Design Unmanned Aerial Vehicle Integrated Camera Near Infra-Red to Observe the Plant Health

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***Abstract* - Plant health is an essential factor to reduce the number of import in a country. In this research, we use paddy as an example to understand plant health. Our research is motivated by our belief that technology might aid in reducing chances of failed paddy harvest in Indonesia. To understand the plant health of paddy, we designed unmanned aerial vehicle (UAV) integrated pocket cameras to record near infra-red (NIR) light. Apart from NIR light data, we obtained the normalized difference vegetation index (NDVI) values of paddy to observe the plant health based on the photosystem metabolism that absorb red light and blue light and reflects green light and NIR light. Based on the test results, the values of NDVI are given -0.819672, 0.395018, 0.346667, 0.032680, 0.705628 and 0.302817. Based on values of NDVI, we conduct a validation test with farmers to compare NDVI values with actual conditions on the ground. Based on the test, the obtained value of NDVI was in accordance with the actual conditions in the field.**

Keyword - Plant Health, Quadcopter, NDVI

I. Introduction

A declining number of paddy's productivity in Indonesia is related to current conventional method used by Indonesian farmers. Without statistic and data, this conventional method lead to ineffective and inefficient use of fertilizer, water and all types of pesticides including herbicides, fungicides, and insecticides. New methods are introduced to help farmers to increase paddy's productivity such as using camera integrated UAV which able to record NIR light paired with georeferenced data. This data is able to analyze Normalized Difference Vegetation Index (NDVI). The used of NDVI data leads to plant's photosystem efficiency or deficiency in holistic aspect that gives important information for farmers. With this data, the farmer can optimize the utilization of fertilizers, water and pesticides to optimize the yield of paddy plants.

II. Working Principle of the System

The principal method in this research is collect aerial photographs data using a UAV integrated with ordinary and modified pocket camera that capable to record the NIR light. The results of aerial photographs from UAV integrated ordinary and NIR camera was rendered and analyzed by using NDVI formula with comparing the wavelength data from ordinary and NIR cameras so that can produce NDVI data which capable to identify the plant health. The Innovations were done toward previous researcher by building a UAV with quadcopter model which is integrated with pocket camera Canon S100. This research gives an alternative technology that is easier, cheaper, and precise to observe the growth of plants.

Pocket cameras Canon S100 was modified to be able to record NIR light. Quadcopter was built integrated with NIR pocket camera and ordinary pocket camera. Unmanned aerial vehicle (UAV) is a flying machine that can be controlled by remote control or with the assistance of a device that has been programmed in accordance with the command given to the UAV. The UAV can execute its mission automatically without pilot (autopilot). Near infrared spectroscopy (NIRS) can also be said as spectroscopy (wave) near inframerah (SIMD). SIMD is a one of the spectroscopic technique that uses infrared wavelength region of the electromagnetic spectrum (800 to 2500 nm). Normalized difference vegetation index (NDVI) is a calculation of the imagery used to determine the level of greenness of plants who excellent as the beginning of the division of vegetation areas. NDVI can show the parameters related with the vegetation parameters, among others, biomass of green leaves and green foliage area which is the value that can be estimated for the division of vegetation. Previous research showed that the value of vegetation index obtained from the equation NDVI is closely related to Fraction of absorbed Photosynthetically Active Radiation (FAPAR) (Myneni and Williams, 1994), strongly correlated with the Leaf Area Index (LAI) and biomass monokulture (Aparicio et al., 2002) and sensitive to chlorophyll content (Zavaleta et al., 2003). The division of objects based on NDVI values refer at Table I.

TABLE I Division of Objects Based on Value Normalized Difference Vegetation Index (NDVI).

Index	NDVI Value
Non Vegetation	< 0
Less Healthy Vegetation	0 – 0.1
Normal Healthy Vegetation	0.2 – 0.3
Very Healthy Vegetation	0.4 – 0.8

The equation used to obtain the value of NDVI is:

$$NDVI = \frac{NIR - red}{NIR + red} \quad (1)$$

The range of NDVI value is between -1.0 until +1.0. The NDVI value can be obtained by comparing data subtraction of NIR band and red band with summation the data of NIR band and red band based on data from the object observed.

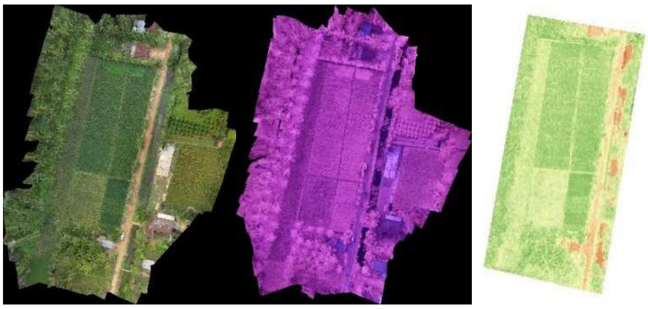

Fig. 1. *Red Green Blue* (RGB) (left), *Near Infra-Red* (Center), *Normalized Difference Vegetation Index* (NDVI) (Right)

III. SYSTEM DESCRIPTION

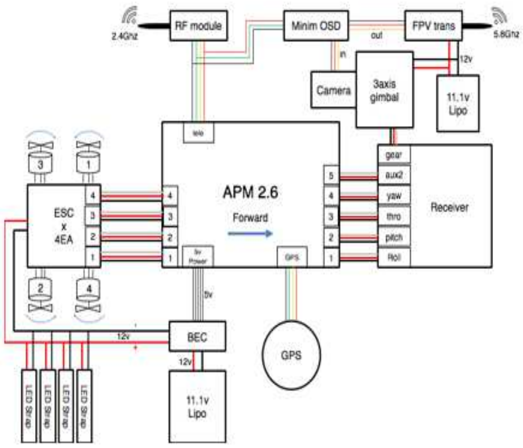

Fig. 2. Diagram Design of Quadcopter (https://airhigh.wordpress.com/tag/*quadcopter*/page/2/)

Fig. 2 is a design system of unmanned aerial vehicle (UAV) with quadcopter model which integrated module Ardu pilot mega (APM) 2560. APM 2560 is a series of electronic devices which integrated with a microcontroller and several sensors. Sensors were located at APM 2560 among other are MPU-6000 3-axis gyroscope and 3-axis accelerometer which gives control stability on the UAV and MS5611-01BA03 sensor air pressure barometric which functioning to determine and control the altitude of the UAV. APM 2560 has a 4Mb chip of data transmission on a flight mission to give telemetry data directly or through a USB cable. At a design UAV with a model quadcopter there are several enhancements that serve to increase the ability of quadcopter. The enhancements are global positioning system (GPS) NEO-6 with digital compass (magnetometer) HMC5883L, telemetry, brushless motor, electronic speed controller (ESC), propeller (propeller), remote control (RC), and battery.

A data collecting process using a ordinary camera, and a camera that can record NIR light. Both cameras are given a script intervalometer to capture images based on the time interval and take images simultaneously by a predetermined time. After the data is retrieved, the result of data will be rendered using software Agisoft Photoscan so that the results can be seen as in Fig 1. The result of images is processed with NDVI analysis using ArcGIS program. The working principle NDVI analysis is to compare the results an ordinary camera image with the result a NIR camera image. The data was analyzed using NDVI formula, so that can obtain NDVI data values that can be used to observe the growth of plants. NDVI analysis results can be seen in Fig. 5. Quadcopter block diagram is shown in Fig. 3.

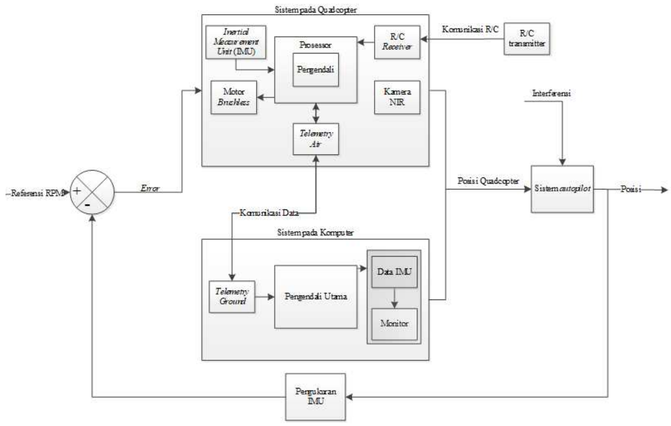

Fig. 3. Block Diagram of Quadcopter

IV. RESULT AND DISCUSSION

This research is discussing about testing quadcopter, testing NIR camera, and testing NDVI to identify health of paddy plants to assist farmers optimizing paddy yields.

A. Testing Quadcopter

In this test conducted testing flight of quadcopter by remote control and GCS. In this test, quadcopter flown in accordance with the command trajectory that is created and ensures quadcopter can fly stably without interruption. Tests was conducted in Desa Sungai Itik, Kecamatan Kakap, Kabupaten Kubu Raya.

In this test, quadcopter was flown using a remote control. After quadcopter fly up till a height of 50 meters, quadcopter was given the command to move automatically in accordance with the trajectory command which given by a GCS. Quadcopter moves suitable the trajectory at a height of 100 meters with a speed of 5 m/s so that the estimated time to finish the trajectory which given to quadcopter was 13 minutes. In this test, the results of the images obtained to be use as a map during flight is as much as 113 images with an area produced as big as 72 hectares.

B. Testing Near Infra-Red (NIR) Camera

This test is conducted by comparing the images from a pocket camera that has been modified using filters roscolux #2007 and ordinary pocket camera. In principle, this test is conducted by taking data in the field, then the images on ordinary cameras was compared with cameras modified filter roscolux #2007.

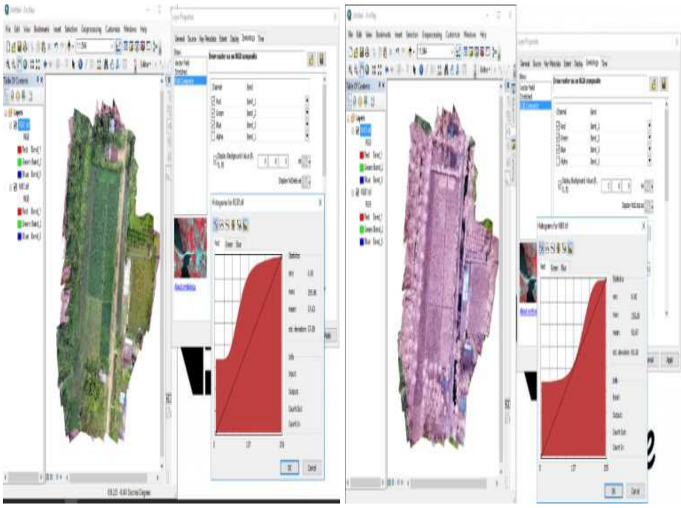

Fig. 4. The Result RGB Camera and NIR Camera

Average histogram value from images which captured by ordinary camera and NIR camera are 57.63 and 92.67. The data composite RGB histogram can be used as a benchmark to measure the value that is read by the camera based on the histogram. Based on combined histogram data of RGB from ordinary camera and NIR cameras, showing an average value combined of the RGB at a NIR camera larger than the average value combined ordinary RGB cameras. This proves that the value of light received by the NIR camera more sensitive than ordinary camera, and the camera captures the light with a wavelength greater than the ordinary camera.

C. Testing Normalized Derivative Vegetation Index (NDVI)

NDVI is calculated based on the measurement of reflection (ρ) in the red and near-infrared territory (NIR) of the electromagnetic spectrum. The red band related to chlorophyll content (high absorption) and NIR bands related by the structure of leaf cells (high distribution). The data analysis of NDVI at the field is shown in Fig. 5.

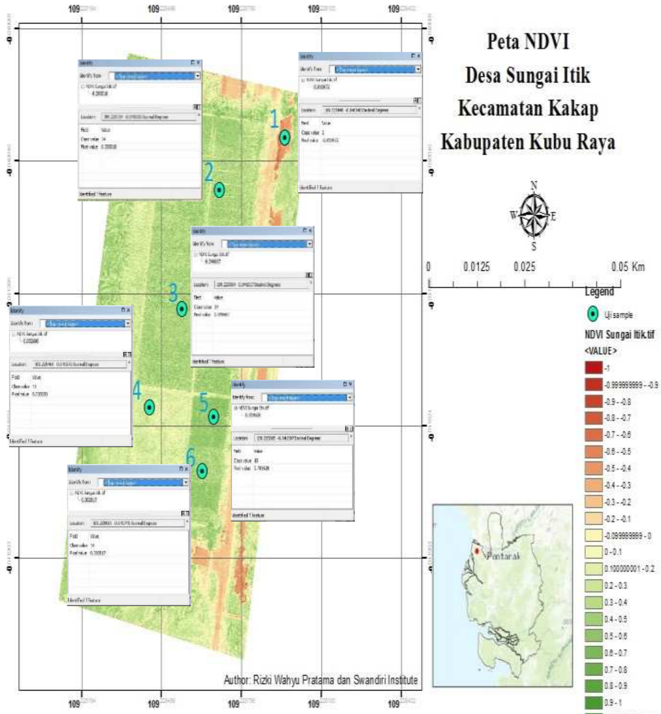

Fig. 5. The Result NDVI Data

In Fig. 5. shows the results of NDVI analysis to determine the plants health in accordance with NDVI data values. In this analysis, the greater the value of NDVI, the plants can be categorized as healthy, otherwise the smaller the value of NDVI, the plants can be categorized as less healthy.

In this test, six samples of data representing each parameter of vegetation conditions was taken. Samples the NDVI data values described in Table 2.

TABLE 2. Sample NDVI Value

Point	Sample Data	**Range NDVI Value**	**Result Validations Test**
1	-0,819672	-1-0	Non Vegetation
2	0,395018	0,2–0,6	Normal Healthy Vegetation
3	0,346667	0,2–0,6	Normal Healthy Vegetation
4	0,032680	0,2–0,6	Normal Healthy Vegetation
5	0,705628	0,6-1	Very Healthy Vegetation
6	0,302817	0–0,2	Less Healthy Vegetation

In this test conducted validation tests in the field with the farmer to prove the method used. Based on the results of testing and validation testing in the field, the result of NDVI data values can be used as a reference for the farmer to observe the growth and the plants health. With this method, farmers can efficiently and effective in using fertilizer, water, and medicines plants, so that can give proper care and generate optimal production.

V. Conclusion

Testing normalized difference vegetation index (NDVI) by comparing the value of the red band on the ordinary camera and a red band on the NIR camera generate NDVI data with ranges from -1 to 1. The data which were taken on paddy plants gives the data in a pixel form is able to declare the plant health based on formula NDVI. Observing the growth of plants in the analysis of NDVI can be used to look at the pixel values and see the changes and degradation of color in the data. In this test the analysis a NDVI data has been tested with test validation together with farmers in the field. The data sample of NDVI value -0.819672, 0.395018, 0.346667, 0.032680, 0.705628 and 0.302817 gives plant health information based NDVI data values that corresponds to the actual conditions in the field.

References

[1] Atmel Corporation. 2012, September 04. 8-bit AVR microcontroller with 8/16/32K Bytes of ISP Flash and USB Controller. May 05, 2015. http://www.atmel.com

[2] Atmel Corporation. 2012, October 04. 8-bit AVR microcontroller with 64K/128K/256K Bytes In-System Programmable Flash. May 05, 2015. http://www.atmel.com

[3] InvenSense. 2013, August 19. MPU-6000 and MPU-6050 Product Specification Revision 3.4. May 05, 2015. http://www.Invensense.com

[4] U-Blox. 2011, December 20. NEO-6 u-Blox 6 GPS Modules Data Sheet. May 05, 2015. http://www.u-blox.com

[5] Measurement Specialites. 2012, October 26. MS5611-01BA03 Barometric Pressure Sensor. May 05, 2015. http://www.meas-spec.com

[6] Honeywell. 2013, February 01. 3-Axis Digital Compass IC HMC5883L. May 05, 2015. http://www.honeywell.com

[7] DIYDrones Development Team, 2015. Arduino-based autopilot for multirotor craft, from quadcopters to multirotor, (Online), (http://copter.ardupilot.com/), diakses May 2015.

[8] Wikipedia. 2015. Near Infrared Spectroscopy, (Online), (http://en.wikipedia.org/wiki/Near-infrared_spectroscopy.html) diakses May 2015.

[9] Public Lab, 2015. Near-Infrared Camera, (Online), (http://publiclab.org/wiki/near-infrared-camera.html) diakses May 2015

[10] Public Lab, 2015. NDVI and NRG, (Online), (http://publiclab.org/wiki/ndvi.html) diakses May 2015

[11] Candiago, Sebastian., Remondino, Fabio., De Giglio, Michaela., Dubbini, Marco., dan Gattelli, Mario. 2015, April 02. Remote Sensing. Evaluating Multispectral Images and Vegetation Indices for Precision Farming Applications from UAV Image, Vol. 7, pp. 4026-4047. May 14, 2015.

http://www.mdpi.com/journal/remotesensing.html

[12] Ai, Mingyao., Hu, Qiangwu., Li, Jiayuan, Wang, Ming., Yuan, Hui., dan Wang, Shaohua. 2015, February 26. Remote Sensing. A Robust Photogtammetric Processing Method of Low-Altitude UAV Images, Vol. 7, pp. 2302-2333. May 14, 2015. http://www.mdpi.com/journal/remotesensing.html

[13] Salami, Esther., Barrado, Cristina., dan Pastor, Enric. 2014, October 22. Remote Sensing. UAV Flight Experiments Applied to the Remote Sensing of Vegetated Areas, Vol. 6, pp. 11051-11081. May 14, 2015.

http://www.mdpi.com/journal/remotesensing.html

[14] Zhou, Yan. 2011. Development of a Data Collection System for Small Unmanned Aerial Vehicles (UAVs) Flight. Cape Peninsula University of Technology.

[15] Nurhakim, Hardiansyah Rahmat. 2010. Sistem Kendali Gerak Continuous Path Tracking dengan Menggunakan Cubic Trajectory Planning pada Robot Manipulator 4 DOF. Universitas Indonesia.

[16] Lukmana, Muhammad Arifudin., dan Nurhadi, Hendro. 2012. Rancang Bangun Unmanned Aerial Vehicle (UAV) Empat Baling-baling (Quadrotor-Arducopter). Institute Teknologi Sepuluh Nopember.

[17] Hidayat, Nur. 2009. Rancang Bangun Sistem Kendali Quadrotor untuk Kesetimbangan Posisi dengan PID. Universitas Indonesia.