Monitoring Early Stage of Rice Crops Growth using Normalized Difference Vegetation Index generated from UAV

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Abstract. Remote sensing is a tool to gather the information about an object or any phenomenon without direct contact or damaging the objects. This technology had numerous application and one of it is in agriculture. Unlike tradition agriculture practiced that difficult to execute and required a large number of man power, implementing this technology will increase the production yield of the crops and improved the agriculture sector in managing and controlling. Remote sensing were able to forecast the crop production, identified the crop type, assess the crop damage and monitoring its progress. Therefore, this research was conducted in order to monitor the early stage of growth of rice crop planted by the farmers in the paddy field using remote sensing. To do so, popular empirical vegetation index known as Normalized Difference Vegetation Index (NDVI) generated from unmanned aerial vehicle (UAV) was selected to monitor the changes of rice crop starting from the day it been planted until eleventh day of planted. Early stage of monitoring the crop growth using NDVI is a best approach to practice. Any damages that occur during this stage will affect the yield production and economy. Result from image analysis shown that NDVI were able to observe the rice crop growth and able to locate the damage part in the paddy plot. Fast action can be made by the farmers to counter attack the damage and treat the problematic points.

1. Introduction
Precision agriculture (PA) is the use of technology to monitor the farm, crop condition and farm management strategies for better yield produced with minimal input and also no harm to environment. This is because the right amount of input placed on that targeted site on right time and place [1]. PA is a systematic because the farmer will know the right way to treat the crop when infection of pest and disease occurred, irrigation system in farm will function at the right time and place at site that need more water, less pollution occurred that caused by excessive use of pesticides because the farmer already know the right time to apply with the right amount and increase the production of the farm [2]. In PA, there are technologies used such as unmanned aerial vehicle (UAV), geographical position system (GPS), smartphones and computer system to collect all the information at field and further will analyse to produce the result for decision making [3]. UAV is a recent technology in remote sensing that use an
aircraft or drone with no pilot on board. The pilot will control from the ground and the UAV will fly above the crop to capture images. UAV is suitable for low fly altitude with higher spatial resolution with detailed information such as ground texture and cover [4]. As this technology give a huge impact, more study carried out by using image analysis application [3]. Rice is a staple food for most country in Asia region and consumed by more than a billion people over the world. As world population increase, demanding on rice also increase. Therefore, a proper management on rice production need to be done to supply enough production on rice demand. However, rice production face major problem in their low production [5] because of pest and disease infection, control method on infection started late and lack of monitoring at field [6]. In development of remote sensing technology, UAV is commonly used to monitor crop as its light weight, easy to carry and less cost in capturing high resolution aerial imagery [7]. From the imagery and spectral bands collection, a vegetation index such as Normalized Difference Vegetation Index (NDVI) can be produced [8]. NDVI generated by using red and near infrared bands to identify vegetation health condition and monitor the crop development [8].

Remote sensing is a technology developed together with a high resolution sensor for spatial, spectral and temporal [9]. This technology is beneficial to use when to gather information where the place is not accessible, require specific time to collect the data and high cost [10]. It is also a method that uses multiple carriers for example UAV that attached together with a sensor to collect aerial imagery information such as RGB images and multispectral images [11]. This technique is use without in contact physically with targeted object and to analyse the properties of the object [11]. In agriculture, the use of remote sensing is to monitor the crop for decision making for farm [9]. The data from agriculture remote sensing is available in different form as were collected from multiple type of sensor [9]. UAV developed to fly lower than a satellite and any aircraft which allows it to collect high resolution images [8]. Besides that, UAV is easy to control and able to go to area that human hard to collect the information [8]. In agriculture, UAV that is equipped together with a sensor such as multispectral camera is use to capture the surface reflectance [8]. Some research conducted at Mexico, a six band of multispectral camera is use to collect the high resolution data [8]. Other research at Kelantan, Malaysia a multirotor UAV with an RGB camera was used for the image acquisition at paddy field for crop monitoring growth at early stage [7]. UAV also been used to capture high resolution images of paddy field that further will identify the yield of the paddy fields located at Tay Ninh province [12]. NDVI obtained from UAV platform that equipped with a multispectral camera to capture the images [8]. NDVI is an image indicator that mainly use in agriculture sector as measurement for remote sensing [13]. To get the NDVI value, the spectral reflectance values used to calculate based on the following formula between near infrared band (NIR) and red band [13].

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 NDVI = \frac{(NIR - RED)}{(NIR + RED)}
\]  

2. Methodology
The study area was located at Ladang Merdeka, Kampung Lundang Paku, Ketereh, Kelantan with total area of the field was 70,692.59 m². The area was a well-organized plot and the variety of the paddy seed was PadiU Putra. This is the latest variety that was invented by UPM researchers that is resistant to leaf blight disease (S1). The experimental period was conducted from January 2018 to May 2018. The methodology used in this study is as shown in Figure 1 below.
The seeds (PadiU Putra) was directly planted in the paddy field and after 20 days of planting, the UAV started the first fly and capture the images of the area. Multi-spectral camera used in this research is Parrot Sequoia multi-spectral camera. This multi-spectral camera can measure in four wavelengths; green (G), Red (R), Red Edge (RE) and Near InfraRed (NIR). With the availability of spectral bands, Normalized Difference Vegetation Index (NDVI) was selected to study the changes of rice growth using data fly on 11th February 2018 and 22nd February 2018. This index is perfect tool to evaluate the crop changes due to chronic water shortage, pest attacked and nutrient deficiencies that affect the photosynthesis activities [14]. The UAV flew around 10 am in the morning where photosynthesis activities at its peak with fixed flying height 70 m from ground which is equivalent to 2.07 cm ground spatial distance (GSD). Flying pattern (flight path) was constructed using Agisoft Phototscan software before data collection take place. Therefore, the whole area can be captured and the issues related to data lost and miss flying can be avoided. The multi-spectral camera collected the information of the crop.

2.1. Image Processing and Analysis
This study used Unmanned Aerial Vehicle (UAV) multirotor and RGB digital camera images to monitor rice crops as a primary input data. Agisoft Photoscan software was used to mosaic and align the image using Structure from Motion (SfM) algorithms. The digital numbers (DNs) from images converted into reflectance values using empirical regression equation. Later, NDVI of the study area was calculated by using the formula (1) in ArcGIS version 10.2. NDVI images for both dates were re-classify based on fixed ranges and the differences in its value were calculated and represented in percentage.

3. Result and discussion
The NDVI values normalized the reflectance captured from images into -1 to 1. A NDVI plant health values between 0 and 0.33 indicates unhealthy or stressed, 0.33 to 0.66 was moderately healthy, and 0.66 to 1 was very healthy. Figure 2 shows the NDVI images computed from UAV multispectral images before planting and after planting.
Figure 2: NDVI images computed from UAV multispectral camera before planting (a) and after 11 days of seed planting (b).

Before planting, the average values of NDVI were ranging from -1 to 0.33. This is because the rice plot area didn’t consist any crop that have an active photosynthesis activity. After planting and the seed sprout, the NDVI values changed and its average value were ranging from 0.33 to 1. This is because the active photosynthesis by young and healthy rice crop during vegetative stage give good reflectance in NIR sensor and absorb red reflectance [15]. However, some part in the rice plot have the NDVI values closed to 0.0. When referring to the RGB ortho-image, the seed that had been planted didn’t sprout and there h no photosynthesis activities happened that can be captured by the sensor. This situation happened due to the damaged, not enough water or being attack by pest and disease. Table 1 shows the differences in NDVI values for fly (a) planting and fly (b) after 11 days of planting.

Table 1. The differences in NDVI values for fly (a) and fly (b) in percentage

| NDVI range     | Fly a (%) | Fly b (%) | Difference (%) |
|----------------|-----------|-----------|---------------|
| -1 to 0        | 69.91     | 53.39     | -16.52        |
| 0 to 0.195     | 9.43      | 15.02     | 5.59          |
| 0.195 to 0.39  | 5.04      | 11.5      | 6.46          |
| 0.39 to 0.725  | 7.38      | 11.37     | 3.99          |
| 0.725 to 0.1   | 8.26      | 8.73      | 0.47          |

From table 1, range 0 to 1 has positive changes meanwhile range -1 to 0 has negative changes. This happen due to active photosynthesis by young and healthy rice crop during 11 days of seed planting. Before planting, the ranging from -1 to 0 are high because the lack of cultivation did not provide the NDVI information [16]. From this result, fast action can be made before the planting cycle end. The loss of production yield can be minimized.
4. Conclusion
Overall, NDVI is a good indicator to measure plant growth. Implementing NDVI into monitoring rice crop growth is a practical approach to increase yield production. This is because farmers can monitor their crops at the early stage and they can locate the damage area faster and overcome the problems. For future study, it is recommended to validate the NDVI values with green seeker values to verify the NDVI map in the rice field.

5. References
[1] Wang Y and Liu Y 2018 Benefits of Precision Agriculture Application for Winter Wheat in Central China Int. Conf. on Agro-geoinformatics (Agro-geoinformatics) (New Jersey: IEEE) p 1-4
[2] Khattab A, Abdelgawad A, and Yelmarthi, K 2016 Design and implementation of a cloud-based IoT scheme for precision agriculture Int. Conf. on Microelectronics (ICM) (New Jersey: IEEE) p 201-204
[3] Tri N C, Duong H N, Van Hoai T, Van H T, Nguyen V H, Toan N T and Snasel V 2017 A novel approach based on deep learning techniques and UAVs to yield assessment of paddy fields Int. Conf. on Knowledge and Systems Engineering (KSE) (New Jersey: IEEE) p 257-262
[4] Hongli L, Zhoumiqi, Y, Jinshui Z and Shuai G 2017 Highly efficient paddy classification using UAV-based orthorectified image Int. Geoscience and Remote Sensing Symp. (IGARSS) (New Jersey: IEEE) p 3230-3233
[5] Orillo J W, Cruz J D, Agapito L, Satimbre P J, and Valenzuela, I 2014 Identification of diseases in rice plant (oryza sativa) using back propagation Artificial Neural Network Int. Conf. on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM) (New Jersey: IEEE) p 1-6
[6] Sasaki T and Ashikari M 2018 Rice Genomics, Genetics and Breeding. Springer
[7] Norasma C Y N, Sari M A, Fadzilah M A, Ismail M R, Omar M H, Zulkarami B and Tarmidi Z 2018 Rice crop monitoring using multirotor UAV and RGB digital camera at early stage of growth Conf. Series: Earth and Environmental Science (London: IOP Publishing) vol 169 no 1 p 012095
[8] Ghazal M, Al KbY and Hajjdiab H 2015 UAV-based remote sensing for vegetation cover estimation using NDVI imagery and level sets method Int. Symp. on Signal Processing and Information Technology (ISSPIT) (New Jersey: IEEE) p 332-337
[9] Huang Y, CHEN Z X, Tao Y, HUANG X Z and GU X F 2018 Agricultural remote sensing big data: Management and applications J. of Integrative Agriculture vol 17 no 9 p 1915-1931
[10] Visockiene J S, Tumeliene E and Maliene V 2019 Analysis and identification of abandoned agricultural land using remote sensing methodology Land Use Policy. 82 p 709-715
[11] Hsuan W C, Hao L S and Kuo Y C 2018 Recognition of rice damage area on UAV ortho-images Int. Conf. on Applied System Invention (ICASI) (New Jersey: IEEE) p 1092-1094
[12] Tri N C, Duong H N, Van Hoai T, Van Hoa T, Nguyen V H, Toan N T and Snasel V 2017 A novel approach based on deep learning techniques and UAVs to yield assessment of paddy fields Int. Conf. on Knowledge and Systems Engineering (KSE) (New Jersey: IEEE) p 257-262
[13] Gowravaram S, Tian P, Flanagan H, Goyer J and Chao H 2018 UAS-based Multispectral Remote Sensing and NDVI Calculation for Post Disaster Assessment Int. Conf. on Unmanned Aircraft Systems (ICUAS) (New Jersey: IEEE) p 684-691
[14] Glenn D M and Tabb A 2018 Evaluation of Five Methods to Measure Normalized Difference Vegetation Index (NDVI) in Apple and Citrus Int. J. of Fruit Science. 1-20
[15] Din M, Zheng W, Rashid M, Wang S and Shi Z 2017 Evaluating hyperspectral vegetation indices for leaf area index estimation of Oryza sativa L. at diverse phenological stages Frontiers in Plant Science 8 820
[16] Fuldain G J J and Varón Hernández F R 2019 NDVI Identification and Survey of a Roman Road in the Northern Spanish Province of Álava Remote Sensing 11 6 725

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