

Automatic Lawn Mower Robot



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Submission Date: 6/01/2025 GC

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1. Motivation / Problem Statement

This days our country is going through an astonishing road-side renovation, which encompasses almost 100 kilometer cities main road.

Where grasses are being planted in many places different areas.

Maintaining lawns in such a residential, commercial, and public areas is labor-intensive, time-consuming, and often inconsistent, especially over large or irregular terrains. Manual mowing requires regular effort, and traditional mowers pose safety and environmental concerns. There is a growing need for a smart, autonomous solution that can perform lawn mowing efficiently, safely, and with minimal human intervention.

2. Objective

To develop an autonomous robot capable of mowing lawns efficiently while navigating uneven or dynamic outdoor environments. The robot will:

- Map and localize itself within the lawn boundary.
- Plan and execute complete and optimized coverage paths.
- Dynamically detect and avoid obstacles such as pets, trees, or garden furniture.
- Maintain safety and precision in different weather and terrain conditions.

3. Application

The lawn mower can be used in different environments for different mowing purposes, the application areas are provided below.

Residential Use:

Automate routine lawn maintenance for homeowners, increasing convenience and safety.

Commercial Landscaping:

Deploy across parks, golf courses, and office lawns to save labor and ensure consistent maintenance.

Sustainable Lawn Care:

Reduce emissions and noise pollution by using electric autonomous mowers.

Smart City Integration:

Coordinate with IoT systems for scheduled mowing, weather adaptation, and remote monitoring.

4. Physical look and components of the robot

Actuators:

- 1.** Chassis: Should be rugged and weather-resistant with appropriate ground clearance.
- 2.** Wheels: Differential drive (2-wheel + caster) is common for maneuverability; consider 4WD for rough terrain.
- 3.** Blades: Safety shielded, electric motor-driven; must automatically stop on lift/tilt.

Sensors:

- Lidar or Ultrasonic: For obstacle detection.
- IMU (Inertial Measurement Unit): For stability and orientation.
- Wheel Encoders: For odometry (distance tracking).
- GPS + RTK: For accurate outdoor localization (especially in large areas).
- Camera (optional): For advanced perception or visual SLAM.

Processing:

Microcontroller + Companion Computer (e.g., Arduino + Raspberry Pi or Jetson Nano) Must support real-time sensor fusion, path planning, and actuation.

5. Development of the Automated Lawn Mower Robot

5.1 Environment Mapping and Localization

5.1.1 Mapping:

SLAM:

GMapping: Useful for structured 2D environments such as fenced gardens.

Cartographer: Offers real-time loop closure, beneficial for large or repetitive outdoor spaces.

Selected Mapping Method: Cartographer

Why: since the lawn mower might need to recharge and it is expected to work even in large areas for long hours.

5.1.2 Localisation:

AMCL (Adaptive Monte Carlo Localization): Works well in known yard layouts with static features.

EKF/UKF (Extended/Unscented Kalman Filter): More suitable for GPS-integrated systems or variable environments with terrain undulations.

Selected Localisation method: *EKF/UKF (Extended/Unscented Kalman Filter):*

5.2. Navigation and Obstacle Avoidance

Potential Algorithms choices:

Global Path Planning:

Plans the route to a target using map knowledge.

Candidate Algorithms:

- A* or Dijkstra's Algorithm: For redefining efficient paths in well-bounded gardens.
- RRT (Rapidly-exploring Random Tree): Useful in dynamic or highly cluttered outdoor spaces.

Local Path Planning:

React to real-time obstacles during movement.

- Dynamic Window Approach (DWA): Reacts to real-time obstacles like pets or toys.
- Teb Local Planner: Maintains smooth and curved paths around curved flower beds or trees.

Selected Navigation and Obstacle Avoidance Algorithm:

Timed Elastic Band (TEB) Local Planner

Why:

The Timed Elastic Band (TEB) Local Planner excels in generating smooth, time-optimized, and feasible trajectories in real time. It considers the robot's kinematics and dynamics, which is crucial for a lawn mower moving through narrow paths, curves, and around static and dynamic obstacles like trees, flower beds, pets, and toys.

- Smooth motion: Essential for consistent mowing coverage.
- Obstacle avoidance: Reacts well to both static and dynamic obstacles.
- Speed & curvature optimization: Avoids jerky movements that can damage grass or miss spots.

5.3 Coverage Path Planning

Systematically cover the entire lawn with minimal overlap and no gaps. The robot will comprise of hybrid coverage planner that the following three algorithms:

4.3.1 Default mode:

This mode is the default mode, where the environment is expected to be small or medium and the shape of the field is rectangular.

Chosen Algorithm: Boustrophedon Coverage

Why: Boustrophedon Coverage: Ideal for rectangular lawns; performs systematic back-and-forth mowing, it also Performs efficient “zig-zag” mowing much like a farmer plowing a field.

Highly efficient in large rectangular zones or after decomposing irregular areas into smaller regular sections.

4.3.2 Expert mode:

This mode will be activated by a button when the train is complex with irregular shape and with different types of obstacles like trees,

Candidate Algorithms: This mode will be implemented using STC (Spanning Tree Coverage) algorithm.

Why: Spanning Tree Coverage (STC) is designed to systematically cover all free space even in irregular, obstacle-filled environments — which is common in real gardens with trees, furniture, or flower beds.

STC Efficiently works around obstacles, it guarantees Full coverage: Ensures every accessible patch is mowed.

STC Can be adapted to grid-based, sensor-based, or map-based implementations. It is the best suited for real-world, non-uniform lawns.

6. Mowing and Simulation

Simulation Environment (e.g., Gazebo):

- Visualize mowed vs. unmowed areas using color-coded patches.
- Simulate blade coverage with virtual contact zones.
- Blade Control Logic: Simulate blade activation only within grass zones to optimize energy use.
- Implement safety cut-off mechanisms if obstacles are detected.