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Towards Safe Cities & Resilient Communities

13 & 14 SEPTEMBER 2018
IMPIANA HOTEL, IPOH, PERAK

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UNMANNED AERIAL VEHICLE (UAV) FOR HERITAGE TREE DETECTION

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Abstract –This paper explores the potentials of Unmanned Aerial Vehicle (UAV) as a satisfying alternative tool to detect potential heritage trees by assessing the tree characteristic - the crown spread. Tree crown spread is an essential variable in tree assessment but is typically costly and time-consuming to measure in the field survey using conventional techniques. The study was carried out by a case study at Taman Perbandaran Tengku Anis, Kota Bharu. The first phase presents the procedure of capturing and processing UAV data to create and digital surface models in GIS environment. This information was used to detect the potential of heritage trees of the average crown spread estimated by the cross method. In the second phase, the researcher validated the accuracy of the methods by comparing the results with ground measurements. The results showed higher agreement between field survey and the UAV data for the crown spread, which were in the range 1.0- 1.5 meters. Overall, the results accuracy was acceptable and showed that the method was feasible for tree crown measurement.Thus,as an alternative way of detecting the potential of heritage tree withindirect measures of tree characteristics. Within this study, the researchers save precious time and money that can be put in to restore before the ground survey was conducted. Reliable information is available within hours. The UAV has proven to be a useful tool for urban forestry providing a cost-effective and reliable system to obtain remotely sensed data. This information offers better method of potential heritage tree detection which is the basis for protection, care, and management of heritage tree for the future.
Keywords - UAV, GIS, Crown Spread, Heritage Tree, Detection

1 INTRODUCTION

Heritage trees are typically large and are instantly recognizable as heritage because of their massive scale. Jim (2017) has listed in his previous research related to the outstanding tree dimension (2017) namely ‘Big tree,' ‘Great tree,' ‘Large tree' and ‘Giant tree.' These heritage trees stand out because of their size and become a landmark. In defining a special status tree - heritage tree, Wadey (2012) and (Lau, Jonathan, & M.S., 2017) highlight the aspects of memorability and visibility of trees through their form, location setting and other notable characteristics, including the size of trees. A tree's size increases with its importance in memories, its uniqueness, and its distinctive meanings to the people. The more rooted values and meanings of trees are especially evident concerning big trees (Barro, Gobster, Schroeder, & Bartram, 1997). Jones et al. (2002) mention trees with their outstanding characteristic such as dimension, shape, and other physical intrinsic aspect create visual attractiveness which can easily engage people senses. Additionally, Burra Charter describes that size is part of criteria that relate to sensory perception in heritage principle.The tree dimension refers to their height, trunk diameter at breast height, and crown spread which widely used as the fundamental criteria to determine whether a tree should be officially designated as heritage trees (Jim, 2017; Polat, 2017). Additionally, an average crown spread is one of the parameters commonly measured in variouschampion tree programs(American Forests, 2015). The crown of any plant refers to the totality of its above-ground structures, such as the trunk/stem, leaves, branches, and reproductive parts. Tree crown spread is an essential attribute of the size of the tree that influences the benefits that a tree provides. Tree crown is the totality of branches, twigs, and leaves extending from the main trunk or stem of a tree. According to Blozan (2006), the crown spread is measured from branch tip in two directions and then averaged. The first measure is taken where the crown is the widest. The second is made at 90 degrees to the first (Figure 1).

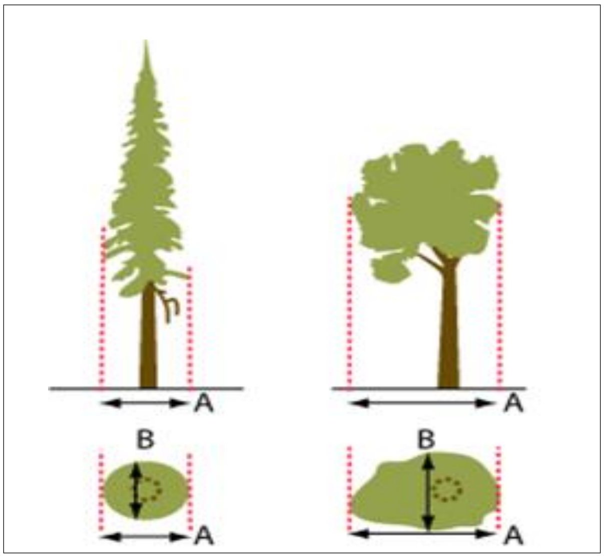

Figure 1The measurement of crown spread (A+B)/2 = Average Crown Spread

Conventionally, the crown is measured by using a measuring tape or hypsometer from the ground survey which is typically costly and time-consuming. The UAV, a remote sensing tool,seems to be more effective than ground surveys with the small areas as a station for investigation, and their cost-effectiveness compared to aerial flights with the photogrammetric camera mounted on the board. It isalso known as a drone, an aircraft designed to operate without a human on the board which can fly autonomously or semi-autonomously by remote control (Zietara, 2017; Colomina & Molina, 2014). Due to a very high spatial resolution of the photos acquired from UAV's, aerial surveys are becoming increasingly popular. Moreover, it also influenced by the rapid increase in affordability for the average consumer. They are no longer expensive machines and can be controlled with ease, e.g., utilizing a handphone application for direct control or feedback (Clark, Meffert, Baggili, & Breitinger, 2017). In contrast to standard aerial imagery, UAV utilizes recent technological advances to provide an affordable alternative for imagery acquisition (Ritter, 2014). The conventional aerial images may be not current images updated real time, so there is a tendency to show different pictures from current status. UAV’s application is found in many different fields including in agriculture and forestry in the last decade (Birdal, Avdan, & Türk, 2017; Goodbody, Coops, Marshall, Tompalski, & Crawford, 2017; Ritter, 2014; Zietara, 2017). UAV is capable of improving the efficiency of acquisition and providing excellent spatial scale data for sustainable resource management (Goodbody et al., 2017). Their technology and data processing capabilities have made it feasible to obtain high-resolution photogrammetry data(Colomina & Molina, 2014), which can provide essential information quite quickly on demand in assessing tree characteristics. All objects captured by UAV including tree attributes are described regardingpoints, lines, and polygons and can be extracted merely by using GIS engine. In other words, GIS relies upon access to content, and UAV is the gamechanger bringing that content to geographic information systems (Breetzke, 2015). In this study, each tree crown was digitized, and the diameter of the speed was measured. In a geospatial database, each of these objects would be grouped into object classes, and their data would be stored in separate tables. Thus, the researchers present an alternative tool to detect potential heritage trees by assessing the tree attributes - the crown spread.

2 METHODS

2.1 Study area

This study was established at Taman Perbandaran Tengku Anis, Kota Bharu. The park was built as part of the national movement to provide large parks for urban residents. It is located at 6°15’6.17” N, 100°15’6.17” E. The effects of the park are especially interesting because it is the closest park to thecity and is surrounded by dense residential areas.The park has been efficiently used by a range of different peoplein recent years which providesa diverse range of space, activities and a large number of mature shade trees (Figure 2).

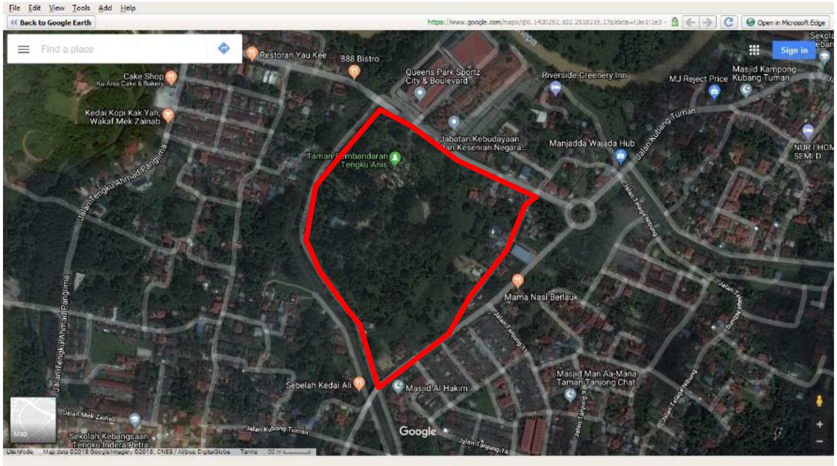

Figure 2 Study boundary used for UAV implementation to collect high-resolution imagery for photo-realistic outputs

A two-phase tree inventory wasimplemented in a case study. The first phase, UAVcapturedmultiple images from the onboard camerathrough a mobile app –Precision flight to produce photo-realistic outputs and digital surface models. The images were processed and stitched together to create a single output image of the study area using Agisoft PhotoScan software. All these objects can be described regarding points, lines, and polygons – and tables of these objects constitute the tabular portion of geospatial data. Points, line, and polygon can be extracted merely by using GIS engine, and each tree crown was digitized, and the diameter was measured. This information then was used to detect the potential of heritage trees regarding the average crown spread identified within anarborist's tree survey in Kota Bharu (MPKB, 2010). In the second phase, the researcher validated the accuracy of the methods by comparing the results with ground measurements.

2.2 UAV Data Processing and GIS Environment

2.2.1 Image acquisition: Flight planning

This study usedthe low-cost drone; a *Phantom 3 Advanced* with the *Precision flight* mobile app for data capturing. The mobile app servedas the controller for many of the Phantom 3’s advanced features. These free mobile apps turned a drone into an advanced remote sensing tool that empowers drone pilots to capture aerial data autonomously. It enabledoperators to create flight plans andguide the drone to capture aerial imagery. After connecting drone with a remote controller, the image pixel size and camera constant will automatically be loaded to the application.The first important consideration in doing flight planning is the place where to start a mission. The possible highest point within the study area was decided as the starting point because it will influence the setting of the flight height. Another consideration was in the aspect of weather and sunlight. According to Zietara(2017), it is a crucial factor which may affect final results in the photogrammetry data. In avoiding sunlight problem that leads to the appearance of a shadow, the flight was performed during a cloudy and windless day. The flight height, side and front overlaps was determined after the study area was marked on the map. This flight mission was used that overlappedof 90% for front and 60%

side overlap respectively to ensure maximum stereoscopy and to avoid holes. The altitude of 100 meters above the ground decided to be an optimal value with standard speed setting. The whole mission lasted about 11 minutes of flight time with the use of one battery (Figure 3).

2.2.2 Image processing

The UAV produces a digital surface modelwhich includes all objects and vegetation above the ground.The image resolution achieved by UAV surveys is exceptionally high. The visual identification of specific plant characteristics can be identified from the aerial imagery. This in turn limits the amount of ground truthing that needs to be done in the field.It resulted in 132 photos required to cover the whole study area (Figure 4).

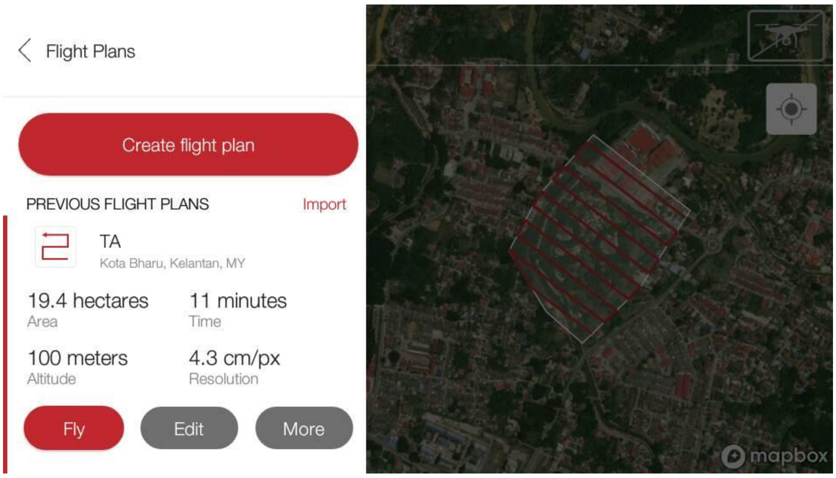

Figure 3 Screen capture of *Precisionflight* software during aerial photo mission. The screen contains flight controls, current mission parameters, communication limits, and flight path(s).

Figure 4 These are part of images are run through the UAV software, georeferenced, stitched together, and a single output image of the study area is produced.

All the photos were processed using Agisoft PhotoScan software after the image acquisition was completed. This software can stitch photos together and output a single composite image- ortho-mosaic by choosing a moderate depth filtering mode. The ortho-mosaic image is a single image of the study area containing the many individual images taken during the survey (Figure 5).

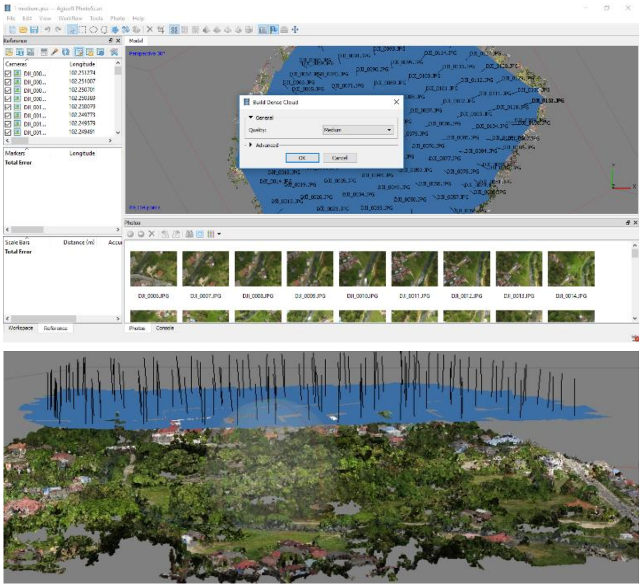

Figure 5 Image processing using Agisoft PhotoScan

Figure 6 Completed georeference mosaic of Taman Perbandaran Tengku Anis.

2.2.3 GIS environment and crown spread measurement

In GIS environment, all object in the land surface such as points, lines, and polygonsconstitute the tabular portion of geospatial data. Points, line, and polygon can be extracted merely by using GIS engine, and each tree crown was digitized, and the diameter was measured. The model describes by (Blozan, 2006) wasused to estimate the crown spread for each tree in the study area (Blozan, 2006). A crown spread is measuredfrom branch tip to branch tip in two directions and then was averaged. In this study, the average crown spread wasobtained by measuring the shortest and longest extent of the crown and averaging the figures.

Where: The measurement of crown spread (A+B)/2 = Average Crown Spread

Then, the second phase entails measuring the tree crown spread on the ground using a measuring tape. It is essential to make a few manual measurements, using a tape measure that enables the researcher to check the accuracy of the ortho-mosaic image (Figure 8). This information then was used to detect the potential of heritage trees regarding the average crown spread. The minimum average size for crown spread identified in arborist's heritage tree survey in Kota Bharu is 10 meters (MPKB, 2010).

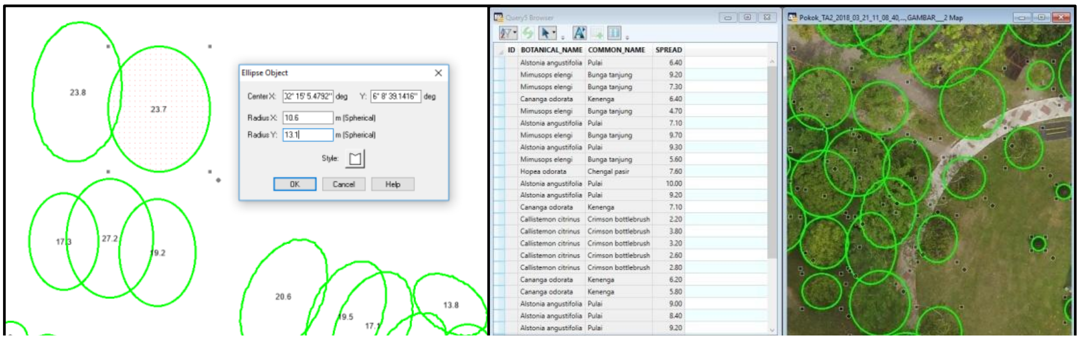

Figure 8 Screen capture of the table in MapInfo 11.5 after field data was collected added to the table

3 RESULT AND DISCUSSION

The results showed higher agreement between field survey and the UAV data for the crown spread, which were in the range 1.0- 1.5 meters. However, the crown spread measurement can be particularly challenging in areas with dense and multilayered trees because of the horizontal and vertical complexity(Bohlman & Pacala, 2012).This method is suitable for use in urban areas with low tree density because the crown outline identification is more pronounced. The potential heritage trees in the study area are 94 trees regardless of other physical characteristic and the health condition.The majority of the trees are from Khaya senegaliensisranging from 10 to 32.5 meters.Overall, the results accuracy was acceptable and showed that the method was feasible for tree crown measurement.Thus,as an alternative way of detecting the potential of heritage tree by indirect measures of tree characteristics.

4 CONCLUSIONS

During the past two decades, research has developed around the world onthe importance, use, and value of heritage trees to support their protection and maintenance.This study offers better method of potential heritage tree detection which the basis for protection, care, and management of heritage tree for the future. Conventional heritage tree identificationis typically costly and time-consuming. By using Unmanned Aerial Vehicle (UAV), this paper introduces the alternative tool and simple method with reduction of coststhat are generally applicableto detect potential heritage trees by assessing the tree characteristic - the crown spread.

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