PLANT ATTRIBUTE EXTRACTION SYSTEM

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CONCEPT OF OPERATIONS

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Concept of Operations
for
Plant Attribute Extraction System

Approved by:

Project Leader	Date
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T/A	Date

Change Record

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1. Executive Summary

Digital Agriculture is a growing industry as the world attempts to optimize the growth of plantations and farms to sustain food for millions of people. Different types of technology have been implemented to provide the ability to grow crops at an increased rate to provide a higher volume of food for people. Most of the technology currently in place involves animal and plant health, data collection of multiple parameters in farming, weather conditions and its effects on farmland, and etc. Our project focuses on data collection of crop growth over a period of time through the use of high-level coding and data management to evaluate the growth of crops to determine the best method of crop growth. The data collected comes from the use of Unmanned Aerial Systems (UAS) to collect photos of the farmland. The photographs taken collect data regarding topology of the land and Digital Surface Modeling (DSM). This data can then be used to calculate multiple parameters involving plant growth and can help researchers and farmers determine the best methods to grow crops. Our task is to aid the Texas A&M AgriLife Extension in Corpus Christi to optimize their data collection and calculate certain attributes of the plants that they will be able to analyze on a website and create a more efficient system than what is currently being used.

2. Introduction

Texas A&M AgriLife has many products and farmlands that need to be monitored and have accurate data acquired regarding their crops. Doing this data collection can be a long and grueling process by hand, especially for larger sections of farmland. Furthermore, human measurement is subject to error, and a sensor/machine can be much more accurate compared to the human eye. With the use of an Unmanned Aerial System (UAS), the team at Texas A&M AgriLife would be able to capture images of the farmland from a birds-eye view. These images can be used to acquire all the data necessary for a farmer at a much faster speed. There are two capabilities of the sensor attached to the UAS for recording all the necessary data, from height/volume values and even to color composition of the crops. This efficiency of this data collection supersedes any human capabilities. This can be especially important for collecting data for agricultural experiments such as irrigation efficiency across the farmland. This data will also be accessible on the website promoting inter-department communication, and the distribution of knowledge through the department.

2.1. Background

The most common use of the UAS in agriculture is for data capturing and distribution of various substances to the crops, typically pesticides. Our project will focus on the data collection capabilities of a UAS. The UAS takes photos of the landscape and creates an orthomosaic image from them. An orthomosaic map is a photorealistic representation of a landscape created by stitching many smaller orthomosaic images together. Orthomosaic imagery is generally created with drone footage because of their ability to get the angle from a bird's-eye view as well as the ability to capture key data like topography or infrastructure. One of the foremost advantages of collecting data using a UAS is the complete independence. The UAS will have a predetermined flight path and has the ability to dock and undock at the predisposed times. Another advantage would be the efficiency with which data is collected on farmland. A farmer recording his data would be a long process, especially for much larger landscapes. Human data collection could also be subject to human error as general inaccuracy. The UAS can provide correct and reliable data at a much faster speed with much less physical effort by the consumer. The UAS could also be used for more extensive data collection as well. For example, one of the sensors on our UAS is an RGB sensor in order to get the color values of the plants below. This information can be very useful for a consumer, it would allow them to identify areas receiving too little or too much water. Once identified they could adapt their water distribution, thus increasing the irrigation efficiency on said farm.

This project has all of the data accessible through website access. Our group is equipped with the task of improving the current website capabilities. Some of the main feature updates include the ability to download the data in multiple file formats; specifically, .shp, .csv, .xlsx, .geojson file extensions. This will allow everyone to access the data in their desired format, whether it be for data comparison, manipulation, computation, etc. Other than the file formats, the website will also add a feature that allows you to have multiple

Canopy Height Models and Orthomosaics selected. The current website capabilities allow the user to select a Canopy Height Model and Orthomosaic, and download the respective files. The updated feature will allow you to select multiple Canopy Height Models and Orthomosaics on the same download file. This can be advantageous for the comparison of plant attributes to determine any correlation between say the height/volume values and the color concentration of the same sector. Currently, the website takes quite a bit of time to produce the file for download. That's why another added feature will be temporary storage of these files on the database after the download is complete. This will provide the user with the ability to simply return to the website and quickly redownload the desired files if lost, corrupted, or most likely be distributed to other parties. Lacking this feature would be very tedious for the user, as they would have to wait for full computation time for a possibly recurring event.

2.2. Overview

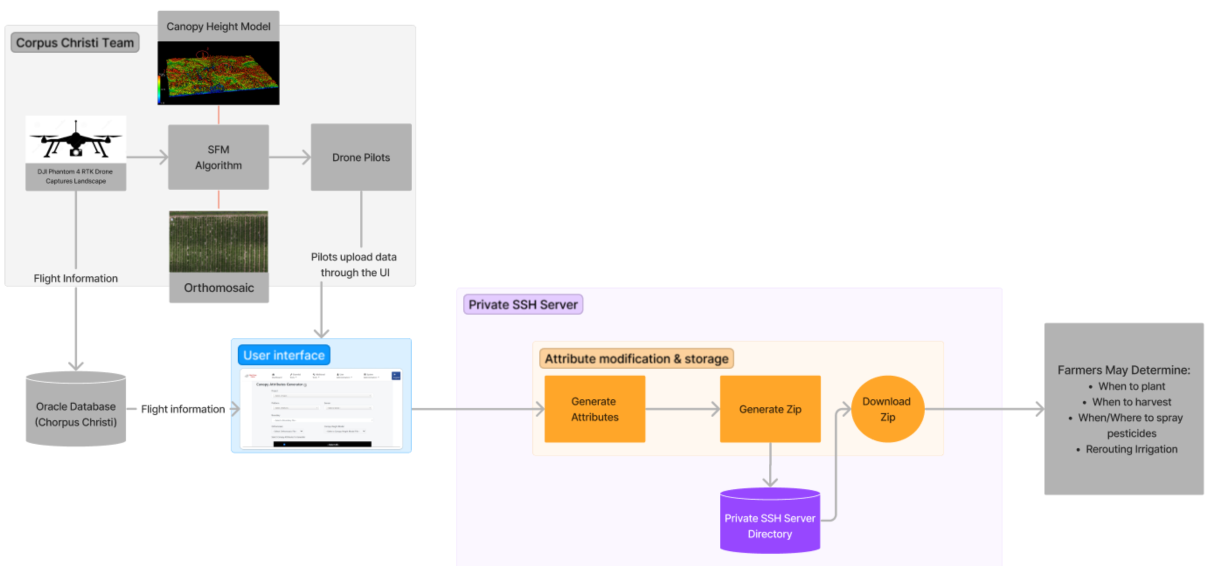

Figure 1: Plant Attribute Extraction Process

The process in place at the Texas A&M AgriLife Center in Corpus Christi revolves around the use of drones to collect image data from the farmland. This type of data is used to generate Orthomosaics and CHM through an SFM algorithm. An orthomosaic is an image composed of many smaller images stitched together, and the CHM is the height of the plant canopy at any given spatial coordinate. The orthomosaic is used to create a "canopy cover" of the land to create a reference boundary around the specific land in question. DSM, or Digital Surface Model, digitally creates the image from the sensor of the drone. That DSM can then be used in Python to create data for the height and volume of the plants based on the orthomosaic canopy. The result will show the boundaries of the crops and the height and volume of the crops.

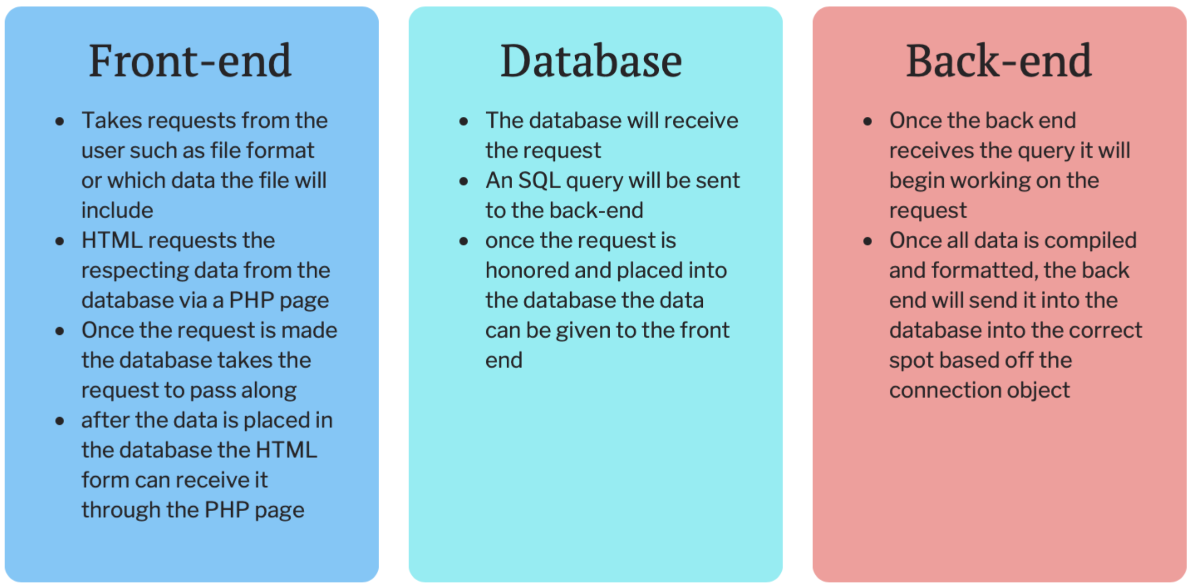

Figure 2: Web development systems

As for the website side of the project, it will consist of three major systems; the front end, the back end, and directory management. Starting with the front end we'll be using html and javascript in order to complete our goals. some of which include expanding the capabilities such as allowing the user to select and generate results for multiple orthomosaics. The front end is the system that the users will actually interact with. Our website UI will let them choose their specific parameters to generate results and allow them to pick their desired attributes and file types. Next, we have the back end development which will consist of Javascript, Python, and PHP. The back end will be in charge of generating the plant attributes, generating the result zip packages, and creating merged csv and shp files if multiple orthomosaic files are selected. The Javascript will pass all of the user inputs to the PHP file, which will then make a python command and execute it on a linux shell. The directory data will then be updated and the python response will then be sent back through PHP back to the javascript to continue with the process. Next we have the directory management which will consist of the same languages as the back end; Javascript, Python, and PHP. This subsystems main role will be making sure to delete old results and check to see if results exist for what the user has input. Therefore, if the users input already exists in the directory, then you can immediately download and skip the lengthy generation. These are the three subsystems in the process of Plant Attribute Extraction.

2.3. Referenced Documents and Standards

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3. Operating Concept

3.1. Scope

The Plant Attribute Extraction System (PAES) will make the collection and storage of crop data self-sufficient as well as more efficient as the current implemented system. The data will be gathered via Unmanned Aerial System (UAS) and stored on a website which will be optimized for the best display and arrangement of said data. The drone collects data by taking pictures with the help of satellite based remote sensing and then stitching all these pictures together in order to create a plot of land with data. Our project does not deal with the collection of data but with the formatting of this data onto the website. After the data is collected and processed into the website it will be deleted after a few days in order to make room for more data collection later in time.

3.2. Operational Description and Constraints

The Plant Attribute Extraction System will be used by the AgriLife Department at Texas A&M Corpus Christi in order to apply optimum inputs and maximize profits in cotton, wheat and corn production. The system itself is all autonomous but the use of data will be used by Agrilife.

3.3. System Description

As for the website side of the project, it will consist of three major systems; the front end, the back end, and directory management. Starting with the front end we'll be using html and javascript in order to complete our goals. some of which include expanding the capabilities such as allowing the user to select and generate results for multiple orthomosaics. The front end is the system that the users will actually interact with. Our website UI will let them choose their specific parameters to generate results and allow them to pick their desired attributes and file types. Next, we have the back end development which will consist of Javascript, Python, and PHP. The back end will be in charge of generating the plant attributes, generating the result zip packages, and creating merged csv and shp files if multiple orthomosaic files are selected. The Javascript will pass all of the user inputs to the PHP file, which will then make a python command and execute it on a linux shell. The directory data will then be updated and the python response will then be sent back through PHP back to the javascript to continue with the process. Next we have the directory management which will consist of the same languages as the back end; Javascript, Python, and PHP. This subsystems main role will be making sure to delete old results and check to see if results exist for what the user has input. Therefore, if the users input already exists in the directory, then you can immediately download and skip the lengthy generation. These are the three subsystems in the process of Plant Attribute Extraction.

3.4. Modes of Operations

Autonomous State

The system is fully autonomous when executing the generation necessary based on the data the user selected for what they want to generate and download. Through another end on the website, a project with the required files (Orthomosaic, Shapefile, and Canopy Height Model) will be uploaded to the website to allow the user to generate the necessary data based on what attributes and file types they would like to download.

3.5. Users

The system will be used and monitored by the researchers at the Texas A&M AgriLife Research Group in Digital Agriculture. Since most of the HTMl that will be implemented does not involve the user knowing HTML, Python, or other programming languages/platforms, the user will need little assistance with the system. The user will need training in the user interface and knowing what is needed to be selected to manipulate the data in their favor. A user manual will be given for users to be able to understand the system and/or troubleshoot the website or code. Comments will also be provided in the code for the users to understand what the coder has added into the code.

4. Scenario(s)

4.1. Research Based Projects

The primary purpose of the Plant Attribute Extraction System is to be used by the Agrilife Department at Corpus Christi in order to have data more accessible and speed up the data collection process. Our system will be completely automated so it helps researchers not have to waste time in data collection and they can put more focus onto the research itself. If optimized it can be used for other crop research projects as well as other environmental terrains that may cause the system issues at the moment.

4.2. Public Market Farmers

The system is made to gather specific crop growth research data but it can be edited in order to collect data farmers would benefit from knowing in order to make the entire agricultural cycle more efficient. Farmers can change the system's code in order to look at the attributes of the crop they want to grow to help them focus on crop maintenance instead of crop overview.

5. Analysis

5.1. Summary of Proposed Improvements

This project has the ability to nurture many improvements to the current system in place. Some of the improvements that can be brought with this concept include:

- ➢ Conversion to a fully automated system without having to manually delete copied files.
- ➢ More efficient data storage in the drive used by AgriLife.
- ➢ Communication of data between the HTML, Python, and SQL code shall be more optimized.
- ➢ Introduction of new file formats between the website and the drive.
- ➢ Ability to access photos from different sensors and different orthomosaics.

5.2. Disadvantages and Limitations

While our project is mainly to optimize the current system in place, there is still expected disadvantages and limitations that the code and website will not be able to accomplish within the scope such as:

- ➢ The project will only be specific to the farmland the data is being collected from and not aid other farmlands since it is plausible that their soil, climate, crops, and environment are different.

- ➢ The land is not in a controlled environment, therefore there could be random changes in the landscape in the future that could affect the current data collected.
- ➢ The DJI drones currently in use cannot be able to record data when winds are greater than 22 miles per hour or when there is rain or a storm. This could limit the data that can be collected for the website where it could be beneficial to track the crops during storms.

5.3. Alternatives

Some alternatives that can be brought into the project could be some implementations of satellites rather than using UAS technology. With the use of satellites, a wider range of land can be evaluated and with a satellite it is plausible that it could track weather which could add more test cases to the project. Another alternative would be to use ground vehicles. This alternative would not be better than what is currently in use, but if the farmer would want something more manual and hands on rather than automated. The vehicle would have cameras placed above the vehicle high enough to get a birds eye view of the crops, although not as high as the UAS could offer. Another alternative would be to collect data for pesticide use in the code to track what areas of the plant are in need of pesticides. This can help prevent crops from being eaten or not suitable for human consumption.

5.4. Impacts

- ➢ Ability to produce crops faster to distribute to general stores.
- ➢ Advancing the role technology has in modern day agriculture.
- ➢ One negative impact it could bring is a breach of privacy if farmers were to implement this technology.