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Multipurpose Solar Agri Bot

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ABSTRACT

This work explores the design and development of solar powered robotic system aimed at automating essential farming activities like soil digging , seed planting , mud covering and water spraying . The robot is powered by a combination of battery and solar energy , offering renewable and efficient solution for agricultural needs .

As agriculture remains the livelihood of large portion of the global population , automating routine farming processes is becoming crucial. The Multipurpose Solar Agribot addresses challenges like labour shortages and operational inefficiencies by employing an intelligent , sensor -driven design . It is equipped with IR -controlled relays , IoT capabilities and microcontroller – based navigation to perform tasks autonomously .

Key operations like soil moisture detection pesticide spraying and seed dispensing are integrated into the robot's functions . Powered entirely by solar energy , the system not only reduces environmental impact but also minimizes reliance on traditional fuel sources , lowering long term costs .

Keywords: Solar powered system , Wireless sensor, IOT smart farming , Autonomous navigation.

1. INTRODUCTION

Agriculture is crucial sector in India, employing over 60 % of the population and ensuring national food security . However , the sector faces growing challenges such as labour shortages , climate variability and declining productivity . Traditional farming methods are increasingly inadequate in addressing these issues . To enhance agricultural efficiency and resilience, integrating modern technologies like automation , IoT and robotics has become essential . These technologies enable real time monitoring, resource optimization and precision farming . This paper proposes a multipurpose solar powered agribot , designed using embedded system and IoT , to automate key farming tasks while promoting sustainable and efficient agricultural practices tailored to India's diverse Agro climatic conditions . India's agricultural sector , though historically robust , is now facing

numerous setbacks such as labour shortages , erratic weather and reduced productivity from Traditional methods . These growing challenges necessitate a shift towards smart farming solutions that blend technology with sustainability . With agriculture remaining a primary livelihood for millions , innovative approaches are essential to ensure food security and economic stability .

Modern farming today is confronted with numerous obstacles, including labour scarcity, rising input costs, and the pressing need for sustainable resource management. Manual farming not only demands extensive labour but also heavily relies on fossil fuels and outdated methods that lack precision.

The **Multipurpose Solar Agribot** emerges as a novel answer to these pressing concerns. By combining solar energy with smart electronics and automation, this robot is capable of carrying out multiple tasks autonomously. Its functionalities include soil moisture detection, seed dispensing, targeted irrigation, and pesticide spraying. The reliance on solar energy ensures that it remains cost-effective and eco-friendly, especially in remote and off-grid farming areas where electricity is either unreliable or unavailable.

This work introduces a Multipurpose Solar Agribot , a solar powered , IoT enabled robotic system designed to automate vital agricultural tasks like seeding weeding and soil monitoring . The system uses various sensors and microcontrollers to collect environmental data , making it a valuable tool for precision agriculture . Powered by solar energy , the agribot operates efficiently in rural areas with limited access to electricity , promoting eco-friendly and sustainable farming practices . This research aims to demonstrate how integrating ECE technologies can transform convectional agriculture into smarter, more efficient process.

LITERATURE REVIEW

H L Kushwaha (2020) highlights the growing importance of robotics in agriculture particularly in improving efficiency and reliance on manual labour . Modern agricultural operations are increasingly turning to automation due to the limitations of conventional machines which often cannot adapt to diverse crops or varying field conditions . Kushwaha emphasizes the use of unmanned systems for tasks like harvesting , spraying and crop monitoring . These robots offer Improved precision , reduced soil monitoring .

Punam K. Jadhav (2021) focuses on robotics based on precision agriculture principles . These robots aim to reduce the time and energy spent on repetitive tasks while improving crop yields . The paper discusses environmental considerations and presents a prototype capable of grass cutting , crop prediction and pesticides spraying. Major concern is that most agricultural robots borrow design elements from industrial robots which can limit their adaptability to out door , uneven terrain .

Ramesh A. P. and Pasupathy N. (2019) underline the importance of remote environmental monitoring for increasing crop productivity . They develop an agricultural robot that collect real time data on soil moisture and temperature . This data is then uploaded to the cloud where it is analysed to make irrigation decisions . This approach enables efficient resource use and improve yield outcomes while minimizing input wastage.

Shivprasad B.S. (2021) and Ravishankara M. N . explore the use of automation to streamline farming process . There project involves robots capable of seed sowing , fertilizers application and soil parameters monitoring such as PH , moisture and temperature . The robot remotely controls and navigates autonomously with the help of DC motor and solenoids .

Chidananda Kashyap (2022) reviews the application of IOT and automation in agriculture to promote ecofriendly and efficient practices **.** The paper discusses robotics system that support land analysis , pesticides spraying weed control and irrigation. It also emphasizes the growing need for reconfigurable multitasking Agricultural robots as a land smart technology helps in maintaining optimal environmental condition for crop growth and sustainable farm .

SYSTEM ANALYSIS

3.1 EXISTING SYSTEMS

An existing system refers to the current setup , process or solution that is already in place within an organization , environment or project to perform a specific function or set of functions .

Over the past few years , various agricultural agricultural robotic systems have been developed with the goal of supporting farmers in their daily tasks . While several of these technologies show promise , most existing systems are either still in the experimental phase or limited to performing a single specific system . For instance , some commercial robots are equipped solely for tasks like seed , sowing , weeding or spraying pesticides . Although these robots may integrate solar power for sustainability , they often lack full autonomy and the capacity to perform multiple functions simultaneously .

Despite the growing interests in automation , there is a noticeable gap in the availability of fully integrated , cost effective and energy efficient robotic solution that caters to small and medium scale farmers . Current technologies are typically designed either for large scale farms or for the real world agricultural challenges in developing countries . Furthermore, most high-end agricultural robots are built with the needs of advanced, technology-rich regions in mind. As a result, they may not function well in developing nations where technical support, spare parts, and training opportunities are limited. Language barriers, low digital literacy, and lack of infrastructure further restrict the adoption of these solutions in rural communities.

In conclusion, while technological advances have introduced numerous robotic systems in agriculture, most of the existing models suffer from high costs, energy inefficiency, and limited functionality. There is a clear demand for a unified, modular, and affordable solution that can cater to multiple agricultural needs—one that does not depend on fossil fuels and requires minimal technical know-how to operate. The **Multipurpose Solar Agribot** seeks to fill this critical gap by offering a compact, solar-powered robotic system capable of executing a variety of farming tasks autonomously. With its renewable energy foundation and flexible design, it stands out as a sustainable, practical alternative for small and mid-sized farms, especially in regions lacking access to modern infrastructure and skilled labour.

3.2 PROPOSED SYSTEM

The Multipurpose Solar Agribot is designed as versatile and sustainable solution for automating essential agricultural tasks . The core idea behind the system is to combine renewable energy with smart technology to develop a robot that can assist in various farm operations All electronic systems need a consistent and regulated power source to operate properly. The Agribot is no different. It utilizes a solar-powered battery system, ensuring its operations run on clean, renewable energy. The system consists of multiple components, including the solar panel, battery, voltage regulators, and filter capacitors.

Solar Panel and Battery:

The robot features photovoltaic panels affixed to its structure. These panels harness sunlight and convert it into electrical energy. This energy is subsequently stored in a rechargeable battery, which acts as the main power source.

Voltage Regulation:

To safeguard delicate electronic parts, a voltage regulator is employed to ensure a stable output voltage, irrespective of variations in the input from the battery or solar panel. Commonly, a 7805 voltage regulator is utilized to deliver a consistent 5V output for the Arduino and various other modules.

Filter Capacitor:

While rectifiers produce a DC output, the resulting signal still has ripples. To eliminate these ripples, filter capacitors are utilized. These capacitors charge and discharge in alignment with the input waveform, ensuring a more consistent voltage across the circuit. The capacitor's value is determined by the anticipated current load and the permissible ripple voltage, which is typically maintained below 10% of the output voltage.

DC MOTOR:

DC motors play a crucial role in the movement and mechanical functions of the Agribot. These motors, which operate on a solar-charged battery, are tasked with several functions:
Movement: High-torque, geared DC motors attached to the wheels enable forward, backward, and turning movements, which are vital for manoeuvrings in the field.
Farming Equipment: The motors also power necessary agricultural tools such as seed dispensers, pesticide sprayers, and irrigation pumps. Rotary mechanisms driven by DC motors aid in distributing seeds at predetermined intervals and spraying pesticides uniformly over crops.

Energy Efficiency:

Because the robot runs on solar energy, motors with great efficiency and low power consumption are used. This guarantees that the battery won't run out while the Agribot is in use for prolonged periods of time.

Field Capacitor:

Despite producing DC output, half wave and full wave rectifiers do not produce a steady output voltage. To do this, we must smooth the waveform that the rectifier sends us. A capacitor, sometimes known as a "filter capacitor," "smoothing capacitor," or "reservoir capacitor," can be used at the rectifier's output to do this. There will be some ripple even after using this capacitor.
In order to maintain the voltage as constant as possible, we add a filter capacitor at the rectifier's output. The capacitor will charge to its maximum value during each half cycle and then gradually release its stored energy through the load when the rectified voltage falls to zero

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3.1 Embedded Systems Evolution

Modern agriculture has undergone a considerable transformation thanks to the development of embedded systems in multipurpose solar agribots. At first, farming was done by hand with crude implements and no machinery. As technology developed, single-purpose operations like soil sensing and irrigation were made possible by simple automation using microcontrollers like Arduino. These technologies eventually developed into solar-powered, semi-automated agribots that could do two or three tasks, like as watering and planting. As more potent embedded systems like the Raspberry Pi and STM32 were developed, multifunctional agribots that integrated many agricultural tasks like crop analysis, soil monitoring, and pesticide spraying came into being. These days, sophisticated embedded systems that use solar energy, sensors, wireless communication, and artificial intelligence (AI) for precision farming are installed in agribots. These intelligent systems are able to process data in real time,

3.1.1 Tools:

In multifunctional solar agribots, various essential tools are utilized to facilitate intelligent and effective farming. Microcontrollers and microprocessors, including Arduino, Raspberry Pi, or STM32, act as the system's brain. Different sensors such as soil moisture, temperature, humidity, and ultrasonic sensors assist in monitoring environmental and soil factors. Solar panels supply sustainable energy to operate the system. Motor drivers and actuators manage the motion of wheels and mechanical arms for functions such as seeding and spraying. Wireless communication systems such as Bluetooth, Wi-Fi, or GSM are utilized for oversight and remote operation. Furthermore, GPS modules aid in navigation, while camera modules facilitate the monitoring of plant health. Collectively, these instruments create a cohesive embedded system that renders the agribot smart, energy-efficient, and able to execute various agricultural functions.

3.2 Resources:

The Solar Agribot for Multiple Purposes is a robot powered by solar energy, intended to automate agricultural activities such as planting seeds, spraying pesticides, and monitoring soil conditions. It employs a solar panel and battery for energy, with a microcontroller (such as Arduino or ESP32) managing the system. Essential elements consist of motors, motor drivers, soil moisture and temperature sensors, along with optional modules such as GPS and camera. It can be controlled from a distance using Bluetooth or Wi-Fi through mobile applications or IoT platforms such as Blynk. This affordable, environmentally sustainable solution integrates embedded systems, sensors, and IoT to enhance smart farming in ECE initiatives.

4.HARDWARE DESCRIPTION

4.1 Arduino:

The Arduino board can easily be powered by just connecting it to a computer with a USB cable. Connecting the USB cable to the board's USB port, marked as connection (1), allows the board to obtain the required power to function without needing external power sources. This configuration not only provides power but also enables the board to interact with the computer for programming and data exchange, making it a simple and user-friendly method to launch your Arduino projects .

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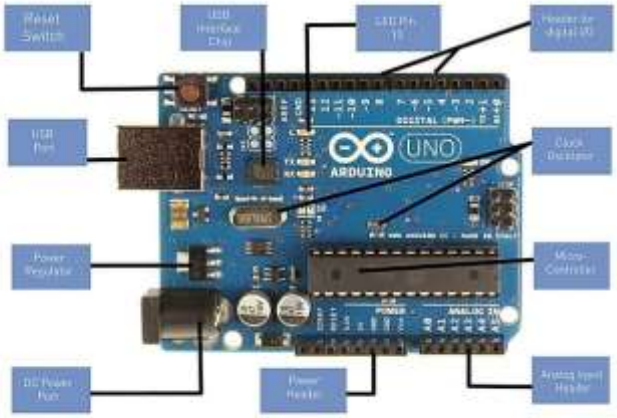


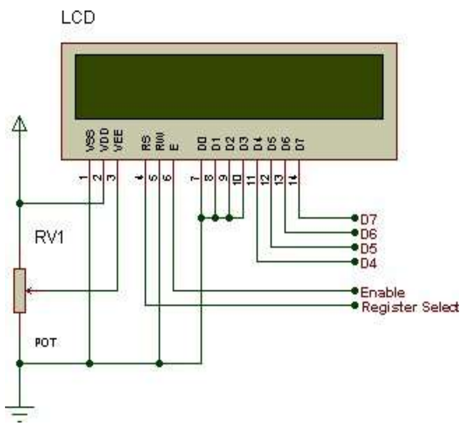
Figure 4.1 ARDUINO Development Board

LCD DISPLAY

LCD Background:

One of the most common devices attached to a micro controller is an LCD display. Some of the most common LCDs connected to the many microcontrollers are 16x2 and 20x2 displays. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

Basic 16x 2 Characters LCD Figure 4.2: LCD Pin diagram



L293D :

The L293D is a dual H-bridge motor driver IC that allows DC motors to be driven in both forward and reverse directions. It can control two motors simultaneously using standard TTL logic signals. Commonly used in robotics, it provides current amplification to safely drive motors from low-power microcontroller signals.

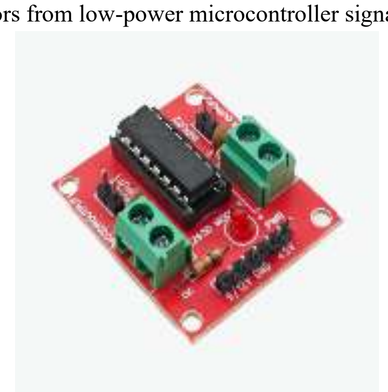


Figure 4.3 L293D diagram

Block diagram:

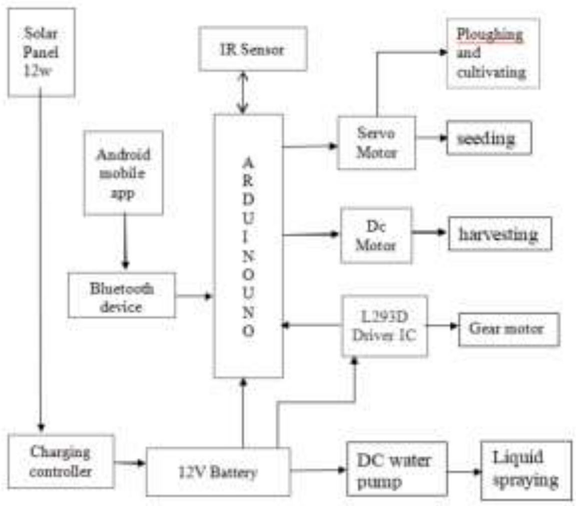


Figure 4.4 block diagram

Circuit Description:

The schematic is quite simple. The circuit of the Multipurpose solar Agribot is designed around an Arduino Uno, Microcontroller, which acts as the central control unit for executing core farming operations such as weed cutting, pesticide sprinkling, ploughing, Water sprinkling, and seed sowing. The system is powered by a solar panel connected to a rechargeable battery through a charge controller, ensuring eco-friendly and uninterrupted power supply. An L293D motor driver is used to control the movement of the Agribot and operate the DC motors responsible for driving the wheels and performing ploughing. Additional motors and servo mechanisms are integrated for operating the weed-cutting blade, controlling the seed sowing unit, and activating the spraying system through a mini water pump. The relay module manages high-power components like the pump, while the enter circuit is optimised for outdoor agriculture use without the need for IOT or environmental sensing features.

SIMULATION TOOLS

This project is implemented using following software's:

Arduino IDE

Proteus simulation

Arduino IBE + Tinker cad

5.RESULTS

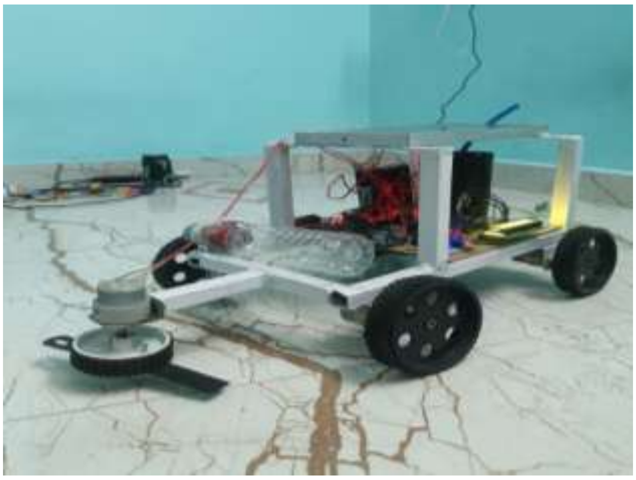


Figure 5.1 result

5.1 ADVANTAGES

1. Energy and cost efficient
2. Environment friendly .
3. Multifunctionality , labour reduction .
4. Precision farming , time saving and scalability .
5. Design is cost-effective and highly efficient.
6. 24/7 operation , remote operation , weather resilience

5.2 Applications:

- Farms
- Greenhouses
- Plantations
- Agro-based research centres
- Advertising system
- Organic farms
- Precision Farming zones
- Nurseries
- Small-scale farming
- Experimental agricultural fields
- Hilly and uneven terrains
- Surveilling
- Broadcasting
- Environmental monitoring
- Lab development

- Student projects
- Detecting
- PC external display

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6.CONCLUSION

In conclusion the Multipurpose Solar Agribot offers sustainable and efficient solution to modern agricultural challenges . By combining solar energy with automation , it reduces labour , saves time and promotes eco-friendly farming . With ongoing technological advancements , it holds great potential to transform agriculture and support farmers in achieving higher productivity .

6.1 Future Scope

The future scope of multipurpose solar agribot is highly promising . It can revolutionize farming by reducing efficiency in tasks like sowing , weeding , spraying and harvesting . With advancements in solar technology and automation , these robots can become more energy efficient and affordable to small scale farmers .

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