The Surveillance System for Rice Diseases Detection Using Color Model

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Abstract - **The surveillance system on the detection of rice diseases based image processing is developed to support agriculture in order to protect the outbreaks of insect pests which cause the rice diseases by reducing the time of exploration, damage of walk-through survey, cost, and dose. The rice diseases in the consideration are Brown Planthopper (BPH) and Rice Leaffolder. The concept of this paper is to monitor the rice paddy field and detect the rice diseases from the difference of rice leaf color values by using aerial photography, Parrot AR. Drone 2.0 send the data via AR. Drone's Wi-Fi connection to mobile in real time. The aerial survey data of the rice field are collected under sunny weather. The experimental area is 4x10 meters. The experimental results present the rice diseases in the infected area that can be detected correctly due to the purpose as 73%.**

Keywords **- Image Processing; Rice Disease; Mobile; AR. Drone**

I. INTRODUCTION

Rice is the most important crop in Thailand in terms of main dish for living and agricultural produce. It is one of the country's main exports that make the world's largest rice exporter in the last 3 decades [1]. It brings in an income to the country each year more than 100 billion baht [2]. According to the high rice prices have increased continuously since 2007, there are insults as an incentive to farmers in irrigated area to produce more rice. However paddy has limited area, farmers have to find other ways involving, increasing rice agriculture by rice planting in various seasons per year which increases off-season rice field from 9 million in 2006 to 15 million in 2014 [3].

One of the pest diseases is Brown plant hopper (BPH) which has transmitted since 1974. The outbreak has continuously intensified, especially in dry season (November 2009-2010) that affected central rice growing areas more than 2.38 million acres [4]. The infestation of BPH in both embryos and larvae absorb nutrient in vascular bundle of rice plant. It makes the rice burn, called hopperburn, and dry out eventually. Besides the BPH disease, there is epidemic disease causes rice leaf color changing from green that is the ordinary paddy fields to another. Rice Leaffolder (LF), is one of the rice diseases, changes rice leaf color from green into linear, pale white stripes that result in membranous patches [5] and reduces photosynthesis in crop process. It often found that its transmission occurs after BPH infestation. It can be observed visually, but in case of large rice paddy fields, especially if there are problems in the center of paddy field which is out of sight of observer, survey with eyes may cause defects. Another way to observe is walk-through survey which may result damages to the rice field and scares off insects to spread even more. Also, walk-through survey cannot explore rice diseases thoroughly because farmers can survey only on the ridge.

There are solutions to solve the problems; The use of rice resistant varieties which can withstand to the BPH as well, but rice plant in a long consecutive season makes the BPH develops an adaptation which finally destroy the rice paddy fields [6]. In addition, the at outbreak period, light trap is applied to monitor or directly reduce populations of insects. And when the epidemic becomes severe, insecticide is applied according to the recommendation of Rice Department and other corresponding official agency [7], but it makes causes damage to farmer's health [8]. The farmers never know all the specific area where the rice diseases are actually occurred, thus it takes a lot of time for extermination. Even the use of the Moderate Resolution Imaging Spectroradiometer (MODIS) [9], SAR or Landsat for monitoring rice field requires high budget, resolution, and area of exploration. Therefore, another way is to use an unmanned aerial vehicles (UAVs) [10] which are highly popular technology using as environmental remote sensing applications currently such as, mapping forests, arid areas, aquatic weeds, soils, and crops [11]. There are relative research of using UAV for agriculture, such as using mini UAV for monitoring crop growth [12] and UAV for assessing crop nitrogen status to quantify different nitrogen application rates [13].

In order to resolve rice disease problems, researchers use the Unmanned Aerial Vehicle System which became relevant for applications in precision farming and in infrastructure maintenance, like road maintenance and dam surveillance [14] by using Parrot AR. Drone 2.0 which it is used for exploring rice paddy fields and surveillance the outbreaks of the BPH and LF diseases by applying its process with computer implemented system based on image processing. The AR. Drone explores the rice paddy fields to computer, and sending the data of flight control from the computer to the drone. The image processing is used for detecting different color based color model technique. The colors of the normal rice field and the infected rice field are obviously different. Thus, the received data can be analyzed the outbreaks from the color of the rice leaf.

An advantage of this technique is making it possible to quickly process the image with good accuracy. Besides the reduction of the rice field damages due to walk-through survey, it comprehensively optimizes rice detection and reduces economic losses.

II. THEORY

A. Color Model

Grayscale color is a range of shades of gray which are different from a binary image that consists of black and white. Grayscale represents color intensity with various levels that depend on the size of bits. Typically, the color information is storage with 8-bit that has a color resolution of 265 colors.

RGB color is a color system composes three main colors; red, green, and blue. It is also a light system that has an additive color mixing form, meaning that if there is no color, it will be seen as black color. On the other hand, if there are colors, it will be seen as white.

HSV (Hue, Saturation, Value) is closer to the human mind than RGB color. Let Hue be the color of the image, saturation be the amount of grey in a color, and value be the brightness of image. The maximum of value will be white color (V = 255).

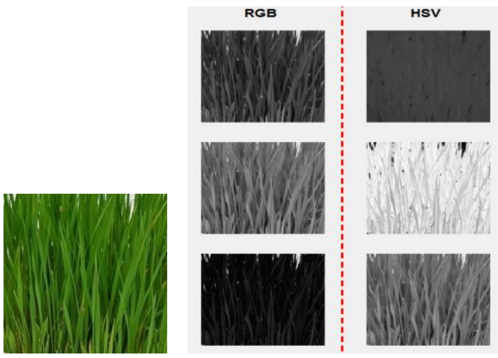


Figure 1. The Image in each Channel of RGB and HSV Color Model

B. Threshold

Threshold is the value used in the grayscale system division that suits for finding objects which are explicitly separated from the background within the image due to the color intensity. It divides into two types; white and black colors. If the value in the pixel is less than the threshold, the pixel will indicate to the black, and if it is more than the threshold, the pixel will indicate to the white. Threshold suits for finding objects which are explicitly separated from the background.

C. Rice Diseases

1) Brown planthopper, usually called BPH, is considered as the major rice insect pest in Thailand. BPH is the carrier of the virus to the plants. It is dangerous for crops because BPH makes crop's leaves become more narrow and shorter with twisted tip than normal. The heavy infection may cause burn symptom called hopper burn and death to the rice plants as shown in Figure 2 [15].

Figure 2. The Outbreaks of the Brown Planthopper

2) Rice Leaffolder, usually called LF, is a very common rice insect pest. This insect usually damages the rice crops from a young stage through flowering. The adult rice leaffolder is a yellow-brown moth. Leaffolder caterpillars fold the rice leaves around themselves and attach the leaf margins together with silk strands which change rice color to white as shown in Figure 3 [16].

Figure 3. The Outbreaks of the Rice Leaffolder.

III. SYSTEM DESIGN

The main components of the surveillance system are the computer and AR. Drone which used as the flight simulator for monitoring the rice field from the top view. In recording data, the AR. Drone flies with the altitude from the ground around 3 meters and the acceleration at 2 m/s. The aerial survey data of the rice field is collected under sunny weather and the Real-time is applied to the system. The program analyzes the data as the video signal received from its camera, and then transfers into frame grabber in the computer process. The frame work is presented in Figure 4. The concept is the surveillance to monitor the rice field and detect the rice diseases when the rice leaf color has changed. The system design to reduce errors while the system works and save time and cost. The structural system has divided into 3 components which are described below;

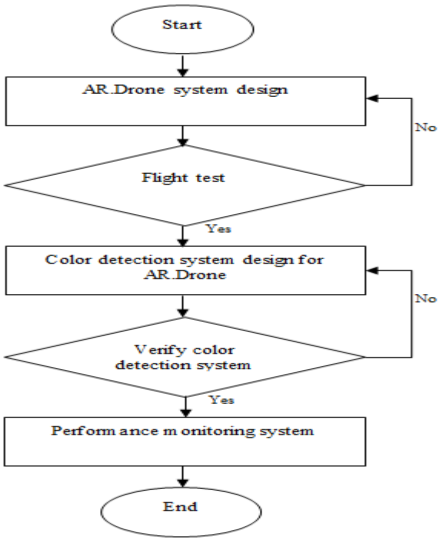


Figure 4. The Surveillance System for Rice Diseases Detection Using Color Model

A. Control System Design of AR. Drone

For controlling system and receiving values between the AR. Drone and computer, the software is designed by using windows operation, Software Developing Kit (SDK) of puku0x [20] and OpenCV. The computer is Windows7, Intel(R) Core(TM) i7-5500U @ 2.40GHz, RAM 16 GB, 64-bit. It is connected via the AR. Drone's Wi-Fi connection which operates as a network communications and data transmission. When firstly take off the drone, it flies with the height of one meter, then wait for the user's order that can be the flight mode or the landing mode. The procedure of the flight control is shown in the Figure 5.

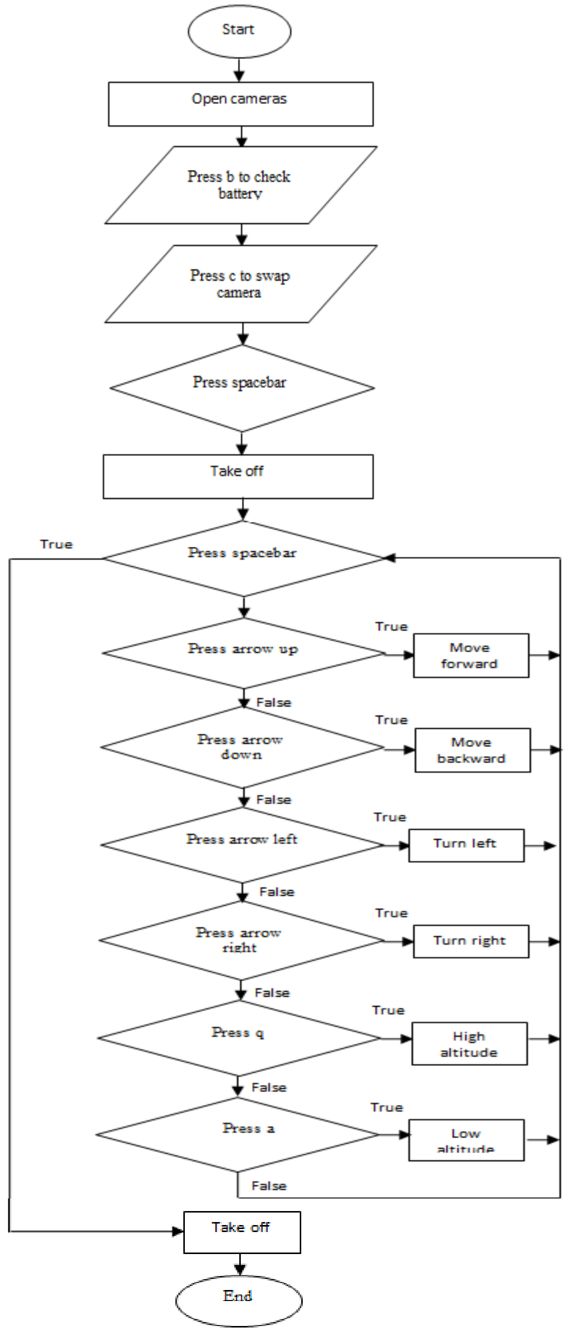


Figure 5. The Flowcart of the AR. Drone Flight Control in the Control System

In order to control the AR. Drone, the computer notebook keyboard is used as the flight commands which comprise 10 buttons;

1) Spacebar	Take-off and landing
2) Left Arrow	Turn left
3) Right Arrow	Turn right
4) Up Arrow	Move forward
5) Down Arrow	Move backward
6) Q	Move upward
7) A	Move downward
8) X	Capture the image
9) C	Swap the camera between front camera and vertical camera.
10) B	Check battery

B. Color Detection System of AR. Drone

Different color detection system of the rice field has designed by processing the captured images from the aerial survey of the AR. Drone, shown in the Figure 6. The process is as follow;

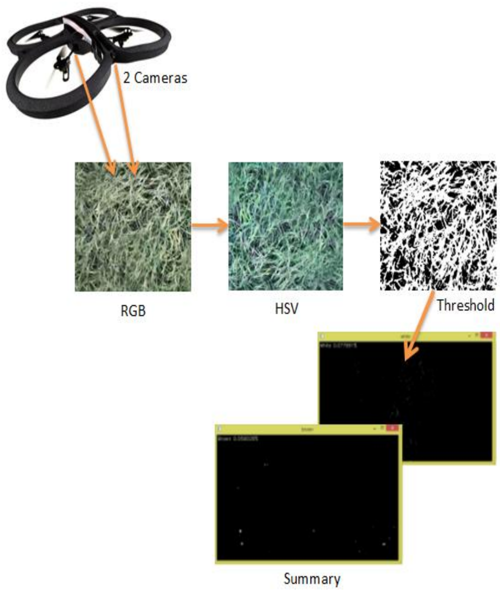


Figure 6. The Process of Color Detection System of AR. Drone

In detection system, the developed system is able to acquire video which are already saved in a form of streaming video. The frame rate is 10 frames per second (fps), Each frame has a size of 640x480 pixels. After dividing all the frames, the system keeps in the frame buffer displayed in the storage module. Thus, the images from the splitting frames are in the form of RGB color image. And, the RGB Image transform to HSV image in order to facilitate the color adjustment more easily. The color detection system design for AR. Drone, It can be done by setting threshold to exam the specific area that is similar to the rice diseases. In the test, the detected image is processed by the Threshold with the value of 100. The threshold accesses each color channel of the image to clear the color and adjust it more explicitly, providing it has low quality. Then, the color values in each color channel, including red, blue and green are separated and adjusted to the high brightness of the color image. After that the pixels of red, green, blue and all of the image's pixels are counted to calculate the percentage of the rice diseases. The colors of the BPH and LF diseases are involved with brown, white and yellow. The percentages of the brown, white and yellow pixels per total pixels are formulated as follows.

$$Brown[\%] = \left(\frac{Brown_{pixel}}{All_{pixel}}\right) * 100$$

$$White[\%] = \left(\frac{White_{pixel}}{All_{pixel}}\right) * 100$$

$$Yellow[\%] = \left(\frac{Yellow_{pixel}}{All_{pixel}}\right) * 100$$

The percentages of the brown, white and yellow pixels per number of the combination of the brown, white and yellow pixels are formulated as follows.

$$Brown_{c[\%]} = \left(\frac{Brown_{pixel}}{Color_{pixel}}\right) * 100$$

$$White_{c[\%]} = \left(\frac{White_{pixel}}{Color_{pixel}}\right) * 100$$

$$Yellow_{c[\%]} = \left(\frac{Yellow_{pixel}}{Color_{pixel}}\right) * 100$$

The ratios of the brown, white and yellow pixels per number of the other color pixels are formulated as follows.

$$Brown_{ratio[\%]} = \left(\frac{Brown_{pixel}}{White_{pixel}}\right) * 100$$

$$White_{ratio[\%]} = \left(\frac{Yellow_{pixel}}{White_{pixel}}\right) * 100$$

$$Yellow_{ratio[\%]} = \left(\frac{Brown_{pixel}}{Yello_{pixel}}\right) * 100$$

Color values of the rice diseases can be determined by storing a lot of examples in the various light conditions, colors, and sizes for computing the statistical values for matching the color characteristics with the rice diseases. From 50 experiments acquired from normal and infected rice field, the value results are stored for finding the outstanding characteristics within the image that are described below: within the image that are described below:

The brown planthopper consists of the brown, white and yellow color in the ratio of the brown and white per total area as shown in

Figure 7. The ratio of the brown and white must be more than the yellow. The rice leaffolder consists of the brown, white, and yellow colors, but the most apparent color is white. It occurs around 80 percent of the total area as shown in Figure 8. Examples of images that are Color Detection of the Normal Rice Field and Color Detection of the Infected Rice Field are shown in Table I and Table II.

Figure 7. Brown Planthopper Disease Detection

Figure 8. Rice Leaffolder Disease Detection

TABLE I
COLOR DETECTION OF THE NORMAL RICE FIELD

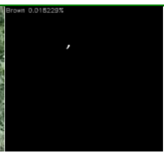
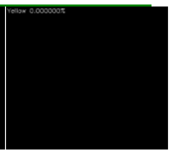
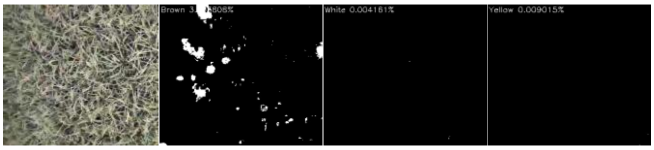
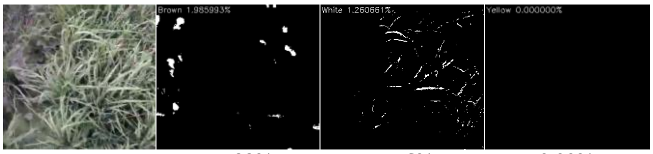
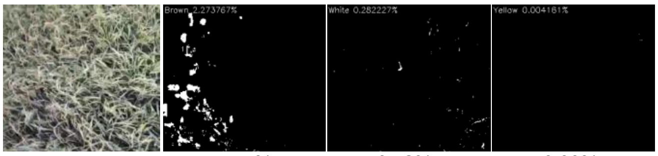
Normal rice field	***Brown***	***White***	***Yellow***
	 0.01%	 0.12%	 0.00%
	 0.03%	 0.1%	 0.00%
	 0.01%	 0.11%	 0.00%

TABLE II
COLOR DETECTION OF THE INFECTED RICE FIELD

Infected rice field	*Brown*	*White*	*Yellow*
	2.62%	0.11%	0.00%
	3.01%	0.00%	0.00%
	1.99%	1.26%	0.00%
	2.27%	0.28%	0.00%

IV. EXPERIMENTAL RESULTS

This paper aims to detect the difference of the rice leaf color values based image processing, and decrease the damage of the rice field caused by the rice insect pest by using the AR. Drone. The performance of the program determines the occurrence of the BPH and LF diseases. The system tests its performance with the model until receiving the correct results, then the system tests in the real rice field which is divided into two types including;

A. Test with Normal Rice Field

The determination of the effectiveness of the program is shown in Table I. According to the experimental results, the graph of the normal rice field shows the percentage of the detected color in the normal rice field. The most detected color is the white, brown and yellow, respectively. The white color is mostly seen in the normal rice field. The value of the white color leads to the error detection as the LF disease. In this case the white color has the minimum percentage of 0.13 percent caused by the sun light reflection on the leaf and water. The graph is shown in Figure 9.

B. Test with Infected Rice Field

According to the experimental results, the graph of the infected rice field shows the percentage of the detected color in the infected rice field. The most detected color is the brown, white, and yellow, respectively. The most percentage of the brown is 3.78 percent at the frame 21st, the white is 3.44 percent at the frame 14th, and the yellow is 0.01 percent at the frame 2nd, 3th, 4th, 6th, and 11th. The brown and white color is mostly seen with the high value unlike the yellow color that does not exist in the infected field. It means that the system can detect the colors of the BPH and LF diseases accurately due to the purpose. The high value of the brown and white color presents the effective of the system. The graph is shown in Figure 10.

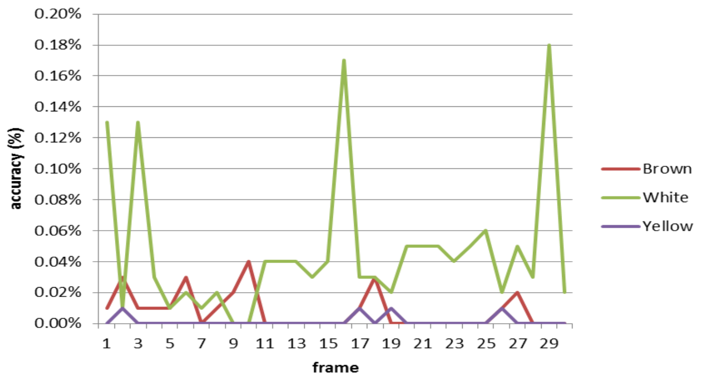


Figure 9. Experimental Results of the Normal Rice Field

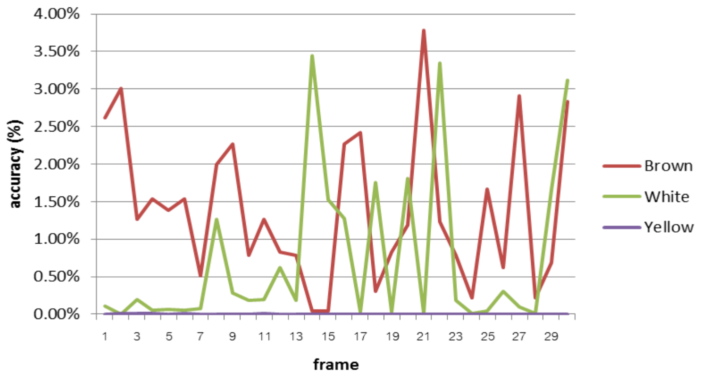


Figure 10. Experimental Results of the Infected Rice Field

The 30 experimental result images of the normal rice field, the results reveal some errors with low value of the detected color. The average error value of the brown color area per total area is 0.008 percent. The errors are caused by the environments that similar to the colors of the BPH disease, such as the soil, water, and light. The average error value of the white color area per total area is 0.047 percent. The errors are caused by the environments that similar to the color of the LF disease, such as the light reflection and water. Noise can be made errors at some point within the image. The average error value of the yellow color area per total area is 0.001 percent. It is the least value of all the colors caused by the soil and noise. It is also similar to the BPH disease. The average error value of the whole color area per total area is 1.867 percent. In the infected rice field, the 30 experimental result images are also considered, and then found that the most average value is the brown color that has 1.395 percent, the second is the white color that has 0.732 percent and the last is the yellow color that has 0.002 percent. The average value of the whole color area per total area is 70.967 percent, It is shown in Table III. Thus, in the infected rice field, the BPH is more infected than LF. The accuracy of the system depends on the outbreak of the insect pests. Therefore, if the insect outbreaks are widely spread, the system will have value high of the brown color of the infected rice leaf.

TABLE III
THE AVERAGE VALUE OF RICE LEAF COLOR DETECTION IN RICE FIELD

Field	Brown	White	Yellow	Whole color
Normal rice field	0.008	0.047	0.001	1.867
Infected rice field	1.395	0.732	0.002	70.967

V. CONCLUSION

In this paper, we determine the effectiveness of the rice diseases detection system based image processing using the AR. Drone. From the experiment of the normal rice field and the infected rice field, which the normal rice field, the system does not found the BPH and LF diseases because there are no any rice diseases in the experimental area. However, there are some errors caused by the environments that their color similar to the BPH and LF diseases, such as the brown color from the soil, ridge, raceway or shadow, and the white color from the light inflection or noise of the image. It leads to the occurrence of the rice disease detection errors. The average error related to the BPH disease is from the brown color which is equal to 0.008 percent. The average error related to the LF disease is from the white color which is equal to 0.047 percent. And the least average error is from the yellow color which is equal to 0.001 percent. In the infected rice field, the system detects the BPH and LF diseases from the difference of the rice leaf color values found in the experimental area. The brown color represents the BPH disease, the white color represents the LF disease and the green color represents the normal rice leaf. The average value of the BPH disease is 1.395 percent and the LF disease is 0.732 percent. The overall detected color values are 70.967 percent. The yellow color is detected as the least value because it does not involve with the rice diseases in our consideration. Therefore, this experimental area has the BPH and LF diseases according to the assumption. The developed system using the AR. Drone for monitoring the rice fields and detecting the rice diseases from the aerial survey can detect the BPH and LF diseases from the difference of rice leaf color values correctly. This system can be used for detecting the rice diseases in real-time, assessing and decreasing damages caused by the rice insect pests and walk-through survey, and also saving time and cost for the rice paddy fields preservation.

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(Arranged in the order of citation in the same fashion as the case of Footnotes.)

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