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OIL PALM TREE GROWTH MONITORING FOR SMALLHOLDERS BY USING UNMANNED AERIAL VEHICLE

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Graphical abstract

Abstract

The development of the latest technology in agriculture such as using Unmanned Aerial Vehicle (UAV) platform, oil palm tree monitoring can be carried out efficiently by smallholders. Therefore, this study aims to determine the spectral response curve of oil palm tree growth for smallholders by using UAV Platform and payloaded with digital compact camera. The series of UAV images are then to be used to generate an orthophotos image whereby contains two types of spectrum bands which are single spectrum of near Infra-Red (NIR) and three spectrums of visible bands (RGB), respectively. Hence, a spectral response curve graph of oil palm tree condition is able to be produced based on the orthophoto as well as on-site ground validation using handheld spectroradiometer. The growth of the oil palm trees also able to be determined by analyzing the reflectance recorded from the images after generating the Normalized Difference Vegetation Index (NDVI) and Modified Soil-Adjusted Vegetation Index 2 ($MSAVI_2$), respectively. This study is successful determined that the low cost UAV platform and digital compact camera able to be used by smallholders in monitoring the oil palm tree growth condition by utilizing remote sensing techniques. As conclusion, this study has showed a good approach for smallholders in determining their oil palm crops condition whereby the results indicate all are identified healthy palm tree after spectral analysis from combination of NIR and RGB UAV images, respectively.

Keywords: Smallholder, palm oil, UAV, spectroradiometer, NDVI, $MSAVI_2$

Abstrak

Perkembangan teknologi terkini dalam bidang pertanian seperti penggunaan pesawat udara tanpa pemandu (UAV), pemantauan pokok kelapa sawit dapat dilaksanakan dengan cekap oleh pekebun kecil. Oleh itu, kajian ini bertujuan bagi menentukan lengkungan tindakbalas spektral pertumbuhan pokok kelapa sawit untuk pekebun kecil menggunakan UAV yang dipasang dengan kamera digital padat. Siri-siri imej UAV kemudian akan digunakan untuk menghasilkan imej ortofoto yang mana masing-masing mengandungi dua jenis jalur spektrum iaitu spektrum tunggal *infra-merah dekat (NIR)* dan tiga jalur spektrum sinar nampak (RGB). Oleh itu, graf lengkungan tindakbalas spektral untuk keadaan pokok kelapa sawit dapat dihasilkan berdasarkan ortofoto serta pengesahan di lapangan menggunakan *handheld* spektro-radiometer. Pertumbuhan pokok-pokok kelapa sawit ini juga dapat dikenalpasti melalui penganalisaan nilai pantulan yang direkod pada imej selepas penghasilan *Normalized Difference Vegetation Index (NDVI)* dan *Modified Soil-Adjusted Vegetation Index 2 ($MSAVI_2$)*. Hasil kajian ini berjaya mengenalpasti UAV kos rendah dan kamera digital padat dapat digunakan oleh pekebun kecil dalam memantau pertumbuhan pokok-pokok tersebut menggunakan teknik penderiaan jauh. Kesimpulannya, kajian ini menunjukkan satu pendekatan yang baik untuk pekebun kecil dalam menentukan situasi tanaman kelapa sawit mereka yang mana hasil kajian menunjukkan kesemua pokok kelapa sawit dapat dikenalpasti berada dalam keadaan sihat selepas dilakukan analisis spektral terhadap gabungan NIR dan RGB imej UAV

Kata kunci: Pekebun kecil; kelapa sawit; UAV: NDVI: $MSAVI_2$

1.0 INTRODUCTION

The oil palm is a tropical crop which is mainly grown for the industrial production of vegetable oil. In Malaysia, the oil palm plantation is one of the important industries which benefited to the investors. Apart from that Malaysia is one of the main global exporters of the oil palm production. Therefore, to support with the demands for the oil palm, the quantity and the quality of the oil palm trees must be sufficient for the industry. With the arrival of new technology for mapping, the use of Unmanned Aerial Vehicle (UAV) can assist the monitoring of oil palm trees growth and identify the condition of the trees using remote sensing technique.

Although exist large oil palm plantation owned by various business entity but the contributions from smallholders are also essential. However, the equipment and planting technologies used by the smallholder are quite different compared with the large-scale planters in term of cost and awareness in the application of up to date technologies. By using UAV, it helps smallholders to make prompt decision for a smaller area within a shorter time period based on the gathered information. Moreover, precision agriculture can be improved through this technique by acquiring a bigger amount of data in a shorter time. Furthermore, the quantifying of the entire plants population can be done based on the crop sampling from the UAV imagery [7].

In addition to the UAV advantages, the images captured will covered the whole area of the oil palm plantation. From the combination of the NIR and RGB images, an orthophoto is produced. Vegetated spectral response curve is then able to be produced from (450-900 nm) acquired by UAV platform, this generated orthophoto after validate with ground sampling. The spectral response graph trend then is interpreted and compared to grooved sampling spectroradiometer graph for the tree growth analysis. Based on range wavelength of 450-900 nm, healthy and none healthy vegetation is able to be determined. Thus, Figure 1 illustrates the trend of the typical spectral reflectance characteristic of vegetation at the range 0.4 um to 1.1 um consists RGB and NIR, respectively whereby provide benchmark to the essential information of oil palm tree analysis in improving management for oil palm tree growth. From the analysis, it is presumed that the result will benefit and support the smallholders in their oil palm planting, growth monitoring and ensure that the conditions of the trees are in a good quality by using the UAV which provide a cost effective way of collecting data. Therefore, this study aims to determine the spectral response curve of oil palm tree growth for smallholders by using UAV Platform with attached a digital compact camera.

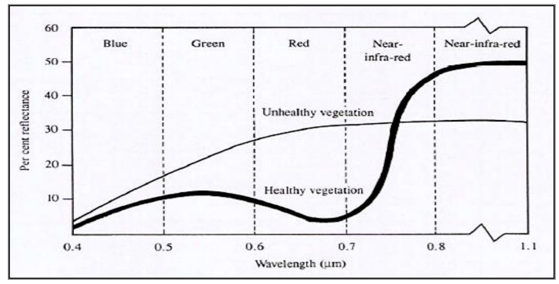


Figure 1 Typical spectral reflectance characteristics of vegetation [4]

2.0 OVERVIEW OF UAV AND VEGETATION INDICES

Recent developments of UAV technology facilitate spatial and temporal flexible acquisition of high resolution optical data [9]. Costs and required expert knowledge are decreasing due to rapid advancements in the development of hardware and software [1]. With regard to the automated inventories on the individual plant level, many point cloud based detection methods have been studied and developed for Aerial Laser Scanning (ALS) data [10]. The use of UAVs have been applied in South Africa and Australia with tasks related to animal care, especially for cattle herds and sheep. In addition, UAVs has been used for mission related to agricultural and farming works, crop monitoring, crop sowing or spraying, and herd monitoring. The practicality of UAVs and the advantages of using this platform are numerous including their cost savings and increased opportunities for usage, flexibility, endurance, and resolution. If it compared to the satellite-based remote sensing applications, UAV-based applications which considered as low altitude remote sensing have a much better resolution up to several centimeters and also have a greater flexibility in selecting suitable payloads and appropriate time and spatial resolutions [8]. Moreover, UAV images are also less interfere by atmosphere. Nowadays, UAV also has been used in vegetation field for capturing remote sensing data such as crop delineation, monitoring hydrology plantation, mapping topography plantation and also about the presentation design and field planning. Furthermore, it also able to monitor the plantation operations at the same time for every month or year and enable further proactive decisions. Consequently, UAV helps the top management, planters and manager to monitor and decision making on their plantation at near to real time.

Based on the UAV images, the analysis of the vegetation can be conducted by analysing the spectral response curve and vegetation indices such as Normalized Difference vegetation index (NDVI) as well as Soil Adjusted Vegetation Indices (SAVI). NDVI reflectance is the ratio of energy that is reflected from an object to the energy incident on the object. Spectral reflectance of a crop differs considerably in the near infrared region (λ = 750-900 nm) and in the visible red range (λ = 600-690 nm) of the electromagnetic spectrum. Plants generally have low reflectance in the blue and red portion of the spectrum because of chlorophyll absorption, with a slightly higher reflectance in the green, consequently plants appear green and healthier to our eyes. Near infrared radiant energy is strongly reflected from the plant surface and the amount of this reflectance is determined by the properties of the leaf tissues: their cellular structure and the air cell wall-protoplasm-chloroplast interfaces [5]. Meanwhile, SAVI was created as a modification of the NDVI to correct the influence of soil brightness when the vegetative cover is low. SAVI has been found to be an important step towards the establishment of simple model "global", which could explain the dynamics of the soil-vegetation system of remotely sensed data.

3.0 METHODOLOGY

Figure 2 shows the flowchart of the methodology in order to accomplish this study. The data acquisitions have been divided into three parts which involved UAV, spectroradiometer and global positioning system (GPS). The details of each step for flowchart of this study will be explained in the following section.

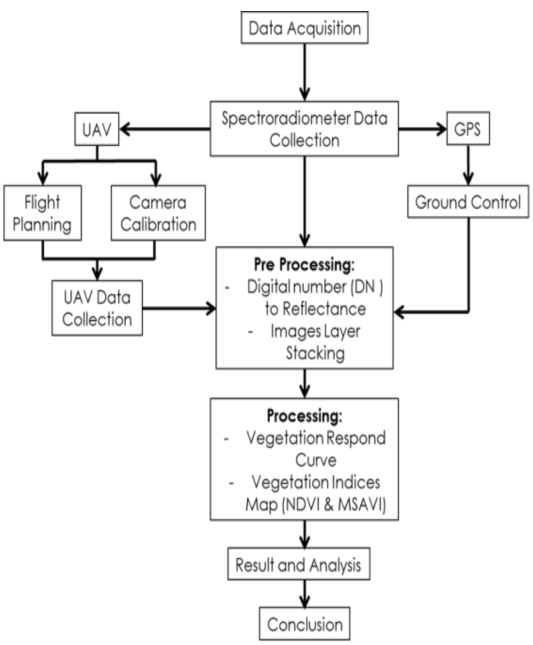


Figure 2 Flowchart of the methodology

3.1 Study Site

There are two locations for this study which situated at Sinaran Baru, Kempas and Sri Mendapat, Yong Peng and both located in Johor. A number of random nine oil palm trees were selected from both plantations and observed for three consecutive months starting from August until October of 2014. Figure 3 shows the location for both study areas (red lines). Figure 4 shows the selected oil palm trees for both study areas which represents nine trees in Kampung Sinaran Baru, Kempas and nine trees in Sri Mendapat, yong Peng, respectively. Then, Table 1 shows the vegetated study areas information for two different smallholders which consists of location, Disrict, Sub-District, Lot number, Area and Temperature.

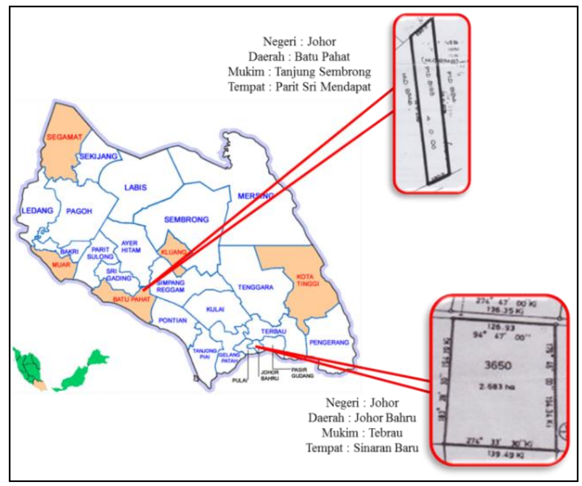


Figure 3 Location of the study area

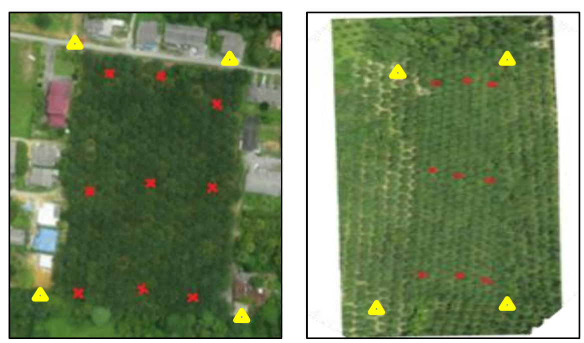


Figure 4 Selected nine of oil palm trees (red dots) and four Ground Control Point (in Sinaran Baru, Kempas (Left) and Sri Mendapat, Yong Peng (Right)

Table 1 : Study area information

No.	Description	Sinaran Baru, Kempas	Sri Mendapat, Yong Peng
1.	District	Johor Bahru	Batu Pahat
2.	Sub-district	Tebrau	Tanjong Sembrong
3.	Lot No.	Lot 3650	PTD 8193
4.	Area	2.583 ha	1.6187 ha
5.	Temperature	Min = 24°C Max = 33°C	Min = 25°C Max = 33°C
6.	Rainfall	Avg= 159mm	Avg= 249mm

3.2 UAV and Spectroradiometer Data Collection

The UAV was used as platform for image acqusition and the handheld spectroradiometer was used for ground measurement spectral vegetation. Nine selected oil palm trees from both locations (Sinaran Baru, Kempas and Sri Mendapat, Yong Peng) were observed by using handheld spectroradiometer in August, September and October 2014, respectively as shown in Figure 4. The UAV images were covered to whole oil palm planted area at smallholders for both places. For this study, the type of UAV platform used is the Quadcopter Walkera XR Q350 Pro (Figure 5) and the compact digital camera used is Canon PowerShot xs260 (Figure 6). The lens of Canon PowerShot xs260 which was built is used to capture RGB images, meanwhile modify filter is used for NIR images. Below are the specifications for both of the UAV and compact digital camera as shown in Table 2 and Table 3 respectively.

Figure 5 XR Q350 Pro UAV

Table 2 Specification of XR Q350 Pro UAV

Criteria	Specification
Main Rotor Diameter	556mm
Main Rotor Blade Length	206mm
Length	289mm
Width	289mm
Height	200mm
Battery	3S 11.1V 5200mAh LiPoly
Flight Time	25 minutes

Figure 6 Canon powershot XS260 camera

Table 3 : Specification of canon powersot XS260 camera

Criteria	Lens
Focal Length	4.5 – 90.0 mm (35 mm equivalent: 25 – 500 mm)
Zoom	• Optical 20x • ZoomPlus 39x • Digital Approx. 4.0x (with Digital Tele-Converter Approx. 1.5x or 2.0x and Safety Zoom[1]). Combined Approx. 80x
Maximum f/number	f/3.5 – f/6.8
Construction	12 elements in 10 groups (1 UA lens, 2 double-sided asphetical lens)
Image Stabilization	Yes (lens shift-type), 4-stop. Intelligent IS
Effective Pixels	Approx. 12.1M

In collecting the spectroradiometer data, the oil palm trees branches need to be cut for spectral observation and to produce the spectral response graph (Figure 8). Figure 7 show the handheld spectroradiometer was used in this study and Table 4 shows its specifications.

Figure 7 FieldSpec handheld spectroradiometer

Table 4 Specification of fieldspec handheld spectroradiometer

Criteria	Specification
Wavelength range	325-1075 nm
Integration times	User selectable; 2n x17 milliseconds for n = 0, 1, ... , 15
Scan Averaging	Up to 31,800 spectral scans can be averaged
Spectral Sampling Interval	1.6 nm
Spectral Resolution	3.5 nm at 700 nm
Size	22 x 15 x 8 cm
Weight	1.2 kg including battery pack

The 17th fronds of the oil palm tree were chosen for the spectroradiometer observation in this study in order to be used as indicator for oil palm growth trends. Therefore, a total of 9 different oil palm trees branches were used in this study for each location.

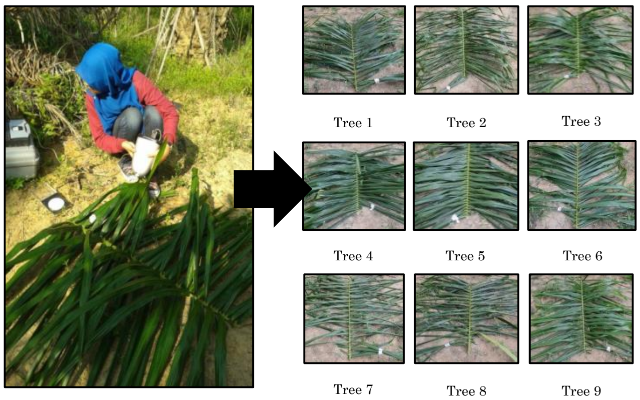


Figure 8 Collecting data of spectral reflectance using spectroradiometer (Left) and Nine of selected 17th frond oil palm trees (Right)

3.3 Flight Planning

Flight planning is one of important aspect for flying a UAV for any purposes of obtaining aerial images. Without flight planning, it is difficult to plot the area of work that need to be covered. In flight planning, it consists of flight lines on the map of the specified area and also the control points for the photos [1]. Additionally, flight lines illustrate the starting and ending point for the UAV to fly in a straight line. A skilled person is needed to fly the UAV according to its planned flight lines in order to capture a reliable image.

The flight planning used specific software for example the Mission Planning software. By using this type of software, the flying altitude, flying speed, the waypoints and also the flying duration of UAV can be simulated. Besides that, the flight lines (Figure 9) are also useful because it will be used for determining the needed number of images to be captured according to the time interval that has been plan in flight planning software.

Figure 9 Flight lines for UAV

3.4 Camera Calibration

In this study, camera calibration was conducted to obtain parameter of the camera calibration for interior orientation processing in image processing. Camera calibration aims to know the values for camera calibration parameters in order to produce accurate spatial information from photo. The camera calibration parameters are focal length (c), radial lens distortion (k_1, k_2, k_3), decentring lens distortion (p_1 and p_2) and also the principle point location (x_p and y_p). Photomodeler software was used in obtaining the values of the camera parameter. Figure 10 show the camera calibration was conducted and Table 5 shows the lists of the camera calibration parameter.

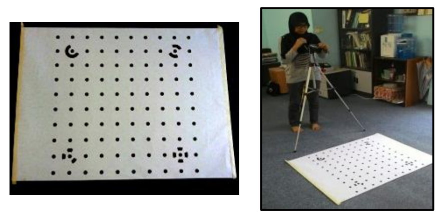


Figure 10 Camera calibration setting up

Table 5 Parameter of the camera calibration

Parameter	Value
C (mm)	4.729283
X_P(mm)	2.785234
Y_P(mm)	2.112750
K_1	9.883×10^{-4}
K_2	1.302×10^{-5}
K_3	0
P_1	-1.830×10^{-4}
P_2	1.454×10^{-4}

3.5 Ground Control Point

Ground control point (GCP) was established for aerial image processing. A total of four GCP were established using Topcon Global Positioning System (GPS) through rapid static technique for both study area respectively as shown in Figure 4. The purpose of establishment of GCP is to produce sufficient points from it to do the aerial triangulation. This step must be done to make sure that each model can be oriented for the stereo compilation in orthophoto accurately. From the aerial triangulation, the ground coordinate for the value of X, Y, and Z are obtained [1]. Table 6 and Table 7 show the GCP coordinates for Sinaran baru, Kempas and Sri Mendapat, Yong Peng respectively.

Table 6 Coordinate of the GCP in Sinaran Baru

Stesen	Latitude	Longitude
1	1° 36' 07.981"	103° 43' 04.563"
2	1° 36' 07.729"	103° 43' 08.341"
3	1° 36' 01.302"	103° 43' 09.074"
4	1° 36' 02.494"	103° 43' 02.233"

Table 7 Coordinate of the GCP in Sri Mendapat

Stesen	Latitude	Longitude
1	1° 56' 55.867"	103° 06' 06.343"
2	1° 56' 57.933"	103° 06' 07.884"
3	1° 56' 51.625"	103° 06' 13.574"
4	1° 56' 49.306"	103° 06' 11.224"

3.6 Mosaicking and Layer Stacking

Mosaicking has been done for stitching the UAV images in order to produce the orthophoto of the study area. Agisoft PhotoScan Professional was used for aerial image processing which involved align photos, build dense cloud, build mesh and build texture. Figure 11 and Figure 12 show the orthphoto of RGB and NIR that has been successfully produced after through image processing process using Agisoft Photoscan Professional software.

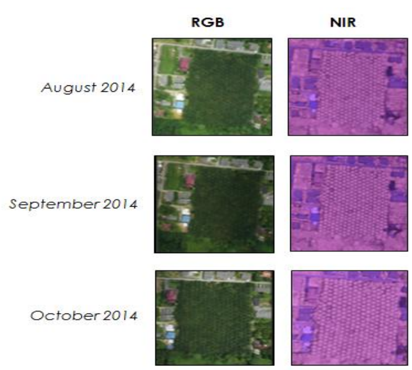


Figure 11 Generated orthophoto in Sinaran Baru, Kempas

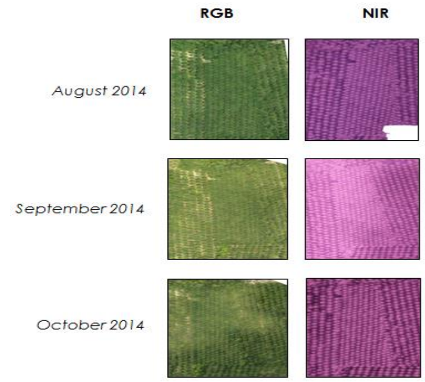


Figure 12 Generated orthophoto in Sri Mendapat, Yong peng

Image layer stacking was processed after doing geomatic correction using image processing software. Image layer stacking process is used for overlapping the images of 4 bands which consists of red, green, blue and NIR data.

3.7 Radiometric Correction

The following formula is deploy to all UAV images in this study to convert the value of digital number to radiance (L_λ) [7] (equation 1):

$$L_\lambda = G_{rescale} \times Q_{cal} + B_{rescale} \qquad (1)$$

Where,

$G_{rescale}$ = The different between the value of $L_{MAX\lambda}$ and $L_{MIN\lambda}$

Q_{cal} = The quantized calibrated pixel value in Digital Number (DN)

$L_{MIN\lambda}$ = The spectral radiance that is scaled to Qcalmin in W/(m2.sr. μm)

$L_{MAX\lambda}$ = The spectral radiance that is scaled to Qcalmax in W/(m2.sr. μm)

After converting the DN to radiance, it is needed to be converted to reflectance value. Below is the formula for converting the radiance to the reflectance value as shown in equation 2:

$$\rho_p = \frac{\pi \times L_\lambda \times d^2}{ESUN_\lambda \times \cos\theta_\lambda} \qquad (2)$$

Where:

ρp = Unitless planetary reflectance

Lλ = Spectral radiance at the sensor's aperture

d = Earth-Sun distance in astronomical units

ESUNλ = Mean solar exoatmospheric irradiances

θs = Solar zenith angle in degrees

After converting to the reflectance then spectral response graph can be generated from all UAV images for Sinaran Baru and Sri Mendapat, respectively.

3.8 Processing

Today, NDVI and MSAVI2 maps were emphasized in this processing topic. These maps were produce for performing the analysis of the oil palm trees in both locations. The NDVI and MSAVI2 formula were used in this study as shown in equation 3 and equation 4 respectively. NDVI and MSAVI2 values are represented as a ratio ranging in value from -1 to +1.

$$\mathrm{NDVI} = \frac{R_{NIR} - R_{Red}}{R_{NIR} + R_{Red}} \qquad (3)$$

Where,
R_{NIR} = the reflectance of NIR radiation
R_{Red} = the represenattive of the reflectance of visible red radiation

$$\mathrm{MSAVI}_2 = \frac{2\times(\mathrm{NIR})+1-\sqrt{(2(\mathrm{NIR})+1)^2-8\,(\mathrm{NIR}-\mathrm{Red})}}{2} \qquad (4)$$

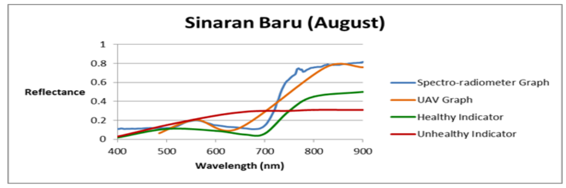
Where,
NIR = the reflectance value of the near infrared band
Red = reflectance of the red band

4.0 RESULTS AND ANALYSIS

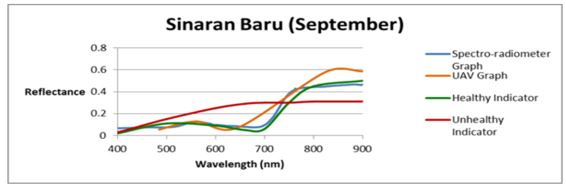
Othophotos were produced for three different months of August, September and October in year 2014. A total of 6 graphs were plotted for the spectral graph reflectance which represents the relationship between the spectroradiometer, UAV, healthy and unhealthy indicator for Sinaran Baru and Sri Mendapat study area respectively. Meanwhile, 2 graphs were plotted the mean reflectance in 3 months which illustrates the relationship between the spectroradiometer, UAV, healthy and unhealthy indicator for both study area. A total of 12 NDVI map and MSAVI2 map were produced for both of study area. NDVI and MSAVI2 values are represented as a ratio ranging in value from -1 to +1 which represents -1 as below -1 is unhealthy while 0 to 1 is healthy indicator of oil palm tree.

4.1 Spectral Response Graph of Reflectance

Based on the spectral reflectance graph from spectroradiometer and UAV respectively, it able to be compare by referring the spectral benchmark of the healthy and unhealthy vegetation indicator. The reflectance graph for UAV and spectroradiometer were derived from the spectral reflectance of the selected nine oil palm trees for every month from August to October. The mean values of the spectral reflectance of selected trees are obtained. Figure 13 and Figure 14 represent the mean graph of reflectance by using spectroradiometer and UAV in three month for Sinaran Baru, Kempas and Sri Mendapat, Yong Peng, respectively.



(a)



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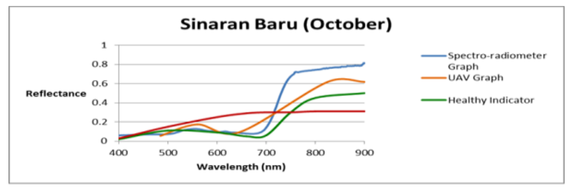
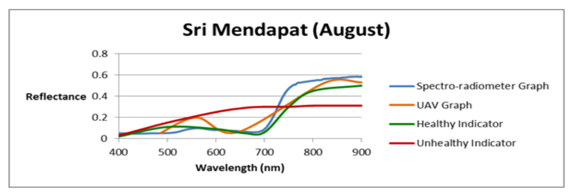
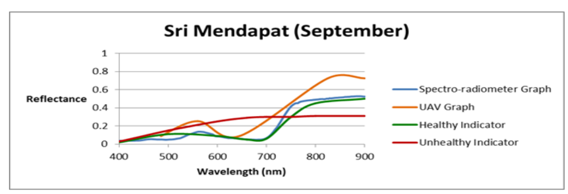


(c)

Figure 13 Comparison of oil palm mean reflectance for Sinaran Baru, Kempas in year 2014 (a) August (b) September (c) October



(a)



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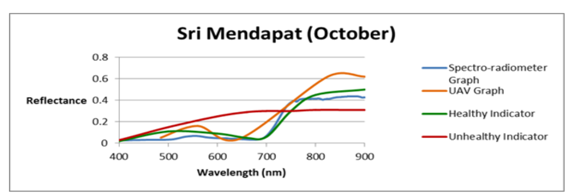


(c)

Figure 14 Comparison of oil palm mean reflectance for Sri Mendapat, Yong Peng in year 2014 (a) August (b) September (c) October

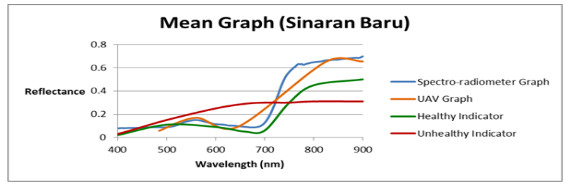
The reflectance value on the wavelength of 750nm until 900nm signify the NIR band which is the band that commonly been used in identifying the vegetation condition. The values for the reflectance are in the range of 0 and 1 or in the percentage which the value indicates the unhealthier and healthier vegetation representatively. Therefore, this value is important to recognize the condition of the vegetation.

Sinaran Baru, Kempas graph of the reflectance in August and October for the spectroradiometer and UAV indicate the healthy palm tree whereas the value of reflectance is above 0.5 or 50 percent as shown in Figure 13 (a) and (b) respectively. Based on the graph shown, it indicates that the nine oil palm trees which were selected are healthy because the reflectance values at NIR wavelength are higher than the trend of healthy indicator. Meanwhile, it has a low value in the visible band shown blue (450-520 nm) and red band (600-690 nm).whereby healthier oil palm tree strongly absorb red, green and blue during photosynthesis process. However, good photosynthesis process demonstrates green spectrum is a bit higher compared to the red and blue spectrum.

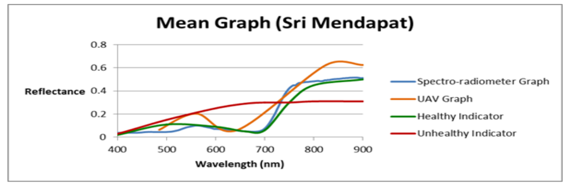
The reflectance values of spectroradiometer in September as shown in Figure 13(b) are slightly below the healthy indicator but simultaneously above the unhealthy indicator. Based on the UAV reflectance values, it demonstrates the healthy condition with the reflectance value of 0.6. It can be seen that spectroradiometer and UAV reflectance value for Sinaran Baru, Kempas in September shown similar increasing trend at the NIR wavelength and indicates that the oil palm trees are healthy which both gives a high number of reflectance respectively.

Meanwhile, Sri, Mendapat, Yong Peng reflectance graph in August and September for the spectroradiometer and UAV indicate above the healthy indicator as shown in Figure 14(a) and (b) which specifically developed from the typical spectral reflectance characteristic of vegetation [4]. It shows that the values of the reflectance are above 0.5 or 50 percent for Sri Mendapat, Yong Peng reflectance graph in August and September respectively. Furthermore, the spectral reflectance of UAV and spectroradiometer graph in October for Sri Mendapat, Yong Peng as shown in Figure 14(c)are above the unhealthy indicator however UAV spectral reflectance revealed a high reflectance value above 0.6 or 60 percent.

Figure 15 show the mean graph of the value of spectral reflectance for the whole 3 month (August, September and October) for both study area situated in Sinaran Baru, Kempas and Sri Mendapat, Yong Peng respectively.



(a)



(b)

Figure 15 Comparison of oil palm mean reflectance for three month (August, September, and October) in (a) Sinaran baru, Kempas and (b) Sri Mendapat, Yong Peng

From the figure shown as above, the mean of the reflectance graph for both study area are above the healthy indicator. Thus it shows that the trend of the spectral reflectance graph between the UAV and Spectroradiometer, respectively produced similar pattern (increasing) which indicate the selected oil palm trees have higher reflectance value more than 0.4 and it can be demonstrated that the selected oil palm trees are healthy for both study area.

4.2 NDVI Map

Orthophoto was generated and have been used for producing the NDVI and MSAVI2 map for both study area which represents for August, September and October in year 2014. These diagrams were used to support the value or the trend of the spectral reflectance graph from the UAV images obtained. Figure 16 until Figure 21 shows the NDVI diagram with its different colour to differentiate the condition of the vegetation based on its range in Sinaran Baru and Sri Mendapat, respectively.

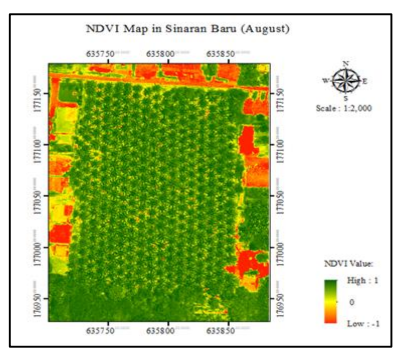


Figure 16 NDVI for Sinaran Baru, Kempas in August, 2014

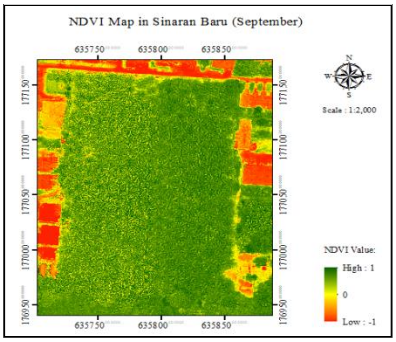


Figure 17 NDVI for Sinaran Baru, Kempas in September, 2014

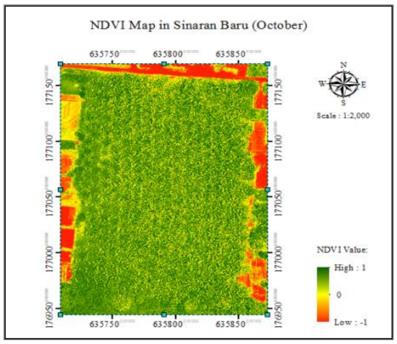


Figure 18 NDVI for Sinaran Baru, Kempas in October, 2014

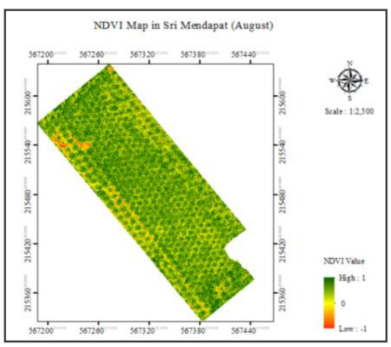


Figure 19 NDVI for Sri Mendapat, Yong Peng in August, 2014

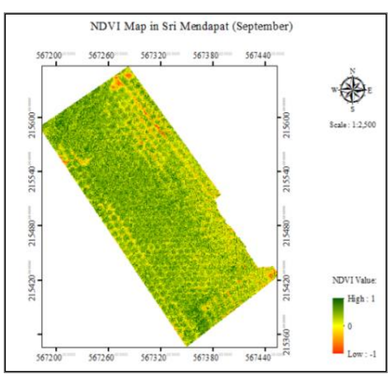


Figure 20 NDVI for Sri Mendapat, Yong Peng in September, 2014

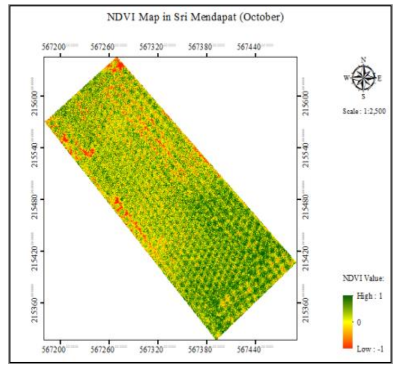


Figure 21 NDVI for Sri Mendapat, Yong Peng in October, 2014

Theoretically, the healthy vegetation generally will absorb most of the visible light that shine on it, and reflects a large portion of the NIR light. Meanwhile, the unhealthy or sparse vegetation will reflects more of visible light and less near-infrared light. Furthermore, bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum. Therefore, the bigger the difference between the near-infrared and the red reflectance, the more vegetation there has to be. From the NDVI maps shown in Figure16 until Figure18, it can be seen that the value of NDVI at Sinaran Baru from August, September until October, the green colour of the trees are varies and indicates the condition of the oil palm trees are mostly healthy because it is range above the level of zero or have a high value. This illustrate that the oil palm trees reflected a high portion of NIR light which signified the trees are healthy.

Morever, for Sri Mendapat, the NDVI maps (Figure 19 until Figure 21) showed that most of the oil palm trees are varies in the green colour and this condition stated that the value of reflectance is near to one which indicates the higher greeness. The red or yellow colour that is showed in the map indicates bare soil and the trees that have low greenness which gives below -1 value.

4.3 MSAVI$_2$ Map

The generations of MSAVI2 are quite similar with the generation of NDVI but each generation has its own purposes. The MSAVI2 has been shown to increase the dynamic range of the vegetation signal while further minimize the soil background influences and resulting in the greater vegetation sensitivity as defined by a "vegetation signal" to "soil noise" ratio. Figure 22 until Figure 27 show the MSAVI2 map that have been produced based on UAV platform images.

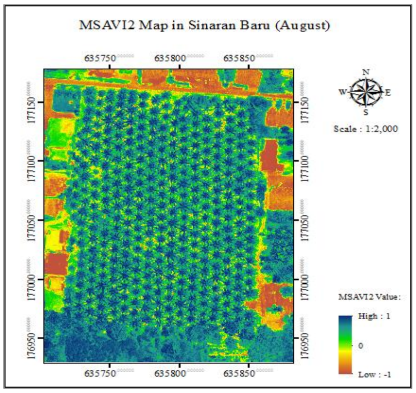


Figure 22 MSAVI2 for Sinaran Baru, Kempas in August, 2014

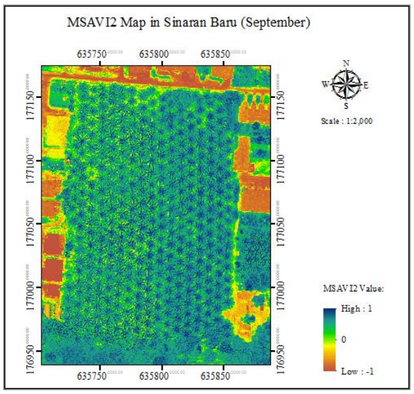


Figure 23 MSAVI2 for Sinaran Baru, Kempas in September, 2014

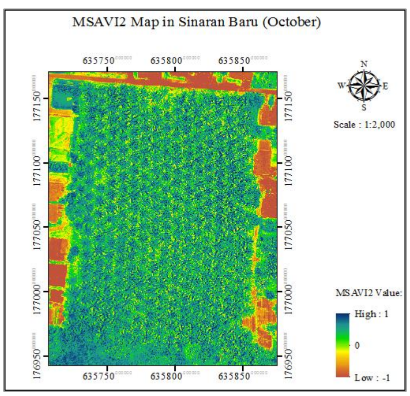


Figure 24 MSAVI2 for Sinaran Baru, Kempas in October, 2014

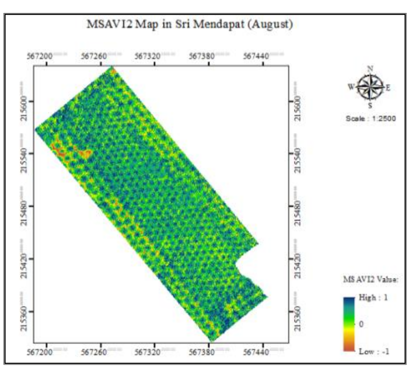


Figure 25 MSAVI2 for Sri Mendapat, Yong Peng in August, 2014

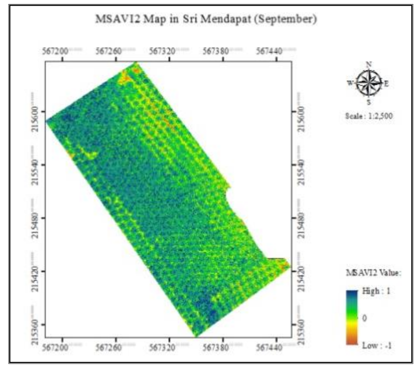


Figure 26 MSAVI2 for Sri Mendapat, Yong Peng in September, 2014

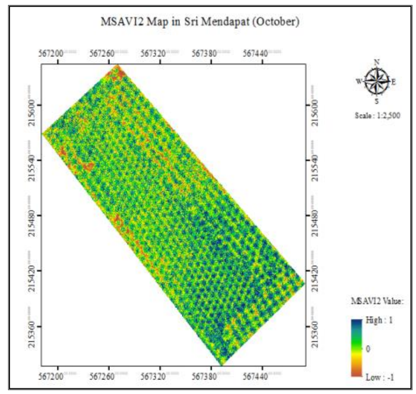


Figure 27 MSAVI2 for Sri Mendapat, Yong Peng in October

The output of MSAVI2 is a new image layer representing vegetation greenness with values ranging from -1 to +1. The highest value shows that the area of study has a high amount of green vegetation.

Based on the MSAVI2 map above, in the area of oil palm in Sinaran Baru, Kempas throughout those three months (August, September and October), majority of the oil palm trees represent a very high dispersion of blue colour which indicate majority of the oil palm trees in this study are healthy. Furthermore, the value that is near to zero represents the low vegetation covered, meanwhile the value that is below zero (negative value) represent the bare soil area (non-vegetation).

Meanwhile, for Sri Mendapat, Yong Peng, the map for MSAVI2 shows the same result as in Sinaran Baru which the oil palm trees shows a high saturation of blue colour (high value of index range) for August, September and October, respectively.

From the result that are obtained which is the spectral reflectance graph, NDVI maps and MSAVI2 maps for August, September and October, study has determined that the increasing trend of the UAV and spectroradiometer graph are supported by the high value of NDVI and MSAVI2 for both study area.

5.0 CONCLUSION

As a conclusion, it can be summarised that the objective of this study were achieved. The spectral reflectance graph of the UAV and the spectroradiometer showthe same trend each other. Furthermore, the use of UAV in identifying the condition or the stated of the oil palm tree growth can be accepted. Besides that, the orthophoto that is generated from the UAV images can be used in the generation of the spectral reflectance graph in order to observe the trend of the graph in the visible band and also in NIR band. The spectral reflectance for the oil palm trees were used in order to identify or to detect the level of the condition of the trees based on the value of the index range. The value of the both vegetation indices shown the result obtained are linked with each other in order to present the value of the oil palm reflectance where the higher the value of the reflectance, so the higher the vegetation cover and more healthier (greenness). Although the areas of this study are different location, but the pattern or the trend of the result produced are similar. Therefore, this study discovered that the UAV platform which classified under low altitude remote sensing technique is a good practice for oil palm tree growth monitoring and provide low cost and quick respond information whereby suitable for smallholders. Based on the study conducted, RGB digital compact camera and NIR filter also are able to generate a good spectral response curve for oil palm that been proved after compare with ground-based spectroradiometer observation.

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