

IOT Based Crop Health Management

MSc Project Research Proposal

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Table of Contents

[**INTRODUCTION** 2](#_Toc89682203)

[**LITERATURE REVIEW** 5](#_Toc89682204)

[**RESEARCH DESIGN AND METHODS** 6](#_Toc89682205)

[**IMPLICATIONS AND CONTRIBUTIONS TO KNOWLEDGE** 11](#_Toc89682206)

[**REFERENCES** 12](#_Toc89682207)

[**Research schedule** 14](#_Toc89682208)

# **INTRODUCTION**

In the face of global population growth and climate change, plant breeders and agronomists strive for improved crop yields and quality to ensure regional food security, regulate the market price of the rice grain, and address food-shortage problems [1]. The rice-panicle density is one of the important agronomic components in understanding the grain yield and determining the growth period Computer-vision methods based on high-spatial-resolution images provide a potential solution to increase the throughput and the accuracy . With the development of deep learning methods, convolutional neural networks have been shown to outperform human beings in diverse fields.

Farming has become increasingly risky with uncertain natural growth processes of crops, weather, disease, pests, other site-specific factors, and lack of support services. The production risk is apparent. Currently, farmers are using manual, labour intensive methods to assess in-situ variations based on their experience and knowledge. There are numerous precision agronomy tools available in the market for balancing field variations and maximizing healthy growth [7]. Mostly they are electronic sensors that attach to machinery to take remote sensing measurements [8]. Although these technologies have increased our ability to understand and monitor field variations, equipment and software are very expensive, technologically advanced, require too much technological support, and do not represent the local field variations.

The project uses low-cost remote sensors to deliver easy to understand, robust information to farmers enabling the precision application of fertilizer and other inputs. guidelines will be developed to indicate plant health and growing condition, nutrient and water deficiencies/excesses. The final product will be a mobile application and a web browser-based information dashboard that compares baseline dataset and farmer’s images and provides site-specific information and advice. It is expected that farmers upload images acquired from fixed low-cost sensors either to the mobile application or information dashboard - the selection depends on the farmer’s choice. The subsequent processing as determined by the outcome of this research project will be done in the background, eliminating complexity and ambiguity for the end-user. The information that the farmers receive in a mobile application or information dashboard will be straightforward and make it easy to determine the best course of action to maintain or increase crop yields. The mobile application works offline unless the user needs to share information with others. Internet connection is required if the farmer decided to use a web browser-based information dashboard instead.

This paper covers the methodology that acquires the images from the farmer and process it for working on the colour bands to define the health of the plant in the field which helps the farmer to detect the health and gives the required output. In the following sections we discuss the methods and pre-processing techniques to work on images and get the required information from images. The goal of this research was to develop a new method to measure the normalized difference vegetation index (NDVI) of soybean plants directly in the field, without the need of remotely piloted air vehicles or any kind of structural building to support the equipment. The decision making in the field must be as quick and accurate as possible and the radiometer (device used currently to measure the NDVI) although it performs very well, its costs and practicality encourage the creation of new techniques and methods more practical and cheaper.

A research question is “a question that a research project sets out to answer”. Choosing a research question is an essential element of both quantitative and qualitative research. Investigation will require data collection and analysis, and the methodology for this will vary widely. Good research questions seek to improve knowledge on an important topic and are usually narrow and specific. In this project we have focused on the three major areas of the research topics. The topics can be mostly concentrated on the areas of the plant’s soya and the corn. The users will be uploading the images to the portal and get the results. This will be flowing through different areas to get the result. It is expected that farmers upload images acquired from fixed low-cost sensors either to the mobile application or information dashboard - the selection depends on the farmer’s choice. The subsequent processing as determined by the outcome of this research project will be done in the background, eliminating complexity and ambiguity for the end-user. The information that the farmers receive in a mobile application or information dashboard will be straightforward and make it easy to determine the best course of action to maintain or increase crop yields. The application can bring the benefits of precision agriculture to a more diverse group of farmers and can be tailored for specific crops and conditions. The output will be as the result of the following machine learning process and gives the suggestions to the end user. The main aim of this project is to develop a mobile application that uses low-cost remote sensors to deliver easy to understand, robust information to farmers enabling the precision application of fertilizer and other inputs. The research questions are as follows:

1. What features need to be considered from an image?
2. What values of the NDVI and simple ratio define the health of the plant
3. How to develop a mobile application and a web browser-based information dashboard to deliver actionable information and advice derived from previous measurements?

In the farming industry, while taking pic of the crop the camera position makes the best role for covering most of the best in the picture. The picture will be the main area to work on and the images. The images captured will be taken to the process and the valuable information will be derived. The derived values will be helpful for the process of the plant life cycle and the user to know the health of the crop. The relation between the plant health and the nutrition, soil will play a vital role in the images. The data collected from the images can be used to identify the soil and temperature such that the data will be helpful to the farmers in the long run. The other essential elements are referred to as plant nutrients, and are provided by the soil, or are added as fertilizers, and enter plants almost exclusively through the roots. Most soils have at least some residual nutrients. Only a soil test can assess this. Fertilizing without the results of a soil test leads to a waste of money and product and can exacerbate an existing nutrient imbalance. Some gardeners do not say that they garden, but rather that they work the soil. This reveals an understanding that good soil conditions are essential to support productive plant growth. Here are a few gardening tips related to soil management [6]. In addition, sometimes nutrients are present in sufficient supply but are unavailable because of too high or too low pH. A soil test can reveal this, and a soil lab professional or crop consultant can recommend practices to resolve such problems. I want to work on the images and get the images from it. The mobile application plays one more important rule. The images can be organised and sent to the cloud for the process. The result of the research will be a mobile application and a web browser-based information dashboard that can allow small, beginning and even established farmers to reap the benefits of precision agronomy with a small capital cost. Timely information delivered to the farmers, based on imagery captured of their crops, will be easy to understand and actionable. Using information delivered by the mobile app will allow inputs to be adjusted to increase yield.

**Data and Datasets:**

The data has been collected from the fields on the regular basis. The cameras installed in the fields captures the images in particular interval of times. The data has been collected from two different fields namely soybean field and corn field. The data consists of images. The dataset consists of two types of images namely RAW and JPEG format. It consists of images of both soybean and corn field. There are total 386 images of soybean and 57 images of the corn field. The images collected are pre-processed and refined for the development of the mobile application.

# **LITERATURE REVIEW**

In the following paper [1]the study describes a methodology for the detection and characterization of Nitrogen deficiencies in corn fields. The authors have used Unmanned Aerial Vehicles and Computer Vision algorithm that operate with information in the visual (RGB) spectrum. This approach promotes a lower-cost solution for detecting N deficits. The authors presented extensive data on the use of commercial RGB sensors to deliver critical information to farmers about the state of their fields, with the goal of reducing N fertiliser consumption and improving crop production.

In the paper [2], The authors have used a RGB camera to capture the images and designed a neural network model with two hidden neurons which uses the pixel values of R,G and B channels as input. They have also concluded that having one camera with two different angles will be giving the best results with the less error rate. The paper[3] where authors have developed a low-cost and non-destructive method that is easy to use to assess the health status of plants, based on the estimation of chlorophyll content of leaves using a portable digital camera. They have concluded that R, G values had good relationship with chlorophyll content.

A UAV that hovers above a stressed area and gathers high quality RGB photos at a low altitude acquires the data first [4]. A recommendation algorithm suggests possible image segments that are candidates for N deficit [5]. A training set is built using the initial suggestions of the recommendation algorithm based on feedback from experts in the field. The crop leaves that show indicators of N deficit are subsequently characterised using supervised learning methods. The  authors of the following paper [6] have tested the sensitivity of multispectral imagery collected from time-series unmanned aerial vehicle (UAV) and satellite imagery to detect herbicide-induced stress in a carefully controlled experiment carried out in a mature *Pinus radiata* D. Don plantation. The results revealed that both data sources were sensitive to physiological stress in the study trees. The UAV data were more sensitive to changes at a finer spatial resolution and could detect stress down to the level of individual trees. The satellite data tested could only detect physiological stress in clusters of four or more trees . The authors found that the higher resolution UAV imagery was more sensitive to fine-scale instances of herbicide induced physiological stress than the RapidEye imagery. Although less sensitive to smaller phenomena the satellite imagery was found to be very useful for observing trends in physiological stress over larger areas.

In the paper [8], aimed to create a model able to calculate the NDVI from common RGB images collected by smartphones in the field through artificial intelligence techniques. A total of 99 Soybean experimental samples were analysed by portable equipment GreenSeeker model RT100 from NTech radiometer and image acquired by smartphone positioned upright. NDVI was calculated with radiometer absorbance value. The images were initially pre-processed and then pixel information was submitted to Simple Linear, Multiple Linear, Isotonic, Rhythm Regression, Additive, and Linear Regression of Least Median of Squares models.

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# **RESEARCH DESIGN AND METHODS**

A Research is an easy way to brainstorm thoughts organically without worrying about order and structure. It allows you to visually structure your ideas to help with analysis and recall. A Mind Map is a diagram for representing tasks, words, concepts, or items linked to and arranged around a central concept or subject using a non-linear graphical layout that allows the user to build an intuitive framework around a central concept. A Mind Map can turn a long list of monotonous information into a colourful, memorable and highly organized diagram that works in line with your brain's natural way of doing things.

In this project the there are many things needs to be concentrated on, In which there are methods that need to be followed to complete the successful project. The works need to be done on connecting devices , getting images and store the data, processing images and many more. For reducing the confusion of the data and points gathered I have used mind map to organise things such that I could get an opportunity to complete the project in a sequential manner. This involves dividing the project into the five steps in which it consists of IOT, Dataset, Image processing, Machine learning, Image processing and Mobile application.

Each states their work and do there best for the work and gives the good result for the project. The mobile industry has adapted by developing a cellular technology class to support MioT. Most IoT applications rely on devices connecting to the cloud (i.e., an external source) for computing and analytics. Technological advancements make it possible to perform those functions on devices without sacrificing budget or efficiency.  If a connection to one satellite fails, another can be picked up in seconds, often without lapses or delays. The mind map helps us to define the key things that need to be  done in the project. The Mind map has the detailed sets of the steps to be followed. The image processing gives the finest images and Machine learning is used for processing, testing and training the data. This has been represented in the above mind map.

The methods followed in this project used to process the image and share the results with the user. The system architecture defines the structure of the proposed system in which it contains the mobile application with the storage and backend ML model. The features that I want to include in this are like getting the number of leaves, the soil content which will be taken into consideration and the model will be developed.

The user can access the mobile application to get the result which will be processed and stored in the application for the future use.There are different libraries in python to extract colour bands from the Image. They are like GDAL/OGR, Pyproj, Rasterio, Geopandas. The multispectral images contains 3 to 10 bands in which Near Infrared, red and green bands are helpful as they are more sensitive for the changes in the plant. Once the band is extracted we calculate the NDVI, Simple Ratio 1 and Simple Ratio 2. Calculating the Normalized Difference Vegetation Index NDVI, Simple Ratio 1 and Simple Ratio 2 which helps in getting the health of the plant. These can be calculated by using the Colour bands. Those Colour bands that are used to get the are Near-Infrared, Red and Green colour bands from the images. The NIR plays the main important role in defining the plant health as the NIR reflects the light more and gets the health of the plant. This NIR and given and used in the formula or NDVI and Simple ratios to get the health of the plant.

**NDVI= (NIR - Red) / (NIR +Red)**

**Graphical user interface

Description automatically generated**

**Fig 2:** System Architecture

The Flow diagram and the flow chart defines the flow of process in the research. The captured images flows through the ML model for processing where the segmentation and feature extraction is done and then sent into the algorithm for statistical analysis an the output will be sent to the mobile application that the user can view. The solution is decide based on the plant health and shown to the user.

Graphical user interface, application

Description automatically generated

**Fig 3:** Flow Diagram

**Diagram

Description automatically generated**

**Fig 4: Flow chart for the research**

**Diagram

Description automatically generated**

**Fig 5:** UseCase Diagram

In machine learning, a programmer usually inputs the data and the desired behaviour, and the logic is elaborated by the machine. This is especially true for deep learning. Therefore, the purpose of machine learning testing is, first of all, to ensure that this learned logic will remain consistent, no matter how many times we call the program. When we run our testing suite against the new code, we'll get a report of the specific behaviours that we've written tests around and verify that our code changes don't affect the expected behaviour of the system. If a test fails, we'll know which specific behaviour is no longer aligned with our expected output.

Quality assurance is required to make sure that the software system works according to the requirements. Were all the features implemented as agreed? Does the program behave as expected? All the parameters that you test the program against should be stated in the technical specification document. However, in machine learning, a programmer usually inputs the data and the desired behaviour, and the logic is elaborated by the machine. This is especially true for deep learning

* **Unit tests.** The program is broken down into blocks, and each element (unit) is tested separately.
* **Regression tests.** They cover already tested software to see if it doesn’t suddenly break.
* **Integration tests.** This type of testing observes how multiple components of the program work together.

Moreover, there are certain rules that people follow: don’t merge the code before it passes all the tests, always test newly introduced blocks of code, when fixing bugs, write a test that captures the bug.

Graphical user interface, application

Description automatically generated

**Fig 6:** Divison of the Dataset for Training and Testing

We're humans, and humans make mistakes. Testing is important because it helps you uncover these mistakes and verifies that your code is working. Perhaps even more importantly, testing ensures that your code continues to work in the future as you add new features, refactor the existing ones, or upgrade major dependencies of your project. There is more value in testing than you might realize. One of the best ways to fix a bug in your code is to write a failing test that exposes it. Then when you fix the bug and re-run the test, if it passes it means the bug is fixed, never reintroduced into the code base.Mobile application testing is a process by which application software developed for handheld mobile devices is tested for its functionality, usability and consistency. Mobile application testing can be an automated or manual type of testing. There are different types of mobile app testing like functional testing, performance testing, Usability testing, black-box testing etc.

In this project, I will be testing my mobile application based on few features like uploading, giving the output to the user, loading the image in the required location. Jest offers describe function to help structure your tests. Use describe to group together all tests that belong to one functionality. Describes can be nested if you need that. Other functions you'll commonly use are before Each or before All that you can use for setting up the objects you're testing. Read more in the Jest API reference. The scripts are written with expected behavior in which the testing gives whether the expected behavior is observed or not.

# **IMPLICATIONS AND CONTRIBUTIONS TO KNOWLEDGE**

The research will help the farmers to identify the health of the plant from the image. The methods used in the project and the application that is feasible to use by the user. The developed helps to get the clear picture of the crop health. With the help of the simple ratio 1 simple ratio 2 and NDVI which is used in the satellite imagery of field health will be used in the application with the enhanced phone camera images. The images taken from the camera will undergo image pre-processing and will be given as a input for the algorithm which calculates the health of the plant. This help the users to get the plant health and will help the user to get the precautions for improving the crop health.

Testing on the application can be further developed with further enhancements of the images and the ML techniques that can help in the better understanding of the health and the precautions can be suggested based on the conditions. The images gathered can be more from the growing season and be helpful for the research.

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# **Research schedule**

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| **Research phase** | **Objectives** | **Deadline** |
| Gathering Information | Acquire information of Images, feature and values for the calculation of NDVI, Simple Ratio1, Simple Ratio 2 | January 17th, 2022 |
| Developing Model and Application | Developing the code for the image processing, Acquiring the colour bands and developing the mobile application. | February 28th, 2022 |
| Testing and Validation | Testing the Model developed with different inputs and Testing the working of the mobile application | March 7th, 2022 |
| Writing Research Paper | Write a paper on the research with the steps and the algorithm | March 28th,2022 |