Design of NDVI Plant Health Monitoring for Pepper Vines

(Reka Bentuk Pemantauan Kesihatan Tanaman Lada menggunakan NDVI)

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Abstract

The advancement in the Internet of Things (IoTs) enables image processing on a small and low-cost scale in the agriculture sector. Low productivity due to the pest and disease has been identified as one of the major pepper production constraints. The classification of images for pepper vines in the early stages will help pepper farmers to identify the health status of the pepper plants, thus help farmers to maximise the pepper production. This project is to propose the use of No InfraRed (NoIR) camera and Global Positioning System (GPS) module with Raspberry Pi to analyse the health of black pepper plants and track the coordinate location of the plants. The NoIR Camera has No InfraRed (NoIR) filter on the lens which makes it capable of doing Infrared photography and taking pictures in low light (twilight) environments. Internet of Things (IoTs) is designed to transfer data over a network without requiring human-to-human or human-to-computer interaction. The utilisation of Normalized Difference Vegetation Index (NDVI) included in the prototype to determine the health of pepper plants. OpenCV is used for NDVI image processing because it is open-source software and portable as it can run on any devices that run C++ or Python. Python language is also used to handle image capturing and image transfer operations. The images and reports of the pepper plant can be viewed via an android application. This application will help the farmers to monitor plant growth efficiently for better production.

Keywords: Internet of Things, Raspberry Pi, Normalized Difference Vegetation Index (NDVI), Image Processing.

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INTRODUCTION

Sarawak is the main producer of pepper (Piper Nigrum L) which the account for more than 95% of the total production of Malaysia. All Sarawak pepper marketed in form of black and white pepper. Recently, green pepper in brine and dehydrated forms have also been produced in substantial quantities for the market.

In Sarawak, the pepper is produced and planted by rural dwellers which ~~are~~ concentrated in certain districts of Kuching, Samarahan, Sri Aman, Betong, and Sarikei Divisions. The crop is very important to Sarawak as the crop supports the livelihood of about 67,000 rural farmers. The present estimated planted area is about 13,000 hectares (DOA, 2020). However, the current practice for black pepper production from land clearing, pest management to harvesting is done via the traditional method. Farmers need to refer to the Malaysian Pepper Board (MPB) for any assistance (Adama et al., 2018).

The breakthrough in agriculture using information technology connectivity is expected to change how farmers are doing their farming activities in the future. The development and deployment of the Internet of Things become a new norm to get more accurate results of plant health status compared to the manual observation by humans.

This project aims to develop a plant health monitoring system for pepper vines using image processing to monitor the condition of pepper plants. The image is captured using a Pi Noir Camera that is connected to a Raspberry Pi to process the NDVI value of the plants.

The NDVI (Normalized difference vegetation index) value is used to determine the pepper vines' health status. NDVI employs the Multi-Spectral Remote Sensing data technique to find Vegetation Index and assess whether the target being observed contains live green vegetation or not (Gandhi et al., 2015). The result will be sent to the server and will be displayed in an Android app which is specially developed for the farmers. It will also display complete information such as the location and the health record of the plant.

LITERATURE REVIEW

Adama et al. (2018) conducted a study which showed that there is lacking efficient tools in guiding farmers in monitoring crop which has constrained efficiency of pest and disease control. The current practice for black pepper farming activities in Sarawak is implemented through the traditional method, whereby farmers need to refer to MPB for any assistance. Most farms are distributed widely in remote areas with accessibility constrain. This conventional working procedure is time consuming, inefficient, and costly.

Lakshmi and Gayathri developed a system using IoT and image processing to compare the status health of banana leaf and paddy plant, whether the plant is healthy or deceased. The system that they developed was to extract the colour, texture, and shape of the leaf (Lakshmi & Gayathri, 2017).

Meanwhile, the work of Patil et al. (2016) presented the survey on a classification method that can be used to classify plant leaf disease based on its different morphological features. Prema and Carmel (2019) developed the image processing and IoT to detect plant leaf disease which was similar to Lakshmi, K., & Gayathri, S. who used image processing by utilising IoT in their plant growth monitoring system (2017). However, in their approach, the authors employed deep learning to identify the leaf disease

SYSTEM DESIGN

Figure 1 shows the architecture of the proposed system. There are five stages of NDVI plant health monitoring for pepper vines.

1. Image Acquisition
2. Image pre-processing
3. Image Segmentation
4. Feature Extraction
5. Classification of plant health

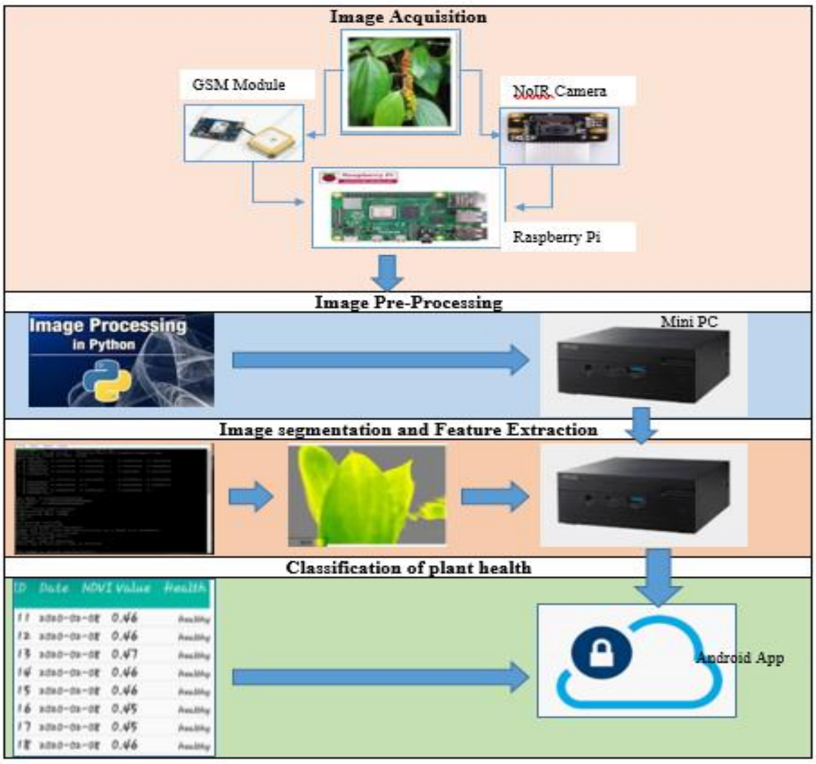

Figure 1. NDVI plant health monitoring for pepper vines architecture

IMAGE ACQUISITION

Images are captured from the field of the pepper farm in Bau district to get the real environment for the pepper vine leaves. To capture the data, the No InfraRed (NoIR) is used which is connected to the Raspberry pi microcontroller to initiate the capture process. In this step, the image dataset is stored in the path created in mini-PC into a variable. A program or function is called in python to load folders containing images into arrays. At the same time, the Global System for Mobile communication module (GSM) is sending the location of the images taken. The coordinates are sent to the cloud server and at the same time, updates the android app for farmer’s information.

IMAGE PRE-PROCESSING

The aim of image pre-processing is to improve image features. The image may contain dust, spores, and other foreign materials which could be referred to as noise. The purpose of this step is to eliminate the noise in the image, so as to adjust the pixel values. This step improves the quality of the image.

IMAGE SEGMENTATION

Images are cropped using the OpenCV function in Python programming which allows cropping for dimension specified by the programmer. To examine the image's size, the system is using the image attribute which is part of the NumPy array. In this system, the image is resized according to ratio, so that the image does not display skewed or distorted. To do this, the system will calculate the ratio of the new image to the old image. The formula of the function is as stated below.

$$r = 100.0/\text{image.shape}[1]$$
$$\text{dim}= (100, \text{int}(\text{image.shape}[0]*r))$$

FEATURE EXTRACTION OF IMAGE

Feature extraction is a process to get parameters from the image, for example, the colour, texture, and shape of the image. Since this system is to monitor the health of pepper vines, only the colour of the pepper leaves is to be emphasized. This system is using the Normalized Difference Vegetation Index (NDVI) to classify the leaf whether the leaf is healthy or otherwise. NDVI is a measure of the state of plant health based on how the plant reflects light at certain frequencies. NDVI is calculated in accordance with the formula as shown.

$$NDVI = \frac{NIR - NED}{NIR + RED}$$

Note: NIR - reflection in the near-infrared spectrum; RED - reflection in the red range of the spectrum

CLASSIFICATION PLANT HEALTH

Finally, based on NDVI calculation, the result of the image being taken will be sent to the database and would be displayed on the mobile app. The classification of the leaf is based on the index of NDVI which is from -0.1 to 1.

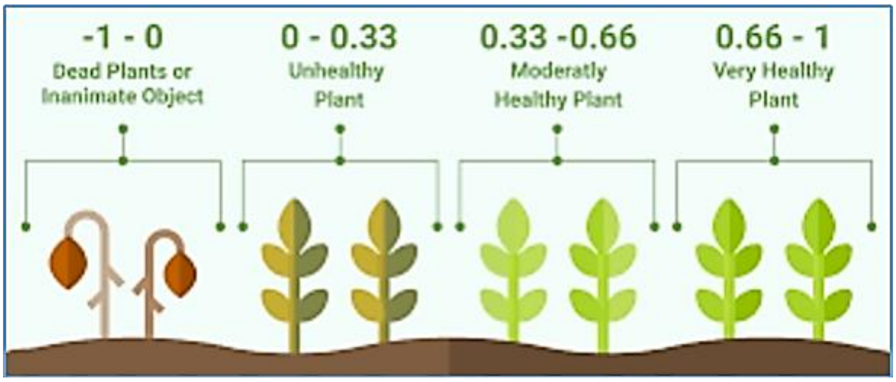

Figure 2. NDVI index value for classifying plant health status

RESULTS

In this section, the author demonstrates the data collected throughout the research. The data can be represented in a table or graph however a concise explanation should accompany any embedded figure. If the figure contains any item which is subject to copyright protection, or that it may infringe individual privacy such as showing a recognizable face, then a granted permission needs to be presented.

CONCLUSION

The prototype has shown that the use of a No InfraRed (NoIR) camera and GPS module with Raspberry Pi to analyse the health of black pepper plants and track the coordinate location of the plants can be implemented. The health of this pepper plant through the NoIR images is displayed by the score of NDVI values. Hence the NDVI values will facilitate, especially the farmers for decision-making in managing the crop such as predicting the amount of nutrients and soil moisture required. The farmers could access this information's in real-time through their smart devices. However, the prototype is not fully tested yet to prove the outcomes are reliable and precise. More researches and development should be executed in order to make it more comprehensive and well-functioned.

The prototype could be enhanced by applying machine learning in the image processing part in delivering a more automated process to obtain the NDVI value. This foresees that big data of images of pepper vines have to be captured in order to prepare the datasets. Thus, the process of training the data and setting the suitable models could be delivered and this would help to improve and ease the process of determining the NDVI values. The prototype could also be tested on drones to collect a canopy of images of pepper vines to see whether the images could be used to get the NDVI values.

Nevertheless, the adaptation of precision farming through the implementation of IoT and a part of the machine learning technology has been exercised through this prototype that will enhance the ability of all stakeholders which includes farmers, researchers, scientists, and government agencies to manage the crop and predict the future harvest.

REFERENCES

Adama, A., Ee, K. P., Sahari, N., Tida, A., Shang, C. Y., Tawie, K. M., ... & Mohamad, H. Dr. LADA: Diagnosing black pepper pest and diseases with decision tree.

DOA (Department of Agriculture Sarawak) website. Retrieved from https://doa.sarawak.gov.my/page-0-0-138-Pepper.html

Gandhi, G. M., Parthiban, S., Thummalu, N., & Christy, A. (2015). Ndvi: Vegetation change detection using remote sensing and gis–A case study of Vellore District. *Procedia Computer Science, 57,* 1199-1210.

Lakshmi, K., & Gayathri, S. (2017). Implementation of IoT with image processing in plant growth monitoring system. *J. Sci. Innov. Res, 6(2)*, 80-83.

Ghavate, S., & Joshi, H. (2020). Smart farming using IOT and machine learning with image processing (No. 2333). EasyChair.

Patil, R., Udgave, S., More, S., Nemishte, D., & Kasture, M. (2016). Grape leaf disease detection using k-means clustering algorithm. *International Research Journal of Engineering and Technology (IRJET), 3(4),* 2330-2333.

Prema, K., & Carmel M., B., (2019). Smart farming: IoT based plant leaf disease detection and prediction using deep neural network with image processing. *International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8*(9), 3081-3083