Review Article
Volume 14:1, 2025

Advances in Robotics & Automation

ISSN: 2168-9695 Open Access

RC Electric Vehicle for Weeding

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Abstract

This research paper explores the development and implementation of a remote-controlled Electric Vehicle (EV) for precision weeding in agricultural fields. The EV, powered by rechargeable lithium-ion batteries, offers a zero-emission alternative to conventional combustion-engine agricultural machinery. Its electric motor propels the vehicle with precision, while the remote-control system allows for precise navigation and weed eradication. The environmental benefits of the EV include reduced greenhouse gas emissions, improved air quality, and quieter operation, promoting the harmonious coexistence of agricultural practices and the environment. The project aims to pave the way for sustainable, clean, and efficient farming practices by eliminating the carbon footprint associated with traditional machinery and herbicide use. The research project considers not only the technological development of the EV and its remote-control system but also the environmental impact assessment, safety considerations, and the development of a robust charging infrastructure. The aim is to optimize weed management and foster a holistic approach to agriculture, where ecological balance and efficiency coexist. The outcomes of this project are poised to contribute to a more sustainable and responsible future for agriculture, where the convergence of technology and ecological responsibility is the guiding principle.

Keywords: Electric Vehicle (EV) • Precision weeding • Sustainable agriculture • Zero emissions • Remote control system • Charging infrastructure • Sustainable farming practices

Introduction

Remote-controlled electric vehicles are revolutionizing various industries, particularly in weed control. They offer a promising solution to the problem of weeds in agriculture and landscaping, as manual weeding is time-consuming and labor-intensive. This essay explores the benefits and challenges of these vehicles, focusing on their efficiency [1].

The remote-controlled electric weeding vehicle significantly improves efficiency and reduces labor requirements by autonomously traversing fields and gardens. This allows for efficient coverage of large areas, freeing up time for other tasks. The vehicle can identify and target specific weed species, minimizing damage to plants. This technology is particularly beneficial in organic farming, where chemical herbicides are not used. Additionally, it offers environmental benefits by following predetermined paths or using sensors to detect weeds [2].

The remote-controlled electric weeding vehicle uses electric power, reducing the environmental impact of traditional herbicides. It effectively targets and removes weeds without damaging plants, reducing greenhouse gas emissions and air pollution. Electric vehicles also eliminate the need for frequent refueling and hazardous fuel disposal. Renewable energy sources like solar or wind power further enhance sustainability. Quieter motors are also available. Remote-controlled electric weeding vehicles offer precision targeting for weed control, particularly in organic farming. This method reduces noise pollution and promotes environmental sustainability by avoiding chemical herbicides.

The remote-controlled electric weeding vehicle, despite its benefits, faces challenges in its implementation. The initial cost of acquiring and implementing this technology can be high, especially for small-scale farmers or landscapers with limited budgets. The technology's precision targeting and electric power can be expensive, making it an invaluable tool in organic farming. Additionally, the vehicle requires regular maintenance and staff, which may lead to technical issues over time. Addressing these challenges is crucial for the long-term viability and effectiveness of the technology, which is essential for farmers and landscapers [3].

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Received: 28 October, 2023, Manuscript No. ARA-23-118620; **Editor assigned:** 31 October, 2023, PreQC No. ARA-23-118620 (PQ); **Reviewed:** 15 November, 2023, QC No. ARA-23-118620; **Revised:** 16 January, 2025, Manuscript No. ARA-23-118620 (R); **Published:** 23 January, 2025, DOI: 10.37421/2168-9695.2025.14.313

Literature Review

An autonomous weeding robot for organic farming

Abstract: The goal of this project is to develop an autonomous field-level device that will replace manual weeding in organic farming. A systematic design method was used in the creation of the autonomous weeding robot, providing a clear picture of the whole design. A car featuring a diesel engine, four-wheel drive, four-wheel steering and a hydraulic gearbox was created. There are no restrictions on the freedom of study for intra-row weed detection and weeding actuator solutions because of the available power and stability of the vehicle. A novel machine vision algorithm was created to perform the task of navigation along the row. An experiment conducted in a greenhouse with sugar beetroot revealed that the algorithm could locate the crop row with an average inaccuracy of less than 25 mm [4].

The design procedure: A phase model is used as the design methodology for the autonomous weeding robot. The design of a product is shown in this phase model as a process that consists of three stages: defining the problem, defining the alternatives, and constructing the solution. Different levels of abstraction have different answers as a result of the various processes.

Determining the design's goal is the first step in the issue definition process. The requirements are also defined during the problem definition stage. There are two types of requirements: Fixed requirements and flexible requirements. A design is rejected if it does not meet the set requirements. A certain level of fulfillment is required for variable needs. The quality of the design is determined by how well these standards are met [5].

The evaluation of potential idea solutions is also based on the changeable requirements. The specification of the robot's functions is the final step in the problem definition process. A function is an activity that a robot must carry out in order to accomplish a certain task. Navigating along the row and intra-row weeding are crucial tasks in our situation. A solution at the first level of abstraction is represented by the functions that are arranged in a function structure.

There are several functions that make up the function structure. certain alternative principles can be employed to achieve certain tasks, such as the eradication of weeds using mechanical and thermal principles. A morphological chart presenting potential alternative principles for each of the functions is provided during the alternative's definition phase.

Conclusion: Using an organized design process has the benefit of offering a thorough perspective of the entire design. Additionally, the design technique compels the designer to consider other options. It is simple to monitor the status of design due to the well-organized flow of design activities. It is simple to find other topics in a study area that need more investigation. However, the research's primary direction is still evident for the time being. A versatile research vehicle was produced by using the autonomous weeding robot's design process. For an autonomous weeding robot in a research setting, the design with a diesel engine, hydraulic gearbox, four-wheel drive and 360-degree four-wheel steering is a solid idea. The plan for the current year is to finish the autonomous navigation and control of the weeding robot. This will be tested in a sugar beet field. Adding an intra-row weeding system is planned for next year. The ultimate test will then be to show that it is possible to weed a whole sugar beet field autonomously by a weeding robot.

Methodology

Weeder development: Developing a remote-controlled electric weeder is an innovative application of Remote-Controlled Electric Vehicles (RCEVs) in the agriculture sector. This concept combines the environmental benefits of electric propulsion with the precision and efficiency required for agricultural weeding. Here's an outline of the development process for a remote-controlled electric weeder.

Conceptualization: This phase involved a need for a more efficient and eco-friendly weeding machine. It has to be designed based on their limitations and areas for improvement. The conceptual design established the structure of the machine and its capabilities.

Design and engineering: Determine the type of RCEV that suits the purpose of a ground-based vehicle with electric weeding mechanisms. Design an electric propulsion system, including motors, batteries, and controllers, to ensure efficiency and ease of remote control. Develop a weeding mechanism that can be controlled remotely, cutting blades or specialized tools. Integrate sensors for obstacle detection, and plant identification to enable precise weeding.

Remote control system: Create a user-friendly remote-control system, which can include a physical controller. Implement cameras and sensors to provide real-time feedback to the operator, enabling them to make informed decisions.

Testing and prototyping: Build a prototype of the weeder to test its functionality, efficiency, and safety. Conduct field trials to assess the device's performance in different agricultural settings and conditions.

Regulatory compliance: Familiarise yourself with local and international regulations related to agriculture, drones, and remote-controlled vehicles. Ensure that your weeder complies with these regulations.

Maintenance and support: Establish a maintenance and support network to assist users with technical issues and repairs. Provide training and resources for users to operate the weeder effectively.

Future development: Continuously improve the weeder based on user feedback and technological advancements. Explore opportunities for scaling up production and expanding into global markets.

Developing a remote-controlled electric weeder can revolutionize weed management in agriculture, offering a more sustainable and efficient alternative to traditional methods. This innovative approach has the potential to make farming more environmentally friendly while increasing productivity and reducing labor costs.

Design principle: Designing a Remote-Controlled Electric Vehicle (RCEV) involves considering a wide range of principles to ensure functionality, efficiency, safety, and user experience.

User-friendly remote control: Design an intuitive and ergonomic controller for easy operation. Incorporate features like auto-calibration and user presets for different driving modes or tasks.

Safety and reliability: Implement fail-safe mechanisms to prevent accidents in case of signal loss or other malfunctions. Use durable and reliable materials for the vehicle's construction to ensure long-term use.

Real-time feedback: Include cameras and sensors to provide real-time data to the operator, enhancing control and situational awareness. The output is displayed in the remote monitoring system.

Adaptability and customization: Design the RCEV to be modular, allowing users to easily swap out components or customise it for different applications. Offer a variety of compatible accessories and upgrades to cater to diverse user needs.

Aerodynamics and efficiency: Streamline the vehicle's design to reduce air resistance, improving both speed and energy efficiency. Minimise aerodynamic drag to extend battery life and range.

Efficient electric propulsion: Choose high-efficiency electric motors and power electronics to maximize energy utilization. Optimize the battery system for energy density, range, and quick charging.

The design of a remote-controlled electric vehicle should focus on providing a seamless, safe, and enjoyable experience for users while fulfilling the specific requirements of the intended applications, whether they are recreational, commercial, industrial, or scientific. Balancing these design principles will lead to a successful and competitive RCEV.

Parameter consideration: When designing a Remote-Controlled Electric Vehicle (RCEV), various parameters need to be carefully considered. These parameters contribute to the effectiveness and efficiency of the weeder.

Power source: Select the appropriate battery chemistry (e.g., lithium-ion, lithium-polymer) to balance energy density, weight, and cost. Determine the battery's capacity to meet the desired operating range and application requirements. Decide on the voltage level that suits the electric motors and overall vehicle design.

Electric motors: Choose the right motor type (e.g., brushed DC, brushless DC, or electric motor) based on efficiency, power, and torque requirements. Decide on the location of the motors (e.g., in-wheel, hub motors, or traditional drivetrain).

Vehicle size and weight: The physical dimensions of the RCEV, considering portability and storage. Balance the vehicle's weight for stability and energy efficiency.

Operating range: The desired range of the RCEV needs to be covered and calculated on a single battery charge. Optimize the vehicle design for energy efficiency to extend the operating range.

Terrain and environment: Consider the terrain the RCEV will operate on (e.g., indoor, outdoor, rough terrain) and design components accordingly. Account for weather conditions, such as rain or extreme temperatures, and ensure the RCEV's components are robust.

Remote control system: Choose the control interface, such as physical transmitters, or computer software. Communication range: Determine the required range for reliable remote control.

Safety features: Implement mechanisms to stop (such as Emergency Stop Button) or return the RCEV in case of signal loss or emergencies. Consider sensors and technologies for obstacle detection and collision avoidance.

Payload capacity: Define the maximum weight or payload the RCEV can carry, which is crucial for industrial and commercial applications.

Speed and performance: Set the vehicle's maximum speed and acceleration capabilities based on its intended use. Optimize the powertrain for the desired performance characteristics.

Autonomy and navigation: Consider the level of autonomy, whether it's manual control, semi-autonomous, or fully autonomous. Implement sensors, GPS, and navigation systems to support autonomous features.

These parameters should be thoroughly analyzed and balanced to create an RCEV that meets the specific needs of its intended users and applications. The design process should involve trade-offs to achieve the desired performance and functionality while considering factors like cost, safety, and environmental impact.

Discussion

EV technology

The automobile industry has experienced significant changes in recent years due to the need to reduce carbon emissions, combat climate change, and reduce environmental impact. Battery Electric Vehicles (BEVs) have emerged as a sustainable mobility option, offering innovative and environmentally friendly solutions for personal and business travel.

BEVs are electric cars powered by rechargeable batteries, unlike hybrid vehicles that combine internal combustion engines with electric propulsion. They offer environmental benefits, increased energy efficiency, economic benefits, and a quieter driving experience, surpassing the environmental concerns of hybrid vehicles. This shift towards electric transportation promises a more pleasant driving experience.

BEVs, due to their efficiency in converting electrical energy into kinetic motion, contribute to cleaner air, lower greenhouse gas emissions, and a significant reduction in environmental impact by eliminating the burning of fossil fuels, making them a crucial player in reducing air pollution and accelerating the transition to sustainable transportation systems.

BEVs are attractive due to their quiet operation, reducing noise pollution, and promoting peaceful cohabitation with urban and rural surroundings. They represent a commitment to responsible and respectful travel, offering calmer rides and reducing noise pollution, making them a significant advancement in transportation.

BEVs offer environmental and acoustic benefits, lower running costs, and continued government subsidies and tax refunds, making them a wise investment for individuals and companies due to their cost-effectiveness compared to petrol or diesel fuel.

This summary explores the mechanics, technologies, and impact of Battery Electric Vehicles (BEVs) on various industries, including personal transportation and agriculture. BEVs represent optimism, innovation, and the potential to change travel patterns while protecting the environment and paving a sustainable transportation future. They are not just a means of transportation.

Battery: Lithium-ion: Lithiu-ion batteries are commonly used in portable consumer electronics like cell phones and laptops due to their high energy per unit mass and volume, high power-to-weight ratio, energy efficiency, good high-temperature performance, long life, and low self-discharge.

Most components of lithium-ion batteries can be recycled, but the cost of material recovery remains a challenge for the industry.

Most of today's all-electric vehicles and PHEVs use lithium-ion batteries, though the exact chemistry often varies from that of consumer electronics batteries. Research and development are ongoing to reduce their relatively high cost, extend their useful life, use less cobalt, and address safety concerns regarding various fault conditions.

Weeding technology

Remote-controlled electric vehicles efficiently perform weeding in agricultural fields using various mechanisms to remove weeds.

- The rotary weeding blade technique is a widely used method in agricultural weeding equipment, utilizing rotating blades or discs to cut, uproot, or destroy weeds as a vehicle moves over the field, offering numerous advantages in soil removal.
- Rotary blades are designed to cut weeds at or below ground level, removing the above-ground portion and uprooting it, thereby reducing weed competition with crops and preventing regrowth.
- It offers versatility by allowing for customization of designs and patterns to target specific weed types or densities, thereby ensuring the blade’s suitability to the specific crop requirements.
- The adjustable height and angle of the blades enable operators to control the depth of weeding and the aggressiveness of the weeding process, allowing them to adapt to different soil conditions and crop growth stages, thus ensuring efficient and effective weeding in various crop stages.
- Continuous operation of the blades in the vehicle facilitates efficient weeding, resulting in high work rates and productivity.
- Rotary weeding blades are easy to maintain and replace compared to other weeding mechanisms like lasers or robotic arms.
- Rotary blades can be used for selective weeding, removing specific types of weeds while avoiding damage to desirable crops with proper design and adjustment.
- It mainly offers mechanical weed control, which is an environmentally friendly alternative to chemical herbicides.

Navigation techniques

Navigating between the crops: The study aims to develop a robust and efficient system using computer vision techniques, specifically HSV colour space analysis and Canny edge detection, for autonomous agricultural robots to navigate between crop rows, identify obstacles, and perform tasks in inter-row farming, focusing on inter-row farming.

Methodology: The initial stage of the process involves image preprocessing to address noise, lighting conditions, and image quality concerns, aiming to enhance contrast and minimise the impact of lighting variations, particularly in outdoor settings.

The HSV colour space is used for colour segmentation, dividing colour information into three components: Hue (H), Saturation (S), and Value (V), crucial for distinguishing between crop colours and inter-row spaces in inter-row farming navigation. The process of segmenting images using specific HSV thresholds helps identify and distinguish between different objects in the agricultural field by isolating the colours of crops and inter-row spaces.

Canny edge detection is a technique that uses images to identify edges within segmented regions, providing valuable information about object and row boundaries, aiding navigation and obstacle avoidance. Object detection techniques are utilized in agricultural fields to identify specific objects like crop rows, obstacles, or weeds, enhancing the robot's navigational decision-making process.

The autonomous robot uses color segmentation, edge detection, and object detection to navigate inter-row spaces, avoiding obstacles, with algorithms and control systems for precise navigation and efficient task execution. The system incorporates a feedback loop to continuously update the robot's navigation based on real-time data from cameras and sensors, ensuring effective navigation in dynamic outdoor environments.

Outdoor agricultural environments require integration with GPS, LiDAR, and ultrasonic sensors for accurate positioning, obstacle detection, and terrain assessment, as these sensors complement computer vision techniques, ensuring accurate and reliable data. The robot's navigation and control system undergo extensive testing and calibration to ensure its effectiveness in real-world conditions, including various lighting conditions, terrains, and crop types.

Environmental impact

The development and deployment of a remote-controlled Battery Electric Vehicle (BEV) for weeding in agricultural fields can have both beneficial and bad environmental consequences. Understanding and minimizing these effects is critical for long-term project planning. We have considered the following environmental consequences:

Positive environmental impacts

- BEVs in agriculture significantly reduce greenhouse gas emissions due to their electricity-powered nature, resulting in zero tailpipe emissions, improved air quality, and a decrease in carbon dioxide emissions.
- BEVs significantly enhance air quality by eliminating emissions from traditional engines, particularly in agricultural areas where traditional machinery can generate harmful pollutants for workers and the environment.
- BEVs offer significant noise reduction, reducing pollution in agricultural areas and potentially benefiting wildlife due to their quieter nature compared to traditional combustion engines.
- BEVs prevent soil and water contamination due to their lack of oil or fuel leaks, reducing the risk of environmental damage and soil remediation.
- BEVs are known for their energy efficiency, resulting in lower overall energy consumption in agricultural operations compared to conventional vehicles.

Negative environmental impacts

Battery-Electric Vehicles (BEVs) have significant environmental impacts, including the extraction of raw materials and disposal of used batteries. The energy source for charging depends on the source of electricity, and fossil fuel-generated electricity may reduce emissions. Charging infrastructure development in remote areas can impact local ecosystems. Mining materials like lithium, cobalt, and rare earth elements for batteries can cause habitat disruption and soil contamination. Responsible disposal or recycling of BEV components is crucial to mitigate environmental impacts associated with electronic waste.

Our project aims to develop a remote-controlled BEV for agricultural weeding, focusing on minimizing environmental impact through key considerations and following sustainability-critical steps to ensure environmental sustainability.

- Choosing sustainable materials for BEV construction, weeding mechanism, and components, focusing on recyclable and eco-friendly options whenever possible.
- Optimizing battery management systems to extend the battery's lifespan and reduce replacement needs. Considering the usage of second-life batteries with significant capacity for our application, even if they're no longer suitable for automotive use.
- Developing a plan for responsible battery disposal and recycling, ensuring environmentally friendly methods to minimize waste and environmental harm.
- Utilizing renewable energy sources like solar or wind power for charging the BEV can significantly decrease the carbon footprint associated with electricity generation.
- Regular maintenance and efficiency checks are crucial for the optimal operation of the BEV and weeding mechanism, thereby reducing energy waste and environmental impact.
- Implementing safety features like spill containment systems for batteries and fluids to prevent environmental contamination in case of accidents or malfunctions.

Challenges and limitations

Cost of investment: Remote-controlled weeding machines can be expensive to purchase and maintain. Small and medium-sized farmers may find it challenging to afford this technology, limiting its adoption in certain regions.

Operational expenses: While these machines can reduce labour costs over time, they come with operational expenses such as maintenance, energy, and the need for skilled operators to control them remotely.

Limited versatility: Remote-controlled weeding machines are often designed for specific crops and conditions. adapting them to different crops or terrains can be complex and may require significant reconfiguration.

Sensitivity to weather conditions: These machines can be sensitive to adverse weather conditions, such as heavy rain, strong winds, or extreme heat. Operating them in unfavorable conditions can lead to reduced effectiveness and potential damage.

Wedding precision: Ensuring that the machines effectively target and remove weeds without damaging crops can be challenging. Some systems may require advanced computer vision or machine learning algorithms to improve precision.

Obstacle detection and navigation: These machines must navigate through fields without damaging crops or getting stuck. Accurate obstacle detection and avoidance systems are crucial, and this technology is still developing.

Energy consumption: Remote-controlled weeding machines require a power source, typically electricity or fuel. High energy consumption can be a limitation, especially in areas with unreliable or expensive power sources.

Data connectivity: The remote-control aspect relies on stable and high-speed data connectivity, which may not be available in all rural agricultural areas.

Lack of adaptability: Weeding machine systems may not adapt well to changing field conditions or unforeseen challenges, which require manual intervention or reprogramming.

Regulatory and safety concerns: The use of remote-controlled machines in agriculture may raise safety and regulatory concerns. For instance, there may be regulations regarding the use of autonomous or semi-autonomous machinery, as well as safety standards for operating them in the vicinity of humans.

Skills and training: Farmers and operators need training to use remote-controlled weeding machines effectively. The knowledge and expertise required may be a barrier to adoption in some regions.

Environmental impact: The use of fuel-powered machines can have environmental consequences, contributing to greenhouse gas emissions. Adopting more sustainable power sources is essential.

Maintenance and repairs: Like any machinery, remote-controlled weeding machines require regular maintenance and occasional repairs. Access to technical support and spare parts can be a limitation in some areas.

Scale and compatibility: The technology may not be suitable for small-scale farming operations, and it may not be compatible with existing farming equipment or practices.

Despite these challenges and limitations, the continued development of remote-controlled weeding machines holds great promise for increasing the efficiency and sustainability of agriculture, especially in larger-scale, technology-ready farming operations.

Conclusion

The development of a remote-controlled Electric Vehicle (EV) for precision weeding in agricultural fields represents a pioneering course toward a more sustainable, efficient, and eco-conscious future for agriculture. The EV, powered solely by rechargeable lithium-ion batteries, represents a decisive departure from traditional combustion-engine agricultural machinery. Its electric motor, propelled by clean and renewable electricity, silently traverses the fields, guided by remote control systems that allow for unparalleled precision in weed management. The elimination of tailpipe emissions, a hallmark of the EV, begets a breath of fresh air for agricultural practices. With a commitment to zero emissions and reduced noise pollution, the EV serves as a testament to the potential for synergy between technology and environmental stewardship.

The project illuminates the myriad advantages of EVs in agriculture, such as reduced greenhouse gas emissions, improved air quality, and energy efficiency. As herbicide usage is minimized, and the carbon footprint is diminished, the BEV offers the promise of a more sustainable and responsible path forward for farming practices. However, the success of the project extends beyond the mere development of the BEV itself, necessitating a comprehensive approach that encompasses environmental impact assessment, safety considerations, and the establishment of an efficient charging infrastructure.

Environmental Considerations

Ensure the weeder's eco-friendliness by using electric power, reducing the need for chemical herbicides. Minimise soil disruption and crop damage during weeding operations.

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How to cite this article: Jagadesan, Sridhar, Soorya B, Mohan S and Aakash R, et al. "RC Electric Vehicle for Weeding." *Adv Robot Autom* 14 (2025): 313.