A Review on Solar Powered IOT Based Multipurpose Agriculture Robot

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Abstract - This paper explores the development of a solar-powered multipurpose agriculture bot designed to address critical challenges in modern farming, including labor shortages, inefficient resource utilization, and environmental sustainability. The proposed system integrates IoT-based sensors for real-time soil and weather monitoring, enabling data-driven decisions for optimized irrigation. Beyond irrigation, the bot automates essential agricultural tasks such as seed sowing, soil ploughing, and pesticide spraying, reducing manual labor and enhancing productivity. Powered by solar energy, the bot promotes eco-friendly practices and operates effectively in regions with limited access to electricity. The paper reviews existing research on smart irrigation and agricultural robotics, highlighting innovations in IoT, renewable energy integration, and automation.

Key Words*: *Solar panel, Robot, Solar energy, Sensors, IoT , cultivating, seed dispensing, insecticide, Weather Monitoring, Ploughing , Water Spraying , Irrigation, Sowing.

I. INTRODUCTION

Agriculture remains the backbone of many economies. Almost 50% of the Indian population is dependent on farming for their livelihood. However, the sector is facing increasing challenges, including labor shortages, inefficient farming practices, and the increasing demand for sustainability in resource usage. Traditional agricultural methods often involve extensive manual labor, which is both time-consuming and physically demanding. These inefficiencies require the incorporation of modern technologies like robotics, IoT (Internet of Things), and renewable energy to solve critical farming issues [1, 2].

The application of robotic technologies in agriculture is still in its infancy, but its potential is immense. Robots equipped with precision tools and automation capabilities can perform tasks like seed sowing, soil ploughing, and pesticide spraying with greater accuracy and efficiency. IoT-based systems help farmers track soil and weather conditions in real-time, so decisions regarding irrigation and crop management can be very data-driven. This combination of robotics and IoT reduces the amount of human effort while increasing productivity and crop yield [3, 4].

One of the major issues facing agriculture today is water scarcity. The use of sensors in monitoring soil moisture levels makes smart irrigation systems optimize the ways of distributing the water. Such systems have proven to greatly conserve water and improve farming efficiency. A more recent study of solar-powered irrigation systems refers to sustainability as it helps reduce the impact on the environment through the use of renewable energy, saving costs of using the system. Its development shows how technology improves eco-friendly agricultural practices [5, 6].

This review focuses on the development of a solar multipurpose agriculture bot: a system that combines IoT-based monitoring with robotic automation. Combining smart irrigation with renewable energy and multi-functionality overcomes the limitations inherent in traditional farming practices and sets ground for sustainable agriculture. This contribution, therefore, is an extension of some of the existing literature along with some innovative contributions towards enhancing productivity and optimizing resources [1, 3, 5, 7].

II. APPLICATION OF SOLAR POWERED IOT BASED ON MULTIPURPOSE AGRICULTURAL BOT

Smart Irrigation Management

The bot integrates IoT-based sensors to monitor soil moisture levels, temperature, and humidity, enabling accurate and automated irrigation. This helps reduce water wastage and provides optimal hydration to crops, particularly in areas prone to water scarcity [1, 5, 7].

Seed Sowing Automation

It is fitted with a seed sowing mechanism to ensure proper seed spacing and depth placement, thus ensuring increased germination and reduced human intervention in time-consuming manual sowing [3, 6]. The system with GPS guidance enhances accuracy further and minimizes human intervention [2].

Soil Ploughing and Preparation

The bot performs soil ploughing and preparation tasks, which are critical for creating a conducive environment for crop growth. Its efficient ploughing mechanism reduces dependency on traditional labor-intensive methods, as highlighted in modular robotic designs [4, 7].

Pesticide Spraying

The bot ensures even application of pesticides through its 360-degree pesticide spraying system, thus minimizing chemical wastage and reducing human exposure to harmful substances. This promotes healthier crops and safer farming practices, as seen in multipurpose agricultural manipulators [1, 5].

Real-Time Monitoring and Control

Real-time monitoring through the mobile application can inform soil and weather conditions about the farmer. This makes it easier to even control the bot from a distance, thus improving the general farm management [3, 6]. IoT has been found to fully optimize farming operations by utilizing real-time data [2, 4].

Sustainable Use of Energy

The bot is powered by solar energy and, therefore, functions effectively in remote areas where electricity supply is scarce. This minimizes the cost of operation and supports eco-friendly farming practices, hence contributing to environmental sustainability [1, 5, 7]. The integration of solar energy with farming systems addresses the dual challenge of energy dependence and sustainability [2, 6].

Multi-Crop Compatibility

Its adaptive design allows the bot to be used in various crops. Thus, it is very useful for small-scale and large-scale farming operations. It will surely meet different agricultural needs due to its versatility [4, 7]. This adaptability is necessary for dealing with the many demands of modern agriculture [3, 5].

Reduced Labor and Cost

The bot significantly reduces the need for manual labor and associated costs by automating labor-intensive tasks. This is especially beneficial in regions facing labor shortages or high labor costs [1, 3]. Modular robotic platforms further reduce dependency on traditional farming methods [4].

Improved Crop Yield and Quality

Through optimal use of resources and improved farming techniques, the bot helps to achieve increased crop yield and better quality crops directly benefitting the farmers and the agriculture sector. Comparable systems have been shown to produce significant enhancements in crop management and yield efficiency [2, 6, 7].

III. METHODOLOGY

The aim of our project is to design and develop a solar-powered multipurpose agricultural bot that automates key farming operations, reduces time, and minimizes human effort. The bot performs tasks such as digging, seed sowing, leveling the soil, and pesticide spraying, powered by solar energy and a battery system.

The robot's frame is constructed from Mild Steel (MS) for durability. Four wheels are attached to the frame, driven by DC motors for movement.

A rotor is connected at the front of the frame to handle harvesting operations, powered by a DC motor for rotation.

A sheet metal plate, attached to the rear of the frame, levels and closes the soil after sowing.

Seeds are stored in a funnel connected to the diggers via hoses. A low-speed motor facilitates the controlled release of seeds into the soil.

A pump and nozzle system is mounted on the bot for pesticide & water spraying. The pump is powered by a DC motor to ensure even application.

A solar panel installed on the top of the frame charges the 12V battery, which powers all the bot's components.

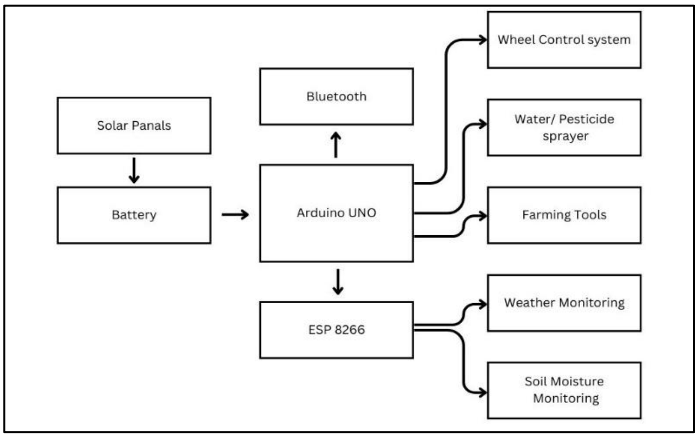

Fig: Block Diagram Of System

IV.OBJECTIVE

The objective of this paper is to present a solar-powered IoT-based multipurpose agricultural bot that automates essential farming operations. In modern agriculture, automation is essential to reduce farmers' efforts and labor costs.

To perform multiple operations such as seed sowing, soil ploughing, leveling, and pesticide spraying simultaneously, increasing productivity and saving time.

The bot is designed for ease of operation, allowing farmers to control it through a user-friendly mobile application.

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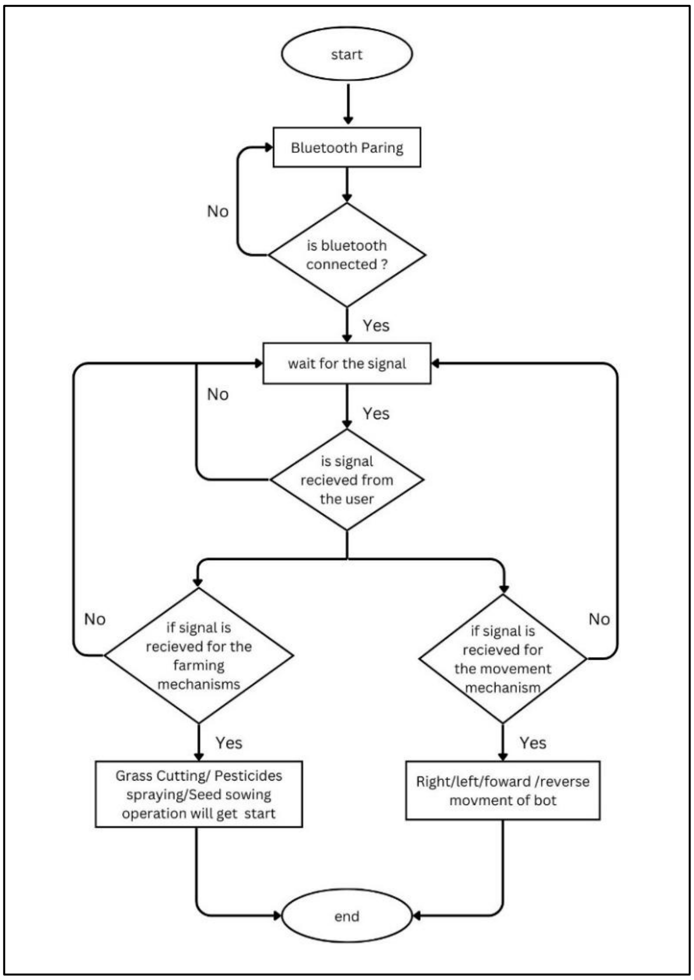
V. FLOWCHART



VI. LITERATURE REVIEW

The integration of solar energy, IoT, and robotics in agriculture has been explored extensively in recent years, with researchers addressing various challenges in modern farming.

Ranjith et al. (2019) designed a solar-powered agricultural robot controlled via Bluetooth, capable of performing seed scattering, grass cutting, and pesticide spraying. While effective, the system faced challenges with signal loss during communication, which could be mitigated by integrating advanced sensors like ultrasonic devices and cameras. [1]

Maheshwari et al. (2019) proposed an IoT-based system for monitoring soil conditions and environmental changes to improve fertilization practices. However, the system's reliance on solar panels limited its efficiency during rainy seasons, indicating the need for enhanced battery storage solutions.[2]

Gokul et al. (2019) developed a robotic system for removing unwanted plants and performing agricultural tasks using Bluetooth technology. Although the system provided a promising solution for automating specific tasks, its communication was restricted to short-range operations.[3]

Y. Nikhil Kumar et al. (2019) introduced a robotic system for digging and seed sowing using Arduino and solar panels, controlled via an Android application. Despite its potential for small-scale farming, the system faced limitations with sprinkling inaccuracies and motor force mismatches, which impacted efficiency.[4]

Shaik Karee Mulla et al. (2018) focused on a GPS and magnetometer-enabled robot for cultivating, sowing, and flattening tasks, particularly useful in hazardous regions for humans. While innovative, the reliance on Arduino ATmega posed challenges in achieving real-time performance. [5]

Durga Sowjanya et al. (2017) proposed a Bluetooth-controlled agricultural robot for cultivating and sprinkling, but the system's short communication range highlighted the need for expanded capabilities, such as UV sensors and cameras for advanced automation.[6]

Sourabhumarkar and Karwankar (2016) emphasized the integration of hardware and software in their agribot design, noting that the high cost of robotic systems remains a significant barrier for widespread adoption.[7]

Amrita et al. (2015) introduced an agricultural robot for automatic ploughing and seeding, focusing on enhancing productivity through automation.[8]

Gunjan Bao et al. (2015) developed a flexible pneumatic end-effector for agricultural robots, enabling precision in tasks like handling and harvesting, which are often challenging with traditional machinery.[9]

Samuel J.O. Corpe et al. (2013) proposed a GPS-guided modular robot for agricultural applications, emphasizing modularity for versatility across various farming tasks.[10]

Joerg Baur et al. (2012) presented a redundant modular multipurpose agricultural manipulator using GPS technology, aimed at increasing the reliability and adaptability of robotic systems in agriculture.[11]

Smys and Ranganathan (2019) discussed robot-assisted sensing and control mechanisms, highlighting how technologies from industries like automotive manufacturing can be adapted for agriculture to improve efficiency.[12]

Earlier research by **Simon Blackmore et al. (2005)** envisioned the future of agricultural robotics, outlining how automation and mechanization could revolutionize farming practices.[13]

R. Eaton et al. , Katupitiya, S.D. Pathirana (2008) extended this vision by developing autonomous farming models and control systems for agricultural machinery, showcasing the potential for large-scale implementation of autonomous systems.[14]

These studies highlight the potential of smart agricultural systems in enhancing productivity and sustainability. However, they also underscore limitations such as communication constraints, energy efficiency, and scalability, which provide opportunities for further advancements in the field.

VII. FUTURE SCOPE

The solar-powered IoT-based multipurpose agricultural bot has immense potential for future advancements. By integrating advanced sensors for nutrient and pH level monitoring, the system can provide comprehensive insights into soil health, further optimizing crop management. Incorporating machine learning algorithms could enable predictive analytics for irrigation, crop yield estimation, and early pest detection, enhancing decision-making.

In future robot also run on PLC and SCADA with fully automated.

VIII. CONCLUSION

The solar-powered IoT-based multipurpose agricultural bot is a step toward modernizing farming by automating tasks such as digging, seed sowing, soil ploughing, leveling, and pesticide spraying.

It addresses key challenges like labor shortages and resource inefficiencies while promoting sustainability through solar energy. IoT integration enables real-time monitoring, optimizing resource usage, and improving productivity.

This adaptable solution is suitable for various crops and farming environments, making it valuable for both small- and large-scale operations.

With future advancements in AI, sensors, and additional functionalities, this system has the potential to revolutionize agriculture and pave the way for fully autonomous farming.

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