AgriTechGuard

An Integrated Automated Farming and Security System

A BTP Report

by

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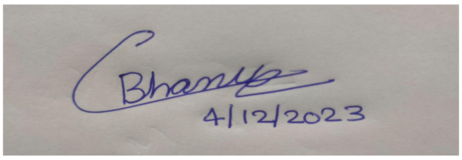
FINAL REPORT

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY SRICITY

CANDIDATE’S DECLARATION

I hereby certify that the work which is being presented in the BTP entitled **“AgritechGuard - An Integrated Automated Farming and Security System”** in the partial fulfillment of the requirements for the award of the degree of B.Tech and submitted in the Indian Institute of Information Technology SriCity, is an authentic record of my own work carried out during the time period from Jan 2023 to Dec 2023 under the supervision of Dr. Paul Braineard, Indian Institute of Information Technology Sri City, India.

The matter presented in this report has not been submitted by me for the award of any other degree of this or any other institute.



Signature of the student with date
Chitluru Venkata Bhanu Prakash

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Signature of BTP Supervisor with date
Dr.Paul Braineard

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ABSTRACT

Modern agriculture, the AgritechGuard project emerges as a groundbreaking solution, addressing multifaceted challenges faced by farmers. By seamlessly integrating cutting-edge technologies, including LoRaWAN for long-range data transmission, computer vision for trespasser detection, and automated irrigation systems, AgritechGuard transforms traditional farming practices. This innovative system not only optimizes water usage through adaptive irrigation but also enhances security through precise trespasser identification. The implementation of robust connectivity solutions allows farmers remote control, ushering in a new era of efficiency and convenience. As agriculture meets technology, AgritechGuard stands as a beacon, offering a sustainable and resilient approach to modern farming. The project's holistic blend of precision, efficiency, and security presents a compelling vision for the future of agriculture, making AgritechGuard an essential read for anyone invested in the evolution of smart farming practices.

INTRODUCTION

Farmers encounter a range of challenges in agriculture, which is crucial for many economies. Unpredictable weather patterns disrupt farming routines, affecting crop cycles and yields. Limited water resources add to the struggle, as farmers work to sustain crops amid varying and often unpredictable rainfall levels, worsening water scarcity problems. Labor shortages present a significant hurdle, with the demanding nature of agricultural work compounded by the migration of younger people to urban areas, leading to a shortage of essential farm labor. Precise crop monitoring, a crucial aspect of traditional farming practices, requires extensive manual efforts, taking up valuable time and causing physical strain. Furthermore, rural areas often face challenges of unreliable internet access and technological infrastructure gaps, hindering the adoption of modern farming solutions.

To overcome these challenges in farming, a balanced approach is needed, blending traditional knowledge with modern technologies for sustainable and resilient agricultural practices amidst changing environments. AgritechGuard steps forward as a game-changing solution to tackle the hurdles faced by agriculture. This comprehensive system utilizes advanced technologies to ease farmers' challenges. By seamlessly integrating automation, remote monitoring, and security features, AgritechGuard aims to significantly improve the efficiency and productivity of farming operations. It caters to the growing need for smart farming by employing state-of-the-art sensor technologies and wireless communication. The main goal of AgritechGuard is to reduce the time farmers spend in the fields by automating irrigation, enabling remote control of motors, and enhancing security measures. This holistic approach not only simplifies everyday farming tasks but also empowers farmers with real-time insights and control over their operations.

RELATED WORK

In the realm of smart agriculture, various projects have explored the automation of irrigation systems to enhance efficiency and productivity. The primary objective of these endeavors has often been the optimization of water usage in agricultural fields. Traditional automatic irrigation systems are designed to monitor soil moisture levels and trigger water pumps accordingly. However, the incorporation of advanced technologies to enable remote monitoring and control has been a recent area of focus.

In simple terms, current systems can make water pumps turn on or off based on how wet the soil is, but now, we've made a big improvement. We added the ability to send data wirelessly, which means farmers can get information from their fields no matter where they are. This is really helpful for making smart decisions about farming. We use different and modern technologies to connect to the internet, so farmers can check and control their irrigation systems from anywhere in the world.

Several commercial solutions already exist in the market, offering smart irrigation systems with varying degrees of automation. These systems often rely on NODE MCU, Wi-Fi or Bluetooth connectivity, limiting their effectiveness in remote and rural locations. The introduction of LoRaWAN in the AgritechGuard project sets it apart, providing an innovative solution that extends the reach of data transmission, making it well-suited for agricultural landscapes with limited internet infrastructure.

Moreover, the ability to incorporate manual control remotely distinguishes AgritechGuard from many existing systems. While automation is a key feature, the flexibility to intervene and control the irrigation system manually can be crucial in responding to specific, on-the-ground conditions that automated systems may not anticipate.

PROBLEM STATEMENT

The agricultural sector faces challenges such as unpredictable weather, labor shortages, inefficient irrigation practices and security issues from trespassers. AgritechGuard aims to revolutionize traditional farming by introducing a comprehensive solution that integrates several sensor technologies, automation, and security features to address these challenges and enhance the efficiency, productivity, and security of agricultural operations.

PROPOSED METHODOLOGY

1. Automated Irrigation System:

The core of the AgritechGuard project lies in its automated irrigation system, leveraging sensors to monitor critical environmental factors. The use of DHT11 sensors for detecting humidity and temperature, coupled with soil moisture sensors distributed across the field, forms the basis of this methodology. The Arduino Uno, acting as the central control unit, processes the data from these sensors. When the soil moisture falls below a predefined threshold, the system activates a relay module, triggering a water pump to irrigate the field. This not only optimizes water usage but also frees farmers from the manual task of monitoring and regulating irrigation.

2. Long-Range Data Transmission:

One of the pioneering aspects of AgritechGuard is the utilization of LoRaWAN technology for wireless data transmission. The project incorporates LoRaWAN modules (Tx and Rx) connected to Arduino Unos in the field and at the receiver side, respectively. This approach ensures seamless communication over distances ranging from 6 to 10 kilometers, overcoming the limitations of conventional wireless technologies like Node MCU, Wi-Fi or Bluetooth. In cases where LoRaWAN may face challenges to transmit for long ranges as specified, However extender nodes can act as intermediaries to ensure robust and reliable data transmission.

3. Remote Monitoring and Control:

The project extends beyond mere automation by providing farmers with the ability to remotely monitor and control the irrigation system. LoRaWAN facilitates internet connectivity, enabling real-time data access from anywhere in the world. The implementation of an LCD display with an I2C module on the Arduino Uno ensures that farmers can receive immediate feedback on environmental conditions and irrigation status. This combination of automated systems and remote accessibility empowers farmers to make informed decisions about irrigation practices without needing a physical presence in the field.

4. Security System with YOLO v8:

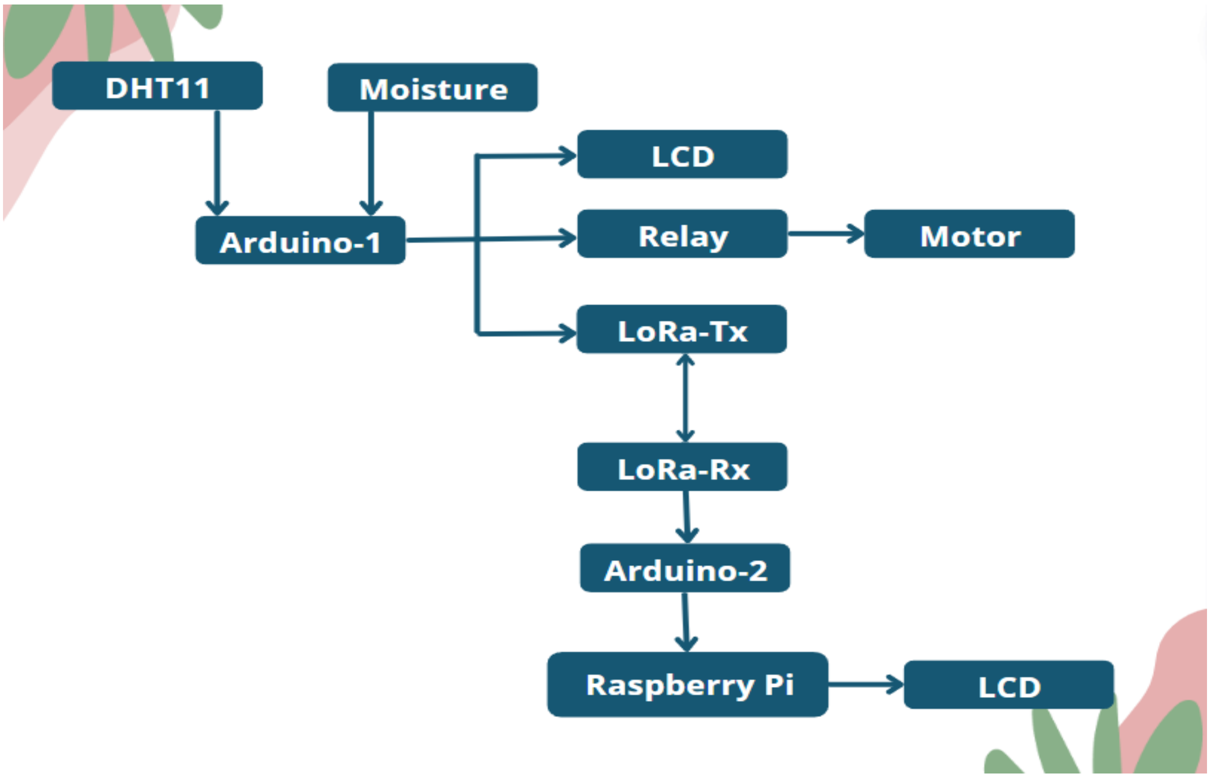
AgritechGuard goes a step further by incorporating a security system using YOLO v8, a state-of-the-art object detection model. This system is designed to detect potential trespassers in the field using COCO dataset, but I have fine tuned it focusing on classes such as person, bicycle, car, and motorbike. The Raspberry Pi3 processes the video frames at a rate of one frame every 10 seconds, analyzing consecutive frames to trigger alerts only if trespassers are detected consistently. This unique approach minimizes false alarms and unnecessary notifications, enhancing the reliability and effectiveness of the security system.

5. Integration with ThingSpeak Database:

To ensure a smooth process of storing and retrieving data, the project seamlessly integrates with the ThingSpeak IoT database. In the case of detecting trespassers, the security system sends alerts to the database, while the irrigation system transmits pertinent data, such as soil moisture levels. This centralized database serves as a repository for both historical and real-time information, offering a comprehensive perspective on environmental conditions and security incidents. The utilization of Python libraries like ultralytics, OpenCV, numpy, and PyTorch enhances the project's data processing and analysis capabilities. Furthermore, this data can be leveraged to send notifications to mobile apps through APIs.

BLOCK DIAGRAMS:

Work done in 6th semester:



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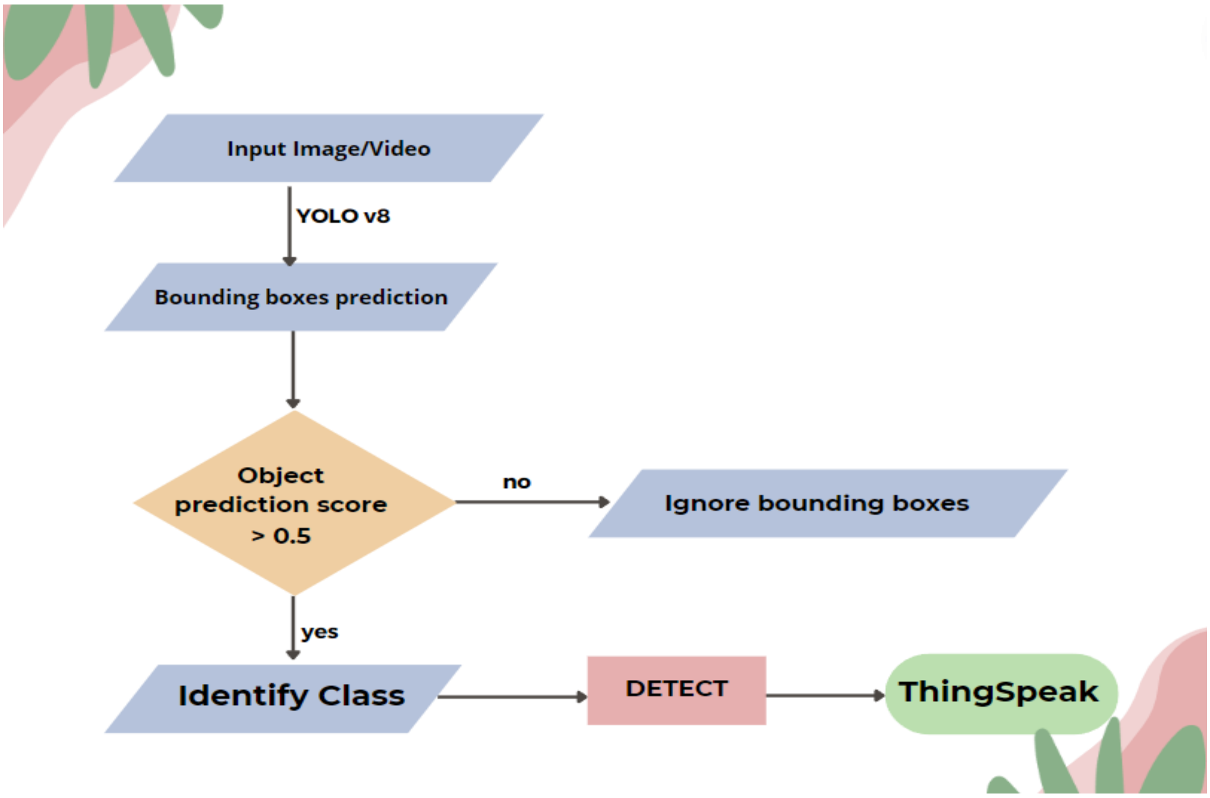


IMPLEMENTATION DETAILS

Sensor Interconnections and Data Flow:

The sensors play a pivotal role in monitoring and gathering essential environmental data. DHT11 sensors are strategically placed to measure humidity and temperature, providing valuable insights into the climatic conditions of the agricultural field. Soil moisture sensors are distributed across the field to assess the moisture content at different locations. The Arduino Uno acts as the central hub, collecting and processing data from these sensors. When the soil moisture falls below a predefined threshold, the Arduino triggers the relay module, activating the water pump for automated irrigation.

LoRaWAN Module Connections:

The implementation of LoRaWAN technology involves connecting LoRaWAN modules to the Arduino Unos in the field (Tx module) and at the receiver side (Rx module). The Tx module is responsible for transmitting sensor data, including soil moisture levels, humidity, and temperature, to the Rx module. These modules communicate wirelessly using the 868 MHz frequency. In cases where the transmission distance might be a challenge, extender nodes can be added between the Tx and Rx modules to ensure reliable and extended coverage.

Trespasser Detection and Consecutive Frame Analysis:

The security system is implemented on the Raspberry Pi3 using Python and YOLO v8. The system captures video frames at a rate of one frame every 10 seconds. Each frame is then processed by the YOLO v8 model, which has been fine-tuned to detect specific classes such as person, bicycle, car, and motorbike. To minimize false alarms, the system checks for consecutive detections across frames. If a potential trespasser is identified in multiple consecutive frames, an alert is triggered. This approach significantly reduces false positives and ensures that alerts are generated only when there is a consistent and genuine threat detected.

Integration with ThingSpeak for Data Management:

To ensure efficient data storage and retrieval, the project integrates with the ThingSpeak IOT database. The Raspberry Pi3, responsible for receiving data from the Arduino Uno which is present in field and processing security alerts, utilizes Python scripts to interact with the ThingSpeak API. When a security event is detected, such as the presence of a trespasser in consecutive video frames, an alert is sent to the ThingSpeak database. Simultaneously, environmental data, including soil moisture levels and irrigation system status, are periodically transmitted to ThingSpeak.

This integration provides a centralized platform for farmers to access historical and real-time data, facilitating informed decision-making. The use of ThingSpeak ensures a secure and scalable solution for managing agricultural data, enhancing the overall effectiveness of the AgritechGuard system. The Python scripts on the Raspberry Pi3 act as the bridge between the diverse components of the project, facilitating the seamless exchange of information between the field and the central processing unit.

EXPERIMENTAL RESULTS

1. Minimizes Time to Spend in Field:

AgritechGuard significantly minimizes the need for farmers to be physically present in the fields. With automated irrigation and remote monitoring, the project reduces on-site requirements to just 10%, allowing farmers to efficiently oversee their fields from home. This streamlined approach optimizes both time and effort. Additionally, the robust trespasser detection system enhances security, providing a comprehensive solution for effective agricultural management.

2. Data Transmission Distances:

In comparison to conventional wireless transmission technologies like Wi-Fi, Node MCU, and Bluetooth, AgritechGuard stands out by leveraging LoRaWAN technology for long-range data transmission. This innovation enables data to be reliably transmitted over distances ranging from 6 to 10 kilometers. This extended range is a critical advantage, especially in rural areas with limited internet connectivity, providing farmers with the capability to access real-time data from remote locations.

3. Remote Monitoring and Control:

The project offers farmers a flexible approach to irrigation management. Through the implementation of Node MCU for internet connectivity, farmers can remotely control the water pump. This includes the option to utilize the automatic irrigation feature or manually intervene based on specific field conditions. The user-friendly interface facilitates seamless control, allowing farmers to adapt the irrigation system to their preferences and requirements.

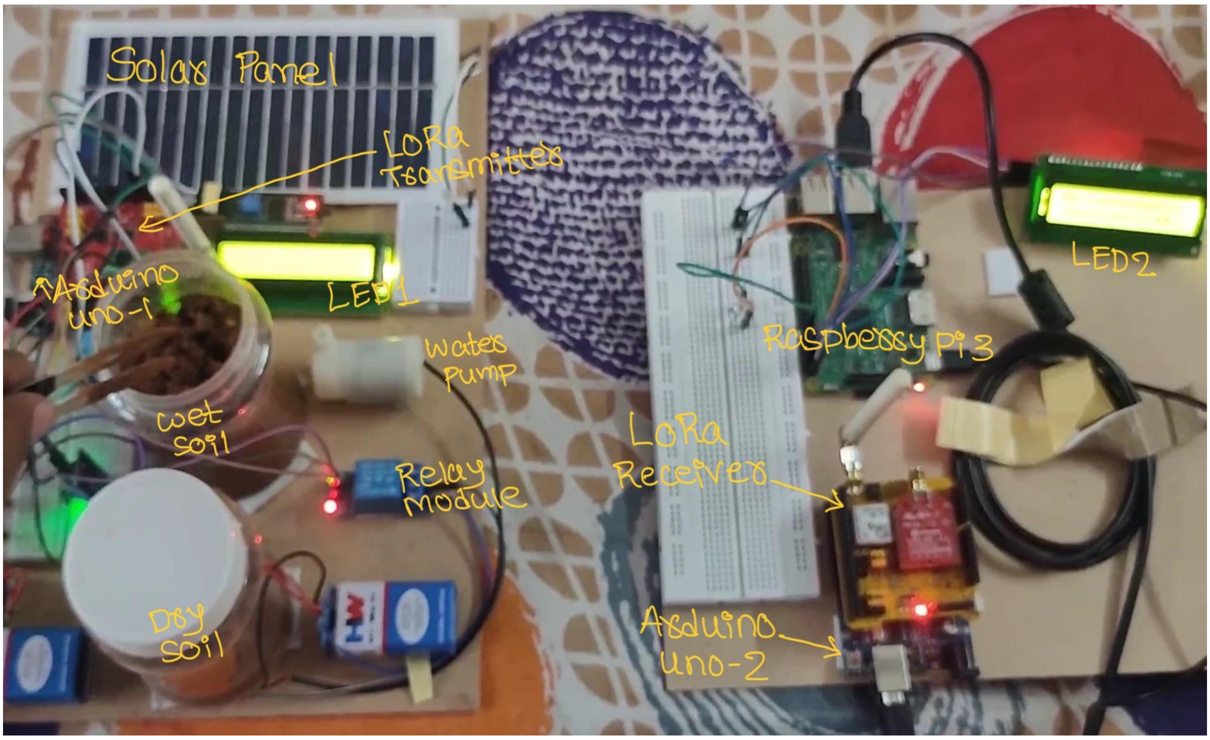
4. Irrigation System Efficiency:

AgritechGuard's automated irrigation system excels in efficiency, conserving water resources by only activating the water pump when necessary. This adaptive approach to irrigation aligns with best practices, ensuring that water is utilized optimally and minimizing wastage. The system responds dynamically to soil moisture levels, promoting sustainable farming practices while maximizing crop yield.

5. Security System Performance:

The integration of a robust security system utilizing YOLO v8 for trespasser detection enhances the overall field security. The computer vision model precisely identifies potential threats such as persons, bicycles, cars, and motorbikes. In the event of a trespasser detection, the system promptly notifies the farmer, bolstering the security measures in place. This proactive approach contributes to creating a secure agricultural environment.

Implemented in 6th semester:



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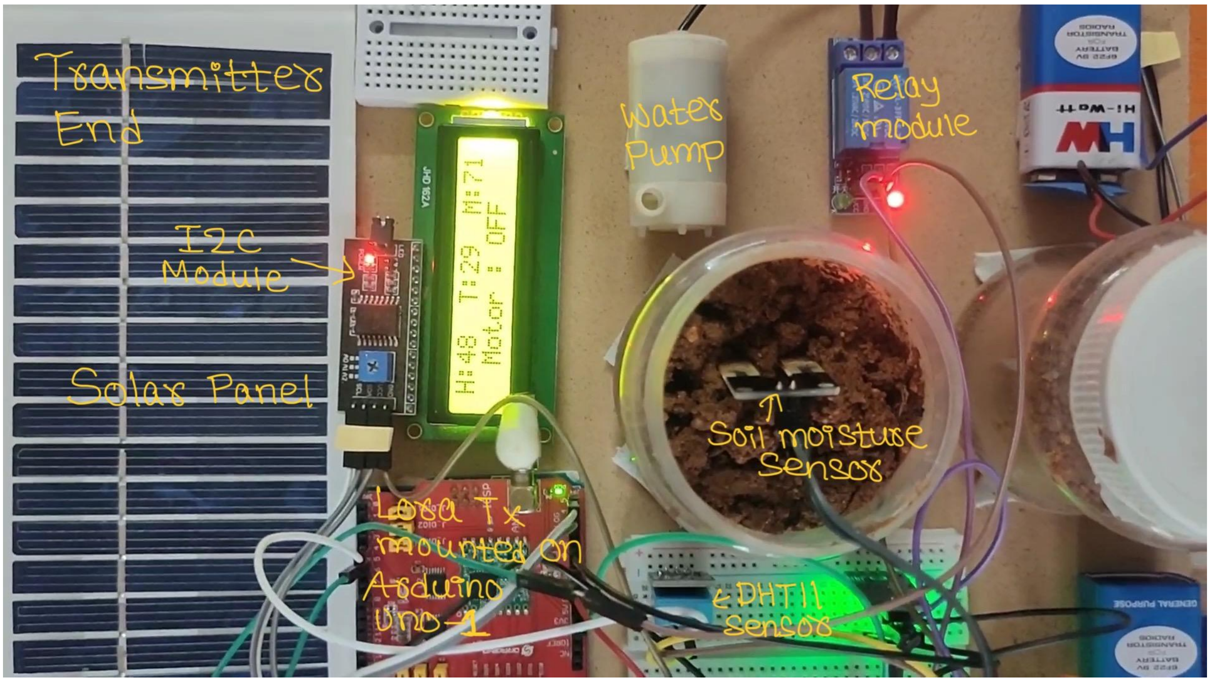
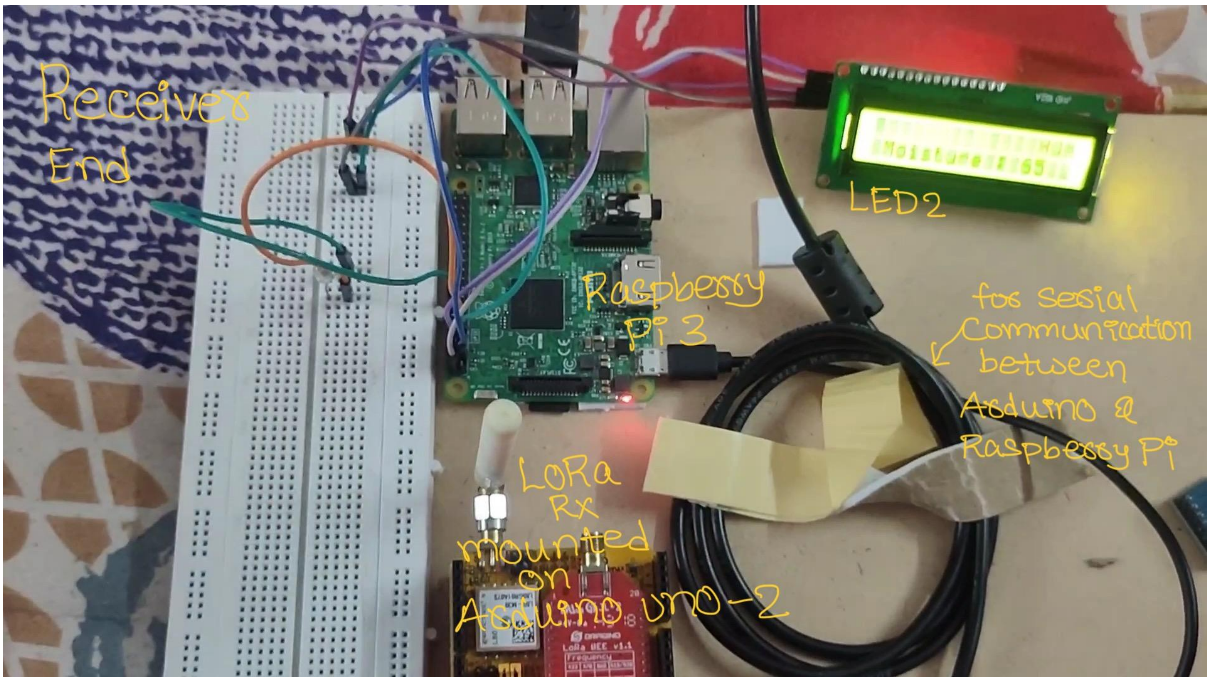


RECEIVER SIDE:



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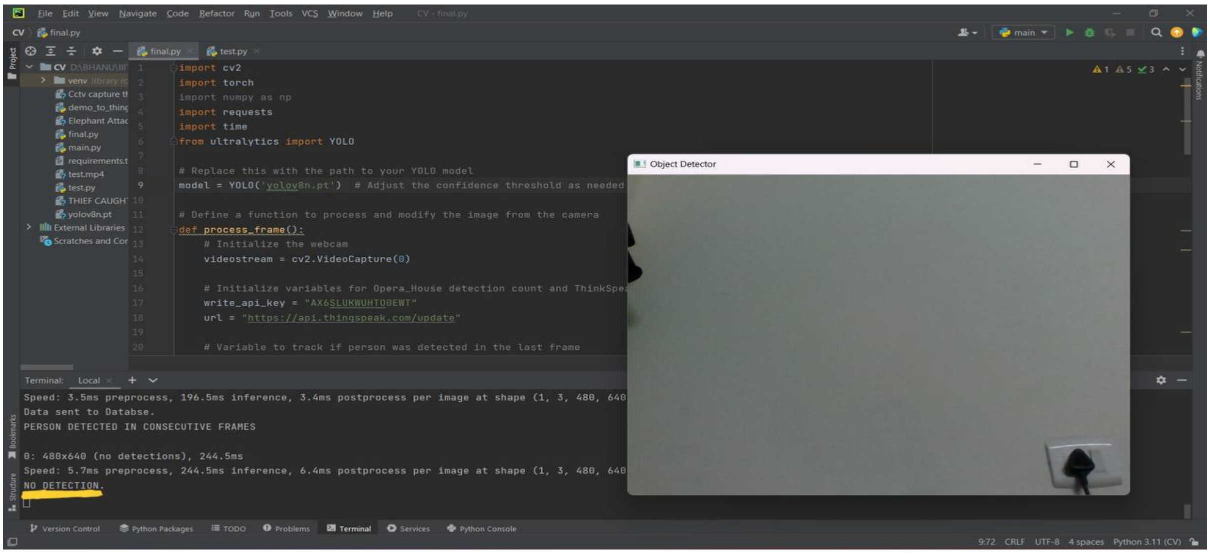

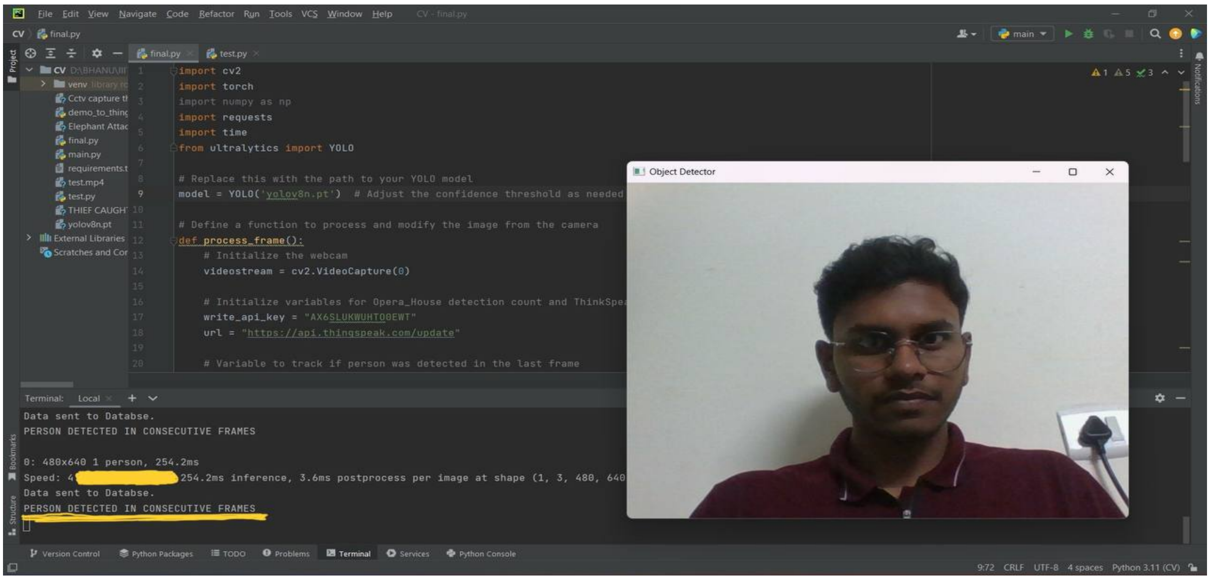

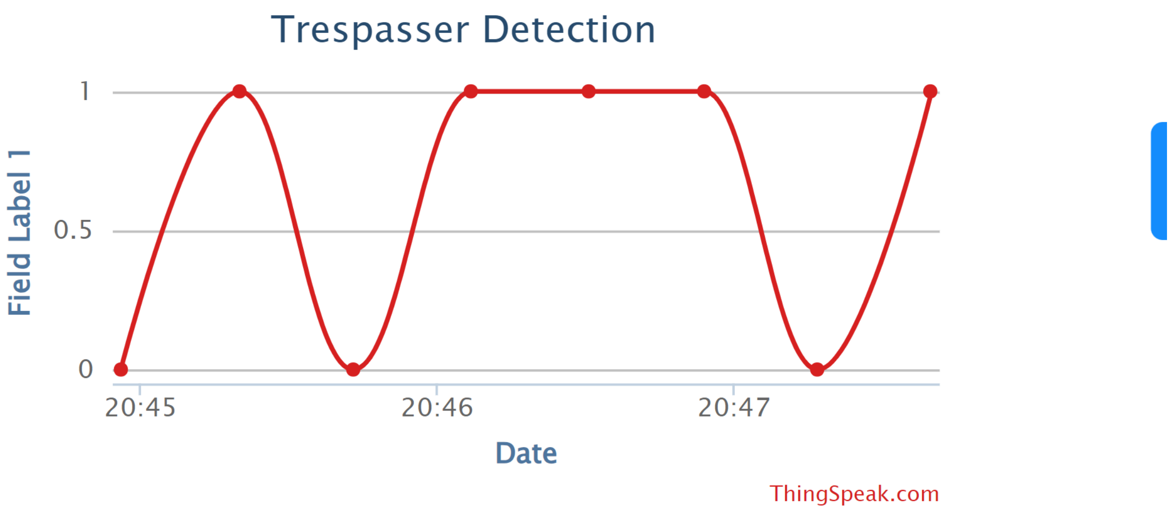

CONCLUSION

AgritechGuard is a multifaceted solution addressing critical challenges in modern farming. Its advanced technology allows for dual irrigation capabilities, offering unprecedented control over water management and contributing to increased crop yield and resource efficiency. The successful integration of LoRaWAN technology ensures adaptability to diverse geographical and infrastructural contexts, making AgritechGuard a versatile tool for monitoring in remote agricultural areas. Sustainability and security are emphasized through features such as solar energy harvesting and the use of the YOLO v8 model for trespasser detection.

Looking ahead, potential avenues for enhancing AgritechGuard's capabilities are outlined. This includes refining the computer vision model for superior accuracy in trespasser detection, exploring additional sensor technologies for expanded parameter monitoring, optimizing energy efficiency, and investigating emerging communication technologies. The proposal of scalability and interoperability considerations aims to position AgritechGuard within a connected and holistic agricultural monitoring ecosystem.

In conclusion, AgritechGuard stands as a substantial contribution to smart farming, effectively addressing current agricultural concerns while paving the way for a sustainable and technologically advanced future. Through advanced irrigation control, connectivity solutions, renewable energy utilization, and robust security measures, AgritechGuard not only meets the needs of contemporary agriculture but also anticipates and adapts to the challenges of tomorrow.

FUTURE WORK

To enhance cybersecurity, robust measures will be implemented to safeguard the system against potential cyber threats and unauthorized access. This may include the integration of encryption protocols, secure authentication methods, and the implementation of regular security audits to ensure the system's integrity is maintained. Additionally, continuous efforts will be made to refine and expand the capabilities of the trespasser detection system through machine learning. This involves ongoing training of the model with diverse datasets and the fine-tuning of algorithms to enhance the accuracy and reliability of object identification, thereby fortifying the overall security system.

Moreover, a focus on optimizing energy efficiency is pivotal, particularly in remote and off-grid areas. This optimization process will explore the integration of more energy-efficient components, the exploration of alternative power sources such as solar energy, and the implementation of power-saving modes to ensure sustainable operation. By addressing these key aspects, the overall functionality and security of the system will be advanced, ensuring its resilience against emerging cyber threats while promoting energy-efficient and sustainable operation, especially in resource-constrained environments.

CHALLENGES FACED

Connectivity Integration Challenges:

Seamlessly integrating the various components of AgritechGuard presented a significant challenge. The intricate interconnectedness of system components demanded meticulous attention to detail. Overcoming discrepancies in connectivity was crucial, as even minor issues could impede the overall effectiveness of the agricultural monitoring system.

Raspberry Pi Integration Complexity:

The integration of Raspberry Pi posed a substantial challenge due to its sensitivity to small errors. The intricate and demanding integration process required careful handling and precise execution. Overcoming challenges in Raspberry Pi integration demanded a combination of expertise and meticulous troubleshooting to ensure a robust and error-free system.

Connectivity Issues with LoRaWAN:

Despite the specified long-range capabilities of LoRaWAN technology, practical implementation revealed challenges in achieving the expected distances. AgritechGuard faced difficulties in transmitting data over extended ranges, necessitating the introduction of extenders to overcome these limitations. This highlighted the importance of adapting technology to real-world conditions.

Computer Vision Object Identification Complexity:

Implementing computer vision for object identification presented a substantial challenge. Accurately identifying objects and specifying their nature proved to be a complex task. Overcoming the intricacies of computer vision for precise object identification demanded continuous refinement and fine-tuning to enhance the system's accuracy and reliability in identifying potential threats.

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LIST OF ABBREVIATIONS

1. DHT11: Digital Humidity and Temperature sensor 11
2. IoT: Internet of Things
3. LCD: Liquid Crystal Display
4. I2C: Inter-Integrated Circuit
5. Rx: Receiver (LoRaWAN module)
6. Tx: Transmitter (LoRaWAN module)
7. Node MCU: Node Microcontroller Unit
8. WiFi: Wireless Fidelity
9. Bluetooth: Wireless technology standard for exchanging data over short distances
10. LoRaWAN: Long Range Wide Area Network
11. COCO: Common Objects in Context (pretrained dataset for YOLO model)
12. YOLO v8: You Only Look Once version 8 (Object detection model)
13. API: Application Programming Interface
14. IOT: Internet of Things
15. ULP: Ultra-Low Power
16. RFID: Radio-Frequency Identification
17. LED: Light Emitting Diode
18. RxPi3: Receiver Raspberry Pi3
19. GPIO: General Purpose Input/Output
20. IDE: Integrated Development Environment
21. USB: Universal Serial Bus

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I express our heartfelt appreciation to Dr. Paul Braineard for his invaluable guidance and unwavering support throughout the completion of this project. His expert advice and insightful feedback have played a pivotal role in shaping the trajectory of this project work. I extend my sincere gratitude for his mentorship, which has been instrumental in my academic journey, fostering the acquisition of valuable knowledge and skills. Dr. Paul Braineard's contributions have significantly enriched the quality and depth of our project, and we are privileged to have benefited from his expertise.