Analysis of aerial photo for estimating tree numbers in oil palm plantation

Rizky Aidil P P¹, Liyantono² and M Solahudin²

¹Agricultural and Food Machinery Engineering Department, Bogor Agricultural University, Bogor
²Department of Mechanical and Biosystem Engineering, Bogor Agricultural University, Bogor

E-mail: aidiltmb47@gmail.com

Abstract. Oil palm is one of the many plant species in Indonesia as a large-scale plantation commodity. In precision agriculture, detecting the vegetation in plantation was a first and crucial step prior to addressing further objectives such as counting plants for monitoring or detecting canopy diameter of the tree for yield estimation. Monitoring and census covering the number of trees and tree conditions in the oil palm plantation is always carried out periodically, which takes time and the number of workers in the area of palm oil plantation. In this study focused on the development of methods that can be applied to accelerate the process of calculating palm trees in plantations using image processing, Unmanned Aerial Vehicle (UAV) and Graphic User Interface (GUI) technology. The planned process of program development is composed of four steps: (1) shooting the aerial picture of the plantation by UAV, (2) User interface for trees counting development, (3) validation result on the program. The procedure of data analysis is mainly focused on separating several image objects with different color compositions for separation into the object label form through the process of erosion, deletion, deletion until calculations can be made directly from the user interface program. Calculation evaluation of the results obtained from the program that has been develop obtained the success tree detection compared with number of tree actual data from the program rate of 96.13% and the accuracy of tree recognition that shown the correction tree detection from the program of 95.5%. Trials on several trees for diameter estimation with different plant ages resulted in Root Mean Square Error (RMSE) of 2.2917 cm and Mean Absolute Percentage Error (MAPE) of 0.1796%.

1. Introduction

Indonesia is one of biggest oil palm production in the word. palm oil is one of the commodities that thrive in Indonesia. In oil palm plantation have a big area for plantation purposes based on the age of planting. Monitoring is one of many important process to check the tree condition in that areas. The big area in the plantation need many worker and time to finish the monitoring process. Precision farming is integrated agriculture system based on the information and the production, to increase the efficiency and productivity.
in the agriculture sector and decrease the risk for the environment [8]. Precision farming use calculation and technology that support precision treatment for every process based on location, time, condition, product and consumer for the specific condition.

In precision agriculture, detecting the vegetation in herbaceous crops in early season is a first and crucial step prior to addressing further objectives such as counting plants for germination monitoring, or detecting weeds for early season specific weed management. Discrimination of the crop plants in their first stages of development needs images at very high spatial resolution, often in the order of mm or very few cm [3].

Many definitions for Precision Agriculture exist and many people have different ideas of what PA should encompass. Precision farming or precision agriculture is a farming or agro-industry management concept based on observing and responding to intra-field variations. It relies on new technologies like imagery and information technology. It is also aided by farmers’ ability to locate their precise position in a field using satellite positioning system like Global Positioning System (GPS). PA is known has the capabilities to: (1) optimize production efficiency; (2) optimize quality; (3) minimize environmental impact; and (4) minimize risk [4]. The procedure of data analysis is mainly focused on separating several image objects with different color compositions for separation different object in the picture and labeling the different object, process of erosion to reduce number of pixel to separate overlap tree with another tree in the picture, dilation to increase the number of pixel after erosion procedure to normalized number of pixel every oil palm canopy, deletion for remove another object except oil palm and number of the trees calculation from user interface development program.

2. UAV for remote sensing application

UAV is unmanned aerial vehicle that powered by electrical motor or combustion engine with remote control or autopilot system and use ground control station. Application of UAV for remote sensing especially in agricultural sector are discussed. UAVs typically fly at low altitudes to acquire remote sensing data also known as low altitude remote sensing (LARS). UAV for LARS application mostly use fix wing type of UAV which lighter and long flight time than another type.

Corcoles, et al [2] use vertical take-off and landing (VTOL) type on micro drone in quadcopter type for determinate land cover in shallot plant. Solahudin, et al (2015) [5] use UAV for Gemini virus analysis in chili plant using bayes segmentation. Berni, et al [1] use helicopter type of UAV with hyper spectral and thermal camera for monitoring on vegetation areas. Based on literature, it’s possible to develop new method for remote sensing in another issue in agricultural sector.

2.1. System description

Characteristics of Indonesia plantations have a big planting areas that require UAV which can use to cover large areas to take an image of oil palm trees. In this part used fix wing type of UAV to get aerial picture of palm oil plantation. In this research, the picture taken in 300 m above surface using RGB camera. UAV picture shown in figure 1.
2.2. Camera sensor and picture

Taken a picture in this research used RGB camera as *Canon PowerShoot S100* which using automatic time interval system in camera. The local length of camera setup is 5 mm on fix mode, the picture took in 300 m of altitude above the surface. In that method, camera setup as shooter speed, and white balance used fix value, but in ISO used auto. The setting shown in table 1.

| Camera          | Canon S100 digital camera |
|-----------------|---------------------------|
| Shooter speed   | 1/1000                    |
| f               | 2                         |
| ISO             | Auto                      |

Altitude camera catchment shown in figure 2 that informed the difference area catchment from the different altitude. In this research the altitude set at 300 m above the surface because in the 300 m altitude
the picture still available to separate into the different object and the resolution in 10 cm/pixel and the coverage area around 15 Ha.

2.3. User interface development
User interface was made in this research to simplify image processing in the picture of oil palm plantation. User interface using a several thresholds in the color of the image to separate every object in the picture in order to get the only oil palm trees for image analysis.

After finished the program, the next step was validation of the program. The validation of the program using comparison of the data from the field and the result of the program as the reference to the error and accuracy value of the program.

2.4. Data field collection
Manual land data collection in oil palm plantation was the important procedure that must been taken to the reference for the accuracy correction of the program result. The data was number of the trees in the field, canopy diameter in the difference ages to validated the result of the program.

2.5. Validation
Validation of this program is done by comparing result data from the program and land data from the field to get the accuracy value and error for the reference in the result of the program and had a value that is close to the actual state in the field. Validation is proof through testing and procurement of objective evidence to prove that the results produced by the model have results that are close to the results obtained directly. Validation is done by equating the number of trees produced with the program and which is done by manual calculation on some oil palm plantations.

2.6. Data analysis procedure
Data analysis is done by using the help of Matlab software. Calculation of the number of trees is obtained from the image that separated by object segmentation and the calculation of the average diameter on the field. The next step of image analysis was to compare the color composition of each pixel to separated types of objects in the image to be identified as a whole and made into binary images to identified the number of the trees and canopy diameter of the trees. Identification in the program is done by comparing the color composition of each object with another objects so that can be separated by different objects (Solahudin 2015) [5].

3. Result and discussion
3.1. User interface development
The program was developed using Matlab where the user interface was created first. The user interface is made to simplify and speed up the user in processing the image. The user interface is shown in Figure 3. The image processing system in the user interface is carried out by doing some threshold on the image because in this research using RGB picture from the oil palm picture. In user interface development, some accent features are given to detect trees and calculate the number of trees in the image and the diameter of the canopy on the tree.

3.2. Image processing
Filtration treatments in the image need to be carried out in several processes because in the oil palm plantations there are other plants that exist on the same area and when viewed based on the levels of red, green and blue have equal values as shown in figure 2.
Figure 3. Composition of object picture (a) red, (b) green, (c) blue.

Figure 3 shows RGB color composition of each object in the image where the RGB values are shown to overlap between the other object’s boundary. In this study used color modification logic to found separator between each object in the picture.

Table 2. Modification of color combination in picture.

| Color    | R    | G    | B    | r/g  | r/b  | g/r  | g/b  | b/r  | b/g  |
|----------|------|------|------|------|------|------|------|------|------|
| Oil palm | min  | 0    | 89   | 1    | 0    | 0    | 0    | 0.895| 0    | 0.01 |
|          | max  | 108  | 255  | 162  | 0.702| 58   | 119  | 188  | 51   | 1.12 |
| another  | min  | 49   | 98   | 0    | 0.212| 0    | 0.61 | 0    | 0    | 0    |
| plant    | max  | 249  | 255  | 103  | 1.645| 56.5 | 4.72 | 44   | 1.73 | 0.72 |
| road     | min  | 73   | 0    | 44   | 0    | 0.29 | 0    | 0    | 0.17 | 0    |
|          | max  | 255  | 190  | 255  | 7.286| 5.8  | 2.56 | 1.172| 3.49 | 2.12 |

Boundaries determination of objects in the image is done by using RGB color from the images that have been obtained and shown in table 2, and table 2 shown that there is no boundary border between each image object when use modification color value in the picture. Image processing is done by image processing method using several times of filtering by utilizing the RGB color from the image. Images produced from taking aerial photographs in the form of images with an RGB camera.

The filtering process was carried out by eliminating some image objects such as roads, shadows, other plant except oil palm trees and palm fronds that touch with other oil palm trees. Object separation in this research applied by using multiple threshold that shown in figure 4.
Transformation of RGB image become multichannel image using precision scale to color properties value between 0-1 that shown in figure 5 and the value of separation limit between oil palm tree and another object in the picture of 0.74 in multichannel scale to separate the object. The function of decoration stretching in multichannel image was increase the scale of color differences in an image. Detection of the oil palm tree using erosion and dilation filter which the function was to separate the double tree in the picture become single tree and dilation filter to restore the real size of the palm oil tree according to the size removed after the erosion filter that shown in figure 6. The next steps after erosion and dilation filter was labeling and deleting the object and the last steps was detecting oil palm trees.

Figure 4. Image transformation process.

Figure 5. Scale value of multichannel image.
Figure 6. Image transformation (a) Erosion, (b) Dilation.

Figure 6 (a) shown oil palm trees size reduction process to separate several connected oil palm trees, and figure 6 (b) shown the restoration size of oil palm trees after erosion filter according to the removed size in the erosion filter. Automatic detection of oil palm trees in program using binary image from the dilation filter that shown in figure 7.

Figure 7. Number of tree counting in GUI.

3.3. Program validation

Number of trees calculation done using a GUI that has been made previously. In figure 7 shown a red circle was a tree detected by the program in the form of diameter in pixels which converted into units of cm. The calculation results of the program shown in table 3 and obtained tree detection accuracy of 96.13% and detection success of 95.477% after validation of the results obtained directly.

| number | Number of tree | Tree detection | Overlap trees | Wrong tree | Program detection | Not a tree error (%) |
|--------|----------------|----------------|---------------|------------|-------------------|---------------------|
| 1      | 1216           | 1161           | 4             | 4          | 1169              | 4.523026316         |
| 2      | 237            | 230            | 0             | 3          | 233               | 2.953586498         |

Calculation of diameter is done by means of a circle multiplied by the resolution obtained at the height that has been set when taking the picture. In diameter detection, it was done by comparing the field results with the results of the program. Field measurements obtained diameter of oil palm canopy of 1076 cm by using a measuring instrument. While with program detection obtained the results shown in figure 8.
Figure 8. User interface detection results for canopy diameter.

The next step was validation of the program using RMSE and MAPE to estimated average diameter error in the program with different altitude with actual data from the field. From Figure 8 shows the testing graph that shown every different altitude can produce same value in the diameter detection. The validation one of several tree with RMSE results of 2.2917 cm and MAPE result of 0.1796%.

4. Conclusion and suggestion

4.1 Conclusion
Application of UAVs to taking pictures and image processing still has a difference from the obtained results. Image processing using image processing method from GUI produces accuracy of tree detection compared with number of actual tree data from the program rate of 96.13% and the success rate of correct trees detection was 95.5% and the detection error of tree canopy diameter using RMSE was 2.2917 cm and MAPE result of 0.1796%. Using this method is expected to shorten the decision making process in the planning of oil palm plantation. With using image processing to monitoring oil palm plantation can reduce the time to make the decision about the number of tree and measurement the canopy diameter. autopilot system feature in UAV can be easy for people to operate a UAV to monitoring the field using sampling method in the field to check the oil palm trees.

4.2 Suggestion
The improvement and development of this method is very applicable, such as increasing the accuracy of the GUI so that the results are far closer to the actual results, as well as the development of the GUI to be able to produce calculations up to the prediction of production on the observed land.

5. Reference
[1] Berni J, Tejada P, Suarez L, Gonzalez D, Fereres F 2009 Int. Arch. Photogramm. Remote Sens. Spatial Inform. Sci 38 6
[2] Corcoles J, Ortega J, Hernandezz D, Miguel M 2016 Biosystems Engineering 115 31
[3] Pena J, Sanchez J, de Castro A, Kelly M, Lopez G 2013 Pone Journal 0077151
[4] Rokhmana Catur A 2015 *Procedia Environmental Sciences* vol 24 (Amsterdam: Elsevier) p 245
[5] Solahudin M, Pramudya B, Liyantino, Supriyanto, Manaf R 2015 *Procedia Environmental Sciences* vol 24 (Amsterdam: Elsevier) p 254
[6] Whelan B, Taylor J 2013 *Field Crops Research* **155** 133