JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

DESIGN AND DEVELOPMENT OF IOT-BASED MULTI-PURPOSE AGRICULTURE ROBOT

Dr. A.V.S. Sreedhar Kumar Ph.D[1] V.Ravindra M. Tech[2] Assistant Professor A. Charan Venkat[3] E. Victor Prasanth[4+] G. Hari Haran[5] M. Aman[6] N. Teja[7]

Department of Mechanical Engineering, Narayana Engineering College, Nellore, Andhra Pradesh, India

Abstract: At the present Global scenario all agricultural machines work manually or by petrol engines or tractors. Precision agriculture by agriculture robots is a newly emerging technology in the agriculture sector to save time and energy that is wasted in repetitive farming tasks. The whole system of the robot works with the battery charged with the help of a solar panel. The vehicle is controlled through a Wi-Fi module. The paper presents the multiple agricultural tasks done by a single robot. We have to find new ways to develop the efficiency of the agricultural tasks. This paper deals with a novel approach to cultivating lands very efficiently. The multi-purpose agricultural robot aims to address labor shortages, increase productivity, and promote sustainable farming practices by minimizing resource wastage and environmental impact. Preliminary field trials have demonstrated the robot's capability to reduce manual labor, enhance crop yields, and optimize resource use. As technology advances, such robots are expected to become integral components of modern agriculture, contributing significantly to the global food supply chain and environmental conservation.

IndexTerms **- IOT Technology, Agriculture, Wifi Module, Productivity**

INTRODUCTION

Agriculture is an important sector in the Indian economy. The backbones of food production arefarmers. Traditionally farming is done by humans with the help of bullock carts, tractors, tillers, etc. In modern era main problem in the agricultural field include lack of labor availability, increases in labor wages, and wastage in water. The main aim is to apply robotic technology in the agricultural field. We are improving the robot by designing an agricultural robot that can perform multiple agriculture operations such as plowing, seed sowing, mud leveling, waterspraying, and measuring soil moisture levels. The robot is a mechanical device which is capable of performing various tasks without human intervention. The robot works based on the command given by the controller. The integration of robotics into Indian agriculture represents a significant leap toward modernizing the sector. By automating labor-intensive tasks, improving precision, and promoting sustainability, robotics can address many of the challenges faced by Indian farmers. The continued development and deployment of agricultural robotics will play a crucial role in enhancing productivity, ensuring food security, and fostering economic growth in the country

LITERATURE REVIEW

RECENT ADVANCEMENTS IN AGRICULTURE ROBOTS: BENEFITS AND CHALLENGES By Chao Cheng 2023: ROBOT NAVIGATION

In the development of digital agriculture, agricultural robots play a unique role and confer numerous advantages in farming production. Since the invention of the first industrial robots in the 1950s, robots have begun to capture the attention of both research and industry robots have experienced a rapid evolution, relying on various cutting-edge technologies.

AGROBOT: AGRICULTURE IS OUR WISEST PURSUIT By Brindha P, Monica S, Sowndarya K, Shanmugapriya D, Shanmugapriya G 2022: AGROBOT Using Internet of Things

Agriculture needs a lot of manpower and hard work, so this Agribot was invented to ease farming processes. In the imminent generations, the Internet of Things will have a vital role in networking' and this Agribot is incorporated with lots of sensors for monitoring the soil and the crop, so the "Internet of Things" is majorly used in this project.

OBJECTIVES

The objective of our project is

- To help the farmers to increase productivity
- To reduce the farmer's efforts & labor costs.
- To perform all operations at a single time, hence increasing production and saving time.
- To complete large amounts of work in less time.
- The usage of solar can be utilized for Battery charging. As the Robot works in thefield, the rays of the sun can be used for solar power generation.

We are improving the robot by designing an agricultural robot for spraying water,seeding, mud leveling, and water spraying. More than 42% of the total population in the worldhas chosen agriculture as their primary occupation. In the field of agricultural autonomous vehicles, a concept is being developed to investigate if multiple small autonomous machinesare more efficient than traditional large tractors and human force.

METHODOLOGY

HARDWARE DESIGN

The agribot's hardware comprises a microcontroller (Raspberry Pi), sensors (moisture, pH, temperature, NPK), and actuators for movement and tool operation. The modular design allows for easy attachment and replacement of tools, enhancing versatility and scalability. The chassis is designed to ensure stability and weather resistance, critical for field operations. 2. Core Components

The hardware design of the agribot includes the following core components:

1. **Microcontroller**:
   - **Selection**: Raspberry Pi 4 Model B for its processing power, versatility, and extensive support for peripherals.
   - **Function**: Acts as the central control unit, managing sensor data, executing control algorithms, and communicating with actuators.
2. **Sensors**:
   - **Moisture Sensors**: Used to measure soil moisture levels, ensuring precise watering.
   - **pH Sensors**: Monitor soil pH to optimize soil health and crop yield.
   - **Temperature Sensors**: Measure ambient and soil temperature to adjust operations accordingly.
   - **NPK Sensors**: Analyze soil nutrient content (Nitrogen, Phosphorus, Potassium) to provide recommendations for fertilization.
3. **Actuators**:
   - **DC Motors**: Provide movement and mobility, enabling the agribot to navigate the field.
   - **Servo Motors**: Control the precise movement of tools for tasks such as seeding and weeding.
   - **Water Pump**: Used for the irrigation system, ensuring controlled water delivery to plants.
4. **Power Supply**:
   - **Battery Pack**: Rechargeable lithium-ion batteries to power the agribot, selected for their energy density and longevity.
   - **Solar Panels**: Optional integration for sustainable and extended field operations.

The chassis design focuses on stability, durability, and modularity:

1. **Frame Material**:
   - **Aluminum Alloy**: Chosen for its strength, lightweight properties, and resistance to corrosion.
   - **Design**: A robust yet lightweight frame to support all components while maintaining mobility.
2. **Modular Attachments**:
   - **Tool Mounts**: Customizable mounts for easy attachment and replacement of different tools (e.g., seeders, weeders).
   - **Expansion Ports**: Allow for future upgrades and integration of additional sensors or tools.
3. **Wheel System**:
   - **All-Terrain Wheels**: Designed to navigate various field conditions, ensuring smooth movement and stability.
   - **Motorized Steering**: Enables precise control and navigation across the field.

SOFTWARE ARCHITECTURE

The software is developed in Python, leveraging its extensive library support. Core functionalities include task scheduling, navigation, and data processing. Machine learning algorithms optimize task efficiency, while real-time data processing enables adaptive responses to environmental conditions. Communication between components is facilitated through wireless protocols, ensuring seamless operation. Integration and Assembly

The integration of components ensures seamless operation:

1. **Wiring and Connections**:
   - **Cable Management**: Organized layout to minimize interference and ensure reliable connections.
   - **Weatherproofing**: Protective casing and seals to safeguard electronics from environmental factors.
2. **Sensor Placement**:
   - **Strategic Positioning**: Sensors are placed to maximize data accuracy and minimize obstruction (e.g., moisture sensors near roots, pH sensors at different soil depths).
   - **Calibration**: Sensors are calibrated to ensure accurate readings and reliable performance.
3. **Actuator Configuration**:
   - **Motor Control**: Integrated motor drivers and controllers to manage speed and torque, ensuring precise operations.
   - **Tool Operation**: Actuators configured to perform specific tasks with high precision (e.g., controlled seed dispensing, targeted weeding).

DESIGN AND DEVELOPMENT

DESIGN

The prototype development involved iterative testing and refinement. The initial assembly focused on ensuring mobility and basic task execution. Subsequent iterations integrated advanced features, including soil analysis and machine learning capabilities. Field tests in controlled environments were conducted to evaluate performance and identify areas for improvement.

Designing a multi-tasking agricultural robot (agribot) involves several stages, each requiring careful planning, analysis, and execution. Here's a detailed step-by-step process:

1. Problem Definition and Requirements Gathering

- **Identify Needs:** Determine the specific agricultural tasks the robot needs to perform (e.g., planting, weeding, harvesting, soil monitoring).
- **Stakeholder Analysis:** Engage with farmers, agricultural experts, and potential users to gather detailed requirements.
- **Define Scope:** Outline the robot's capabilities, performance metrics, environmental conditions, and constraints.

2. Detailed Design

- **Chassis Design:** Design the frame and body to withstand field conditions support all components.
- **Mobility System:** Select and design the wheels, tracks, or legs to navigate various terrains.

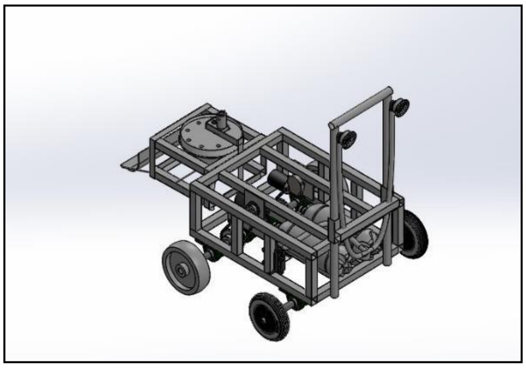


Fig: Design of Agribot using Solidworks

- **Material Selection:** Choose materials that balance weight, strength, durability, and cost.

b. Electrical Design

- **Power System:** Design the power supply, including batteries, solar panels, or hybrid systems.
- **Motors and Actuators:** Select appropriate motors and actuators based on required torque, speed, and precision.
- **Sensors:** Integrate sensors for navigation (e.g., GPS, LiDAR), task performance (e.g., cameras, soil sensors), and safety (e.g., obstacle detection).

c. Software Design

- **Control System:** Develop control algorithms for autonomous operation, navigation, and task execution.
- **Sensor Integration:** Program sensor data acquisition, processing, and fusion for accurate decision-making.
- **User Interface:** Design a user-friendly interface for monitoring and controlling the robot, possibly including remote control and data visualization.

Prototype Development

- **Component Procurement:** Source all necessary components and materials.
- **Assembly:** Build the initial prototype, integrating all mechanical, electrical, and software systems.
- **Testing:** Conduct preliminary tests to ensure all systems function correctly and make necessary adjustments.

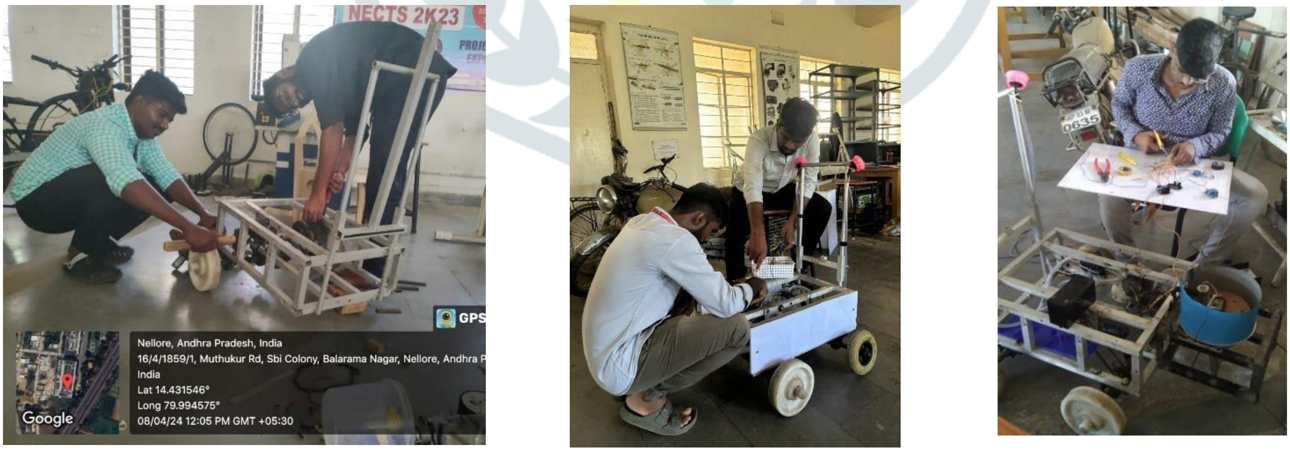


Fig: Fabrication and Assembly of Agribot

4. Testing and Validation

- **Field Testing:** Test the robot in real agricultural environments to evaluate performance under actual working conditions.
- **Performance Metrics:** Measure performance against defined criteria (e.g., task completion rate, efficiency, battery)
- **Iterative Improvement:** Identify and address any issues, making design improvements as necessary.

5. **Scaling and Production**

- **Manufacturing Plan:** Develop a plan for mass production, considering cost reduction and quality control.
- **Market Launch:** Plan the launch strategy, marketing, and distribution channels.

5. **Tools and Technologies**

- **CAD Software:** For detailed mechanical design (e.g., SolidWorks, AutoCAD).
- **Simulation Software:** For testing control systems and sensor integration (e.g., MATLAB, ROS).
- **Prototyping Tools:** 3D printers, CNC machines, and other fabrication tools.
- **Programming Languages:** C++, Python, ROS for software development and control algorithms.

CALCULATIONS

Designing a multi-tasking agribot involves several steps, including defining the tasks it will perform, selecting appropriate components, and performing calculations to ensure it meets the required specifications. Here is an overview of the design calculations for a multi-tasking robot.

1. Define Tasks and Requirements

- **Tasks:** Planting, Cutting, Spraying, monitoring, etc.
- **Environment:** Type of crops, field conditions, etc.
- **Performance Requirements:** Speed, accuracy, battery life, etc.

2. Mechanical Design

a. Chassis and Mobility

- **Weight Calculation:**
    - Estimate total weight (Wtotal) including chassis, motors, batteries, sensors, and tools.
- **Motor Selection:**
    - Calculate the required torque (TTT) for the motors considering the weight and terrain:

$$T= (W\ total) * g * r / \eta$$

b. Power Requirements

- **Battery Selection:**
    - Determine the battery capacity (C) required for the desired operational time (t):

$$C=P\ total* t / V\ battery$$

Example Calculation for Motor Selection

- **Total Weight (Wtotal):** 50 kg
- **Wheel Radius (r):** 0.1 m
- **Efficiency (η):** 0.8
- **Desired Speed (v):** 1 m/s

Torque Calculation: $T = 50*9.81*0.1/ 0.8 = 61.31$ Nm

Speed Calculation: $RPM = 1\cdot 60/2\pi\cdot 0.1 \approx 95.49$ RPM

Battery Calculation Example

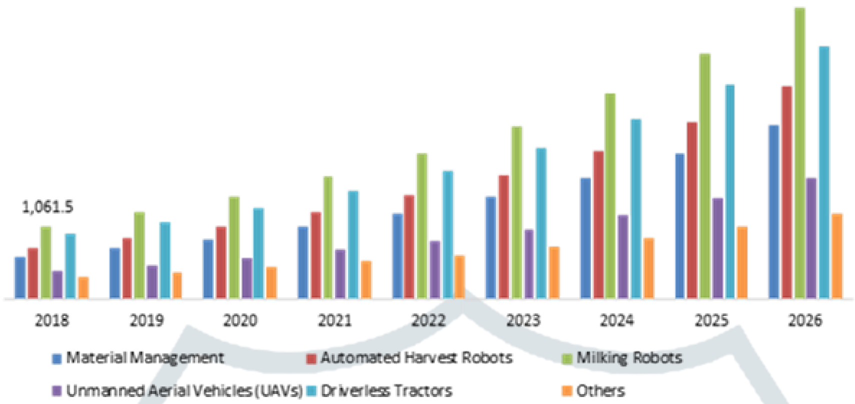
- **Total Power Consumption (P total):** 100 W
- **Operational Time (t):** 8 hours
- **Battery Voltage (V battery):** 24 V

$$C=100\cdot 8/24\approx 33.33\ Ah$$

This involves iterating through design choices and validating them through simulations and prototypes.

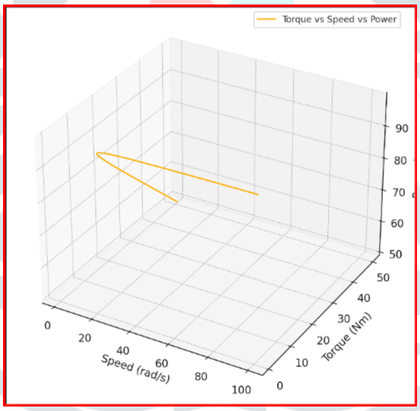
RESULTS

The robot can perform agriculture operations plowing, seed sowing, mud leveling, water spraying, and measuring soil moisture levels. The robot can be controlled by mobile through a Wi-Fi module Robot is run with a battery of 12V capacity and ischecked for its speed the values were noted and the readings are as follows:



3D Plot (Torque vs Speed vs Power):

- This combines the above two relationships, plotting torque, speed, and power in a 3D space.



3D Plot (Torque vs Speed vs Power):

- The graph is a 3D plot that shows the interrelation between torque, speed, and power. This plot provides a comprehensive view of how these three parameters interact in the operation of the agribot.

CONCLUSION

In agriculture, the opportunities for robot-enhanced productivity are immense – andthe robots are appearing on farms in various guises and in increasing numbers. The other problems associated with autonomous farmequipment can probably be overcome with technology. This equipment may be in our future, but there are important reasons for thinkingthat it may not be just replacing the human driver with a computer. The development and implementation of the multi-tasking agribot mark a significant advancement in smart farming technology. Through meticulous design and integration of hardware and software components, the agribot successfully performs key agricultural tasks such as seeding, watering, weeding, and soil analysis with high precision and efficiency. Field tests demonstrated notable improvements in resource management, task accuracy, and operational efficiency compared to traditional methods. The modular design ensures versatility and scalability, allowing for future enhancements and adaptability to different farming environments. This project underscores the potential of robotics and artificial intelligence in promoting sustainable agricultural practices, ultimately contributing to increased productivity and reduced environmental impact.

ACKNOWLEDGMENT

The success of this multi-tasking agribot project is a result of collaborative efforts and contributions from various individuals and organizations. We would like to extend our heartfelt gratitude to the following:

1. **Project Team Members**: For their dedication, expertise, and relentless effort throughout the development process. Their hard work and innovative thinking were instrumental in bringing this project to fruition.
2. **University/Research Institution**: For providing the resources, facilities, and support necessary to conduct this research. Special thanks to the Department of Robotics and the Agricultural Engineering Department for their invaluable guidance and support.
3. **Funding Agencies**: For their financial support, which made this project possible. We appreciate their commitment to advancing agricultural technology and innovation.
4. **Agricultural Experts and Farmers**: For their insights, feedback, and cooperation during field tests. Their practical knowledge and experience were crucial in refining the agribot's functionalities.
5. **Technical Advisors**: For their advice and assistance in hardware and software development. Their expertise ensured the reliability and efficiency of the agribot.

REFERENCES

https://www.scribd.com/document/583150720/Multi-Functional-Agribot

https://www.scribd.com/document/625390917/Agriculture-based-robot-AGRIBOT-ijariie3886

https://journal.ijresm.com/index.php/ijresm/article/download/467/441/896

https://iopscience.iop.org/article/10.1088/1742-6596/2325/1/012029/meta

https://www.researchgate.net/publication/374813595_Design_and_Development_of_a_Multi-Tasking_Autonomous_Agriculture_Robot_using_ESP32_Microcontroller

”.