Autonomous Robotic Lawn Mowers in Residential Gardens: Efficiency, Performance, and User Experience – A Focused Case Study

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Abstract. Robotic lawn mowers that operate on their own have become a cutting-edge way to maintain home gardens. They provide efficiency, convenience, and smart home ecosystem integration. In addition to advanced navigation innovations, sensors, and artificial intelligence, these machines can cut without much help from people. IoT connectivity, smart home device penetration, and advancements in battery and navigation systems are important factors (Global Growth Insights, 2025). Robotic lawnmowers are environmentally friendly and save time (Home Garden Report, 2025). High acquisition costs, terrain restrictions, battery limitations, setup complexity, and cyber security issues are still obstacles, but (Market Business Insights, 2025). In order to lay the groundwork for next studies and adoption tactics, this overview summarizes recent research, industry reports, and new developments. This case study consolidates information about autonomous robotic lawn mowers gathered from scholarly articles, industry reports, market analyses, and technical research. A thorough dataset for this study was formed by merging data from product launches by companies, testing of prototypes, and market predictions. The present review looks at important technologies like sensors navigation and path planning to show how robotic mowers can function dependably safely and effectively. Aspects of the user experience such as upkeep noise levels ease of setup usability and adaptability to various lawn types are also considered. Among the obvious advantages of autonomous mowers are labor savings better lawn care time savings and possible environmental benefits through eco-friendly mowing techniques and optimal energy use.

Keywords: Lawn Mower. Autonomous robot, Design, Residential Gardens, Artificial Intelligence

1 Introduction

Home garden areas can be maintained by battery-powered autonomous lawn mowers without constant supervision from humans. Their origins can be found in consumer robots and early automated ground vehicles, including robotic vacuum cleaners, which proved that home autonomous systems were feasible (Wired, 2004). In order to travel and trim lawns autonomously, modern lawnmowers use sensors, GPS or RTK navigation, computational (AI), and mobile connectivity [1-4]. The integration of

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these mowers with IoT-supported smart home ecosystems, such as voice-activated gadgets, smartphone apps, and automated time management, has increased consumer interest (Global Growth Examination, 2025) [4–6]. These gadgets have technological and societal ramifications that need to be carefully considered [7–9]. The results of market research, industrial insights, technology analysis, and academic literature on autonomous lawn mowers are compiled in this review. Future developments are also highlighted, including eco-friendly alternatives, enhanced batteries and charging, adaptive AI, modular designs for customizable performance, and interaction with intelligent home systems. Technological developments and business solutions keep expanding capabilities and lowering adoption obstacles. Wider residential use is anticipated as a result of improved user experience and operational efficiency. The study examines user input and operational outcomes using real-world data from a home case study in addition to user-friendly safety features and maintenance requirements. Furthermore the research aims to pinpoint obstacles and constraints in the application of robotic lawn mowers offering practical suggestions for buyers contemplating their integration in residential settings.

2 Research Methodology

The present case study compiles information about autonomous robotic lawn mowers from academic literature, industry publications, market research, and technical studies. A comprehensive dataset of the present work was obtained by combining data from product releases by industries, prototype testing, and market forecasts. In order to demonstrate how robot mowers may function safely, effectively, and dependably, the review looks at important technologies like navigation, path planning, and sensors. Additionally, it takes into account aspects of the user experience, including maintenance, noise levels, ease of setup, usability, and adaptation to various lawn patterns. Time savings, better lawn care, less work, and possible environmental benefits from optimal energy consumption and eco-friendly mowing patterns are just a few of the obvious advantages of autonomous mowers. There are still difficulties, such as expensive setup expenses, restrictions on uneven terrain, limitations on battery capacity, and sporadic problems with safety or dependability.

2.1 Number of publications over the last 15 years

The trend of publications for autonomously robotic lawn mowers over the past 15 years is depicted in Figure 1 above. The number of publications increased steadily between 2010 and 2025, with a higher increase between 2010 and 2025, according to the graph above. The trend shows that, in the midst of technological developments in the use of robotics in residential lawn mowing, academics and industry are becoming more interested in the field. The graph's spikes for particular years show the progress and uptake of technology.

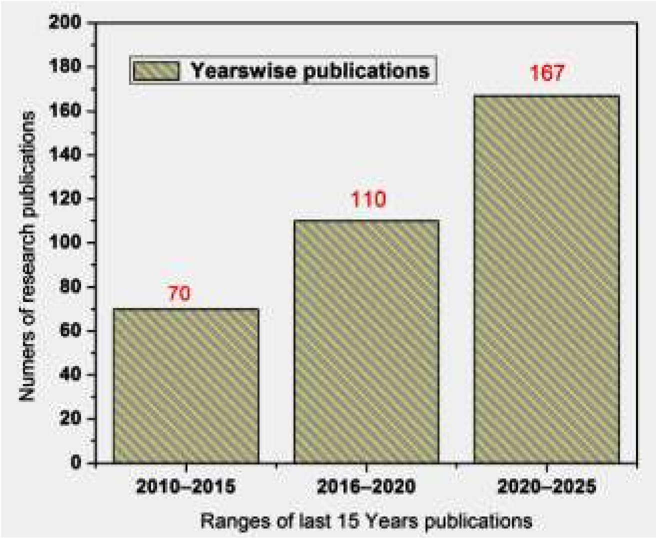

Fig.1. Graph showing the number of publications over the last 15 years

The main themes addressed in recent research on autonomous robotic lawn mowers are summarised in Table 1. This list includes ecologically adaptable cutting techniques, modular, along with design-based solution designs, and even environmental sustainability analyses, ranging from path planning and learning through reinforcement that deals with optimal navigation strategies to AI-based garden navigation solutions. Aside from that, other studies provide a comprehensive overview and synopsis of current developments as well as the prospects for robotic lawn remedies in residential settings.

Table.1 Thematic study on Robotics Lawn Mowers

Several studies on robotic lawn Mowers	**Work carried out by the academicians /Researchers**
Path Planning & Reinforcement Learning	Chen et al. (2025)[9], Helenprabha et al. (2025)[4]
AI & Navigation for Residential Gardens	Kanade et al. (2025) [10]
Ecologically Adaptive Mowing	Beckers et al. (2025) [11]
Design & Modular Systems	Ji (2024)[12], Liao et al. (2021)[13-14]

Environmental & Sustainability Analysis	Saidani et al. (2021) [15]
Reviews & Surveys	Ritwik & Patel (2023)[16]

2.2 Market size and trends

The dynamics of the global market for autonomous lawn mowers are shown in Figure 2. With a compound annual growth rate (CAGR) of 3.7% from 2025 to 2033, the market, which was initially valued at USD 3,085.1 billion in 2024, is predicted to increase to USD 3,199.2 billion in 2025 and then to USD 4,278.3 billion by 2033. As shown in the graphical representation of market dynamics below, this is primarily due to consumer preferences for smart and practical lawn mowers, robotics developments, and environmental concerns about decreased use and adoption of sustainable landscaping equipment worldwide [17].

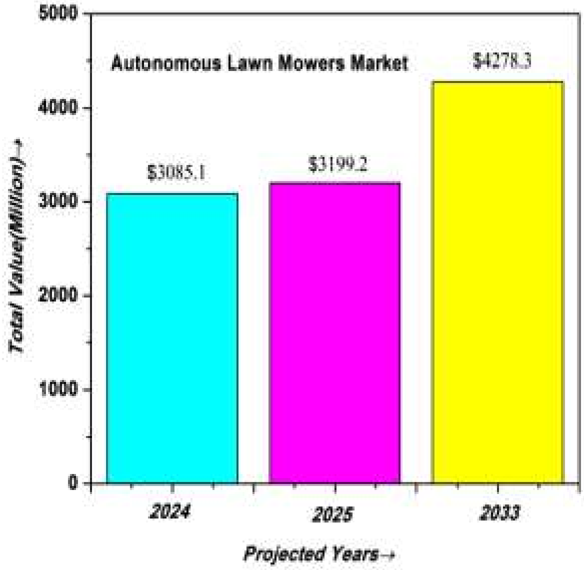

Fig.2. Graph showing the Autonomous Lawn Mowers Market

As consumers embrace cutting-edge, time-saving solutions for outdoor jobs, the market for autonomous lawn mowers is expanding quickly. Over 60% of the market is currently occupied by robot lawn mowers, and this trend is predicted to continue. In order to effectively navigate challenging settings, modern mowers are increasingly equipped with sophisticated sensors and GPS systems. AI is used in about 40% of new mowers to enhance performance on various terrains.

Additionally, the market is moving toward eco-friendly products. Due to environmental concerns and the need to lessen carbon footprints, over half of customers prefer energy-efficient, rechargeable battery mowers instead of gasoline-powered models. Since many consumers use connected devices to operate mowers, intelligent house integration is another factor driving growth. About 25% of the market is made up of commercial implementation, such as that of golf courses and huge estates. These environments require high-performance lawnmowers with deep learning algorithms that improve efficiency and decision-making, able to manage expansive lawns with little human intervention.

2.3 Essential Features for Best Robot Lawn Mowers

Attaining genuinely hands-free superior outcomes requires a few indispensable technological capabilities. The essential parts of the top robot lawn mowers are described in Figure 3. The best self-sufficient lawn mowers available incorporate multiple essential systems.

(i) Using a combination of technologies such as GPS RTK LiDAR or AI vision Intelligent Navigation and Obstacle Detection (i) maps the garden plans effective routes and safely avoids objects like trees furniture toys and garden beds.

(ii) (ii) Accurate Cutting and Regular Coverage: Intelligent path planning and a sharp balanced cutting disc or blade guarantee that every square inch of the lawn is trimmed uniformly and without any missed patches.

(iii) The agility of the system or adaptive terrain handling. For thorough and dependable coverage in non-flat gardens motors and wheels that can handle slopes uneven terrain and various grass types are essential.

(iv) Dependable power management is essential to the systems longevity. A strong battery should have enough runtime to cover the assigned area and the intelligence to automatically return to its charging station so that it can start up again after it has been charged.

(v) The systems interface requires user-friendly app control. The creation of no-go zones simple scheduling cutting height adjustment real-time monitoring and maintenance alert receipt are all made possible by a smartphone application.

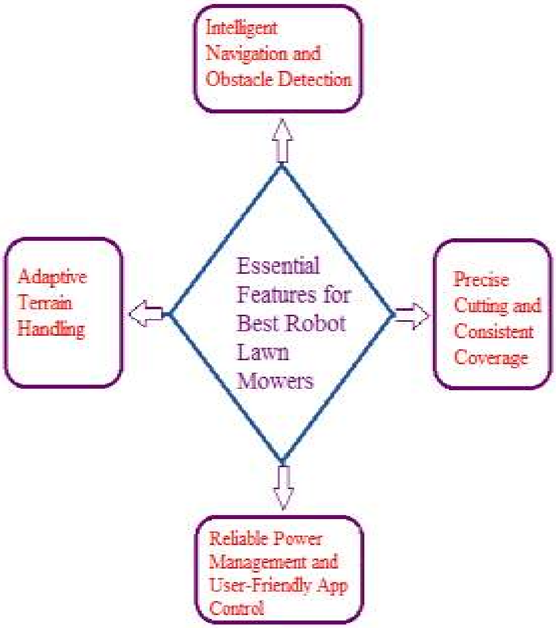

Fig.3. Displays the key characteristics of top-tier robot lawn mowers.

3 Technological Overview

3.1 **Operating Principles and Navigation Technologies**

Different navigation and recognition systems are used by autonomous robotic lawn mowers. Conventional models define mowing zones using perimeter wires. This method involves time-consuming and technical installation, but it keeps the mower inside a predetermined region. For accurate location without boundary wires, more recent versions make use of GPS and RTK (Real-Time Kinematics). Path planning and obstacle identification are enhanced by visual sensors, LiDAR, and ultrasonic radar (Time – Mammotion Luba 2 AWD, 2024) [18]. Adaptive mowing, dynamic avoidance, and effective coverage are made possible by AI-based systems that integrate several sensor inputs, such as GPS, cameras, and bump sensors (ResearchGate IRJET, 2025) [19]. These technologies enable operation without boundary wires in a variety of garden layouts. The system layout of an autonomous robotic lawnmower is displayed in Figure 4. Navigation sensors (GPS, boundary wires, recording devices, ultrasonic sensors), along with safety sensors (lift, tilt, bump), provide inputs to the centralised control unit (sometimes called the microcontroller or CPU). It decides how to travel, avoid obstacles, and operate safely in real time. The wheels and blade for movement and lawn cutting are then driven by motor controllers. All components receive energy from the power system, which consists of a battery with a rechargeable capacity, power management circuitry, and a charging dock interface. Manual control, monitoring, and scheduling are all possible using a mobile app or user interface. The block diagram shows how the subsystems of sensing, control, actuation, and power cooperate to provide completely autonomous grass mowing.

The schematic block designs for autonomous robotic lawn mowers' (a) navigation technology and (b) boundary wire navigation are displayed in Figure 5. The navigation system in Figure 5(a) makes use of a variety of sensors, including cameras, wheel encoders, GPS/RTK-GPS, and proximity sensors. In order to efficiently design routes, avoid obstacles, and cover the grass, the navigation and localisation module handles these inputs using techniques like SLAM. The boundary wire system depicted in Figure 5(b) uses a low-frequency signal that is sent around the lawn via a perimeter wire. The wire detection sensor on the mower keeps an eye on this signal and provides the control unit with feedback. Every time it detects a wire, the mower modifies its course to stay inside the designated region. These schematics demonstrate how autonomous lawn mowers accomplish safe area containment and accurate navigation while in use.

4. Benefits of Autonomous Lawn Mowers

4.1 Convenience and Time Savings

Homeowners' time savings are one of the biggest benefits of robotic lawn mowers. Once set up, these gadgets keep the lawn at a constant height without the need for human intervention, freeing up time for other activities or leisure (Home Garden Assessment, 2025). The main advantages of autonomous robotic lawn mowers are convenience and time savings because they run on their own with little assistance from the operator. Once set up, the mower can be programmed to operate automatically, doing away with the need for supervision and hand mowing. User effort is further decreased by features like self-navigation, the avoidance of obstacles and automatic charging dock return. Robotic lawn mowers ensure that the grass is kept tidy without the need for human effort, saving users a great deal of time by performing typical lawn care activities consistently and efficiently [20].

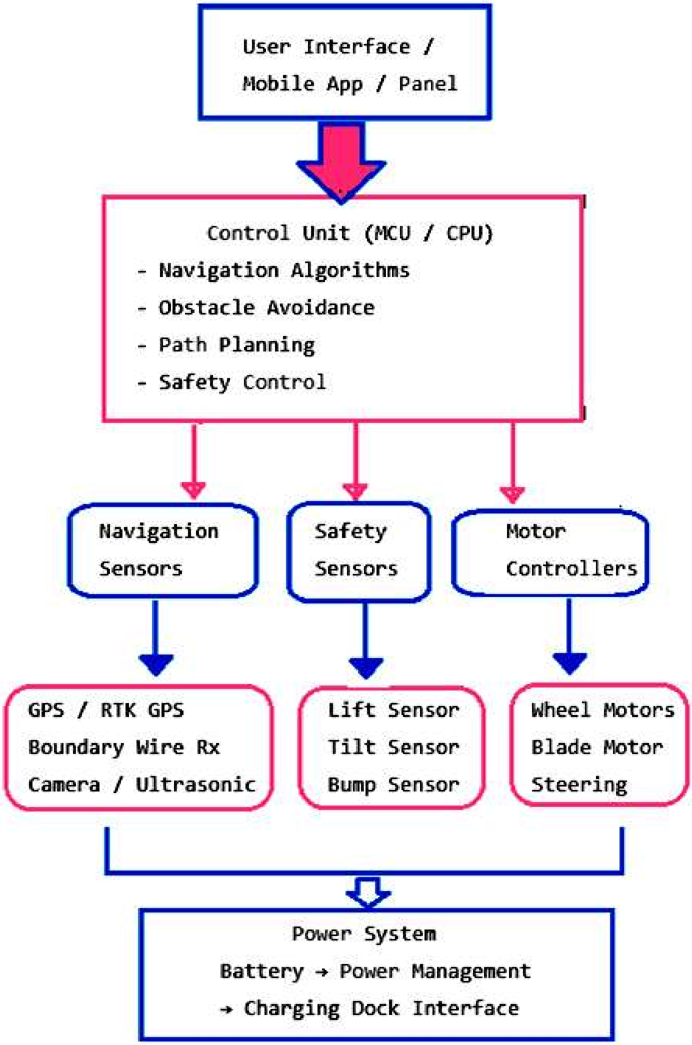

Fig.4. Overall System Schematic (Block Diagram)

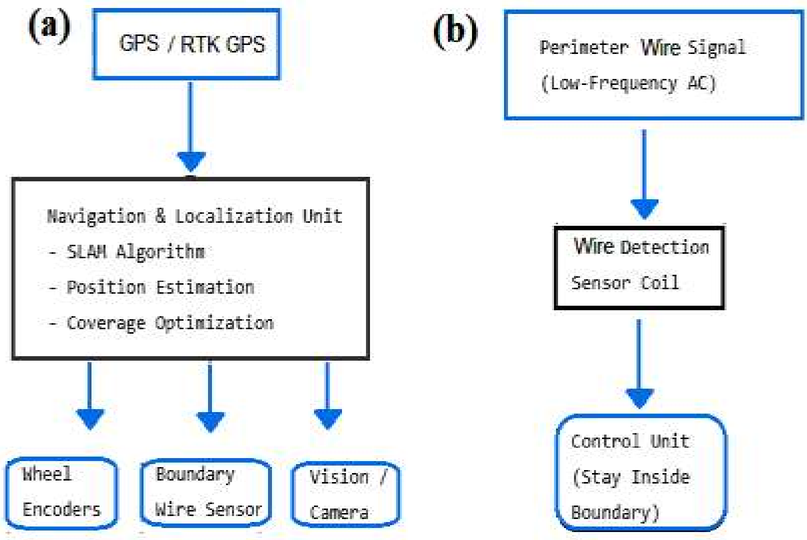

Fig.5. Schematic Block Diagram (a) Navigation Technology (b) Boundary Wire Navigation

4.2 Consistent Lawn Maintenance

Frequent, planned mowing encourages denser, healthier turf and helps maintain uniform grass height (Home Garden Report, 2025). This is accomplished via autonomous robotic lawn mowers, which run without human intervention at predetermined intervals. These mowers maintain consistent height and naturally mulch the clippings by regularly cutting small amounts of grass, which promotes better lawn development. Sensors, control algorithms, and navigation systems guarantee complete grass coverage, steer clear of obstructions, and maintain the mower within predetermined bounds. This methodical strategy decreases the need for hand mowing, prevents overgrown spots, and lessens uneven growth. It eventually produces a lawn that is visually consistent and well-maintained [20].

4.3 Eco-Friendly Operation

Robotic mowers are quieter than gas-powered models and emit no direct emissions because they run on electricity. Fine clippings from these machines are usually left on the grass, where they can naturally break down and become mulch (Home Garden Report, 2025). Since autonomous robotic lawn mowers run on electricity rather than fossil fuels, they have the significant benefit of being environmentally friendly. Compared to traditional gasoline-powered mowers, the use of rechargeable batteries greatly decreases noise pollution and eliminates direct exhaust emissions. Additionally, frequently mowing with fine mulching blades reduces the need for chemical fertilizers, along with waste management by allowing grass clippings to naturally decay. Robotic lawn mowers are an eco-friendly option for routine lawn care because of their energy-efficient motors and improved navigation, which further reduce power usage [20].

4.4 Smart Home Integration

Mower operations can be remotely scheduled, monitored, and customised thanks to connectivity to voice assistants or mobile apps, which is in line with growing smart home desires (Global Growth Insights, 2025). By enabling autonomous robotic lawn mowers to smoothly integrate with current smart home ecosystems, smart home integration improves their functionality. Users can plan mowing sessions, keep an eye on the status of the mower, and receive notifications from a distance via mobile applications, Wi-Fi, or Bluetooth connectivity. Voice commands, along with coordinated operation with other smart devices, including weather systems that stop mowing in the rain, are made possible by integration using smart assistants and home automation platforms. Lawn care is now an intelligent and integrated component of a contemporary smart home setting because of this connectivity, which enhances user management, flexibility, and general convenience [17].

5 Challenges and Limitations

5.1 High Initial Costs

Compared to conventional push or ride-on mowers, autonomous lawn mowers are frequently far more expensive to buy up front. Many homebuyers are discouraged by this cost barrier, particularly in price-sensitive countries (Market Business Information, 2025; P Marketing Research data). One key drawback of autonomous lawn mowers is their high initial costs due to the complex technologies used in their development. When compared to traditional lawn mowers, components like satellite navigation or RTK-GPS modules, numerous sensors, onboard computers, and smart communication systems raise production and acquisition costs. Setup costs may also be increased by installation requirements like charging stations or perimeter boundary wires. Even though lower labour and maintenance costs can result in long-term benefits, many potential customers are nevertheless put off by the initial cost [21].

5.2 Setup and Technical Complexity

Installing and configuring boundary wires might be difficult for non-techies. Complex settings and software configuration continue to be a barrier to widespread use, even with innovations like RTK GPS (PMarketResearch, 2025) [22]. Implementation of autonomous robotic lawn mowers is hampered by setup and technical complexity since initial setup and configuration can be difficult and time-consuming. Careful setup and user comprehension are necessary for tasks including installing boundary wires, assessing navigation systems, scheduling mowing, and configuring smart connectivity. Software upgrades and troubleshooting may also be necessary for advanced versions with GPS, vision technologies, or intelligent home integration. Users with little technical expertise may find this level of technological complexity challenging, which could compromise usability during initial setup.

5.3 Terrain, Weather, and Operational Constraints

Lawns that are comparatively level and devoid of obstructions are ideal for robotic mowers. Wet grass, slopes, uneven terrain, and heavy debris can all impair efficacy and necessitate human intervention (RC Lawn Mowers, 2024) [23]. The usefulness of autonomous lawn mowers that are robotic can be limited by terrain, weather, and operating constraints because their performance is dependent on the qualities of the lawn and the surrounding environment. Mowing effectiveness may be decreased or manual intervention may be necessary due to uneven ground, steep slopes, or impediments like tree roots and rocks. Heavy rains as well as wet grass are examples of unfavourable weather conditions that can impair traction, safety, and cutting quality and frequently cause an automated pause or shutdown. It's crucial to take these limitations into account while deploying the mower for reliable and secure performance because elements like lawn dimensions, shape, and surface texture might affect battery life, coverage configurations, and overall functioning.

5.4 Battery Limitations

One important factor to take into account for autonomous robotic lawn mowers is battery restrictions. Rechargeable batteries are the only source of power for them. Particularly on large lawns, a limited battery capacity may limit the amount of time that can be spent cutting, requiring the mower to return to the charging dock before it is done. Over the course of time, battery performance may deteriorate, decreasing efficiency and runtime. Battery life, along with charging speed, can also be impacted by extreme heat or cold. In order to ensure consistent lawn care, these constraints necessitate careful planning of mowing routines and occasional battery replacement. Large lawns may have less coverage due to a short battery life, requiring several recharge cycles and reducing single-run operations' efficiency (Global Growth Perspectives, 2025).

5.5 Security and Privacy Risks

Autonomous robotic lawn mowers, particularly those with smart connectivity as well as mobile app integration, may raise security and privacy issues. Internet-enabled lawn mowers that permit remote control or tracking may be susceptible to hackers or illegal access. Navigation-related cameras and sensors may take pictures or data from nearby property, creating privacy concerns. To safeguard the equipment and user data, secure connections to the network, strong passwords, and appropriate data management are crucial. Because hackers may target gadgets connected to home networks, connectivity raises cyber security risks. Because of the possible data exposure, privacy-conscious customers would be reluctant to use these mowers (P Marketing Research, 2025) [22].

6 Case Studies and Product Developments

The capabilities of robotic lawn mowers have advanced, as demonstrated by recent product debuts. Some instances of commercial autonomous prototypes with various designs and functionalities are shown in Figure 6. The Roborock Rock Mow Series comprises the small, effective mower shown in Figure 6(a). It is appropriate for small to medium-sized lawns since it uses smart navigation, supports boundary wiring, and provides app-based scheduling. The sturdy, all-wheel-drive Mammotion Luba 2 AWD is depicted in Figure 6(b). With sophisticated sensors for precision navigation and obstacle recognition, it can tackle vast areas and difficult terrain. These illustrations show the range of robotic mowers on the market, from affordable models to high-end models. Performance, handling of terrain and technological sophistication are all different. Many have sophisticated slope management, customized grass-cut patterns controlled by mobile apps, and hybrid navigation (RTK + vSLAM) (The Verge, 2025) [24].

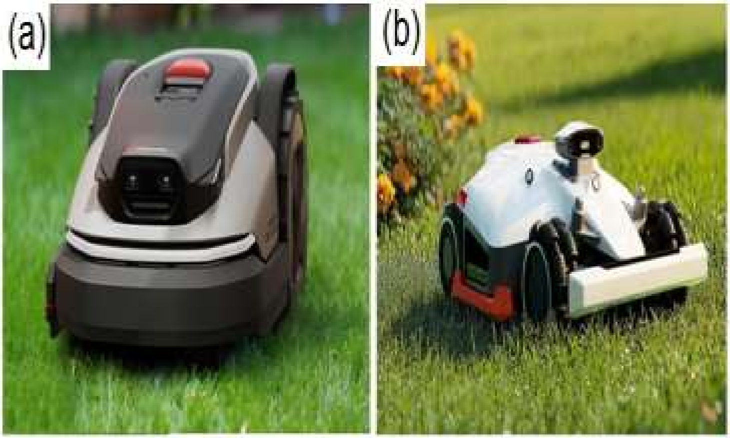

Fig.6. Example of autonomous robotic lawn mowers (a) Roborock Rock Mow **Series [24],** (b) Mammotion Luba 2 AWD [18]

For effective grass mapping and avoidance of obstacles, wireless robotic lawn mowers currently come with sensor suites that include GPS, cameras, and radar (Time – Mammotion Luba 2 AWD, 2024) [18]. These developments enable broader features, including wildlife-friendly modes and sophisticated terrain handling, as well as more autonomous operation [18–24]. Honda has a long history of providing lawn care services, dating back to 1978 when it introduced the HR21, its first walk-behind mower.

Because of their effectiveness, use, and safety, its mowers are well-liked all around the world, particularly in North America and Europe. Honda debuted the "Miimo" robotic lawnmower in 2012 to automate lawn maintenance and lower labour costs. In North America, where effective lawn care was in great demand, Honda concentrated on landscape management for businesses, public buildings, and large residences by 2025. As a result, the provisions autonomous electric lawnmower for commercial use was created.

7 Future Prospects and Research Trends

Increased autonomy, reduced consumption of energy, and adaptive behavior are the main technological advancements in robotic lawn mowers. In order to combine mowing chores with ecological goals, such as fostering lawn biodiversity, new prototypes employ deep visual embeddings (Beckers et al., 2025). Future mowers might require fewer external navigation aids, according to research on the combination of sensors and path planning algorithms, such as reinforcement learning and vision-based navigation (Taghibakhshi et al., 2021) [25]. Raspberry Pi-based prototypes and other low-cost AI-powered devices could increase performance and accessibility (IRJET, 2025) [19–25]. The work patterns of proficient operators at various locations are documented by the ProZision Autonomous. After guaranteeing safety, it can then independently reproduce the mowing path, enabling operators to assign mowing. Productivity is greatly increased as a result. Honda created the ProZision Autonomous for assisting landscape management companies in saving labour costs while operating with zero emissions. This mower helps Honda achieve its goal of making all of its operations and products carbon neutral by 2050.

Table 2. Summary of the Performance Metrics of Autonomous Lawn Mowers

Performance Metric	Description	Range/Details	Refs.
Efficiency & Coverage	Mowing Area per Charge	600 m² to 3,000 m² per charge	26
Charging Time	Time required for full charge	60 minutes to 120 minutes	27
Cutting Performance	Cutting Height	20 mm to 60 mm	28
Cutting Width	Width of the cutting area	18 cm to 28 cm	29
Battery Life & Charging, Battery Capacity, Battery Lifespan	Battery Type Measured in Ampere-hour (Ah) Lifespan of lithium-ion batteries	Common capacities include 2.0Ah to 6.0Ah for smaller yards and up to 12Ah for larger, more demanding, or sloped areas. Li-ion batteries in robotic mowers typically last for 500–800 charging cycles.	30
Terrain Handling	Slope Capacity	20° to 45° depending on model	31
Obstacle Navigation	Ability to detect and avoid obstacles	Uses ultrasonic, infrared, and sometimes LIDAR sensors	32
Noise Level	Sound Output	55 dB to 65 dB (quiet operation)	33
Navigation Precision	GPS Accuracy	2 cm to 5 cm with GPS-based models	34
User Interface	App Control & Connectivity	Smartphone app control, integration	35

		with voice assistants (Google, Alexa)	
Safety Features	Emergency Stop	Auto-stop with lifting, tilting, or obstacle collision	36
Cost & Value	Price Range	$500 to $3,000 depending on features and model	37

The main performance indicators used to assess the efficacy, efficiency, and dependability of autonomous lawn mowers are presented in Table 2. These measurements offer a consistent framework for evaluating the operating capabilities of various robotic mowing systems across a range of terrain and climatic circumstances. The provided ranges and values in Table 2 represent the variety of robotic lawn mower designs, sensing technologies, navigation algorithms, and operating situations. They are taken from current research.

8 Conclusions

To speed up the adoption of EVs, the Indian government has taken a deliberate, multifaceted strategy. These initiatives promote economic modernization, energy security, and sustainability. As India strives to achieve net-zero carbon emissions by 2050, they are essential. EVs. Because they provide convenience, reliable lawn care, and easy integration with smart home systems, autonomous robotic lawn mowers have revolutionized household gardening. These mowers map lawns autonomously, avoid obstacles, and maintain consistent grass height using cutting-edge navigation technology like GPS, cameras, LiDAR, ultrasonic sensors, and AI-based control algorithms. In order to accomplish accurate and effective mowing, modern models rely on sensor fusion and path-planning algorithms rather than perimeter wires. Due to their effectiveness, environmentally friendly operation, and intelligent connectivity, robotic lawn mowers are becoming more and more popular among consumers, according to recent market trends. AI is used in many models for slope handling, obstacle detection, app-based scheduling, adaptive mowing, and hybrid navigation systems. Large lawns and expert landscaping are catered to by commercial-grade mowers, which exhibit performance and terrain handling ability. Time savings, less effort, constant lawn height, as well as natural mulching that supports healthy turf, are just a few advantages of these mowers. By reducing energy consumption and doing away with the usage of fossil fuels, they also promote sustainable lawn care. But there are still difficulties. Adoption is hampered by high initial prices, short battery life, topographical limitations, and cybersecurity issues. Extreme temperatures and battery deterioration can shorten lifespan, and connected devices need secure networks to safeguard data and privacy. These constraints are intended to be addressed by ongoing advancements in AI, navigation systems, rechargeable batteries, and user-friendly design. Autonomous robotic lawn mowers will probably become a standard element in residential landscapes as prices fall and dependability increases. They pledge to encourage both convenience and environmentally friendly gardening techniques by making lawn care effective, sustainable, and incorporated into future smart houses.

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