DEVELOPING METHODOLOGY TO MAP TREE CANOPY IN URBAN AREAS FROM LOW COST COMMERCIAL UAVS

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ABSTRACT:

Urban Green Spaces are essential for the well-being of the urban society. Mapping and monitoring of tree canopy in urban landscapes are an integral part of the Urban Planning. Recent popularity and improvement of UAV technology enables planners to assess available urban green spaces in high resolution with greater accuracy. One of most famous UAV series is Phantom drone series. In this study, we have used Phantom 3 drone (Professional Edition) which has 4K camera, approximately 20minutes flight time and range of maximum 5 km. But, most of the available commercial Drones lacks Near Infrared (NIR) observation which is crucial to map and monitor vegetation. In this paper, we are exploring an efficient methodology which is based on textural information from RGB image and elevation information derived from a drone, to extract tree canopies in Urban Area. A university environment which consists of a desirable amount of tree canopy and buildings have been mapped to demonstrate this methodology in this paper. Finally, results were compared to digitized tree canopy layer to validate the results.

1. INTRODUCTION

Urban planning means dealing with the constant change as communities, cities, and towns which continue to evolve. In response, professional planning, aside from requiring expertise, understanding, and political savvy, requires the correct technology to collect topographical information/data to facilitate effective translation of strategic visions into strategic action plans. However, collecting data is a challenging aspect of urban planning, because, effective urban planning requires large amounts of accurate data, which is difficult to collect since most often, locations, prove difficult to access. Further, most of the traditional technology for aerial surveys is highly expensive. An ideal methodology that is cost effective, highly accurate, and able to navigate difficult locations is required. One such methodology is UAV photogrammetry.

UAV technology has revolutionized the aerial photogrammetric mapping, and its applications are speedily increasing. When compared with present day conventional methods of photogrammetry, UAV photogrammetry has improved and facilitated the creation of an advanced tool for photographic measurement. The major components of a UAV include an unmanned aircraft, a transmitter, a communication link, an image sensor such as a digital or infrared camera and mission planning. UAV photogrammetry can also be integrated with a LiDAR system. UAV photogrammetry facilitates both autonomous and semi-autonomous remote controlling and ensures the accuracy of an approximate 1cm to 2cm. Further, it creates new opportunities for application in close range domains by combining terrestrial and aerial photogrammetry, but its major advantage is that it is highly cost effective, as it enhances problem-solving applications and offers an alternative to the traditionally manned and high-cost aerial photogrammetry. UAV photogrammetry enables application in both small scale and large scale, with varying or similar system costs, depending to an extent on the intricateness of the system. Nevertheless, this study utilizes a UAV system approach and its cost effective applications to develop a methodology that facilitates mapping tree canopies in urban areas.

Digital images can be directly captured by use of a digital camera, or they can be scanned from aerial photographs. Being in digital form facilitates the easy storage and management of the photographic information as digital maps, digital orthoimage and DEM in a computer. This method of using a computer to process digital images and aerial photography is called the digital photogrammetric method.

A consumer grade UAV system was used to acquire the aerial photographs required for the study. Specifically, the Professional Edition, DJI Phantom 3 with a Sony EXMOR camera was utilized as the system for data acquisition of aerial photographs of the area of study.

2. STUDY AREA AND DATA USED

2.1 Study Area

The University environment (The Asian Institute of Technology, Thailand) was selected as the study area. Because, it has land-cover type consists of combination of buildings and trees, which can be, considers as eco-friendly urban setting.

Figure 1: Study Area (c WorldView-2 image 2012 DigitalGlobe)

2.2 Data from UAV System

Phantom 3 professional drone is selected as the platform to collect aerial images of the study area which are processed to make the orthoimage and DSM. Phantom series drones by DJI are one of the most common civilian drones among the community, mainly used for photography and as a hobby. In recent studies, accurate mapping capacity of phantom 3 drone is exploited and it is used in this task to acquire aerial images. The drone is chosen considering the affordability and mobility. According to DJI, the Phantom 3 professional weights 1280g and falls to the micro UAV category. It is listed with a flight time of 23 minutes with a fully charged lithium polymer battery. The included remote control unit operates on a 2.4GHz ISM frequency and has the ability to communicate with the Phantom 3 up to 5 km range from the remote control. The 12 megapixel Sony EXMOR camera is factory built and mounted in 3 axis stabilization gimbal which provides clear stabilized images.

Flight planning was done with a software named Map Pilot for DJI, which is used to execute full autonomous flight. The advantage of modern flight planning software is requirement of minimal interference for operators which allows to focus on field operation rather than calculation. The app automatically computes the exposure location and flight paths according to the given flying altitude and image overlap. Flying altitude is set to 100m above ground level, which provides 4.2cm per pixel average resolution in unprocessed photographs. Both sides overlap and forward overlap were set to 80% to provide more key points as possible for accurate photogrammetric processing. The total number of 1670 near vertical photos were collected by 7 successive flights which were processed together to obtain DSM and orthoimage.

3. METHODOLOGY

3.1 DSM & Orthoimage Generation

The DSM & orthoimage generation was carried out using Agisoft PhotoScan software. The below diagram show the basic processing steps of the software.

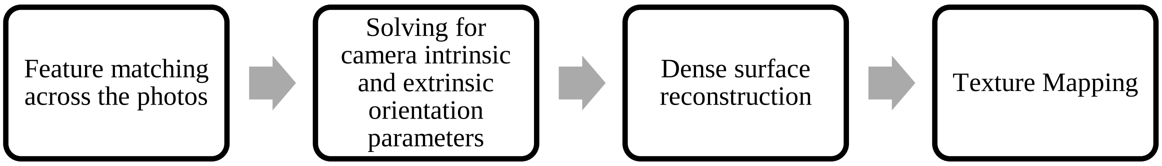

Figure 2: Processing steps of Agisoft PhotoScan

The first step is the feature matching across photos. Here the PhotoScan software identifies, in the source photos, the stable points under variations of viewpoint and lighting. After identifying, the software produces descriptors for the stable points based on their local neighborhood. The produced descriptors are then utilized to discover any correlation, communication or consistency among the photos. Aspects of this process are similar to the popular SIFT approach, but unlike the SIFT approach, this software employs different algorithms to acquire an alignment of slightly higher quality. Subsequently, the PhotoScan software applies a greedy algorithm to approximately locate the camera positions and then with the use of a bundle adjustment algorithm, proceeds to refine them. A variety of algorithms are at hand at the following dense surface reconstruction phase. Here, the methods dependent on the pairwise depth map computation are the exact, height field and smooth methods while the one depends on the multi-view approach is the fastest method. In the next phase, the software develops a texture atlas by creating parameters of the surface, possibly by cutting it (the surface) into smaller pieces and blending source photos. Resulted DSM and orthoimage shown below.

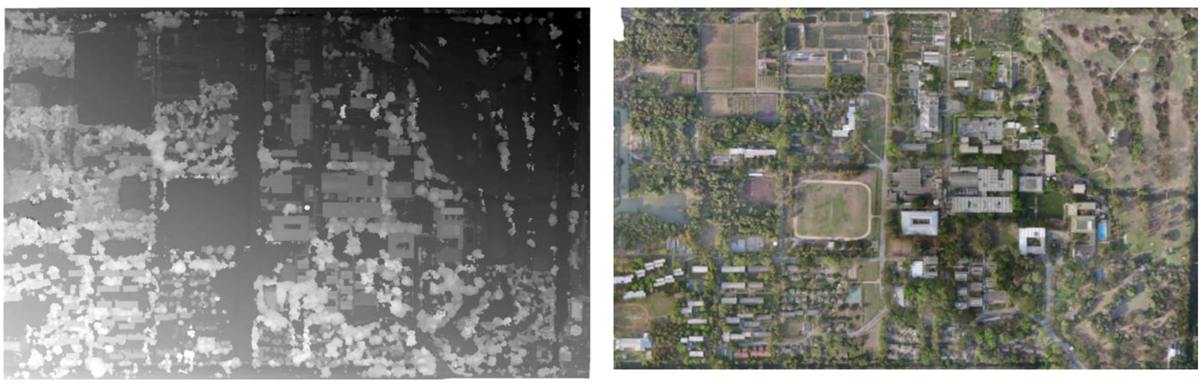

Figure 3: Left: DSM; Right: Orthoimage

3.2 Tree Canopy Mapping

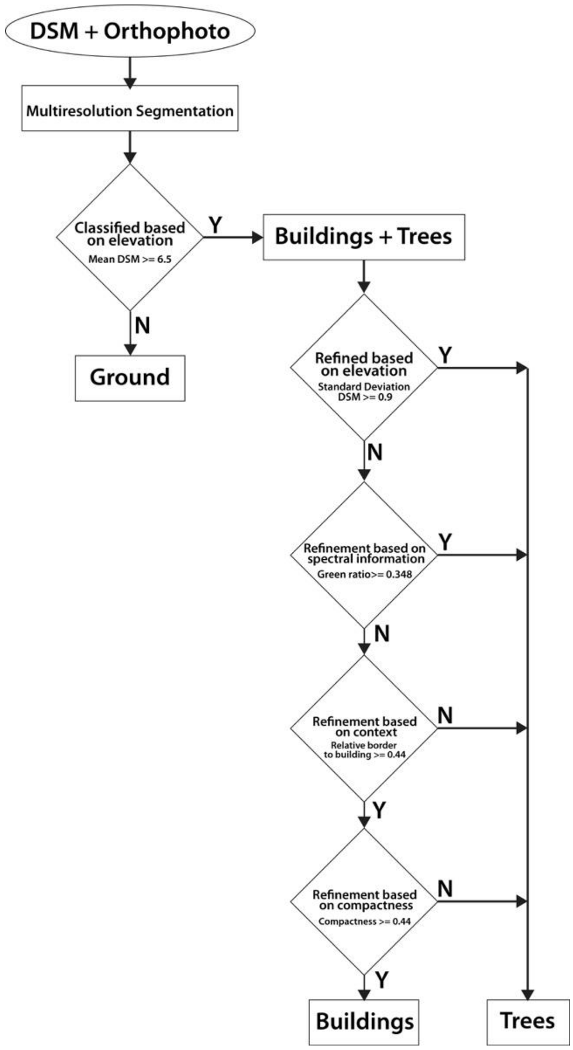

Figure 4: Decision Tree

A decision tree was developed to map the tree canopy (See Figure 4). Tree canopy mapping proves to be a complex task without near infrared band. So we used the height information and object parameters to map the canopy. This task was carried out using eCognition software package.

The most elementary step while using eCognition for image analysis is the segmentation or separation of a scene depicting an image turn, into image objects. Therefore, segmentation at the initial stage involves the separation of an image into isolated regions that are represented by simple unclassified image objects, known as 'image object primitives''. To get the most realistic image objects, the necessary elevation information must be represented, and it should not be too big or too small for the analysis task.

The first step involved is creating image objects. To do this, the multiresolution segmentation algorithm was utilized. This is because it organizes the image into objects, regions with similar pixel values. Therefore, the areas that are homogenous produce objects that are larger, and areas that are heterogeneous produce smaller objects. How homogeneous/heterogeneous the objects are allowed to get is operated by the 'scale parameter'.

An assumption, that the buildings and trees were always elevated was made. Further, the study area had not experienced much change in terrain elevation, so simply the applying elevation threshold is good enough to classify elevated objects. In the second processing step, the trees had to be separated from buildings, as both were elevated objects. Here again the DSM information was used. It is apparent that Elevation (DSM) texture of the buildings is far smoother than trees, which can be represented by object's standard deviation (Trees - high Elevation Standard Deviation and Building - law Elevation Standard Deviation). So, the thresholding on Standard Deviation was used to separate Trees and Buildings, which are both elevated objects.

Therefore, the standard deviation of the DSM was applied to separate the trees and the buildings. Nonetheless, some trees were still classified as 'Buildings' even after refining the classification using the standard deviation of the DSM layer. It was obvious that the green layer contained significant information about vegetation. So well know Green Ratio "green/(red+green+blue)", which measures green component of the color was used for further refinements. Some areas of the buildings had not thus far been classified or were de-classified again because they accomplished one of the conditions before. Some of the not classified objects were highly surrounded by 'Buildings' objects. If an unclassified object had a high common border to 'Buildings' objects it ought to belong to the class 'Buildings'. The neighborhood relationships of objects were then used to refine the classification. There were still some misclassified objects, but they were very small. The compactness of the 'object of interest' was the separating condition here, based on the assumption, that the buildings have a regular shape. Refining the classification depended on that characteristic.

4. RESULTS

Results showing the separation of Tree Canopy from the building is shown in Figure 4. Additionally, these results were compared with respect to manual digitized results of the study area, which is shown in Table 1. 64% of Total Accuracy was obtained through this methodology using consumer-grade UAV.

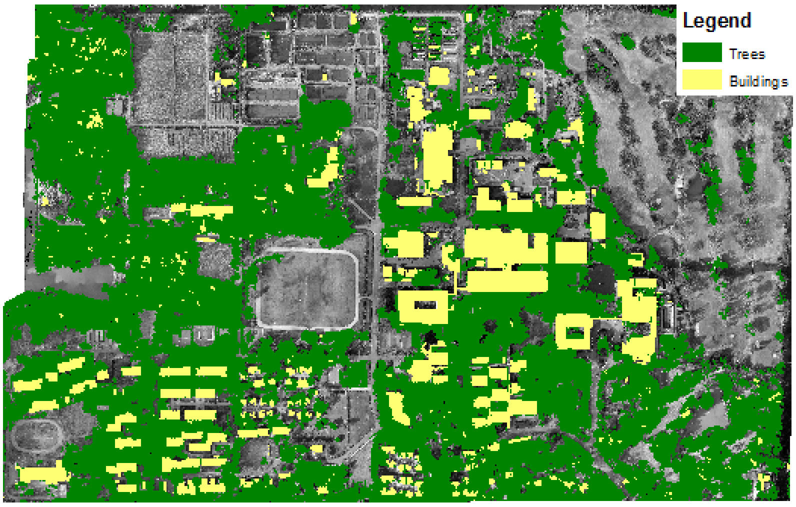

Figure 5: Resulted tree canopy map

Table 1: Accuracy Assessment of the Classification

		Manual Digitizing	
		Tree	Non-Tree
Classification Results	Tree	18 %	4 %
	Non-Tree	32 %	46 %
Total Accuracy: 64%			

5. CONCLUSION AND DISCUSSION

Total Accuracy with respect to manual digitizing and visual inspection of the results; validate the approach that we have used in this paper. Even without Near Infrared band, which is not available in consumer-grade UAV's, this approach successfully maps the Vegetation Canopy. It is prominent that this accuracy was good enough for urban planners to assess accessibility to green spaced of urban population for sustainable planning of the urban environment.

Unavailability of freely available Software for Object Oriented Classification, high cost of UAV's and legal barriers associated with UAV are the main obstacles to this approach. With the current advancement of technology and the popularity of UAVs will help to overcome these obstacles in the future.

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