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Static Positioning Technique For Ground Control Point Determination For Precise Mapping Using Unmanned Aerial System

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Graphical abstract

Abstract

Mapping can be intense and laborious with the current method in term of the work environment, manpower, cost, time, and obviously, the equipment used for the work. Traditional mapping technique uses photogrammetry, total station and GPS. The level for detailing and levelling is not convincing fast enough to catch up with the revolution of the world. However, aerial photogrammetry had been introduced to improve the mapping method in terms of accuracy, work done and speed. Unmanned Aerial System (UAS) is the latest realization of aerial photogrammetry to the mapping world. This technique is capable of mapping large area compared to conventional technique of mapping in short time with less work and effort, while the accuracy is maintained. This paper highlights the capability of UAS to replace the conventional technique of mapping. To test the accuracy of this product, the technique used in determining the ground control point (GCP) is studied. The accuracy of GPS plays big impact in the accuracy of the map produced, due to its role in establishing the GCP for the map. In this study, the conventional technique in determining the GCP is hereby replaced with better technique to produced better accuracy. The technique of GPS observation used is static with network processing which is never been used before in UAS. The concept here is the accuracy of map is improved by improving the accuracy of GCP. Furthermore the technique of GPS observation determined the accuracy of GCP. This paper, presents a new procedure using UAS for precise mapping and this method is expected to replace the conventional technique of producing topographic map.

Keywords: UAS, static network, GCP

Abstrak

Pemetaan boleh menjadi sukar dan memenatkan dengan kaedah semasa dari segi persekitaran kerja, tenaga kerja, kos, masa, dan terutamanya, peralatan yang digunakan. Teknik pemetaan tradisional menggunakan fotogrametri, total station dan GPS. Tahap untuk data perincian dan aras tidak meyakinkan cukup pantas untuk mengikuti edaran revolusi dunia. Walau bagaimanapun, fotogrametri udara telah diperkenalkan untuk menambah baik kaedah pemetaan dari segi ketepatan, kerja yang dilakukan dan kepantasan kerja. Sistem udara tanpa pemandu (UAS) adalah pencapaian terbaru fotogrametri udara kepada dunia pemetaan. Teknik ini mampu memetakan kawasan besar berbanding teknik pemetaan secara konvensional dalam masa yang singkat dengan lebih mudah, manakala ketepatan dikekalkan. Kertas kerja ini membincangkan keupayaan UAS untuk menggantikan teknik konvensional pemetaan. Untuk menguji ketepatan produk ini, teknik yang digunakan dalam menentukan titik kawalan bumi (GCP) dikaji. Ketepatan GPS memainkan impak yang besar dalam ketepatan peta yang dihasilkan, kerana peranannya dalam mewujudkan GCP untuk peta. Dalam kajian ini, teknik konvensional dalam menentukan GCP digantikan dengan teknik yang lebih baik untuk menghasilkan ketepatan yang lebih baik. Teknik pemerhatian GPS digunakan adalah statik dengan pemprosesan rangkaian yang tidak pernah digunakan sebelum ini oleh UAS. Konsep di sini adalah ketepatan peta itu bertambah baik dengan meningkatkan ketepatan GCP. Tambahan pula teknik pemerhatian GPS menententukan ketepatan GCP. Kertas kerja ini, membentangkan prosedur baru menggunakan UAS untuk pemetaan tepat dan kaedah ini dijangka menggantikan teknik konvensional untuk menghasilkan peta topografi.

Kata kunci: UAS, rangkaian statiK, GCP

1.0 INTRODUCTION

Detail for map can be selective and tedious by using ground conventional technique. Surveyor has to move the total station from one station to another and the prism need to be placed at every edge of building or selected features. At certain point the work had to stop and continue later due to fatigue, hazardous and weather.

Nowadays this job can be done in one go. UAS is the technology of aerial photogrammetry which had been increasingly used in geomatic field, unfortunately not in engineering survey. UAS work by flying at certain altitude to collected digital image. The UAS had been used for different application such as monitoring work like land slide monitoring, vegetable plantation, heritage documentation, and ect[1,2].

It is an idea to bring this method for engineering survey work as it is advantages will help in the production of map. It does not just speed up the process, but it also help to reduce the cost, risk and man power, while the accuracy is maintain. However, the current practice technique of UAS is not convincing to produce precise mapping as its accuracy vary from tens of centimeter to meter. This unfortunately is not acceptable for precise mapping of engineering survey.

Therefore this study is conducted to provide a technique of using UAS for precise mapping and show that it is superior than classic method. The procedure in UAS is divided to two sections which are digital image collection and GPS observation. Procedure for image collection will be the same as classic method, while GPS observation will be discussed in detail as it is the main part of this study.

2.0 UAS COMPONENT

There are two component of UAS; (i) an Unmanned Aerial Vehicle (UAV) to collect detail from an altitude without touching/contact the object on the ground (ii) Ground control system (GCS). The UAV used in this study is called Helang, a fixed wing UAV. Helang is a low cost UAV equipped with 12 megapixel digital camera, weigh approximately 2-3 kg, 1.68 m wing span and additional video capability. Helang capable to fly at maximum 500m altitude and total distance travel of approximately 32km for 40 minutes with wind speed 40km/h. There is a GPS unit attached on the UAV but it is used for the navigation. Figure 1 show the images of Helang UAV.

The ground control system comprise of portable computer, software and communication unit. The coordinate of ground control point (GCP) determined the accuracy of map. There are various GPS technique for GCP determination and each technique give different accuracy. In other word, the GPS technique determined the accuracy of GCP[3].

Classically, GCP is determined by using rapid static technique where the observation take 5 to 15 minutes for every point, radically. Radically means, the point is observer as its own direct to base point and no connection to other points. By applying this technique for establishment of GCP, an accuracy of tens of centimeter level can be achieved.

Figure 1 Helang UAV

3.0 STATIC NETWORK GCP

In this study, the GPS technique of static observation with network processing is employed. This technique usually used for control survey where accuracy is highly concerned. This technique involves data collection for long period than other technique. This long period of observation is one of the reasons for its good accuracy with the data redundancy and with the assumption that the selected area is good enough for GPS observation to reduce all the effected error[4].

GPS Static observation take minimum 30 minutes to 24 hours. It can be observed radically like rapid static, however, it can also be observed as a network. Network shall contained close loop where the start point will be the end, and each loop must related to one another at least by one baseline. GPS static network is a technique that employs more than a receiver simultaneously to collect data redundancy and will be processed together to cancel common error between the connected stations[5].

The network have to be designed base on two factors; number of GCP and number of instrument used. For this study, there are 10 GCPs and four GPS instrument used. From this variable, a network was designed. A good network is known as it follow three factors; (i) station is connected by at least two independent baselines, (ii) series if interconnecting and closed loops, (iii) repeated baselines measurement[5]. Figure 2 shows the network designed for the study area. The instrument is label as A, B, C and D while the point is label from number one to ten and every session is determined by different colour of closed loop. From Figure 2 we can understand the network is design with four session and the instrument may move or stay to form closed loop. Every session is observed for an hour and start simultaneously.

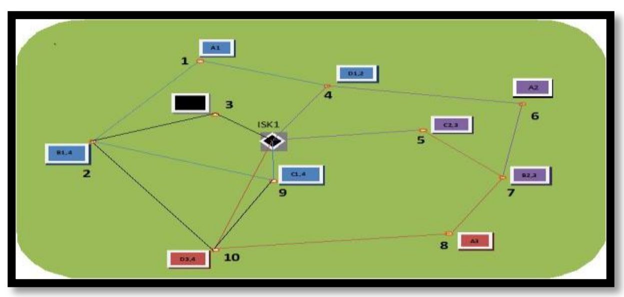

Figure 2 Network design of the study area

4.0 APPLYING GCP FOR PRECISE MAPPING

In mapping, usually, GCP is used for data processing. The accuracy of GCP determined the accuracy of map. It is highly expected to produce precise map with static network GCP as it's the best technique that GPS observation can be done. There are differences in the map produced by this technique compare to classic technique.

The collected UAV images by flying Helang is downloaded to the software and process to produced orthophoto. However, this orthophoto is uncontrolled as no GCP is used. Next, to produce controlled orthophoto, coordinate of minimum five GCP is inserted into the Agisoft PhotoScan software to produced orthophoto. The coordinates of GCP are processed by Topcon Tool Software by network processing; all point were processed simultaneously by connecting it to the base station known as Iskandarnet1.

After all ten GCP are inserted then Agisoft PhotoScan software is rerun to produce the orthophoto. The produced orthophoto can be consider as control map and the detail should be the same as the real world detail at certain scale. The comparison can analyzed in term of size, coordinate and detail shifted. To see the difference, the orthophoto is compared with orthophoto produced by rapid static GCP. Furthermore, true value of detail in real world is measured by measuring tape for additional comparison. The analysis is shown in result section.

5.0 CONCLUSION

The main analysis is comparing the coordinate of points from the generated orthophoto using static network GCP and GPS observation. Coordinates of point from orthophoto are analyzed by using ArcGIS software while GPS coordinate are processed by Topcon tool software. Coordinates from the orthophoto must be almost equal to GPS point as it is used as the reference. Table 1 show the coordinate value. From the table, it is clearly shown that the coordinate value are almost similar with differences only in millisecond.

Table 1 Comparison between Orthophoto and GPS coordinate.

POINT	GPS COORDINATE		STATIC NETWORK GCP		Different	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
G11	1°33'29.6437"	103°38'13.3195"	1°33'29.6474"	103°38'13.3128"	0.0037”	0.0067”
FHGT	1°33'38.6505"	103°38'07.1673"	1°33'38.6590"	103°38'07.1699"	0.0085”	0.0026”
SUB	1°33'30.0486"	103°38'24.4373"	1°33'30.0498"	103°38'24.4364"	0.0012”	0.0009”
IBNU	1°33'43.2386"	103°38'27.0739"	1°33'43.2444"	103°38'27.0641"	0.0058”	0.098”

Another analysis is made by overlapping the two different orthophotos in ArcGIS software. One of the orthophoto is set 50% transparent to see the differences. Figure 3 shows the overlapping images. The figure shows how the detail are not match in position. For additional data, the length of red line in Figure 3 is measured using measuring tape. The value is compared to the both orthophoto as shown in table 2. The measured length of real world detail is used as the reference length. It is clearly shown that the measured length using static network is better than the rapid static method.

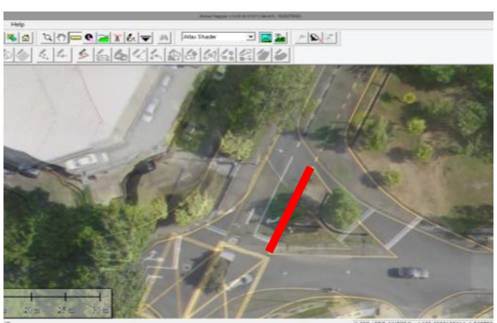

Figure 3 Overlapping images of two different orthophotos

Table 2 Comparison of red line value

Rapid static orthophoto	Measuring tape	Static network orthophoto
16.102 m	16.620m	16.621m

6.0 ANALYSIS

By comparing the orthophotos, it is shown that there are difference as both process used different accuracy of GCP. The result in Table 2 show that orthophoto produced from static network give accurate value as compare to real detail. This clearly show that GCP determined static observation with network processing are capable to produced high precision map. It is concluded that GPS static observation with network processing can be used in UAS for precise mapping.

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