Analysing and Surveying the Damaged Bagan Pagodas

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***Abstract* -Analysing and surveying are the critical tasks for the damaged ancient Bagan pagodas due to the impact of earthquake. In this paper, we will present the some resent results of the area photo survey and 3D map producing project. That project will provide to maintain, rescue, renovation and reconstruction processes after disaster. The hexa rotor aircraft is applied for image acquisition. Before generating the 3D map and 3D model by Pix4D, the image enhancing, alignment and removing processes are performed based on the imaging geometry and morphological operations for obtaining the accurate 3D aerial map. By removing the un-required images and performing the alignment process, the time complexities will be reduced and accuracy rate will be increased. The effectiveness of this proposed approach can be confirmed through the comparison of the experimental results.**

***Keywords* - Damaged ancient pagodas, Analysing and surveying, Renovation, Reconstruction, Image alignment, Morphological processing.**

I. INTRODUCTION

Bagan, the heart of 'Golden Land Myanmar', is located in the Mandalay Region. During the kingdom's height between the 11th and 13th centuries, over 10,000 Buddhist temples, pagodas and monasteries were constructed in Bagan. In present day, Bagan was rich of more than 2,200 structures, including pagodas and temples. In August 24, the magnitude 6.8 quake was centered about 15 miles west of Chauk, a town south of Bagan. It struck quite far below the earth's surface at a depth of about 52 miles and caused at least four deaths and damaged nearly 200 Buddhist pagodas and temples. The analysing the damaged level and surveying of damaged pagodas are essentially needed for renovating of the damaged ancient pagodas. According to the requirement of Department of Archaeology and National Museum, Ministry of Culture, University of Computer Studies, Yangon and Myanmar Aerospace Engineering University are collaborated to the Arial photo survey and 3D map and 3D model producing project. Some resent results of the project will area photo will present in this paper.

Unmanned aerial vehicles (UAV) or unmanned aircraft vehicle systems (UAVS) have becoming very popular in recent years, due to their accessibility to targets, promptness of dispatch, and high-spatial resolution of acquired images. In our project, a Hexa-rotor Aircraft, or Hexa-rotor helicopter is applied for image acquisition. That hexa-copter is lifted and propelled by six rotors. Its lift is generated by a set of revolving narrow-chord airfoils. This Hexa-copter (See Fig. 1) is the product of Myanmar Aerospace Engineering University (MAEU) and the system performance is shown in Table 1.

There are various kinds of existing developed software for viewing and generating the 3D model and 3D map [1-9]. Agisoft [8] and Pix4D [9] are well known 3D mapping drawing software and many geographers are applied. Agisoft PhotoScan is a stand-alone software product that performs photogrammetric processing of digital images and generates 3D spatial data. Uncertain neighboring pixels of the object will removed in the corresponding computing stage of Agisoft. According to this situation, some parts of object can't be reconstructed. Pix4D mapper software [9] is very often used in GIS applications, cultural heritage documentation, and visual effects production for indirect measurements of objects of various scales. In the corresponding computing stage of Pix4D, the uncertain neighboring pixels of the object are added to the object features. The neighbor objects are mixed to the object.

A new 3D model generating approach is introduced. In our approach, the image enhancing, alignment removing processes have been done among the UAV images before the 3D map generating by Pix4D. These processes are performed based on the imaging geometry and morphological operations. The time complexities will reduce by removing the un-required images and the accuracy rate will be increased by the alignment process. The comparison results will be described to confirm the proposed approach work adequately.

Fig. 1 Image Acquisition by Hexa- copter

TABLE I
PERFORMANCE OF THE AIRCRAFT SYSTEM

Features of Hexa-copter	
Payload Capacity	5 kg
Flight Height	2500 m
Transmission Distance	5-20 km
Flight Speed	8-15 m/s
Flight Time	20-60 min
Wind Resistance	level 7

II. System Design

The over view of system design is illustrated in Figure 2. Mainly four stages such as image enhancing (pre-processing), removing the duplicated image, image alignment and 3D mapping generating are included in the proposed system design. About 300 to 400 images are taken by the Hexa-copter moving around the pagoda. Acquired UAV image contained the position, latitude and longitude of each point in a scene.

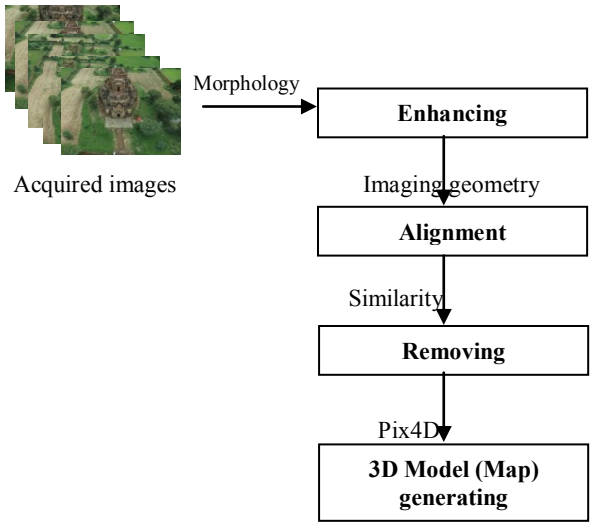


Fig.2 System Flow Diagram

III. Image Enhancement

In image research area, image enhancement is one of the most important and difficult techniques. The enhancing process supported to obtain more suitable result than the original image for a specific application. Image resizing, gray scale converting, noise filtering and intensity transformation stage are included in the enhancing process. Some images like medical images, satellite images, aerial images and daily life photographs suffer from noise and poor contrast. It is necessary to enhance the contrast and remove the noise to increase image quality. The objective of image enhancement is either to improve the visual appearance of an image or to provide a better transform representation for future automated image processing.

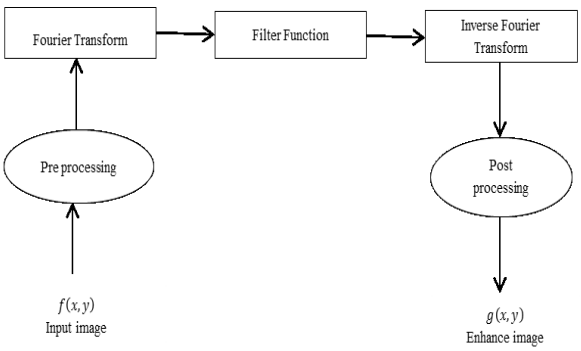


Fig.3 Image Enhancing

The image enhancing technique can be classified into two broad categories: Spatial based domain image enhancement and Frequency based domain image enhancement. The enhanced image $g(x,y)$ of original image $f(x,y)$ can be described by as following:

$$g(x,y) = h(x,y) * f(x,y)$$

where $h(x,y)$ is filter function.

Spatial based domain image enhancement operates directly on pixels. The main advantage of spatial based domain technique is that they conceptually simple to understand and the complexity of this technique is low which favours real time implementations. But these techniques generally lacks in providing adequate robustness and imperceptibility requirements. Frequency based domain image enhancement is a term used to describe the analysis of mathematical functions or signals with respect to frequency and operate directly on the transform coefficients of the image, such as Fourier transform, discrete wavelet transform (DWT), and discrete cosine transform (DCT). The basic idea in using this technique is to enhance the image by manipulating the transform coefficients.

The advantages of frequency based image enhancement includes low complexity of computations, ease of viewing and manipulating the frequency composition of the image and the easy applicability of special transformed domain properties. The basic limitations including are it cannot simultaneously enhance all parts of image very well and it is also difficult to automate the image enhancement procedure. The flow diagram of image enhancing is presented in Fig. 3.

IV. Image Alignment

Image alignment is one of the most important tasks in 3D image reconstruction. Various image alignment techniques provide point or region correspondence in an image sequence for image motion analysis. An essential step for object recognition is pose determination, which can be accomplished by image alignment techniques. In automated visual inspection, image alignment between the inspection image and the reference image is usually the first and the most crucial step for most inspection problems.

A large number of image alignment techniques have been developed to improve the accuracy, generality, robustness and speed of image matching. They can be classified into two categories; i.e. the feature-based matching approach and intensity-based matching approach.

The feature-based matching approach requires reliable feature extraction as well as robust feature correspondence to overcome missing feature and outlier problems due to partial occlusion. Its main advantage is the robustness against illumination changes.

The intensity based matching approach is mainly based on the SSD (Sum of Squared Differences) formulation [2], which does not require feature extraction or direct correspondence between two sets of features. However, this approach is more sensitive to illumination changes than the feature based approach. In addition, the conventional SSD-based formulation is not robust against occlusion.

In this proposed work, feature-based matching approach is used for alignment of image. Feature-based matching approach is described as follow:

Given images A and B

1. Compute image features for A and B
2. Match features between A and B
3. Compute homography between A and B using least squares on set of matches.

V. Experiments and Results

An I7PC with 32 MB memory is used in this experiment. And the high performance computation and visualization software visual C++ version 6 is employed to analyze the data. Several experiments have been done for generation the 3D model of pagoda in our project. The comparison results with our approach will present in this section. Figure 4 shows the some acquired UAV images of Damayazaka pagoda. Four hundred images of Damayazaka pagoda is taken by Hexa-copter with mounted canon camera.

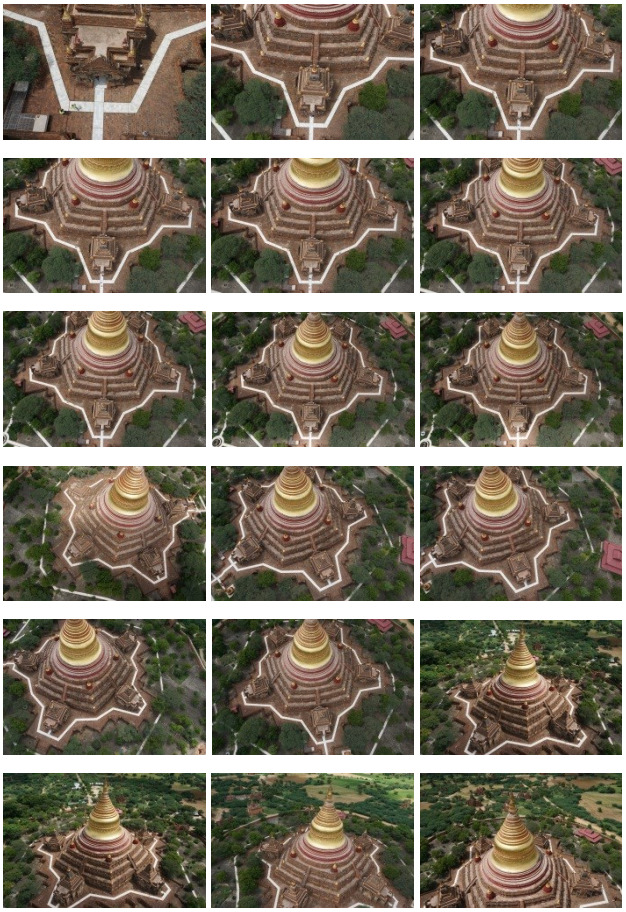
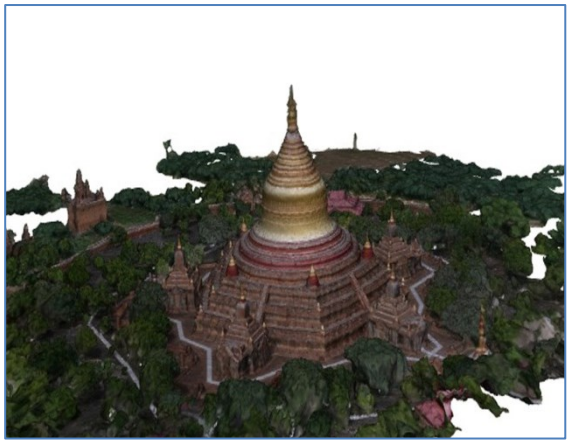


Fig. 4 Some UAV Images of Damayazaka Pagoda

Figure 5 described the reconstructed results of 3D model of Damayazaka pagoda in bagan ancient city. Figure 5(a) and Fig.5 (b) illustrated the reconstruction results using popular software Agisoft and Pix4D, respectively. Fig. 5(c) shows the result of performing the image alignment before generating the 3D model.

(a) Reconstructed Result by Agisoft

(b) Reconstructed Result by Pix4D



(c) Reconstructed Result by Proposed Approach

Fig. 5 The results of 3D model generation

VI. Conclusions

According to reconstruction results, some limitations are remained in existing 3D mapper. As described in previous section, the entire shape can't get at Fig. 5(a). And some of the parts of trees are integrated to the reconstructed 3D model Fig. 5(b). In this research, the new 3D model generating approach is introduced for improving the accuracy of 3D model reconstruction. The processes of image enhancing, removing the duplicated images and image alignment have been done among the UAV images before the 3D map generating by Pix4D. These processes are performed based on the imaging geometry and

morphological operations. The time complexities will reduce by removing the un-required images and the accuracy rate will be increased by the alignment process. The effectiveness of the proposed approach can be confirmed though the experimental result.

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