AI-Driven Rover for Precision Agriculture

Mr. Mohammad Raza Jawed Shaikh

Department of Computer Science and Engineering School of Computer Sciences and Engineering
Sandip University Nashik

Abstract

This project presents the design and development of an intelligent six-wheeled agricultural rover tailored for precision farming in Indian agricultural landscapes. The rover integrates advanced hardware and software systems to support real-time crop health monitoring, pest detection, and remote field navigation. Powered by the BeagleBone AI-64, the rover utilizes a high definition camera system for image and video acquisition, even while in motion at speeds up to 30 km/h. Captured visual data is processed locally and augmented via cloud-based AI models to identify pest infestations and crop anomalies. Remote operation is facilitated through a 4G module, GPS-guided navigation, and a user-friendly mobile/web application interface. The rover's modular architecture includes motor control, telemetry sensors, a power distribution board, and a long-lasting battery pack with solar charging provision for sustained field operations. Designed with scalability and cost-efficiency in mind, this AI powered rover empowers Indian farmers with an accessible tool for boosting yield, reducing manual labor, and enabling data driven agriculture.

Keywords: Precision Farming, BeagleBone, AI-64, Crop Health Monitoring, AI-Powered, Rover, Pest Detection

INTRODUCTION

India's agriculture sector, while vital to the nation's economy, faces numerous challenges such as pest infestations, inefficient resource utilization, and a lack of real-time monitoring tools. In response to these issues, this project introduces an AI-powered sixwheeled agricultural rover designed to enhance precision farming and support Indian farmers with intelligent field surveillance. Developed using the BeagleBone AI-64 platform, the rover integrates high-definition imaging, real-time video streaming, GPS-based navigation, and AI-driven crop health diagnostics. Equipped with advanced sensors and 4G connectivity, the system empowers users to remotely control the rover, analyze crop conditions, detect pests or plant diseases, and make informed decisions. This project, carried out in collaboration with Mirach Innovations, aims to bridge the technological gap in Indian agriculture by offering a robust, scalable, and affordable solution for smarter farming practices.

Farming in India often requires a lot of hard work, time, and manual effort. To help farmers make their work easier and more effective, this project introduces a smart six-wheeled farming robot, also called an agricultural rover. This robot is specially designed to work in Indian farms and assist in tasks like checking the health of crops, spotting pests early, and moving around the field without human help.

The rover uses a powerful computer called the BeagleBone AI-64 and a high-quality camera to take pictures and videos of crops, even while moving fast. It can understand these images using artificial intelligence to find problems like diseases or pest attacks in the crops. Farmers can control the rover from far away using a mobile app or website, thanks to 4G and GPS technology.

The robot is built with different parts like motors, sensors, a battery that lasts long, and even solar charging, making it perfect for long hours in the field. This smart rover is a helpful tool for farmers to increase crop production, reduce hard labor, and use modern technology to make better decisions.

LITERATURE SURVEY

1. "Design and Development of an Agricultural Robot for Crop Monitoring" This paper talks about building a robot that can help farmers keep an eye on their crops. It explains how the robot uses cameras and sensors to move around the field and take pictures of the crops. The system uses image processing to detect crop health and any signs of stress. The research shows that such robots can reduce the need for manual checking and save a lot of time and labor.
2. "AI-Based Pest Detection System in Agriculture Using Deep Learning Techniques" This study focuses on how artificial intelligence can help in finding pests early by looking at images of plants. The researchers trained a deep learning model to recognize different types of pests and diseases. The system showed high accuracy and could help farmers treat problems before they spread. This approach reduces the use of pesticides and helps grow healthier crops.
3. "Autonomous Navigation System for Agricultural Robots Using GPS and Sensor Fusion" This paper describes how an agricultural robot can move on its own in a farm using GPS and other sensors like gyroscopes and accelerometers. The robot follows a pre-set path and avoids obstacles without needing human help. This type of system can be useful in large farms where constant supervision is difficult. The research proved that GPS and sensor fusion can give good results for farm navigation.
4. "Smart Farming Using IoT and Mobile Application for Real-Time Crop Monitoring" This research presents a system that connects farming equipment to the internet (IoT) and allows farmers to monitor crops through a mobile app. It includes sensors for temperature, soil moisture, and humidity, and sends the data to the cloud. The mobile app gives farmers instant updates about their crops and suggests actions. This study shows how digital tools can make farming more modern and efficient**.**

METHODOLOGY

The intelligent agricultural rover is designed to help farmers by monitoring crops and moving around fields without needing much human involvement. The system is built using both hardware (physical parts) and software (programs and code) that work together to perform different tasks. First, the core of the rover is the BeagleBone AI-64, a small but powerful computer that controls everything. It connects to a high-definition camera, which captures images and videos of the crops while the rover moves at speeds of up to 30 km/h. These images are analyzed using artificial intelligence to check for signs of pests, diseases, or unhealthy crops. The rover is guided through the field using GPS and other sensors, helping it move in a straight path and avoid obstacles like rocks or uneven ground. A 4G module is included so farmers can control or monitor the rover remotely using a mobile app or website. This makes it easy to get updates or change the rover's path without being in the field. For power, the rover has a battery pack that lasts a long time and can also be charged with solar panels, allowing it to work even in remote areas where electricity is not available. Inside the rover, there are different modules for motor control, sensor data collection, and power distribution, all working together to keep the rover running smoothly. The AI software runs partly on the rover (for quick results) and partly on the cloud, where more powerful AI models can process the data in detail. This setup ensures real-time feedback while also supporting advanced analysis. In summary, the rover is a combination of smart hardware and intelligent software that can move around farms, collect data, and help farmers take better care of their crops using modern technology..

OBJECTIVE

1. To help farmers monitor crop health easily by using a smart robot that can take pictures and detect problems like pests or diseases.
2. To reduce manual labor in the fields by allowing the rover to move on its own and perform tasks that usually need human effort.
3. To provide real-time updates to farmers through a mobile or web application, so they can make quick decisions based on current crop conditions.
4. To enable remote control and monitoring of the rover using 4G and GPS, so farmers don't need to be physically present in the field all the time.
5. To use solar power for longer operation in the field, making the rover energy-efficient and suitable for rural areas with limited electricity.

PROBLEM DEFINATIONS

Farming in India is often challenging because of the large amount of manual labor needed to take care of crops, monitor their health, and detect pests or diseases. Farmers have to spend a lot of time walking through fields, inspecting crops, and dealing with issues like pests or plant diseases, which can reduce crop yield and quality. In addition, farmers in rural areas may not always have easy access to the latest tools and technologies that could help them manage their farms better. Currently, there is no easy-to-use, affordable solution that can help farmers quickly detect issues like pests or unhealthy crops without spending too much time and effort. Traditional methods of pest control and crop monitoring can be inefficient and often involve heavy use of chemicals, which can harm the environment and the crops themselves. This project aims to solve these problems by introducing a smart, six-wheeled agricultural rover that can automatically monitor crop health, detect pests, and navigate fields without needing constant human attention. By using technology like AI, GPS, and remote control, the rover will make it easier for farmers to keep track of their crops, improve crop yield, and reduce the need for manual labor

FUCTIONAL REQUIREMENTS

1. Crop Health Monitoring:

The rover must be able to capture high-quality images and videos of crops using its camera system. It should analyze these images using AI to detect any signs of crop diseases, pests, or other health issues in real time.

2. **Autonomous Navigation:**
   The rover should be able to move around the farm independently, using GPS and sensors to follow pre-set paths and avoid obstacles. It should be able to navigate fields at speeds up to 30 km/h without human guidance.
3. **Remote Control and Monitoring:**
   Farmers must be able to control the rover remotely via a mobile or web application. The system should allow farmers to start, stop, and change the rover's path, as well as receive live updates and alerts about the crop health and field conditions.
4. **Solar-Powered Operation:**
   The rover should have a long-lasting battery and the ability to charge itself using solar panels. This will ensure it can operate for extended hours in the field, especially in areas without a reliable power supply.

NON FUCTIONAL REQUIREMENTS

1. **Reliability:**
   The rover should be able to perform its tasks consistently without failure. It must be able to operate in various weather conditions (e.g., rain, dust, heat) without compromising its performance. The system must ensure the rover’s hardware and software are robust enough for long-term use in the field.
2. **Scalability:**
   The system should be designed in a way that allows it to be easily upgraded or expanded. For example, as technology improves, the rover should be able to accommodate new sensors or AI models without major changes to its design. It should also support multiple rovers working in the same field or farm area.
3. **Performance:**
   The rover should be able to process images and videos quickly, providing real-time feedback to farmers. It should have minimal lag or delays in sending updates or responding to remote commands. The AI models used for pest detection and crop health monitoring must work efficiently without taking too long to process data.
4. **Energy Efficiency:**
   The rover must be energy-efficient, using minimal power while performing tasks. It should have a well-optimized battery and solar charging system that can keep it running for extended periods without the need for frequent recharging, especially in remote areas.

CONCLUSION

The intelligent six-wheeled agricultural rover is a smart solution designed to make farming more efficient and less labor-intensive. By combining advanced technology like AI, GPS, and solar power, the rover helps farmers monitor their crops, detect pests, and navigate fields without needing constant human supervision. It can work in real-time, sending important updates to farmers through an easy-to-use mobile or web app.

This rover has the potential to greatly improve crop health, reduce manual labor, and help farmers make better, data-driven decisions. With its scalability, energy efficiency, and remote operation, it provides an affordable and sustainable solution for farmers, especially in rural areas. Ultimately, this technology will contribute to smarter farming practices, leading to better crop yields and more sustainable agriculture in India.

REFERENCES

1. Panda, S. K., Lee, Y., & Jawed, M. (2023). Agronav: Autonomous navigation framework for agricultural robots and vehicles using semantic segmentation and semantic line detection. *Proceedings of the 2023 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW)*, 667–676. https://doi.org/10.1109/CVPRW59228.2023.0066\

2. Aluthgama Acharige, R., Halgamuge, M. N., Wirasagoda, H. A. H. S., & Syed, A. (2021). Effective deep learning strategies to detect pest insects. *IEEE Journal of Agricultural Systems*, 10(2), 1–9. https://doi.org/10.1109/JAS.2021.1004317

3. Acharige, R. A., Halgamuge, M. N., Wirasagoda, H. A. H. S., & Syed, A. (2023). Crop monitoring and smart farming through mobile app. *Proceedings of the 2023 IEEE International Conference on Internet of Things (iThings)*, 1–8. https://doi.org/10.1109/iThings55666.2023.00001

4. Baby, T., Gohil, M. K., & Bhattacharya, B. (2024). Autonomous navigation of 4WIS4WID agricultural field mobile robot using deep reinforcement learning. *arXiv preprint arXiv:2412.18865*. https://arxiv.org/abs/2412.18865