CONSTRUCTION OF NATIONAL CULTURAL HERITAGE MANAGEMENT SYSTEM USING RC HELICOPTER PHOTOGRAPHIC SURVEYING SYSTEM

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KEY WORDS: RC Helicopter, National Cultural heritage, Close Range Photogrammetry, CCD Video Camera, Web, VRML, Management

ABSTRACT

Structure-typed cultural heritage, objects of preservation are positioned as one of very important heritage in national aspect, and its preservation of prototypical structure become influential against national development and natural disaster. From this reason, Digital Close Range Photogrammetry has recently been used diversely. Despite popular use, the measurement has limits to be unsuitable for photographing precisely cultural heritage situated at high a mountainous terrain or where people can not approach easily, high gigantic stone statues among the preserved structure-typed cultural heritage. In order to supplement the limits, when using the measurement, a camera tripod with +30m, a ladder truck and a shore should be equipped, which means additional equipment leads uneconomical waste of cost and time.

In this vein, this study developed a device, in detail, used a RC Helicopter installed with CCD(Charge Coupled Device) video camera with easiness of control, safety, equipment, carrying, movement and approach, then checked images shot by wireless modem at real time and considered economical efficiency without re-photographing. Next, this paper digitized the images of nationally designated structure-typed cultural heritage, used materials about them restored as the third dimension in order to construct the integrated management-information system for cultural heritage.

Through the above processes, this study can provide specific information on 3D images and 3D CAD sections of structured-typed cultural heritage for both public and specialists on the web. Moreover, it suggests the foundation to restore the damaged cultural heritage in the future by the aim of effective management and preservation for them.

1. Introduction

A variety of projects for cultivating the land are currently under way buoyed by the increased demand of infrastructures accompanied with the rapid economic growth and qualitative improvement of life. And, the global warming is due to the natural full-scale weather change phenomena such as El Nino and the greenhouse gases such as CO_2 or CFC happening all over the world from the late of twenty century, to which the natural disasters are gradually increasing. According to this, the cultural heritages, which are archeologically of great value, are damaged or destroyed by wind and weather, inflicting a big loss on the country. Thus, in order to prevent the archeological cultural heritages from developments of the land and from the natural disasters, the performance of the advanced projects is necessary to the original preservation of cultural heritages. And for the original preservation of cultural properties, the existing actual measurement has been largely used for observation, but in recent, Digital Close-Range Photogrammetry (DCRP) is being used for it.

As DCRP can acquire an accurate 3D data from 2D data stored by a analysis of the stochastic images based on the reappearance of photographing conditions, it is having been wide application as a precise technique measuring digital data. Also, as DCRP can measure a photograph taken by camera minutely and repeatedly, it is largely applying to a spatial analysis such as engineering works structures including bridge and tunnel, building structures location, size and transformation, human technology, field investigating traffic accident as well as police and law sciences field, and roads present condition.(Henri v. George V, 1998; Younian Wang, 1998; Frank A. van den Heuvel, 1998; Petros Patias, 2000; Nicola D` Apuzzo, 2000)

Structure-typed cultural heritage, objects of preservation are positioned as one of very important heritage in national aspect, and its preservation of prototypical structure become influential against national development and natural disaster. From this reason, Digital Close Range Photogrammetry has recently been used diversely. Despite popular use, the measurement has limits to be unsuitable for photographing precisely cultural heritage situated at high a mountainous terrain or where people can not approach easily, high gigantic stone statues among the preserved structure-typed cultural heritage. In order to supplement the limits, when using the measurement, a camera tripod with +30m, a ladder truck and a shore should be equipped, which means additional equipment leads uneconomical waste of cost and time.

In this vein, this study developed a device, in detail, used a RC Helicopter installed with CCD(Charge Coupled Device) video camera with easiness of control, safety, equipment, carrying, movement and approach, then checked images shot by wireless modem at real time and considered economical efficiency without re-photographing. Next, this paper digitized the images of nationally designated structure-typed cultural heritage, used materials about them restored as the third dimension in order to construct the integrated management-information system for cultural heritage.

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2. RC Helicopter Photogrammetry System

A radio control helicopter (RC Helicopter) photogrammetry system is a system photographing scenes caught by RC Helicopter under the control of an earthly

monitor, which RC Helicopter is mounting camera on the gimbal that is able to maintain vertical condition without regard to the body of a light helicopter controlled by radio and the vibration or a rolling of it.

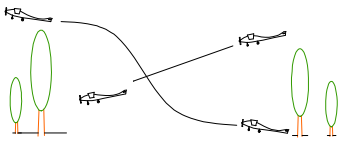
When helicopter, which people get on board to handle directly, cant fly in a difficultly approachable spot or within an area of a narrow width, or for a mountainous area such as gorge that is difficult for people to approach, it is possible to be reasonably taken a close photograph by RC Helicopter, as RC Helicopter photogrammetry system is controlled by an advanced technology of RC Helicopter and an earthly monitor as shown by Table 1. The manned helicopter leads to a skilled training of controller, a high cost of itself and a high cost for boarding. On the other hand, as RC Helicopter can be directly controlled through a low cost of itself and a short training, it is excellent in aspects such as economy, mobility and rapidity.

Table 1. The analysis according to conditions

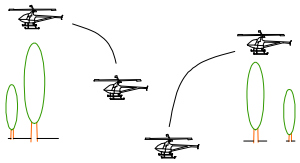
Method / Clause	RC Airplane	RC Helicopter	Hot-air Balloon	Balloon	Air-ship	Long Tripod	Aluminium Tower
Manufacture degree	D	D	D	A	E	A	B
Construction expense	C	B	D	A	E	B	C
Maintenance expense	A	A	B	C	E	A	A
Movement and Approach	A	A	B	A	D	A	C
Control	C	B	D	B	A	A	B

Also, by maintaining flight altitude to about 200 meter (visibility range) from the earth, RC Helicopter can take a photograph of a dynamic and static image of the wanted object - the selection of sites such as house, apartment and factory, the whole view of buildings such as school and factor, the progress of public works such as roads, harbors and bridges, the news of the press and broadcasting station, film, the other air photo such as advertising by airship -- with cameras such as Still, Digital, Digital Video and general Video in the industry field.

As RC Helicopter of these features can make a flight such as a hovering, a vertical descent and nose-dive, a moving forward and backward, and a flank without any change of the body, it can directly fly from a spatial point to other point. Accordingly, alike an airliner and a fighter that the wing is fixed, RC Helicopter can make a flight such as a vertical taking-off and landing in where a roomy airstrip is unnecessary as Figure 1.



(a) RC Airplane



(b) RC Helicopter

Figure 1. Property of RC Airplane and RC Helicopter in flight

Also, when an engine is out of order, it can safely land on the earth by using the auto rotation on the body based on the proper control procedure of controller. RC Helicopter examined by this study used EAGLE 90 of HIROBO Co, the figure and the various factors is as Figure 2 and Table 2, respectively.

Figure 2. Model of RC Helicopter

Table 2. Specifications of RC Helicopter

Name	HIROBO & EAGLE 90
Length	1400 mm
Hight	470 mm
Width	250 mm
Main roter diameter	1500 mm
Tail roter diameter	270 mm
Gear ratio	9.5 : 1 : 5
Maximum payload weight	8500 g
Maximum operation radius	200m(depends on flight conditions)
Endurance	approximate 20 minutes
Typical Applications	photogrammetry, surveying, cartography, archeology, environmental protection, arhitecture, civil engineering, marketing

According to Figure 2 and Table 2, RC Helicopter, which is made into the light and solid material of high-intensity, propel a main and tail roter with a glow engine (15cc), and is equipped with the capacity of fuel that can fly for about twenty minutes. The skilled controller can handle flight altitude in space from the earth to about 200 meters with radio as occasion demands.

According to Figure 3, the set-up part of camera, which is made up of the iron part of the taking-off and landing, can load cameras such as miniature (35mm), medium (6x4.5cm), Panorama (6x12cm), DV (6mm 3CCD), 35mm film movie and digital video (CCD: charge coupled device).

This set-up part, which can adjust an angle of axis by the radio control, is designed for a gimbal. A gimbal is a buffer that can absorb noises and vibration. In addition, this study designed a CCD digital video camera and video transmitter to show images taken a photograph on flights way through connection with the earth monitor at real time.

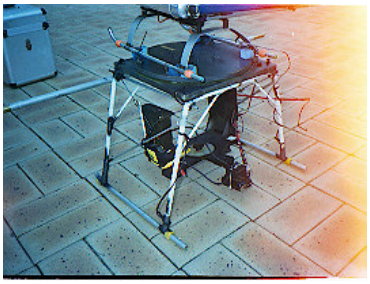


Figure 3. Construction of gimbal mount

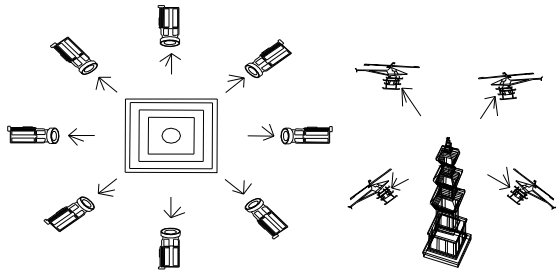
3. The Method of Observation

3.1 The Loaction of Observation

This study took a photograph of the cultural heritages such as Cheomseongdae and Goseonsaji Samcheung Seoktap (national treasure No. 31 and 38) located at Gyeongju-si, Gyeongsangbuk-do, Dansoksaji Dong.Seo Samcheung Seoktap (treasure No. 72 and 73) located at Sancheong-gun, Gyeongsangnam-do, and Changnyungsuljeongri Dong.Seo Samcheung Seoktap (national treasure No. 34 and treasure No. 520) located at Changnyung-gun, Gyeongsangnam-do.

3.2 Photographing using RC Helicopter

First, to materialize 3D image of the stone tower shaped as an exact squire, it used Ring technology that rotate camera into 360°. Second, when snapshot the difficultly approachable stone tower, it divided into all eight section to use a tripod that can mount a digital video camera to about six meters height as Figure 4(a). This camera tripod can stretch into 5 phases such as 1.70m, 2.59m, 3.52m, 4.70m and 5.51m. Third, in order to photograph the top of that, it used RC Helicopter photogrammetry system to rotate video camera into 360° as Figure 4(b).



(a) (b)

Figure 4. Positions of camera photographing

This study used VideoCap Pro 2.0 of SAVIT MICRO Co., which provide systems stability and high-definition, to capture the photographed digital video dynamic image as a static image in the video editing board. Also, it used Power Director 2.5 Pro to acquire a static image, which has a resolution of 720x480, in the editing software as Figure 5.

Figure 5. Acquisition of static image

3.3 Digital Photogrammetry Program

A digital photogrammetry program of this study is a method that handles an image data from 3D coordinates of the set up photograph, which have attempted a new approach for the photogrammetry of the earth. This program used Photomodeler 4.0, Digital Close-Range Photogrammetry program of EOS System Co., which many studies have been in advanced.(C.S Fraser, 1998; L. Dorffner and G. Forkert, 1998; C. L. Ogleby, 1999)

A Photomodeler 4.0 of EOS System Co., which is proud of an accurate analysis, is not only easy to acquire the top coordinate in the complicated digital image, but also can automatically perform all processes that handle image data. This study is divided digital image handling process into eight phases as Figure 6.

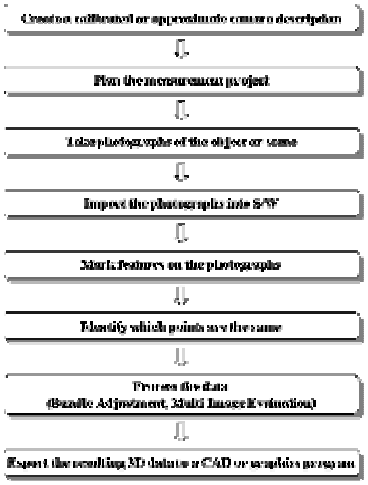


Figure 6. The flow chart of data processing

3.4 The Results and Analysis

Figure 7 diagrammatized Root Mean Square Error (RMSE) on the image acquired by Digital Close-Range Photogrammetry program. And, Figure 8 diagrammatized the mean value of RMSE on it.

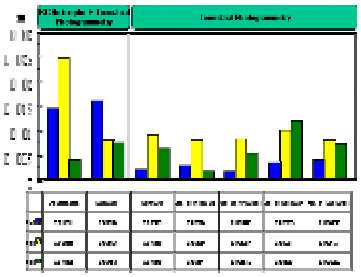


Figure 7. RMSE of check point[X, Y, Z]

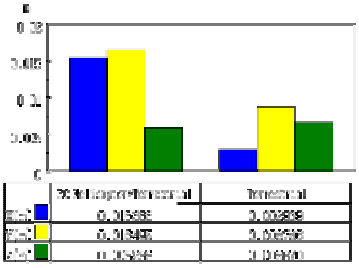


Figure 8. RMSE average of check points[X, Y, Z]

4. Cultural Heritage Management Information System

The conventional Web technologies allow Web browser to approach Hyper Text Markup Language (HTML) documents or executive files through Web server. But a gearing between Web system and database system is very important, as many organizations store both an essential business data and management data to database. Development of database application by the gearing with Web can facilitate the building of a multimedia and graphic user interface (GUI) environment as well as the support of a variety of platform. And Webs flaw in an aspect of document management can be resolved by an outstanding data management function of database. Therefore, a desirable development for application of large-scale data service is possible by a mutual assistant integration between database, Web and multimedia.

There are several gearing techniques exemplarily, by common gateway interface (CGI) and by java database connectivity (JDBC) - between Web and database to provide users with a unified interface, Web browser, and with a global service based on the popularity of Internet. CGI formalize SQR delivered by gearing with database as HTML, providing users with it. JDBC, which can maintain advantages-portability and compatibility-as it is, define Java Applet used for user Web interface as Web browser.

Cultural heritages management information system, which is built as Figure 9, used digital photogrammetry program to be databased VRMLs wrl data and CADs dxf data that is visualizing as 3D. Accordingly, it allow experts and general users to search easily various data about cultural heritages by using the databased data such as Cosmo Player, Java and HTML under Web basis. Table 3 is showing an environment of this system.

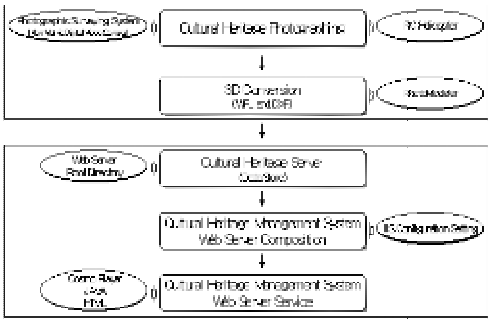


Figure 9. Flow chart of cultural heritage management information system

Table 3. Environment of cultural heritage management information system

Division	Content	Remark
C P U	Pentium 1.2 GHz	H/W
Operating System	Windows 2000 sdvanced server	S/W
Hard Disk	17GB	H/W
Memory	256 MB RAM	H/W
Cosmo Player	Version 2.1.5	S/W
HTML	Version 4.0	S/W

This study designed Web server system to help many users search and read easily 3D data of cultural heritages, which photograph to edit with Digital Close-Range Photogrammetry, through the worldwide Internet. The following data are necessary to establishment of this system.

First, this study provided experts and general users with data such as 3D image, a variety of factor and present location of cultural heritages.

Second, it provided users with Cosmo Player, worldwide public program, and with its manual to help them use it easily in this system as part of application for giving the photographed data as 3D to them on the Web.

Third, it provided users with convenience to help them search easily cultural heritages divided into three types of the large, middle and small in this system by using the hierarchy structure of Java, Web application development language.

This study designed this systems function as the total of five frames. The layout, first frame, is designed to view HTML in the Internet explorer. Figure 10 show basic layouts that will apply Virtual Reality Modeling Language(VRML)s wrl file visualized as 3D through the photogrammetry program to Cosmo Player. The top, second frame, named this system as Pukyong national heritage management information system as Figure 11.

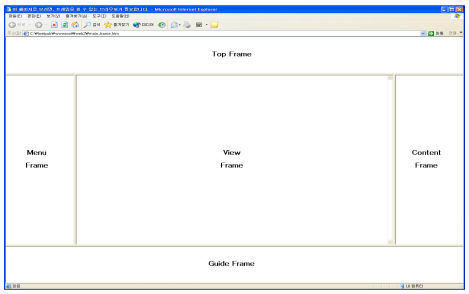
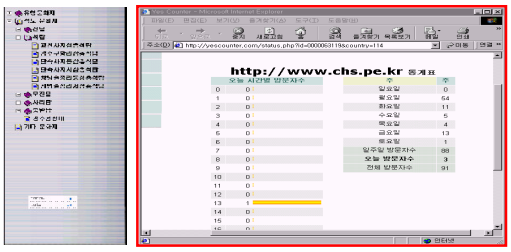


Figure 10. Frame layout

Figure 11. Top frame

The menu, third frame, classified a stone heritage, tangible cultural asset, by hierarchic types to help users search it easily in this system as Figure 12(A). And, if click a statistical table of visitor, users can know about the number of visitor by time, week and the whole as Figure 12(b).



(a) (b)

Figure 12. Menu frame

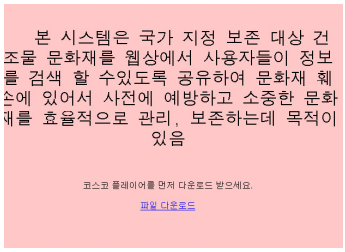
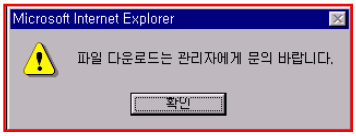


Figure 13. View frame

The view, fourth frame, is designed to deliver users not only contents related to an efficient damage precaution, management and preservation of important cultural heritage designated by nation, but also Cosmo Player, public program that help them see wrl file-qualitative data that they select cultural heritage in the menu frame-on the Web as Figure 13.

The content, fifth frame, include the detailed explanation and location information about cultural heritages that users select in the menu frame as Figure 14(a) and Figure 14(b), respectively. And, it is designed to deliver dxf(dwg)-3D CAD file-to users as Figure 14(c). When send CAD file, however, it must transmit after it is necessarily permitted from server systems operator.

(a) (b)



(c)

Figure 14. Content frame

Guide frame showed information about this system operator to help users require information about wrl and CAD file, or question about this system as Figure 15.

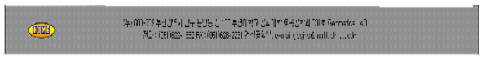


Figure 15. Guide frame

Figure 16 is a main menu of this system, and Figure 17 is an early menu of the stone heritage expressed by Cosmo Player.

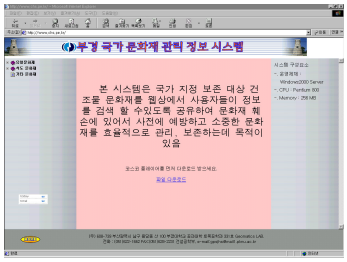


Figure 16. Main menu of cultural heritage management information system

5. Conclusion

This study developed this system on the personal computer of Windows basis. For this, it used factors such as images photographed by RC Helicopter with digital photogrammetry system, quantitative data and a variety of quick data acquired by digital photogrammetry program, Java and HTML as Web Application development language, and Cosmo Player as public program. The result on this is as following.

Figure 17. Main menu of Cultural Heritages

First, RC Helicopter photogrammetry system can make a quantitative analysis of a rapid and accurate data acquired by hovering-RC Helicopter photogrammetry technique-in where it is inappropriate to measure in detail such as cultural heritage located at a high mountainous district, a big stone structure and a difficultly approachable place.

Second, it can visualize stone heritages, or Cheomseongdae-the oldest astronomical observatory in East Asia-and stone tower, as 3D with 3D CAD file. And it can acquire images photographed by digital video camera for non-surveying in the precision measurement of cultural heritage. The result indicated a satisfactory value by 6 to 16mm (RMSE). Also, it is very effective in installation cost of an additional facility and times efficiency that is necessary to the existing Earth Digital Close-Range Photogrammetry.

Third, it is designed to help experts and general users view the related cultural heritages by unifying a qualitative data and a 3D drawing data dualized by the existing cultural heritage management system.

Fourth, it is designed to help them search cultural heritage information-a quantitative or qualitative data-on the Internet using Web server by establishing information system that conserve cultural heritage designated by the nation on the Web using Java, HTML and Cosmo Player.

Fifth, the existing system have been reappeared cultural heritage only with a dynamic image and data of 3D drawing, but this system can reappear it so as to be able to look alike by materializing Virtual Reality Modeling Language(VRML) on the Web browser.

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