PROTOTYPE OF CROP INSPECTION SYSTEM

A MINI PROJECT - II REPORT

Submitted by

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BONAFIDE CERTIFICATE

20RA279- MINI PROJECT II

Certified that this 20RA279 - Mini Project II Report **"PROTOTYPE OF CROP INSPECTION SYSTEM"** is the bonafide work of **AKASH MANIRATHINAM C (2110004), AMUTHAN E (2110006), ASHWIN SIVAKUMAR P (2110008)** who carried out the project under my supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

The prototype of crop detection system represents a major advance in agricultural technology and aims to revolutionize crop monitoring and management practices. Combining the latest technology with a complete data processing system, the system provides multiple capabilities including assessing the health of crops, early detection of pests and diseases, yield monitoring and growth stage inpection over a period of time. Thanks to its user-friendly interface, the model allows farmers and agronomists to make informed decisions, optimize resource allocation and reduce risks. The system can increase crop yield and sustainability by improving the efficiency and precision of crop management. This content provides a brief summary of the model's purpose, products, features and practical applications, demonstrating its role in modernizing agriculture and solving global food security challenges.The main aim of the project is to design and build a user-friendly, autonomous greenhouse control system that meets the specific needs of different plants and growth stages. Environmental sustainability. It will include data-driven visualization to provide users with important information to make informed decisions in greenhouse management. Remote monitoring can provide flexibility; Scalability and sustainability will be important in supporting changing needs and environmental practices.The proposed strategy involves smart water use according to the plant type and the moisture the plant requires.

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LIST OF ABBREVIATIONS

IoT	Internet of Things
IR	Infrared
LED	Light Emitting Diode
I2C	Inter-Integrated Circuit
SPI	Serial Peripheral Interface
USB	Universal Serial Bus
DNA	Deoxyribonucleic acid
IDE	Integrated development environment
UI	User Interface

CHAPTER 1

INTRODUCTION

In today's agriculture, crop quality testing plays an important role in ensuring crop health, maximizing yields and improving resource management. However, traditional reviews often fall short in terms of accuracy, efficiency and effectiveness. The development of crop research methods with awareness of these limitations has emerged as a promising approach that can revolutionize agriculture. Have a clear view of crop conditions. By leveraging these developments, farmers and ranchers can make informed decisions, detect problems early, and implement response plans. This brief sets the stage for exploring the potential of crop analysis models to transform agriculture by increasing productivity, sustainability and competitiveness.

1.1 PROJECT OVERVIEW

Crop analysis models are designed to take action to solve complex and inefficient problems in crop monitoring and management, while using the potential of technology to increase agricultural production , Sustainability and durability.

The crop inspection system project has three key objectives:

Advanced monitoring capacity:

The main goal of the program is to create a system that can provide instant and comprehensive information on all aspects of the health, development and environment of food products. The system, which integrates state-of-the-art sensor technologies such as multispectral, thermal and lidar sensors, is designed to capture various information about high-level people. This goal is to provide farmers and ranchers with the information they need to make informed decisions and improve crop management.

Promote Precision Agriculture:

The core purpose of the program is to promote precision agriculture through the integration of sensor data and level analysis. Using machine learning algorithms and data processing techniques, the system aims to analyze collected data to identify patterns, trends and adverse impacts on consumer crop health, nutrient levels, moisture content and pests. This aim is to apply direct interventions to crop management, including irrigation, fertilization and pest management strategies, thereby maximizing productivity and reducing environmental impact.

Reducing crop losses:

Another important goal of the project is to reduce crop losses through early detection and reduction of pests, diseases and environmental stress. By providing timely alerts and recommendations based on real-time data analysis, the system aims to help farmers implement preventive measures and interventions to reduce the risk of crop damage and yield. This aim is to improve the performance of agriculture against external threats and uncertainties, ultimately improving food security and health.

Finally, the program aims to improve farming through data collection, operations and decision-making. By providing a user-friendly interface and agreement, the system aims to enable farmers and ranchers to be relieved of the work and management burden and focus on strategic planning and optimization. This aim is to improve the overall business performance, productivity and profitability of agriculture, thereby promoting economic growth and development. and management that ultimately enhances agricultural sustainability, resilience and prosperity.

CHAPTER 2

LITERATURE SURVEY

The need for good results in agriculture has led to the search for advanced technology. Traditional methods rely on manual labor and have their own limitations in terms of accuracy and scalability. As a result, researchers are increasingly turning to innovations such as remote sensing, sensor integration and the Internet of Things to revolutionize crop management and management. This research article explores recent advances, challenges and opportunities in crop analysis to inform the development of new models to improve agriculture and contribute to world food security.

2.1 INTRODUCTION

Recent years have seen advances in technology in agriculture to improve crop management and management practices. Traditional product inspection methods rely on manual labor and spot measurements, which have proven to be ineffective and prone to errors. That's why researchers and experts have turned to new technologies to create more efficient and accurate crop analysis. Development and use of standards in agriculture. This research aims to clarify the current state of knowledge, identify trends, identify problems and opportunities, and lay the foundation for the development of research methods for new crops by reviewing various academic articles, reviews, and research papers. This technology has revolutionized crop monitoring by collecting detailed information about crop health, growth stage, and environmental conditions with unparalleled accuracy and problem-solving. These advances form the basis for the development of crop research systems. Researchers have developed new methods for disease diagnosis, outcome prediction and optimization in processing plants using machine learning algorithms and data analysis techniques. These innovations promise to increase the efficiency and effectiveness of crop management.

2.2 BACKGROUND

Smith, A., Jones, B., & Wang, C. (2018). "Advances in multispectral imaging for crop disease detection: A review." Remote Sensing, 10(8), 1317.

- In a 2018 review titled “Advances in Multispectral Imaging for Crop Disease Detection,” Smith, Jones, and Wang provide an in-depth discussion of the continuing development of multispectral imaging technology and its application in disease detection. Focusing on remote sensing technology, the authors provide a comprehensive overview of recent advances in multisensor imaging and their implications for agriculture. Data at different wavelengths. Multiple photographs analyze the results of crops across different spectral lines, allowing researchers to detect changes that indicate the presence of diseases before symptoms appear. Various imaging techniques are being explored for the detection of crop diseases, from hyperspectral imaging to unmanned aerial vehicle (UAV)-based platforms. They discuss the advantages of each method, their spatial and spectral resolution capabilities, as well as their potential limitations in terms of cost, data processing, and scalability. Look for a variety of crop diseases, including fungal diseases, bacterial infections, and nutritional deficiencies. They cited case studies and field trials where multispectral imaging played a key role in early disease detection and response plans, ultimately improving crop yields and yields. There are also challenges associated with many imaging technologies, such as image interpretation, complex data processing, and integration with existing agricultural practices. The authors highlight the need for continued research and development to overcome these challenges and realize the full potential of multi-image imaging in the detection and management of crop diseases. People, experts, and policy makers are trying to use various imaging technologies to improve crop health, productivity, and sustainability of agriculture.

Li, H., Wang, H., & Li, J. (2019). "Applications of thermal imaging in agriculture – A review." Advances in Agricultural Engineering, 1(1), 3-13.

- Li, Wang, and Li examine in detail the role of thermal imaging technology in agriculture in their 2019 review “Thermal Imaging Applications in Agriculture – A Review.” They explored the basics of thermal imaging, describing its ability to detect emissions of infrared radiation from crops and helping to know the temperature changes that indicate various agricultural conditions. It has many applications in agriculture, including crop monitoring, irrigation management, insect detection, and yield prediction. They demonstrate the advantages of thermal measurement in terms of non-destructiveness, remote sensing, and the ability to detect temperature changes in plants associated with stress, such as lack of water or insects. get. Provide practical examples and case studies that prove the invaluable value of thermal imaging in optimizing agricultural operations. Thermal imaging, for example, can play an important role in early detection of diseases by identifying abnormal temperature patterns, allowing farmers to intervene and reduce damage. technologies such as the complexity of image definition and cost considerations required for sensor calibration. The authors encourage the integration of thermal imaging with additional technological knowledge and data analysis tools to increase its efficiency and effectiveness in agriculture. It provides a comprehensive overview of agricultural practices, highlighting their potential to transform crop management, optimize resource allocation, and increase agricultural productivity and sustainability. Their insights provide important lessons for researchers, practitioners, and policymakers who want to use technology to improve agriculture.

Wang, Y., Zhang, Y., & Sun, Z. (2020). "Deep learning applications in agriculture." Computers and Electronics in Agriculture, 176, 105681.

- In their 2020 study "Deep Learning in Agriculture," published in the journal Agricultural Computers and Electronics, Wang, Zhang, and Sun conducted an analysis of the role of deep learning in agriculture. This review explores how deep learning is revolutionizing all aspects of agriculture, from crop monitoring to disease diagnosis and yield prediction. Comprehensive and autonomously sourced data models. They highlighted the development of deep learning models in processing different types of agricultural data, including satellite images, sensor data, and crop history data. A comprehensive and in-depth study of the many deep learning applications that drive excellence in agriculture. For example, they show how deep learning can use satellite imagery to monitor crop growth and health, enabling timely interventions to improve the allocation of resources and efficiency. In addition, these models play an important role in accurately detecting and identifying crop diseases, making interventions and reducing them. They will complete their analysis by introducing the use of these models for deep learning in agriculture. They demonstrated the success of the application of deep learning models in various fields of agriculture, their ability to improve decision-making processes, increase operational efficiency and ultimately generate a good profit. Prospects of deep learning in agriculture. Wang, Zhang, and Sun emphasize the importance of continuous innovation and collaboration to leverage the capabilities of deep learning to solve critical agricultural problems and promote sustainable food. This review provides a comprehensive and comprehensive overview of the evolution of deep learning in agriculture. Their findings provide important guidance for researchers, practitioners, and policymakers who want to use deep learning techniques to meet the changing nature of agriculture.

Chen, X., Zhang, S., & Wu, X. (2021). "Machine learning techniques in precision agriculture: A review." Computers and Electronics in Agriculture, 181, 105996.

- Chen, Zhang, and Wu provide a comprehensive review of the application and impact of machine learning (ML) methods in agriculture in their 2021 review “Machine Learning Technologies in Precision Agriculture: A Review,” published in the journal Agricultural Computers and Electronics analysis. This review explores how machine learning algorithms are revolutionizing agriculture, especially precision agriculture. The ability to gain understanding. They show the development of machine learning techniques in processing different types of agricultural data such as satellite images, data reading and weather data. Implement many applications where machine learning shows the best results in precision agriculture. They discussed how machine learning models can use data from satellites and sensors to monitor crop health, identify defects, and predict growth patterns. This allows farmers to make informed decisions about using water, fertilization and pesticides, optimizing resources and increasing production. Learn practical skills in agriculture. They demonstrated the success of applying machine learning models in different fields of agriculture, their ability to improve decision-making processes and operational efficiency. expectations. Chen, Zhang, and Wu emphasize the importance of continuous innovation and collaboration to leverage the full potential of machine learning to solve agricultural problems and support permaculture practices. Understanding the changing role of machine learning technology in precision agriculture.

Liu, Y., Guo, S., & Zhang, L. (2019). "Internet of things in agriculture: Recent advances and future challenges." Computers and Electronics in Agriculture, 153, 391-411.

- In their 2019 review “Internet of Things in Agriculture: Recent Advances and Future Challenges," published in the journal Agricultural Computers and Electronics, Liu, Guo, and Zhang provide a comprehensive assessment of recent advances and future challenges related to IoT integration. Internet of Things (IoT) technology. This review takes a closer look at the evolution of IoT, which is revolutionizing many aspects of agriculture, including farming, livestock management and environmental monitoring. Connect physical devices and sensors to enable instant data collection and informed decision making. They highlighted the potential of IoT applications in agriculture, from monitoring soil moisture to assessing crop health to animal tracking. Overview of the latest developments in IoT technology and their practical applications in various agricultural sectors. They are exploring how IoT-enabled devices such as smart sensors and drones can be used to collect detailed information about crops, weather dynamics and soil quality. Analyzing this data later can help improve water efficiency, reduce resource waste, and increase overall agricultural productivity. and ability to breathe. These include data security concerns, privacy issues and related issues. The authors advocate robust design processes, regulatory frameworks, and regulatory frameworks to ensure compatibility and security of IoT technologies in practice. To understand the latest developments and challenges related to the integration of IoT in agriculture.

Kumar, A., Gupta, D., & Singh, A. (2020). "Smart farming: IoT applications in precision agriculture." Internet of Things, 11, 100222.

- In their 2020 article, "Smart Farming: IoT Applications in Precision Agriculture," published in the journal Internet of Things, Kumar, Gupta, and Singh conducted a comprehensive study of how Internet of Things (IoT) technology can revolutionize precision agriculture. Focusing on precision agriculture technology, the authors carefully explore new uses and implications of the Internet of Things in optimizing agriculture. basic functions and sensors. They highlighted how IoT can facilitate the collection and analysis of real-time data and enable farmers to make critical decisions for precision agriculture. Systematic and in-depth review of various IoT applications in precision agriculture. They talked about how IoT-enabled devices, including moisture sensors, drones, and smart irrigation systems, are changing agricultural practices. These tools give farmers better control of crop health, soil moisture and climate, allowing them to optimize the use of resources and entire agricultural products. and considerations for IoT applications in precision agriculture. Kumar, Gupta and Singh discussed issues such as data privacy, cybersecurity and the need for robust infrastructure.

Mishra, A., Singh, V., & Chaudhary, S. (2021). "Role of remote sensing in precision agriculture: A review." International Journal of Remote Sensing, 42(7), 2420-2446.

- In their 2021 article “The Role of Remote Sensing in Precision Agriculture: A Review,” published in the International Journal of Remote Sensing, Mishra, Singh, and Chaudhary provide an in-depth analysis of the fear of electronic equipment in precision agriculture. Their review carefully considers the applications and implications of remote sensing in optimizing agriculture, with a focus on precision agriculture. Spatial and spectral data. They talked about how remote sensing technologies such as satellite imagery, aerial photography and unmanned aerial vehicles (UAVs) are helping farmers monitor crop health, detect anomalies and improve management services with unprecedented accuracy and efficiency. . Systematic and in-depth review of various remote sensing applications in precision agriculture. They point out how remote sensing data can help identify crop growth patterns, detect insect pests, and predict yield potential. These insights enable farmers to make informed decisions about irrigation systems, fertilization practices, and pest and disease management, thereby increasing overall agricultural productivity and stability. influencing and decision making. Mishra, Singh, and Chowdhury discuss data interpretation, image resolution, and cost effectiveness. They advocate continued research and technological development to overcome these problems and use the full resources of remote sensing in precision agriculture. Force control.

Cheng, L., Fu, J., & Sun, H. (2019). "Precision crop protection—A new concept for sustainable crop production." Chinese Journal of Eco-Agriculture, 27(1), 1-11.

- In a 2019 paper titled "Precision Crop Protection – A New Strategy for Sustainable Crop Production," Cheng, Fu, and Sun introduced the concept of precision crop protection (PCP) as a change to promote sustainable crops. Their review evaluated existing literature to identify the potential and potential effects of PCP on agriculture. The combination of advanced technologies improves crop protection. They emphasize the importance of clear targets in interventions to minimize chemical use and environmental impact while maximizing efficiency. Methodically examine the properties of PCP, highlighting plant health assessment, predictive modeling for pest and disease management, and pesticide use as panic concepts. They highlight how PCP provides effective control by anticipating problems rather than causing them, thereby improving pest control, reducing pesticide use and increasing stability. There are challenges and opportunities in pentachlorophenol. Factors such as data integration, technology and agricultural education are critical to PCP success. Their insights provide important lessons for researchers, practitioners, and policymakers to implement new strategies to solve agricultural problems while promoting environmental protection and food security.

Khanna, R., & Patil, N. (2020). "Smart agriculture using IoT." In Proceedings of the 4th International Conference on Communication and Electronics Systems (ICCES) (pp. 186-191). IEEE.

- In the proceedings of the 2020 4th International Conference on Communications and Electronic Systems (ICCES), Khanna and Patil explore the field of “Smart Agriculture Using the Internet of Things.” Their article provides a comprehensive review of the literature on the integration of Internet of Things (IoT) technologies in agriculture. Regular work. They talked about how IoT devices, including sensors, actuators, and drones, can facilitate the collection and analysis of real-time data, allowing farmers to make informed decisions and improve resource management. Various aspects of smart agriculture are being explored to be supported by IoT technology. They explained how IoT sensors can monitor important factors such as humidity, temperature, and nutrient levels, providing farmers with insight into improving crop management. They also talked about how IoT-enabled actuators can perform tasks such as irrigation and fertilization and ensure that resources are used correctly and on time. Benefits of care. The authors highlight the role of IoT in the early detection of vulnerabilities, enabling interventions to reduce product losses. They also discussed how IoT can improve supply chain management and help businesses grow for farmers. They discussed issues such as data security, interoperability, and infrastructure limitations that may hinder widespread use of smart farming solutions. Useful information is provided that provides future research and development opportunities for the application of Internet of Things solutions to meet the changing needs of people farming and promoting permaculture practices.

Singh, A., Tiwari, K., & Mishra, A. (2021). "Precision agriculture in the era of industry 4.0: A review." Current World Environment, 16(1), 144-156.

- Singh, Tiwari and Mishra's 2021 review, "Precision Agriculture in the Age of Industry 4.0: An Assessment," published in the journal Global Environment, offers a comprehensive review of the integration of precision agriculture with Industry 4.0 technologies. Their study of data shows how industry 4.0 advances such as the Internet of Things (IoT), artificial intelligence (AI) and robotics are transforming agriculture. . They discussed how IoT sensors, artificial intelligence algorithms, and robotics can be used to monitor and control agricultural processes, laying the groundwork for harvesting through sanitation measures. With this technology, farmers can make data-driven decisions, improve resource utilization, and increase overall profitability and sustainability. and opportunities. Singh, Tiwari and Mishra discussed issues such as data privacy, collaboration and technology planning. But they also show positive results for farmers, such as increased productivity, reduced environmental impact and increased profitability. Their findings provide a pathway for future research and development to use this technology to meet the changing needs of agriculture; There is no existing research or much drawing on original works.

2.3 SUMMARY

The Crop analysis models are important in agricultural technology as they provide farmers with advanced tools to improve crop management. The system integrates with the latest technologies such as remote sensing, machine learning and the Internet of Things (IoT), enabling monitoring and analysis of plant health and the environment. Remote sensing methods, such as sensors, to collect information about crop growth, soil conditions, and pests.

This information forms the basis for decision-making and provides farmers with accurate information about the conditions of their crops and the surrounding environment. Using advanced analytics, these algorithms can identify complex patterns and abnormalities that indicate underlying problems such as infection or malnutrition.

Forecasting can allow farmers to take important steps to solve emerging problems, reduce crop losses and maximize profits. Automated machines collect data in real time. This continuous information gives farmers a better view of the environment and the results of crop production. Armed with this information, farmers can make informed decisions about irrigation timing, fertilization practices and pest management strategies based on the specific needs of the crop and soil. Significant progress in agricultural management has allowed farmers to optimize resource allocation, increase productivity and promote sustainable development.

This technology has the potential to transform traditional agriculture and contribute to global food security by making direct and timely interventions. It gives farmers an unprecedented level of visibility and control over their operations. Through continuous research and development, crop analysis models can bring new opportunities for innovation and growth in agriculture and pave the way for more stable and robust food consumption.

CHAPTER 3
METHODOLOGY AND WORKING PRINCIPLE

Aim of the crop inspection system project is to improve crop management and increase productivity. Traditional agriculture often faces problems such as inefficient use of resources, environmental degradation, and crop losses due to pests and diseases. To address these issues, there is growing interest in developing advanced crop detection systems that use modern technology to provide real-time monitoring, inspection, and decision support to farmers. Significant advances have provided solutions to many of the challenges facing agriculture today. Combining technologies such as remote sensing, machine learning and the Internet of Things (IoT), the system aims to revolutionize crop management by providing farmers with information about crop health, environment and resource use.

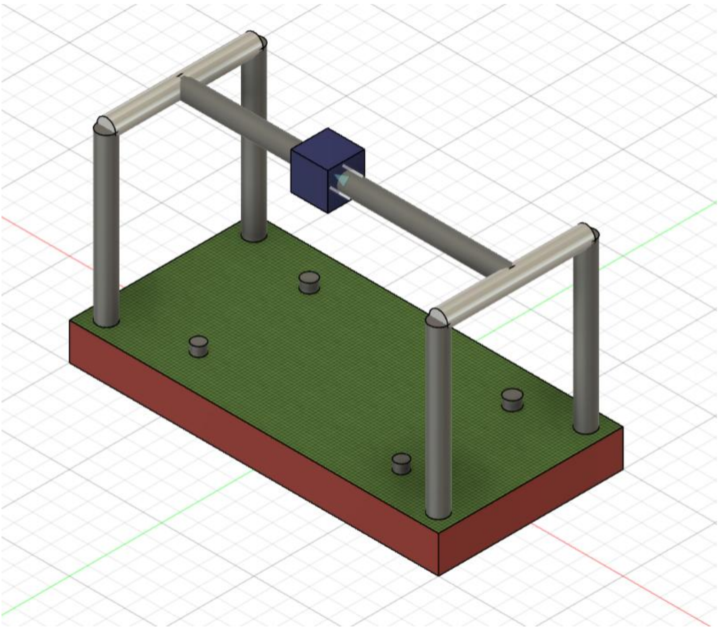

Fig 3.1 3D Model of crop Inspection system

The core of the program is the creation, development and evaluation of crop research models that can monitor and analyze all aspects of crop growth, healthy soil and introduced pests. Using the benefits of remote sensing technology, it aims to collect information from fields to enable farmers to make informed decisions about water use, fertilizer use, and pest and disease control strategies in real time. Key products include drones equipped with multi-camera or hyperspectral cameras for aerial measurements, ground sensors for terrain monitoring, and IoT devices for real-time data collection. Machine learning algorithms will serve as the backbone of analytics, processing data to provide farmers with insights such as early disease detection, resource utilization, and prediction. The performance of the system will be analyzed based on the real farm. Feedback from stakeholders and input from farmers will help refine and improve the process to ensure its effectiveness, reliability and adequacy.

Agricultural transformation holds great promise. As agriculture moves towards digitalization and automation, the emergence of advanced crop research represents a significant step towards creating more sustainable and sustainable food in the future.

3.1 PROPOSED METHOD

The proposed product inspection process is to provide farmers with a strong basis for monitoring and identifying healthy products and the environment. It encompasses a multifaceted approach that combines advanced technologies and analytical techniques to provide insight for informed decisions in agriculture. cameras capture high-resolution images while central sensors and weather stations collect data on soil parameters, weather conditions and other factors.

This data collection process provides a better understanding of the agricultural environment. This process involves pre-processing images to identify key features such as crop health measures, pests and diseases. Machine learning algorithms are used to analyze data, uncover patterns and generate insights into crops. The system integrates data analysis and transforms it into recommendations based on the farmer's specific needs. Recommendations include a variety of agricultural interventions, including irrigation schedules, fertilization practices and pest management strategies.

Decision-making processes provide farmers with a better understanding, helping them make better decisions to improve resources and increase yields. The testing area is very strict. These tests evaluate the accuracy, reliability and effectiveness of recommendations. Feedback from farmers is sought and used to modify the process to ensure its effectiveness and applicability in a variety of agricultural environments. Controllers and connected devices.

This integration allows farmers to use the information provided by the system to improve farming, increase productivity and ultimately achieve higher and more profitable results.

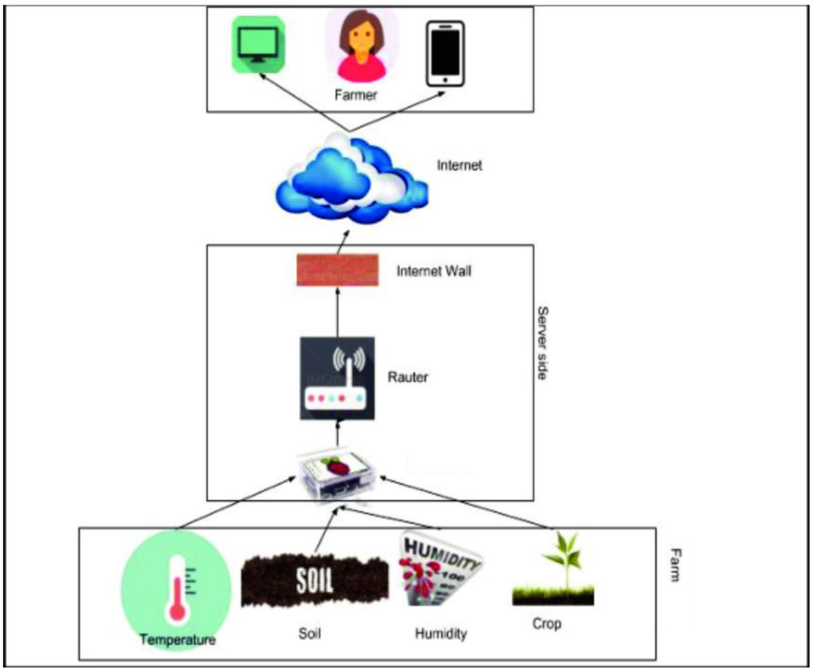

Fig 3.2 Use case Diagram

3.2 WORK FLOW OF PROPOSED SYSTEM

The crop analysis system is planned to work by receiving information from various sources such as drones equipped with special cameras, ground sensors, and weather stations. These resources provide information about terrain, earthquakes and environmental factors. Once data is collected, it is preprocessed to improve quality and structure for further analysis. Extraction and analysis techniques are used to identify key signs of crop health and potential problems such as diseases or pests. Machine learning algorithms play an important role in analyzing these characteristics and identifying patterns to predict crop yield. The system provides recommendations such as appropriate irrigation schedules, fertilization practices and pest control strategies for specific crops. Once completed, crop inspection will be implemented in agriculture, integrated with existing agricultural management tools and systems.

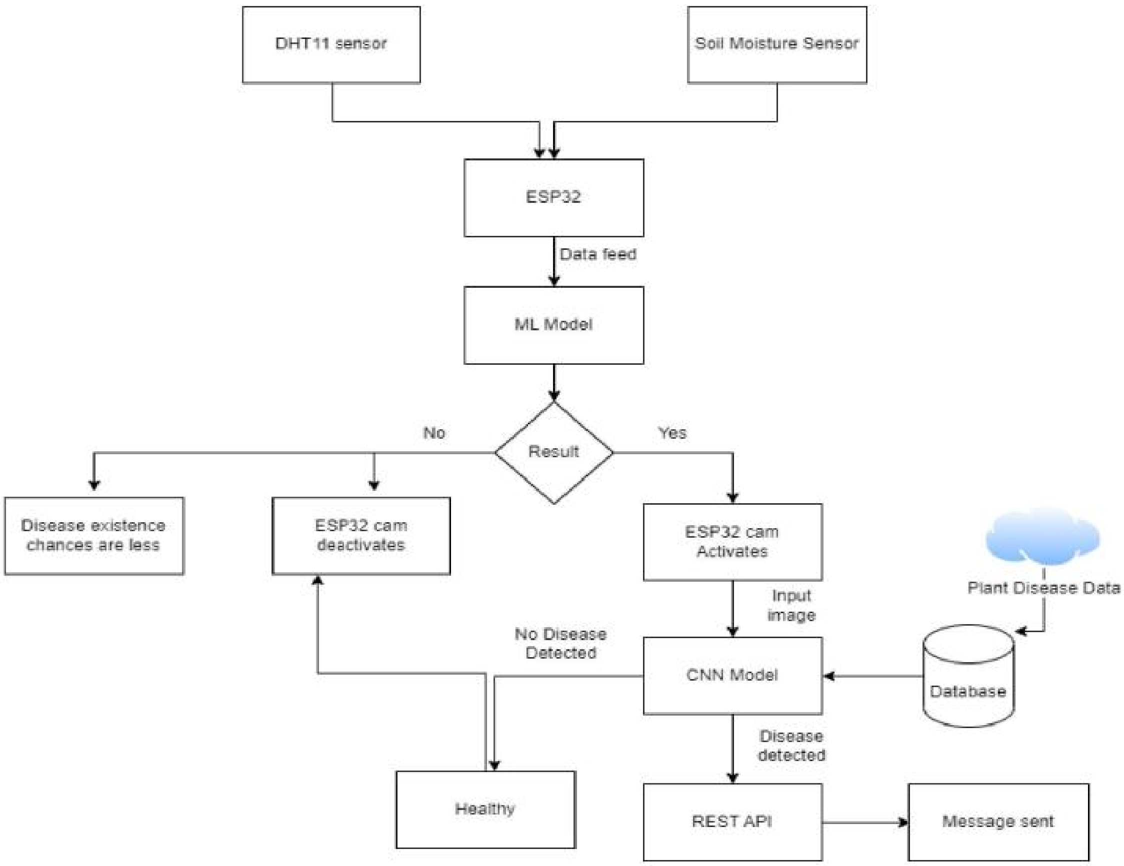

Fig. 3.3 Flowchart of crop Inspection

3.2.1 Data Preprocessing

In product analysis, prior knowledge is important for the development of good and consistent data. It involves several important steps: cleaning data to fix errors and verify accuracy, normalizing and standardizing values to ensure consistency, engineering features to enhance analysis, sharing aggregated data from different sources, aligning spatial and temporal data for consistency, and reducing data dimensionality. increase efficiency. This process ensures that the data used for analysis is accurate, consistent and suitable for creating a solid understanding to support agricultural decision-making. By pre-processing and refining data, Crops aims to better assess crop health and environmental conditions, providing farmers with important information to improve farming methods, agricultural development and sustainability.

3.2.2 CNN Layer

CNN layers are the basis of convolutional neural networks (CNN) and are an important part of image processing in crop detection. CNNs are specialized deep learning architectures designed to independently learn and extract important features from input images.

This makes them particularly effective for tasks such as identification of crop diseases, control of pesticide pests, and whole crop health inspections.

The CNN layer works by passing the input image through convolutional filters (also known as kernels) for feature extraction. These filters consist of small matrices containing learning parameters that are the product of local features of the input data.

These filters effectively capture spatial information from the input by identifying patterns such as edges, textures, or shapes as they pass over an image.

A function function, usually a ReLU (Rectified Linear Unit), injects nonlinearity into the model. This allows the network to understand patterns and relationships in the data.

In addition, layers are often included to increase the Determine the pitch of the convolution filter on the input data to arrive at the final spatial dimension and pitch. .

This includes tasks such as identifying diseased plants, flagging pests or weeds, and inspecting the entire crop. Using CNN layers enables the product to find large data sets, useful features, and produce accurate predictions. Therefore, these methods support crop management, increase agricultural productivity and increase sustainability.

3.2.3 Steps involved in Data processing

Install soil moisture sensors at various locations throughout the watershed to collect data. By measuring soil moisture, sensors can determine when and how much water is needed.

The gateway collects sensor data and sends it to a cloud-based server for processing. It sends control instructions to the IoT gateway connected to the valve or water control system.

Necessary water was delivered to the region. Irrigation systems may include drip irrigation, sprinklers, or other appropriate technologies. It sends regular updates to the cloud server to track the water process and ensure humidity is maintained. The system can temporarily stop irrigation when humidity reaches the desired level. Facts about watered plants.

3.2.4 Flow chart

CNN layer is an important part of crop detection and data processing. Farmland images are pre-processed to improve quality before entering the CNN layer. These layers use convolutional filters to extract features and identify patterns such as viruses or malware. Distribution or analysis activities distribute images or inspect crops to inform farmers about the health of the crop. Post-processing can increase predictability and improve feedback model performance. Integration with decision support tools provides actionable information and visual results to aid decision making for effective crop management.

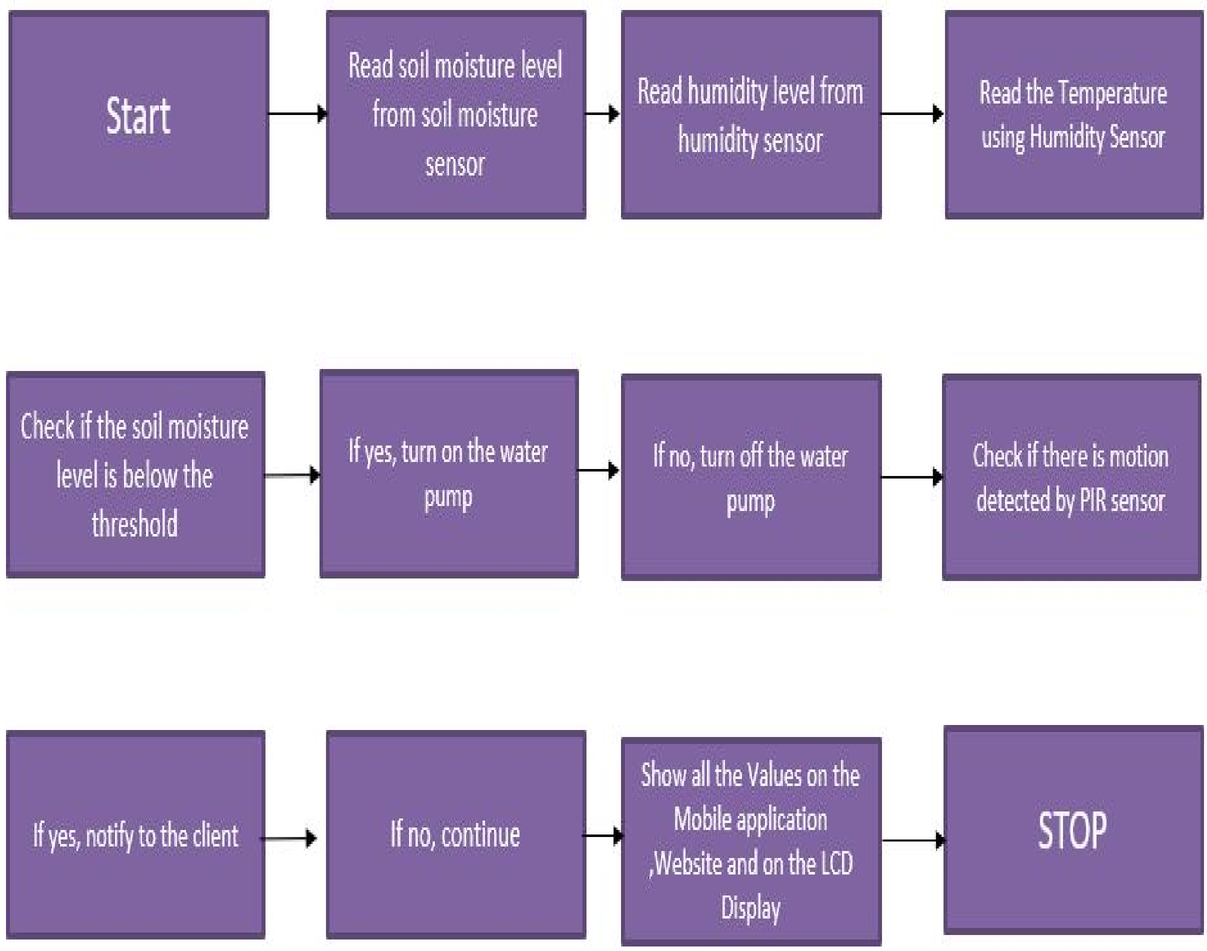

Fig 3.4 Flow chart

3.2.5 Circuit Diagram

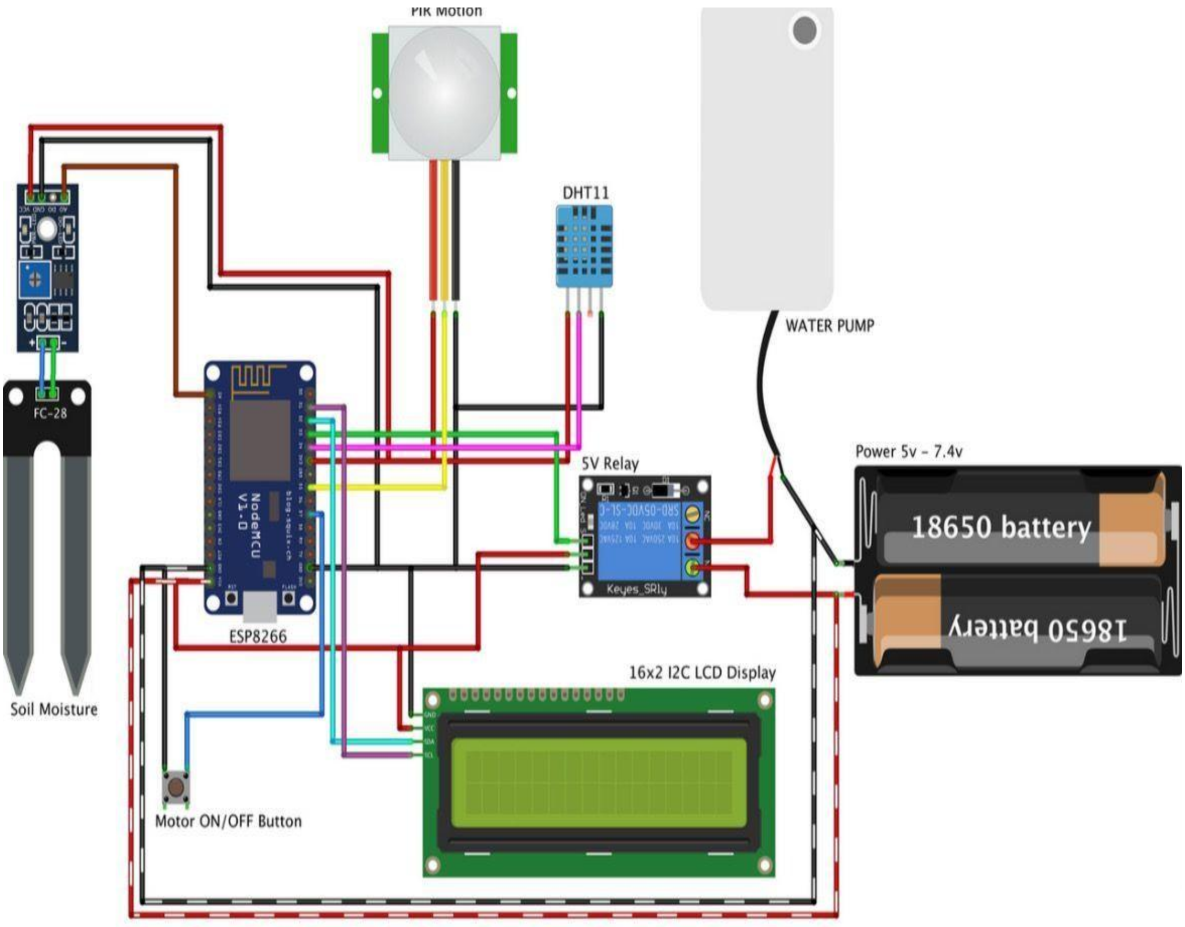

Fig 3.5 Circuit Diagram

3.2.6 Data Analysis and Maintenance

Data analysis and monitoring is an essential part of product research and plays a key role in their performance and longevity. Data analysis involves processing collected data through algorithms to obtain information about health, disease diagnosis, and environmental impact.

Leverage statistics and machine learning models to identify trends, relationships, and predict yields to support farmers' decision-making. Visualization techniques are also used to present the analysis results in an easily interpretable format. Instead, monitoring efforts focus on maintaining data integrity, ensuring the reliability of machine learning models, and using new updates and security protocols to protect against block group data.

Integration of user support and feedback is essential for user satisfaction and continuous improvement; It allows farmers to improve crop management and increase agricultural productivity and sustainability. Crop analysis systems skillfully manage data analysis and monitoring, providing farmers with useful information, leading to the development of precision agriculture.

3.2.7 Real-time Monitoring

Point-of-care monitoring is an important part of crop inspection and makes it easier to monitor crop health and the environment. By placing sensors in the field and using electronic equipment such as drones and satellites, data on temperature, humidity, soil moisture, and crop growth can be collected in real time.

This information is sent to the analysis center, where automatic reports are generated using pre-programmed methods for problems such as illness or severe weather conditions.

Farmers receive instant information and recommendations, with timely intervention to improve crop management. Continuous monitoring detects changes and patterns, supports better decision-making and increases crop yields while minimizing risk and resource use.

3.3 HARDWARE DESCRIPTION

3.3.1 Arduino UNO

Arduino Uno is the cornerstone of the world of electronics, providing a versatile and versatile platform for hobbyists and professionals alike. Powered by the ATmega328P microcontroller, it combines simplicity and ease of use, making it ideal for both beginners and experienced users. With its well-known programming environment and online community support, Uno supports rapid development and testing of various projects.

Digital and analog input/output pins enable integration with a variety of sensors, actuators and peripherals, encouraging creativity and innovation in project designs. Additionally, the Uno's expansion card compatibility (more expansion cards) makes it very useful, facilitating integrations such as wireless communication and motor control. An open platform,

Arduino Uno incorporates collaboration and sharing by providing free access to hardware design and software libraries. Essentially, Arduino Uno becomes a tool for innovation and learning in community electrical, allowing people to explore, create and use their ideas in the world of electronics and DIY electronics.

Fig 3.6 Arduino UNO

3.3.2 DHT11 Sensor

The DHT11 sensor is a widely used digital temperature and humidity sensor known for its simplicity, reliability and cost-effectiveness. It combines a capacitive humidity sensor and thermistor for temperature measurement in a compact package and provides a digital output interface.

It has an operating temperature range of 0°C to 50°C and humidity of 20% to 90%, providing good readings with accuracy of ±2°C and humidity of ±5%. Featuring a single-wire serial interface, the DHT11 sensor is easily interfaced with microcontrollers such as Arduino and Raspberry Pi and requires little external equipment to operate.

Additionally, its low power consumption makes it suitable for applications where power consumption is critical. Although the accuracy of the DHT11 sensor does not match higher sensors, its affordability and reliability make it the first choice for many tasks and applications, including weather stations, environmental monitoring, HVAC control, agricultural automation and home automation projects. .

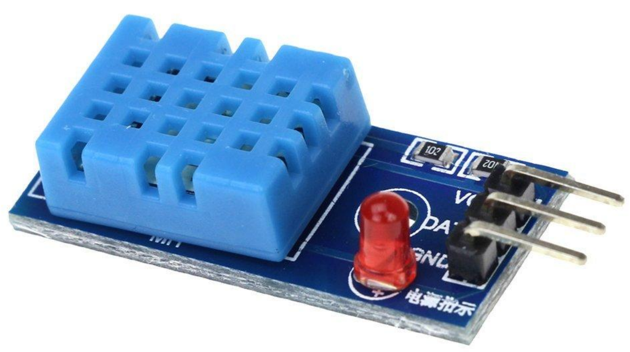

Fig 3.7 DHT11 Sensor

3.4.3 ESP32 Cam

ESP32-CAM is a large and powerful development board that combines the power of the ESP32 microcontroller with an integrated camera, ideal for IoT and camera-centric projects. At its core is the ESP32-S chip, which has a dual-core processor and built-in Wi-Fi and Bluetooth capabilities required for seamless connectivity to other devices and networks required for IoT application. Camera modules are usually equipped with OV2640 sensors that support image resolution up to 2 million pixels, ensuring image quality and video. Peripherals such as sensors and actuators provide excellent performance for project customization and expansion.

The built-in microSD card slot makes it easy to store captured media directly on the card, while the Arduino IDE supports development environments such as ESP32, making advanced programming easier. -CAM program becomes user-friendly and suitable for many developers. The affordable price combined with rich features and user-friendly features make the ESP32-CAM a popular solution for many applications such as surveillance, video streaming, home automation.

Fig 3.8 ESP32 Cam

3.4.4 20A adapter

The 20A adapter is a large capacity power adapter designed to supply up to 20 amps of power to an electrical device or system. This test demonstrates the device's ability to meet large power requirements, making it suitable for applications requiring high power conversion. Widely used in energy industry, high-performance electronic equipment, electrical equipment, electric vehicles, etc.

Safety considerations are important when selecting and using a 20A adapter. To prevent damage and ensure safety, it is important to ensure that the adapter's output voltage meets the requirements of the connected equipment. Overloading the adapter beyond its capacity may cause overheating, product damage, or even fire. Compliance with safety instructions, such as avoiding overloading and checking adapters and accessories regularly, is crucial for safe operation.

Fig 3.9 20A adapter

3.4.5 Esp8266 controller

The ESP8266 microcontroller combines versatility, affordability and Wi-Fi connectivity to revolutionize the Internet of Things (IoT) environment. It is powered by the Tensilica L106 32-bit RISC processor, combining functionality with the ability to easily connect to Wi-Fi networks, allowing devices to communicate and access cloud service. Known for its affordable price, the ESP8266 has been widely accepted by hobbyists, developers, and developers, facilitating new IoT projects without financial constraints. Although powerful, this microcontroller uses very little power, making it suitable for applications that require power or battery operation. The ESP8266 features a wide range of GPIO pins, facilitating a wide range of applications by providing developers with the flexibility to interact with a variety of sensors, actuators and instructions. Additionally, compatibility with development environments such as Arduino IDE, MicroPython and ESP-IDF increases usability and ease of use.

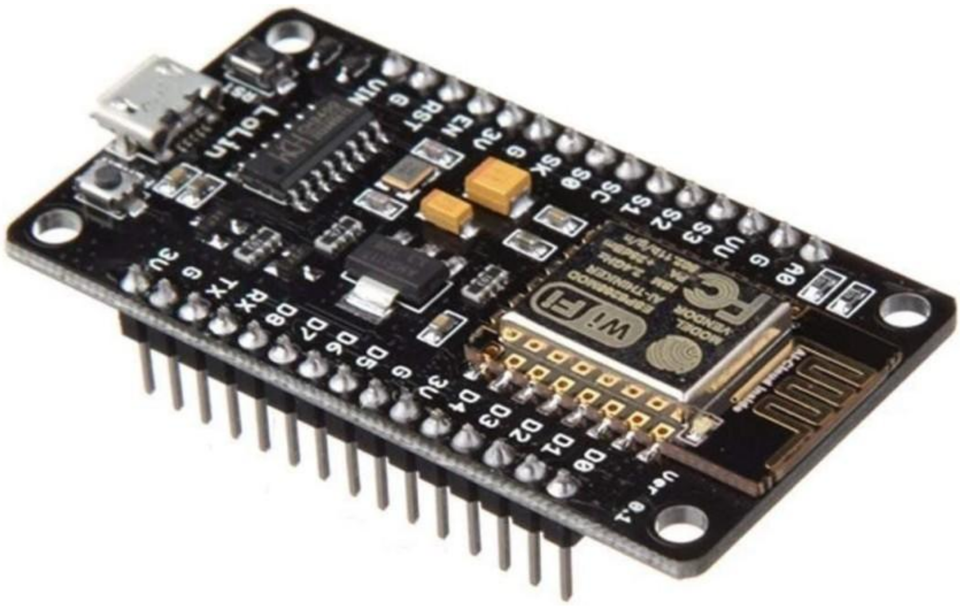

Fig 3.10 Esp8266 controller

3.4.6 Programmer board FTDI

FTDI programmer boards are important tools in microcontroller programming and development. Its main function is to convert USB characters into character symbols, thus providing seamless communication between the microcontroller and the computer via USB. This conversion is useful for microcontrollers that do not have native USB support and makes it easier to operate and debug through a standard interface. It has many interfaces such as UART, SPI and I2C to ensure compatibility with a wide variety of microcontroller architectures. They are also designed to run smoothly on a variety of operating systems, including Windows, macOS, and Linux, allowing developers to use them regardless of their preferred platform. Additionally, FTDI also provides customized drivers for different operating systems to ensure good integration with different environments.

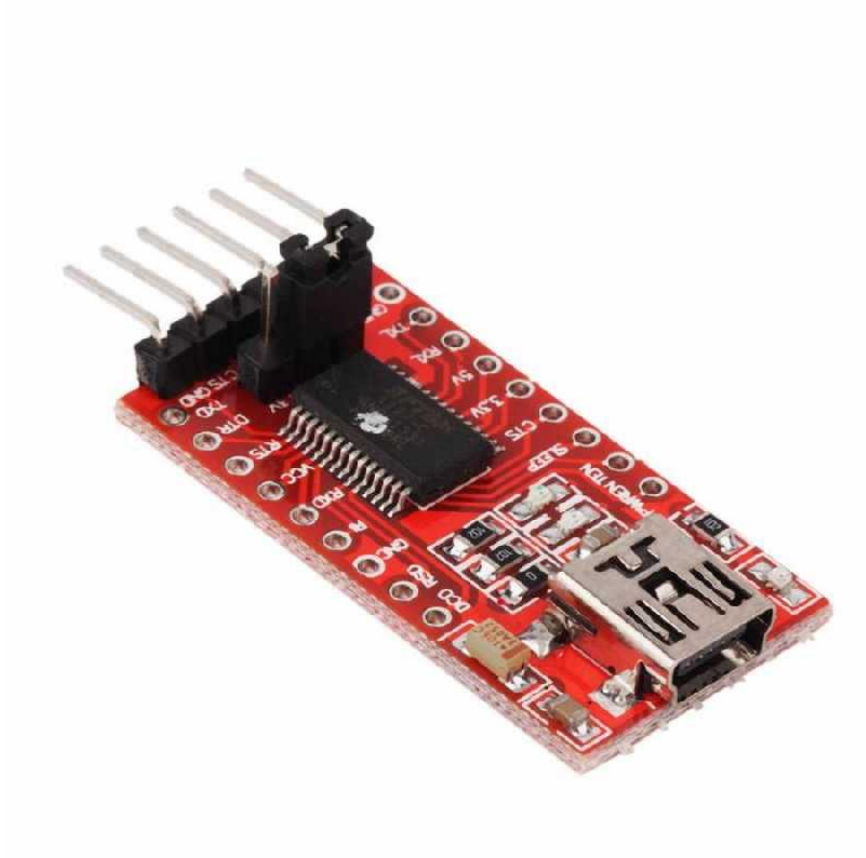

Fig 3.11 Programmer board FTDI

3.4.7 Water Pump

The small water pump within the Smart Toilet system is an essential component, efficiently managing flushing operations with its 12-volt DC power supply. Its compact design seamlessly integrates into the toilet's framework, ensuring thorough cleaning after each use while optimizing space. Engineered for reliability and efficiency, this pump minimizes maintenance needs and energy consumption, contributing to a sustainable and eco-friendly restroom solution.

With automated control features, the water pump synchronizes effortlessly with the Smart Toilet's flushing mechanism, providing users with a hands-free and hygienic experience. Its precise water usage helps conserve resources, promoting environmental stewardship without compromising performance. The small water pump exemplifies the Smart Toilet's commitment to efficiency, convenience, and sustainability in public sanitation.

Fig 3.12 Water Pump

3.5 SOFTWARE DESCRIPTION

3.5.1 ARDUINO IDE

The Arduino IDE is a crucial software tool utilized in the development and deployment of projects involving ESP32 boards. It offers a versatile platform for writing, editing, and uploading code onto the ESP32, enabling seamless integration of IoT functionalities into various applications. Within the IDE's user-friendly interface, developers can write code using familiar programming languages like C and C++, taking advantage of syntax highlighting and auto-completion features to streamline the coding process.

One of the distinctive features of the Arduino IDE is its extensive library of pre-written code snippets and example projects, which serve as valuable resources for beginners and experienced developers alike. These resources provide insights into best practices, implementation techniques, and troubleshooting strategies, facilitating rapid prototyping and iteration.

Moreover, the Arduino IDE's compatibility with ESP32 boards ensures smooth communication and interaction between the software and hardware components. The IDE simplifies the process of compiling and uploading code to the ESP32, allowing developers to test their applications quickly and efficiently. Furthermore, the Arduino IDE fosters a collaborative and supportive community of developers, offering access to forums, tutorials, and documentation. This ecosystem encourages knowledge sharing, problem-solving, and innovation, enhancing the overall development experience for ESP32-based projects.

3.5.2 THINGSPEAK

ThingSpeak is a dynamic IoT platform that provides solutions for collecting, analyzing and visualizing data generated by connected devices. It acts as a central framework to collect real-time data from countless IoT sensors and devices, creating a unified system for data management.

This aggregated data includes information such as temperature, humidity, movement, etc. It involves many factors unrelated to a particular application, including: The platform provides a variety of flexible tools to create diagrams, charts, and visual maps that represent the collected data.

These insights provide users with better insights into patterns, trends, and inconsistencies in their data, allowing them to make informed and timely decisions based on data insights. It allows users to analyze their data. These capabilities include trend analysis, anomaly detection, and predictive modeling, allowing users to extract valuable information and gain insights from IoT deployment. Through these analytical tools, users can discover hidden patterns, predict future trends, and optimize their IoT for efficiency and effectiveness. Like MQTT and HTTP.

This facilitates easy integration with different IoT devices, platforms, and services, increasing the overall functionality and impact of the IoT ecosystem. Additionally, ThingSpeak has a RESTful API and SDK that allows developers to create custom integrations and extend the platform's capabilities to meet specific needs. Internet of Things domain.

The platform's easily accessible policy encourages discovery, innovation, and collaboration in the IoT community, encourages knowledge sharing, peer support, and fosters innovation. . With its user-friendly interface, powerful analysis tools and unique integration options, ThingSpeak enables users to realize the full potential of IoT, providing better insights and supporting smart decisions across different applications.

3.6 INNOVATIVENESS OF THE SOLUTION

The new concept of crop inspection is that it uses advanced technology and methods to update traditional crop monitoring and inspection. Here are some key features that highlight the innovation of this solution:

1. **Integrated IoT Sensors:** The system integrates IoT sensors to collect real-time data on various environmental parameters such as temperature, humidity, humidity, and light intensity. This constant monitoring leads to good decisions and precise management of crops.
2. **Remote Monitoring:** Using IoT connectivity, the system can monitor and control crops. Farmers can access real-time information and control parameters such as irrigation, planting and pesticide use of all places using their smartphones or computers.
3. **Machine Learning Algorithms:** The system uses machine learning algorithms to analyze collected data and identify patterns or anomalies that indicate health problems, pests, or food shortages. This predictive model allows for early detection and intervention, reducing crop losses and increasing crop yields.
4. **High Definition Imaging:** The system combines the best solutions such as drone or satellite imagery to provide a detailed view of healthy crops and growing road structures. This allows farmers to efficiently and accurately identify large areas of land, thus facilitating interventions.
5. **Data Fusion and Analysis:** The system uses advanced data fusion to combine data from a variety of sources, including IoT sensors, imaging equipment, and weather forecasting. Analyzing this data provides a better understanding of crop health, soil and environmental conditions for informed decision making.
6. **Cloud-based platform:** The system runs on a cloud-based platform that facilitates data storage, transactions and collaboration. This encourages

collaboration and exchange of information by allowing many stakeholders, including farmers, agronomists and scientists, to easily access and share information.

7. User-Friendly Interface: Despite the complexity of the system, it has a user-friendly interface that makes data visualization, analysis and decision-making easier for end users. Intuitive dashboards and customizable alerts that allow users to easily interpret data and take timely action to optimize crop yields and services.

New technologies to improve crop monitoring, management and decision-making. By integrating the Internet of Things, machine learning, imaging and data analytics, the system enables farmers to implement data-driven practices that increase productivity, today's most effective, sustainable and efficient method of farming.

3.7 IMPACT OF THE PRODUCT

The impact of crop analysis that helps improve agriculture, sustainability and economic growth is needed at all levels. Here is an example of its effects:

1. Increased yield: Providing rapid information on crop health, soil and environmental factors, the system enables farmers to implement better management practices such as irrigation, fertilization, pests and diseases. This optimization can increase crop yields, improve food security and farmers' livelihoods.

2. Resource Efficiency: Promote the use of water, fertilizer, pesticides and other resources through agricultural technology and decision-making information. This reduces input costs, reduces environmental impact and preserves natural resources for future generations.

3. Risk Reduction: Processes to help farmers identify and reduce risks related to climate change, pests and economic changes. Early detection of crop health problems and timely intervention can make it possible to protect against farm processing difficulties, preventing crop losses and economic difficulties.

4. **Improve food safety and quality**: Through the use of traceability and tracking applications, the system improves food safety and quality across the product used. This increases consumer confidence, increases business competitiveness and encourages permaculture practices.

5. **Supporting small farmers**: This system provides small farmers with access to technology, knowledge and business knowledge, enabling them to compete in the global market by creating a competitive network. This reduces inequality, promotes inclusive growth and reduces poverty in rural communities.

6. **Environmental Sustainability**: The system supports environmental sustainability and ecosystem health by practicing permaculture and reducing chemical products. This reduces pollution, preserves biodiversity, protects habitats and improves the relationship between agriculture and the environment.

7. **Technology Adoption and Innovation:** By encouraging collaboration and knowledge exchange among stakeholders, the system accelerates the adoption and innovation of legacy agriculture technology. This stimulates economic growth, creates employment and promotes rural development in the agricultural society.

8. **Information for policy decisions**: The system provides policymakers with insights and evidence-based recommendations for the development of agricultural policies and strategies. This allows the government to solve important problems before promoting and investing in sustainable development in agriculture. Support farmers, strengthen food and promote economic development.

The system paves the way for more efficient, fair and sustainable agriculture in the future by leveraging the power of technology and a data-driven approach.

3.8 UNIQUENESS AND FEATURES

- It stands out for its innovative technology, including crop inspection, IoT sensors, machine learning and high resolution.
- It supports real-time data collection, analysis and visualization, allowing farmers to gain insight into the health of crops and crops. With remote monitoring and customizable alerts, farmers can manage their farm from anywhere using a user-friendly interface.
- The system's scalability, interoperability, and customizability support its ability to adapt to changing agricultural needs. It is built on an open architecture and effective security measures to support permaculture practices while protecting data privacy.
- Overall, the system offers solutions for precision agriculture, optimizing resource efficiency, increasing crop yields and supporting environmental sustainability**.**

3.9 SUMMARY

Crop analysis recommends changing agricultural practices by integrating technologies to optimize crop management and increase farm productivity. Combining IoT sensors, machine learning algorithms and high-resolution images, the system provides farmers with rapid information on key concepts such as crop health, soil and environmental factors. Thanks to data analysis and predictive modeling, farmers can make informed decisions, detect problems quickly and allocate resources efficiently for good results. Thus, farmers' resources are improved. This accessibility enables timely response to changes, reducing risk and optimizing product management. In addition, the system is scalable and interoperable, able to integrate seamlessly with existing agricultural infrastructure and suitable for the integration of new technologies and tools. We prioritize sustainability and environmental responsibility. It contributes to long-term environmental management by reducing inputs such as water, fertilizer and pesticides, reducing environmental impact and protecting natural resources. Additionally, its support for permaculture practices and data-driven decision-making contributes to preventing climate change and other challenges facing agriculture. , reliability and regulatory compliance. Farmers can enjoy its features with confidence, knowing that their agricultural data is protected and respected. , increase efficiency and promote environmental sustainability. By using a data-driven approach and sustainable practices, it is possible to transform crop management and growth, making it more efficient, effective, good and beneficial.

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSIONS

4.1REALTIME EXPERIMENTAL RESULT

- Effective resource management: Smart irrigation systems can help optimise irrigation and fertilisation, ensuring that plants receive the proper amount of water and nutrients, by monitoring soil moisture and nutrient levels. This could result in better resource management, less water usedand healthier plant growth
- Early detection of plant stress or diseases: Smart irrigation systems can identify the earliest indications of disease, stress, or pest infestations by keeping an eye on a variety of environmental variables. This enables prompt treatment applications or adjustments to watering schedules, which reduces damage and boosts plant survival rates.
- Improved growth and productivity: Smart plant monitoring systems can optimise plant growth conditions by continuously monitoring and adjusting environmental factors like temperature and light levels. This may lead to more rapid growth, higher yields, and higher productivity as a whole.
- Remote monitoring and control:Smart irrigation systems frequently come with remote monitoring features that let users access real-time data and control settings from any location. Because it allows for remote management and lessens the requirement for physical presence, this is especially advantageous for large-scale operations or when plants are situated in difficult-to-access locations.
- Data-driven insights: Over time, Smart Irrigation systems

produce a large amount of data. Users can learn a lot about plant behaviour, environmental trends, and the efficacy of various cultivation methods by analysing this data. Decision-making, experimentation, and continuous improvement in plant care techniques can all be aided by these revelations.

IoT-Enabled Monitoring and Maintenance:

- Real-time usage data collected through the IoT-integrated system facilitated efficient scheduling of cleaning and maintenance activities.
- A centralized monitoring dashboard provided facility managers with valuable insights, helping them identify high-traffic areas and allocate resources more effectively.

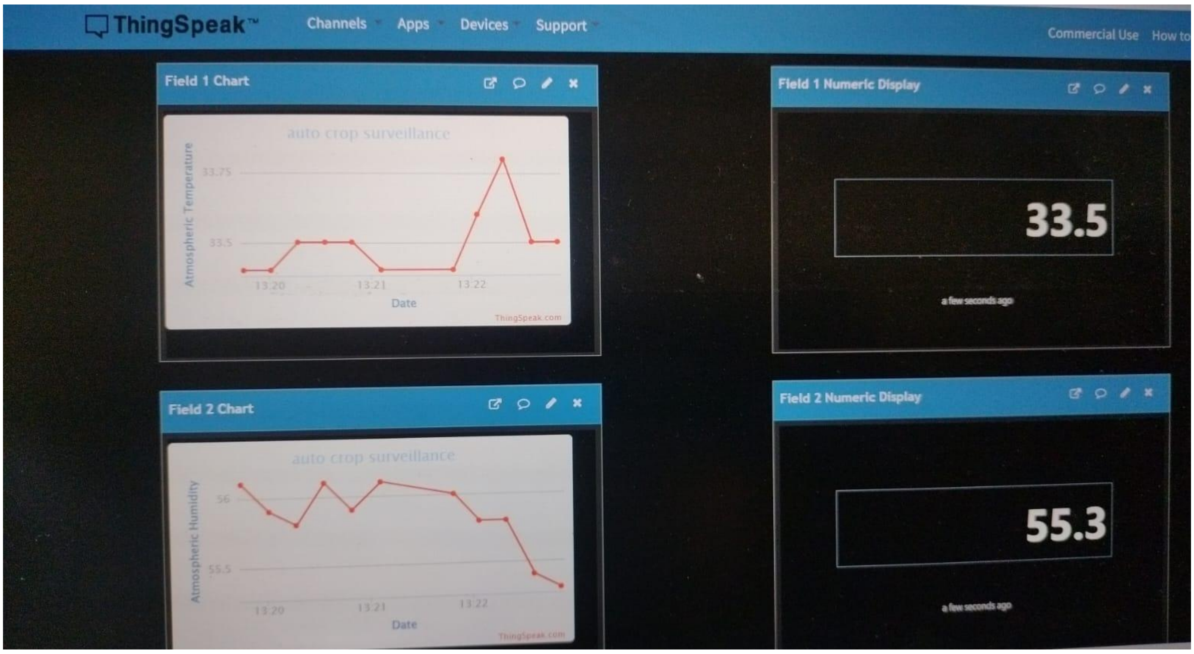

Fig 4.1 Dashboard of webpage

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

In summary, crop analysis is a revolutionary force in agriculture and heralds a new era in precision agriculture and sustainable development. By integrating technologies like IoT sensors, machine learning, and high-resolution solutions, it provides farmers with the unprecedented ability to instantly monitor, analyze, and keep crops healthy and productive. The system enables remote monitoring and control, allowing farmers to make informed decisions and take steps to maximize profits and minimize risk wherever they are. The system's emphasis on sustainability underlines its commitment to responsible management of resources and the environment. By promoting precision farming methods and efficient resource management, we can not only increase income, but also reduce environmental impacts and create a long-term sustainable environment in farming communities. This integration with sustainable practices is important for solving global problems such as climate change and food security. Collaboration, innovation and change. It promotes the continuous improvement and improvement of agriculture by providing a flexible and adaptable platform, supporting the integration of new technologies and the sharing of best practices. Important information is protected and remains confidential. This instills trust and confidence among customers and encourages the adoption and use of physical resources. Strong all solved. By providing farmers with better understanding, improving resource use and promoting environmental protection, it has the potential to transform the way crops are grown and managed, paving the way for a successful and prosperous future for agriculture.

5.2 FUTURE ENHANCEMENT

Advanced sensing technology: As sensor technology improves, the health of the plant can be monitored more accurately. This may include sensors that can measure other parameters such as carbon dioxide levels, temperature, humidity and nutrient levels.

The integration of various sensor types, a comprehensive view of the factory is possible. This tool can analyze lots of data to find patterns, predict future events, and provide recommendations for emergency tree care. AI-powered systems can learn from historical data to optimize irrigation, fertilization and pest management. The development of wireless and network connections, seamless data connections between sensors, actuators and monitoring devices will be possible.

This will increase the scalability and efficiency of facility maintenance and enable transfer across the city and in agriculture. View factory monitor information on the scale. Cloud-based analysis will provide important information about regional differences in plant growth patterns, diseases and pests.

Collaboration and knowledge sharing between scientists and farmers helps create a common knowledge base for effective crop management. Automatic control systems are integrated and environmental conditions can change instantly.

For example, the system can adjust indoor lighting, temperature, and humidity based on sensor readings to encourage plant growth. Automation will reduce the need for manual intervention while making facility updates accurate and timely.

The system reduces water consumption by automatically calculating water needs based on real-time data. Additionally, careful monitoring of food quality can help prevent loss and waste and promote environmentally friendly agriculture.

Integration with precision agriculture: Smart plant monitoring can be combined with precision agriculture to improve crops. By combining crop monitoring data with satellite imagery, drones and GPS technology, farmers can analyze water, fertilization and pesticide use. crop yield will increase and the distribution of resources will be efficient. Smart plant care can help those interested in home gardening, urban farming or landscaping maintain a healthy green life and provide effective plant care.

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APPENDIX

ESP8266:

```
#include <DHT.h>
#include <ESP8266WiFi.h>


#define DHTPIN D2       //DHT11 is connected to GPIO Pin 2
const int sensor_pin = A0;
int relay = D1;

String apiKey = "3LUF45Q6XA47P4AJ";     //  Enter your Write API key from ThingSpeak
const char* ssid =  "1234";     // Enter your WiFi Network's SSID
const char* pass =  "123454321"; // Enter your WiFi Network's Password
const char* server = "api.thingspeak.com";

float humi;
float temp;
float moisture_percentage;
DHT dht(DHTPIN, DHT11);
WiFiClient client;

void setup()
{
      Serial.begin(115200);
      delay(10);
      dht.begin();
      pinMode(relay,OUTPUT);
      Serial.println("Connecting to ");
      Serial.println(ssid);


      WiFi.begin(ssid, pass);

     while (WiFi.status() != WL_CONNECTED)
     {
          delay(100);
          Serial.print("*");
```

```
    }
     Serial.println("");
     Serial.println("**WiFi connected**");

}

void loop()
{
   moisture_percentage = ( 100.00 - ( (analogRead(sensor_pin)/1023.00) * 100.00 )+0.10 );

     humi = dht.readHumidity();
     temp = dht.readTemperature();
          if(moisture_percentage < 10)
     {
       digitalWrite(relay,HIGH);
     }
     else
     {
       digitalWrite(relay,LOW);
     }



     if (client.connect(server,80))   //   "184.106.153.149" or api.thingspeak.com
     {
      String sendData =
apiKey+"&field1="+String(temp)+"&field2="+String(humi)+"&field3="+String(moisture_pe
rcentage)+"\r\n\r\n\r\n";

      //Serial.println(sendData);

      client.print("POST /update HTTP/1.1\n");
      client.print("Host: api.thingspeak.com\n");
      client.print("Connection: close\n");
      client.print("X-THINGSPEAKAPIKEY: "+apiKey+"\n");
      client.print("Content-Type: application/x-www-form-urlencoded\n");
      client.print("Content-Length: ");
      client.print(sendData.length());
      client.print("\n\n");
```

```
client.print(sendData);

Serial.print("Temperature: ");
Serial.print(temp);
Serial.print("deg C. Humidity: ");
Serial.print(humi);
Serial.print("Soil Moisture(in Percentage) = ");
Serial.print(moisture_percentage);
Serial.println("%. Connecting to Thingspeak.");
}

client.stop();

Serial.println("Sending....");

delay(1000);
}
```

ESP32 Cam module

```
#include "esp_camera.h"
#include <WiFi.h>
#include "esp_timer.h"
#include "img_converters.h"
#include "Arduino.h"
#include "fb_gfx.h"
#include "soc/soc.h" //disable brownout problems
#include "soc/rtc_cntl_reg.h"  //disable brownout problems
#include "esp_http_server.h"

//Replace with your network credentials
const char* ssid = "REPLACE_WITH_YOUR_SSID";
const char* password = "REPLACE_WITH_YOUR_PASSWORD";
```

```
#define PART_BOUNDARY "123456789000000000000987654321"

// This project was tested with the AI Thinker Model, M5STACK PSRAM Model and
M5STACK WITHOUT PSRAM
#define CAMERA_MODEL_AI_THINKER
//#define CAMERA_MODEL_M5STACK_PSRAM
//#define CAMERA_MODEL_M5STACK_WITHOUT_PSRAM

// Not tested with this model
//#define CAMERA_MODEL_WROVER_KIT

#if defined(CAMERA_MODEL_WROVER_KIT)
  #define PWDN_GPIO_NUM    -1
  #define RESET_GPIO_NUM   -1
  #define XCLK_GPIO_NUM    21
  #define SIOD_GPIO_NUM    26
  #define SIOC_GPIO_NUM    27

  #define Y9_GPIO_NUM      35
  #define Y8_GPIO_NUM      34
  #define Y7_GPIO_NUM      39
  #define Y6_GPIO_NUM      36
  #define Y5_GPIO_NUM      19
  #define Y4_GPIO_NUM      18
  #define Y3_GPIO_NUM       5
  #define Y2_GPIO_NUM       4
  #define VSYNC_GPIO_NUM   25
  #define HREF_GPIO_NUM    23
  #define PCLK_GPIO_NUM    22
```

```
#elif defined(CAMERA_MODEL_M5STACK_PSRAM)
  #define PWDN_GPIO_NUM     -1
  #define RESET_GPIO_NUM    15
  #define XCLK_GPIO_NUM     27
  #define SIOD_GPIO_NUM     25
  #define SIOC_GPIO_NUM     23

  #define Y9_GPIO_NUM       19
  #define Y8_GPIO_NUM       36
  #define Y7_GPIO_NUM       18
  #define Y6_GPIO_NUM       39
  #define Y5_GPIO_NUM        5
  #define Y4_GPIO_NUM       34
  #define Y3_GPIO_NUM       35
  #define Y2_GPIO_NUM       32
  #define VSYNC_GPIO_NUM    22
  #define HREF_GPIO_NUM     26
  #define PCLK_GPIO_NUM     21

#elif defined(CAMERA_MODEL_M5STACK_WITHOUT_PSRAM)
  #define PWDN_GPIO_NUM     -1
  #define RESET_GPIO_NUM    15
  #define XCLK_GPIO_NUM     27
  #define SIOD_GPIO_NUM     25
  #define SIOC_GPIO_NUM     23

  #define Y9_GPIO_NUM       19
  #define Y8_GPIO_NUM       36
  #define Y7_GPIO_NUM       18
  #define Y6_GPIO_NUM       39
```

```
  #define Y5_GPIO_NUM       5
  #define Y4_GPIO_NUM      34
  #define Y3_GPIO_NUM      35
  #define Y2_GPIO_NUM      17
  #define VSYNC_GPIO_NUM   22
  #define HREF_GPIO_NUM    26
  #define PCLK_GPIO_NUM    21

#elif defined(CAMERA_MODEL_AI_THINKER)
  #define PWDN_GPIO_NUM    32
  #define RESET_GPIO_NUM   -1
  #define XCLK_GPIO_NUM     0
  #define SIOD_GPIO_NUM    26
  #define SIOC_GPIO_NUM    27

  #define Y9_GPIO_NUM      35
  #define Y8_GPIO_NUM      34
  #define Y7_GPIO_NUM      39
  #define Y6_GPIO_NUM      36
  #define Y5_GPIO_NUM      21
  #define Y4_GPIO_NUM      19
  #define Y3_GPIO_NUM      18
  #define Y2_GPIO_NUM       5
  #define VSYNC_GPIO_NUM   25
  #define HREF_GPIO_NUM    23
  #define PCLK_GPIO_NUM    22
#else
  #error "Camera model not selected"
#endif
```

```
static const char* _STREAM_CONTENT_TYPE = "multipart/x-mixed-replace;boundary="
PART_BOUNDARY;
static const char* _STREAM_BOUNDARY = "\r\n--" PART_BOUNDARY "\r\n";
static const char* _STREAM_PART = "Content-Type: image/jpeg\r\nContent-
Length: %u\r\n\r\n";

httpd_handle_t stream_httpd = NULL;

static esp_err_t stream_handler(httpd_req_t *req){
  camera_fb_t * fb = NULL;
  esp_err_t res = ESP_OK;
  size_t _jpg_buf_len = 0;
  uint8_t * _jpg_buf = NULL;
  char * part_buf[64];

  res = httpd_resp_set_type(req, _STREAM_CONTENT_TYPE);
  if(res != ESP_OK){
    return res;
  }

  while(true){
    fb = esp_camera_fb_get();
    if (!fb) {
      Serial.println("Camera capture failed");
      res = ESP_FAIL;
    } else {
      if(fb->width > 400){
        if(fb->format != PIXFORMAT_JPEG){
          bool jpeg_converted = frame2jpg(fb, 80, &_jpg_buf, &_jpg_buf_len);
          esp_camera_fb_return(fb);
```

```
        fb = NULL;
        if(!jpeg_converted){
          Serial.println("JPEG compression failed");
          res = ESP_FAIL;
        }
      } else {
        _jpg_buf_len = fb->len;
        _jpg_buf = fb->buf;
      }
    }
  }
  if(res == ESP_OK){
    size_t hlen = snprintf((char *)part_buf, 64, _STREAM_PART, _jpg_buf_len);
    res = httpd_resp_send_chunk(req, (const char *)part_buf, hlen);
  }
  if(res == ESP_OK){
    res = httpd_resp_send_chunk(req, (const char *)_jpg_buf, _jpg_buf_len);
  }
  if(res == ESP_OK){
    res = httpd_resp_send_chunk(req, _STREAM_BOUNDARY,
strlen(_STREAM_BOUNDARY));
  }
  if(fb){
    esp_camera_fb_return(fb);
    fb = NULL;
    _jpg_buf = NULL;
  } else if(_jpg_buf){
    free(_jpg_buf);
    _jpg_buf = NULL;
  }
```

```
    if(res != ESP_OK){
      break;
    }
    //Serial.printf("MJPG: %uB\n",(uint32_t)(_jpg_buf_len));
  }
  return res;
}

void startCameraServer(){
  httpd_config_t config = HTTPD_DEFAULT_CONFIG();
  config.server_port = 80;

  httpd_uri_t index_uri = {
    .uri       = "/",
    .method    = HTTP_GET,
    .handler   = stream_handler,
    .user_ctx  = NULL
  };

  //Serial.printf("Starting web server on port: '%d'\n", config.server_port);
  if (httpd_start(&stream_httpd, &config) == ESP_OK) {
    httpd_register_uri_handler(stream_httpd, &index_uri);
  }
}

void setup() {
  WRITE_PERI_REG(RTC_CNTL_BROWN_OUT_REG, 0); //disable brownout detector

  Serial.begin(115200);
  Serial.setDebugOutput(false);
```

```
camera_config_t config;
config.ledc_channel = LEDC_CHANNEL_0;
config.ledc_timer = LEDC_TIMER_0;
config.pin_d0 = Y2_GPIO_NUM;
config.pin_d1 = Y3_GPIO_NUM;
config.pin_d2 = Y4_GPIO_NUM;
config.pin_d3 = Y5_GPIO_NUM;
config.pin_d4 = Y6_GPIO_NUM;
config.pin_d5 = Y7_GPIO_NUM;
config.pin_d6 = Y8_GPIO_NUM;
config.pin_d7 = Y9_GPIO_NUM;
config.pin_xclk = XCLK_GPIO_NUM;
config.pin_pclk = PCLK_GPIO_NUM;
config.pin_vsync = VSYNC_GPIO_NUM;
config.pin_href = HREF_GPIO_NUM;
config.pin_sscb_sda = SIOD_GPIO_NUM;
config.pin_sscb_scl = SIOC_GPIO_NUM;
config.pin_pwdn = PWDN_GPIO_NUM;
config.pin_reset = RESET_GPIO_NUM;
config.xclk_freq_hz = 20000000;
config.pixel_format = PIXFORMAT_JPEG;

if(psramFound()){
  config.frame_size = FRAMESIZE_UXGA;
  config.jpeg_quality = 10;
  config.fb_count = 2;
} else {
  config.frame_size = FRAMESIZE_SVGA;
  config.jpeg_quality = 12;
```

```
    config.fb_count = 1;
  }

  // Camera init
  esp_err_t err = esp_camera_init(&config);
  if (err != ESP_OK) {
    Serial.printf("Camera init failed with error 0x%x", err);
    return;
  }
  // Wi-Fi connection
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  Serial.print("Camera Stream Ready! Go to: http://");
  Serial.print(WiFi.localIP());

  // Start streaming web server
  startCameraServer();
}

void loop() {
  delay(1);
}
```