A Robust Artificial Intelligence Based Crop Monitoring System for Pakistani Agricultural Land

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Certification

This is to certify that **Mehak Arshid, CUI/FA20-BCE-035/ATD** and **M. Raees Azam**, **CUI/FA20-BCE-010/ATD** have successfully completed the final project **A Robust AI Based Crop Monitoring System for Pakistani Agricultural Land,** at the **COMSATS University Islamabad, Abbottabad Campus**, to fulfill the partial requirement of the degree **BS Computer Engineering.**

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Abstract

Agricultural yield is vital for food safety around the world. It is important for agriculture-based economies like Pakistan. Plant disease can adversely have an effect on the yield and damage the crop. Therefore, crop monitoring is essential. The traditional guide methods to reveal vegetation are increasingly becoming inefficient and infeasible. Modern imaging and AI technologies can help us analyze the plant life to take remedial action. In this project, we will develop a system for monitoring the crop. The system will used an aerial drone with RGB camera for taking the imagery of plants. Image processing and AI techniques can be used to evaluate the crop fitness. The system will analyze the imagery to reveal where there's an issue with crop health.

Keywords: AI (Artificial Intelligence), Image processing, RGB (Red-Green-Blue), Aerial Drone, Crop Fitness, Disease segmentation.

Undertaking

I certify that the project **A Robust Artificial Intelligence Based Crop Monitoring System for Pakistani Agricultural Land** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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Acknowledgement

"And (He desires) that you should complete the prescribed period and that you should glorify Allah for having guided you and that you may give thanks." (Al-Baqarah 2:185)

We express profound gratitude to Allah, whose blessings and mercies have been instrumental in guiding me through the completion of this assignment. we extend our heartfelt thanks to my mother, father, siblings, and family for their continuous guidance, prayers, and support, which played a pivotal role in bringing this mission and report to fruition.

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Acronyms

RGB	Red Green Blue
NIR	near Infrared
HSI	Hue Saturation Intensity
AI	Artificial Intelligence
UAV	Unmanned Aerial Vehicle
CNN	Convolutional Neural Network
ANN	Artificial Neural Network
UNET	U Shaped Network
FDN	Fourier Dense Network
FF-Dense	Fast Fourier Dense
IoT	Internet of Things

Chapter 1

1.1 Introduction

Agricultural yield is important for food safety around the world. It is even more essential for agriculture-primarily based economies like Pakistan. The economy of Pakistan is reliant on agriculture. It is critical for feeding the sector, however it faces many demanding situations like unpredictable climate situations and pests. New technologies, specifically Artificial Intelligence (AI), can assist make agriculture smarter. This thesis focuses to develop a crop monitoring system by using Artificial Intelligence.

1.2 Statement of the problem

Since, crop diseases are a significant threat in Pakistan with annual losses amounting to millions of tons of crops. For instance, wheat rust alone leads to losses of 15-20%. Moreover, pesticide-related illnesses are common with approximately 20,000 cases reported annually in Pakistan [2], [3]. Therefore, an AI-based crop monitoring system is desired to reduce the impact of crop diseases along with optimized resource utilization and decreased human health risks in Pakistan's agricultural sector.

1.3 Goals

The goal of this project is to introduce the modern technology into the agriculture business and better crop production via gathering the actual-time reputation of Plants and spraying pesticides on plants.

The primary goal of the project is to improve crop monitoring system. The Expected outcome is a fully useful system comprising aerial drones with RGB camera, image processing algorithms, and deep learning algorithm for plant and disease type.

•The system intends to optimize the usage of resources like water, insecticides, and fertilizers.

•Early disease detection can assist farmers take timely remedial actions, reducing crop losses and the need for good chemical remedies.

•The mission can also contain training local farmers in the usage of the crop health monitoring system.

1.4 Motivation

To meet the demand of increasing food need, there's a crucial need to enhance agricultural productivity. AI helps to facilitate targeted and precise interventions, decreasing the environmental effect. The main objective of this project is to create a user-friendly and AI-based crop monitoring system helps in early detection of disease in plants and improves crop productivity. A lot of work has already been done in the area, and much more is being carried out. However, we want to increase the accuracy rate and reduce the detection time through our research.

1.5 Assumption and Dependencies

Assumptions:

- The assumption here is that the crop monitoring system will effectively capture and process multispectral imagery to identify crop health indicators accurately.
- It assumes that the AI algorithms developed for disease segmentation and classification will perform effectively in real-time scenarios.
- Assumption that the targeted pesticide spraying mechanism will accurately identify and treat diseased plants while minimizing environmental impact.

Dependencies:

- The effectiveness of the crop monitoring system depends on the integration of RGB and NIR cameras for comprehensive data collection.
- The success of disease segmentation and classification methods is dependent on the accuracy of the image processing algorithms and the training data provided.
- The targeted pesticide spraying method relies on the decision-making capabilities of the AI algorithm to identify diseased plants and determine the optimal spraying locations.

1.6 Methods

The methods outlined in the project include:

Development of Monitoring System:

- Designing and implementing a monitoring system utilizing RGB and NIR cameras to capture multispectral imagery for assessing plant health.

Image Processing and AI Implementation:

- Developing and deploying image processing algorithms and AI techniques for real-time detection and identification of crop diseases based on multispectral imagery.

Disease Classification Model:

- Training an AI algorithm to classify and identify specific crop diseases using patterns extracted from multispectral imagery.

Targeted Pesticide Spraying:

- Implementing a mechanism for targeted pesticide spraying based on the detection of diseases by the AI algorithm, with the aim of minimizing environmental impact and optimizing resource usage.

1.7 Report Overview

The report provides an overview of:

Introduction:

Highlights the importance of agricultural yield and the challenges faced by the agricultural sector in Pakistan, introducing the concept of using AI for crop monitoring.

Project Background:

Describes the challenges posed by crop diseases and the need for timely detection and control, leading to the development of a Crop Monitoring System.

Multi-spectral Imagery:

Explains the use of multispectral imaging for assessing crop health and environmental conditions.

Role of Artificial Intelligence:

Discusses the application of AI in agriculture, particularly in crop monitoring and disease detection.

Diseased Plant Segmentation:

Outlines the technique of isolating and delineating areas of plant images showing signs of disease for targeted treatment.

Targeted Pesticide Spraying:

Describes the importance of targeted pesticide spraying for environmental sustainability and the mechanism for its implementation using UAV technology.

Motivation:

Highlights the need for improving agricultural productivity through AI-based interventions.

Problem Statement:

States the significant threat posed by crop diseases in Pakistan and the necessity for an AI-based crop monitoring system to mitigate their impact.

Objectives:

Lists the objectives of the thesis, focusing on introducing modern technology into agriculture and improving crop production through real-time monitoring and intervention.

Scope of Work:

Defines the key areas of the project, including the development of monitoring systems, implementation of AI algorithms, disease classification, and targeted pesticide spraying.

These sections collectively provide a comprehensive overview of the project's goals, methods, and expected outcomes.

Chapter 2

2.1 Literature Review

This literature overview the existing research and development in AI based crop monitoring, with a particular focus on disease detection and pesticide application**.**

2.1.1 Artificial Intelligence Based Algorithm

Artificial Intelligence (AI) algorithms leverage historic facts as input to predict new output values, demonstrating a getting to know technique similar to system studying. The focus is on enabling algorithms to autonomously research and make predictions without direct human intervention. The essence of AI algorithms lies in their capacity to determine patterns within provided records, facilitating the deduction of insights based totally on found times. Artificial Intelligence (AI) algorithms are often classified on the basis of how an algorithm learns to become more efficient in predicting outcomes. There are four basic approaches:

2.1.2 Supervised learning

Supervised learning is a type of machine learning where a labeled dataset is used to trained the model meaning the input data is paired with the output. The motive is to learn a mapping from input to output so that the model can make predictions or decisions when new, unseen data is used. The different types of supervised learning algorithm are:

- **Linear Regression**
- **Logistic Regression**
- **Decision Trees**

- **Random Forests**
- **Support Vector Machines (SVM**
- **Naive Bayes**
- **K-Nearest Neighbors (KNN**
- **Neural Networks**

2.2 Review of Existing Algorithm

Many researches have been done in the field of plant disease detection. Developers used artificial intelligence and deep learning approaches. Research projects that have been done in this field is given below:

2.2.1 Wheat Plant Disease Detection with CNNs and UAVs

On March 5, 2022, a dataset consisting imagery of wheat plants turned into Employed for Object-Based Agricultural Field Segmentation using Convolutional Neural Networks (CNNs) and Unmanned Aerial Vehicles (UAVs). The deep learning carried out to categories plant disease accomplished a Wonderful accuracy of 94.59%.This demonstrates the effectiveness of CNNs And UAVs in collecting targeted data for unique agricultural field segmentation, Allowing accurate identification and category of plant diseases. The high Accuracy underscores the potential of this method for early ailment detection in wheat vegetation, contributing to progressed crop management Practices and improved yield. The detail of this research paper can be seen In [3].The results taken by this paper is shown in Figure 2.1

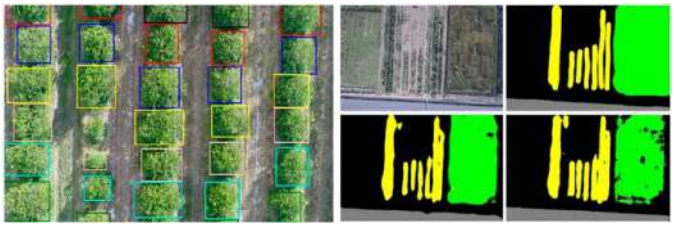

Figure 2.1: object-based (left) and pixel-based (right) crop classification

2.2.2 Pesticide Spraying using ANN

In June 2023, a dataset offering imagery of Paddy fields, Tea crops, and Banana bushes are used for precision pesticide spraying. Artificial Neural Network (ANN) became utilized as the method, attaining a splendid Accuracy of 99.97%.The excessive accuracy underscores the efficacy of ANN in accurately figuring out target areas for pesticide spraying in diverse Agricultural settings. The potential of ANN for optimizing pesticide use and Minimizing environmental effect in unique plants. The dataset's awareness On these plants complements the precision of pesticide application, Contributing to efficient agricultural practices. The detail of this research Paper can be seen in [4]. How they implemented and got results are shown in

(a) (b)

Figure 2.2: UAV application in agricultural field (a) Field Mapping (b) Crop monitoring.

Chapter 3

3.1 Research Methodology

The research methodology section highlights the systematic method employed In conducting the project. It information the techniques, strategies, and tools Applied to gain the project objectives efficaciously. Our research methodology Includes a literature review to become aware of challenges, designing and Imposing the system the use of UAV technology and AI algorithms, optimizing Overall performance by simulation and experimentation, amassing facts for Validation, and evaluating performance for system refinement.

3.1.1 Proposed Methodology

Our AI-based crop monitoring system leverages a combination of Modern-day technology to revolutionize agricultural practices. By Integrating UAV generation with machine learning and deep Learning techniques, our purpose is to create a strong system Capable of monitoring crop health and efficiently spraying Pesticides. An AI-based crop monitoring system is desired to lessen the impact of crop illnesses alongside optimized resource Usage and decreased human health risks in Pakistan's agricultural Quarter.

3.1.2 Methodology Flow Chart

The methodology flow chart visually represents the sequence of steps and approaches followed in undertaking the project. Each step Inside the flow chart represents a specific task taken throughout the project procedure. How our Model will work on the basis of above steps mentioned is shown in the flow diagram in figure 3.1.

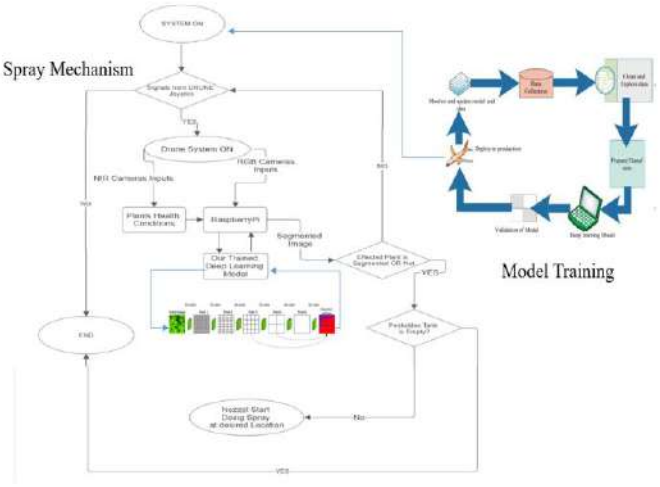

Figure 2: project flow chart

Steps of our project flow chart are:

- **Development of Monitoring System:**
  Designing a monitoring system utilizing RGB camera for plant fitness.
- **Image Processing and AI Implementation:**
  Developing and deploying image processing algorithms and AI techniques for the actual-time detection and symptoms of crop illnesses**.**
- **Disease Classification Model:**
  Training an AI algorithm to classify and identify particular crop diseases based totally on patterns extracted from multi-spectral imagery.
- **Targeted Pesticide Spraying:**
  After the detection of disease pesticide is sprayed on disease plant based on decision made by Artificial Intelligence algorithm and minimizing environmental effect and optimizing resource usage.

Chapter 4

4.1 Proposed Solution

Our Proposed solution consist of crop monitoring system in which there is Training phase on software and then deployment on hardware. Proposed Algorithm is a Fully Convolutional Network (FCN8) for image Segmentation, specifically for binary segmentation responsibilities. Utilize The FCN8 model for binary image segmentation. And for classification of Plant disease we use Convolutional Neural Network (CNN) Preprocess Data, train the model, and evaluate its performance.

These are the main steps of the proposed algorithm:

- Input RGB (the red, green, blue) image.
- Data Loading and Preprocessing
- Model Initialization
- Training Data Preparation
- Model Compilation and Training
- Reading and applying mask.
- Visualization
- Final output images

4.2 Software and Hardware Requirements

4.2.1 Software Requirements

- Software required for developing and implementing crop monitoring
- System Includes the Google Colab's environment. Google Colab is
- Cloud-primarily based platform that offers a Jupyter notebook
- Environment for writing and executing Python code. It gives unfastened
- Access to GPUs and TPUs, which may be beneficial for training machine
- Learning models used in crop monitoring.

4.2.2 Hardware Requirements

Hardware for a crop monitoring system encompasses diverse tools and Devices utilized to collect data, monitor crop fitness, and manage Agricultural operations. Here's a listing of crucial equipment generally Utilized in crop monitoring system is shown in table 3.2 below:

S.No	Items/Description
1	Readytosky 40A ESC 2-4S Brushless ESC 5V/3A BEC
2	Quadcopter Drone A2212 2200KV Brushless DC Motor
3	Pair of 10 inches 25.4cm 1045 Propellers
4	Pixhawk 2.4.8 Gps M8n ublox telemetry 500mw 433mhz combo kit
5	X4 500mm carbon fiber Quadcopter frame
6	FlySky FS-i6 AFHDS 6CH Transmitter
7	CNHL G+Plus 70C Lipo Battery with XT90 Plug
8	IMAX RC B3 Pro 2-3S Lipo Battery Balance Charger
9	Landing Gear Skid for DJI Sk480 Multi-rotor Quadcopter
10	Raspberry Pi Night Vision Camera Module 5MP OV5647
11	Raspberry Pi High Quality HQ Camera Micro Brushless Gimbal
12	Raspberry Pi 4 8GB RAM Model B Quad Core CPU 1.5Ghz Development Board

Fig. 3.2: table of hardware items

Chapter 5

5.1 Discussion

This chapter focuses on the the critical evaluation and interpretation of the Task's findings and methodologies. It affords an in-depth discussion of the Proposed diseased plant segmentation approach and its implications inside The context of existing research. Additionally, we discover the significance Of utilizing Google Colab for engaging in simulations and discuss the Challenges and opportunities encountered all through the projects Improvement. This discussion targets to clarify the challenges Contributions to the sector and discover regions for future studies and Improvement.

5.2 System Configuration

The simulations have been performed on a computing environment Featuring the following specs:

- **Processor**: Google Colab's virtual environment with comparable performance to a Core-i7 processor
- **Memory:** Utilizing 12 GB of available RAM
- **Processing Speed**: Leveraging the processing capabilities of Google Colab, which provides a computational speed equivalent to or greater than 2.50 GHz

5.3 Simulation Tool

For the implementation and assessment of our proposed technique, we Utilized the Google Colab's environment. This aggregate provided us with The important gear and computational resources to execute our simulations

5.4 Simulations Results

5.4.1 Segmentation Results:

Training images Segmentation results is shown below in fig

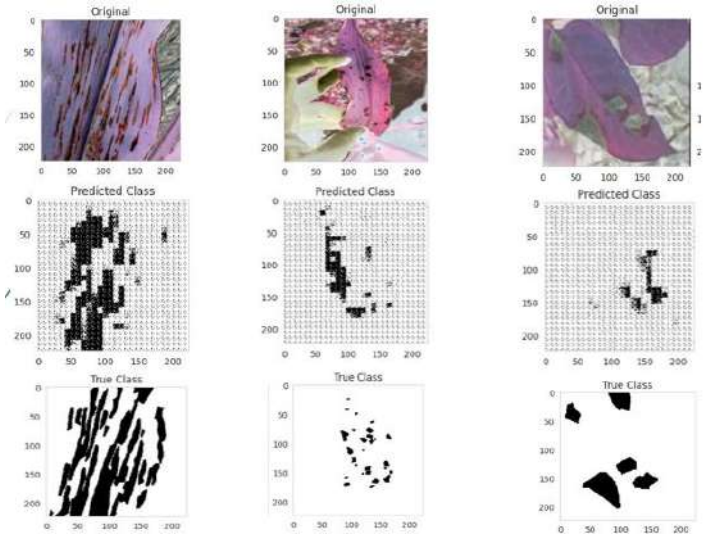

Figure 5.1: Original, Predicted and Ground truth results

Testing images Segmentation results is shown below in fig

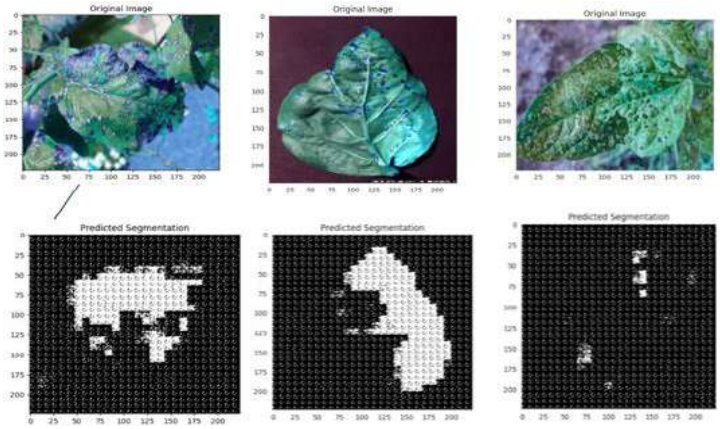

Figure 5.2: Testing Results

Chapter 6

6.1 Summary and Future work

6.1.1 Summary:

This thesis/project aimed to address the significant threat of crop diseases in Pakistan through the development and implementation of an AI-based crop monitoring system. The project's primary goal was to introduce modern technology into the agricultural sector, particularly focusing on real-time monitoring of plant health and targeted pesticide spraying. Methods employed included the development of monitoring systems utilizing RGB and NIR cameras, image processing algorithms, and deep learning techniques for disease classification. The project emphasized early disease detection to enable timely remedial actions, thus reducing crop losses and the need for chemical remedies. Throughout the project, the significance of AI in enhancing agricultural productivity and minimizing environmental impact was highlighted. Various methodologies, such as supervised learning and convolutional neural networks, were utilized to achieve the project objectives. The simulations and experimentation were conducted using Google Colab's environment, providing computational resources for assessing the proposed techniques.

6.1.2 Future Work:

While the current project has made significant strides in the development of an AI-based crop monitoring system, several avenues for future research and improvement remain. Firstly, there is a need for further refinement and optimization of the developed algorithms to enhance their accuracy and efficiency in real-world agricultural settings. Additionally, the integration of additional sensors and data sources could improve the system's capabilities for comprehensive crop monitoring. Collaborative efforts with

Agricultural experts and stakeholders would be beneficial for validating the system's effectiveness and usability in practical farming scenarios. Moreover, exploring the potential of emerging technologies such as block chain and IoT for enhancing data security and connectivity in the agricultural sector could be a promising direction for future research. Overall, continued innovation and collaboration are essential for further advancing the field of AI-based crop monitoring and improving agricultural sustainability.

Chapter 7

7.1 Conclusion

The development of crop monitoring systems signifies an essential Advancement towards sustainable agriculture.AI based Crop monitoring System classify the disease plants and healthy plants and than perform Segmentation on disease plants to identify the exact region of disease in Plants .This segmentations help in early detection of disease in plants. As Technology evolves, integrating those systems into farming practices gives Mammoth ability to revolutionize the enterprise. Our segmentation result Shows the exact disease region in plants. Training accuracy of our result is 95% and testing accuracy is 86%.Collaboration amongst agricultural Stakeholders is critical to refine and adopt these technology extensively, Ensuring their one-term advantages for farmers and society. By embracing Crop monitoring systems we pave the manner for a more resilient, profitable, And environmentally accountable destiny in agriculture.

References

1. "National Agriculture Policy 2020" by PARC (Pakistan Agricultural Research Council), 2020.
2. Khan, I. A., et al. (2020). "Challenges and Economic Losses due to Plant Diseases and Pests in Pakistan." International Journal of Agriculture and Biology, 23(5), 571-578.
3. Bouguettaya, Abdelmalek, et al. "Deep learning techniques to classify agricultural crops through UAV imagery: A review." Neural Computing and Applications 34.12 (2022): 9511-9536.
4. Hafeez, Abdul, et al. "Implementation of drone technology for farm monitoring & pesticide spraying: A review." Information processing in Agriculture (2022).
5. El Hoummaidi, Lala, Abdelkader Larabi, and Khan Alam. "Using unmanned aerial systems and deep learning for agriculture mapping in Dubai." Heliyon 7.10 (2021).
6. Lin, Chih-Wei, et al. "Fourier dense network to conduct plant classification using UAV-based optical images." IEEE Access 7 (2019): 17736-17749.
7. P., David P. Hughes, and Marcel Salathé. "Using deep learning for image-based plant disease detection." Frontiers in plMohanty, Sharada ant science 7 (2016): 1419
8. Neupane, Krishna, and Fulya Baysal-Gurel. "Automatic identification and monitoring of plant diseases using unmanned aerial vehicles: A review." Remote Sensing 13.19 (2021): 3841.
9. Shafi, Uferah, et al. "Precision agriculture techniques and practices: From considerations to applications." Sensors 19.17 (2019): 3796.
10. Hafeez, Abdul, et al. "Crop Monitoring and Automatic Weed Detection using Drone." 2021 International Conference on Control, Automation, Power and Signal Processing (CAPS). IEEE, 2021.
11. Jagadeeswari, M., et al. "Artificial Intelligence based Crop Recommendation System." 2022 4th International Conference on Inventive Research in Computing Applications (ICIRCA). IEEE, 2022.