Digital photogrammetric survey from aerial images for architectural documentation in sites and monuments: a case study of Wat Mahathat Lop Bury, Thailand

M. L. Varodom Suksawasdi

1 Faculty of Architecture and Planning, Thammasat University, Pathumthani, Thailand.
2 Research Cluster in Livable Environment and Architectural Design Laboratory (LEAD-Lab)

Email: varodom@ap.tu.ac.th

Abstract. This study is a part of research to describe a way to obtain various photogrammetric products from aerial photograph using a drone. The aim of the project was to develop a methodology to obtain information for a case study of the architecture documentation in Wat Mahathat Lop Bury, Lop Bury Province, Thailand which a combining the manoeuvrability and low cost of a drone with the accuracy of the results of the Agisoft PhotoScan software. These will be improvements for architecture documentation working with limited budgets or with limited access to sites.

1. Introduction
The architecture documentation must be have accuracy and alignments of each structure which to analyze data such as accurate measurements of dimensions, structure, construction and technology. The architecture documentation use to preservation and restoration for revitalization sites and monuments [1]. Maps of Thailand sites and monuments available in the literature have an insufficient precision to perform such research; consequently, for the study of each architectural site, a precise survey must be done [2]. Several solutions are available for architectural survey such as a topographical survey can produce accurate measurements that can be processed with software to obtain maps and 3D models. Nevertheless, with a total station, it is impossible to register each stone and deformation of the ruins. Thus, the representation is a synthesis and an interpretation of the information. A second solution would be using a laser scanner. Unfortunately, archaeological sites can be quite widespread and have many monuments, so the number of stations to be performed and the number of point cloud to be processed would demand too much post processing resources. A third solution is to use a drone to acquire aerial photographs of sites, and process them to create orthophotos and 3D point clouds.

2. Developments of Photogrammetric product in Architecture documentation
Photogrammetric product has existed for over a hundred years [3]. But just expanding to architecture two decades ago. Knowledge resulting from the combination of scientific principles and the arts in relation to measurement technology and photography. In the field of architecture conservation is
applied to surveying buildings with limitations such as access, primitiveness and risk of damage is being withdrawn. The two important steps are photography and creating orthophotos as shown in Figure 1. First step have a shooting methods, image preparation and image distortion correction before processing and Second step have a process uses principles to establish relationships of objects, directions, and distances from images, which can be referenced using geometric theories. The results obtained are processed. And advanced calculations Nowadays, there are complex computer software which their will get three-dimensional images, coordinates, object locations, sizes, shapes, proportions and distances of buildings or locations [4].

![Figure 1. Adjacent but overlapping aerial photos are called stereo-pairs and are needed to determine parallax and stereo/3D viewing.](image)

Cultural heritage is a complex and highly political phenomenon. There are few social elements and types of tourism that are more hotly contested at so many levels. These groups have at some point in history been oppressed by the ethnic group in power, which has resulted in their pasts having been deemphasized or even written out of official history in some cases while many countries are embarrassed by the cruelties performed against racial minorities (and sometimes majorities) throughout history, special interest groups and proponents of heritage commemoration are forcing legislators and other public officials and organization’s to acknowledge the atrocities of the past and commemorate them [5]. Cultural heritage tourism limitations that it had been prevented tourists from participating in areas or activities. Mostly it is caused by personal factors and external factors. These could be divided into 4 limitations; accessibility, education preparation, disability and psychological constraints [6]. These limitations will be reduced by presenting 3D models which are created by the process of photogrammetry.

3. Research methodology

Study and collect data from flying with Dji Mavic 2 pro drone with a sensor 1” CMOS, FOV Lens about 77°, maximum flight time (no wind condition) about 31 minutes and find suitable procedures for flight. By flying around the object to collect images in each of the images circling and assessments to use of this system in comparison between the use to 3D Scanner. The desired result is the point cloud formats for both systems. Finally, look for limitations in studying this process and for further study in the future shown in Figure 2.

The review also none highlighted the need for any operation to be fully compliant with aviation regulations and health and safety provisions, to be covered by comprehensive insurance and aware of privacy issues (See Table 1). We also consulted external organisations with more experience in using UAVs in sites and monuments recording, and the consistent advice was that it would be risky to purchase an expensive 3D scanner without first experimenting using Professional.
Table 1. Options review for Historic Environment Thailand sites and monuments unmanned aerial vehicles (UAV) photographic applications [2].

| Options         | Pros                                           | Cons                                                   |
|-----------------|------------------------------------------------|--------------------------------------------------------|
| Buy UAV         | In Thailand, readily available at short notice  | Cost of equipment, maintenance, training, developing competence, operations manual |
|                 | Flexibility to use at short notice             | Must be used regularly to maintain operator competence |
|                 | Sites and Monuments imperatives drive image capture | Potential damage/total loss of equipment                |
|                 | Takes less time                                | Insurance and public liability                         |
|                 | Suitable for both Sites and Monuments          | Rapidly developing field, legal framework likely to change |
| Buy 3D scanner  | High quality imagery                           | More expensive than UAV                                |
|                 | High accuracy (Color of material)              | Requires staff time (ideally 3 operators)              |
|                 |                                                 | Not Suitable to small work.                           |

4. Results

The sites and monuments considered is situated at Mueang Lop Buri of Lop Buri province shown in Figure 3. It was the religious center of a Lop Buri ancient city and had been reduced to the role of the central location. These resulted in a flying height of 30 meters from the ground (in Thailand restricted fly more than 90 meters from the ground). The maximum rate of the photographs was chosen (Around to object) and a flying speed of 5 m/s was calculated. The exposure time used was $1/320$ sec, the ISO 100, aperture 5 and the focal length 10.26 mm. The flight plan consists of around to object. The flight editor announces a flight time of 20 min. between flights the UAV lands in order to change the battery sets.

To obtain orthophotos and 3D models, Agisoft PhotoScan software, was used. I got 26 images that were processed to obtain the aerial photograph shown in Figure 4. The software starts searching the reference point between the images, before calculating the distortion parameters and thus the calibration of the camera. It turned out that the 3D point cloud representing the tie points presents a bending which is not in accordance with the reality [4]. After this the commands for the creation of orthophotos and 3D Models can be launched.
Figure 3. Show photos at Wat Mahathat Lop Buri are taken on 2 March 2019.

Figure 4. Show photos in time shot mode using the DJI Mavic2 drone and continue processing it in an Agisoft PhotoScan software.

Figure 5. Show the introduction of results that can tell the correct proportion (true shape) of archaeological sites.
5. Conclusions
This study can applied in presentations to display interesting exhibits in the museum and stimulates the mind to become increasingly concerned about the disappearance of the national heritage. Such as Understanding the concept of the cosmolgy and architectural planning from this concept [7]. For future generations to see imaging reconstruction and cultural landscape of architecture that has been lost. In the presentation with 3D modeling, if the building is complete, architectural documentation by the survey makes too easy to know the true distance shown in Figure 5. Therefore, the case study is archaeological sites and buildings are incomplete. And the materials that make up the structure are bricks and laterite. Photogrammetry Easier to do. On the other hand, images are presented with 3D Modeling. When brought into an application to display architectural images. It can open the side view (elevation) and cut view (section). By doing this, be able to understand the physical characteristics of that archaeological site. For example Building proportion Decorative elements or missing parts. It also speculates the characteristics of the structure. The style of construction and materials, the original color of the building. The discrepancy of calculations with Agisoft PhotoScan Also available to create 3D Modeling as in the Table 2.

| Count | X error (cm) | Y error (cm) | Z error (cm) | XY error (cm) | Total (cm) |
|-------|--------------|--------------|--------------|---------------|------------|
| 32    | 0.47         | 0.51         | 0.68         | 0.69          | 0.98       |

As for the geometrical accuracy, it has already been found in several projects that photogrammetry, in combination with using targets, is able to product very accurate result [8]. Further of this study had been helping decision between participant and stakeholders in architectural conservation and improved planning for building preservation.

6. References
[1] Charnnarong S 2012 Photogrammetry in architectural conservation: Literature review and possible applications for Thai traditional architecture NAJUA 9 pp 159-184
[2] Cowley DC, Moriarty C, Geddes G, Brown GL, Wade T and Nichol CJ 2018 UAVs in Context: Archaeological Airborne Recording in a National Body of Survey and Record Drones 2(1) 2
[3] Burtch R 2006 History of Photogrammetry (The center for Photogrammetric Training) Ferris State University
[4] Mouget A and Lucet G 2014 Photogrammetric Archaeological Survey with UAV ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences 2(5) 258
[5] Timothy DJ and Boyd SW 2006 Heritage tourism in the 21st century: Valued traditions and new perspectives Journal of heritage tourism 1(1) pp1-16
[6] Timothy DJ and Boyd SW 2003 Heritage tourism (Harlow England) New York Pearson Education
[7] Jirathasanakul S 2001 Wat: Buddha of Thai Architecture (Thammasat Printing House) Bangkok
[8] Waagen J 2019 New technology and archaeological practice. Improving the primary archaeological recording process in excavation by means of UAS photogrammetry Journal of Archaeological Science 101 pp11-20

Acknowledgement
The authors gratefully acknowledge the financial support provided by Thammasat University Research Fund under the TU research Scholar, Contract No. 125/2561 and this research has been approved by a research ethics committee of Thammasat University.