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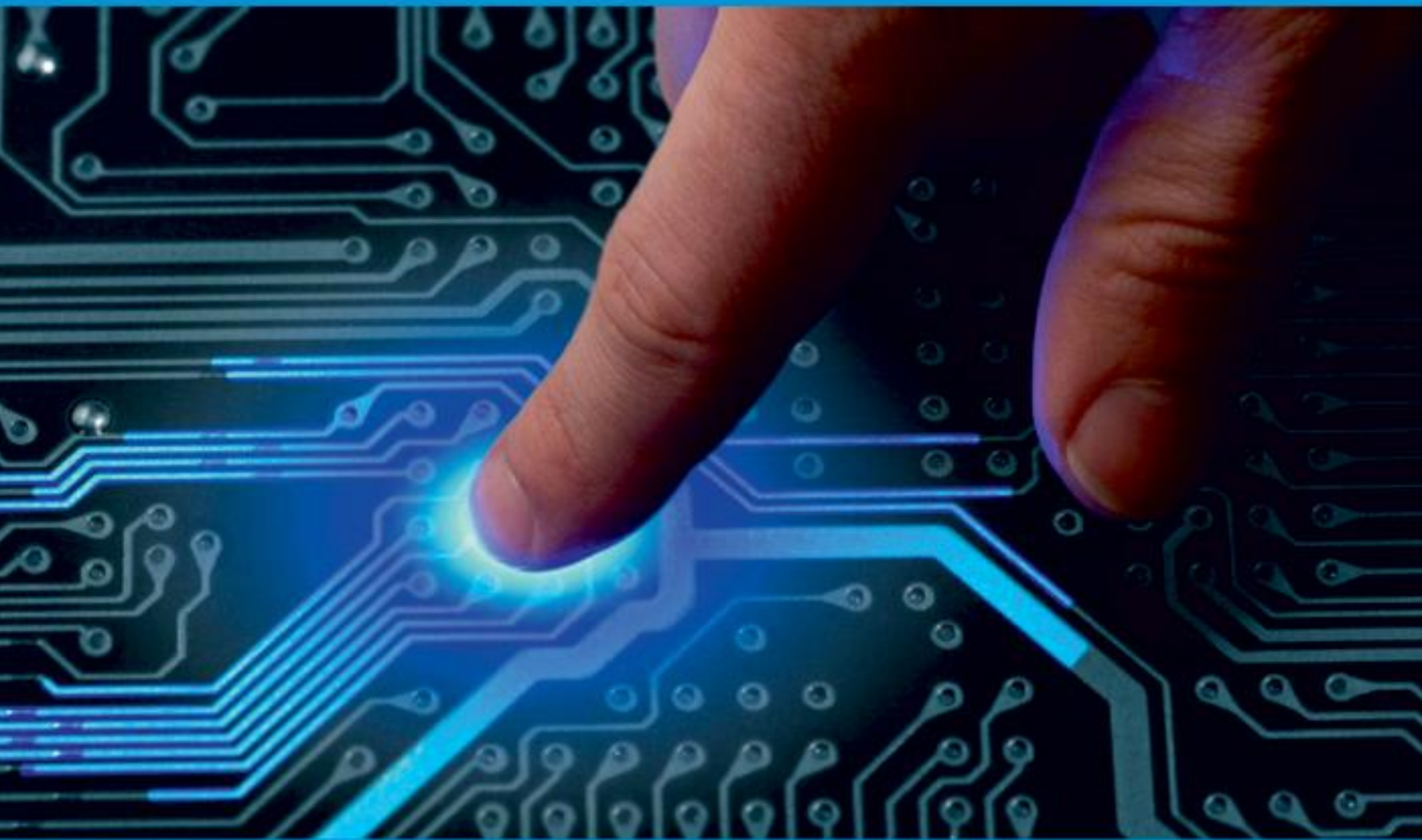

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Design & Development of AGV (Automated Guided Vehicle) for Industrial Applications

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ABSTRACT: The use of Autonomous Guided Vehicle (AGV) robots, particularly line-following robots, has developed as a method for optimising products transit in industrial and office environments. These robots use radio frequency identification (RFID) and infrared (IR) sensor technology, as well as the Arduino Uno microcontroller, to recognise and navigate lines precisely. The infrared sensor distinguishes between surface properties to properly trace lines, and RFID technology improves navigational skills by recognising specific items or destinations via RFID tags. The Arduino Uno, when programmed with this information, adjusts motor speeds and performs actions accordingly, helping to create efficient and autonomous transportation systems. This innovative approach not only underscores the significance of AGV robots in industrial automation but also highlights the potential of integrating RFID technology for enhanced navigation and stopping mechanisms, fostering precise transportation within industrial *and commercial environments.*
Keywords: AGV-Autonomous Guided Vehicle, RFID- Radio Frequency Identification, IR-Infrared.

I. INTRODUCTION

Manual transportation methods frequently fail in today's dynamic industrial, office, and healthcare environments, resulting in inefficiencies and potential mistakes in vital procedures. Whether it's the transportation of items along assembly lines in factories or medical supplies in hospitals, relying on manual handling can cause delays and issues [1-3]. To address these issues, the use of automated technologies, particularly Automated Guided Vehicles (AGVs), has grown more widespread. Among these, line-following robots are notable for their potential to expedite transportation procedures and improve operational efficiency.

The development of AGVs marks a significant leap forward in automation, driven by the pressing need for efficiency, reliability, and safety across various industries. From revolutionizing material handling in the automotive sector to optimizing inventory management in warehouses, AGVs equipped with sophisticated navigation systems like RFID and IR sensors, alongside intelligent control algorithms, are reshaping traditional transportation paradigms. Despite the continued use of manual methods, their vulnerability to inefficiencies and mistakes emphasizes the need for automated solutions. This study aims to fulfil these imperatives by focusing on the design and deployment of an industrial line follower robot that incorporates cutting-edge technology to demonstrate its capabilities in accurate navigation and task execution across a variety of operating environments. Through thorough design, development, and testing procedures, the project intends to prove the usefulness of AGVs in solving transportation problems and increasing operational efficiency in real-world settings.

Several researches have looked at the design and deployment of line-following robots. Some focus on using Bang-Bang controllers [4], while others investigate PID controllers [5-7], [8]. Furthermore, research has focused on kinematic modelling and control methodologies for differential drive mobile robots [9, 10]. Trajectory control approaches for mobile robots have been thoroughly described in [11], which uses mathematical modelling and differential drive kinematics. In the context of trajectory control, error computation based on angular departure from the straight route is critical, with the error feeding into the PID controller to provide suitable control signals. Researchers have written publications about the design of line-following robots. Some just consider the Bang-Bang controller, whereas others consider PID controllers [12], [13]. [14] and [15] presented kinematic models and control for Differential Drive mobile

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robots. [16] talks about trajectory control for mobile robots. We have provided mathematical and differential drive kinematics models for trajectory control. The error is computed based on the angular deviation from the straight line and sent into the PID controller. The controller provides the appropriate control signal to the actuator, bringing the error to zero.

II.METHODOLOGY

- **Design and System Architecture**

The first step entails designing the robot's architecture, establishing system requirements, and choosing suitable components and technologies. Integration of RFID and IR sensors, motor control systems, and the Arduino Uno microcontroller are all important concerns.

- **Hardware Development**

This phase focuses on assembling components and constructing the physical prototype. Integration of motors, sensors, power supplies, and the microcontroller onto a suitable chassis platform is executed with attention to wiring, connectivity, and component placement.

- **Software Implementation**

Programming the Arduino Uno microcontroller to control navigation, sensor data acquisition, and decision-making processes occurs concurrently with hardware development. Algorithms for line detection, tracking, obstacle avoidance, and RFID tag identification are developed and optimized.

- **Testing and Validation**

Comprehensive testing protocols are devised to evaluate navigation accuracy, response time, sensor reliability, and system robustness. Real-world scenarios and simulated environments are utilized to validate capabilities and identify improvements.

- **Data Collection and Analysis**

Data collection mechanisms are employed to gather quantitative and qualitative performance metrics. Sensor readings, motor control signals, and operational parameters are recorded and analyzed to assess behavior under various conditions.

- **Iterative Optimization**

Based on testing findings, iterative optimization cycles refine the robot's design, algorithms, and operational parameters. Feedback from stakeholders and end-users is incorporated to enhance performance and usability.

The objectives of this paper is as follows, Automated Guided Vehicles (AGVs) play a crucial role in material handling within manufacturing environments, facilitating the efficient movement of materials or parts throughout production lines or workstations. However, integrating AGVs with other robots and sensors poses a challenge, necessitating the development of distributed computer system architecture to achieve seamless data fusion.

Another problem is establishing collaboration between AGVs and manufacturing workers. To overcome this, ways must be created to allow people and robots to collaborate and interact in the industrial environment.
Speed and mobility provide additional issues, as AGV capabilities, such as reverse driving and turning radius, are specified by manufacturers. AGVs missing rear-facing sensors may have limited speed and maneuverability. To address this issue, acquiring AGVs with rear-facing sensors and zero-turn radius capabilities can boost efficiency. Alternatively, limiting speed and optimizing navigation for cargo pickups and drop-offs can improve AGV performance.

Fleet management poses its own set of challenges, as AGVs rely on maps of the factory floor to navigate obstacles. However, AGV sensors may misinterpret storage racks with legs as passable passages, leading to potential accidents. Proper programming to recognize rack legs or adding low walls to rack legs can address this issue, ensuring safe and efficient fleet management.

Overall, addressing these challenges requires a combination of technological innovation, strategic planning, and effective programming. By overcoming these obstacles, AGVs can significantly enhance material handling processes in manufacturing environments, leading to increased efficiency and productivity.

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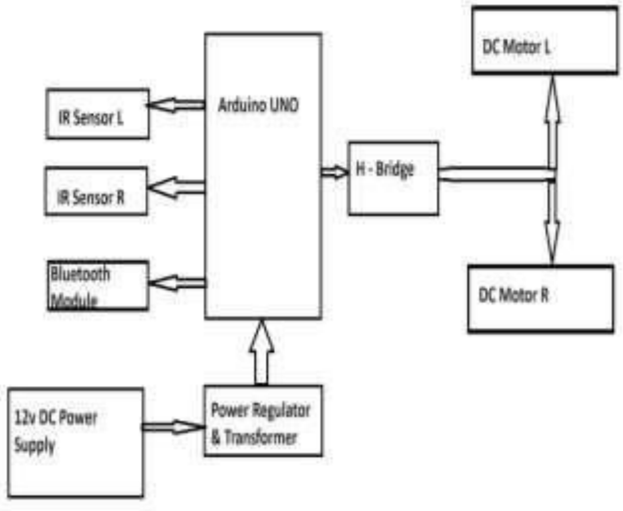

Fig. Block Diagram

Components

- Arduino UNO
- Regulated Power Supply/Transformer
- Jumper Wires
- Motor Driver Circuit
- DC Motors
- Track wheel
- Chassis
- Battery
- IR Sensors
- Bluetooth Module

Algorithm

Algorithm: Industrial Line Follower Robot Operation

1. Initialize Components:
- Initialize IR sensors, RFID readers, motors, and other components.
- Set up communication interfaces (Serial, Software Serial).

2. Setup Function:
- Initialize pin modes for sensors, motors, and peripherals.
- Initialize LCD Display.
- Display initial messages on LCD screen.

3. Main Loop (Loop Function): - While True:
- Check for incoming commands from Serial interface. - Execute corresponding path function based on received command.

4. Path Functions: - Path1 to Path8:
- Display current path on LCD screen.
- Continuously perform line detection and lane following.
- Perform RFID scanning at predefined intervals or triggered events.
- Execute actions based on detected RFID tag.
- Repeat until end of path or stop condition.

5. Lane Detection Function: - While True:
- Monitor IR sensor states for line color detection.
- Determine movement direction based on sensor readings.

6. RFID Scanning Functions: - While True:
- Perform RFID scanning when triggered by path functions.

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- Read RFID tag data from RFID reader.
- Compare read tag data with predefined values.
- Execute actions based on detected RFID tag.

7. Movement Control Functions: - Forward, Reverse, Left, Right:

-Control motor direction and speed for smooth movement.

-Adjust motor parameters based on lane detection and RFID scanning.

8. Stop Function: - Stop:

- Halt all robot operations.
- Reset system if necessary.

9. Error Handling:

- Implement mechanisms to handle sensor failures, communication errors, or invalid commands.
- Display error messages on LCD screen if encountered.

10. Cleanup and Shutdown:

- Perform necessary cleanup operations before system shutdown.
- Release resources and close communication interfaces.

End Algorithm

Fig. Flowchart

III.RESULTS

1. Path Selection via Bluetooth Communication: - The AGV successfully receives path selection commands from a remote controller via Bluetooth communication

- Commands transmitted wirelessly allow for flexible and convenient route selection, enhancing system usability and operator control.

2. Lane Detection and Following:

-IR sensors accurately detect variations in surface color, enabling the AGV to follow predefined paths with precision.

-Real-time lane detection ensures continuous tracking and adjustment of the AGV's trajectory, maintaining alignment within the designated route.

3. RFID-Based Navigation:

-The RFID reader effectively scans RFID tags placed along predefined paths, allowing the AGV to autonomously navigate and verify its location. - Each RFID tag's unique identifier is recognized by the AGV, triggering appropriate actions such as turning or stopping as per predefined instructions

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4. Motor Control and Manoeuvrability: - DC motors respond promptly to control signals from the motor driver, facilitating smooth acceleration, deceleration, and direction changes.
- The AGV demonstrates reliable manoeuvrability, executing turns and stopping manoeuvres with precision and stability.

5. System Integration and Reliability: - The integration of hardware components and software logic results in a cohesive and reliable AGV system.
- The system operates consistently under various conditions, demonstrating robust performance and resilience to environmental factors.

6. Operational Efficiency and Autonomy: - The AGV's autonomous navigation capabilities streamline operations and reduce the need for manual intervention.
- Efficient path following and RFID-based navigation contribute to overall operational efficiency and productivity in industrial and commercial settings.

7. Scalability and Customization:
-The modular design of the AGV system allows for scalability and customization to meet specific application requirements.
-Future enhancements and expansions can be easily integrated into the existing system architecture, ensuring adaptability to evolving needs and technologies.

Overall, the results demonstrate the successful development and implementation of an autonomous AGV system capable of reliable navigation along predefined paths, with potential applications across various industries for enhanced efficiency and automation.

Applications

- Industry Warehouses
- Office Environments
- Hospitals (Pandemic Time)
- Academic Institutions
- Manufacturing Facilities
- Retail Stores
- Airport Logistics
- Agriculture
- Smart Cities
- Logistics and Distribution Centers

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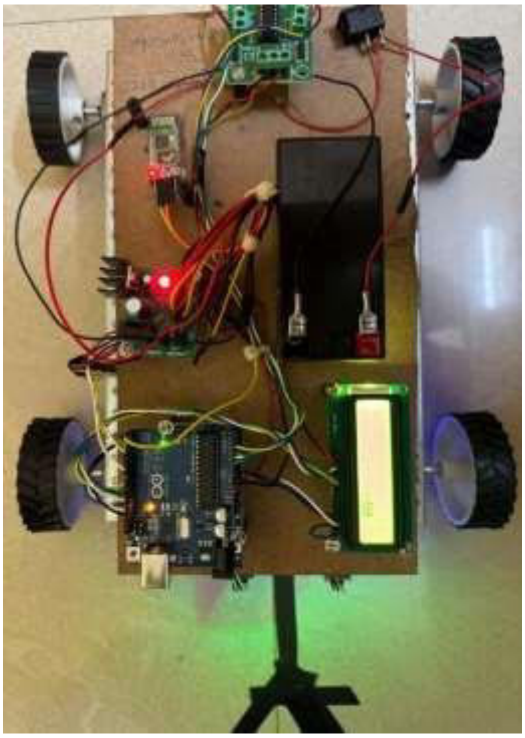

Fig. AGV(ON)

Fig. Bluetooth Connection (Setup Process)

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IV. CONCLUSION

The development and implementation of the Automated Guided Vehicle (AGV) system have met the project's objectives, providing an efficient and autonomous solution for navigating predefined paths in industrial and commercial settings. Integrated with components like Arduino Uno, Bluetooth module, RFID reader, and IR sensors, the AGV demonstrates robust functionality in path selection, lane detection, and RFID-based navigation. Utilizing DC motors ensures precise movement control, facilitating smooth traversal along designated routes. The system's architecture and code implementation ensure reliable performance, with RFID technology enhancing autonomy and navigation accuracy. The modular design allows for scalability and customization, making it suitable for various applications like warehouse automation and logistics. The AGV's success highlights its potential to revolutionize transportation and automation methods, offering increased efficiency and productivity in real-world scenarios. This project sets the stage for further advancements in autonomous vehicles and robotics, contributing to modern industrial automation solutions.

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