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Solar Powered Autonomous Multipurpose Agriculture Robot

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Abstract*: Our project, the "Solar Powered Autonomous Multipurpose Agriculture Robot," represents a significant step forward in modern farming. We're using clean, renewable energy from solar panels to keep the robot running, reducing our reliance on traditional power sources and minimizing harm to the environment. To make the robot move precisely and efficiently, we're using high-performance DC motors. These motors allow it to navigate different types of terrain smoothly. For planting seeds accurately, we've incorporated servo motors. We're also using a dedicated DC motor pump for precise pesticide application to protect crops. And for cutting grass effectively, we rely on a high-torque GC motor, making the robot versatile in various agricultural tasks. All of these components are controlled by an Arduino microcontroller, which acts as the robot's central brain. It manages interactions between the different parts, ensuring that tasks are carried out in real-time. To make the robot user-friendly, we've developed an intuitive Android app. This app lets operators control and monitor the robot remotely. The connection between the app and the robot is established through Bluetooth, ensuring a reliable link between the mobile application and the agricultural machine. By combining clean energy, advanced motor technology, and a sophisticated microcontroller, our Solar Powered Autonomous Multipurpose Agriculture Robot is set to improve farming efficiency while minimizing harm to the environment. This abstract provides a glimpse of the critical components and functions we'll delve into in the following sections of our project report.*

Keywords: Solar-powered, Agriculture Robot, Advanced Motor Technology, Arduino

I. INTRODUCTION

1.1 Overview

In the world, the primary occupation 42% of total population is Agriculture .It plays a significant role in the life of the people. For the betterment of the life and growth of world economy, mechanization of agriculture process especially agricultural autonomous vehicle is important in order to improve the overall productivity. In recent years, the development of autonomous vehicles in agriculture has experienced increased interest .This development has led many researchers to start developing more rational and adaptable vehicles. In the field of agricultural autonomous vehicles, a concept is being developed to investigate if multiple small autonomous machines would be more efficient than traditional large tractors and human force. These vehicles should be capable of working throughout out the day and year round, in most all weather conditions and have the intelligence embedded within them to behave sensibly in a semi- natural structured or unstructured environment over long periods of time(1). Applying robotics in plant production requires the integration of robot capabilities, plant culture, and the work environment. Commercial plant production requires certain cultural practices to be performed on the plants under certain environmental conditions.

Agriculture's history dates back thousands of years, and its development was driven and defined by very different climates, cultures and technologies. So the agriculture system should be advanced to reduce the efforts of the farmers. The model developed automatically sows the seeds, spray the pesticides and also cut the grass. The prototype represents the advanced system for improving the agricultural processes such as seed sowing, grass cutting and pesticide spraying based on robotic assistance. The organization of the paper is as follows. Section II presents previously published related works. The proposed design of multipurpose agricultural robot is presented

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in Section III. The algorithm implementation is discussed in Section IV. In Section V prototype results of the work are discussed.

1.2 Motivation

The motivation behind the development of the solar-powered autonomous multipurpose agriculture robot project is rooted in the critical challenges and opportunities within the agriculture sector.

Agricultural labor shortages have become a common issue in various regions, making it increasingly challenging to perform essential farming tasks. This automation project seeks to address this labor shortage by introducing a robot capable of carrying out various farming activities autonomously.

Furthermore, as the global population continues to grow, there is an ever-increasing demand for higher food production. This project is motivated by the need to enhance agricultural efficiency and yield to meet this growing demand effectively.

The project aligns with the global push for environmental sustainability. By utilizing solar power as its energy source, it reduces the carbon footprint associated with conventional farming practices. This commitment to sustainability is a driving force behind the project.

The concept of precision agriculture, which focuses on optimizing resource use and precise application of inputs, is essential in modern farming. The project's motivation is deeply rooted in its ability to conduct seeding and pesticide spraying tasks with precision, contributing to the adoption of precision farming practices.

Cost savings are a substantial motivation for this project. Traditional farming can be capital-intensive, with labor costs being a significant portion of expenses. The automation of various farming operations can lead to significant cost savings, thereby making agriculture more economically viable and sustainable for farmers.

This project also aims to make agriculture more accessible to a wider demographic, including individuals with physical limitations. By relieving farmers from physically demanding tasks, it opens the door for a more diverse range of individuals to participate in farming activities.

The motivation for this project is also fueled by the rapid advancements in robotics, automation, and renewable energy technologies. It aims to leverage these technological advancements to modernize and revolutionize farming practices for increased efficiency and productivity.

Incorporating remote monitoring and control through an Android application is another key motivation. This feature provides farmers with the convenience and flexibility to manage their agricultural operations from anywhere, contributing to improved farm management and decision-making.

1.3 Problem Definition and Objectives

The agriculture sector faces challenges related to labor shortages, increasing food demand, environmental sustainability, and cost-efficiency. To address these issues, there is a need for an autonomous agricultural robot powered by solar energy, capable of performing various tasks, and remotely controllable via an Android app. This project aims to provide a solution that improves farming efficiency, reduces labor dependence, and promotes eco-friendly practices.

- Automate essential farming tasks such as seeding, pesticide spraying, and grass cutting.
- Increase agricultural efficiency and productivity.
- Reduce the reliance on fossil fuels by utilizing solar power.
- Lower operational costs for farmers through automation.
- Make farming more accessible to a wider demographic.
- Promote precision agriculture practices.
- Enhance environmental sustainability.
- Provide remote monitoring and control for convenience and real-time management.
- Leverage advanced technologies to modernize and optimize farming operations.

1.4. Project Scope and Limitations

The scope of the "Solar Powered Autonomous Multipurpose Agriculture Robot" project encompasses the design, development, and deployment of a versatile agricultural robot capable of autonomously performing tasks such as seeding, pesticide spraying, and grass cutting. The project will focus on integrating solar panels for energy, various motors for mobility and task-specific operations, and an Arduino microcontroller for control. The project also includes the development of an Android application for remote monitoring and control via Bluetooth. The primary aim is to enhance agricultural efficiency, reduce labor intensity, promote sustainability, and offer cost-effective solutions to farmers.

Limitations As follows:

- **Limited Battery Storage:** The robot's operational time is constrained by the energy storage capacity of the onboard batteries.
- **Terrain Dependency:** The robot's efficiency may be compromised on challenging terrains, impacting its ability to perform tasks optimally.
- **Seed Variety Compatibility:** The precision of seed planting may be influenced by the diversity of seed types, limiting the robot's applicability to specific crops.
- **Pesticide Application Challenges:** External factors like wind speed and direction may affect the accuracy of pesticide application, potentially leading to uneven coverage.
- **Cost Constraints:** The incorporation of advanced technologies, such as high-performance motors and solar panels, may result in a higher initial cost, potentially limiting widespread adoption by smaller farms.

II. LITERATURE REVIEW

Iot based smart multipurpose agricultural robot. Was proposed by prof. Dr. S. B. Dhoble , mrunmayee gahukar , ankita rahate roshani borkar , dipali bansod this robotic system is named as agricultural robot, nothing but the machine which assembles with electronic equipment or components & performs specific operation as directed by instructor. This technology provides optimum and efficient solution for wide range of production in agriculture field. The robot is capable of performing operation like automatic ploughing, seed sowing and chemical spraying.

Iot based mechanized robot: an integrated process involving fulltime multipurpose control, automation and surveillance system proposed by abdullah all mamun anik, istiak habib , shuvodip adhikary, dr. Abdul gafur — the internet of things (iot) is the next generation of wireless technology that automates routine tasks and reduces labor. Software, sensors, and actuators are combined into a network of linked devices in the internet of things. The gadgets may exchange data and communicate over a network. Our laboratories have used this technology to make appliances more convenient and automated. One of the key reasons for this increase is its capacity to both secure and facilitate research. The iot innovation can provide fantastic content for modern automation. This study proposes an internet-based smart laboratory and laboratory machine automation, cloud storage data gathering, and monitoring system to efficiently operate types of machinery, online live data streaming, and monitor mechanical work devices. The iot microcontroller devices are connected to the robot to gather different sensors data, control and monitor the types of machinery and lab appliances in a smart lab environment. Any android phone, laptop, or computer may operate the robot wirelessly. All sensors data and parameters can be collected from google's cloud storage platform blynk and used to operate all appliances and devices. It will supply us with live streaming video of the laboratories with a specific ip address, and we can monitor the laboratory using this robot.

A multipurpose agricultural robot for automatic ploughing , seeding and plant health monitoring chandana r, nisha m, pavithra b this approach is on the designing of agricultural robot for various tasks. Certainly robots are playing an important role in the field of agriculture for farming process autonomously. In agriculture, the opportunity for robot is enhancing the productivity and the robots are appearing in the field in large number. The proposed system focuses on implementing all the farming process especially in the field of ploughing and seeding by using microcontroller,hc-05 and hc06 bluetooth models, various sensors etc,.the robot detects the planning area by using sensors and seeds need to be planted in the corresponding field using gripper arrangement of the robot. In a continuation, the rest of remaining process could be done automatically. In recent years the development of the

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autonomous vehicles in the agriculture has experienced more interest. This robot will help the farmers in doing the farming process more accurate.

Multi-functional robot using arduino for farming purpose siddhartha verma, tushar srivastava, vikalp mishra, er. Ankita khare in our country agriculture plays an important role for development in food production. In order to this smart farming improves the quality and quantity of agricultural products and the smart agricultural technique is required to save manpower and increase the efficiency with the help of multi-tasking robot . Smart agriculture is very efficient because the iot sensors are capable of providing information about agriculture field and then act upon that. Smart farming is a concept that increases the efficiency at low cost without compromising the quality of the crop. The main objective of this paper is to design and development of a multitasking robot which is capable of doing some agricultural activities like ploughing of field, sowing of seeds, watering the crop by measuring the soil moisturizing sensors and tracking the sun for solar energy for the night vision purpose. This agri-bot gets energy from the solar plate mounted on the bot and this will also help in conservation of renewable energy resource on a large scale and is operated by arduino ide .in this revive paper, we discuss the potential of embedded system and iot, the robotics and automation can play a significant role in agricultural production need and this mechanical vehicle will reduce the work cost, speed up and increase the exactness of the work.

An iot based multifunction agribot a. R. Uday1 , d. Nisarga , syeda arshiya, a. Deepak, j. Sudha griculture is the science and art of cultivating plants and livestock. More than 40 percent of the population in the world choose agriculture as the primary occupation. In recent years, increased interest has grown for development of the autonomous vehicles like robots in agriculture. The proposed system aims at designing multipurpose autonomous agriculture robotic vehicle which performs the tasks such as ploughing, seed sowing, watering the crops. This robotic vehicle is an agricultural machine of a considerable power and great soil clearing capacity. This multipurpose system gives an advance method to sow, plow, water the crops with minimum man power and labor making it an efficient vehicle. The machine will cultivate the farm by considering particular rows and specific column at fixed distance depending on crop. Moreover, the paper aims at making use of evolving technology i.e. Iot and bluetooth which results in smart agriculture. The whole process calculation, processing, monitoring is designed with motors & sensor interfaced with microcontroller.

Iot and solar energy based multipurpose agricultural robot for smart farming Ashok g meti, kirangouda s biradar, manoj g h, —in india, nearly 70% of people depend on agriculture. In the agricultural field, various operations such as seed sowing, grass cutting, pesticide spraying, ploughing are carried out. Automation of agricultural operations is a current demand to increase productivity through the use of tools and technology. At the moment seed sowing, pesticide spraying, and grass cutting are all difficult tasks. The equipment needed for the aforementioned actions is both expensive and inconvenient to use. As a result, india's agricultural system should be advanced through the development of a system that reduces reliance on human labour and time. The proposed agricultural robot is a user-friendly, internet of things (iot)-based system that can be used in any type of soil. Users can use a web page to monitor the crop's condition as well as perform some specific operations. The objective of this project is to design, develop, and build a robot that can sow seeds, cut grass, spray pesticides, pluck fruit, and detect soil nutrition levels and irrigation. Solar energy is used to power the entire system.

Iot based multipurpose surveillance robot divakar u, ningaraju a.m, sudarshana chakravarthy, suraj sharma s, - the main goal of iot based multipurpose surveillance robot is to design and develop a surveillance robot that is capable of being used for rescue and spying in military operations. It is known that humans cannot venture into hazardous/disaster-affected places as it can be lifethreatening and hence robots are required where human intervention is nearly impossible. Wireless surveillance robots can help to prevent the endangerment of humans or animals. The robot acts as a surveillance device to capture the intruder's surrounding information before the intruder attacks the soldiers. The issues related to short-range communication to control the movement of the robot are overcome by using iot technology and therefore real-time video can be transmitted to the intended recipient. An android phone can control the robot's movement from a distance. This project comprises the following phases: controlling the robot in manual mode using iot technology via android application, phone acting as a camera for live video streaming, ir, gas and metal detection sensors, and rechargeable batteries. The work aims to reduce loss of lives during military operations, ensure safety on the war field and help provide footage of disaster struck regions.

III. REQUIREMENT AND ANALYSIS

Requirements for Solar Powered Autonomous Multipurpose Agriculture Robot:

Solar Power System:

- Utilize high-efficiency solar panels to harness solar energy.
- Implement a robust energy storage system (batteries) for continuous operation during low sunlight conditions.
- Ensure an optimal power management system for efficient energy utilization.

Mobility and Navigation:

- Integrate high-performance DC motors for precise and efficient movement across diverse terrains.
- Implement sensors (e.g., ultrasonic, infrared) for obstacle detection and avoidance.
- Enable autonomous navigation capabilities to follow predefined paths and adapt to field conditions.

Planting Mechanism:

- Incorporate servo motors for accurate and consistent seed planting.
- Ensure adaptability to various seed types and planting depths.
- Integrate a feedback system to monitor and adjust planting parameters in real-time.

Pesticide Application System:

- Utilize a dedicated DC motor pump for controlled and precise pesticide application.
- Integrate sensors to assess crop health and optimize pesticide usage.
- Implement a modular system for different types of pesticides and herbicides.

Grass Cutting Mechanism:

- Utilize a high-torque GC motor for effective grass cutting.
- Implement adjustable cutting heights to accommodate different crop requirements.
- Ensure safety features to avoid damage to crops or obstacles during cutting.

Central Control Unit:

- Utilize an Arduino microcontroller as the central processing unit.
- Implement real-time communication between different components for seamless coordination.
- Include a user interface for manual control and monitoring.

Communication System:

- Develop an Android app for remote control and monitoring.
- Establish a reliable Bluetooth connection between the app and the robot.
- Ensure real-time data exchange and status updates.

Environmental Adaptability:

- Design the robot to withstand varying weather conditions, such as rain and extreme temperatures.
- Implement protective measures for sensitive components during adverse weather.

Analysis of Solar Powered Autonomous Multipurpose Agriculture Robot:

Energy Efficiency:

- Evaluate the overall efficiency of the solar power system concerning energy conversion and storage.
- Analyze the robot's ability to operate continuously under different light conditions.

Navigation Precision:

- Assess the accuracy of the robot's navigation system, considering its ability to follow predefined paths and avoid obstacles.
- Evaluate adaptability to different terrains and potential challenges.

Planting Accuracy:
- Analyze the precision of the planting mechanism in terms of seed placement and consistency.
- Evaluate adaptability to various seed types and potential adjustments needed for optimal performance.

Pesticide Application Effectiveness:
- Evaluate the precision and coverage of the pesticide application system.
- Assess the robot's ability to respond to changing crop conditions and adjust pesticide usage accordingly.

Grass Cutting Efficiency:
- Analyze the effectiveness of the grass cutting mechanism in terms of cutting quality and efficiency.
- Assess the adaptability to different crops and cutting height requirements.

Central Control and Communication:
- Evaluate the responsiveness and reliability of the Arduino microcontroller in coordinating various tasks.
- Assess the user-friendliness of the Android app and the stability of the Bluetooth connection.

Weather Resilience:
- Analyze the robot's performance under different weather conditions, including rain and extreme temperatures.
- Identify potential vulnerabilities and propose improvements for enhanced environmental adaptability.

Cost-Benefit Analysis:
- Conduct a cost-benefit analysis considering the initial investment, maintenance costs, and potential yield improvements.
- Assess the economic feasibility and scalability of the robot for different farm sizes.

By conducting a thorough analysis of these aspects, the project team can ensure the successful development and deployment of the Solar Powered Autonomous Multipurpose Agriculture Robot, addressing potential challenges and optimizing its performance in real-world farming scenarios.

IV. SYSTEM DESIGN

4.1 System Architecture

The below figure specified the system architecture of our project.

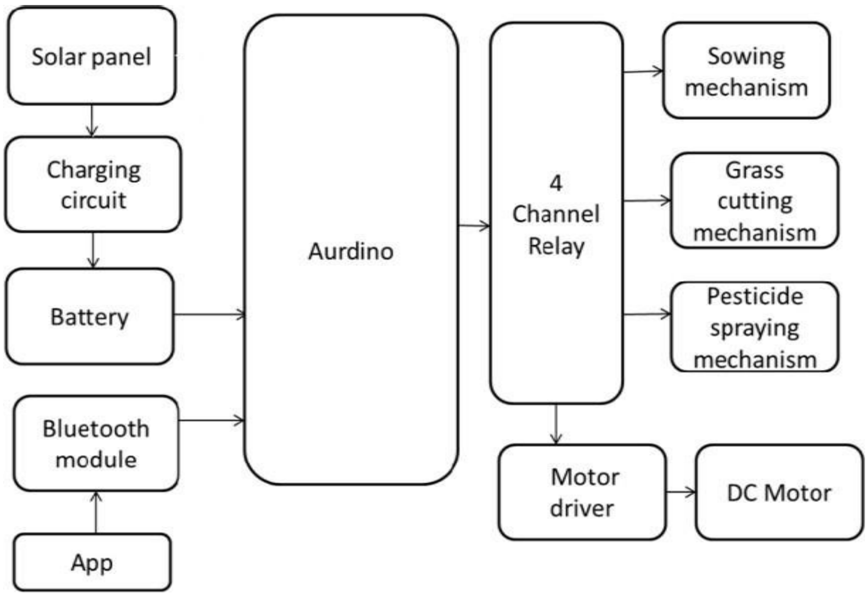

Figure 4.1: System Architecture Diagram

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4.2 Working of the Proposed System

The proposed solar-powered agricultural robot operates seamlessly through the integration and collaboration of its key components. The system begins with the solar panel, positioned at the core, capturing sunlight and converting it into electrical energy. This harvested energy is then directed to the battery, serving as the robot's energy reservoir during periods of sunlight. The rechargeable and long-life battery ensures the robot's sustained operation even in the absence of direct sunlight.

At the heart of the robot's intelligence is the Arduino microcontroller, functioning as its central brain. The microcontroller receives commands from the user through the Android app, establishing a communication link via the Bluetooth module. These commands are translated into precise actions, managing the timing, logic, and sequencing of the robot's tasks.

The motor driver, a critical component, governs the DC motors responsible for the robot's movement and the operation of various agricultural implements. It regulates motor speed, direction, and safeguards against potential damage, providing the necessary precision for tasks like seeding, pesticide spraying, and grass cutting. The choice of high-torque DC motors ensures the robot can efficiently handle the physical demands of diverse agricultural operations.

The adaptability and versatility of the robot are realized through agricultural implements, which act as attachments or tools for specific tasks. These implements, such as seeders, pesticide sprayers, and grass cutters, enable the robot to address a wide range of agricultural needs. The ability to switch seamlessly between these implements enhances the robot's functionality and utility in different farming scenarios.

The Bluetooth module serves as a vital communication gateway, connecting the robot with the user through the Android app. This allows users to remotely control the robot, directing its movement, switching between implements, and monitoring its status. Real-time information, including battery levels and GPS location, is accessible through the user-friendly app interface.

In operation, the solar panel continuously captures sunlight, replenishing the battery's energy reserves. The Arduino microcontroller orchestrates the entire process, ensuring efficient use of energy and precise execution of tasks. The motor driver regulates the DC motors, propelling the robot and activating agricultural implements as needed. The Bluetooth module maintains a seamless link with the Android app, enabling real-time control and monitoring.

These solar-powered agricultural robots offer substantial benefits to modern farming practices. Their reduced reliance on fossil fuels makes them environmentally friendly, while their capacity to operate for extended periods without human intervention enhances efficiency and reduces labor costs. The robots' adaptability to various tasks positions them as invaluable tools, representing a harmonious fusion of technology and agriculture for a more sustainable and efficient future in farming.

4.3 Hardware components:

1. Solar Panel
2. DC Motors
3. Servo Motors
4. DC Motor Pump
5. High-Torque DC Motor
6. Arduino Microcontroller
7. HC-05 Bluetooth Module

4.4 Software components:

1. Arduino IDE:
2. Android App:
3. Proteus
4. Easy eda

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4.3 Hardware Modules:

1. Solar Panel:

At the heart of the system is the solar panel. This device is responsible for capturing sunlight and converting it into electrical energy. The energy generated is then used to charge the robot's battery. Solar panels consist of photovoltaic cells that utilize the photoelectric effect to produce an electric current when exposed to sunlight. The efficiency of the solar panel determines how quickly the battery can be charged. Advances in solar technology have made these panels more efficient and cost-effective.

2. Battery:

The battery is the energy reservoir of the robot. It stores the electrical energy generated by the solar panel during periods of sunlight. This stored energy is later used to power the robot's various components, making it operable even when sunlight is not available. Batteries used in these robots are often rechargeable and designed to have a long lifespan. This ensures that the robot can operate for extended periods without the need for frequent recharging.

3. Arduino Microcontroller:

The Arduino microcontroller serves as the "brain" of the robot. It is responsible for coordinating and controlling all the robot's components. The microcontroller receives commands from the Android app via the Bluetooth module and translates them into actions. It manages the timing, logic, and sequencing of these actions to ensure that the robot performs tasks accurately and efficiently. Arduino microcontrollers are highly versatile and can be programmed to suit a wide range of applications.

4. Motor Driver:

The motor driver plays a crucial role in controlling the robot's movement. It manages the speed and direction of the DC motors. It also ensures that the motors are protected from overcurrent and other potential damage. By controlling the DC motors, the motor driver allows the robot to move precisely and perform tasks such as seeding, pesticide spraying, or grass cutting. The ability to vary the motor speed and direction gives the robot its agility and versatility.

5. DC Motors:

The DC motors are the mechanical workhorses of the robot. These motors are responsible for moving the robot and powering the various agricultural implements, which could include mechanisms like seeders, pesticide sprayers, and grass cutters. The design and power of these motors are essential to the efficiency of the robot's operations. Higher torque motors are often used to ensure the robot can handle the physical demands of agricultural tasks.

6. Agricultural Implements:

Agricultural implements are attachments or tools that the robot can use for specific tasks. The versatility of these robots lies in their ability to adapt to various agricultural needs. The implements can range from seeders that plant crops with precision to pesticide sprayers that protect crops from pests and diseases. Grass cutters can maintain the field, ensuring that it is ready for planting or harvest. The ability to switch between these implements enhances the robot's functionality.

7. Bluetooth Module:

The Bluetooth module is the communication gateway between the robot and the Android app. It allows the robot to receive commands, updates, and information from the app, making it a remotely controlled agricultural assistant. Users can control the robot's movement, switch between agricultural implements, and monitor its status through the app. Real-time information such as the battery level and GPS location can also be displayed on the app's interface.

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V. CONCLUSION

5.1 Conclusion

The "Solar Powered Autonomous Multipurpose Agriculture Robot" project introduces a sustainable, efficient, and accessible solution for modern farming. By harnessing solar energy and employing advanced robotics, it addresses labor shortages, enhances productivity, and reduces environmental impact. The integration of mobile control via an Android app makes farming operations more convenient and technology- driven. This project exemplifies the potential of innovation in agriculture, promising a brighter, more efficient future for farming.

5.2 Future Work

- Enhanced Task Automation: Expand the robot's capabilities to encompass a wider range of agricultural tasks, such as weed control, harvesting, and soil analysis, further reducing the need for manual labor.
- Sensor Integration: Integrate advanced sensors for real-time data collection, enabling the robot to make informed decisions and adapt to changing field conditions.
- Machine Learning and AI: Implement machine learning and artificial intelligence algorithms to enhance the robot's decision-making capabilities, improving task efficiency and resource management.
- Multi-Robot Systems: Develop the concept of swarm robotics, where multiple robots can work collaboratively in a coordinated manner, covering larger areas and tackling complex tasks.
- Energy Efficiency: Explore energy-efficient technologies and storage solutions to ensure uninterrupted robot operation, even during cloudy or nighttime conditions.
- Remote Sensing and Imaging: Incorporate cameras and sensors for crop health monitoring, disease detection, and yield prediction, providing valuable insights to farmers.
- Localization and Mapping: Develop robust navigation and mapping systems that allow the robot to navigate complex and dynamic agricultural environments.

5.3 Applications

Precision Farming:

The solar-powered autonomous agriculture robot is designed for precision farming, enabling accurate and efficient tasks such as precise seed planting, targeted pesticide application, and effective grass cutting. This application enhances crop yield and reduces resource wastage.

Environmentally Friendly Agriculture:

By harnessing clean solar energy, the robot promotes environmentally friendly agricultural practices. It minimizes reliance on traditional power sources, reducing carbon footprint and contributing to sustainable farming methods.

Labor Efficiency and Cost Reduction:

The robot's autonomous capabilities and versatility in handling various agricultural tasks contribute to labor efficiency and cost reduction. It operates for extended periods without constant human intervention, optimizing workforce utilization and reducing manual labor costs.

Adaptability to Diverse Crops:

With the ability to switch between different agricultural implements, the robot adapts to diverse crops and farming requirements. This application ensures flexibility in addressing the specific needs of various crops throughout the agricultural cycle.

Remote Monitoring and Control:

The integration of a user-friendly Android app allows for remote monitoring and control of the robot. Farmers can efficiently manage and supervise agricultural operations, receiving real-time information on the robot's status, battery levels, and GPS location.

Energy Sustainability in Agriculture:

The solar-powered design of the robot contributes to energy sustainability in agriculture. It reduces dependence on non-renewable energy sources, offering a more sustainable and eco-friendly solution for modern farming practices.

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