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Design and Development of an IR Sensor-Based Automated Guided Vehicle for Efficient Material Handling

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Abstract: This research presents the design and development of an IR sensor-based Automated Guided Vehicle (AGV) prototype for efficient and autonomous material handling. The AGV is designed to navigate through multiple stations using IR sensors, eliminating the need for manual intervention in the pickup, assembly, and delivery of components. At each station, the AGV collaborates with robotic arms to pick a shaft and pulley, perform assembly, and transport the final package to the designated endpoint. The system uses a set of IR sensors for path following, station detection, and object verification, combined with an Arduino Mega controller and a relay-driven motor **system. The solution offers a low-cost, reliable, and scalable automation system suitable for small-scale industrial applications.**

Keywords: Automated Guided Vehicle, IR Sensors, Arduino Mega, Robotic Arm, Path Following, Industrial Automation.

I. INTRODUCTION

Automation in industries is becoming increasingly important to boost efficiency, minimize human error, and streamline repetitive tasks. One critical area of focus is automated material handling, which often involves transporting components between different process stations. This research introduces a compact Automated Guided Vehicle (AGV) designed using IR sensors for navigation and interaction, offering a cost-effective and reliable solution for small-scale automation setups. The AGV operates in sync with robotic arms to perform material pickup, assembly, and delivery with minimal human assistance.

II. PROBLEM IDENTIFICATION

Manual methods of material handling such as human labor or forklifts are often inefficient, time-consuming, and error-prone. They require continuous supervision and are not easily adaptable to process changes. These limitations increase operational costs and reduce overall workflow efficiency. A sensor-based AGV can address these challenges by providing a flexible, autonomous, and safe alternative for transporting and processing materials.

III. OBJECTIVE

The objective of this project is to develop a fully autonomous AGV prototype that can:

1) Follow a defined path using IR sensors
2) Detect stations and perform logical stops
3) Interact with robotic arms for component pickup and assembly
4) Confirm object handling operations with IR feedback sensors
5) Operate without human intervention once initialized

IV. SCOPE OF THE PROJECT

1) Manufacturing and Warehousing
2) Material Handling: Automates transportation of components (shaft and pulley) between workstations
3) Assembly Integration: Supports robotic arms in real-time component handling and packing
4) Compact Storage Environments: IR-guided path following enables precise movement in tight layouts
5) Logistics and Distribution
6) Package Delivery: Final assembled box is transported to the endpoint without manual handling
7) Operational Efficiency: Reduces labor costs and improves throughput by automating repetitive tasks

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V. METHODOLOGY

A. System Design and Planning

The AGV's structure and control layout are conceptualized to ensure smooth motion, path accuracy, and stable operation.

B. Component Selection

Key components including DC motors, IR sensors, relay, and Arduino Mega are selected based on performance requirements.

C. Mechanical Fabrication

The AGV chassis is built to support multiple workstations and accommodate onboard electronics and battery systems.

D. Sensor Integration and Control

IR sensors are configured for:
Path following (2 sensors)
Station detection (1 sensor)
Object detection (2 sensors for shaft and pulley pickup, 1 for box detection)
A relay module controls motor switching through Arduino logic.

E. Programming and Logic Flow

The Arduino Mega is programmed to interpret IR sensor signals, control motors through relay switching, and sequence actions at each station.

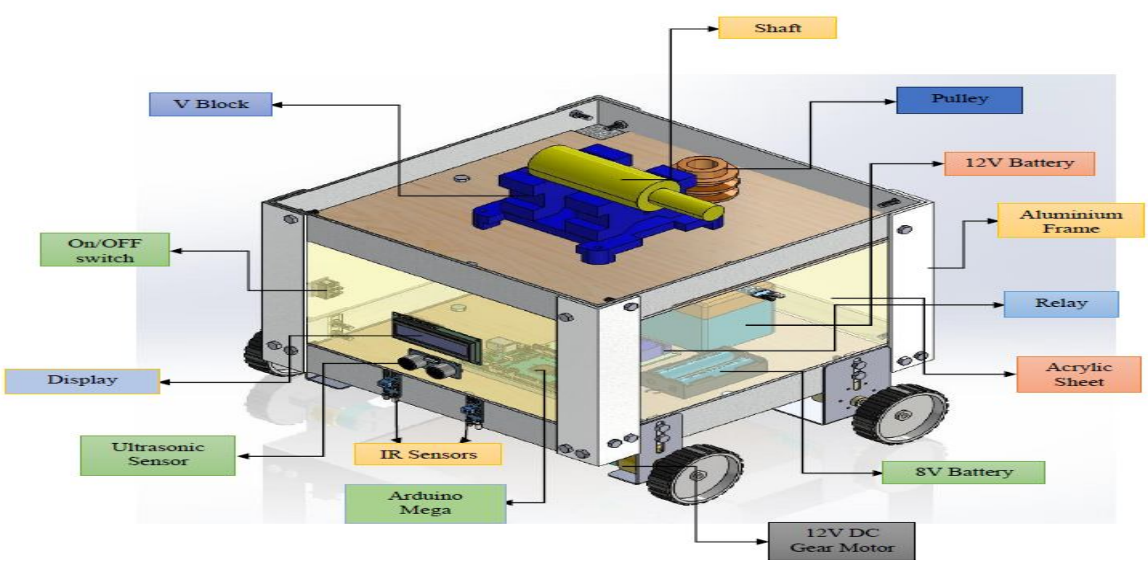
F. Testing and Optimization

The AGV is tested on a predefined path with all three stations. Logic is refined to improve stop accuracy, sensor reliability, and coordination with robotic arms.

VI. WORKING OF AGV SYSTEM

The AGV starts at its initial position and begins path-following using two IR sensors. It approaches Station 1, where an IR sensor detects the location, prompting the AGV to stop. A robotic arm picks up a shaft, and a separate IR sensor confirms the pickup.
Next, the AGV moves forward to Station 2, where it stops again using an IR sensor. A robotic arm picks up pulley from AGV, which is also confirmed via IR detection. The AGV then travels to Station 3, the assembly and packaging station.
At this station, the robotic arms assemble the shaft and pulley into a box and place it on the AGV. Another IR sensor confirms that the box has been placed. Once verified, the AGV moves to the final drop-off point, completing the cycle.

A. Design



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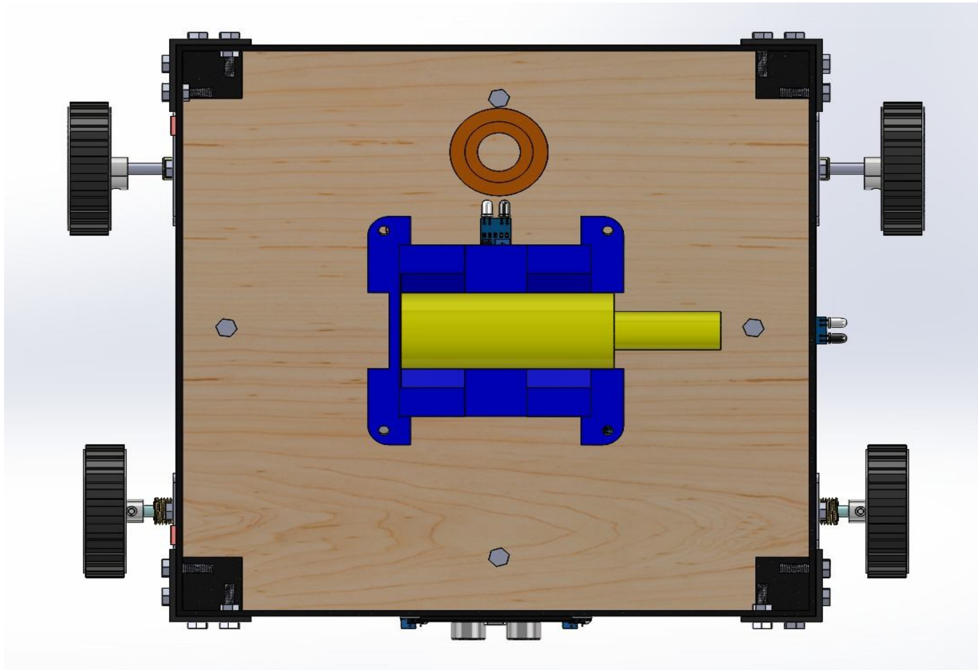
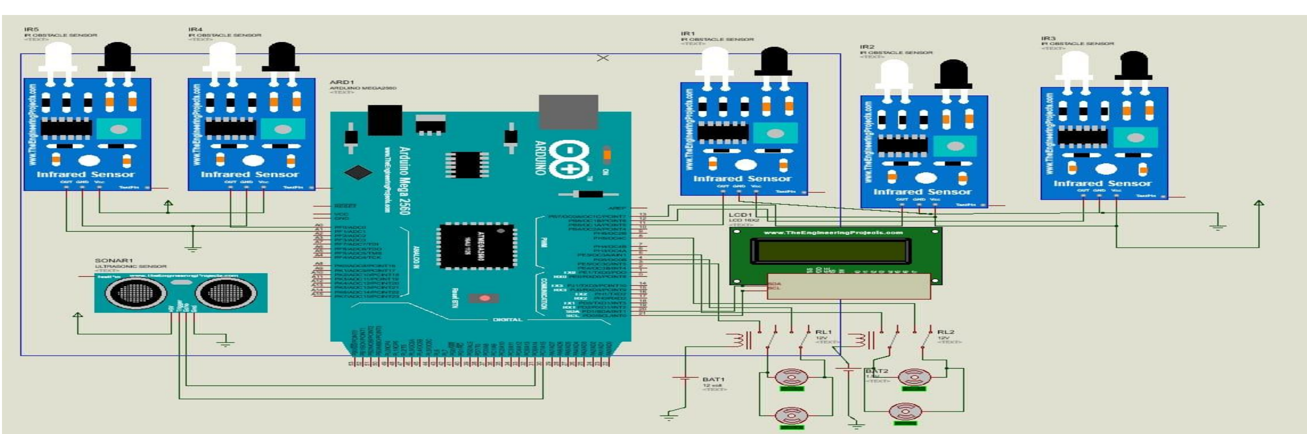
B. Top View



VII. COMPONENTS USED

Component	Specifications / Role
Arduino Mega	Microcontroller for logic control and I/O handling
4 × DC Motors	Drive system for movement and turning
1 × Relay Module	Controls direction and on/off switching of motors
5 × IR Sensors	2 for object detection (shaft & pulley), 1 for station detection, 2 for line following
1 × Voltage Sensor	Monitors battery voltage level
1 × Display Module	Displays system status (optional)
12V Battery	Powers the motors
8V Lithium-Ion Battery	Powers the Arduino and sensors
1 × Ultrasonic Sensor	Used for distance measurement and obstacle detection
2 × On /Off Switch	One for Arduino Mega and other for DC Motors

VIII. CIRCUIT DIAGRAM



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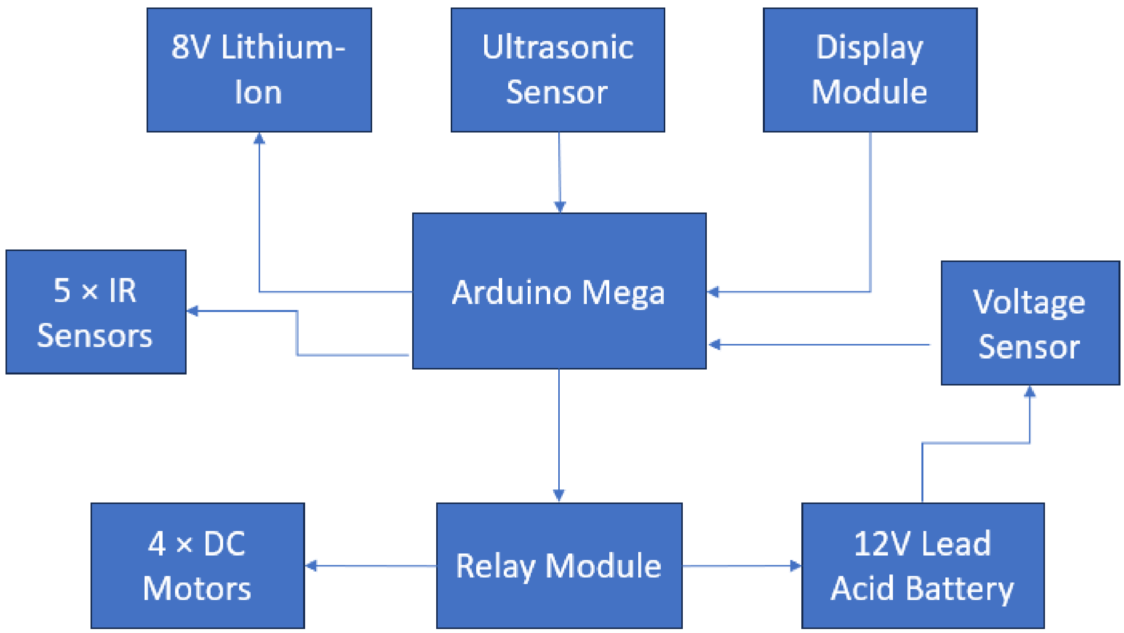
IX. BLOCK DIAGRAM



X. CONCLUSION

The developed AGV prototype offers a practical and efficient approach to material handling and assembly using a sensor-driven autonomous platform. With the integration of IR sensors and robotic arms, the system effectively reduces human involvement, improves accuracy, and increases workflow speed. Its modular design allows easy scaling and customization for various industrial setups. This IR-based solution is especially suited for small-to-medium automation tasks where low cost, simplicity, and flexibility are key.

XI. ACKNOWLEDGMENT

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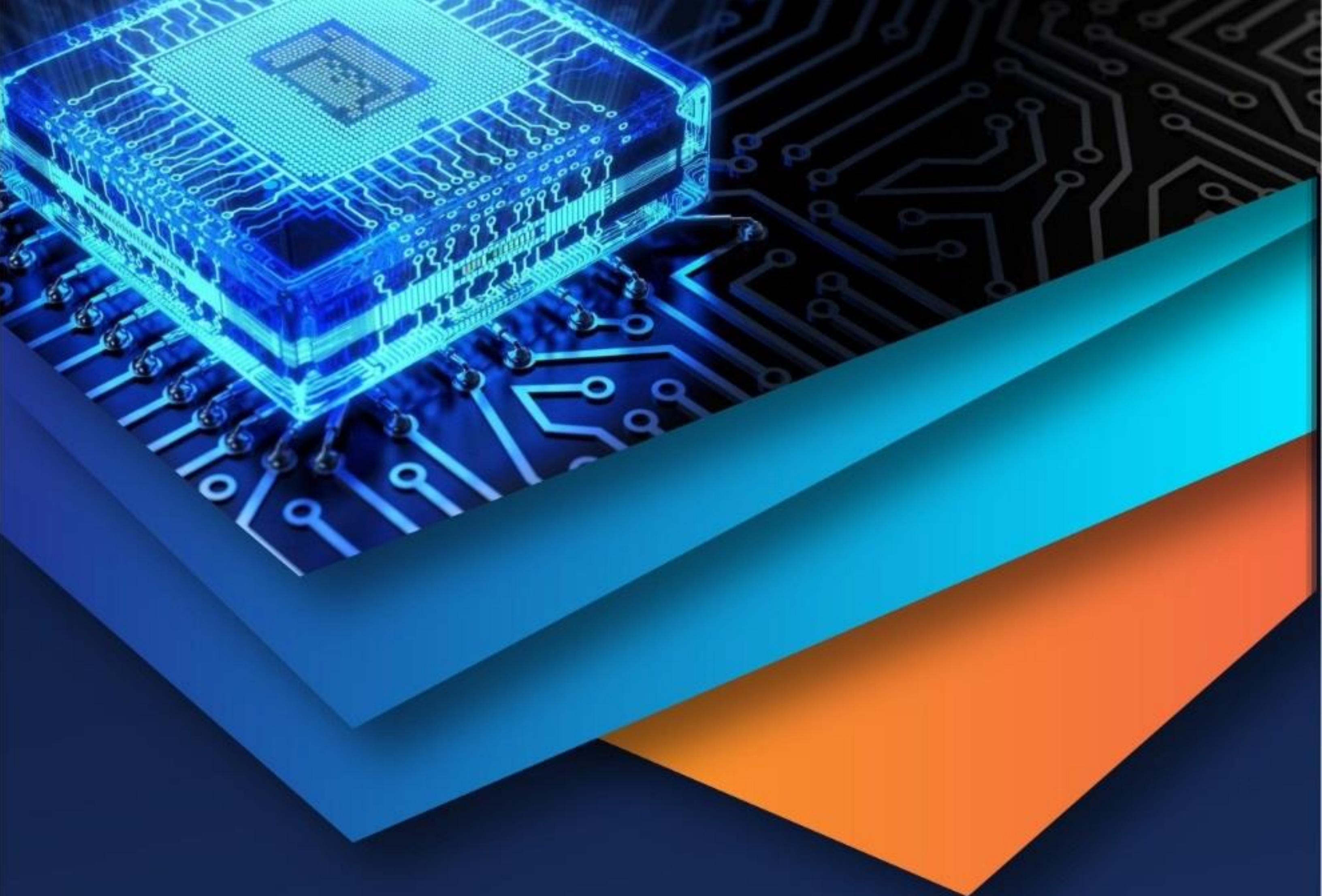

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