Evaluation The Accuracy of Oil Palm Tree Detection Using Deep Learning and Support Vector Machine Classifiers

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Abstract. Oil palm is one of the important sources of vegetable oil that is mostly consumed by the Malaysian citizen. Because the demand of vegetable oil is high in Malaysia, the expansion of oil palm tree plantation has been increasing rapidly. Remote sensing application in monitoring and detecting oil palm trees has become a very useful tool to help minimize the human energy to monitor in large plantations. The aim of this study is to evaluate the accuracy of oil palm tree detection using deep learning and support vector machine (SVM) approaches using high-resolution remote sensing images. Deep learning is one of the base frameworks for oil palm tree detection using high-resolution remote sensing images. Deep learning also is a counting tool provided in newest technology software such as ArcGIS Pro, where the tools use the pattern recognition concept as a template in detecting objects in a high-resolution image. In machine learning, support vector machines are supervised learning models with associated machine learning algorithms that analyse data for classification analysis. Based on this study, 91% of the oil palm trees detected using deep learning approach gained higher accuracy than SVM classifier with 86%. The accuracy of oil palm tree detection using deep learning is higher than the accuracy of support vector machine classifier. Based on the findings, deep learning approach create better object interpretation than SVM. The oil palm tree detection using both classification approaches had also been displayed by using a spatial map distribution for easier analysed and observation.

1. Introduction

Oil palm trees in Malaysia are one of the most important economic crops in agriculture. Oil palm production in Malaysia has become the world’s second largest producer in Asia after Indonesia. According to Malaysia Palm Oil Industry (MPOB), based on 2016 data collected, the total planted area of palm oil in Malaysia was 4.917 million hectares [1]. However, the large area of oil palm trees in Malaysia has also brought negative effects and become an issue since deforestation, loss of living space and other social issues has occurred [2]. The locals have to deal with various obstacles and dangers including wildlife wandering around without their homes and the increasing number of homeless people as the result of excessive oil palm tree development [2]. Therefore, detecting, monitoring and counting oil palm trees in local areas are important to make sure the issues stated can be overcome and increase the profitability of the country.

Modern approach of object detection has many phases of classification development in remote sensing applications. They are categorized as pixel-based classification, object-based image analysis, machine learning and deep learning-based classification approaches. In this study, deep learning and machine learning image classification methods are used to detect oil palm trees using high-resolution remote sensing images. Machine Learning is a study of computer algorithms in a hardware program and
also a subset of an artificial intelligence program [3]. Machine learning is a predictive analysis used to classify or detect objects in a wide area using remote sensing imagery [3]. Meanwhile, deep learning is the modern detection remote sensing and GIS application that has been used by many researchers recently. Deep learning is more accurate than other classification approaches as it combines neural networks from artificial intelligence in machine learning and object features classifiers in a software [4].

2. Methodology

This section discusses the related procedures used in evaluating the accuracy of oil palm trees detection using deep learning and SVM classifiers as shown in figure 1. In this study, high spatial resolution of Unmanned Aerial Vehicle (UAV) imagery is used. UAV imagery is suitable for oil palm tree detection using deep learning and support vector machine methods as it contains high-spatial resolution data [5]. Data processing involve creating training dataset for deep learning and SVM model, set the image dataset label prediction and using deep learning and SVM model to generate the spatial distribution map of oil palm trees as results.

Figure 2 shows the study area that is located in D’QNut Chalet and Restaurant, Kuala Sungai Baru, Malacca. Based on Figure 2, the UAV imagery had processed using Pix4D software. The pixel size for this image is 0.028m. The image is in .tif format with four numbers of bands altogether. The projected coordinate system used in this image is World Geodetic System (WGS) 1984 in UTM Zone 47N and the projection used is Transverse Mercator.

![Figure 1. Research Methodology](image-url)
2.1. Pre-Processing
Aerial photography need to be geometrically corrected before being used for further process by establishing the relationship between the image coordinate system and the geographic coordinate system using calibration data of the sensor, measured data of position and attitude, ground control points and many more [6].

After geometric correction has been made, the image has to be subset. Subset image is important as it can crop or subset the image according to the desired study area without losing its data value or pixel values [7].

Next, the number of oil palm trees is manually interpreted by digitizing in GIS software to produce the reference data for accuracy assessment. Once the high-resolution images are obtained, the images used as input data in any GIS software to be digitized. In this study, ArcGIS Pro software is used to digitize manually the total number of oil palm trees using Edit Tools provided in ArcGIS Pro. The output data obtained in manual digitizing is used as a reference dataset for accuracy assessment in this study.

2.2. Data Processing
Data processing in this project involve in using two methods of classifications tools that is deep learning and support vector machine methods using ArcGIS Pro software. ArcGIS Pro is an advance software that may support analysis for raster and vector data simultaneously. Both of the classification methods used to classify oil palm trees and produced accuracy assessment to be compared and analysed at the end of this study after obtained the results.

2.2.1 Deep Learning Classification Method. There are three (3) steps regarding the deep learning process, it includes preparing training data, training a deep learning model and using the model to classify oil palm trees using deep learning classification tools in ArcGIS Pro software.

First step is to create the training samples which in this project are oil palm trees on the UAV imagery data in the ArcGIS Pro software. In ArcGIS Pro, users can create training samples using Label Objects for Deep Learning tools. Users can identify and label the objects first before proceeding to train a deep learning model using the neural network. The train model then will be used to perform inference results on data [8].

Second step is to train a deep learning model using PyTorch or other third-party deep learning framework such as TensorFlow or Keras that uses the specified Python raster function to process each object in an image. A train deep learning model must run on an input raster and an optional feature class to produce a feature class or table in which each input object or feature has an assigned class or category.
label in the previous step. To train a deep learning model, image chips must be used, obtained by previous step, by the output of exportation training data for deep learning tools [9].

Third step in the deep learning method is to use geo-processing tools to generate the output of oil palm tree detection by using Detect Objects Using Deep Learning tool in ArcGIS Pro software.

2.2.2 Support Vector Machine (SVM) Classification Method. Support Vector Machine classification method is a new modern technique of supervised classification for the features using remote sensing images. SVM used a machine learning algorithm to classify the features on the images accurately with great performance. This method requires only one training sample for each of the features to produce a great accuracy result. However, to obtain a perfect result, the more the training samples collected for each feature, the more the accuracy gain in the output result.

First step is to create the training samples for the features visible on the high-resolution UAV image. The image used in this study, obtained only three features available or visible on the image, there are oil palm tree, soil and gaps features. Support vector machine can detect all the features on the image using one sample of each feature only. But in this study, to achieve an accurate result, five samples for each feature on the UAV image is done.

Second step is to run the support vector machine (SVM) detection by using Classify tools in ArcGIS Pro software. Classify tool is a classification technique to classify pixels or objects or features in a raster dataset, based on this study is UAV image.

Third step is creating accuracy assessment points using Create Accuracy Assessment Point tools in ArcGIS Pro software. This tool is specifically used to extract the accuracy value for the features detected using classification image with single band or integer data type.

Fourth step is to classify the existing class features into its original features, based on the ground truth data. From this process, an analysis of accuracy assessment can be obtained by performing the compute confusion matrix. Confusion matrix tables can visualize to the analyst the accuracy of each feature processed using support vector machine classification.

2.3 Accuracy Assessment
Accuracy assessment is to determine the accuracy of the classification result with a reference dataset. In this study, the accuracy assessment for both deep learning and support vector machine classification methods are using the different formula and computation to gain their own classification accuracy, using ArcGIS Pro software. Both results obtained from the processing involved in ArcGIS Pro, be compared to the ground truth data and the UAV image itself.

\[
\text{Precision} = \frac{\text{Number of correctly detected palm trees}}{\text{Number of all detected trees}} \tag{1}
\]

\[
\text{Recall} = \frac{\text{Number of correctly detected palm trees}}{\text{Number of palm trees in ground truth}} \tag{2}
\]

\[
\text{Overall Accuracy} = \frac{\text{Precision} + \text{Recall}}{2} \tag{3}
\]

Detection results from deep learning classifier were assessed using three equations which consist of precision, recall and overall accuracy formula to be computed using oil palm detection [10]. The precision is the probability value that a detected oil palm tree is valid as in equation (1), recall is the probability value that an oil palm tree in ground truth is detected as in equation (2) and the overall accuracy is the average of precision and recall as in equation (3), and also can be used to assess the oil palm tree detection using deep learning classifier.

Confusion matrix was using to assess the tree detection from SVM classifier. Computes a confusion matrix with errors of omission and commission and derives a kappa index of agreement and an overall accuracy between the classified map and the reference data.
3. Results & Analysis

3.1. Classifying the Oil Palm Trees
The results of classifying the oil palm trees in this study are divided by two different classification approaches applied using ArcGIS Pro software, which are deep learning and support vector machine classifiers.

![Figure 3. Result of oil palm trees detection using deep learning](image)

Figure 3 shows the result of oil palm tree detection using a deep learning method using ArcGIS Pro software. Based on Figure 3, the results of deep learning processes shown in the yellow colour box are not merged directly on top of the oil palm trees in the UAV imagery. The yellow box is located in a long range between one another and also the oil palm trees itself. The total number of correctly detected oil palm trees is 75, as there are four yellow boxes that incorrectly detected the oil palm tree. Each of the yellow boxes represents as one tree feature. The deep learning detection based on the output of the oil palm tree detected and the ground truth data is 79 trees and 86 trees respectively, which means that the percentage of the detection performance is 92%.

![Figure 4. Result of palm trees detection using support vector machine](image)

Figure 4 shows the result of oil palm trees classification using the SVM classifier. As in Figure 4, there are three features indicated with three different colours altogether. There is dark green colour which indicates the oil palm trees, brown colour indicates soil, light brown colour indicates gaps, between the palm trees, on the imagery.
3.2 Comparison of Accuracy for Oil Palm Detection

The results of the accuracy of oil palm trees classification in this study are divided by two different methods applied using ArcGIS Pro software, which are deep learning and SVM classifiers as shown in Figure 5.

![Figure 5](image-url)

Figure 5. Comparison accuracy of oil palm trees classification. (a) tree detection from deep learning, (b) tree detection from SVM

Evaluating accuracy of the performance of oil palm tree detection using deep learning classification method, involves the precision, recall and overall accuracy of the oil palm tree detection results through comparison with the manually digitizing oil palm trees.

| Evaluation Index                        | Deep Learning | Support Vector Machine |
|----------------------------------------|---------------|------------------------|
| Number of oil palm trees in ground truth | 86            | 86                     |
| Number of all detected trees            | 79            | 48                     |
| Number of correctly detected palm trees | 75            | 57                     |
| Precision                              | 0.949         | -                      |
| Recall                                 | 0.872         | -                      |
| User Accuracy                          | -             | 0.941                  |
| Producer Accuracy                      | -             | 0.774                  |
| Overall Accuracy                       | 0.911         | 0.858                  |
| Overall Accuracy Percentage            | 91%           | 86%                    |

Table 1. Evaluation the accuracy of oil palm tree detection

Based on Table 1, the number of correctly detected oil palm trees derived from deep learning is 75 trees. The accuracy assessment for the oil palm trees in support vector machine classification is computed as the User’s accuracy is plus with Producer’s accuracy and divided by two, to get the overall accuracy assessment for oil palm tree feature using support vector machine classification. The User’s accuracy for palm feature is 0.941. The Producer’s accuracy of the palm feature is 0.774. So, the number of overall accuracy assessment for oil palm tree feature in support vector machine technique is 0.858.

In this study, deep learning achieved 91% of accuracy, while support vector machine achieved 86% of accuracy for detecting oil palm trees using orthophoto. Deep learning achieved 91% and is the
highest accuracy because it is only used on one feature or object to process and detect the objects. Deep learning obtained the highest accuracy also because the method only classifies one specific homogeneous pattern and pixels for one object.

Furthermore, even though deep learning method produced higher overall accuracy for detecting oil palm trees than support vector machine, User Accuracy and Producer Accuracy obtained in support vector machine are also high in accuracy for oil palm tree feature detection. User Accuracy achieved 0.941 which is represented as 94% of accuracy for oil palm tree features. This means that there are less errors of commission, therefore the User Accuracy is high. Meanwhile, Producer Accuracy gained is 0.774 or 77% for detecting oil palm tree feature on the orthophoto. There are less errors of omission, therefore the Producer Accuracy is high.

3.3 Map distribution of Oil Palm Tree Detection

![Figure 6. Map distribution using deep learning method](image)

Two distribution maps of oil palm tree detection were produced using deep learning support vector machine approaches. Figure 6 shows the map distribution of oil palm trees by using a deep learning method in ArcGIS Pro software. The coordinate system used in this map is World Geodetic System (WGS) 1984.
Figure 7. Map distribution using support vector machine

Figure 7 shows the map distribution of oil palm trees using the support vector machine method in ArcGIS Pro software. The map consists of three classes which are palm feature represent as dark green colour, soil feature represents as brown colour and gaps feature represent as light brown colour in the raster image of the final output from support vector machine classification technique.

4. Conclusion

This study successfully evaluates the accuracy of oil palm trees detection using deep learning and support vector machine classifiers. The classified oil palm trees using deep learning obtained by producing many yellow boxes that identified one yellow square box as a one palm tree. Whereas, the classified oil palm trees in support vector machine method produced in raster image, as a supervised classification result, following with the shape or the crown of the oil palm trees itself.

The accuracy obtained for oil palm trees classification using deep learning and support vector machine methods had been compared and produced its analysis. The accuracy of oil palm tree detection using deep learning method is 91%, which is higher than the support vector machine classifier which is 86%. Both classifiers produced good detection results with more than 85% accuracy, however a deep learning classifier was capable to detect accurately with 75 trees as compared to 48 detections using SVM classifier. Hence, deep learning classifier is recommended to be used for oil palm trees detection and may assist for accurate tree detection.

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