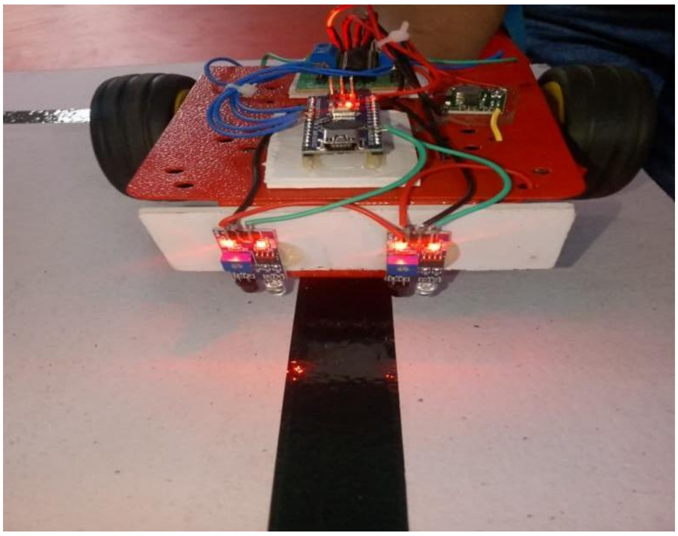
4. Arduino Nano: An Arduino Nano, as shown in Figure (2.7), will be used as the microcontroller for this robot because of its small size, lightweightness, clock speed (16MHz) and high number of GPIO pins. However, an ESP32 Development Board is also a viable option. It is not being used in this robot because it is mainly used in IoT applications since it has the ESP32 WiFi Module which is not needed for this robot and increases the power consumption.

5 .ACTUAL CIRCUIT



Firstly, all of these components need to be attached to the robot chassis. The QTR-8RC, N20 Motor Mounts and N20 Caster Wheels can be screwed into the holes on the chassis. Next, the L298N Motor Driver and breadboard will be attached to the chassis using double sided tape into their slots on the chassis. Finally, the battery and the arduino nano will be taped to the robot chassis since they will have to be removed from time to time to be charged and for new code to be uploaded. Now it's time to make the electrical circuitry. Firstly, the battery needs to be connected to give power to the L298N Motor Driver and the Arduino Nano. The positive terminal of the battery needs to be connected to both the 12V terminal of the L298N Motor Driver and the vin pin of the Arduino Nano and the negative terminal of the battery needs to be connected to both the GND pin of the Arduino Nano and the GND terminal of the L298N.

6. RESULT

The result of a line follower robot is that it automatically detects and follows a predefined path, usually a black or white line, using sensors and a control system. It continuously adjusts its direction by controlling the motors, allowing it to move forward, turn left or right, and stay on track without any human intervention.

7. CONCLUSION

In conclusion, a line follower robot is a simple and efficient autonomous system that uses sensors and motor control to follow a predefined path accurately. It demonstrates the basic principles of robotics, such as sensing, decision-making, and movement, making it a useful project for understanding automation and real-world robotic applications.

8. REFERENCE

Arduino Nano USB Port - Search Images 33939.pdf

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The line follower robot: a meta-analytic approach