Web-based 3-D GIS for Location Query in Real Estate Application

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Key words: Location, Web-based GIS, 3-D Visualization, City Model, Land Management.

SUMMARY

The Web-based 3-D GIS would be the most appropriate tool for decision-maker of land management and development. Because, it provides with not only the basic GIS functions, e.g. the positioning and the measurement of distance and area, but also more realistic landscape and architecture detail. It also gives the user an immersive virtual reality environment through the Internet that is rather different from merely through texts, pictures or videos. The main topic of this study is to provide sufficient location information for the user to select the optimum living environment through a Web-based 3-D GIS platform. At the beginning, we reconstruct a photo-realistic city model based on a 2-D GIS building layer that contains building ground plans and attributes, e.g. number of storey. For the purpose of increasing The Internet data streaming efficiency and reducing cost in building modeling, a multi-scale building modeling is proposed in this research such as block model, generic texture model, photo-realistic economic model, and photo-realistic detailed model. For the last one, the arcades and the billboards which extruded from the facade are both modeled for buildings along the major roads because they represent a distinguishing feature of the buildings in Taiwan. In real estate applications based on the designed Web-based 3-D GIS platform, a location query system for selecting the optimum living environment has been established. When a user starts the query, the 3-D scene will transit to a specific position and shows the environmental information to the user. Some geo-spatial query and analysis functionalities were performed, such as address and road-junction positioning, and profile analysis etc. Therefore, users can make efficient decisions on real estate market through this system.

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1. INTRODUCTION

Real estate refers to land and improvements attached to it. The business activity about it is closely related to economy, banking, finance, and social stability of a country. Real estate constitutes a fairly large proportion of a country's GDP which is the major asset of a country. From the prospect of macro economy, real estate influences construction, banking, servicing, and other related business sectors. It constitutes a fairly large percentage of people's wealth. Still, most people transact real estate only once or twice throughout their life. Moreover, tax for transaction of real estate is one of the major incomes of the government. Therefore, government's policy on real estate is crucial to either a country herself, or an enterprise, or an individual.

In recent years, applications related to real estate that applying GIS spatial analysis and 3-D visualization tools to observe abundant analysis results, efficient assessments, and rational decision-makings have been getting more and more. Yin and Hastings (2007) assessed hotel development scenarios by means of 3-D GIS. Yu *et al*. (2007) evaluated the benefit of high-rise apartments and suggested the pricing strategies on reconstructive apartments through 3-D GIS. Yang *et al*. (2007) applied this tool to evaluate urban design. Nowadays, the trend sharing geo-information with each other via the Internet has been more and more popular. Hanzl (2007) demonstrated the potentials of Web-based 3-D GIS as a tool for public participation in urban planning.

Due to large amount of geo-spatial data and narrow network bandwidth, in order to visualize and manipulate 3-D building models and other geo-information over the Internet in real time are really challenges. Zhou *et al*. (2006) visualized a 3-D city model based on a proposed data structure using a relational GIS database. Zhang *et al.* (2007) developed a node-based data models as topology to organize 3-D spatial objects for spatial queries. However, the façade textures of these researches are not photo-realistic which contains large amount geo-data volume. Furthermore, they are not detailed enough as to geometric shapes and not high enough as to density of buildings, and not large enough as to quantity of buildings.

A 3-D GIS based photo-realistic city model should include not only common GIS functions, i.e. positioning, measuring, and spatial analysis, but also representing the similarity of city texture and shape which allows users to overview the whole city in 3-D virtual reality and realize the location conditions around a specific position. Thus, people can make more rational decisions on real estate issues, such as planning, assessment, and evaluation. However, presently city models released through GIS Internet server are hardly to cover a large area of photo-realistic city. Normally, they contains either only a few scattered architecture building models, or block models, or generic texture models, so that makes the applications on them are so limited.

In this paper, we propose a multi-scale photo-realistic city model and a location query scheme based on Web-based 3-D GIS which is capable of displaying high resolution aerial ortho-images and photo-realistic building models. This system is designed to assist people improving their decision-making quality on real estate market.

2. MULTI-SCALE PHOTO-REALISTIC CITY MODELING

The most essential task of 3-D city reconstruction is geometric building modeling and façade texture mapping. People can thus observe 3-D photo-realistic city model from any view angle and any view position interactively.

Google Earth and Virtual Earth released Web-based city models in 2005. At the beginning, these city models are of block models without any texture. In recent years, photo-realistic city models are set up in dozens of cities in the US, Europe, and Japan. However, these two platforms do not distribute enterprise edition except in North America, which makes its application fairly limited. Moreover, these two platforms are not based on GIS and therefore have only functions of browsing and simple inquiring that do not conduct any spatial analysis functionalities yet.

Building model is the major content in 3-D GIS. There are many ways of geo-data acquisition for large amount of building models, such as Airborne Laser Scanning or LIDAR (LIght Detection And Range), Aerial Photography and Close-range Photogrammetry, High-resolution Satellite Imagery, or the fusion of above mentioned sensors. There are four building model schemes mostly used to describe 3-D constructions, i.e. namely wire-frame model (Vosselman and Veldhuis, 1999), boundary representative model (B-Rep) (Huang and Trinder, 1999), polyhedral model (Rau and Chen, 2003), and constructive solid geometry (CSG) (Tseng and Wang, 2003). Some of the aforementioned models are either structurally so complex or require so large quantity of data storage that they are not easy to apply volume calculation and Boolean operation. On the contrary, some of them are structurally too simple to present main features of irregular objects, and to perform spatial analysis.

Any scheme of building models based on computer graphics can never be perfect in every aspect, such as shape realism, topology integrity, and geo-information generalization.

Considering the limitation of facilities, man power, budget and available time, Gröger and Plümer (2005) mentioned that in order to achieve the goal of real 3-D GIS current descriptions of 3-D topology based on 3-D GIS are too complicated or too large in data volume. Thus they developed a 2.8-D GIS axiom for 3-D visualization and capable of maintaining the 2-D and 2.5-D topology. In this paper, it is therefore we propose to start from a 2-D GIS building layer and reconstruct 3-D photo-realistic building model through a GIS-based building modeling tool which would be an optimal solution for both 3-D visualization and GIS applications purposes.

2.1 GIS-based building modeling

Since GIS map contains geometry, attribute, and topology data, we can carry out not only text based graphical query and graphics based attribute query, but also spatial analysis, such as route network, view-shed, view-corridor, shadow, buffer zone, and profile analyses. In general GIS, the city is could be 3-D visualized automatically by assigning building height, façade texture, and roof type to each specific field of attribute table for each building polygon. By this GIS-compatible modeling tool, it is easily to meet the need of 3-D GIS applications. Thus, in this study we adopt PilotGaea Scene Producer™ (PilotGaea, 2009) as the modeling tool, because it is a GIS-based 3-D modeling tool which supports multi-scale building modeling from the block model to the photo-realistic detailed model.

2.2 Multi-scale building modeling

Given that the scope of most cities may reaches more than 10 square kilometers, it needs much more manpower, budget, and time to establish a fully photo-realistic city model. Because of the modeling cost, the constraints of network bandwidth, server's computation ability, and client's display performance, the establishment of a whole city model should not be without priorities or without limited degree of detail. Therefore, under the criteria of the cost-effectiveness, the Internet data streaming efficiency and multiple applications, this study proposes a multi-scale building modeling scheme by identifying a building's importance and assigning an appropriate level of detail to each building with respect to its accessibility and application. Four levels of detail were adopted, namely block model, generic texture model, photo-realistic economic model, and photo-realistic detailed model.

In order to realize it in a Web-based 3-D GIS environment we propose two types of photo-realistic building model, namely economic and detailed one. Normally, the photo-realistic model is the most delicate buildings in structure and appearance. It can be applied to large-size and geometrically complex landmark buildings. However, its reconstruction is time consuming and labor intensive so that makes it more difficult to be set up. In the meantime, comparing with other type of building model it occupy more data storage that need more memories to process it and more powerful GPU(graphic processing unit) to render it in real time. It also requires wider network bandwidth over the Internet data transmitting. The photo-realistic economic model is less delicate to the detailed one. However, it can demonstrate the major feature of most buildings. Therefore, it is suggested that buildings along the main roads could be assigned as photo-realistic economic model given its important usage in commerce and transportation, because the main roads are surrounded by traffic arteries and business centers. On the other hand, those buildings not located along the main roads but within a building block can be established with generic texture model to meet the need of overall visual effect. This mechanism can reduce GPU consumption and increase the display performance during rendering. For the rest of buildings located outside of interest area, the block model is proposed because there is no need for texture mapping and its data load was least among these various detailed levels of building models.

3. SYSTEM OVERVIEW

The bottleneck of display performance lies on insufficient network bandwidth as well as the performance of client's GPU and CPU (central processing unit). To promote applications on the Internet, the Web system must have the capability of fast transmission of geo-spatial data and powerful performance of rendering 3-D scene. PilotGaea Universe™ (PilotGaea, 2009) raises data transmission efficiency by applying frustum culling method before a client's display. This mechanism first assembles visible data sets of viewing frustum which is formed by view point, view angle, and visible distance to the camera, and then preselects, image pyramiding, and compresses the data. After that, data from the server were progressively transmitted to the clients. The client side undertakes the rendering of the scene. This approach can lessen the load of the server side and reduce the requirement of bandwidth. In case a user changes his view point, these geo-spatial data, i.e. geometric nodes and texture, within the original frustum will not release from GPU right away until these unforeseeable geo-spatial data disappear from new frustum. It thus reduces the I/O load of GPU and increase the efficiency when rendering.

3.1 Server and client

On the server side, PilotGaea Universe™ is responsible for data storing, preprocessing, transmitting as well as receiving request from the client side. Re-sampling, re-projection, data analysis, format transformation, image pyramiding and compression, and geo-spatial data delivery were all carried out by the server side, thus the client side would share most part of the whole process as possible as it could so that the server can provide service for many concurrent clients, meanwhile.

PilotGaea Universe^{TM} Client is a set of primitives, designed for the users, which were developed based on Microsoft Visual C++ and DirectX. It is comprised of a visible subset of ActiveX controllers and another invisible subset of COM primitives, both were embedded in the Web browser. When the users first time visit the Web page of the system, these primitives will be automatically downloaded and installed. The developer can utilize HTML, JavaScript, and VBScript to develop a customized graphical user interface (GUIs) for specific 3-D Web GIS application.

3.2 Integration of the system.

The server-client framework of this system is shown in Fig. 1. The COM primitives of the PilotGaea Universe^{TM} can be divided into the following modules.

1. *UniverseView*: This is the main component part, which connects to the server and is responsible for controlling the scene rendering.
2. *MoveFun*: It is responsible for camera movement and controls the flying mode.
3. *3-D CustDraw Entity*: It is in charge of drawing objects for a user on the client's monitor.
4. *3-D Entity*: It controls various scenes of GIS data for the project.
5. *Layer*: It manages 2-D vector layers.
6. *Geo*: It carries out the functions of delete/add of geometric objects.
7. *3-D CustDraw Layer*: Other kinds of primitives are assorted in this module, such as *Projection* is for projection transformation, *Analysis Engine* for spatial analysis, *3-D Panoramio* for connecting objects from Google, etc.

These modules, connecting with one another, provide an integrated Web environment for interaction, query, analysis, and rendering for large geo-spatial data.

3.3 Location query system in real estate application

The PilotGaea Universe^{TM} was adopted as Web-based 3-D GIS server to manage a plenty of geo-spatial information and the different scale of building models. For the realization of real estate application using Web-based 3-D GIS, we integrated Hyper Text Markup Language (HTML), JavaScript and VBScript to develop Internet-based GUIs for the location query system. The location query is crucial for users to understand the environment around an interesting building and geographic relationship to any specific facilities. A detailed description of designed functions will be discussed later.

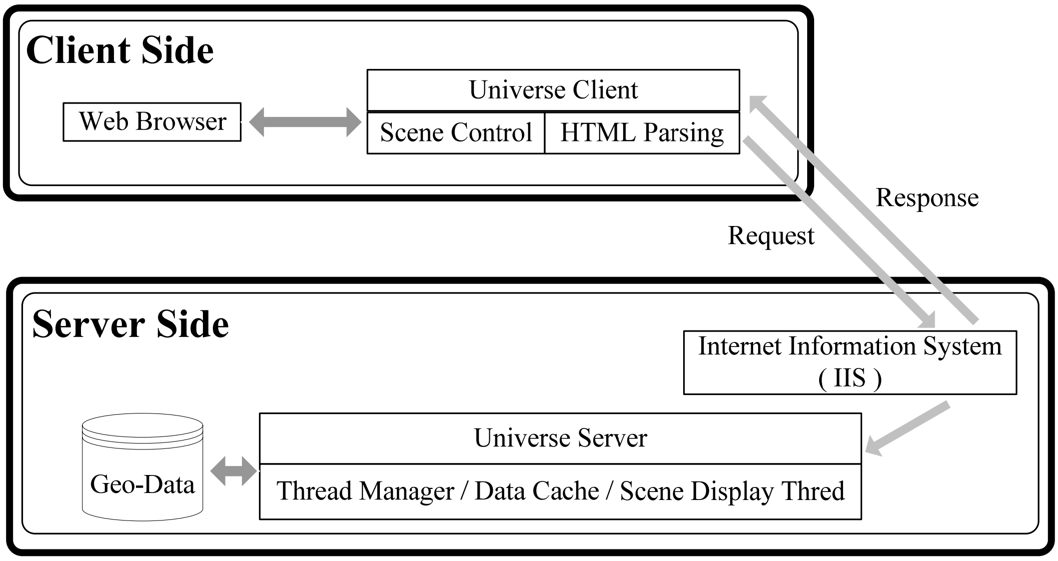

Fig.1. The server-client framework

4. CASE STUDY

Tainan City is located in the west-southern coast of Taiwan island. It is known as the cultural ancient capital of Taiwan, for its abundant of historical relics. Because Tainan was established as the capital of Taiwan from the mid 17^{th} century to the late 19^{th} century, it has played an important role in Taiwan's political, economic, and cultural development. Its historical relics, which account for about one-third of all in Taiwan, possess exceptional value in illustrating or interpreting the heritage of Taiwan's recent history. Chiu and Lan (2001) developed "Discovery of Historical Tainan" for this city in a digital way of understanding historical buildings by means of computer graphics simulation. In particular, Anping, one of Tainan's districts, was considered as the origin of Taiwan's culture. Many well-known ancient monuments, such as the first western fort, the first castle, the first business street, and the first foreigner trade buildings were located in Anping. Under these circumstances, a popular saying indicates that "Getting to know Taiwan starts with Tainan. Getting to know Tainan starts from Anping." This is why we choose Anping District as our study area. Fig. 2 illustrates the geographic maps of Anping District and Tainan City.

Tainan City has an area of 175.6 km^2, in which the Anping District has approximately 11 km^2.

This study first created a multi-scale building model using the proposed GIS-based modeling tool, and then further establishes a Web-based location query system on a 3-D GIS platform. By the integration of 3-D virtual and comprehensive information of a specific location, this system can serve as an analysis tool for users to make more rational and effective decisions on the real estate market.

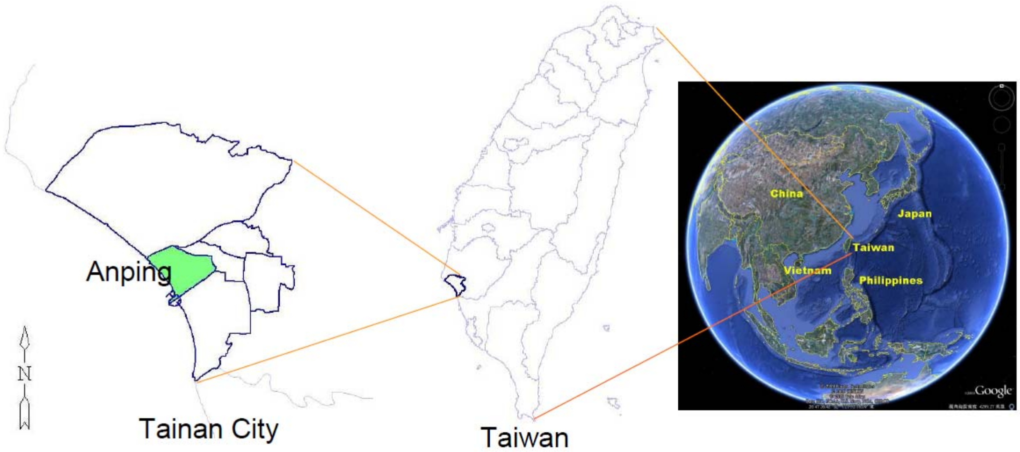

Fig. 2. The geographic map of Anping District and Tainan City

4.1 Tools and materials

Depending on the real estate applications, this study establishes an assortment of digital theme maps, as illustrated in Table 1. It includes NIMBY (Not In My Back Yard) map, landuse and zoning map, and living functions map. The NIMBY map is used to depict facilities where people don’t like to live next to, and it is particularly useful information for real estate applications. Thus, within the NIMBY map, we further sub-categorized it into thirteen layers, as shown in Table 2. The “Road junction” is another special designed layer denoting the position of road junction where the users may have demand to search for.

Table 1. The adopted geo-spatial information.

No.	Item	Feature
1	Aerial ortho images of Anping (GSD10cm)	Grid
2	Digital topological model, Tainan City. (5m x 5m)	Grid
3	Route network map, Tainan City(1/1,000)	Line
4	Street address map, Anping (1/1,000)	Point
5	Building/Architecture map, Anping (1/1,000)	Polygon
6	Topographic map, Anping (1/1,000)	Polyline
7	Block model, Tainan City. (1/1,000)	Polygon
8	Generic texture model, Anping (1/1,000)	Polygon
9	Photo-realistic economic model, Anping	Model
10	Photo-realistic detailed model, Anping	Model
11	Road junction map, Anping	Point
12	NIMBY maps, Tainan City. (a total of 13 layers)	Point
13	Landuse and zoning map, Tainan City. (two layers)	Polygon
14	Landmark map, Tainan City.	Point

Table 2. The total thirteen layers of NIMBY (Not In My Back Yard)

No.	Layer Name	Feature
1	Dump	Point
2	Gas station	Point
3	Gas tank	Point
4	Grave field	Point
5	The haunted house	Point
6	Factory	Point
7	Mobile base station	Point
8	Parking tower	Point
9	Taoism temple	Point
10	High-voltage power line	Point
11	Radiation contaminated house	Point
12	Salt-sand house	Point
13	Substation	Point

4.2 The modeling strategy

In this study, the PilotGaea Scene Producer^{TM} software was used for 3-D GIS modeling tool. Different building models were generated to accommodate different building features. For buildings outside the Anping District, the block model was established. The photo-realistic texture model was applied to the buildings inside the Anping District. There is a total of 42.6 km main road within Anping District. Those buildings along to the main roads were modeled as photo-realistic economic model, with extruded billboards. As for buildings not along to the main roads, a generic texture model was used. The generic texture library was created by in-situ photos. For buildings around main road junction where major traffic sites were located at, the photo-realistic detailed model is proposed. In the meantime, this model is also applied to some landmark buildings, such as the City Hall, scenic spots, shopping malls, and historic monuments. Since the arcades and the billboards extruded from the building's facade are the most distinguished features of commercial buildings in Taiwan, they were included in the photo-realistic detailed model.

Table 3 compares the modeling strategy used in this study for establishing the multi-scale building models. Figure 3 indicates the distribution of various scales of building models used in the study.

Table 3. The strategies for multi-scale building modeling.

No.	Item	Distribution	Modeling method
1	Block model	Buildings **outside** the Anping District.	Automatically extruded from a GIS building ground plans with height attribute.
2	Generic texture model	Buildings **not** along to the main road within the Anping District.	Automatically extruded from a GIS building ground plans with height attribute and automatic texture mapping using a texture library.
3	Photo-realistic economic model	Buildings **along** to the main road within the Anping District.	Create block model, perform texture mapping using in-situ photos, and extrude billboards.
4	Photo-realistic detailed model	1. Landmark Buildings 2. Buildings along the main road junctions within the Anping District.	Create block model, perform texture mapping using in-situ photos, create arcades, and extrude billboards.

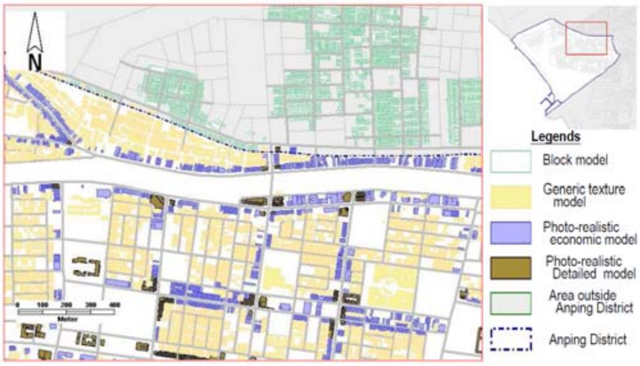

Fig. 3. The distribution of various detailed levels of building models

5. RESULTS AND DISCUSSION

The study was established by two stages. The first stage focused on the development of a multi-scale building modeling, by integrating various scales of building models. The second one will focus on the development of a location query system, using the real estate market as an example that integrate GIS query and spatial analysis tools within an Internet-based user query interface.

5.1 Results of multi-scale building modeling

Examples of the photo-realistic detailed model, photo-realistic economic model, generic texture model, block model, and bird-eyes images are shown in Figure 4 to Figure 8, respectively. In Figure 4, one will find out that the photo-realistic detailed model can produces a comparable detailed model in geometry when comparing with commercialized 3-D modeling software. In Figure 5, the high-resolution texture of the photo-realistic economic model allows for detailed identification of characters and signage, which demonstrated the potential for further applications. Figure 6 shows the buildings that are not along to the main roads, produced by the generic texture model. Despite the purpose of this model was not on producing high quality photo-realistic facade texture which improves visual amenity for the users. Figure 7 shows the block model, which was located outside of the Anping District. Figure 8 shows a bird-view image demonstrating the produced multi-scale building models for the whole study area. It shows that the model developed by this research is able to provide users a more photo-realistic visual experience.

Old Tait & Co. Merchant House

The rear square of National Tainan Living Art Center

Fig. 4. Examples of photo-realistic detailed model.

Ang-Ping Road

Ping-Tung Road

Fig. 5. Examples of photo-realistic economic model.

Fig. 6. An example of generic texture model.

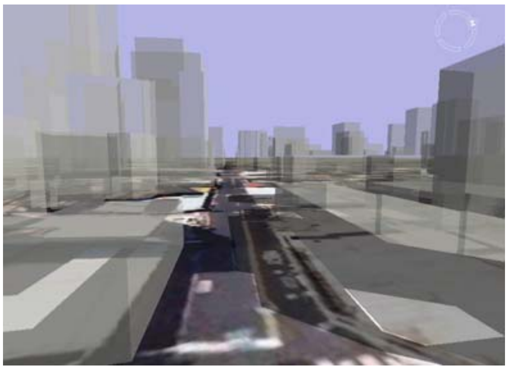

Fig. 7. An example of block model.

Fig. 8. A bird-eye image for the whole study area.

5.2 GIS query and analysis

Two types of GIS techniques were applied in this study, i.e. the query and spatial analysis. In terms of spatial queries, we applied both text based geographical positioning query and graphic based geographic entity attributes query. In terms of spatial analysis, we apply the buffer zone and profile analysis. The buffer zone analysis, as shown in Figure 9 and 10, was used to identify the location criteria for a specific position by analyzing the NIMBY, landuse and zoning map within a certain radius of the given position. The information provided by profile analysis can help the users to evaluate the flooding trend, as shown in Figure 11. In the meantime, the area measurement is a useful tool to assist the uses to estimate the area of an interested region. Figure 12 depicts an example of area measurement.

	
Fig. 9. Buffer zone analysis by address.	**Fig.10. Buffer zone analysis by landmark**
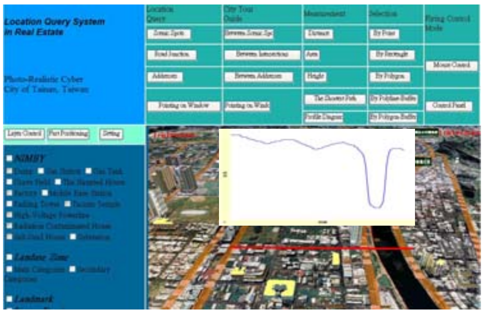	
Fig. 11. Profile analysis.	**Fig. 12. Area measurement.**

6. CONCLUSIONS

In this research, a multi-scale building modeling strategy was proposed and a Web-based 3-D location query system was developed and applied to the real estate market. This study has effectively examined the applicability of a wide area and large scale city model with photo-realism on a Web-based 3-D GIS platform.

The multi-scale building model is composed of four levels of detail, namely the block model, generic texture model, photo-realistic economic model, and photo-realistic detailed model. The application and distribution of these four scales of model are depended on the importance and significance of a building itself and its relative position to the main roads. A proper dispersion of these models can effectively reduce the load of computation, network bandwidth and video display. It can also reduce the cost in building modeling and enhance the performance of 3-D rendering on the Internet.

Started with 2-D GIS layers, this study employed a GIS-based 3-D modeling technique to develop a large area as well as large scope of photo-realistic city model. The study also incorporated a 3-D GIS distributed Web server that supports a text-based or graphic based query interface. Furthermore, this study has shown that the system can provide a powerful and effective tool for real estate applications by incorporating GIS spatial analysis functionalities, i.e. buffer zone and profile analysis. Developers can add more other spatial analysis, such as slope, shadow, view-shed, and view-corridor analysis, to the query system depending on their specific requirements.

In order to achieve the geo-spatial analysis demands and its application, the platform of multi-scale building models needs to be set up based on the 3-D Web GIS for both efficient geo-spatial data transmission and various boarder applications. Otherwise, the application of city model is rather limited but browsing. There are many commercially available 3-D Web GIS platforms which prevailed in some specific domain in the market nowadays. To promote the successful probability of Web-based 3-D GIS applications, the evaluation and selection for both modeling tool and server is quite an important task, which may affect budget planning, geo-data transmitting, 3-D building modeling, texture pyramiding, and Web browsing quality.

The monetary and time consumption for the development of a photo-realistic city model are so huge. The cost-effectiveness is very difficult to achieve if it was set up only for single objective or application. It can affect multiple benefit effects, if photo-realistic city model can be integrated simultaneously with various applications on a Web-based 3-D GIS platform, in the areas such as land administration, tourism, urban planning, emergency preparedness, etc. The system may become a useful geo-spatial information technique after the GPS navigation applications among governments and the folks.

7. ACKNOWLEDGEMENT

The authors would like to thank the Tainan City Government for providing the original digital topographic map, 5m x 5m DTM, Z/I DMC ortho-images, and the other geo-spatial information. The authors also appreciate PilotGaea Technologies Inc. for offering Scene Producer™ and Universe™ software, and AVirtual Geomatic Tech. Inc. for producing four categories of multi-scale building models, respectively.

REFERENCES

Chiu, M.-L., and Lan, J.-H., 2001, Discovery of Historical Tainan: a Digital Approach. Automation in construction. Vol.10, No. 3, pp. 355-364.

Gröger, G., and Plümer, L., 2005. How to Get 3-D for the Price of 2-D—Topology and Consistency of 3-D Urban GIS. GeoInfomatica.Vol. 9, No. 2, pp. 139-158.

Hanzl, M., 2007. Information Technology as a Tool for Public Participation in Urban Planning: a Review of Experiments and Potentials. Design Studies. Vol. 28, pp. 289-307.

Huang, H., and Trinder, J.C., 1999. Object Recognition Based on Boundary Description. Photogrammetric Engineering and Remote Sensing. Vol. 65, No. 8, pp. 915-921.

PilotGaea, 2009. Home page of PilotGaea: Available: http://www.pilotgaea.com.tw/html/ (8.31.2009)

Rau, J.-Y., and Chen, L.-C., 2003. Robust Reconstruction of Building Models from Three-Dimensional Line Segments. Photogrammetric Engineering and Remote Sensing. Vol. 69, No.2, pp. 181-188.

Tseng, Y.-H. and Wang. S., 2003. Semi-Automated Building Extraction Based on CSG Model-Image Fitting. Photogrammetric Engineering & Remote Sensing. Vol. 69, No. 2, pp. 171-180.

Vosselman, G., and Veldhuis, H., 1999. Mapping by Dragging and Fitting of Wire-Frame Models. Photogrammetric Engineering & Remote Sensing, Vol. 65, No. 7, pp. 769-776.

Yang, P. P.-J., Putra, S. Y., and Li, W., 2007. Viewsphere: a GIS-based 3-D Visibility Analysis for Urban Design Evaluation. Environment and Planning B: Planning and Design. Vol. 34, pp. 971-992.

Yin, L., and Hastings, J., 2007. Capitalizing on Views: Assessing Visibility by Using 3D Visualization and GIS Technologies for Hotel Development in the City of Niagara Falls, New York. Journal of Urban Technology. Vol. 14, No. 3, pp. 59-82.

Yu, S.-M., Han, S.-S. and Chai, C.-H., 2007. Modeling the Value of View in High-Rise Apartments: a 3D GIS Approach. Environment and Planning B: Planning and Design. Vol. 34, pp. 139-153.

Zhang, L., Yang, C., Tong, X., and Rui, X., 2007. Visualization of Large Spatial Data in Networking Environment. Computer & Geosciences. Vol. 33, pp. 1103-1139.

Zhou, G., Tan, Z., Cen, M., and Li, C., 2006. Customizing Visualization in Three-Dimensional Urban GIS via Web-Based Interaction. Journal of Urban Planning and Development. Vol. 132, No. 2, pp. 97-103.

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