WSUAG-Arduinoapp

Project Description

AgriData Intelligence

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I. Introduction

In the Palouse region, precision agriculture is vital in maximizing crop production. The Palouse region is known for its high crop yields but has challenges like diseases, pests, droughts, and nutrient issues. That is where the project comes in.

At its core, the project has a clear mission to modernize crop monitoring in the Palouse region by utilizing an Internet of Things (IoT) system based on Raspberry Pi sensors to capture wheat development for a growing season in the Palouse region. Thousands of images were collected. In this project, the driving force behind this endeavor is equally straightforward: to automate data analysis, simplify image processing, and efficiently handle substantial data volumes to explore crops responding to diverse factors by implementing advanced computing solutions. The ultimate aim is to provide local farmers with real-time insights, democratizing precision agriculture and ushering in more implementations of heightened crop productivity.

II. Background and Related Work

This project is in the field of advanced farming, with a particular emphasis on monitoring and analyzing crops in the Palouse region of the Pacific Northwest. This region is renowned for its wheat and legume production, particularly under rain-fed conditions, making it essential to maximize agricultural productivity [6]. However, the industry faces challenges from both biotic (diseases, pests) and abiotic (drought, heat, nutrient deficiency) stress conditions[7]. This project employs an IoT-based sensor (AGIcam) to continuously monitor wheat crops (winter and spring wheat) in field conditions across three seasons (2020–2022). In 2022, twenty AGIcam units were installed, each producing about 1000 images; thus, it is crucial to ensure efficient automated data extraction and analysis on edge or cloud computing platforms is performed.

In the field of precision agriculture, various technologies and methodologies have been developed to enhance crop monitoring and analysis. The developed IoT-based sensor systems have gained prominence due to their cost-effectiveness and versatility in field monitoring as the systems are online and real-time monitoring approaches. Previous research and teams demonstrated the feasibility of utilizing this IoT-based sensor system using Raspberry Pi products for continuous crop monitoring.

A critical aspect of the project involves the automated extraction of features, including a pseudo-reference panel for image correction, plot segmentation, and digital traits extraction. These are essential for high-throughput plant monitoring and phenotyping analysis of the vast amount of acquired data. The clients and stakeholders have proposed deep learning-based approaches for automated reference panel detection and image correction. These methods significantly reduce the need for manual intervention in the data processing pipeline.

To execute the project successfully, the team will need to acquire or enhance their technical skills in Python for image processing, machine learning using TensorFlow, image correction techniques, and the development of APIs [1],[3],[5]. Moreover, expertise in time series analysis and data visualization is vital for modeling dynamic crop responses.

The project will also leverage domain expertise in agricultural sciences and precision agriculture, including access to field locations for practical testing and validation. This approach aims to bridge the gap between advanced technology and practical agriculture, offering a valuable solution for real-time crop monitoring and data-driven decision-making in precision agriculture.

III. Project Overview

In previous research, the clients were able to assemble and analyze a large number of photos of crops taken each day to track the progress of crops. However, the previous process was time-consuming and labor-intensive for identifying relevant parts of images to analyze, which presents a problem for scaling the project[8]. Thus, this project aims to use machine learning and algorithmic methods to minimize the human component of the data analytics process.

The first task is to detect the reference panel used to normalize the image. The location of the reference panel will be detected, and the pixel information on this specific panel will be used to adjust the reflectance values of an entire image. The image adjustment will use a pre-existing algorithm. This process should be performed with as little human intervention as possible; none is ideal; however, it is acceptable to require a small amount.

The second task is identifying and tracking a specific plot (plot segmentation). The current method is to outline each plot manually. The approach would take a graduate-level research assistant at least a month. The project's objective is to find a method to identify a specified plot automatically and use previously developed methods to monitor the plant's development over time. This should require minimal human input; however, if necessary, some is allowed.

The third task is a more open-ended research task if the team successfully completes the first and second tasks. Building off the work in the first two, the team would develop a deep-learning model to extract crop features from individual plots or images. It is unknown how accurate the results machine learning can produce for this task; thus, part of the task will be to look into different models and see if any are viable to perform this task from given resources and time frame.

In this project, several notable contributions are expected to be made:

- **Automated Reference Panel Detection:** The project will focus on creating and training machine learning models, potentially using TensorFlow, to detect the black reference plate in each image. This reference panel serves as a pseudo-reference for image correction.

- **Image Correction and Plot Segmentation:** The project will automate image correction based on the reference panel. Additionally, the team will explore the use of other machine learning models for locating and segmenting areas of interest within the images, such as individual plots.
- **Efficient Data Processing:** The team will emphasize the development of an image processing pipeline that is both time-efficient and capable of handling the substantial volume of data generated by the 25 AGIcam units, each with thousands of images per season.

Future potential expectations:

- **Machine Learning for Dynamic Crop Responses:** Time series machine learning algorithms will be developed to analyze dynamic crop responses, considering factors such as weather conditions and crop variety.
- **Edge Computing Solutions:** The project aims to develop APIs that can be integrated into sensor systems like AGIcam, enabling real-time data display and interpretation. This contribution supports the broader adoption of edge computing in agriculture.

IV. Client and Stakeholder Identification and Preferences

Clients:

In our precision agriculture project, we have two primary clients: Professor Sindhuja Sankaran and Dr. Worasit Sangjan. Both aim to leverage machine learning for automating repetitive tasks in agriculture, emphasizing the need for accuracy and efficiency to enhance their research efforts.

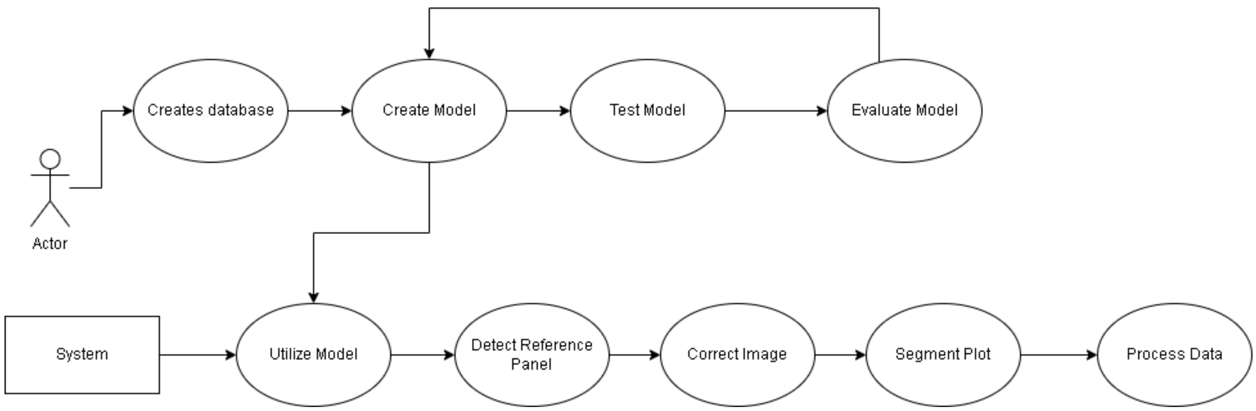
Stakeholders:

Beyond our immediate clients, two key stakeholders are future researchers and farmers. First, there are future researchers who may build off of our work, use our work to inform their research, or choose different avenues of research because of our work. Second, there are farmers who will either benefit from the functionality we add to this system, or who will indirectly benefit from knowledge researchers gain by using this system.

In summary, our project aligns with the goals of our clients, emphasizing automation and efficiency, while also considering the broader implications for future researchers and farmers, who value practicality and ease of use in precision agriculture solutions.

V. System Requirements Specification

a. Use Cases



Locate Reference Panel:

Aspect	Description
Pre-condition	Images with reference panels are available.
Post-condition	The reference panel is accurately identified in each image.
Basic Path	- System processes images to locate reference panels - Machine learning models identify reference panels.
Alternative Path	Manual confirmation for reference panel detection.
Related Requirements	Reference panel detection models.

Image Correction:

Aspect	Description
Pre-condition	Raw images and reference panel data are available.
Post-condition	Images are uniformly corrected for consistent analysis.
Basic Path	- System identifies the reference panel in images. - Image correction algorithm standardizes image reflectance.
Alternative Path	Manual correction for specific cases.
Related Requirements	Image correction techniques.

Plot Segmentation:

Aspect	Description
Pre-condition	Images with plots need to be segmented.
Post-condition	The system accurately identifies and isolates individual plots.
Basic Path	Machine learning model segments plots within images.
Alternative Path	Manual segmentation for specific cases.
Related Requirements	Plot segmentation models.

Process Image Data:

Aspect	Description
Pre-condition	Image processing pipeline is to be implemented.
Post-condition	The system can process a large volume of image data efficiently.
Basic Path	- Images are fed into the image processing pipeline. - System processes images with minimal time delay. - Processed data is ready for further analysis.
Alternative Path	Scaling the pipeline to handle additional loads.
Related Requirements	Time-efficient image processing pipeline. Handling large data volumes.

Quality Control Check:

Aspect	Description
Pre-condition	Perform a quality control check on the detected reference panels.
Post-condition	The system confirms the accuracy of detected reference panels.
Basic Path	- Reference panels are detected in images. - Quality control algorithms verify detection accuracy.
Alternative Path	Manual review and adjustment of reference panel locations.
Related Requirements	Quality control algorithms for reference panel detection.

Crop Feature Extraction:

Aspect	Description
Pre-condition	Images with segmented plots are available.
Post-condition	The system can extract key crop features from images.
Basic Path	- System processes segmented plot images. - Machine learning models extract crop features.
Alternative Path	Manual adjustment of feature extraction for specific cases.
Related Requirements	Crop feature extraction models.

Data Storage and Retrieval:

Aspect	Description
Pre-condition	Processed image data is ready for storage.
Post-condition	The system can store and retrieve processed data efficiently.
Basic Path	- Processed data is saved to a storage system. - Users can retrieve specific data when needed.
Alternative Path	Data backup and recovery processes.
Related Requirements	Data storage and retrieval system.

b. Functional Requirements

Module 1: Reference Panel Detection

Detect Reference Panel:

Description	The system must accurately detect the location of the black reference panel in each captured image.
Source	Clients
Priority	0

Extract Panel Information:

Description	The system shall extract pixel information from the reference panel to

	adjust the reflectance values of the entire image.
Source	Clients
Priority	0

Real-time Detection:

Description	Reference panel detection should occur in real-time, with minimal processing delay.
Source	Clients
Priority	1

Module 2: Image Correction

Automated Image Correction:

Description	The system must automatically apply image correction based on the reference panel data.
Source	Clients
Priority	0

Ensure Consistency

Description	Image correction should ensure that all images are based on the same reference values for accurate analysis.
Source	Clients
Priority	0

Module 3: Plot Segmentation

Identify Plots:

Description	The system shall identify and segment individual plots within the images, differentiating between breeds of plants.
Source	Clients
Priority	0

Minimize Manual Intervention:

Description	Plot segmentation should require minimal manual intervention, ensuring efficient data processing.
Source	Clients
Priority	0

Tracking Over Time:

Description	Once plots are identified, the system shall allow for the tracking of plant development over time.
Source	Clients
Priority	0

Module 4: Data Processing Pipeline

Time Efficiency:

Description	The system should have a time-efficient data processing pipeline capable of handling the substantial volume of data generated by AGIcam units.
Source	Clients
Priority	0

Handling Large Data Volumes:

Description	The system must efficiently manage and process thousands of images per season generated by up to 25 AGIcam units.
Source	Clients
Priority	0

Data Storage:

Description	The system should provide efficient data storage, allowing for the retention and retrieval of historical data.
Source	Clients
Priority	0

c. Non-Functional Requirements

System shall be accurate:

Image processing should accurately be able to segment crops and identify the reference panel and correct color based on said reference panel.

System shall be user-friendly:

The system should be designed in such a way that the intended users are able to easily pick it up and utilize it effectively.

System shall be adaptable:

The system should be able to be used with many crop setups, whether it be one type of crop or an entire breeding program.

System shall be reasonably quick:

At the user end, the system should not require constant waiting.

System shall be documented:

There should be clear documentation available for the system. The documentation should be complete and accurate.

VI. Glossary

Edge Computing - A method where computers do jobs right where they are needed, in order to make things faster and more efficient.

Image Correction - Correcting the images in order for them to all be based on the same base reference values.

IoT - Internet of Things (IoT) devices are everyday devices that are connected to the internet and to each other.

Phenotype - The observable characteristics of an organism.

Plot Segmentation - The division of images of crops into separate plots of different breeds of plant.

TensorFlow - A machine learning library that lends itself well to this kind of work

VII. References

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