Application of advanced Geoinformatics for planning the maintenance schemes in tourism management: A case study of Kae Dum wooden bridge, Maha Sarakham province, Thailand

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ABSTRACT

Maintenance is an essential task in tourism management which requires the regular operation according to the schedules. However, a prolong maintenance can disrupt the attraction of tourists and cause the decreasing number of tourists eventually. With the advent of advanced technology of Geoinformatics and computer-aided design, these technologies can identify the destruction parts precisely which are essentially repaired response to the priority of the maintenance program. This study presents an implementation of Unmanned Aviation Vehicle (UAV) in investigating a sightseeing place, Kae Dum wooden bridge, which is highlighted on an antique wooden bridge crossing Kae Dum reservoir and connecting between two communities. Regarding the beautiful scenery and ecological system, the bridge attracts many tourists, in particular, a large number of secondary school students. According to the intensive use, this causes several damaged parts to the bridge which urgently requires the maintenance orderly. The application of advanced geoinformatics can be applied to illustrate the damaged parts of the bridge rapidly and precisely. As the results of this study, it shows the severity levels of the damaged parts and their location geographically along the wooden bridge. The technology-aided implementation will astonishingly assist the tourism management so far regarding tourist safety and maintenance resource management.

CCS Concepts

• Applied computing → Physical sciences and engineering → Engineering → Computer-aided design

Keywords

Geoinformatics; tourism management; UAV mapping; computer-aided design; UAV photogrammetry

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1. INTRODUCTION

Kae Dum wooden bridge is an ancient bridge older than 100 years old located in Kae Dum sub-district (Figure 1), Kae Dum district, Mahasarakham province, Thailand. It is not only the sightseeing place but also the connection of neighboring communities. Regarding its ancient and reputation of beautiful scenery, the provincial authority promotes Kae Dum wooden bridge as an attractive place of the province. It is to say that there are averagely 100 tourists visiting this wooden bridge a day [1]. According to the intensive use of the bridge, it was partially repaired by the local communities for the temporary usage until these current days. In term of the tourism management, it can be conducted differently regarding the nature and characteristics of the places [2-4]. For this case, the lack of proper maintenance may cause the danger to the tourists inevitably. Furthermore, the absence of maintenance scheme also causes the delay to this mission and disrupts the sightseeing activity of the tourists [5]. This study aims to present an advanced Geoinformatics technology in identifying the damaged parts with the severity levels for prioritizing the maintenance scheme in the tourism management.

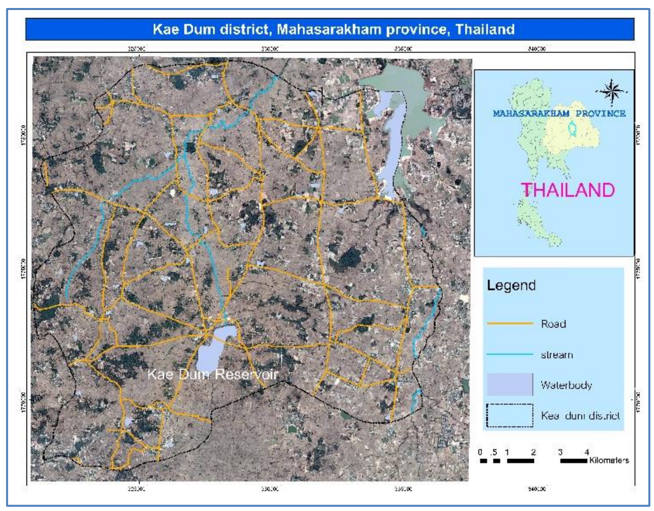

Figure 1. Kae Dum reservoir in Kae Dum district, Mahasarakham province, Thailand

2. UAV mapping

High-resolution imagery and Geographical Information System (GIS) have been applied with tourism and leisure management, particularly for presentation and proposal strategies in order to maximize the promotional appeal of tourism and their main assets [6-8]. The advanced technology of Unmanned Aviation Vehicle (UAV) currently enhances the capacity of the prompt availability of high-resolution imagery on demands. In order to qualify the high-resolution image from the UAV, some parameters have to be carefully set based on the photogrammetric theory, such as Ground Sampled Distance (GSD), overlapping and side-lapping degree with the same focal length in a flight [9]. The GSD relies on the focal length, the flying height, and pixel size, as the following equations [9].

$$GSD = \frac{H}{f}\mu \qquad (1)$$

$$\mu = \frac{W}{S_W} = \frac{H}{S_H} \qquad (2)$$

Where H is flying height (m.), f is focal length (mm), GSD is Ground Sampled Distance (m), μ is pixel size (μm), W is the width of CCD (mm), H is the height of CDD (mm), S_W is the number of pixels for W, S_H is the number of pixels for H.

According to the dimensions of the wooden bridge, the size of Kae Dum bridge is around one meter wide and 453.5 meters long. Regarding the very high-resolution imagery, the smallest GSD is calculated by using Equation 1 and 2 in order to present the smallest GSD and pixels representing this ancient wooden bridge virtually. Therefore, the average Ground Sampling Distance (GSD) is 3.42 cm.

In this study, the DJI Phantom 4 was used to capture Kae Dum wooden bridge and proximity areas. The flight plan and parameters were set according to the dimension of the bridge in order to present the high-resolution imagery for visualization in maintenance scheme.

Table 1. Setting parameters for Kae Dum bridge project

Parameters	Values
Flight height	80 m.
Overlapping size	80%
Side-lapping size	80%
Camera Angle	90°
Starting flight time	10.00 am
Ending flight time	10.30 am
Number of the flight plan	2 flight plans
Sky	Sunny
Date and season	26th April 2018: Summer

Following these set parameters, an index was created after computing the parameters and equation 1, 2. Several flash spots were occurring on the image due to the reflectance of the sun on the water surface during the capturing process by the UAV sensors. However, these spots do not affect the primary purpose of the project. The entire length of the wooden bridge was divided into three major parts, section A, section B, and section C regarding the alinement of the bridge. The index of Kae Dum wooden bridge is illustrated in figure 2.

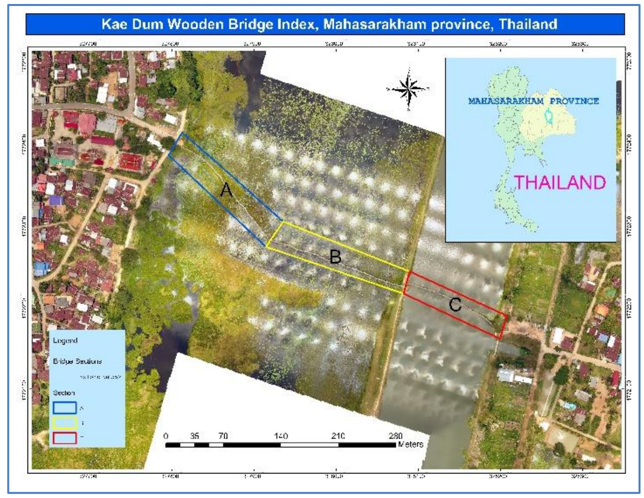

Figure 2. Kae Dum wooden bridge sections

After capturing the image from the UAV-borne sensors, the optical image presenting RGB spectral was further processed in the following major steps.

1. Compute image and tie point positions
2. Adjust block bundle details
3. Rectify geolocation details
4. Generate DSM (Digital Surface Model)
5. Produce Orthomosaic image

Regarding the photogrammetric processes, the geolocation details were computed accurately within the acceptable range. The RMS Errors in X, Y, and Z are 2.032 m., 3.701 m., and 6.381 m. respectively.

3. RESULTS AND DISCUSSIONS

3.1 Damaged part identification

Regarding the high resolution of the image taken by the UAV-borne optical sensors, all gaps (GSD is larger than 5 cm.) on Kae Dum Wooden Bridge were identified remarkably. It is found that there are many damage parts in every section of the bridge. It is noticeable that there are many primary-school students visiting this site daily. Regarding the foot size of these school students, the average size of the foot is 15 cm[10]. Therefore, these students are easily falling into the gaps which are larger than 15 cm. Considering the wood material on the bridge, the damage levels were classified by the following criteria.

1) Severe damage level: big size of the gap (larger than 15 cm.), small wood sticks (less than 15 cm.), and the gaps appear continuously.
2) Medium damage level: medium size of the gap (from 10-15 cm.), the gaps appear continuously.
3) Low damage level: small size of the gap (from 5-10 cm.), the gaps appear continuously.

From these criteria, the very high-resolution map from UAV was observed at the fixed scale of 1: 20. The results of the observation and field survey validation were done as shown in figure 3, 4, and 5 with the measured details in table 2, 3, and 4 respectively.

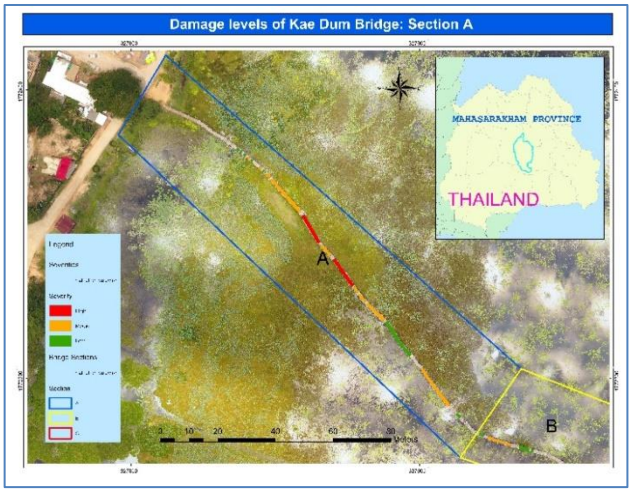

Figure 3. Damaged levels of Kae Dum wooden bridge: Section A

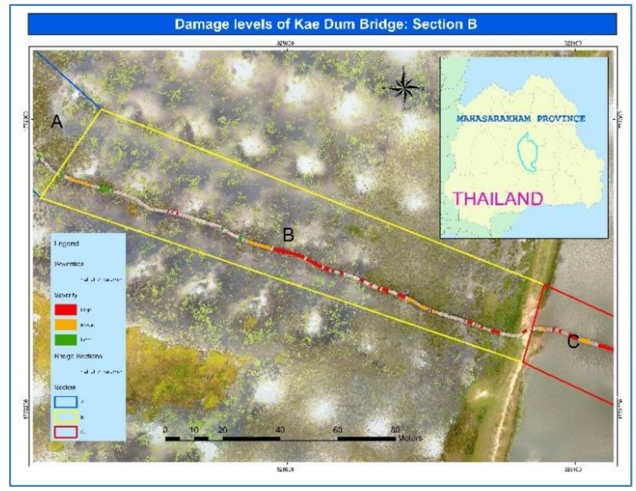

Figure 4. Damaged levels of Kae Dum wooden bridge: Section B

Table 2. Damaged parts of section A, explored by UAV mapping

Severity	Length (m)	Mid Reference Position (UTM)	
		X	Y
High (49.573 m)	24.426	327862	1772352
	25.147	327874	1772337
Medium (127.188 m)	3.850	327841	1772376
	4.085	327845	1772373
	5.651	327847	1772370
	32.907	327854	1772363
	11.978	327867	1772344
	6.441	327878	1772331
	8.805	327880	1772328
	18.825	327885	1772323
	34.644	327906	1772297
Low (57.595 m)	4.172	327837	1772379
	3.617	327838	1772378
	3.529	327839	1772377
	3.579	327842	1772376
	3.114	327846	1772372
	2.295	327846	1772371
	31.486	327892	1772314
	5.803	327913	1772287

Table 3. Damaged parts of section B, explored by UAV mapping

Severity	Length (m)	Mid Reference Position (UTM)	
		X	Y
High (131.312 m)	2.967	327959	1772268
	2.848	327960	1772268
	3.899	327962	1772267
	25.001	328000	1772254
	14.568	328009	1772250
	6.401	328014	1772248
	3.756	328016	1772247
	4.637	328019	1772246
	5.423	328026	1772244
	3.732	328029	1772243
	4.276	328032	1772241
	6.761	328034	1772241
	8.511	328040	1772239
	3.080	328049	1772234
	3.264	328050	1772233
	2.772	328062	1772230
	5.668	328063	1772229
	2.882	328065	1772229
	3.009	328066	1772228
	4.010	328068	1772228
	8.679	328072	1772226
	5.168	328082	1772226
Medium (64.140 m)	18.818	327928	1772278
	9.888	327988	1772257
	11.203	327992	1772256
	8.451	328043	1772237
	8.226	328047	1772235
	3.906	328051	1772233
	3.649	328052	1772233
Low (31.233 m)	5.139	327922	1772281
	9.775	327936	1772276
	4.132	327939	1772275
	4.070	327977	1772262
	4.964	327984	1772259
	3.153	327985	1772258

Figure 5. Damaged levels of Kae Dum wooden bridge: Section C

Table 4. Damaged parts of section C, explored by UAV mapping

Severity	Length (m)	Mid Reference Position (UTM)	
		X	Y
High (191.630 m)	4.021	328093	1772227
	4.566	328095	1772226
	9.688	328099	1772224
	48.468	328119	1772218
	5.910	328132	1772213
	7.211	328135	1772211
	7.350	328138	1772210
	7.271	328142	1772208
	6.277	328145	1772206
	8.606	328147	1772205
	4.912	328152	1772202
	3.961	328154	1772201
	3.960	328155	1772201
	9.175	328158	1772199
	8.809	328162	1772197
	5.619	328165	1772195
	7.440	328167	1772194
	14.525	328176	1772189
	6.209	328182	1772184
	5.731	328184	1772183
	3.257	328185	1772181
	4.202	328187	1772180
	4.462	328190	1772177
Medium (16.918 m)	6.090	328089	1772227
	10.828	328104	1772223

3.2 Maintenance priority

Regarding the results of this study, it is clearly shown that the section C presents the most critical danger to visitors and passengers. Apart from section C, the most dangerous part of section A and B are listed in table 5 respectively.

Table 5. Dangerous parts, length and locations on Kae Dum bridge sections

Priority	Length (m)	Mid Reference Position (UTM)	
		X	Y
Section C	48.468	328119	1772218
Section A	25.147	327874	1772337
Section B	25.001	328000	1772254

Regarding the identified middle referencing positions, the maintenance can be done easily by accessing the listed positions in table 5. It is also convenient to prepare the number of wood sticks regarding the length of the damaged parts of the bridge.

4. CONCLUSIONS

Applying the UAV-borne sensors is extremely useful to investigate the damaged parts of Kae Dum wooden bridge. The explored results are also beneficial to further the tourism management. Regarding the finest GSD in this recent day, it is proved that the very-high-resolution image from UAV displays more details than the high-resolution image from Google map as shown in figure 6. The maximum expansion of UAV-borne image and google image are 1:20 and 1:3,000 respectively with clear visual objects. It is confirmed that the UAV-borne image is more appropriately applied to investigate the construction conditions of Kae Dum wooden bridge in this sightseeing place.

Figure 6. Detail comparison from high-resolution images of the same position on the bridge section C

Regarding the results of this study, it is clear that the bridge section C urgently requires the first priority of maintenance for the safety reason. The reparation would start from the position X, Y = 328119, 1772218 m. Applying this technic, the Kae Dum wooden bridge was prioritized and initially repaired response to the explored results, while the other parts, section A and B, would be able to serve the tourists normally. This approach provides the compromising way for tourism management in which to maintain the number of tourists correspondingly to repair the most severity part of the bridge. This damage is about 48.468 m. With the advantage of UAV photogrammetry, the damaged parts will be able to measure to estimate the materials required for the maintenance scheme correctly. It would say that this technic can assist the tourism management in term of maintenance and restoration efficiently.

5. ACKNOWLEDGMENTS

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