Tree Species Identification Using High Resolution Remotely-Sensed Data

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Key words: Forest, Tree, remote sensing, LiDAR

SUMMARY

Mapping and identification of tree species is a key component in forest conservation and management. The spatial mapping of tree species has becoming more important due to locational interest of high market value timber or can be used for medicational purposes. Conventional method using surveying techniques was adopted in order to identify the location of different tree species in forests. This technique is rather challenging at inaccessible area, labour intensive and time consuming. Recently, high resolution remote sensing imagery and LiDAR technology provide very high spatial resolution information of Earth surfaces. This study presents an approach for mapping individual tree species using combination of airborne LiDAR and WorldView-2 imagery. Combination of both WorldView-2 imagery and airborne LiDAR data provides a very promising remote-sensing source for mapping tree species of the study area.

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1. INTRODUCTION

The identification of tree species is important for a variety resource management and monitoring activities including riparian buffer characterization, wildlife habitat assessment, wildfire risk assessment and biodiversity monitoring (Brandtberg, 2007). The traditional way of identification of tree species using large-scale aerial photographs are costly affair, time-consuming and not suitable to isolated areas or large areas. Nowadays, many digital data such as aerial photographs, satellite imagery and high resolution data can be used to find the tops of trees, estimation tree length, sizes and volumes. The image processing has made possible to measure height and vertical structure of forest structure and may be able to proceed in combination with other optical data. LiDAR data can be used for determination tree species, their location and others characteristic

Light detection and ranging (LiDAR) is also used to describe at an unprecedented level of detail the biophysical characteristics of woody vegetative communities. LiDAR has proven to be of great assistance to ecologists and foresters by efficiently determining tree heights and other forest attributes (Alia et al., 2008). Moreover, LiDAR can characterize forest ecosystem in more detail than typical remote sensing applications by determining stand structure, composition et. The coupling of LiDAR with other remote sensing methods can be used for extraction of tree height, leaf area index, basal area, crown dimensions and aboveground biomass (Korpela et al., 2010). Identification of tree species using high resolution Worldview-2 remotely sensed data enabled a finer discrimination of tree species and spectral properties (Abd Latif et al., 2012). The spectral characteristics of tree species were studied at various scales from leaf to stand scales and spectral reflectance of tree species has been studied by different types and ages of the tree species (Abd Latif and Blackburn, 2011). The objective of this study is to examine the feasibility of using LiDAR data and WorldView-2 imagery for tree species determination and classification.

2. MATERIALS AND METHOD

2.1 Study area

The study area for this research was Bukit Nanas Forest Reserve Kuala Lumpur, one of the oldest permanent forest reserves in Malaysia. The forest reserve is geographically located at latitude 03° 09’ 06” and longitude 101° 42’ 07” neighboring to the famous KL Tower. Earlier known as Bucket Weld Forest Reserve and Bukit Nanas was declared as a forest reserve in 1906. The forest was gazette as a Wildlife Reserve and Bird Sanctuary in 1934 and the only remaining tropical rainforest in the heart of Kuala Lumpur

Figure 1. Aerial view of study area, Bukit Nanas Forest Reserve, Kuala Lumpur.

2.2 LiDAR and Worldview-2 Data

The Digital Terrain Model (DTM) of the bare earth was interpolated from the TIN model and Digital Surface Model (DSM) generated from LiDAR point clouds. DSM which includes vegetation and buildings were computed by assigning to each cell and the highest first echo LiDAR point inside. The absolute height of trees or Digital Tree Height Model (DTHM) or Canopy Height Model (CHM) was computed by a height difference between the DSM and DTM. The CHM was computed between tree canopy hits and the corresponding LiDAR-derived terrain elevation values. The DTM and DSM are created in LastTools and were exported to ArcGIS (ESRI) and CHM was thus obtained by subtracting DTM from DSM.

WorldView-2 image was re-projected from UTM/WGS 1984 in Zone 47 North Geocentric projections to Kertau RSO Malaya Geocentric projection. NDVI image was created to subset area with only vegetation. Then WorldView-2 image were overlaid onto the LiDAR height data. The 3D tree positioning data (X,Y,Z) were overlaid to determine the accuracy of tree position derived from the Worldview-2 imagery. Image segmentation was conducted using panchromatic band of the WorldView-2 image. The panchromatic band of 0.5m resolution was used to easily delineate tree crowns. Region based algorithms extracted information by grouping spatially and spectrally similar pixels into homogenous area of an image object. Segmentation was done by registering the scale level and the merge level of the trees crown. This procedure is also known as feature extractions and for that 20m scale level and 80m merge level were used. This is based on the capability of the merge level to actually segment different tree crowns. The supervised nearest neighbour classification was applied to classify the tree crowns at the species level. The mean value of NIR1, NIR2 and Red-Edge band of pan-sharpened image and maximum value of CHM was chosen in object features for the classification. Maximum likelihood classifiers were adopted for better class-specific tree delineation of the study area.

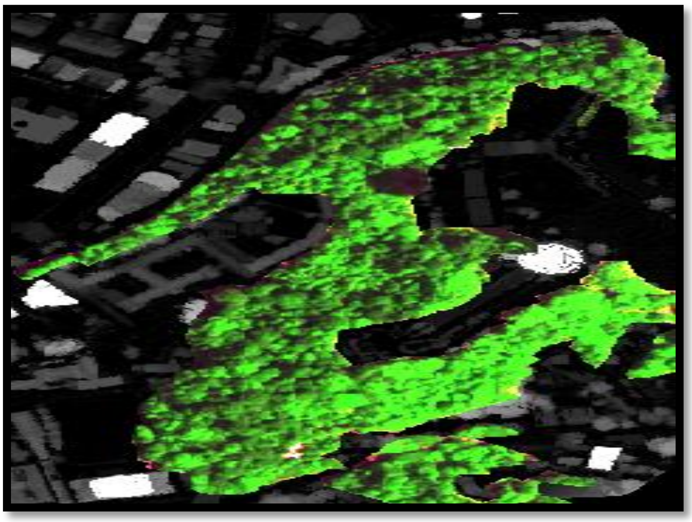

Figure 2. NDVI image overlaid on LiDAR point clouds

2.3 Image segmentation and classification

Image segmentation is the process by which an original image is partitioned into some homogeneous regions by subdividing merging and reshaping operation of the image object. It is a preliminary and critical step in segment based classification and assumes that segmentation result directly affect the performance of the subsequent classification (Yogendra Kumar, 2012). Segmentation was conducted using panchromatic band of the WorldView-2 image. Band panchromatic was used for this study to easily delineate tree crowns. This is because this band has 0.5 meter resolution in which it is very useful for this purpose of study. Region based algorithms extracted information from the image by grouping spatially and spectrally similar pixels into homogenous area to from an image object. In this research, WorldView-2 image was applied to segmentation tree crown. Segmentation was done by registering the scale level and the merge level of the trees crown. This procedure is also known as feature extractions and for that 20m scale level and 80m merge level were used. This is based on the capability of the merge level to actually segment different tree crowns. From the segmentation result it can be seen the undefined crowns are which the areas that cannot be segmented. It is because, the pattern of the trees in natural forest in which they are often multi layered and the same height within a group of area. Therefore, it was difficult to interpret how many trees lies in one segment on the multilayered crowns of the tree species.

The supervised nearest neighbour classification was applied to classify the tree crowns at the species level. The image of tree crown was classified into eight species altogether on the basic of training data collected from field or in situ measurement. The tree that was clearly recognized and annotated in the image were used as training sample as a test data for accuracy assessment in case of each major dominant species. The mean value of NIR1, NIR2 and Red-

Edge band of pan-sharpened image and maximum value of CHM was chosen in object features for the classification.

Thus, we used maximum likelihood classifiers with the datasets that allowed a much better of the class-specific delineation in the study area. The processed dataset were also used to collect and redefine the training area. Then, the dataset must be ordered to maximize the classification result with reducing the sample size for the different tree species. A classified image of eCognition was exported to ERDAS Imagine 9.1 using export thematic raster files algorithm and export type as classification in edit process window of eCognition. The exported raster file should be changed to thematic layers as data a type was in continuous layer.

2.4 Accuracy Assessment

The accuracy assessment was a step to compare two maps based on remote sensing data and other sources. The percentage of accuracy assessment is depending on the different data used. To evaluate accuracy, the crown maps and truth ground of the tree are used. Then, the total of the tree species was plotted in Erdas Imagine 9.1. For classification, we combined LiDAR data, multispectral imagery and field data in order to plot in map scatter and then produced the final map of tree species. Accuracy assessment was carried out on the basis of allocated test sample. Confusion matrix, Kappa statistic and overall accuracy report was generated to calculate complete statistical measures. The model thus obtained was validated with the in-situ measured data in case of each major dominant tree species. The R^2 and root mean square error (RMSE) was used to assess the performance of the model. RMSE explains the difference between model predicted values and the calculated values. Similarly, RMSE in percentage was calculated from the ratio of RMSE and average calculated of tree species.

3 RESULTS AND DISCUSSION

3.1 *In-situ* field measurement

Based on *in-situ* field measurement, 8 dominant tree species were selected for this research. A total of 188 trees were surveyed using conventional surveying techniques which include the *Hopean Odorata Roxb* (Merawan Siput Jantan), *Shorea Leprosula* (Meranti Tembaga), *Neobalanocarpus Heimii* (Cengal), *Gymnacranthera Bancana (Ihiq) Sinclair* (Penarahan), *Rusty Sterculia* (Kelumpang), *Palaqium Rostratum* (Nyatoh Putih), *Eugenia Oleina* (Kelat) and *Dyera Costulata* (Jelutong). *Eugenia Oleina* has the largest percentage (44%) and *Neobalanocarpus Heimii* has the lowest percentage (1%).

3.2 LiDAR Canopy Height Model

LiDAR data was processed to extract ground points which were then interpolated to generate the DTM. DSM was created by interpolating the first return point clouds. which are often located on top of the trees. Figure 3(a) shows the CHM which was obtained by subtracting DTM from DSM. The actual tree height in 3D view is shown in Figure 3 (b).

a) b)

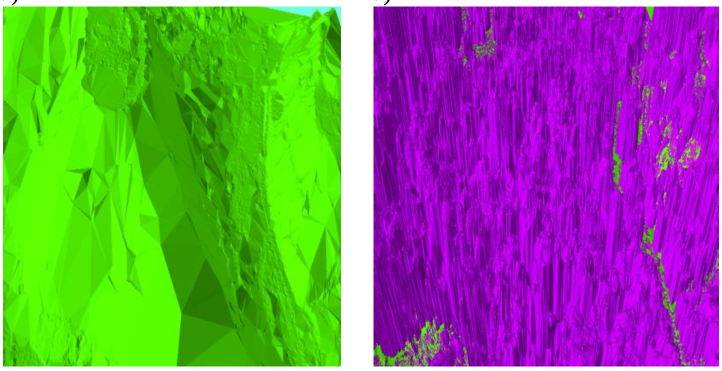

Figure 3. a) LiDAR-derived DTM, b)LiDAR DSM

3.3 Spectral Separability of Tree Species using WorldView-2 Image

Figure 4 illustrates the spectral signatures of eight dominant tree species plotted against the eight bands of WorldView-2. The spectral signatures were used for assessing the potential of image spectral separability before the classification process. The species can be separated in NIR1, NIR2 and Red-Edge bands where near infra-red bands have higher reflectance compared to the visible bands. The use of the three bands of Worldview-2 able to detect and separate all the eight classes of different tree species in the study area.

3.4 Mapping of tree species

Figure 5 shows classification map of eight dominant tree species using combination of both Worldview-2 imagery and LiDAR. The overall accuracy was 89% and kappa coefficient of 0.75. The accuracy was higher after combined with the LiDAR data. Nevertheless, the range of previously reported accuracy value by [7] suggested that the tree species classification in this study is comparatively successful using LiDAR point density data and WorldView-2. The RMSE for X and Y tree positions are 0.4m respectively and 0.2m for tree height.

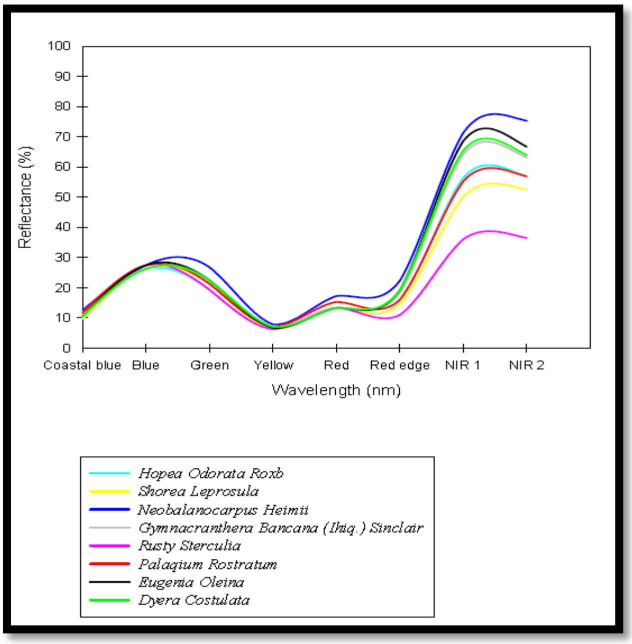

Figure 4. Spectral signature of eight dominant tree species along the spectrum of Worldview-2 imagery

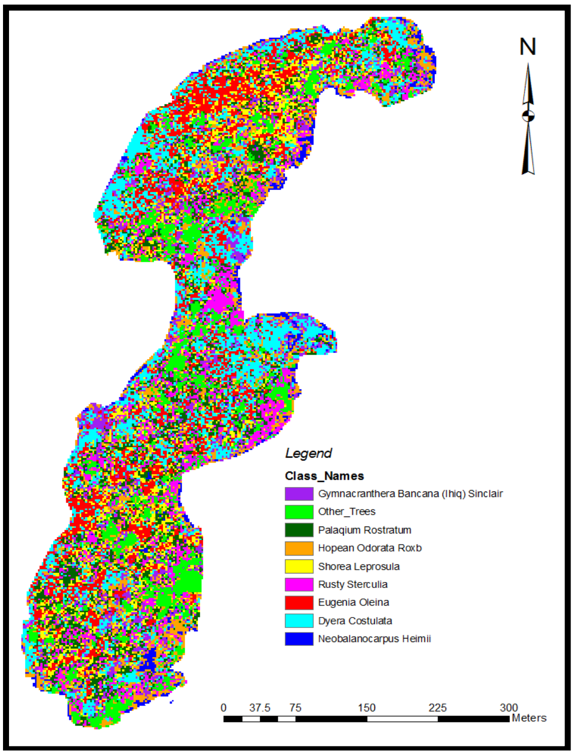

Figure 5. Tree classification map of eight dominant species at Bukit Nanas Forest Reserve

4 CONCLUSIONS

The results indicate that WorldView-2 satellite imagery and airborne LiDAR data are very promising remote-sensing sources for determination of tree species of Bukit Nanas Forest Reverse, Kuala Lumpur. Eight dominant tree species were successfully classified using the combination of both Worldview-2 and LiDAR data. However, mixed species that are grouped in one area plus the same range of heights of different tree species makes it harder to interpret the segmentation. This research is contributed for further studies on tree species determination in natural rainforest.

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BIOGRAPHICAL NOTES

Dr. Zulkiflee is currently Head of Applied Remote Sensing and Geospatial Research Group and Assistant Professor at the Centre of Studies for Surveying Science and Geomatics, Universiti Teknologi MARA, Shah Alam, Malaysia. He received his Bachelor of Geomatics at the University of Melbourne, Australia and Ph.D. in Remote Sensing at Lancaster University, UK. His research interest focuses on developing remote sensing and GIS techniques for environmental applications, particularly in climatology, ecology and biodiversity.

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