Title of Proposed PhD Thesis Project

Automation of crop yields estimation using UAV-based hyperspectral imaging.

Project Background

The world population continues on an upward trajectory. The projected addition between 2019 and 2050 is over one billion people. Sub-Saharan Africa countries are expected to account for more than half of this projection (United Nations & Social Affairs, 2019). In line with this, food security continues to be a topic of discussion amongst leaders drawn from various disciplines.

Food security is one of the goals in sustainable development agenda, and the ability to estimate and monitor crop yields before pre and post-harvest is of high importance. Likewise, agricultural production aims at achieving maximum crop yields at inputs minimums (Dahikar & Rode, 2014). Developing systems for early detection and management of crop yield associated problems can be the solution to achieve this aim. Estimation or prediction is one of the systems needed, coupled with reliable data that meet spatial-temporal requirements of specific crops.

Remote sensing data and crop models are essential tools for estimating agricultural crop yields, at coarse spatial resolutions. Using higher resolution inputs require machine learning models that have high computational ability (Folbertha, et al., 2018).

Remote sensing has for a longer time replied on satellite imaging, but Unmanned aerial vehicle (UAV) is an emerging technology for imaging that is suitable for agricultural applications (Adão, et al., 2017)

Problem Statement

The 2030 agenda for sustainable development set to eradicate all forms of malnutrition by ensuring access to safe, nutritious and sufficient food for all people all year round. Ten years remain to eliminate hunger and ensure access to food for all (FAO, IFAD, UNICEF, WFP and WHO, 2020). Arable land is on a downward trajectory, population is on an upward trajectory, and food production remains constant. Arable land is giving way to urbanization to cater for growing population. According to (FAO, IFAD, UNICEF, WFP and WHO, 2020), that 8.9 percent of the world population is experienced hunger. The report also estimates about 10 million people in one year and by nearly 60 million in five years will go hungry. Global food demand is increasing driven by population, economic growth and urbanization, particularly in developing countries. To match food production and demand, developing countries need to embrace smart or precision agriculture despite shrinking arable land. In developing countries UAV system are now gaining popularity in agriculture. Hyperspectral camera onboard the UAV, provides a suitable solution for small-scale and medium-scale farming in precision agriculture. The study will focus on selected potato farms in Nakuru and Nyandarua Counties, Kenya.

Literature Review

In recent times, the use of unmanned aerial vehicle (UAV) technology has increased in the field of surveying, precision agriculture, and monitoring. Mounting spectral sensors make the technology ideal for agricultural applications. (Ishidaa, et al., 2018) conducted a UAV based aerial survey with a liquid crystal tunable filter (LCTF) based hyperspectral sensors over several vegetated areas, and the spectral reflectances of 14 different ground objects were measured. The classification results using support vector machine (SVM) were satisfactory.

(Zheng, et al., 2018) integrated ground-based hyperspectral data with multispectral imagery from unmanned aerial vehicle for plant nitrogen concentration estimation in rice. The study established that UAV sensing has a future in precision agriculture, as UAV imagery produced both vegetation indices and texture measurements.

In precision weed management, (Casa, et al., 2019) successfully discriminated weeds from maize UAV-based hyperspectral imaging. In a related study, (Jurado-Expósito, de Castro, Torres-Sánchez, Jiménez-Brenes, & López-Granados, 2019) also obtained high performances using cokriging with the UAV-secondary variables when mapping weed infestations in wheat fields. (Jurado-Expósito, de Castro, Torres-Sánchez, Jiménez-Brenes, & López-Granados, 2019) concluded that there is great potential of high-resolution UAV imagery as a source of ancillary information to improve the accuracy of spatial mapping.

A research by (Ballesteros, Ortega, Hernandez, & Moreno, 2018) focused on estimating crop biomass from high-resolution red, green, blue imaging obtained with an unmanned aerial vehicle. The results of the study suggested that obtaining biomass using aerial images are a good alternative to other sensors and platforms as they have high spatial and temporal resolution to perform high-quality biomass monitoring

Research Objectives

This research will focus on the following objectives;

1. Assess the potential of using hyperspectral UAV images for potato yield estimation.
2. Develop a yield estimation model based on selected variables.
3. Develop an automated web-based yield estimation application

Research Design

1. Data acquisition

The research aims to acquire data for yields estimation using a hyperspectral sensor mounted on an unmanned aerial vehicle during the crop planting, development and maturing stages. During planting stage, the data to be acquired, will include; soil parameters, planting spacing, soil moisture and amount of fertilizer used. In development stage the data to be acquired will include; temperature, crop indices, canopy, management and random variables.

2. Data processing

The UAV imagery will first be pre-processing to correct for geometric and radiometric distortions. Then the resulting product be used to calculate the vegetation indices of crops.

3. Model development

Estimation relies on a model that models the interactivity between variables. This research will come up with a web-based estimation model for the crop estimation.

4. *Yields estimation*

In testing and validating the model, sample data will be subjected to the model to generate yield estimates for comparison with actual yields.

5. *Model deployment*

Once the model has achieved, acceptable results, then the application will be available to target users.

Significance of the Research

The main aim of this research therefore, is to explore the potential of unmanned aerial vehicles hyperspectral imaging with machine learning algorithm for precision agriculture to regional areas in Africa.

The significance of this research is to provide a tool to both small and medium-scale farmers for yield estimation. These tools will assist in yields optimization as it will inform of yields expectations, from which mitigation measures can be taken before crop maturity.

Expected Results

The research aims to achieve the following;

i. Present the potential of UAV images in precision agriculture.
ii. Maps and statistics.
iii. Develop an automated web-based yield estimation.

Project Schedule

Year	**Duration**	**Activity**
Year 1	January – April	Literature review
Year 1	May – August	
Year 1	September – December	Research design
Year 2	January – April	
Year 2	May – August	Data collection
Year 2	September – December	
Year 3	January – April	Model development
Year 3	May – August	Model development and testing
Year 3	September – December	Validation and reporting

Table 1. Timeframe of the project

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