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Multipurpose Agri BOT: An IoT and AI-Based Autonomous System for Smart Farming

Dr.Mary Vidya John
Associate Professor,
Department of Artificial Intelligence and Machine Learning,
Vemana Institute of Technology, Bengaluru, India
maryvidyajohn@vemanait.edu.in
https://orcid.org/0000-0002-5860-9359
Lahari Lavakumar, Sharan Chandan C, Madhu S, P. N. Ajith Kumar
Department of Artificial Intelligence and Machine Learning,
Vemana Institute of Technology, Bengaluru, India
laharilavakumar@gmail.com, sharanchandan5415@gmail.com
madhusvit2004@gmail.com, ajithkumarreddy1804@gmail.com

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Orcid: https://orcid.org/0009-0004-9398-7488

Abstract: Agriculture remains the backbone of the Indian economy, but conventional farming practices continue to face limitations due to labor dependency, inefficiency, and lack of automation. This paper presents the design and implementation of a Multipurpose Agri Bot, an IoT-enabled and AI-integrated robotic system that automates essential farming operations such as ploughing, seed sowing, irrigation, and grass cutting. The system uses an Arduino Mega 2560 microcontroller interfaced with sensors including soil moisture, temperature, humidity, and ultrasonic sensors. A Flask-based machine learning API, powered by the Gemini AI Random Forest model, predicts the top five suitable crops based on real-time soil data. The bot is powered by a solar energy system, promoting sustainability and reducing dependence on non-renewable energy sources. Controlled through a Bluetooth-enabled mobile application built in MIT App Inventor, the bot offers remote control, data monitoring, and crop recommendation features. The results demonstrate improved accuracy, cost efficiency, and resource utilization compared to traditional methods, making it suitable for small and medium-scale farms.
Keywords: culture Automation, IoT, Machine Learning, Smart Farming, Arduino, Solar Energy, Crop Prediction

I. INTRODUCTION

India's agricultural sector provides livelihoods to more than 50% of the population. However, conventional farming methods are labor-intensive and inefficient, making modernization essential. The Multipurpose Agri Bot addresses these challenges through automation and intelligent decision-making. Using sensors, actuators, and AI-based analytics, it performs multiple field operations autonomously while monitoring environmental conditions. The integration of IoT, renewable energy, and AI transforms manual agricultural practices into a data-driven precision farming model, enabling efficient crop management and reduced human intervention.

II. LITERATURE REVIEW

Several studies have explored agricultural automation and AI-based crop prediction systems. Annor et al. (2025) developed a microcontroller-based robot performing sowing and irrigation tasks but lacked real-time AI decision-making. Beldar et al. (2024) designed a solar-powered multipurpose robot, yet limited control and low battery life restricted usability. Gadekar et al. (2024) introduced the Helioagribot combining solar energy and IoT, but without adaptive intelligence. Murugesan et al. (2024) implemented smartphone-based control but lacked ML integration, while Begam et al. (2024) proposed an IoT robot with ESP32 camera and ThingSpeak cloud for monitoring but with limited autonomy.

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Recent works by Rani et al. (2023) and Hasan et al. (2023) employed machine learning algorithms for crop prediction with high accuracy but lacked physical integration into field robots. The proposed system bridges this gap by merging mechanical automation, IoT, and AI prediction within one integrated platform.

III. METHODOLOGY

The system architecture combines hardware, software, and AI layers for coordinated operation. Hardware components include Arduino Mega 2560, DC and servo motors, sensors (Soil Moisture Sensor, DHT11, ultrasonic), and solar power system. The software stack uses Arduino IDE, Python-Flask for API and ML model, MIT App Inventor for user interface, and MongoDB with Streamlit for data management and visualization. Sensor data is processed via Bluetooth to the mobile app and forwarded to the Flask API for machine learning–based crop prediction. The Random Forest model trained on soil and environmental data achieved 99.3% accuracy in predicting suitable crops.

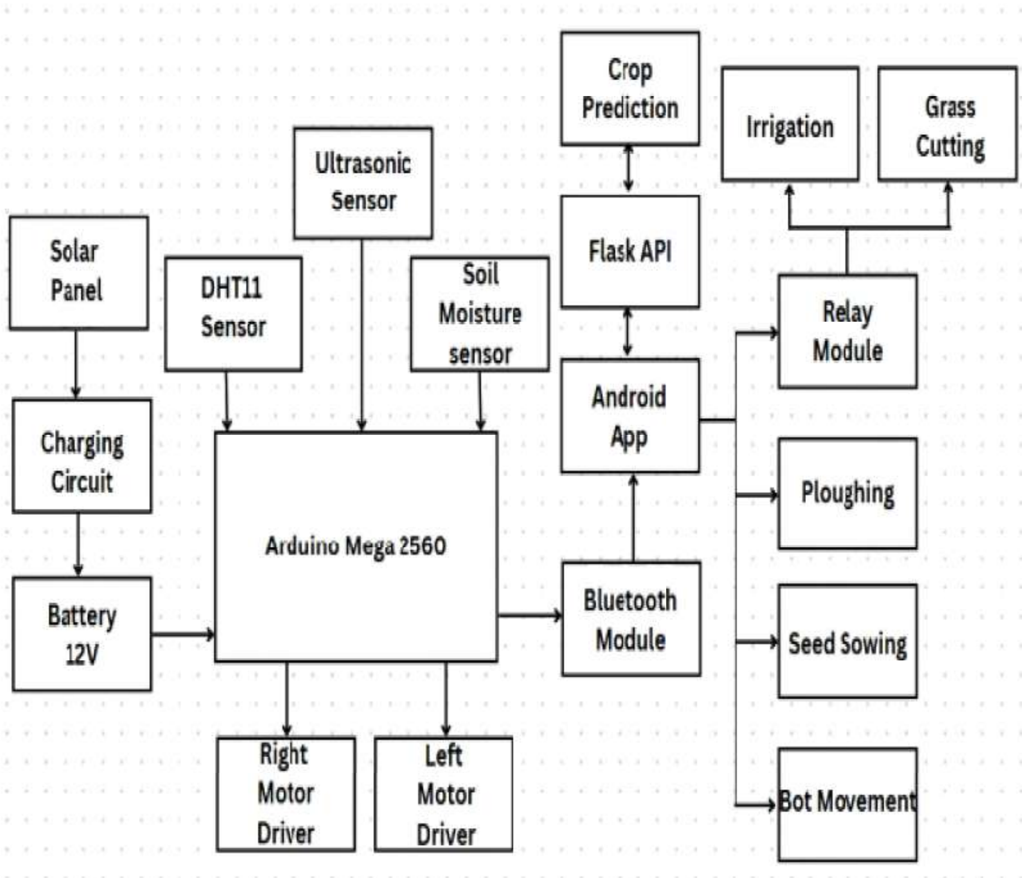

Fig. 1 Overall System Architecture of Multipurpose Agri Bot

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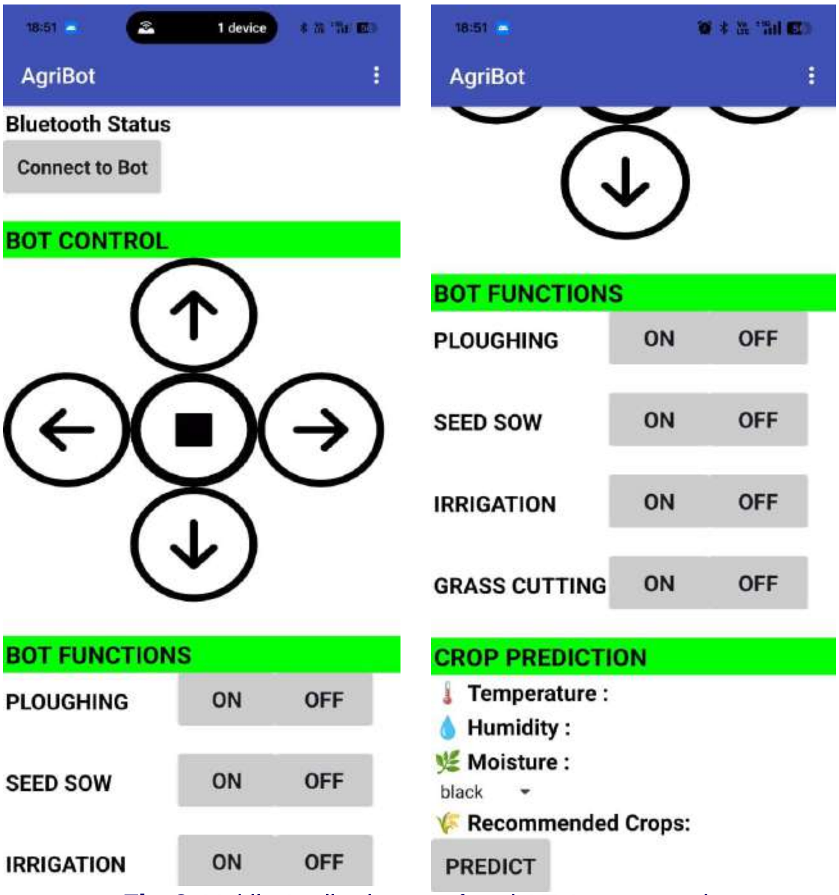

Fig. 2 Mobile Application Interface (MIT App Inventor)

IV. RESULTS AND DISCUSSION

The Multipurpose Agri Bot was successfully tested for core field operations such as ploughing, seed sowing, irrigation, and grass cutting. Each function performed smoothly, with servo-controlled mechanisms providing precise depth and spacing. The system showed an overall efficiency improvement of about 30–35% compared to manual methods, while automated irrigation reduced water usage by nearly 40%, ensuring optimized resource utilization and consistent field coverage. The AI-based crop prediction module, powered by a Flask API and Random Forest algorithm, achieved 99.3% accuracy in identifying suitable crops based on soil and environmental parameters. Predictions closely matched agronomist recommendations, confirming the reliability of the machine learning model. The real-time display of top five crops and confidence levels in the MIT App Inventor app enhanced user interaction and decision support.

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Fig. 3 Multipurpose Agri Bot

Solar power testing demonstrated reliable 8-hour continuous operation under normal sunlight, reducing battery dependence and promoting sustainable energy use. Bluetooth communication between Arduino and the mobile app maintained stable connectivity with minimal delay. Overall, the bot proved to be a cost-effective, intelligent, and eco-friendly solution for automating key agricultural tasks, suitable for small and medium-scale farms.

V. CONCLUSION AND FUTURE SCOPE

The Multipurpose Agri Bot successfully demonstrates the integration of IoT, artificial intelligence, and renewable energy into a single, efficient platform for sustainable agriculture. By automating critical farming operations such as ploughing, seed sowing, irrigation, and grass cutting, the system significantly reduces human effort, operational time, and water consumption. The bot's performance shows measurable improvements in field efficiency, energy utilization, and accuracy compared to traditional farming methods. The use of a Flask-based AI model for real-time crop prediction achieved 99.3% accuracy, validating the potential of data-driven agricultural intelligence for improved productivity and informed decision-making. The inclusion of a solar-powered energy system ensures uninterrupted operation in remote rural environments, making the solution cost-effective and eco-friendly. The Bluetooth-enabled mobile application, developed using MIT App Inventor, provides a user-friendly interface for real-time monitoring and control, encouraging technology adoption even among small-scale farmers. Furthermore, the modular design of both hardware and software makes the system easily adaptable for additional features, allowing it to serve as a scalable foundation for future smart-farming solutions. In the future, the project can be extended by integrating computer vision for weed and disease detection, GPS and autonomous navigation for self-guided field traversal, and cloud-based data analytics for remote farm monitoring. Implementation of edge AI can enable faster decision-making in the field without dependency on external servers. Additionally, integration with IoT cloud platforms like ThingsBoard or Blynk can facilitate long-term data storage, analysis, and predictive insights for large-scale agricultural networks. With continued development, the Multipurpose Agri Bot has the potential to become a fully autonomous, intelligent, and sustainable farming assistant that transforms conventional agriculture into a smart, data-driven ecosystem.

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