

AUTOMATED LINE MARKING ROBOT WITH REAL TIME SENSING AND CONTROL UNIT

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Abstract— Automation has become an essential part of modern infrastructure maintenance and industrial applications to improve efficiency, accuracy, and productivity. Line marking is a critical operation widely used in roads, parking areas, sports grounds, industrial layouts, warehouses, and institutional premises to ensure proper guidance, safety, and systematic movement. Conventional line marking methods are labor-intensive, time-consuming, and often produce inconsistent results due to human errors, uneven paint application, and excessive material wastage. To overcome these limitations, this study focuses on the design and development of an Automated Line Marking Robot with Real Time Sensing and Control Unit for precise and efficient line marking applications.

The proposed robotic system is developed to automate the line marking process using real-time sensing, control mechanisms, and programmable motion systems. The robot integrates major components including an Arduino-based control unit, DC geared motors, ultrasonic sensors, motor drivers, servo mechanism, battery system, and paint dispensing arrangement to achieve accurate and consistent line marking. Real-time sensing enables the robot to detect obstacles.

The fabricated prototype was tested under different operating conditions to evaluate movement stability, marking precision, obstacle detection, and paint consistency. Experimental results indicate that the developed system significantly reduces manual effort, improves marking uniformity, minimizes paint wastage, and enhances overall operational efficiency when compared to conventional manual methods. The robot demonstrates effective performance in marking straight and predefined paths with improved reliability and repeatability.

The developed automated line marking robot provides an economical, compact, and technologically advanced solution suitable for road marking, sports fields, parking spaces, industrial applications, and institutional infrastructure. The proposed system contributes toward smart automation by reducing labor dependency, improving precision, and increasing productivity in line marking operations.

Keywords— Automation, line marking robot, real-time sensing, Arduino IDE, ultrasonic sensor, control unit, robotic system, path tracking, industrial automation, smart mobility system.

I. INTRODUCTION

The advancement of automation and robotics has significantly transformed industrial operations, infrastructure maintenance, and transportation systems by improving efficiency, accuracy, and productivity. In recent years, automated robotic systems have increasingly replaced conventional manual methods to reduce human effort, minimize operational errors, and enhance performance. Among various maintenance activities, line marking is an important process widely used in roads, parking areas, sports grounds, warehouses, industrial facilities, airports, and institutional premises to provide guidance, safety, and systematic movement control.

Traditional line marking methods are generally performed manually using paint rollers, brushes, chalk powder, or spraying equipment. These conventional methods are labor-intensive, time-consuming, and highly dependent on skilled labor for maintaining alignment and uniformity. Human fatigue, inaccurate measurements, inconsistent paint flow, and improper path tracking frequently result in uneven markings and excessive material wastage. In large-scale applications such as sports fields, industrial layouts, and road infrastructures, manual marking often becomes inefficient and costly.

At present, line marking processes require frequent supervision and repeated corrections to maintain accuracy and consistency. Inaccurate markings can create confusion, reduce visibility, and negatively affect operational safety. Particularly in sports grounds and road applications, improper markings may influence movement control, navigation, and regulatory compliance.

With the rapid growth of smart automation technologies, robotic systems have emerged as an effective solution for overcoming the limitations of conventional line marking methods. Automated robots provide improved consistency, higher precision, reduced execution time, and minimized human intervention. These systems are capable of maintaining accurate path tracking and uniform material dispensing through integrated sensing and control mechanisms.

The **Automated Line Marking Robot with Real Time Sensing and Control Unit** is developed to provide an efficient, economical,

and reliable solution for automated marking applications. The proposed robotic system integrates an Arduino-based control unit, ultrasonic sensors, DC geared motors, BTS7960 motor drivers, servo motor mechanism, battery system, and paint or material dispensing arrangement to perform accurate and consistent line marking.

The real-time sensing system plays an important role in improving navigation and operational performance. Ultrasonic sensors continuously monitor surrounding conditions and detect obstacles during movement. Based on sensor feedback, the control unit adjusts motor movement and direction to maintain proper alignment and smooth path tracking. This significantly reduces operational errors and improves marking precision.

The robot operates using differential drive mechanisms controlled through programmed logic in the Arduino IDE. Pulse Width Modulation (PWM) signals regulate motor speed and directional movement, enabling the robot to execute straight and curved paths effectively. The servo-controlled dispensing mechanism ensures controlled release of marking material, thereby improving consistency and reducing wastage.

The developed system is compact, portable, and suitable for different applications including sports field marking, parking lot marking, industrial floor marking, warehouses, and institutional infrastructure. By automating the line marking process, the robot reduces labor requirements, minimizes downtime, improves marking accuracy, and enhances operational efficiency.

The present study focuses on the design, fabrication, programming, and testing of the automated line marking robot to evaluate its performance, sensing capability, movement accuracy, and practical feasibility. The proposed system aims to contribute toward intelligent automation and provide an economical solution for modern infrastructure maintenance applications.

II. LITERATURE REVIEW

A detailed literature review was carried out to understand the recent developments in automated robotic systems, sensing technologies, motor control mechanisms, and intelligent line marking applications. Several studies related to Arduino-based automation, robotic mobility, obstacle detection, and autonomous navigation were analyzed to identify suitable methodologies and technologies for developing the **Automated Line Marking Robot with Real Time Sensing and Control Unit**.

Yash Panchal et al. [1] proposed a smart dustbin system aimed at improving waste management

through automation using an Arduino Uno microcontroller, an HC-SR04 ultrasonic sensor, and a servo motor. The ultrasonic sensor detects nearby objects and automatically activates the servo motor to open and close the dustbin lid. The system demonstrated effective automation, ease of operation, and cost efficiency. This study provided useful insights into sensor integration and servo-based actuation, which influenced the sensing and control mechanism of the proposed line marking robot.

O. Sergeyeva et al. [2] developed a Wi-Fi-controlled mobile robotic platform using Arduino Nano and standard robotic components. The robot was designed with compact dimensions and integrated with a high-quality camera system for image transmission under different environmental conditions. The study emphasized flexibility, additional sensor integration, ease of navigation, and remote operation capabilities. The use of Arduino Nano and modular robotic architecture in this work contributed significantly to the controller selection and compact system design of the proposed robot.

Robots Khanam et al. (2019) [3] proposed the design and implementation of an automated field marking robot capable of converting graphical user input into navigational commands for autonomous field marking. The robot utilized servo motors for directional movement and chalk or paint dispensing mechanisms for marking operations. Image processing techniques were used to convert field layouts into coordinate points, enabling the robot to mark fields with an accuracy of approximately ± 5 cm over long distances. This study established a strong foundation for automated field marking and highlighted the importance of precision, repeatability, and terrain adaptability.

Impressco (2025) [4] proposed an automated robot for sports field line marking focused on cost-effective and semi-automated solutions for educational institutions and small sports facilities. The system incorporated an Arduino microcontroller with limestone dispensing mechanisms suitable for rough and inclined terrains. The research demonstrated the feasibility of automated line marking while reducing labor dependency and maintaining standard marking quality. This work emphasized affordability and ease of implementation, which influenced the low-cost design approach adopted in the present study.

IEEE Conference Paper (2024) [5] presented an automatic line marking robot integrated with ultrasonic sensors, wheel encoders, and PID control algorithms to improve trajectory tracking and movement precision.

The paint dispensing mechanism used a solenoid valve for controlled material release, while autonomous navigation was achieved through preloaded coordinates and sensor feedback. Experimental results showed high marking accuracy with minimal error margins, demonstrating the effectiveness of real-time sensing and control systems in robotic marking applications. This study significantly contributed to understanding path correction and automated movement control.

Melo et al. (2025) [6] proposed an efficient line detection method for robotic soccer systems using enhanced edge detection algorithms and RGB transition classification to improve line visibility under varying lighting and grass conditions. Optimization techniques such as Particle Swarm Optimization (PSO) were employed to improve detection efficiency while minimizing computational complexity. The research highlighted the importance of intelligent sensing and accurate line detection in autonomous robotic applications, which supports the development of improved navigation systems in automated marking robots.

From the literature survey, it is observed that automated robotic systems integrated with Arduino-based controllers, ultrasonic sensors, servo mechanisms, and intelligent control algorithms provide effective solutions for automation and precision tasks. However, there is still a need for an economical, compact, and efficient robotic system capable of performing accurate line marking with real-time sensing and minimal human intervention. Therefore, the present study focuses on designing and developing an **Automated Line Marking Robot with Real Time Sensing and Control Unit** to improve marking accuracy, operational efficiency, and automation.

III. EXPERIMENTAL SETUP

The experimental setup for the **Automated Line Marking Robot with Real Time Sensing and Control Unit** was designed to evaluate the operational efficiency, movement accuracy, sensing capability, and line marking performance of the developed robotic system. The setup involved the integration of mechanical, electronic, and control components to achieve automated movement and precise line marking with minimal human intervention.

The developed robotic platform consists of a mild steel

chassis integrated with a motorized drive mechanism, Arduino Nano controller, ultrasonic sensing system, BTS7960 motor drivers, Paint Pump, battery supply, and a line dispensing mechanism. The robot was fabricated to operate on different ground surfaces such as sports fields, parking areas, industrial floors, and institutional premises.

The mechanical frame of the robot was designed to ensure structural rigidity, movement stability, and ease of mobility. A mild steel sheet metal chassis was used due to its strength, durability, and cost-effectiveness. The structural dimensions were selected to maintain proper balance and smooth operation during movement and marking activities.

The movement of the robot is achieved through a differential drive system consisting of **12V DC geared motors (200 RPM)** connected to wheel assemblies. The differential drive mechanism enables the robot to perform straight movement, directional control, and smooth turning operations. Caster wheels were incorporated to improve stability and provide easy maneuverability during marking operations.

The electronic control system was developed using an **Arduino Nano microcontroller**, which acts as the central processing unit of the robot. The Arduino Nano processes input signals from sensors and controls the movement of motors and dispensing mechanisms through programmed instructions developed in the Arduino IDE environment.

For obstacle detection and real-time sensing, an **HC-SR04 ultrasonic sensor** was integrated into the system. The ultrasonic sensor continuously measures the surrounding distance using the Time-of-Flight (ToF) principle and provides feedback to the controller. Whenever an obstacle is detected within a specified threshold distance, the robot performs corrective actions such as stopping, changing direction, or navigation adjustment to ensure uninterrupted operation.

The **BTS7960 motor driver modules** were used to control the high-current requirements of the DC motors. The motor drivers receive Pulse Width Modulation (PWM) signals from the Arduino Nano and regulate motor speed and directional movement. Independent control of left and right motors enables differential steering and precise path tracking.

A **Diaphragm Self-Priming Paint Pump** mechanism was incorporated to control the line marking system. The pump regulates the flow of paint in a controlled and continuous manner during robot movement, ensuring uniform paint distribution and consistent line thickness.

The robot was powered using a **12V battery system**, which supplies electrical power to the motor drive system, controller, sensors, and dispensing mechanism. Proper power distribution and grounding arrangements were maintained to ensure smooth operation and avoid voltage fluctuations during working conditions.

The experimental trials were conducted under controlled conditions to analyze:

- Movement accuracy
- Obstacle detection capability
- Stability during operation
- Path tracking performance
- Consistency of line marking

Several test runs were performed on predefined paths to evaluate robot performance in straight-line movement, directional changes, and continuous marking operations. The collected observations confirmed that the developed system successfully performs automated line marking with improved precision, reduced manual effort, and consistent operational performance.

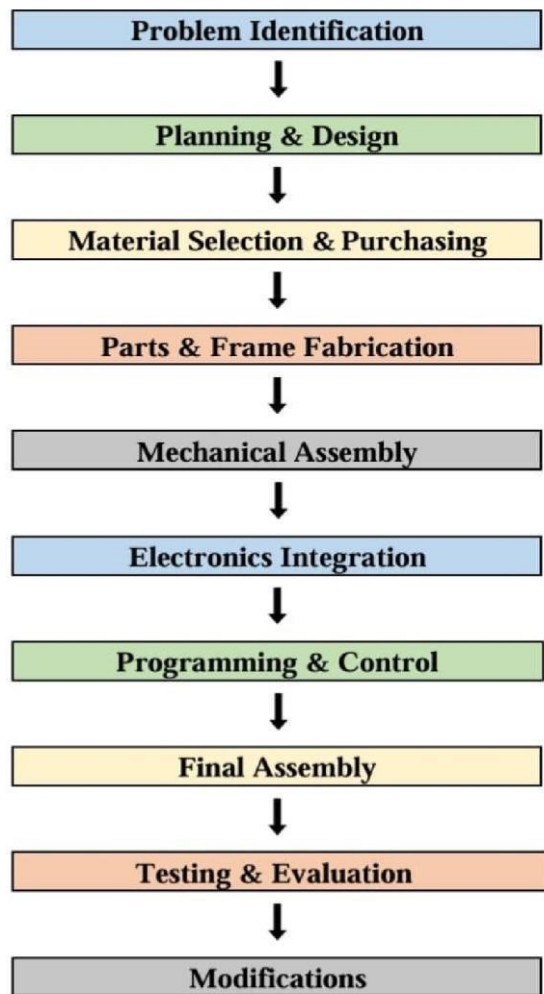


FIG.1: WORKING FLOWCHART.

IV. COMPONENTS

The following components were selected and integrated for the design and development of the **Automated Line Marking Robot with Real Time Sensing and Control Unit**. Each component plays an important role in ensuring smooth operation, movement control, sensing, obstacle detection, and accurate line marking performance.

1. Arduino Nano

The Arduino Nano acts as the central processing and control unit of the robotic system. It processes sensor inputs and controls motor movement, obstacle detection, and the marking mechanism through programmed instructions developed in the Arduino IDE. Due to its compact size, low power consumption, and ease of programming, Arduino Nano was selected for this project.

2. BTS7960 Motor Driver

The BTS7960 motor driver module is used to control the speed and direction of the DC geared motors. It receives PWM (Pulse Width Modulation) signals from the Arduino Nano and supplies the required current to operate the motors efficiently. The motor driver enables forward, reverse, and differential steering movement of the robot.

3. Ultrasonic Sensor (HC-SR04)

The HC-SR04 ultrasonic sensor is used for real-time obstacle detection and distance measurement. It operates based on the Time-of-Flight (ToF) principle by transmitting ultrasonic waves and measuring the reflected signal. The sensor helps the robot avoid obstacles and maintain smooth navigation during operation.

4. Diaphragm Self-Priming Paint Pump

The **Diaphragm Self-Priming Paint Pump** is incorporated to control the paint dispensing mechanism of the robot. The pump enables controlled and continuous flow of paint during the line marking operation, ensuring uniform paint distribution and consistent line thickness.

5. 12V DC Geared Motors (200 RPM)

The robot utilizes **12V DC geared motors with 200 RPM** for movement and navigation. These motors provide adequate torque and controlled speed necessary for smooth and stable operation of the robot during line marking activities.

6. 12V Battery

A **12V rechargeable battery** is used as the primary power source for operating the motors, sensors, controller, and other electronic components. The battery provides stable power supply and ensures uninterrupted operation of the robotic system.

7. Mild Steel Sheet Metal

Mild steel sheet metal is used for fabricating the robot chassis and supporting structure. It offers good strength, durability, rigidity, and ease of fabrication while maintaining cost-effectiveness.

8. Wheels and Caster Wheels

The wheel arrangement provides smooth mobility and movement stability. Caster wheels are incorporated to improve balancing and ensure easy directional movement during turning operations.

9. Connecting Wires and Electronic Accessories

Various connecting wires, switches, breadboards, connectors, and supporting electronic accessories are used for circuit integration, power distribution, and system connectivity.

V. METHODOLOGY

The methodology adopted for the development of the **Automated Line Marking Robot with Real Time Sensing and Control Unit** involves systematic stages including system design, component selection, mechanical fabrication, electronic integration, software programming, testing, and performance evaluation. The methodology was planned to ensure efficient movement, accurate line marking, obstacle detection, and smooth automation with minimal human intervention.

1. Project Design and System Architecture

Design Approach

An iterative engineering design approach was adopted to develop an efficient and reliable robotic system. The design process focused on integrating mechanical, electronic, and software systems into a compact and cost-effective robotic platform capable of performing automated line marking operations.

The system was designed to achieve:

- Accurate line marking
- Smooth movement and stability
- Real-time sensing capability
- Obstacle detection
- Controlled material dispensing
- Easy maintenance and operation

System Architecture

The robot follows a **closed-loop control system architecture**, where the **Arduino Nano microcontroller** continuously receives input data from the ultrasonic sensor and processes commands to control motor movement and the marking mechanism.

The control system performs:

- Sensor data processing
- Directional movement control
- Speed regulation through PWM signals
- Obstacle detection and correction
- Controlled operation of the dispensing mechanism

This architecture improves operational precision and enhances automation efficiency.

2. Mechanical Fabrication and Chassis Assembly

The chassis of the robot was fabricated using **mild steel sheet metal** due to its strength, durability, ease of fabrication, and low cost. The frame was designed to support all electronic and mechanical components while maintaining balance and movement stability.

Fabrication Procedure

The fabrication process included:

- Cutting sheet metal according to required dimensions
- Bending and shaping for structural rigidity
- Mounting motor supports and wheel assemblies
- Fixing sensor and controller positions
- Installation of dispensing mechanism

The **12V DC geared motors (200 RPM)** were securely mounted to provide differential drive movement. Caster wheels were installed to maintain stability and allow smooth directional movement during operation.

The marking mechanism was integrated with a Paint Pump to regulate the controlled release of paint or marking material for accurate line formation.

3. Electronic Hardware Integration

The electronic hardware integration involved assembling all electrical and electronic components into a functional robotic system.

Arduino Nano and Motor Driver

The **Arduino Nano** was used as the central controller to

process sensor data and execute movement commands. The **BTS7960 motor driver modules** were integrated to handle the higher current requirements of the DC motors.

The motor drivers receive PWM signals from the Arduino and regulate:

- Forward movement
- Reverse movement
- Speed control
- Differential steering

Ultrasonic Sensor Integration

The **HC-SR04 ultrasonic sensor** was installed to measure surrounding distance and detect nearby obstacles using ultrasonic waves.

Whenever an object is detected within the threshold distance:

- The robot stops automatically
- Direction correction is initiated
- Safe navigation is maintained

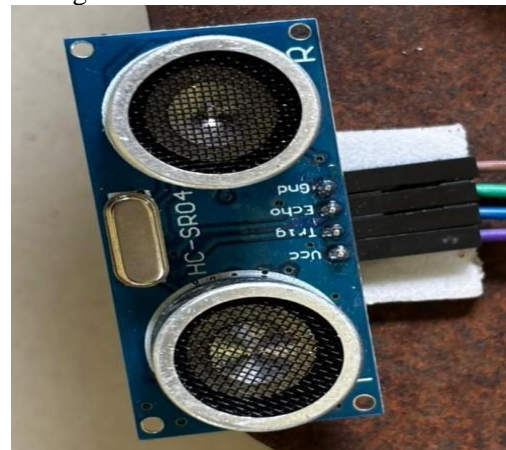


FIG.2: Ultrasonic Sensor.

Paint Pump Integration

A **Diaphragm Self-Priming Paint Pump** was incorporated to operate the line marking mechanism. The pump is used to deliver paint continuously and uniformly during robot movement. It regulates the paint flow efficiently, ensuring proper line thickness and reducing paint wastage.

The self-priming mechanism enables uninterrupted paint supply without the need for continuous manual intervention. The pump provides stable pressure for smooth paint dispensing, thereby improving marking consistency and operational reliability during line marking applications.



FIG.3: Diaphragm Self-Priming Paint Pump.

Power Supply

A **12V rechargeable battery** was used to supply power to the controller, motor drivers, motors, and sensing system. Proper grounding and voltage distribution were maintained for uninterrupted operation.



FIG.4: DC Motor Drivers.

4. Software Development and Control Algorithm

The robotic system was programmed using the **Arduino IDE (C/C++)** environment. The software logic was developed to ensure smooth movement, accurate navigation, and automated line marking.

Movement Control

The robot utilizes a **differential drive mechanism**, where independent control of left and right motors enables straight and curved movement.

PWM signals are used to:

- Regulate motor speed
- Maintain movement stability
- Improve directional accuracy

Obstacle Detection Logic

The ultrasonic sensor continuously measures surrounding distance. When an obstacle is detected:

1. The robot stops
2. Movement correction is performed
3. A new path direction is established

This prevents collision and ensures safe operation.

Line Marking Operation

During movement, the servo-controlled marking mechanism dispenses paint or marking material at predefined intervals to maintain consistent line thickness and uniform marking quality.

5. Testing and Validation

After fabrication and assembly, the robot was tested under different working conditions to evaluate overall system performance.

Functional Testing

The following tests were conducted:

- Motor speed testing
- Ultrasonic sensor response testing
- Battery performance verification
- Differential steering performance

System Integration Testing

Complete system testing was performed to verify:

- Robot mobility
- Path tracking performance
- Obstacle detection capability
- Stability during operation
- Consistency of line marking

The testing confirmed that the developed robotic system

successfully performs automated line marking with improved precision, reduced human effort, and efficient operational control.

VI. WORKING PRINCIPLE

The working principle of the **Automated Line Marking Robot with Real Time Sensing and Control Unit** is based on automated navigation, real-time sensing, motorized movement, and controlled marking operations using an **Arduino Nano** microcontroller. The system integrates sensors, motor drivers, Paint mechanisms, and DC geared motors to perform accurate and efficient line marking with minimal human intervention.

1. System Initialization

When the robot is powered ON, the **Arduino Nano microcontroller** initializes all connected components including the ultrasonic sensor, Paint Pump, motor drivers, and DC geared motors. The system checks the operational status of sensors and actuators before starting movement.

The control program loaded into the Arduino IDE begins execution and prepares the robot for navigation and line marking operations.

2. Movement and Navigation

The robot moves using a **differential drive mechanism**, where two **12V DC geared motors (200 RPM)** independently control the left and right wheels.

Based on programmed instructions:

- Both motors rotate at equal speed for straight movement
- Speed variation between motors enables turning operations
- PWM signals from Arduino regulate movement speed and directional control

This arrangement allows smooth navigation and accurate movement during line marking.

3. Real-Time Sensing and Obstacle Detection

The **HC-SR04 ultrasonic sensor** continuously measures the distance between the robot and nearby obstacles using ultrasonic wave transmission and reception based on the **Time-of-Flight (ToF) principle**.

When an object is detected within a predefined threshold distance:

- The sensor sends feedback to the Arduino Nano
- The robot automatically stops
- Direction correction or movement adjustment is initiated
- Collision is avoided and safe navigation is maintained

This real-time sensing capability improves operational safety and movement accuracy.

4. Motor Control Mechanism

The movement of the robot is controlled using **BTS7960 motor driver modules**, which receive Pulse Width Modulation (PWM) signals from the Arduino Nano.

The motor driver controls:

- Forward movement
- Reverse movement
- Speed regulation
- Directional steering

Independent control of the left and right motors enables smooth path tracking and stable robot operation.

5. Line Marking Operation

During movement, the robot performs line marking through a **Diaphragm Self-Priming Paint Pump mechanism**. The pump regulates the flow of paint in a controlled manner to ensure accurate and continuous marking during robot movement.

The line marking operation functions as follows:

- The robot follows the predefined path
- The **Diaphragm Self-Priming Paint Pump** activates automatically during movement
- Paint is supplied continuously and uniformly through the marking nozzle
- Consistent line width and spacing are maintained throughout the marking process

The self-priming pump ensures a smooth and uninterrupted paint supply, reducing paint wastage and improving marking accuracy.

6. Path Correction and Control

If deviation occurs during movement, the control system continuously adjusts motor speed based on sensor feedback.

The Arduino Nano:

- Monitors movement conditions
- Adjusts motor speed using PWM signals
- Corrects directional errors
- Maintains alignment during operation

This closed-loop control mechanism improves repeatability and ensures uniform marking quality.

7. Stopping Condition

The robot stops operation automatically when:

- The predefined marking distance is completed
- A stop command is received
- An obstacle interrupts movement
- Battery power becomes insufficient

This ensures safe and controlled operation of the robotic system.

Advantages of the Working Principle

- High marking accuracy and consistency
- Reduced manual effort
- Real-time sensing and obstacle detection
- Smooth automated navigation

VII. RESULTS AND DISCUSSION

The developed **Automated Line Marking Robot with Real Time Sensing and Control Unit** was successfully fabricated, assembled, and tested to evaluate its operational efficiency, movement accuracy, sensing capability, and marking performance. The experimental

analysis focused on assessing robot mobility, obstacle detection, marking consistency, control system performance, and overall automation efficiency.

The developed robotic system effectively integrates mechanical, electronic, and software components to perform automated line marking with minimal human intervention. The test results demonstrate satisfactory performance in terms of navigation, movement stability, sensing response, and marking accuracy.

1. Prototype Testing

Initial prototype testing was conducted to verify the functionality of individual components integrated into the robotic system.

The testing confirmed:

- Proper functioning of **12V DC geared motors (200 RPM)** for robot movement
- Accurate response of the **HC-SR04 ultrasonic sensor** for obstacle detection
- Stable operation of the **BTS7960 motor driver modules** during speed and direction control
- Reliable execution of programmed instructions through the **Arduino Nano microcontroller**

The results confirmed successful communication between hardware and software components.

2. Movement and Navigation Performance

The robot demonstrated smooth and stable movement using a **differential drive mechanism** controlled by PWM signals.

The navigation testing indicated:

- Smooth straight-line movement
- Accurate turning capability
- Stable movement on different surfaces
- Controlled directional adjustments

The independent operation of left and right motors improved path tracking performance and enabled efficient navigation during marking operations.

3. Real-Time Sensing and Obstacle Detection

The **ultrasonic sensing system** effectively detected nearby obstacles and enabled safe robot operation.

The sensor successfully:

- Measured surrounding distance accurately
- Detected obstacles within predefined threshold range
- Sent immediate feedback to the Arduino controller
- Triggered automatic stopping and movement correction

This real-time sensing capability improved operational safety and reduced the risk of collision during robot movement.

4. Line Marking Accuracy and Consistency

The servo-controlled marking mechanism successfully dispensed marking material in a regulated manner.

Experimental observations showed:

- Uniform line width
- Consistent material flow
- Reduced marking errors

- Improved alignment and spacing

The automated system significantly minimized inconsistencies commonly observed in manual line marking methods.

Compared to traditional approaches, the developed robot reduced human effort and improved marking precision.

5. Control System Performance

The Arduino Nano-based control system demonstrated stable and reliable operation throughout testing.

The control algorithm effectively:

- Processed sensor inputs
- Controlled motor movement using PWM signals
- Regulated movement speed
- Managed marking operations automatically

The integration of sensors and motor drivers enabled smooth coordination between navigation and marking mechanisms.

6. Operational Efficiency

The developed robotic system improved operational efficiency by reducing manual labor and minimizing marking time.

The major operational improvements observed include:

- Reduction in human effort
- Improved marking consistency
- Better movement precision
- Reduced material wastage
- Faster execution of marking operations

The system proved suitable for applications such as:

- Sports field marking
- Parking area marking
- Industrial floor marking
- Institutional pathway marking

7. Overall System Performance

The experimental testing confirmed that the developed **Automated Line Marking Robot with Real Time Sensing and Control Unit** performs efficiently under controlled operating conditions.

The robot successfully achieved:

- Automated movement
- Real-time sensing capability
- Obstacle avoidance
- Consistent line marking
- Controlled navigation

The developed prototype demonstrated satisfactory reliability and practical feasibility for automation-based marking applications.

Key Outcome

1. **Automation Achieved:** The robot successfully performs line marking automatically with minimal human intervention.
2. **Improved Accuracy:** The system provides uniform and well-aligned line marking with improved consistency.

3. **Real-Time Sensing:** The ultrasonic sensing mechanism improves navigation and obstacle avoidance.
4. **Reliable Control System:** Arduino Nano-based control enables smooth movement and coordinated robot operation.
5. **Reduced Human Effort:** Automation significantly minimizes manual labor and operational fatigue.
6. **Ease of Fabrication and Maintenance:** The modular structure allows easy fabrication, maintenance, and future upgrades.

VIII. CONCLUSION

The **Automated Line Marking Robot with Real Time Sensing and Control Unit** was successfully designed, fabricated, and tested to automate the process of line marking with improved precision, consistency, and operational efficiency. The developed system effectively integrates mechanical components, real-time sensing, motor control mechanisms, and Arduino-based programming to perform automated line marking with minimal human intervention.

The experimental results demonstrated that the robot is capable of smooth navigation, obstacle detection, controlled movement, and consistent marking operations. The integration of the **HC-SR04 ultrasonic sensor** enabled real-time obstacle detection and improved navigation safety, while the **BTS7960 motor drivers** and **12V DC geared motors** provided stable movement and accurate path control. The **Motor-controlled spraying mechanism** ensured uniform marking and reduced material wastage.

Compared to conventional manual methods, the proposed robotic system significantly reduces labor dependency, operational time, and marking inconsistencies. The robot offers improved accuracy, better alignment, and reliable performance, making it suitable for applications such as **sports fields, parking lots, industrial floors, warehouses, and institutional premises**.

The developed system also provides advantages such as low cost, compact design, ease of operation, and simplified maintenance. Furthermore, the modular structure of the robot allows future modifications and technological improvements. In future scope, the system can be enhanced by integrating:

- GPS-based navigation systems
- IoT-enabled remote monitoring
- Camera vision for intelligent path tracking
- AI-based automatic field pattern generation
- Improved autonomous navigation for complex layouts

Overall, the proposed **Automated Line Marking Robot with Real Time Sensing and Control Unit** provides an effective, economical, and technologically advanced solution for automated line marking applications and contributes toward the advancement of smart robotic automation systems.

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