This Article is under Formatting; the PDF's ready file will be replaced soon.

Trends in Mechanical Engineering & Technology

Volume - 16, Issue - 2, Year – 2026

ISSN No.: 2231-1793

Research Article

Received Date: 13 January 2026

Accepted Date: 6 April 2026

Published Date: 13 June 2026

Intelligent Automated Guided Vehicle (AGV) System for Optimized Material Handling

Karan R. Wadalkar[1], Prasad V. Salunke[2], Pratik S. Satalkar[3], Sayli J. Tambe[4], Abhinandan Kondekar*[5], Naveen Kumar[6]

[1]Student, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, India
[2]Student, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, India
[3]Student, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, India
[4]Student, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, India
[5*]Student, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, India
[6]Student, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, India
Corresponding author's email id: tnpabhinandan@sanjivani.org.in

Abstract— This project is the development of an Automated Guided Vehicle (AGV) system that has been developed to handle materials in the high-accuracy, reliability, and efficiency in industrial settings. The AGV is a combination of a blend of advanced technologies including sensor fusion, real-time path planning, and AI-based navigation to allow smooth and intelligent operation with minimal human intervention. The vehicle is able to efficiently identify, and evade obstacles by using a combination of sensors, such as RADAR sensors, computer vision systems and dynamically plan the most optimal routes in changing and uncertain environments. A hybrid control approach is adopted to increase adaptability and performance, which involves machine learning algorithms with a rule-based motion planning. This will enable the AGV to react intelligently to real time conditions and still retain stability and precision in its movements. The Internet of Things (IoT) capabilities further enhance the system by providing the possibility of remote monitoring, the ability to schedule preventative maintenance and the ability to centrally manage multiple AGVs in a networked industrial environment. The proposed system has several advantages in that it enhances speed in transportation of material, decreases reliance on human labor, minimizes human error, and lowers operational costs. It is especially useful in the manufacturing and warehouse setting where efficiency and consistency are very important. As experimental evidence shows, the developed AGV is capable of successfully carrying the payloads of up to 4 kg along the predetermined routes and maintaining the stable and reliable performance. It also displays good obstacle detection and avoidance systems as well as easy navigation during various surface conditions. The strength,

adaptability, and scalability of the system has made it a prospective solution to the modern automated material handling programs.

Keywords— Automated Guided Vehicle, Navigation, Sensor Integration, Industrial Automation, IoT, Smart Logistics, Motion Planning.

---

1. Introduction

Automated Guided Vehicles are remote controlled machines made to help with moving materials around in industries, factories, warehouses, and other places. They use different types of navigation, like optical sensors or built-in smart systems, that let them move accurately and efficiently without human effort [1, 2]. With more and more industries going towards automation, AGVs are becoming an important part of the system. they help make things faster, reduce costs, and improve safety too. You'll find AGVs being used in many areas, like warehouses, electronic assembly lines, and even in risky places where it's not safe for people to work [3-6]. Big industries have started using AGVS to make their production lines run quicker. And as industries keep growing and taking on more difficult tasks, AGVs are turning out to be a reliable, efficient, and cost-effective way to handle the daily life job of moving materials from one point to another.

1.1. Problem Definition

During our college days, we noticed something simple but interesting some of the staff were constantly walking from one class to another just to move files. It's repetitive, and that's where the idea came to us: What if we had a small automated vehicle that could handle these tasks?

In many industries and even on campuses, moving materials from one place to another is still done mostly manually. Whether it's carrying files, tools, or raw materials, a lot of human effort is involved. This not only takes up time but also causes delays and increases the chances of errors or accidents.

The problem becomes even bigger in large industries or warehouses, where depending on human efforts for such tasks can lead to [7-10]:

- Delays in deliveries.
- Risk of injuries from carring loads
- Difficulty adapting to frequent layout changes in busy environments

2. Graphical Development of AGV:

AGV was designed using CAD Software. Github link contains Designs of AGV Parts, Including Dimension of parts, Assembly and 3D Design Images: **https://github.com/SayliTambe/AGV-Designs**

2.1 Laser Cutting of AGV Parts

- ❖ Design of Components: CAD Software was used to make the components of the AGV.
- ❖ Selection of Material: Acrylic Material Were Chosen for Their Properties.
- ❖ File Conversion: Designs were converted into DXF format for compatibility with laser cutting machines.
- ❖ Laser Cutting Process: Machine parameters such as power, speed, and focus were optimized for accurate cutting.
- ❖ Post-Processing: Cut parts were cleaned, smooth edges, and holes/slots were verified for alignment. Laser cut parts are shown in Figure 1.

Figure 1. Laser Cut Parts

In this project Acrylic material is used. The properties of Acrylic material, such as tensile strength of material used, Speed and Temperature are provided in Table 1.

Table 1. Properties of Acrylic material

Properties	**Value**
Tensile strength of acrylic material	Around 60-80 MPa
Flexural Strength of Acrylic Material	Range of 100 – 120 MPa
Elongation at Break	Around 2-5%
Density	Approx. 1.18 g/cm^3
Glass Transition Temperature (Tg)	Around 105°C

Laser Cutting Speed	Varies based on thickness
Melting Temperature	Between 130 - 140°C
Coefficient of Thermal Expansion	Approx. 70 – 80 x 10-6/°C

2.2 Integration of AGV Parts

The steps followed are:

- ❖ Assemble the chassis of the AGV and mount the components securely onto it.
- ❖ Connect 12V motors to the motor driver, ensuring the polarity for forward and reverse motion.
- ❖ Interface the motor driver with the Arduino UNO Microcontroller. The pins are connected to Arduino's output pins to control the motors' direction and speed using PWM signals. The pin-out in brief is provided in Table 2.

Table 2: Connection of Components with Arduino/Pixhawk

Component	**Connected To**	**Pin Number/Port**
L298N Motor Driver	Arduino UNO	IN1 → D7, IN2 → D8, IN3 → D9, IN4 → D10
GPS M8N Module	Pixhawk 2.4.8	GPS Port
ESP8266 Wi-Fi Module	Arduino UNO	TX → D2, RX → D3
TFLuna Radar Sensor	Arduino UNO / Pixhawk	UART (TX/RX)
Buzzer	Arduino UNO	D12
12V Motor	L298N Motor Driver	Motor Output
Lead Acid Battery	Power Supply	12V Input
FlySky RC Receiver	Pixhawk 2.4.8	RC Input Port

- ❖ The Pixhawk 2.4.8 is mounted centrally and configured for high-level navigation control. It interfaces with the GPS and other sensors to determine path and orientation.

- ❖ Connect the M8N GPS module to the Pixhawk for real-time location tracking and path following.
- ❖ Integrated the ESP8266 Wi-Fi module with Arduino UNO to enable wireless communication and Monitoring.
- ❖ Power is supplied using a Lead-Acid Battery and voltage regulators are used to supply 5V and 3.3V where it is needed.
- ❖ Connect the TFLuna Radar Sensor for obstacle detection and distance measurement.
- ❖ The Buzzer is used as an alert to indicate low battery warnings or obstacle detection.
- ❖ The Flysky RC is used for Human control and override during testing.
- ❖ All grounds (GND) of components are connected to a common ground to maintain a stable reference and prevent erratic behavior.

2.3 Mission Planner Software (ArduPilot) – Usage in AGV Project

Mission Planner is a more powerful ground control software that is used for configuring, planning, and controlling autonomous vehicles like AGVs and drones with the help of GPS tracking. In this project, it was used to define points, configure parameters, and simulate the path of AGV on a real-world map. Mission planner software is shown in Figure 2.

Key features used:

- ❖ Live telemetry of the vehicle with simulation
- ❖ Real-world path planning.

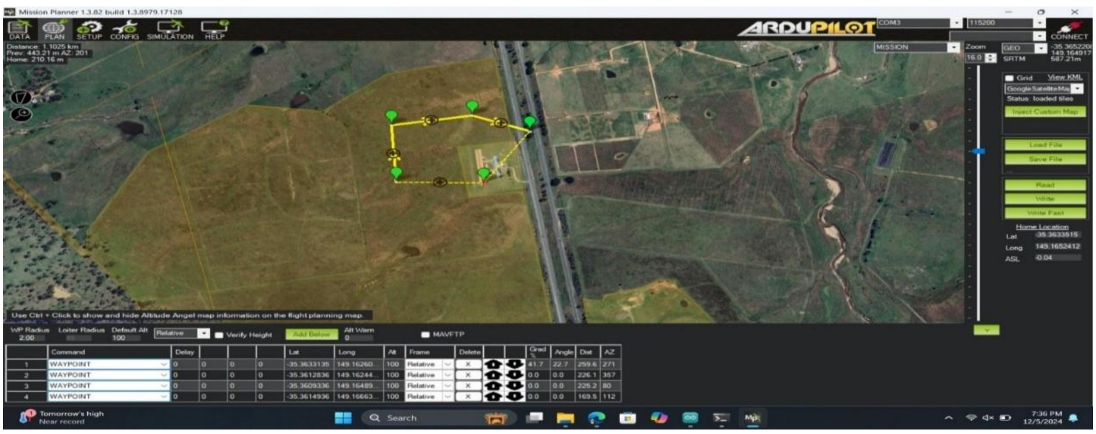

Figure 2. Mission Planner Software

2.4 Circuit Diagram for AGV using Pixhawk and Arduino

Circuit Diagram Overview

- The AGV is powered by a 12V Lead Acid Battery and a LiPo battery, regulated via a power module.
- Pixhawk 2.4.8 acts as the main controller, managing all motor controllers and GPS data.
- Arduino Uno is used for sensor integration or logic support.
- L298N Motor Driver controls DC motors based on signals from Pixhawk.
- GPS module with compass provides real-time navigation data.
- All components are properly connected for smooth power flow and communication. Software circuit integration is shown in Figure 3.

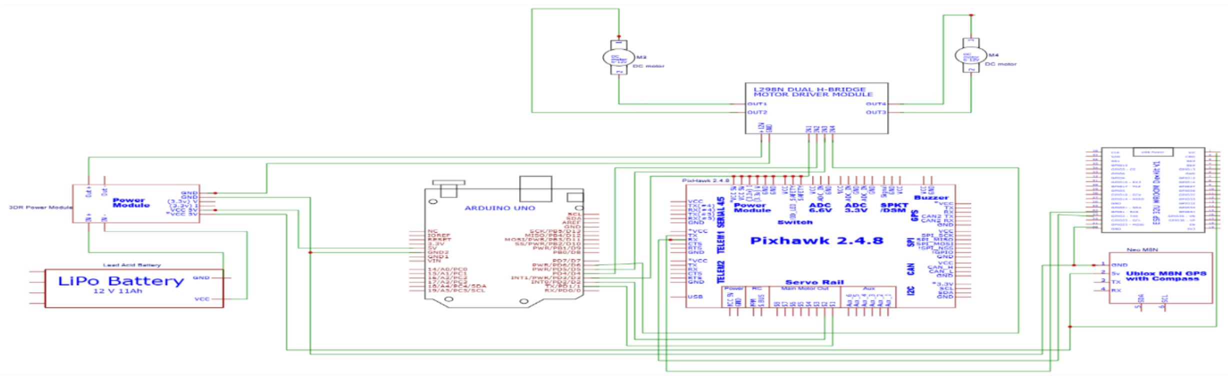

Figure 3. Software Circuit Integration

3. Kinematics of AGV

The motion of an Automated Guided Vehicle (AGV) can be analyzed using differential drive kinematics. The Movement of AGV depends on the velocity of the wheels on both sides.

Let:

- v = Linear velocity of the AGV
- w = Angular velocity of the AGV
- r = Wheel Radius
- L = Distance between left and right wheels
- wL = Left wheel Speed of AGV
- wR = Right wheel Speed of AGV

The equations for the AGV's motion are:

$$\mathbf{v = (r / 2) * (wR + wL)}$$
$$\mathbf{w = (r / L) * (wR - wL)}$$

Equations allow us to compute the Linear and Angular motion of the AGV. By varying the speed of all wheels, AGVs can move softly or turn in a specific direction.

4. Results and Observations

The Created AGV successfully shows the movement and obstacle detection using a Radar sensor. Whenever an obstacle is detected, it is used to stop or turn with the help of a radar sensor when the destination is reached. It takes the signal from the receiver and transmits it to the AGV for path detection.

The structure of the AGV is built with acrylic sheets, which are lightweight so that the AGV can smoothly move in forward and backward directions.

Power supply through battery, motor drivers, Pixhawk microcontroller, and all the components were stable throughout testing. The system was able to run efficiently.

4.1 Performance Metrics

Performance metrics are shown in Table 3.

Table 3: Performance Metrics

Parameter	**Value**
Average Speed	0.6 m/s
Load Capacity	Upto 4kg
Obstacle Detection Range	Approx. 1.5 meters (Radar)
Accuracy in Navigation	93% route-following accuracy
Charging Time	4 hours (Lead Acid Battery)
Battery Backup	~3 hours

4.2 Comparative Analysis

Comparative Analysis is shown in Table 4.

Table 4: Comparative Analysis

Feature	Existing AGV 1	Existing AGV 2	Proposed AGV
Navigation Type	Line Following	RFID Based	GPS + Radar
Obstacle Avoidance	Basic (IR only)	None	Radar Sensor
IoT Integration	Not available	Not available	Yes

Load Capacity	2-3 Kg	3 Kg	4 Kg
Battery Backup	1.5–2 hours	2 hours	~3 hours

4.3 Advantages of AGVs

- Reduces manual labor
- Increases efficiency and safety

4.4 Disadvantages of AGVs

- High initial cost
- Difficult for maintenance

4.5 Future Scope

- Uses a RADAR Sensor for obstacle avoidance
- It improves battery life and self-charging Devices

5. Conclusion

In this project, Automated Guided Vehicle (AGV) designed for material handling is built and tested successfully, showing just how powerful automation can be in modern industrial settings. Main goal of this project was to create an AGV that could move materials along set paths with very little human help, using a combination of smart electronics and strong mechanical components.

- Pixhawk microcontroller and RADAR sensor enabled smooth and adaptive operation, even in changing or dynamic environments.
- The AGV features a robust frame structure, allowing it to move efficiently over various and uneven surface types.
- It can transport payloads up to 4 kg consistently along a predefined route.
- The system maintains stability and performance without compromise, regardless of terrain.
- Due to its efficiency, compact design, and autonomous operation, the AGV is well-suited for integration into Industrial settings, Warehousing systems, Automated production lines, etc.
- It presents a cost-effective and scalable solution for smart material handling and logistics.

References

1. M. A. Goodarzi, H. Askarpoor, and A. Shariatmadar, "Design and implementation of an Arduino-based AGV for warehouse automation," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 6, no. 3, pp. 202–208, 2017.

2. G. Singh and M. Arora, “Development of AGV for Small-Scale Manufacturing Units,” International Journal of Innovative Research in Science, Engineering and Technology, vol. 7, no. 5, pp. 5242–5247, 2018.

3. M. Vishnu, V. S. Mohan, “Design and Fabrication of Automated Guided Vehicle (AGV) for Industrial Purpose,” International Journal of Engineering Research and Applications, vol. 8, no. 4, pp. 41–45, April 2018.

4. N. Kumar, P. Sharma, “Obstacle Avoiding and Path Detecting AGV using IR Sensors,” International Research Journal of Engineering and Technology (IRJET), vol. 6, no. 6, pp. 1102–1105, June 2019.

5. D. J. Dailey, Ed., Advances in Artificial Transportation Systems and Simulation. Amsterdam, Netherlands: Elsevier, 2012. [Online]. Available: https://www.sciencedirect.com/book/9780123970411/advances-in-artificial-transportation-systems-and-simulation

6. J. Borenstein and Y. Koren, “The vector field histogram—fast obstacle avoidance for mobile robots,” IEEE Transactions on Robotics and Automation, vol. 7, no. 3, pp. 278–288, June 1991.

7. S. Thrun, W. Burgard, and D. Fox, Probabilistic Robotics. Cambridge, MA, USA: MIT Press, 2005.

8. R. Siegwart, I. R. Nourbakhsh, and D. Scaramuzza, Introduction to Autonomous Mobile Robots, 2nd ed. Cambridge, MA, USA: MIT Press, 2011.

9. L. E. Parker, “Path planning and motion coordination in multiple mobile robot teams,” in Handbook of Robotics, B. Siciliano and O. Khatib, Eds. Berlin, Germany: Springer, 2016, pp. 133–154.

10. M. Quigley, K. Conley, B. Gerkey, J. Faust, T. Foote, J. Leibs, R. Wheeler, and A. Y. Ng, “ROS: An open-source Robot Operating System,” in Proc. IEEE Int. Conf. on Robotics and Automation Workshop on Open Source Software, Kobe, Japan, May 2009.