Journal of Theoretical and Applied Information Technology
15th February 2018. Vol.96. No 3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A STUDY ON CONSTRUCTION OF ANALYSIS MODEL FOR BUILDING VIEW ENVIRONMENT USING UAV

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ABSTRACT

View environment has become a new index for evaluating the economic value of buildings. Therefore, demand for environmental analysis is increasing. The current method used for analyzing a view environment involves conducting a field survey or the use of a simulation method based on actual survey data as well as satellite and aerial survey data. However, the analysis of the view environment through a field survey has limitations in the planning or design of buildings. Simulation methods using actual survey or satellite and aerial survey have an economical limitation in that they require considerable manpower and time. Recently, ICT(Information and Communication Technologies) and UAV(Unmanned Aerial Vehicle) technologies have rapidly increased, and it possible to acquire high resolution spatial information and 3D modeling. In this study, a small UAV was used to analyze the view environment of buildings and construct a model. In order to achieve the purpose of this study, an aerial photograph was taken using a UAV for urban areas, and spatial information (orthophoto and Digital Elevation Model) of the urban areas was constructed. Virtual buildings were modeled using BIM and a view environment analysis model was constructed for buildings by combining the virtual buildings with the constructed spatial information. Finally, this study established the framework of the construction of the view environment. This study proposed a methodology for constructing a view environment model for buildings using UAV. It is expected that the results of this study will be useful in the future planning and design of building view environment. Furthermore, this study provides a preliminary demonstration of view environment analysis modeling based on actual background; it is expected that various applications will be developed using future IoT(Internet of Things) and VR(Virtual Reality) technologies.

Keywords: *View Environment, UAV, Spatial information, Building, Analysis Model*

1. INTRODUCTION

With Korea being recently recently labeled as one of the advanced countries and with the increase in its income level, the demand for residential space has shifted from quantitative to qualitative aspect. Particularly, the desire for a healthy and comfortable living environment to maintain human life is increasing[1]. Especially, apartment houses are becoming more popular in the dense and complicated urban land use. In addition, as the height of apartment buildings is increasing continuously, the profit of the view is considered as a critical factor of determining trading price in the real estate market beyond simple aesthetic and subjective value and is associated with property values[2][3]. In other words, the benefits of viewing river, lake, sea, golf course, and mountains are influencing the standard market price and housing price. In recent years, the profit of the view has had economic and objective value rather than just simple aesthetic and subjective value and it has become a consciousness of the right[4] [5].

As the importance of the building view environment has been spotlighted, studies on the formation process of the view environment and system, preference, landscape analysis and evaluation techniques for managing it has been actively conducted[6][7][8][9]. Consequently, a remarkable improvement has been achieved with respect to the methods of constructing the view environment [10]. However, as the view environment has become significant according to various urban development aspects, there is a need to establish methods for visual simulation that can reflect the field situation more precisely.

Until now, the view environment of buildings was analyzed based on simulations conducted by acquiring the surrounding spatial information through actual survey or satellite and aerial photography[11][12][13]. However, it is not economically efficient to construct a simulation model by actual survey owing to the considerable manpower and time required. In addition, the data obtained by actual survey must be manually converted into a simulation model, which might degrade the model's objectivity and reliability. Similarly, construction of a simulation model by satellite and aerial photography is costly and does not take into account changes in the terrain and structure of small areas[14][15].

In this study, a small UAV(Unmanned Aerial Vehicle) is used to analyze the view environment of buildings and construct a model. This approach is relatively economical compared to actual survey and aerial photography and can be used on-demand when the data is required.

The model constructed in this study can analyze the view environment of buildings by acquiring spatial information of the surrounding environment using UAV and modeling virtual buildings using a BIM(Building Information Modeling). The procedure followed in this study is shown as a flow chart in Figure 1.

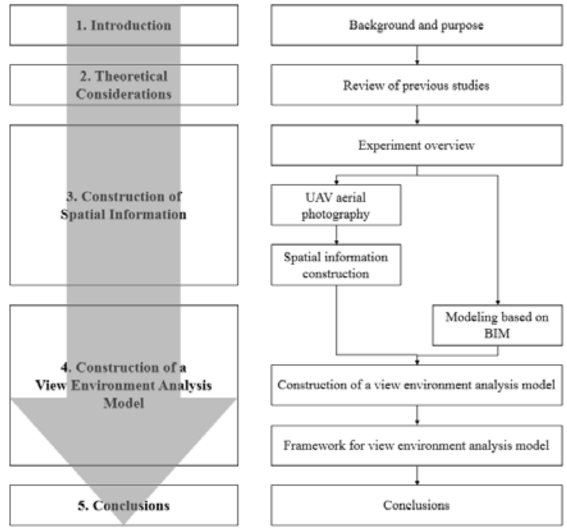


Figure 1: Flow chart of research

2. THEORETICAL CONSIDERATION

2.1 Theoretical Consideration for Unmanned Aerial Vehicle

UAV is commonly referred to as aircrafts or aircraft systems that are remotely or automatically controlled without any pilots[16]. It includes all kinds of aircraft that are manipulated remotely from outside and that perform its missions flying autonomically[17]. Compared to photography using a satellite or a manned aircraft, a UAV-based aerial photographic survey is easier to set up the required equipment and is more economical[18][19]. In addition, a UAV-based aerial photographic survey can photograph hard-to-reach or unapproachable spots, and can be used widely because it can obtain data immediately[20]. Myeong-jun Kim (2016) conducted a study on analysis of location accuracy in forest using UAV[21]. Seung-wook Lee (2015) investigated the asbestos cement slate roofs of the downtown area using UAV-based low-altitude and high-resolution aerial photography[22]. Jang-soo Kim (2017) tried to evaluate availability of UAV in order to calculate erosion rate of sea cliff quantitatively[23]. Myeong-jun Kim (2017) carried out onsite investigation on the damaged area of PNW(Pine Wood Nematode) using UAV[24]. Ju-seok Jeong (2017) developed construction site monitoring system using UAV and by applying it to the actual construction site, its availability of the system was verified. Besides, they compared the existing indirect field management method with efficiency improvement through a number of onsite investigation[25]. Like this, UAV are widely

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

employed in various fields, and researches related to its utilization are clearly on the rise[26][27][28][29]. Based on the advantages of UAVs, the current study was aimed at constructing a view environment analysis model and examining the impact of the visibility of new buildings by using a UAV.

2.2 Consideration on the Previous Research on Analysis of the View Environment.

The dictionary definition of the view is 'to see further or the scenery itself'. Broadly, the view means to look far in the distance, and generally it can be understood that the view is something that can be seen outside such as a scenery or landscape. In a narrow sense, it is to look at a beautiful scenery or landscape. That is, a view signifies a feeling of esthetic satisfaction and mental relaxation by viewing landscapes such as natural, historical or cultural institutions and custom[4].

In a previous study, Jin-wook Park (2013) overlapped and analyzed visibility and land use status using the geographic information system (GIS), and created a perspective view through three-dimensional (3D) simulation. Based on this, he analyzed urban view characteristics[30]. Joo-hyeon Jeong (2010) predicted the view of each apartment in the planning stage through 3D simulation, derived an appropriate layout, and applied it to high-rise apartment buildings[31]. Ji-won Moon (2006) conducted a field survey to analyze the view preference characteristics by extracting 24 cases by location based on the derived survey point types, constructing photographic data, and conducting preference evaluation[32]. Cheol-hyeon Choi (2011) selected viewpoints in urban areas using GIS and space syntax[33].

The current method used for view environment analysis involves conducting a field survey or use of a simulation method based on actual survey data as well as satellite and aerial survey data[30][32]. However, the method of analyzing the view environment through a field survey has limitations in the planning or design of buildings. Simulation methods using actual survey or satellite and aerial survey have also limitations economically in that they require considerable manpower and time.

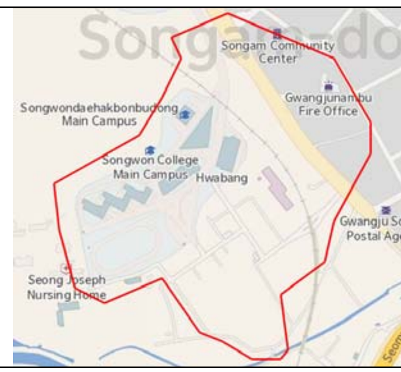
Recent developments in ICT(Information and Communication Technologies) have expanded the scope of applications of UAVs. With respect to surveying, the development of advanced UAV communication and sensor technologies has enabled the acquisition of high-resolution spatial information and 3D modeling[34]. UAVs are economical compared to field surveys and aerial photography, and data acquisition is possible on-demand[26]. Therefore, a view environment analysis model was constructed using UAVs in this study.

3. CONSTRUCTION OF SPATIAL INFORMATION

3.1 Overview of Experiment

This study was aimed at constructing a view environment analysis model for buildings by using UAVs and BIM. An area near the Songwon University in Gwangju City, South Korea, was selected as the study site (target area: 402,000 m^2), and UAV-based aerial photography was conducted to collect data and construct spatial information. General information about the site is shown in Table 1.

Table 1: Overview of the target area

Classification	Content
Survey area	
Site	73, Songam-ro, Nam-gu, Gwangju, Republic of Korea
Target area	402,000 m^2

The eBee model of SenseFly in Switzerland was used as the UAV in this study and Canon IXUS 127HS was used as the camera sensor. The technical specifications of the UAV and camera sensor are listed in Table 2[35][36].

The aerial photography was performed at 13:20 on October 28, 2014, and 55 raw data points were acquired through a flight that lasted approximately 9 minutes. The photographing altitude was 150m, and the photographing overlap for image stitching was set to 65% in the overlap and 75% in the side lap[37]. A part of the photographed raw data is shown in Figure 2.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 2: Specification of UAV

Type	Fixed Wing
Length	960 mm
Height	110 mm
Weight	405 g
Maximum flight time	50 minutes
Nominal cruise speed	11-25 m/s
Camera	Canon IXUS 127HS

Figure 2: Raw data

As it is possible to analyze the exterior walls and the surrounding landscape of the buildings by using the raw data, this data was used to construct the spatial information for analyzing the view environment.

3.2 Construction of Spatial Information

The raw data obtained from the procedure described in section 3.1 was used to construct a DEM and the orthoimages that constitute the spatial data required for this study. Spatial information was constructed using a point cloud-based application. Currently, several Point cloud-based software and Open Source are used, and the characteristics of each product are shown in Table 3[38].

Table 3: Feature of point cloud-based software

	PhotoScan		Pix4D	Mic-Mac
Feature	Professional	Standard		
Photogrammetric triangulation	O	O	O	O
Dense Point Cloud	O	O	O	O
3D Model	O	O	O	O
Fisheye and spherical correction	O	X	O	O
Dense Point Cloud Classification	O	X	O	X
DSM/DTM Export	O	X	O	O
Orthomosaic Export	O	X	O	O
Measurements	O	X	O	O
GCP support	O	X	O	O
Multispectral imagery processing	O	X	O	O
Real Time Visualization	O	O	O	X

In this study, spatial information was constructed using Agisoft PhotoScan Professional. Initially, the Point Cloud finds tie-points by using the SIFT algorithm in the overlapped image area. The extracted tie-points perform internal orientation, calibration of image subset and relative orientation steps. In addition, the algorithm conducts geo-referencing for the images by identifying all GCP's in images. Even after the completion of a geo-referencing process, the algorithm repeats the geo-referencing process if the result of bundle adjustment is not acceptable [39]. Next, the images pass through dense reconstruction, which creates dense point cloud data and finally produces a 3D model through the mesh generation process. The DEM was then created based on the 3D model. Next, two-dimensional orthoimages were created by mapping the texture of the raw data to the produced

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

3D model. Figure 3 shows the study site's spatial information constructed through the point cloud method.

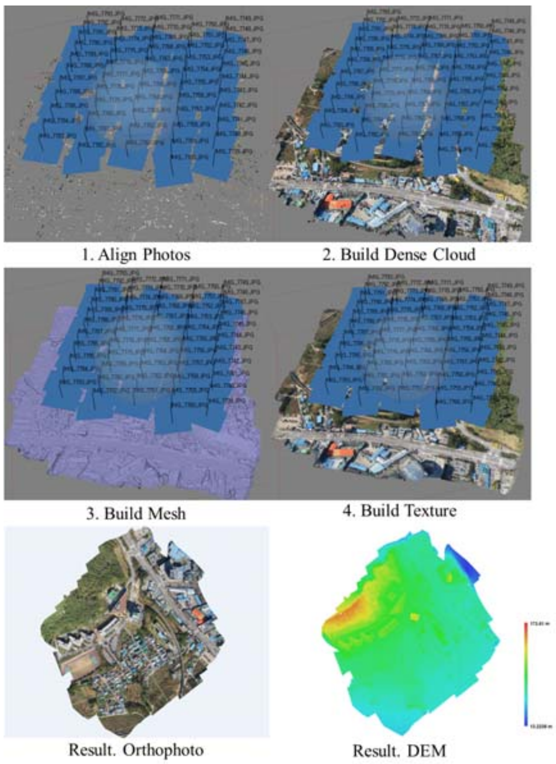


Figure 3: Spatial information of targeting area

4. CONSTRUCTION OF ANALYSIS MODEL FOR BUILDING VIEW ENVIRONMENT

4.1 Construction of Analysis Model for Building View Environment

In this study, a view environment analysis model was constructed by merging the buildings modeled through BIM with the spatial information constructed in section 3.2. SketchUp was used as the BIM tool and four apartment buildings with 13 floors each (45m in altitude and 1,090m^2 in area) were modeled. Then, the BIM model and the constructed spatial information were merged. The following Figure 4 shows the constructed view environment analysis model.

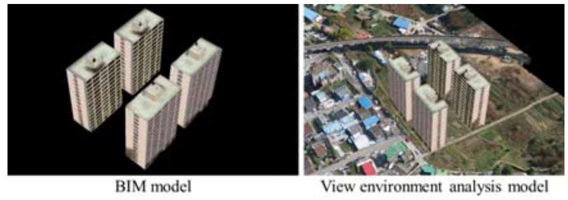


Figure 4: View environment analysis model

In this study, the view environments of the 1st floor (5m in altitude), 7th floor (24.2m in altitude), and 13th floor (43.4m in altitude) of the BIM model were analyzed using the constructed view environment analysis model. The results are shown in Figure 5.

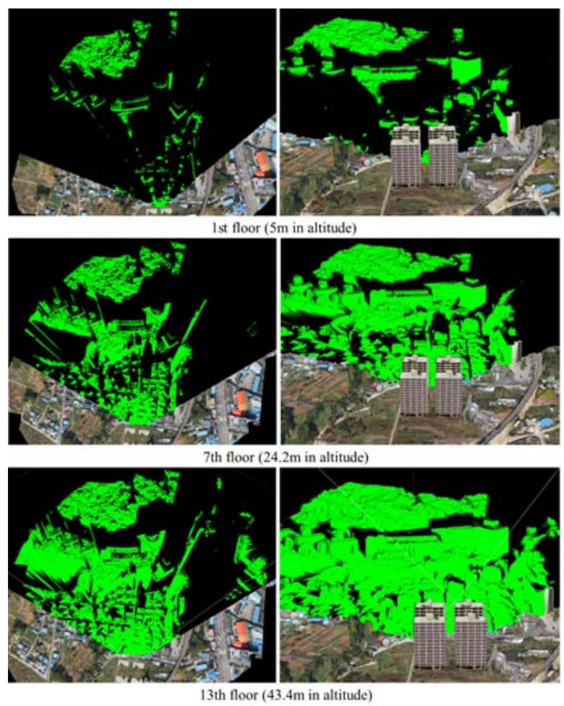


Figure 5: View environment analysis

4.2 Construction of Framework for View Environment Analysis Model

In this study, the framework construction of the analysis model for the UAV-based building view environment is divided into three steps: spatial information acquisition, spatial information construction, and building BIM modelling according to DB.

The first step of the framework is to acquire spatial information of the target site using UAV,

Journal of Theoretical and Applied Information Technology
15th February 2018. Vol.96. No 3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

and the detailed procedure is summarized as follows.

Phase1: Acquisition of spatial information

Task1-1: Designed for aerial photography planning – Site selection and establishment of detailed flight-planning

Task1-2: Aerial photography – Acquisition of 2D image of the target site through aerial photograph

Task1-3: Checking raw data – Estimation on high-quality of aerial photograph of the target site

The second step of the framework is to process the spatial information of the target site acquired in the step 1 into spatial information that can be available in analysis model of the view environment. In this study, it was utilized with Point Cloud technique and the detailed procedure is summarized as follows.

Phase 2: Construction of spatial information

Task2-1: Align Photos – Calculate the camera position and orientation for each photo and builds a sparse point cloud model[40]

Task2-2: Build Dense Cloud - Based on the estimated camera positions the program calculates depth information for each camera to be combined into a single dense point cloud[40]

Task2-3: Build Mesh - Build mesh based on point clouds

Task2-4: Build Texture - Mapping texture of the original image on mesh model

Task2-5: Generate orthophoto and DEM - Construction of spatial information on orthophoto and DEM based on 3D texture-model

The third step of the framework is to build a BIM-based DB of the building subjected to analysis of the view environment, and the detailed procedures are summarized as follows.

Phase3: BIM modeling of building

Task3-1: Building Design - Building design for analyzing the view environment.

Task3-2: 3D modeling based on BIM - BIM-based 3D modeling using design information

Figure 6 shows the framework of the analysis model for the UAV-based building view environment proposed in this study.

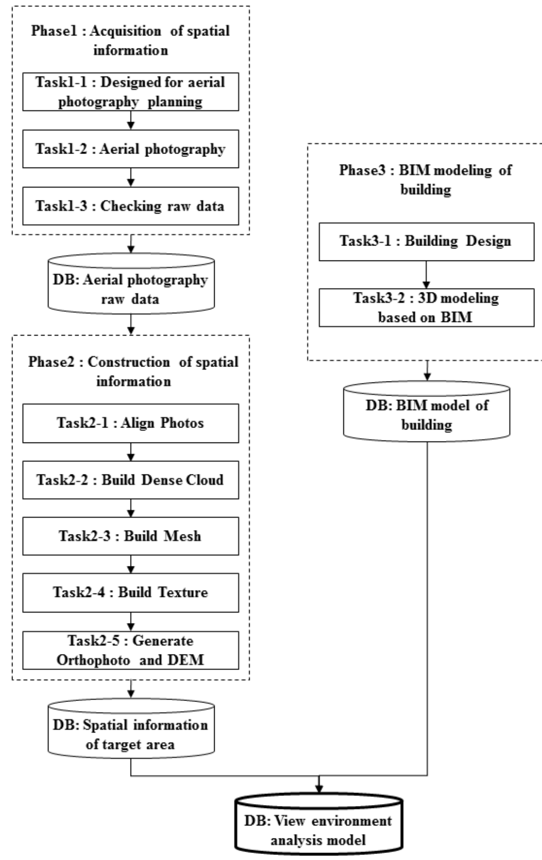


Figure 6: Framework of analysis model construction for the UAV-based building view environment

4.3 Discussion

This study aimed to identify limitations of the existing methods for establishing a view environment analysis model, and then develop a building view environment analysis model by using a UAV and a framework. In this study, actual image-based spatial information was developed and a building view environment analysis model was established using IT-based digital construction technology. The model created in this study can be used as follows.

(Actual environment-based construction plan) With stronger desire for urban development in the design aspect and eco-friendly construction, related regulations are more sophisticated and developed in a wide range. Under such circumstances, preliminary planning or designing in construction becomes more important. Owing to the overcoming of reckless local development through planning and designing of large-scale urban development projects such as new town development and urban redevelopment, as well as considering urban space

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

from the macroscopic viewpoint, an interest in city view and environment is rapidly increasing and reasonable project management is been focused to form a city from the future-oriented perspective. From small and large residential complexes to various urban developments, surrounding environment should be considered. In other words, not only sunshine, traffic, and drainage but also cooperation with the urban design field including conservation of environment and balance with adjacent areas becomes significant, and accordingly corresponding preliminary planning and designing are required[41]. Currently, simulation methods are used to plan and design buildings by considering various regulations and surrounding environments; however, such methods are limited in showing the real environment objectively, as it is still a virtual environment. In this study, a view environment analysis model was established based on actual image and not a virtual simulation so that the view environment can be shown realistically and quantitatively. The model proposed in this study is deemed to be used well for IT-based construction planning as it can objectively consider various regulations and surrounding environments in the construction planning and designing stage.

(Expansion of applications of IT-based digital construction) The future changes in the construction industry from basic design to construction stages could be expressed through five key words: digitalized measurement evaluation, 5D BIM platform, digital collaboration and mobile, intelligent asset management, and DB [42]. BIM, one of the major technologies in IT-based digital construction, can support these future changes. This technology is a process of modeling a facility in a virtual space including planning, designing, engineering (structure, facility, and electricity, etc.), construction, and even maintenance and disposal in a multi-dimensional virtual space[43]. BIM was first applied worldwide in 2010 as a new paradigm that can conduct integral management of construction stages and efficiently lead the innovation of construction processes[44]. Many government agencies responsible for controlling public buildings, including GSA of the U.S., Senate Properties of Finland, Stats by gg of Norway, and BCA of Singapore, obligate BIM-based design. Moreover, in Korea, a BIM technology application roadmap has been established at the government level, and public building construction projects, which have been provided by the Public Procurement Service since 2016 have been subject to mandatory BIM application[45]. In the future, most of new buildings will be subject to application of BIM technology from their designing stage. The UAV-based view environment analysis model proposed in this study is deemed to be able to expand applications of BIM DB of new buildings.

(Expansion of VR applications) VR (Virtual Reality) technology artificially develops movements and turns, which the user can hardly experience in reality, through interactions in three-dimensional virtual space established in a computer environment. Currently, VR technology is applied to lead developments in the design, manufacturing, medical, construction, tourism, media, entertainment, and education and training sectors[46]. In particular, it is being spotlighted because it can visualize information three-dimensionally in the field of visualization of buildings and large-scale complexes.[47] As the view environment analysis model proposed in this study is based on actual image, it is expected to be greatly used when establishing basic DB of virtual environments.

5. CONCLUSIONS

This study intends to construct an analysis model of UAV-based view environment as well as the framework while recognizing its limitation in the existing analysis technique of the building view environment. Therefore, it acquires spatial information of the target site using UAV and constructs spatial information with Point Cloud technique. Also, after constructing a virtual building using BIM, it sets up analysis model of the building view environment in conjunction with spatial information of the target site, and finally it establishes the framework of analysis model construction for the view environment. The results of the study are summarized as follows.

Acquisition of spatial information – 55 sheets of 2D image are acquired using UAV (it took 9 minutes by flight)

Construction of spatial information – It builds three-dimensional spatial information (orthophoto, DEM) that is needed for analysis of the view environment by applying Point Cloud technique.

BIM modelling – It creates BIM-based 3D Model of a virtual building using BIM tool

Construction of analysis model and the framework – It builds analysis model of the building view environment combining the built spatial information with BIM model, and examines the view environment of the 1st floor(the lowest), 7th floor(the middle) and 13th floor(the top floor). In addition, it establishes the framework of the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

construction of the view environment based on the process of this study.

This study proposed a methodology for constructing a view environment model for buildings using UAV. The Point Cloud technique was used to construct the view environment model in this study. The limitation of this method is that it requires a significantly long time to construct the spatial information (DEM, orthophoto) with the images acquired by UAVs. Furthermore, several types of noises are generated while using the Point Cloud technique in the tie point extraction process and the point cloud model construction. Thus, it is necessary to develop an efficient Point Cloud algorithm that can overcome these limitations. If these limitations of the proposed methodology are resolved through further research, it is expected that the results of this study will be useful in the future planning and design of building view environment. Furthermore, this study provides a preliminary demonstration of view environment analysis modeling based on actual background; it is expected that various applications will be developed using future IoT(Internet of Things) and VR(Virtual Reality) technologies.

ACKNOWLEDGEMENT

This research was supported by a grant (16SCIP-C116873-01) from construction technology research Program funded by Ministry of Land, Infrastructure and Transport of Korean government

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