Estimation of Nitrogen Concentration of Paddy Leaf Using Aerial Image Captured By Drone

M. Saifizi¹, Cuthawat¹, Wan Azani Mustafa¹, Syed Zulkarnain Syed Idrus², Mohd Aminudin Jamlos¹

¹Department of Electrical Engineering Technology, Faculty of Engineering Technology, University Malaysia Perlis
²Center of Excellence Geopolymer and Green Technology, Universiti Malaysia Perlis, 01000 Kangar, Perlis, Malaysia.

saifizi@unimap.edu.my

Abstract. Paddy crops are one of the major sources of income in the country as rice is the main food of the population. Rice is a basic necessity and it's very high demand among consumers in the country causes farmers to use fertilizer to produce enough rice. The use of fertilizers will bring benefits to farmers but if the quantities of fertilizer are not controlled then it can cause losses. Typically, fertilizers contain nitrogen which is the source of environmental pollution if nitrogen levels are too high. The rate of use of fertilizer or nitrogen plays an important role in the process of growing paddy trees. The concentration of nitrogen levels can be determined through the colour of the leaf of the paddy tree such as yellowish green, light green and dark green. The colour indicates the concentration of nitrogen contained in the rice plant. The yellowish green colour indicates that the rice trees do not get enough fertilizer and the growth of stunted rice trees. While the dark green colour indicates high nitrogen levels, the mature process of rice trees becomes slow. The light green leafy paddy is a healthy tree and the nitrogen content contained in paddy is perfect. Traditionally, farmers identify nitrogen concentrations manually by surveying the rough eyes. However, this method requires a lot of workforce, time and not consistently. In addition, that method is impossible to get accurate results and there is an error in the survey process because different people will have a different opinion specific task. The purpose of this project is to provide an image processing system to estimate the concentration of nitrogen in paddy trees through leaf colour. Concentration is estimated by using image processing techniques, automated detection and extraction system besides data collection aims to help farmers in the future.

1. Introduction

The paddy industry is one of the major industries in the country as rice is the staple food of its population. Paddy is a basic requirement and demand is very high among consumers in the country. In paddy production, nitrogen fertilizer is very important but if fertilizers are excessively cultivated, the growth of paddy will be affected and environmental pollution will occur [1]. Paddy is highly dependent on inputs of nitrogen fertilizer to achieve optimum production in agricultural systems. Hence, excess nitrogen fertilizer is frequently supplied to obtain a high yield in most modern agricultural production systems. The increasing cost of chemical nitrogen fertilizer production, its energy requirement and numerous negative environmental effects such as water pollution and greenhouse gas emission. Improving the congruence between paddy demand and the nitrogen supply available from the soil and applied fertilizer is the strategy to enhance the nitrogen use efficiency of...
paddy crops. Paddy is one of the most important crops in the world, it is important to determine the size of the paddy field accurately using fast methods such as remote sensing and GIS [2]. The Landsat program has provided facilities to map the soil on the surface of different study areas since 1972. Landsat 8 images are used to determine paddy fields for rice production. Remote sensing data is a tool used to determine the distribution of soil and land use. The image processing technique of the Normalized Different Vegetation Index (NDVI), is a result of original and composite images, Principle Component Analysis (PCA) and band combination techniques used to create new images and to calculate the accuracy of the overall classification for each image generated.

Four digital image processing steps are used to measure the height of paddy crops automatically which is band selection, filtering, thresholds, and altitude measurements [3]. Band selection is used to eliminate excessive features. Filter extracts of important marker bar features. Threshold method is used to separate object and boundary bar boundaries compared to other areas. The marker bar is detected and compared to the initial marker bar to measure the height of paddy crops. The height of the rice crop can be measured indirectly from the image by measuring the height of the marker bar compared to the height of the initial marker bar. The study found irrigation fertilizer irrigation is a method of fertilizing plants with water that is widely used in the agricultural sector [4]. The method causes soil pollution as a result of excessive use of fertilizers. Plant fertility is monitored using Leaf Colour Chart (LCC) and appropriate fertilization is performed. The pH value and the steel temperature determine the fertility of the crop. Estimates Near Infrared (NIR) reflection with camera data seen based on regression for the Normalized Vegetation Index (NDVI) estimation proposed together to detect insect damage in paddy fields found that there is a high correlation between NIR reflection and green colour reflection [5]. It is possible to estimate the reflectance NIR camera data that can be viewed with the possibility to estimate NDVI data seen by the drone camera installed because the protein content in rice plants are highly correlated with the intensity of the NIR and rice leaf reflectance.

Many image processing techniques are widely used in the field of agricultural science and provide protection to crops as well as can lead to the growth of crop production [6]. Monitoring automatically reduces manpower and mistakes made by humans. Implementing different image processing techniques to detect and identify pest insects by establishing an automatic detection system to estimate the density of pests in paddy fields. The results show that the system provides easier, efficient and fast solutions in detecting pests in paddy fields. This previous research used image acquisition, image pre-processing, detection in image, filtering and extraction in the image. The network of wireless cameras was setup together with the sticky traps to capture the insect pests. In this study, the authors convert the RGB image into a grayscale image. The authors compared the two images are used in detecting the difference image pixel values of the successively captured images from the camera. The first image served as the reference image that represents the reference pixel values for comparison purposes, while the second image served as the input image. The two images were compared to each other and the differences in pixel values were determined.

Based on the study explain the processing of images that detect rice crop from rice paddy image [7]. The reflection of sunlight should be avoided to keep track of paddy rice fields. Images of paddy fields can be divided into small areas reflecting the same intensity light. Rice seed pixels in the image are detected in every area. To detect rice seed pixels, three methods of the differential calculus processing in eight areas of each pixel neighbourhood, the analysis of brightness lines and line colour analysis in the areas of each row was discussed. The result is that rice seed pixels have been clearly identified in weather conditions regardless of the reflection of light.

Methods that can be used to compare the colour of the leaves of plants with leaf colour chart (LCC) have been proposed to get details about the plant, enough to get the results before the affected [8]. By leveraging the image processing technology a simple and robust method for the colour prediction of paddy crops has been discussed along with mathematical modelling that can provide a great platform for agricultural advisory bodies for atomization. The research has been carried out using the real time images of paddy plants and a MATLAB generated LCC. The LCC was designed in such a way that all shades of green could lie in the range. The image acquisition devices capture the image in RGB format, which is not the same as the phenomenon of the retina of the human eye. So if
the processing is done in RGB mode, its results may differ from the actual ones, raising the validation problems. For the above mentioned conversions, it has been assumed that RGB values have been normalized between 0 to 1 and the angle theta is measured with respect to the red axis of HSI color space. Image compression, morphological operations and masking are used to be done for getting a precise and quick response. To make the compatibility of MATLAB compilers, only the portion of the image was selected which contains the leaf.

2. Methodology

DJI Mavic Pro is a drone used to capture the image of paddy leaves in this project. Images are taken from different altitudes for the best results for process image processing. DJI GO fly the drone and make the capturing images easier and efficient. An advantage of this application is that it can help to control the drone by autopilot mode or mapping mode. The images at a height of 3 meters will be selected because the color of the leaf is clearer than other height so the result that obtains from image processing will be more accurate.

Software part is the most important to make this project successfully achieved the objectives. Software part is used to analysis image the paddy image and collect the result of segmentation. This software will calculate then estimate the percentage of nitrogen concentration in paddy field. Colour based segmentation used in this image is image acquisition technique, RGB to the grayscale converter, contrast adjust the image, sharper image, split colour band image and thresholding.

3. Result and Discussions

Paddy image was capture by drone controlled by DJI GO application. The mage is obtained from the directory in JPG format with resolution 4000x3000 as shown in Figure 1. All the image are RGB images.

![Figure 1. Paddy image with 5 meter higher captured by drone as an input image](image1.jpg)

Paddy image with RGB format has been converted into the grayscale format as shown in Figure 2. When converting from RGB to grayscale, it is said that specific weights to channels R, G, and B ought to be applied. Grayscale images can be the result of measuring the intensity of light at each pixel.

![Figure 2. Grayscale image after converting process](image2.jpg)
An image lacks contrast when there are no sharp differences between black and white. Brightness refers to the overall lightness or darkness of an image. In this process, pixel values below a specified value are displayed as black, pixel values above a specified value are displayed as white, and pixel values in between these two values are displayed as shades of gray as shown in Figure 3.

![Figure 3. The contrast adjustment image](image)

Sharpness process is actually the contrast between different colours. A quick transition from black to white looks sharp as shown in Figure 4. A gradual transition from black to gray to white looks blurry. Sharpening images increases the contrast along the edges where different colours meet.

![Figure 4. Image after sharpening process](image)

The colour based segmentation is split the image into RGB colour band. This process is the extraction of colour band of Red, Green, and Blue colour has split from the image. This process is to make easier to determine the colour needed in research. Figure 5 (a), (b) and (c) show the red colour band, the green colour band and the blue colour band respectively.

![Figure 5. Colour based segmentation into split image (a) red, (b) green, (c) blue](image)

After the split the colour band, the next process is threshold the image. The threshold is a sort of image segmentation that detaches dividing an image into a front and background image. The colour thresholding is used to determine the nitrogen concentration. Image thresholding is a simple but effective the way of partitioning an image into an object and background. This image analysis technique is a type of image segmentation that isolates objects by converting grayscale images into binary images. Image thresholding is most effective in images with high levels of contrast.
Table 1. Colour thresholding value of paddy leaf based on LCC

| Paddy colour based on LCC | Threshold value               |
|--------------------------|-------------------------------|
| Yellow                   | Red = 123-144                 |
|                          | Green = 150-170               |
|                          | Blue = 33-47                  |
| Light Green              | Red = 87-111                  |
|                          | Green = 137-157               |
|                          | Blue = 42-67                  |
| Green                    | Red = 80-104                  |
|                          | Green = 127-141               |
|                          | Blue = 45-63                  |
| Dark Green               | Red = 57-77                   |
|                          | Green = 102-127               |
|                          | Blue = 59-78                  |

Table 1 shown the colour thresholding value used to determine the nitrogen concentration based on LCC. Yellow colour refers to low concentration, for its thresholding value are Red=132-144, Green=150-170 and Blue=33-47. Next, light green refers to moderate concentration of nitrogen, for its thresholding value are Red=87-111, Green=137-157 and Blue=42-67. While green refer to perfect concentration of nitrogen for its thresholding value are Red=80-104, Green=127-141 and Blue=45-63. Lastly, dark green refer to the high concentration of nitrogen for its thresholding value are Red=57-77, Green=102-127 and Blue=59-78. Figure 6 (a), (b), (c) and (d) shown the yellow segmentation, the light green colour segmentation, the green colour segmentation, the dark green colour segmentation after the thresholding process respectively.

Figure 6. Colour segmentation after thresholding of (a) yellow, (b) light green, (c) green and (d) dark green

Figure 7 shown the 20 sample paddy images after segmentation process. All the images were segmentation into 4 types of nitrogen concentration that are the lowest concentration, medium concentration, perfect concentration and highest concentration.
| No | Original Image | Lowest Concentration | Medium Concentration | Perfect Concentration | Highest Concentration |
|----|----------------|----------------------|----------------------|-----------------------|-----------------------|
| G1 | ![Image](image1) | ![Image](image2) | ![Image](image3) | ![Image](image4) | ![Image](image5) |
| G2 | ![Image](image6) | ![Image](image7) | ![Image](image8) | ![Image](image9) | ![Image](image10) |
| G3 | ![Image](image11) | ![Image](image12) | ![Image](image13) | ![Image](image14) | ![Image](image15) |
| G4 | ![Image](image16) | ![Image](image17) | ![Image](image18) | ![Image](image19) | ![Image](image20) |
| G5 | ![Image](image21) | ![Image](image22) | ![Image](image23) | ![Image](image24) | ![Image](image25) |
| G6 | ![Image](image26) | ![Image](image27) | ![Image](image28) | ![Image](image29) | ![Image](image30) |
| G7 | ![Image](image31) | ![Image](image32) | ![Image](image33) | ![Image](image34) | ![Image](image35) |
Figure 7. 20 samples paddy images after segmentation process

All the percentages concentration showed the area of each of the nitrogen types that contain in every single paddy image. The type of 4 area percentages value is the lowest concentration, medium concentration, perfect concentration and highest concentration. Table 2 shows the area percentages values of the 4 type of nitrogen concentration based paddy leaf images.

Table 2. Percentage of nitrogen area by each colour of the image.

| Concentration | No. | Lowest % | Medium % | Perfect % | Highest % |
|---------------|-----|----------|----------|-----------|-----------|
| G1            | 0.001986137 | 2.409432163 | 0.952104312 | 96.63647739 |
| G2            | 0 | 0.364832836 | 0.195484522 | 99.43968264 |
| G3            | 0 | 0.047636933 | 0.025650656 | 99.92671241 |
| G4            | 0 | 0.028350866 | 0.018900577 | 99.95274856 |
| G5            | 0 | 0.028119052 | 0.008652016 | 99.96322893 |
| G6            | 0 | 0.024758221 | 0.01650548 | 99.9587363 |
4. Conclusion

This aim has successfully achieved with capturing images with the height of the difference between drone and paddy field. At 5 meter height, the images captured more to accurate and easy to identified the classes of paddy population. There are several suggestions and improvements for further research to produce a nitrogen concentration system on paddy in the agricultural industry. The system needs to be improved by using the high quality drone so that the images taken will be more clarity and quality. In addition, image capture techniques also need to be enhanced as the perception factors play an important role in image processing. There are many image processing techniques besides RGB methods that can be implemented in this system so that the results are more accurate and effective.

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