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Auditing Road Maintenance Work Using Unmanned Aerial Vehicle

(Pengauditan Kerja Penyenggaraan Jalan Menggunakan Kenderaan Udara Tanpa Pemandu)

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ABSTRACT

Road maintenance works performed by contractors require validation upon completion. Conventional methods are typically chosen to validate the works. Geographic Information System (GIS) is applied in this study to produce accurate data such that waste from road maintenance costs can be minimised. In this study, Unmanned Aerial Vehicle (UAV) was used to observe the images of two roads, namely Jalan Gelanggang and Jalan Temuan, both of which are under maintenance at the Universiti Kebangsaan Malaysia. The objectives of this study are; to determine the ability of UAV technology in supervision and verification of maintenance works, and the effectiveness of spatial works in road maintenance. This study then proceeds with analysing data by using ArcGIS and AutoCAD software to determine the width, perimeter, and area of the road that has been maintained. Comparisons were made between these two data which are the data that has been claimed and provided by the contractors (as-built data) and images data of the UAV whenever to get the percentage of the difference for several features of the road. Results from this study showed that the value for width, perimeter, and area of the as-built data for both roads are greater than the value of the image where the UAV data show percentage differences of shape area for Jalan Gelanggang is 3.27% and for perimeter is 1.35%. While percentage differences of shape area are for Jalan Temuan is 4.83% and for perimeter is 2.44%. Therefore, if UAV is used for work validation, the total saving on road maintenance work costs are saved at least RM6,386.28 for Jalan Gelanggang and RM5,775.24 for Jalan Temuan.

Keywords: Road maintenance works; validation; geospatial; Unmanned Aerial Vehicle (UAV)

ABSTRAK

Kerja-kerja penyelenggaraan jalan raya yang dilakukan oleh pihak kontraktor memerlukan pengesahan setelah kerja tersebut selesai. Aplikasi Sistem Maklumat Geografi (GIS) digunakan dalam kajian ini bertujuan untuk menghasilkan data dan maklumat yang tepat supaya pembaziran dapat dielakkan sewaktu pembayaran kos kerja penyelenggaraan jalan kepada kontraktor. Dalam kajian ini, salah satu aplikasi GIS iaitu Kenderaan Udara Tanpa Pemandu (UAV) telah digunakan untuk mencerap imej jalan yang telah diselenggara di Universiti Kebangsaan Malaysia iaitu Jalan Gelanggang dan Jalan Temuan. Tujuan kajian dijalankan adalah untuk mengenal pasti kemampuan teknologi UAV dalam pengesahan kerja-kerja penyelenggaraan jalan raya serta menentukan keberkesanan kerja-kerja spatial dalam penyelenggaraan jalan raya. Kajian kemudian diteruskan dengan analisis data menggunakan perisian ArcGIS dan AutoCAD bagi menentukan lebar, perimeter serta luas jalan yang telah di selenggara. Perbandingan dilakukan antara dua data iaitu data yang telah dituntut dan disediakan oleh pihak kontraktor (data as-built) serta data dari imej UAV bertujuan untuk mendapatkan peratusan perbezaan terhadap beberapa ciri jalan. Hasil daripada kajian ini menunjukkan bahawa data as-built mempunyai nilai lebar, perimeter serta luas kedua-dua jalan lebih besar berbanding dengan nilai untuk data dari imej UAV di mana perbezaan keluasan untuk Jalan Gelanggang ialah 3.27% dan perbezaan perimeter ialah 1.35%. Manakala perbezaan keluasan untuk Jalan Temuan ialah 4.83% dan perbezaan perimeter ialah 2.44%. Oleh yang demikian, sekiranya teknologi UAV digunakan untuk kerja validasi, penjimatan kos bagi pembayaran balik kepada kontraktor yang dapat dilakukan adalah sekurang-kurangnya RM6,386.28 bagi Jalan Gelanggang dan RM5,775.24 untuk Jalan Temuan.

Kata kunci: Kerja-kerja penyelenggaraan jalan; pengesahan; geospatial; Kenderaan Udara Tanpa Pemandu (UAV)

INTRODUCTION

Technology is the use of scientific knowledge for practical or application purposes to meet a human need. Progress in human life is made when they decided to use the technology than using conventional methods because of the widespread usage allows users to set up jobs faster and can solve problems quickly and efficiently.

A new technology is used in this study to determine the accuracy of road maintenance work performed by the contractor. Maintenance work performed by the contractor requires verification after completion of the work they carry out. The prescribed time period for verification is short and validation work needs to be done quickly and the result must be precise. The quality of the road pavement should be in high standard. Furthermore, the safety of drivers at UKM will be more assured especially to 2-wheeled vehicles users such as motorcycles and bicycles (Dawood & Rahmat 2015).

Verification is conducted to ensure the as-built data of the road maintained is accurate so that the waste from the road maintenance cost can reduced. Previously, only conventional methods used to verify the work but this method produces inaccurate data, and take a longer period to verify. In addition, maintenance information storage was done improperly and systematically. Therefore, the most appropriate technology is used to overcome the constraints and validation problems of road maintenance work using photogrammetric technology. According to experts, there are various definitions of photogrammetry. Mohd. Tahir (1990), defines photogrammetry as a study of science, art or technique of measurement made on photos taken using metric camera whether the photo was taken from the air or from the earth's surface.

This study applies photogrammetry in the form of Unmanned Aerial Vehicle (UAV). UAV is a latest aerial technology and capable of solving the geospatial issue especially in measuring objects (Abdul Aziz et al. 2017; Alessandro & Piero 2015; Darwin & Ahmad 2014; Pérez et al. 2013). The objectives of this study are; (i) to identify the applicability of UAV in monitoring and verifying the road maintenance work, (ii) to generate a database for UAV data and as-built data which were produced by the contractor and, (iii) to determine the effectiveness of spatial works in road maintenance. The study area will be focused on the road in the Universiti Kebangsaan Malaysia which includes Jalan Temuan and Jalan Gelanggang where recently contractors have conducted maintenance work on these two roads. Geographical Information System (GIS) is a powerful tool for analysing all the spatial data especially in road distress and maintenance (Fendi et al. 2014; Jagadeesh et al. 2013; Nor et al. 2016).

METHODOLOGY

The data used in this study was obtained from various reliable sources. In order to validate and verify the road maintenance work done by the contractors, several aspects and features must be considered. Hence, this study will specify width, shape length and area of the roads to determine the accuracy of its maintenance work. The process of data collection starts from obtaining as-built data from the archive of Prasarana UKM for Jalan Gelanggang and Jalan Temuan. Prasarana UKM gave the sample for as-built data in the form of road design drawing and Bill of Quantity and these data are prepared by the contractors' upon completion of work. In addition, the image findings for both roads were collected from the archive of the Earth Observation Centre (EOC) UKM.

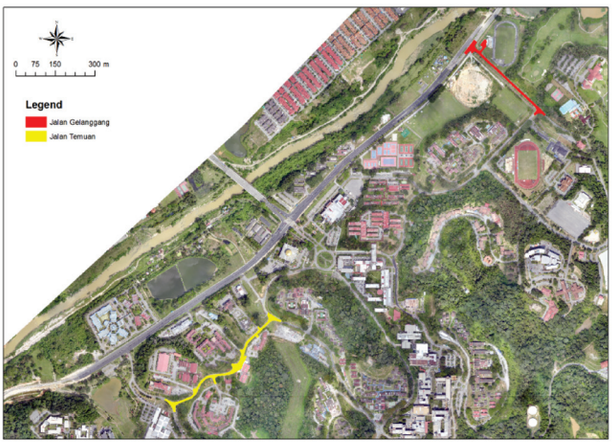

FIGURE 1. Location of Jalan Gelanggang and Jalan Temuan in UKM Bangi

EOC applied photogrammetry at Jalan Gelanggang and Jalan Temuan using the Cumulus One UAV, right after both roads had been maintained. Subsequently, all data that had been obtained and collected will be processed. For both as-built data and UAV images, the data processing method started by dividing Jalan Temuan and Jalan Gelanggang into several parts. By using AutoCAD software, every 10 meters of road length had been measured and labelled as a chainage. The process started from the beginning of line until the end of the road which was maintained only. Then, the data processing is continued by measuring the width at every chainage of the roads by using the function in AutoCAD software. Hence, width comparison for every chainage between two different roads can be observed. Figure 2 shows an example of the method to determine the chainage for the study area.

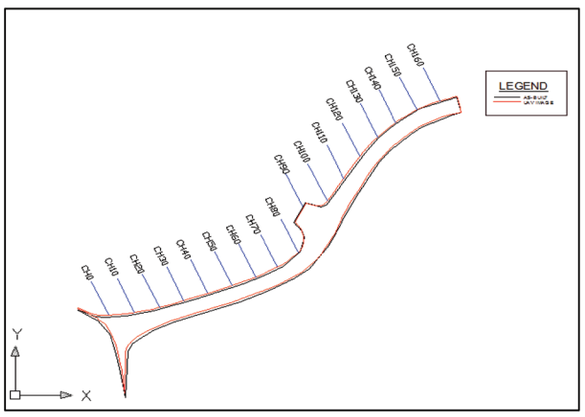

FIGURE 2. Method to determine the chainage for Jalan Temuan

The data processing is continued by overlapping as-built data and UAV images. By using ArcGIS software, both data were adjusted to be in the same coordinate system which is Universal Transverse Mercator 47 (UTM47). Then, the data were digitized in ArcGIS software before overlapping process between as-built data and UAV images for both roads took over. From digitizing and overlapping process, the results for overall shape length and area for Jalan Gelanggang and Jalan Temuan can be obtained.

RESULTS AND DISCUSSION

Each chainage's width was labelled at every 10 meters for Jalan Gelanggang and Jalan Temuan. The road's width for as-built data and UAV images were measured by using AutoCAD software to compare if there are any differences. Table 1 and Figure 3 show the results of width for every chainage and the differences at Jalan Gelangggang while Table 2 and Figure 4 show the results of width for every chainage and the differences at Jalan Temuan.

TABLE 1. Width for every chainage at Jalan Gelanggang

Chainage	As-Built	UAV Images
0	13.673	14.405
10	9.498	8.706
20	9.845	7.473
30	7.36	7.317
40	7.342	7.321
50	7.303	7.286
60	7.333	7.37
70	7.341	7.355
80	7.144	7.355
90	7.184	7.278
100	7.227	7.154
110	7.259	7.193
120	7.282	7.239
130	7.214	7.112
140	7.232	7.098
150	7.221	7.13
160	7.282	7.263
170	7.349	7.279
180	7.252	7.213
190	7.132	7.077
200	7.058	7.095
210	7.053	7.187
220	7.114	7.138
230	7.109	7.15
240	7.223	7.194
250	7.210	7.119
260	7.14	7.071
270	7.23	7.245
280	7.262	7.316
290	7.304	7.39
300	7.248	7.365
310	7.247	7.567

TABLE 2. Width for every chainage in Jalan Temuan

Chainage	As-Built	UAV Images
0	18.656	21.192
10	10.464	10.063
20	7.685	7.551
30	7.227	6.993
40	7.068	7.009
50	7.314	7.065
60	7.039	7.034
70	6.962	7.110
80	8.243	8.005
90	21.438	21.296
100	11.743	11.861
110	9.621	9.461
120	8.924	8.995
130	8.215	8.106
140	7.971	7.677
150	7.765	7.361
160	7.320	7.203

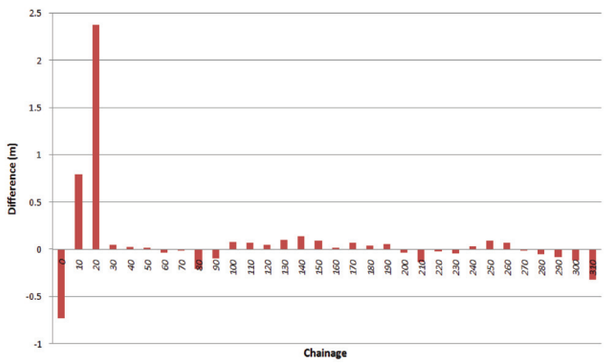

FIGURE 3. The differences between as-built survey and measurement by uav for every chainage at Jalan Gelanggang

From Table 1 and Figure 3, it shows that width for overall chainages for as-built data is larger compared to UAV data and for Jalan Gelanggang, the range of percentage differences of width between as-built data and UAV images are 1% to 4%.

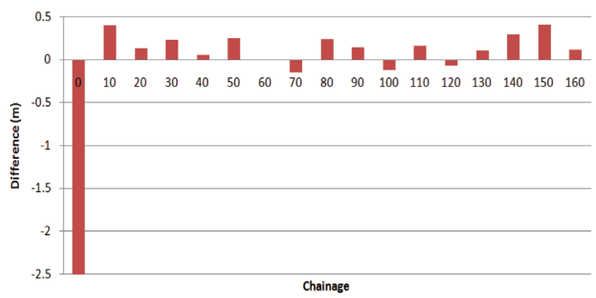

FIGURE 4. The differences between as-built survey and measurement by uav for every chainage at Jalan Temuan

From Table 2 and Figure 4, it is shown that the width for overall chainages for as-built data is larger compared to UAV data. For Jalan Temuan, the range of percentage differences of width between as-built data and UAV images are 1% to 6%.

Overall area and perimeter for Jalan Gelanggang and Jalan Temuan were measured by digitising the roads with ArcGIS software. After digitising, the two roads were overlapped between as-built data and UAV images to compare their area and perimeter. Figure 5 shows that as-built data overlaid with UAV images for Jalan Gelanggang while for Jalan Temuan in Figure 6.

After digitizing the roads, the results for overall shape area and length can be obtained from the attribute table in ArcGIS software. Table 3 shows the overall area and perimeter for both roads for as-built and UAV data.

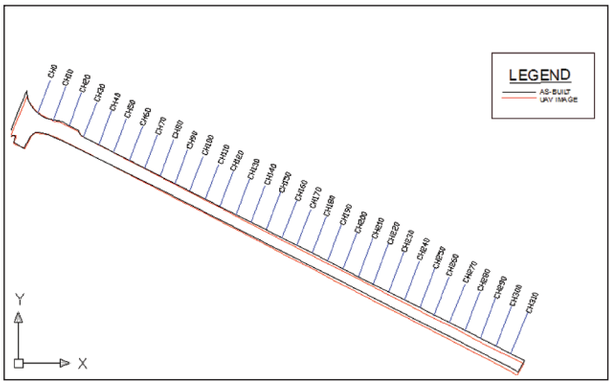

FIGURE 5. Overlapping of as-built data with UAV image for Jalan Gelanggang

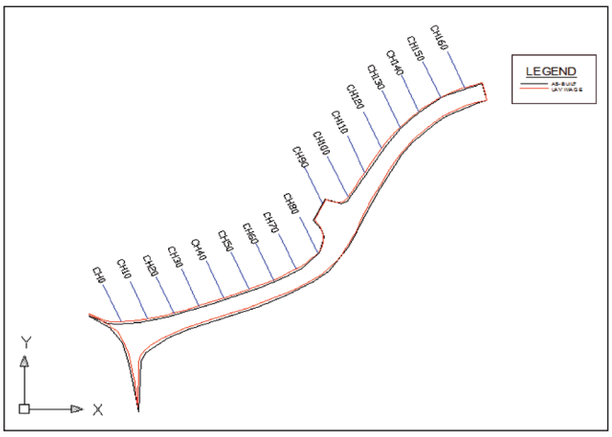

FIGURE 6. Overlapping of as-built data with UAV image for Jalan Temuan

TABLE 3. Perimeter and area for Jalan Gelanggang

	Road	As-Built Data	UAV Data
Perimeter (m)	Jalan Gelanggang	718.84	699.62
	Jalan Temuan	457.28	435.52
Area (m²)	Jalan Gelanggang	2653.07	2485.01
	Jalan Temuan	1649.38	1497.4

From both tables, it is shown that there is a slight difference in shape area and length for as-built data and UAV images. After analysing between as-built data and UAV images, the difference in the percentage of shape area for Jalan Gelanggang is 3.27%, while for perimeter is 1.35%. Next, the percentage difference of shape area for Jalan Temuan is 4.83% while for perimeter is 2.44%. It is clear that, compared to UAV data, the as-built data has larger area and perimeter for both roads.

For road maintenance works; the tolerance on width, perimeter, and area of the roads shall be within range of ±10% (JKR Standard Specification). Based on our findings, the percentage difference of width, perimeter and area between as-built and UAV data are still within the boundaries of the tolerance. Overall, the percentage differences of width, perimeter and area of Jalan Gelanggang are less than those of Jalan Temuan. This indicates that contractor in Jalan Gelanggang completed the road maintenance work according to specifications compared to Jalan Temuan.

As precautionary measure to minimise the costs and wastage in road maintenance works, UAV technology can be used as a verification medium instead of using conventional method. Costing for pavement for road of 50 mm thickness is approximately RM34.00 to RM38.00 per m² (Prasarana UKM). After analysing the results, the amount of savings that can be made for Jalan Gelanggang is at least RM6,386.28 while for Jalan Temuan is at least RM5,775.24. By using UAV technology to validate the road maintenance works, it is highly likely to yield more accurate results because it measures every end and vertex of the road by using digitizing method while conventional method measures from vertex to vertex of the road by using theodolite. Therefore, contractors will get an accurate payment based on the road maintenance works they had done.

CONCLUSION

The usage of UAV is clearly more efficient than using the conventional method as a verification medium. It is beneficial as it saves cost, produces accurate data and verifies road maintenance work systematically. Compared to the conventional method, this research used GIS software which is ArcGIS 10.3. This software is proven to be effective as it can generate the database for UAV data and as-built data which is produced by the contractor and determine the effectiveness of spatial works in road maintenance by measuring the width, perimeter and area of the roads. It is highly recommended to use UAV technology as a verification medium together with GIS software to validate the road maintenance works.

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