Enhanced Speed Control of BLDC Motor Using Dwarf Mongoose Optimizer

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Abstract— In an age of automation, adaptable robotic systems are vital. This study crafts a Line Follower Robot with advanced obstacle detection to address this need. By enhancing obstacle avoidance, it surpasses traditional models, expanding practical utility. Incorporating obstacle detection ensures safe navigation through crowded spaces, enhancing versatility. This project aims to merge precise line following with intelligent obstacle detection, offering a holistic solution for diverse applications. This robot's ability to navigate complex courses and avoid obstacles dynamically marks a significant step forward in robotic development, enhancing its suitability for real-world deployment.

Index Terms- Line Follower Robot, Obstacle Detection, Mobile Robot.

I. INTRODUCTION

Developing and implementing intelligent systems that can navigate complex settings with ease is becoming increasingly important in the rapidly changing field of robotics. Self-governing mobile robots are becoming more and more important among the many uses of robotic technology, particularly in situations where accurate navigation is critical. This work presents the creation of a Line Follower Robot with an enhanced obstacle detection mechanism, a technological combination that aims to improve the performance of traditional line-following robots. The research attempts to address a critically important feature of mobile robotics.

Due to its ability to follow predetermined courses, line-following robots have been used for a long time in a variety of applications, including industrial automation and educational tools. But these robots' intrinsic shortcoming is that they are easily harmed by unforeseen obstructions or detours from the planned path. Industry demands for automated systems that can navigate unpredictably are growing, which makes it necessary for a robot to have both cognitive obstacle detection and precise line following.

By providing a system that combines the accuracy of line following with the agility provided by intelligent obstacle recognition, this research seeks to close the gap between theoretical developments in robotics and real-world application. By combining these functions in a fluid manner, the created robot hopes to rewrite the rules for mobile autonomous robots and make them more capable of managing the complexity of contemporary, dynamic surroundings. This study presents a holistic approach toward the implementation of an intelligent and adaptable robotic system by exploring the finer points of the robot's design, the integration of sensors, and the algorithms used.

II. LITERATURE SURVEY

For effective line following, the robot in question makes use of LED and LDR sensors. As transmitters (Tx) and receivers (Rx), two sets of LEDs and sensors are arranged to detect reflected light from the surface. A comparator, logic circuit, diode matrix, and driver circuits are used to process the resulting analog signals before the driving motors are finally turned on. Interestingly, less than two sensors are needed on either side of the track for ideal line following. By using LED as a light source, the robot can trace lines well in a variety of environments, thanks to the resistance of LDR changing according to the color of the surface [1].The design, development, and testing of a flexible line follower robot with the goal of following black lines are described in this study. line following, 90 and 110 degree turns, intricate line patterns (jag line, butterfly, circle, half-circle, square), adjusting to reversed line colors, battery-operated operation in dimensions of 15*15*15 cm, keeping a 20 cm distance from each line side, and the ability to travel a path more than once are among the goals. Due to its many functions, the robot may be used in a variety of situations, demonstrating its versatility and accuracy when performing complex movements and line following [2]. In order to ensure that the wooden board (9 by 12 inches) was thick enough to hold the robotic hand, battery, and other components, it was shaped to AutoCAD measurements during the creation of the line follower robot. Heavy weights were positioned close to the wheels that were directly connected to the motors by load distribution calculations. A problem with the H-bridge motor driver, L293D, emerged, though, as each motor could only receive 600 milliampers from a 7.2 Ampere-hour battery. As a result, the motors could only operate at half of their rated RPM. To mitigate signal noise in the infrared sensors, a microcontroller constraint was implemented, requiring that data from the ADC module be used only when 900 out of 1024 digital digits had been achieved. Furthermore, noise interference was decreased with 100uF 25V capacitors on each ADC pin. To get the best race performance, the final design was modified. The robot demonstrated flexibility in navigating a variety of line patterns, including circles, jagged lines, and inverted colors, despite the architectural restriction. Test runs were conducted to examine the reactions of the sensors in terms of ADC values and microcontroller feedback using pulse width modulation.[3]. An L298N IC motor driver circuit is used by the line follower robot to operate DC motors, providing simultaneous direction and speed control. The Arduino microcontroller communicates with the L298N motor driver by deciphering input signals from infrared sensors and sending appropriate output signals. Two wheels, each attached to a motor, plus a caster wheel enabling seamless rotations make up the robot's locomotion mechanism. Motor speed is moderated by reduction gears, and directional control is accomplished using H-bridge switches. The robot is powered by lithium polymer batteries, which are also excellent for current electronic gadgets and radio control applications since they offer great power and prolonged operation. The comprehensive six different movement kinds highlight the robot's motor control system's adaptability and accuracy [4]. Initializing IR sensors, motor output pins, and ultrasonic sensor variables are part of the Arduino software for the line follower robot. The robot can stop until the obstruction is cleared when the ultrasonic sensor finds one, stopping all motors. When there are no barriers or black lines in its path, the robot advances by executing alternate motor rotations on each turn. Based on individual sensor data, the computer distinguishes between left and right turns. Notably, the robot follows the line until both sensors are on black surfaces, in which case it pauses. The software guarantees dynamic reactivity, allowing the robot to successfully interpret sensor inputs and navigate a variety of settings [5]. Using two infrared sensors, the Line Follower Robot recognizes black lines by analyzing fluctuations in surface reflectance. It is steering by line detection and is controlled by an Arduino UNO. It increases productivity in healthcare environments by streamlining processes like medication distribution. The prototype can't handle heavy loads, and it has trouble making fast curves and declining speed as a result of battery exhaustion. The robot shows promise for healthcare logistics in spite of these shortcomings. An more effective and adaptable application in real-world situations could result from addressing these constraints [6]. The Line Follower and Obstacle Avoiding Algorithm To navigate along a predefined course, the robot combines inputs from infrared and ultrasonic sensors. When an impediment is detected by the ultrasonic sensor within 15 cm, the robot uses a predetermined algorithm to overcome it and then retraces its route. When the robot pauses due to track loss, the GSM module initiates and sends out an emergency warning. According to experimental studies, it takes around 10 seconds longer to overcome a barrier for every 5 cm increase in length. Robot traversal time can be shortened by increasing speed, but only to a point (150 mm/s), after which line sensor response problems occur. Effective obstacle avoidance, autonomous path retracement, and emergency indication are all shown by the suggested system in practical situations [7]. An obstruction detecting mechanism is incorporated into the suggested low-cost watering system to reduce water waste and improve irrigation efficiency for gardens. The prototype lowers total expenses by doing away with the requirement for wireless and moisture sensors. In contrast to current systems that need individual valves and sensors for every plant, this model presents a more effective and transportable option. The suggested system outperforms previous irrigation models covered in the introduction by identifying different pot shapes and differentiating between moveable and stationary items, hence resolving issues with earlier robotic plant care systems. It also performs better than a wireless sensor network-based method by providing an affordable substitute without sacrificing efficacy[8].With the use of ADC for analog-to-digital conversion in response to surface conditions, the suggested robotic system makes use of white line and infrared proximity sensors. The flowchart controls the robot's motions by allowing forward travel on white lines, pausing when impediments are detected, and reversing course when sensors detect deviations. It is possible to obtain motion stability at both low and high speeds. The surface type is identified by the voltage levels across white line sensors, which helps with precise route following. When IR proximity sensors identify impediments within a 10-cm radius, they automatically stop and send out wireless ZigBee messages. White line following and obstacle avoidance are successfully demonstrated by the experimental findings [9].An LED with red, blue, and green lights is used as the color sensor in this project. Using variable resistors to adjust for brightness, the resistance of the LED light-to-voltage ratio (LDR) is varied according to the lux levels of reflected light. In order to maintain consistent current and voltage for the LEDs, the L293D motor driver acts as a switching device. By identifying the strongest color reflection for route guiding, ADC decimal data (0–1024) helps with color recognition. On the basis of the communicated input, the system turns on the matching LED. Voltage level analysis is possible because high LDR resistance signals low light. Each LED turns on in turn, and the voltage level that the LDR receives determines the color of the light [10].

III. PROPOSED SYSTEM

The primary objective of this project is to develop an efficient and real-time forest fire detection system that can swiftly identify the presence of a forest fire in order to facilitate rapid response and action. This system is designed to leverage a variety of data sources, including cameras, drones, and satellite imagery. At its core is an image processing model that is continuously refined and improved through the integration of multiple feature extractors and machine learning classifiers.

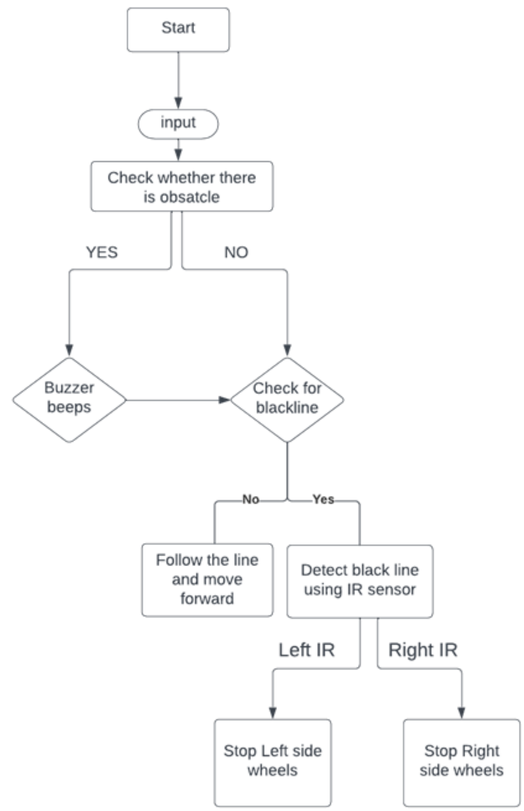

Fig.1. Flowchart of Proposed system

IV. METHODOLOGY

In response to the evolving demands of Industry 4.0, the proposed system, termed "Spatial-Sense AGV," is engineered to revolutionize industrial automation through the fusion of cutting-edge technologies. This section delves into the intricate design and functionality of Spatial-Sense AGV, outlining its line-following mechanism, spatial awareness integration, and the incorporation of real-time audio feedback.

4.1 Line Following Mechanism:

The foundational element of the Spatial-Sense AGV's navigation system lies in its robust line-following mechanism. Harnessing the power of Arduino Uno, precision is achieved through a network of infrared (IR) sensors strategically placed beneath the AGV chassis. The L298N motor driver facilitates seamless motor control, ensuring the AGV accurately adheres to predetermined paths in dynamic industrial environments.

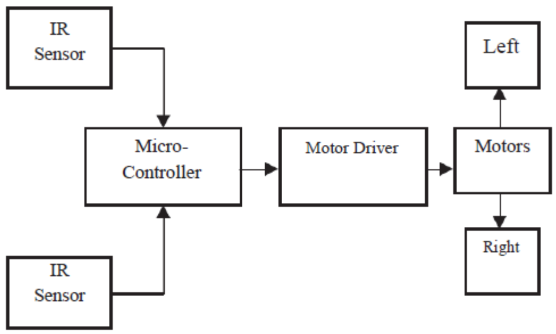

Fig.1. Block diagram of proposed system

4.1.1 Arduino Uno Integration:
The heart of the system, Arduino Uno, acts as the central processing unit orchestrating the AGV's responses. Customized algorithms interpret signals from IR sensors, enabling real-time adjustments in motor speed and direction, ensuring the AGV stays precisely on its designated path.

4.1.2 IR Sensor Network:
Strategically positioned IR sensors continuously scan the ground beneath the AGV, detecting the contrast between the line and the surrounding surface. This data is processed to make instantaneous decisions on steering adjustments, maintaining optimal alignment with the predefined path.

4.1.3 L298N Motor Driver:
The L298N motor driver provides the necessary control interface between the Arduino and the AGV's motors. This component translates the digital commands from the Arduino into precise motor movements, allowing for the nuanced adjustments required for accurate line following.

4.2 Spatial Awareness and Object Detection:
In elevating the Spatial-Sense AGV beyond traditional line-following capabilities, an ultrasonic sensor system is introduced to confer spatial awareness and object detection capabilities.

Mounted strategically on the AGV, the ultrasonic sensor constantly emits ultrasonic pulses and measures the time taken for their return. By interpreting these measurements, the AGV gains real-time insights into its surroundings, enabling the detection of obstacles and dynamic adjustments to its trajectory.

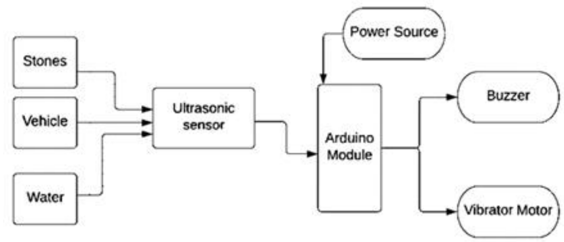

Fig.2. Block diagram of proposed system

4.3 Real-time Audio Feedback System:
To enhance the AGV's responsiveness and provide real-time alerts, a speaker system is incorporated into the Spatial-Sense AGV.

4.3.1 Speaker Integration:
The speaker component translates system alerts into audible signals. When an obstacle is detected, the AGV emits audio signals, alerting nearby personnel and contributing to a safer working environment.

4.3.2 Alert System:
The audio feedback system operates in conjunction with the object detection module, providing distinct alerts for various scenarios. This auditory communication mechanism adds an additional layer of safety and awareness to the AGV's operation.

4.4 System Integration and Synergy:
The proposed system achieves seamless integration of the line-following mechanism, spatial awareness components, and real-time audio feedback system. This holistic approach ensures that the Spatial-Sense AGV operates as a cohesive unit, capable of navigating intricate industrial environments with efficiency and safety at its core.

In summary, the Spatial-Sense AGV represents a paradigm shift in industrial automation, leveraging a sophisticated line-following mechanism, advanced spatial awareness, and real-time audio feedback. The next section will detail the experimental methodology and results, validating the efficacy and adaptability of this innovative AGV system.

V. RESULT

The experimental results affirm the outstanding performance of the Spatial-Sense AGV across key parameters. In terms of line-following accuracy, the AGV exhibited remarkable precision and reliability, maintaining a consistent trajectory along the predefined path across various speeds. The ultrasonic sensor, a pivotal component for object detection and spatial awareness, showcased remarkable adaptability. The AGV adeptly detected and navigated around both static and dynamic obstacles, validating its real-time responsiveness to environmental changes. The audio feedback system proved highly effective, providing clear and distinct alerts during simulated obstacle encounters, even in ambient noise reflective of industrial settings. In replicability and variability testing, the AGV demonstrated robustness and adaptability, consistently delivering reliable performance under diverse conditions. These results collectively underscore the Spatial-Sense AGV's potential as a sophisticated and versatile solution for enhancing automation efficiency in industrial settings.

CONCLUSION

In conclusion, the Spatial-Sense AGV emerges as a pioneering solution in the realm of industrial automation, exhibiting exceptional capabilities in navigation, object detection, and safety features. The precision demonstrated in line following, coupled with the agility showcased in adapting to dynamic environments through the ultrasonic sensor, positions the AGV as a reliable and versatile tool for modern manufacturing. The real-time audio feedback system adds a layer of situational awareness, enhancing the AGV's safety protocol. The comprehensive evaluation under varied conditions affirms the AGV's robustness and adaptability, essential qualities for seamless integration into diverse industrial settings. This study contributes to the field by presenting a holistic AGV solution that not only adheres to predefined paths with precision but also dynamically responds to the challenges posed by obstacles. As industries continue to embrace the era of smart manufacturing, the SpatialSense AGV stands as a promising technology at the intersection of efficiency, safety, and adaptability, laying the groundwork for future advancements in industrial automation.

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