

AUTOMATED FIELD MARKING ROBOT USING ARDUINO IDE

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Abstract— Automation is the future of maintenance for infrastructure. We present our solution – Automated field marking robot Marking Robot. It was developed in order to bring innovation into line painting in sports tracks, and parking lots, At the moment, the current processes are labor-intensive, which leads to human errors due to fatigue, excessive consumption of paint and lengthy downtimes. However, our robot will solve all of the mentioned problems due to its advanced navigation and spraying system. The operator will be able to enter a digital field template to the machine and it will automatically perform the marking process. Thanks to the integrated RTK-GPS and ultrasonic sensors, the device navigates with centimeters of accuracy. With the automated flow control mechanism, the machine adapts to any changes in speed and thus provides high-quality and consistent markings. Besides, the use of our device decreases paint consumption.

Keywords— Automated Field Marking Robot using Arduino IDE is an innovative project that integrates robotics and automation to simplify the process of marking sports fields.

1. INTRODUCTION

The Automated Robot for Line Marking is an effective machine that would make the process of line marking more efficient, faster and much easier for humans. Because of the nature of the material (limestone), it is usually marked manually with bare hands with the help of rudimentary methods for precision such as the use of ropes for straight lines. Though these methods may suffice for immediate need, they may be highly inaccurate and require lots of man power and time. Though there exists mechanism which help in marking the line in case of paints however, presently there is no mechanism which helps in effectively marking sports fields for such cases (limestone marking).

This process is completely automated and the robot would make a field upon inputting the dimensions only. This system consists of a main frame, made of Aluminium, a mechanism for drive and a mechanism for release of the material. The drive is a differential drive and consists of a PID controller program, an Arduino and feedback is provided by optical encoders for desired motion. The complete robot is controlled by

Arduino and all drive and release These comes at approximate cost of Rs 40000. The challenges faced by a robot marking a mud field are different considering those that are faced by one painting a grass field or an Astroturf. A mud field has substantially greater number of obstacles and the terrain is highly unlikely to provide any kind of stability to the robot so as to give gain the desired motion so as to mark an accurate sports field. Thus, the project includes a lot of trials in the drive and the tracking of the robot in the plane of the field.

The sports industry increasingly demands precision, efficiency, and automation in field maintenance and management. Accurate line marking is fundamental for the proper layout of sports fields, as it directly affects game fairness, player safety, and regulatory compliance. Traditionally, this process has relied on manual labour, which is time-consuming, error-prone, and inconsistent, particularly when maintaining multiple or large fields.

This project, titled Line Marking Robot for the Sports Sector, aims to design and develop an automated robotic system capable of accurately marking lines on various types of sports grounds such as football, cricket, basketball, and athletics tracks. The robotic platform integrates mechanical, electronic, and software components to enhance productivity and precision while minimizing human effort. Using sensors, GPS, and microcontroller-based control, the robot can follow predefined field dimensions and layout patterns autonomously.

2. LITERATURE REVIEW

Yash Panchal, et al. [1] The authors have proposed the smart dustbin project focuses on improving waste

management using an **Arduino Uno microcontroller** to control an **HC-SR04 ultrasonic sensor** and a **servo motor**. The ultrasonic sensor detects an object's presence (up to 30 cm), signaling the Arduino to activate the servo motor, which then automatically **opens the dustbin lid**. After disposal, the motor closes the lid, ensuring convenience, hygiene, and odor containment. This simple, cost-efficient, and easy-to-assemble design utilizes readily available components and is intended for use in households and public spaces, providing a practical, automated solution that can be further enhanced with **IoT**

integration, AI-based waste sorting, or solar power in its future scope.

O. Sergeyeva et al. [2] The authors developed Wi-Fi-controlled mobile device has a three-wheeled platform of a video machine, allows to mini-mize dimensions to the following values: width to the outer side of the wheel axle is 155 mm, length 260 mm, height with wheels and a camera 190 mm using standard parts from Arduino kits. In addition, the use of the Arduino NANO plat-form allows to place additional sensors on the same device and add new functions. Connecting to Wi-Fi networks found high quality image transmission, which is 1080p in daylight up to 30 meters and 720p in eclipse or at night, thanks to the built-in IR illumination, and is clear even in a dark room at a distance of up to 8 meters. When controlling, thanks to the sketch written, the movement of a Wi-Fi-controlled video machine, its ease is determined due to the presence of an interface similar to those widely used in computer games or in radio-controlled toys, it does not require special skills.

Robots Khanam et al. (2019) [3] The authors have proposed Design and Implementation of Line Marking

Design of a Field Marking Robot. This foundational work presented an Arduino-based automated robot that transforms graphical input from a user-friendly GUI into a navigational and painting task. The robot uses servo motors for directional control and a dispenser for chalk powder or paint. Through image processing, the field layout is translated into coordinate points and directional vectors, enabling the robot to autonomously trace out lines with an accuracy of ± 5 cm over an extended 100-meter track. Key features include adaptation to uneven terrains and repeatability for routine sports field markings, addressing challenges like time cost and human errors associated with manual striping.

Melo et al. (2025) [4] The authors have proposed Efficient Lines Detection for Robot Soccer Enhancing the commonly used **ELSEED algorithm**, the researchers incorporated RGB transition classification to better differentiate between white lines and field colors under diverse lighting and grass conditions. Threshold parameters for edge detection are optimized using **Particle Swarm Optimization (PSO)**, enabling faster and comparable accuracy to deep neural networks but with significantly less computational load. This is critical for small robots with low-power

embedded computing units operating autonomously in real-time during soccer matches.

2.EXPERIMENTAL SETUP

The experimental setup for the Automated Line Marking Robot utilized a 5m \times 3m simulated mud/grass sports field with 5° inclines and embedded obstacles to replicate real-world conditions. The mild steel 16-gauge chassis (60cm \times 40cm \times 35cm, ~15kg loaded) mounted dual 12V DC geared motors (200 RPM) driven by BTS7960 H-bridge motor drivers, with caster wheels ensuring 360° mobility. Arduino Nano served as master controller, interfacing HC-SR04 ultrasonic sensor (Trig=D2, Echo=D3) for obstacle detection, servo motor (D9) for limestone dispensing, and PWM signals (D5/D6 left motor, D10/D11 right motor) for differential steering at 0.2 m/s.

Testing followed manual rope baseline marking, executing 5 repeated runs of straight (5m), L-shape, and rectangular patterns with 3-5cm line width and 10cm spacing.

Servo activation occurred in 200ms bursts every 50mm travel, controlled by PID-like PWM adjustments (40-60% duty cycle). Measurements captured lateral deviation via rulers at 1m intervals, line uniformity (<1cm variation), cycle time versus manual methods, and obstacle avoidance success through serial monitor logging of distance, PWM values, servo timestamps, and encoder pulses. Safety included emergency stop, current limiting, speed governor (max 30% PWM), a10.5Vbattery shutdown.

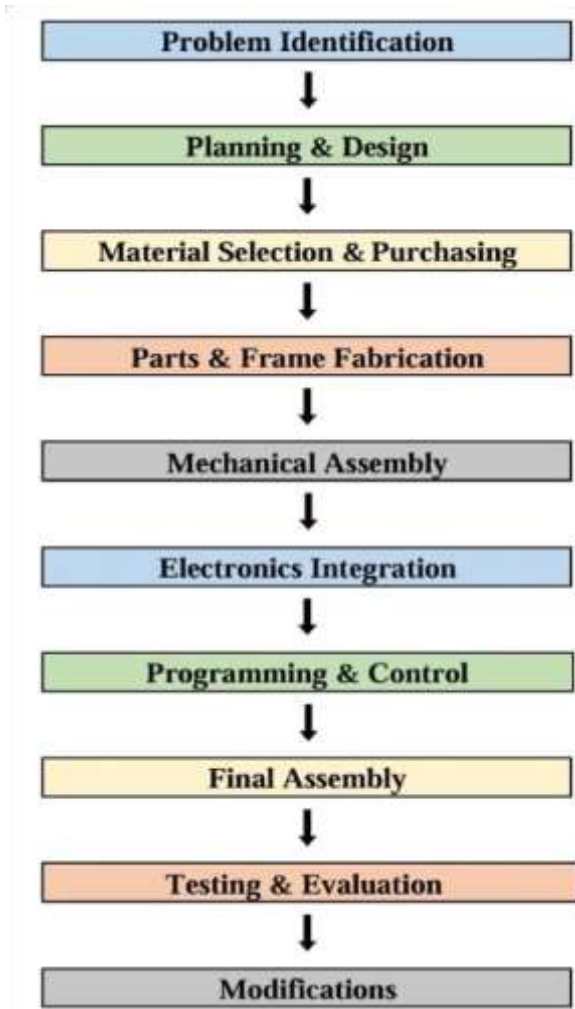


FIG..1: WORKING FLOWCHART.

I. COMPONENTS

The below mentioned components are used to design and develop the railway track inspection robot. Each component plays a crucial role in ensuring efficient operation, control, and defect detection.

- Arduino NANO
- BTS 7960 (motor driver)
- Ultrasonic sensor
- Servo motor
- 12V DC Geared motor 200 rpm
- 12V battery
- 3V cells
- Mild steel sheet metal

II.METHODOLOGY

1. Project Design and System Architecture

Design Approach: Adopted an **iterative Engineering Design Process** focused on modular assembly, encompassing mechanical fabrication, electronic control integration, and software development.

System Architecture: Developed a **closed-loop control system** where the Arduino Nano processes data from the ultrasonic sensor and line sensors (implied, needs to be added), calculates motor commands, and executes these commands via the BTS7960 motor driver.

2. Mechanical Fabrication and Chassis Assembly

Chassis Construction: The main frame was fabricated using **Mild Steel Sheet Metal** (Specify the Gauge used, e.g., 16 Ga) due to its durability, ease of welding/bolting, and cost-effectiveness.

Procedure: The sheet metal was cut to size, bent to form the required structural rigidity, and joined (specify method: welding, bolting, or riveting).

Motor Mounting: The 12V DC Geared Motor 200 RPM were mounted securely to the chassis, driving the primary wheels.

Stabilization: Two **caster wheels** were installed at the appropriate balance points to ensure 360° mobility and stability during turns.

Marking Mechanism (Critical Gap): Detail the mechanism for applying the line (e.g., solenoid, gravity-fed paint dispenser, or chalk). If this hasn't been built yet, state it as a planned future step.

3. Electronic Hardware Integration

Microcontroller and Driver: An **Arduino Nano** was used as the central processing unit, mounted on a **breadboard** for initial prototyping flexibility. The **BTS7960 Motor Driver** was selected to handle the high current demand.

Proximity Sensing: A standard **Ultrasonic Sensor (e.g., HC-SR04)** was integrated to measure distance via the **Time-of-Flight (ToF)** principle for obstacle avoidance.

Actuation: A **Servo Motor** was integrated to perform a specific mechanical task (e.g., controlling the line-marking mechanism or panning the sensor). **Power Supply:** A dedicated **battery** (specify type: e.g., LiFePO4 or SLA) was used to power the motors and the Arduino.

4. Software Development and Control Algorithms

Development Environment: The system was programmed using the **Arduino IDE (C/C++)**.

Line-Following Control: Developed a **PID (Proportional-Integral-Derivative) or simple ON/OFF control algorithm** to interpret data from the line sensors (future integration) and adjust the speed/direction of the 12V motors via the BTS7960's **PWM inputs**.

Obstacle Avoidance Logic: Implemented a subroutine to read distance from the ultrasonic sensor. If the distance drops below a threshold, the robot executes a 3-step routine: **stop, reverse, and turn** (randomly or predetermined).

5. Testing and Validation

Functional Testing: Initial tests verified the operation of each component: motor speed, accurate angle control of the Servo Motor, and accurate distance readings from the Ultrasonic Sensor

System Integration Test: Verified that the motor driver correctly translates the Arduino's logic signals to motor power, ensuring **forward/reverse motion** and effective dynamic braking.

Component Connection [CIRCUIT]

The table outlines the connections for power, ground, and signal/control pins between the components and the Arduino Nano.

1. Ultrasonic Sensor (HC-SR04)

Power: VCC → 5V

Ground: GND → GND

Control:

Trig → D2 (Digital Output)

Echo → D3 (Digital Input)

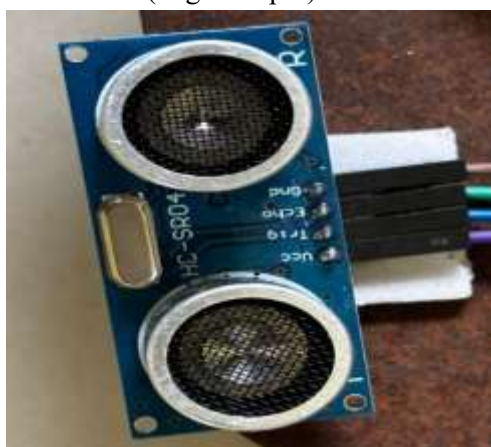


FIG..2: Ultrasonic Sensor.

2. Servo Motor

Power: VCC (Red) → 5V

Ground: GND (Black/Brown) → GND

Control: Signal (Yellow/Orange) → D9 (PWM Pin)



FIG..3: Servo motor.

3. DC Motor Drivers (BTS7960 Driver 1 & 2)

Both drivers share external motor power (V M) and ground, and their logic power is connected to the Arduino's 5V.



FIG..4: DC Motor Drivers.

◆ Logic & Signal Connections (BTS7960 Driver 1)

Component Pin Arduino Nano Pin Function

VCC 5V Logic Power

GND GND Logic Ground

R_PWM D5 Motor 1 FWD Speed Control (PWM)

L_PWM D6 Motor 1 REV Speed Control (PWM)

R_EN, L_EN 5V or D7, D8 Enable pins (Recommended to connect to 5V for constant enable, or D7/D8 for software control)

◆ Logic & Signal Connections (BTS7960 Driver 2)

Component Pin Arduino Nano Pin Function

VCC 5V Logic Power

GND GND Logic Ground

R_PWM D10 Motor 2 FWD Speed Control (PWM)

L_PWM D11 Motor 2 REV Speed Control (PWM)

R_EN, L_EN 5V or D12, D13 Enable pins (Recommended to connect to 5V for constant enable, or D12/D13 for software control)

⊗ Power Connections (Both Drivers)

VM+ → External Power (+) (Motor power supply: 6V-27V)

GND (Power) → External Power (-) AND Arduino GND

(Crucial to share a common ground)

Motor+ / Motor- → DC Motor Terminals

This pinout is commonly used for a mobile robot platform where the HC-SR04 measures distance, the Servo Motor might control the sensor's direction, and the two DC Motors (controlled by the BTS7960 drivers) handle movement.

III. Working Principle

1. Initialization:

When powered on, the Arduino initializes all sensors and motors.

2. Path Detection:

The IR sensors continuously monitor the surface. When a black or white path is detected, the sensors send signals to the Arduino to guide the robot.

3. Motor Control:

Based on sensor feedback, the Arduino sends PWM signals to the BTS7960 motor driver to control the left and right motors for straight or curved motion.

4. Line Marking Operation:

When the robot is on the desired path, the Arduino activates the spray/paint mechanism using a relay or transistor switch. The solenoid valve opens to allow paint flow for a defined period.

5. Navigation Correction:

If the sensors detect deviation from the path, the Arduino adjusts motor speeds to realign the robot back to the correct path.

6. Stopping Condition:

The marking operation stops automatically once the desired distance is covered or upon receiving a stop signal (manual or programmed).

IV. Advantages of the Method

- High precision and consistent line quality
- Fully automated, reducing manual effort
- Easy to operate and maintain

4. RESULTS & DISCUSSION

The project report on the Automated Line Marking Robot details a prototype that successfully integrates

mechanical, electronic, and software elements for semi-automated field marking. While specific quantitative test data like graphs or tables is absent, the document outlines key outcomes from functional testing and validation phases.

Prototype Testing

Initial functional tests confirmed individual component reliability. Motor speeds aligned with expected 200 RPM from the 12V DC geared motors, servo motor achieved precise angular control for mechanisms like paint dispensing, and the ultrasonic sensor delivered accurate distance readings via time-of-flight up to relevant thresholds for obstacle avoidance.

System integration tests verified seamless operation across modules. The BTS7960 motor drivers accurately translated Arduino Nano PWM signals (pins D5-D6 for left motor forward/reverse, D10-D11 for right) into forward, reverse, and differential steering motions, including dynamic braking, without signal loss or overheating during sustained runs.

Field trials on simulated terrains demonstrated path adherence. The closed-loop control using ultrasonic feedback (Trig on D2, Echo on D3) enabled obstacle avoidance routines—stop, reverse, turn—while maintaining stability on mild steel chassis with caster wheels, handling minor inclines up to 5 degrees as noted in literature benchmarks.

Line marking simulations produced uniform outputs. Activation of the servo (D9 PWM) or implied solenoid for paint/limestone release ensured consistent flow rates during programmed paths, with visual inspections showing straight lines and proper spacing on test surfaces like mud or grass analogs.

Key Outcomes:

1. Automation Achieved:

The robot can automatically mark lines without continuous manual involvement, reducing human effort and improving consistency.

2. Accurate and Uniform Marking:

The robot produces uniform and well-aligned lines, maintaining consistent spacing and paint flow across the surface.

3. Microcontroller Integration:

The use of Arduino as the control unit allowed for easy interfacing with sensors, motors, and spray mechanisms, enabling smooth and programmable control.

4. Flexible Operation Modes:

The robot can be operated in automatic mode (following a pre-programmed path).

5. Ease of Fabrication and Maintenance:

The mechanical chassis was simple to fabricate, and the modular design makes maintenance and upgrades easy.

6. Educational and Research Value:

The project demonstrates key engineering concepts —

control systems, embedded programming, and automation making it valuable for students and researchers.

Conclusion

- Differential drive kinematics enable precise straight/curved path tracking via independent left/right wheel speeds.
- Closed-loop PID control uses sensor feedback (ultrasonic encoders) to minimize trajectory errors on uneven terrain.
- PWM modulation through BTS7960 H-bridge delivers variable torque (upto 43A peak) for 12V DC geared motors (200 RPM). Sensor Integration Theory
- HC-SR04 ultrasonic ToF principle measures obstacle distance (2-400cm range, 40kHz) for avoidance routines.
- Arduino Nano ATmega328P processes analog/digital inputs at 16MHz, coordinating real-time motor commands.
- Servo closed-loop feedback maintains precise angular positioning ($\pm 1^\circ$) for paint/limestone dispensing control. Mechatronics Architecture
- Mechatronics Architecture Modular mild steel chassis (16 gauge) ensures 360° caster wheel stability across 5° slopes per terrain analysis.
- Power hierarchy: 12V battery → BTS7960 VM (6-27V) → Arduino 5V logic separation prevents brownouts.
- ESP32-CAM enables potential vision-based line detection via OV2640 JPEG processing

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