ICBAA2017-18

EVALUATION OF eCOGNITION SOFTWARE FOR OIL PALM TREE COUNTING UNDER DIFFERENT PLANTING CONDITIONS AND AGES

Haryati Abidin, Mohd Na'aim Samad, Lee Yang Ping and Muhammad Khairul Anuar Mohd Noor

Felda Global Ventures Research & Development Sdn Bhd, Level 14, Menara Felda, Persiaran KLCC, 50088, Kuala Lumpur, Malaysia
haryati.a@feldaglobal.com
mnaaim.s@feldaglobal.com
yangp.lee@feldaglobal.com

***Abstract**:* Oil palm tree counting is a process of calculating the number of individual trees using either labour intensive manual or remote-sensing method. This information can be used later in estate management and research in plant health monitoring for cultivation area. Tree counting information is a starting point in managing the background information of each palm tree using Geographic Information System (GIS). Agronomic and breeding information can be stored in the GIS table and retrieved at any time. Currently, the palm count figures provided by ground worker are labor-intensive and error-prone exercise of manual counting without using new mapping technologies to periodically monitor tree counting. The consequence of the incorrect palm count could be low bunch yield and fertilization regime is not optimized as per hectare basis. By using remote sensing and GIS technology, precise and accurate map of palm count can be produced and exact amount of fertilizer can be determined correctly to optimize fertilizer dosage and hence cost saving. The eCognition Oil Palm Solution is one of the palm counting software in the market that manages to calculate the palm trees automatically. In this paper, we evaluated the palm counting accuracy from the software under different oil palm planting conditions and ages.

Keywords: oil palm, automated palm counting, remote sensing, Unmanned Aerial Vehicle (UAV), eCognition, precision farming

INTRODUCTION

Oil palm is a perennial monocot plant with a long production cycle of fruit bunches for about 25 years. It is an important economic crop in tropical areas of Southeast Asia, Africa and South America. Oil palm is the most efficient oilseed crop in the world when compared to other oilseed crops such as soybean, sunflower, rapeseed or canola, peanut, cottonseed, coconut, olive, etc. One hectare of oil palm plantation can produce up to ten times more oil than other leading oilseeds [1].

The information on the exact number of oil palm trees is essential for predicting the yield of fresh fruit bunch, monitoring the growth of palm trees and maximizing their productivity [2]. Accurate inventories and monitoring of oil palm cultivation areas are critical for plantation management and planting area expansion. Currently, the manual palm counting activities are performed by ground workers. This method is intensive man-hours without using new mapping technologies to obtain accurate counting and periodically perform tree counting every two years. Labour intensive of manual palm counting activities hindrance our effort to predict the fertilisation regime and the oil yield per hectare basis.

Remote sensing is one of the most reliable measurement tool for accurate monitoring over large areas [3]. By using remote sensing and GIS technology, precise and accurate map of palm counting can be produced and exact amount of fertilizer can be determined correctly to optimize fertilizer dosage and hence cost saving. Automated palm counting software is one of the crucial steps for the management to continuously monitor the accurate inventories

of the palm numbers utilizing remote sensing images. The eCognition Oil Palm Solution is one of the palm counting software in the market that manages to calculate the palm trees automatically.

METHODS

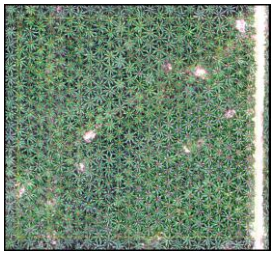
Image data has been collected using Fixed-wing UAV model namely CD Skywalker equipped with RGB Canon S100 with built-in GPS. Detail specifications of this UAV are described in Figure 1.

Particular
CD Skywalker UAV System :
Model : CD Skywalker UAV
Auto Pilot : Auto Pilot Mega 2.5 with GPS and power module (open source)
Ground Control Station : Planner Software
Camera : Canon S100 GPS 12.1 MP
Telemetry : RDF 900 Long Range Modem (>5km)
Flight Duration : 40 minutes depends on weather condition
Material : EPO and Carbon Fiber
Power System : Electric Power
Endurance : 45 minutes
Light Rain Resistance : No
Wind Ressistance : Up to 30 KM/H
System Weight : 2.2 Kg
Replacement Parts : Off the shelf professional quality hobby product.

We digitally mapped four different estates with different types of terrain and planting age as stated in Table 1. Definition of young palm is where the palm tree has produced bunches and harvested before with the small crown with no contact with adjacent palm trees. On the other hand, matured palm is where the palm crown is in contact and mix with adjacent palm trees. Young age tree is around 1 to 6 years and matured palm is around 7 to 25 years.

Table 1: The planting condition category, location and output image resolution.

No.	Planting Condition Category	UAV Image	Area (ha)	Image Output Resolution	Location
1.	Hilly with young palm tree		3.5 ha	Ortho = 10cm DSM = 40cm	Lepar Utara, Pahang
2.	Hilly with mature palm tree		3.5 ha	Ortho = 10cm DSM = 39cm	Kerteh, Terengganu

3.	Flat with young tree		3.5 ha	Ortho = 7cm DSM = 27cm	Serting, Negeri Sembilan
4.	Flat with mature tree		3.5 ha	Ortho = 8cm DSM = 31cm	Tembangau, Negeri Sembilan

Raw images obtained from UAV were processed using Agisoft Photoscan Version 1.2 software. The images were processed with medium quality of image and digital surface model (DSM) to generate ortho image. All processed images were exported to Trimble eCognition Oil Palm Solution software. Each image representing different planting area must include three main types of data which were ortho image, DSM and boundary of the image area. We tested three levels of crown detection sensitivity (30%, 60% and 90%) for each ortho image and DSM data and the results has been collected and compared.

The details of the flow of works can be clearly defined as in Figure 2:

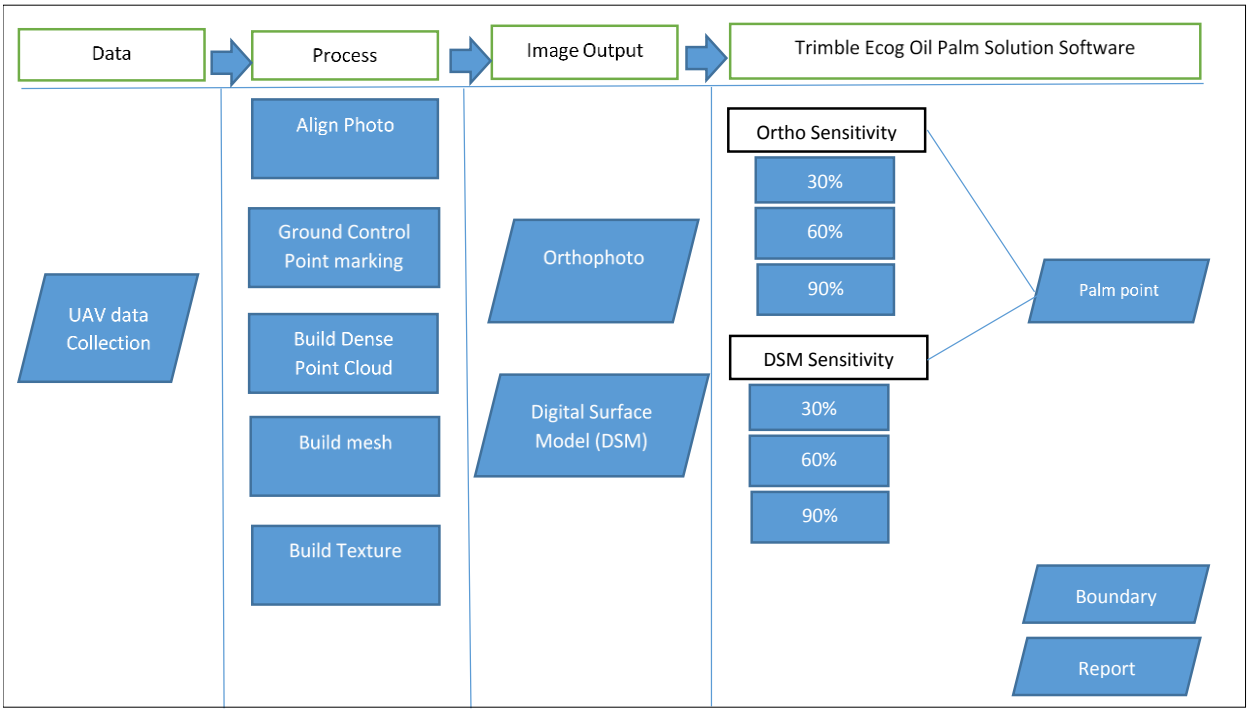


Figure 2: Methodology of the processing using Agisoft Photoscan and Trimble eCognition oil palm solution software.

RESULTS AND DISCUSSION

There were 4 images that represented hilly and flat area (Table 1). The first two images represented hilly area planted with young palms at Lepar Utara, Pahang and the other one is matured palms at Kerteh, Terengganu. There are 2 flat areas that were used as study area which was Serting Hilir, Negeri Sembilan that is planted with young palms and Tembangau, Negeri Sembilan that is planted with matured palm. Table 2 shows the result of automated palm counting using Trimble eCognition oil palm solution software with different setting of image and DSM sensitivity. The number of palms counted using eCognition software were compared with manually counted palm number as shown in Table 2.

Table 2: Total number of palm counted from Trimble eCognition oil palm solution software with different sensitivity.

Hilly	Actual Palm Count	eCognition Software Sensitivity (Number of Palm)														
		0% ortho, 30% DSM	0% ortho, 60% DSM	0% Ortho, 90% DSM	30% ortho, 30% DSM	30% ortho, 60% DSM	30% Ortho, 90% DSM	60% ortho, 30% DSM	60% ortho, 60% DSM	60% Ortho, 90% DSM	90% ortho, 30% DSM	90% ortho, 60% DSM	90% Ortho, 90% DSM	30% ortho, 0% DSM	60% ortho, 0% DSM	90% Ortho, 0% DSM
Young Tree 1 to 6 Years **Lepar Utara**	**526**	18	103	172	18	103	172	140	209	268	604	611	630	0	128	604
Matured 7 to 25 Years **Kerteh**	**361**	14	65	147	30	81	163	339	380	449	505	541	608	16	330	500
Flat	Actual Palm	Ecognition Software Sensitivity (Number of Palm)														
		0% ortho, 30% DSM	0% ortho, 60% DSM	0% Ortho, 90% DSM	30% ortho, 30% DSM	30% ortho, 60% DSM	30% Ortho, 90% DSM	60% ortho, 30% DSM	60% ortho, 60% DSM	60% Ortho, 90% DSM	90% ortho, 30% DSM	90% ortho, 60% DSM	90% Ortho, 90% DSM	30% ortho, 0% DSM	60% ortho, 0% DSM	90% Ortho, 0% DSM
Young Tree 1-Jun **Serting**	**544**	312	430	479	312	430	479	317	434	481	614	620	625	0	17	601
Matured Jul-25 **Tembangau**	**447**	33	84	115	52	101	130	439	449	464	474	484	499	21	431	468

Figure 3 until 6 show the number of automated palm counting. The most left graph shows the variation of automated palm numbers where both ortho image and DSM sensitivity was changed from 30%, 60% and 90%. The centre graph shows the variation of automated palm count numbers where only the DSM sensitivity changed and ortho image sensitivity remained at 0% (the sensitivity of ortho image were not used). The most right graph shows the variation of automated palm count number where the DSM sensitivity were not used, and only the ortho image sensitivity were changed.

Table 3 until 6 show the accuracy between the actual and eCognition palm counting numbers. In Lepar Utara where the area is hilly and the palms are young (1 to 6 years), the highest accuracy achieved was 87.09%, with 90% ortho image sensitivity and 30% DSM sensitivity. With the ortho sensitivity of 90% and DSM sensitivity of 60%, the accuracy was up to 86.09%. A slightly higher accuracy was achieved with 87.09% accuracy with the ortho sensitivity of 90% and DSM sensitivity of 30% or 0%. This result shows that for young palms planted at hilly area, the use of DSM did not produce a good accuracy. For mature palms at hilly area in Kerteh (Table 4), 60% ortho and DSM sensitivity was sufficient to obtain accuracies up to 95%. Even without DSM sensitivity (or 0%), the accuracy of palm counting in Kerteh was up to 91.41% (60% of ortho sensitivity). To detect young palms at flat area in Serting, 7 out of 15 tests produced accuracies more than 85% (Table 5). The highest accuracy produced was 90.52% where no DSM sensitivity and 90% of ortho sensitivity selected. Lastly, for flat area with matured palms, the highest accuracy achieved was 99.55% with 60% ortho and DSM sensitivity.

Table 3: Accuracy of palm counting number for young palms planted at hilly area in Lepar Utara, Pahang.

Ecognition Software Sensitivity	Number of Palm extracted from eCognition software	Number of Actual Palm	Accuracy (%)
0% Ortho, 30% DSM	18	526	3.42
0% Ortho, 60% DSM	103	526	19.58
0% Ortho, 90% DSM	172	526	32.70
30% Ortho, 30% DSM	18	526	3.42
30% Ortho, 60% DSM	103	526	19.58
30% Ortho, 90% DSM	172	526	32.70
60% Ortho, 30% DSM	140	526	26.62
60% Ortho, 60% DSM	209	526	39.73
60% Ortho, 90% DSM	268	526	50.95
90% Ortho, 30% DSM	604	526	87.09
90% Ortho, 60% DSM	611	526	86.09
90% Ortho, 90% DSM	630	526	83.49
30% Ortho, 0% DSM	0	526	0.00
60% Ortho, 0% DSM	128	526	24.33
90% Ortho, 0% DSM	604	526	87.09

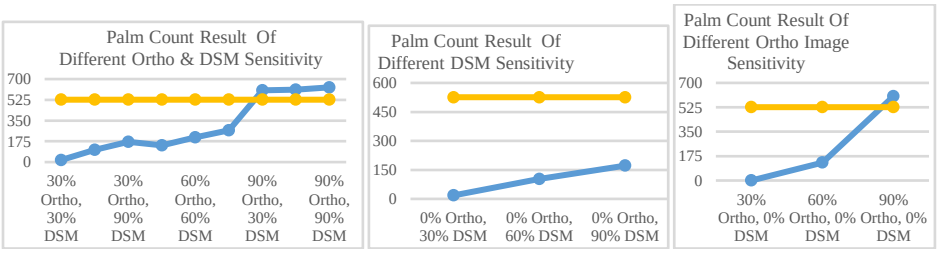


Figure 3 : Result of automated palm count number for young palm trees in hilly area.

Table 4: Accuracy of palm counting number for mature palms planted at hilly area in Kerteh, Terengganu.

Ecognition Software Sensitivity	Number of Palm extracted from eCognition software	Number of Actual Palm	Accuracy %
0% Ortho, 30% DSM	14	361	3.88
0% Ortho, 60% DSM	65	361	18.01
0% Ortho, 90% DSM	147	361	40.72
30% Ortho, 30% DSM	30	361	8.31
30% Ortho, 60% DSM	81	361	22.44
30% Ortho, 90% DSM	163	361	45.15
60% Ortho, 30% DSM	339	361	93.91
60% Ortho, 60% DSM	380	361	95.00
60% Ortho, 90% DSM	449	361	80.40
90% Ortho, 30% DSM	505	361	71.49
90% Ortho, 60% DSM	541	361	66.73
90% Ortho, 90% DSM	608	361	59.38
30% Ortho, 0% DSM	16	361	4.43
60% Ortho, 0% DSM	330	361	91.41
90% Ortho, 0% DSM	500	361	72.20

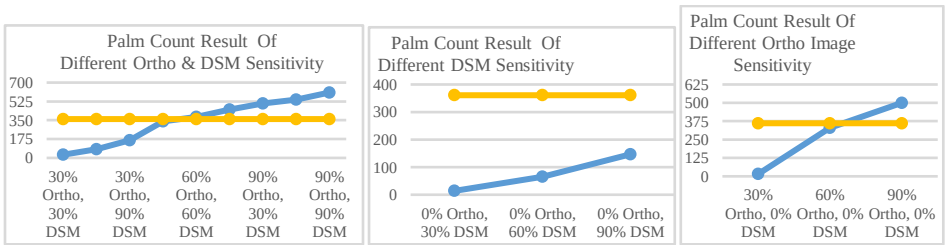


Figure 4: Result of automated palm count number for matured palm trees planted at hilly area.

Table 5: Accuracy of palm counting number for young palms planted at flat area in Serting, Negeri Sembilan.

eCognition Software Sensitivity	Number of Palm extracted from Ecognition software	Number of Actual Palm	Accuracy %
0% Ortho, 30% DSM	312	544	57.35
0% Ortho, 60% DSM	430	544	79.04
0% Ortho, 90% DSM	479	544	88.05
30% Ortho, 30% DSM	312	544	57.35
30% Ortho, 60% DSM	430	544	79.04
30% Ortho, 90% DSM	479	544	88.05
60% Ortho, 30% DSM	317	544	58.27
60% Ortho, 60% DSM	434	544	79.78
60% Ortho, 90% DSM	481	544	88.42
90% Ortho, 30% DSM	614	544	88.60
90% Ortho, 60% DSM	620	544	87.74
90% Ortho, 90% DSM	625	544	87.04
30% Ortho, 0% DSM	0	544	0.00
60% Ortho, 0% DSM	17	544	3.13
90% Ortho, 0% DSM	601	544	90.52

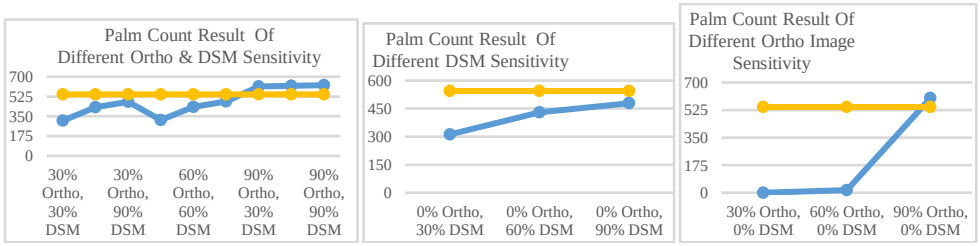


Figure 5: Result of automated palm count number for young palm trees planted at flat area.

Table 6: Accuracy of palm counting number for matured palms planted at flat area in Tembangau, Negeri Sembilan.

Ecognition Software Sensitivity	Number of Palm extracted from Ecognition software	Number of Actual Palm	Accuracy %
0% Ortho, 30% DSM	33	447	7.38
0% Ortho, 60% DSM	84	447	18.79
0% Ortho, 90% DSM	115	447	25.73
30% Ortho, 30% DSM	52	447	11.63
30% Ortho, 60% DSM	101	447	22.60
30% Ortho, 90% DSM	130	447	29.08
60% Ortho, 30% DSM	439	447	98.21
60% Ortho, 60% DSM	449	447	99.55
60% Ortho, 90% DSM	464	447	96.34
90% Ortho, 30% DSM	474	447	94.30
90% Ortho, 60% DSM	484	447	92.36
90% Ortho, 90% DSM	499	447	89.58
30% Ortho, 0% DSM	21	447	4.70
60% Ortho, 0% DSM	431	447	96.42
90% Ortho, 0% DSM	468	447	95.51

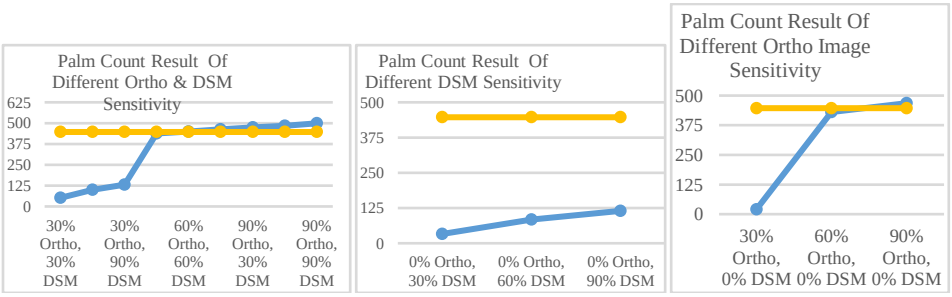


Figure 6: Result of automated palm count number for matured palm trees planted at flat area.

CONCLUSIONS

For the hilly area, automated palm counting number obtained from eCognition analysis for both young and matured palm achieved with high accuracies even without the DSM sensitivity as long as the ortho image quality is good and the resolution is high (10 cm). For the flat area planted with young palms, with ortho image of 7 cm resolution, we achieved the best accuracy without the DSM sensitivity and only relies on ortho image sensitivity. With 8 cm resolution and 31 cm DSM resolution for flat area planted with mature palms, a high palm counting accuracy was

achieved. In order to get the best result in flat and matured palm trees, the sensitivity of both ortho and DSM should be around 60% for both ortho and DSM. İn conclusion, the medium quality of UAV image is sufficient to generate automated palm counting from Trimble eCognition Palm Solution Software.

REFERENCES

Palm Oil Facts and Figures. Available online: http://http://www.simedarby.com/upload/ Palm_Oil_Facts_and_Figures.pdf.

Weijia Li, Haohuan Fu, Le Yu and Arthur Cracknell **"**Deep Learning Based Oil Palm Tree Detection and Counting for High-Resolution Remote Sensing Images" Remote Sens. 2017, 9, 22, www.mdpi.com/journal/remotesensing.

Panu Srestasathiern, Preesan Rakwatin "Oil Palm Tree Detection with High Resolution Multi-Spectral Satellite Imagery" Remote Sens. 2014, 6, www.mdpi.com/journal/remotesensing

The Oil Palm Tree, www.mpoc.org.my.

J.N Lee, K.C Kwak "A Trends Analysis of Image Processing in Unmanned Aerial Vehicle " World Academy of Science, Engineering and Technology, International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol:8, No:2, 2014.