A STUDY OF 3D SPATIAL MODEL OF URBAN MIXED-USE VISUAL SIMULATION IN TAIPEI CITY

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Abstract: In the past years, computer visual simulation is more important in many research domains. Architect and developer can easy estimate architectural design in specialized field with tools of computer-aided design (CAD). But it is not enough for urban planning and design. Because a real urban environment must links to other spatial information. Besides, the urbanization is very fast in Taiwan, mixed-uses is common situation in every city. It is not only 2D problems, also distribute over 3D space. So this research is aimed at discussing how to represent mixed-uses in different city or in different scale to satisfy urban planer or designer that require the information of abundant urban activity.

Keywords：Spatial Data Model、Computer Visual Simulation、Urban Simulation

1.The purpose of this study

The computer visual simulation application became very important to different research fields in recent years. [1] As for architecture, CAD allows architect and developer easier to evaluate the architectural design from their professional point of view, but it is not sufficient enough for an urban planner because a real city must link to related space information.[2] Therefore, this study focuses on 3D spatial data link; if we can display the information on the urban 3D model, it will be a great help to urban planning.

Also due to the fast city urban development in Taiwan, it is very common to have mixed-use space. Lots of activities in the urban spaces reflect a chaos situation, especially the 3D spatial spread problem. Therefore, this study takes the mixed-use type of building as an example to construct the 3D spatial model of land use visual simulation.

The purpose of this study is to study links of the attribute information and 3D objects in urban 3D spatial model to satisfy different user's needs on building 3D spatial information and develop building using mixing degree computer visualization prototype.

This study also simulates the Asian World commercial area in Taipei City to further understand the real help of computer visualization on mixed-use building, and provides a referenced procedure in the future construction of related urban spatial information computer visualization.

Besides, as for the mixed-use building, it can also be used as a tool of evaluating the mixed-use building to express the mixed-use building using condition. It could further check the current using condition and proceed legal using behavior simulation in the future.

The summary of this article's structure is in the following: Chapter 2 explains the related system simulation concept, Chapter 3 introduces the system simulation operation, Chapter 4 is the study result, Chapter 5 is conclusion and suggestion.

2.System simulation concept

2.1 Model Concept

The urban environment is object oriented, it is constituted by many small, medium and large structures. The result of combining those different structures is the divided, vertical hierarchy systems constituted by environmental objects of whole urban area.

Therefore, this study uses the hierarchy concept (figure 1) to study the data link of urban 3D spatial information including attribute, 3D object, layer and view. We also analysis it by dividing the urban space into multi-layers; they are district, street, base, building, side, unit, and establish the 3D spatial computer visualization data with the concept of layer and hierarchy. (figure 2).
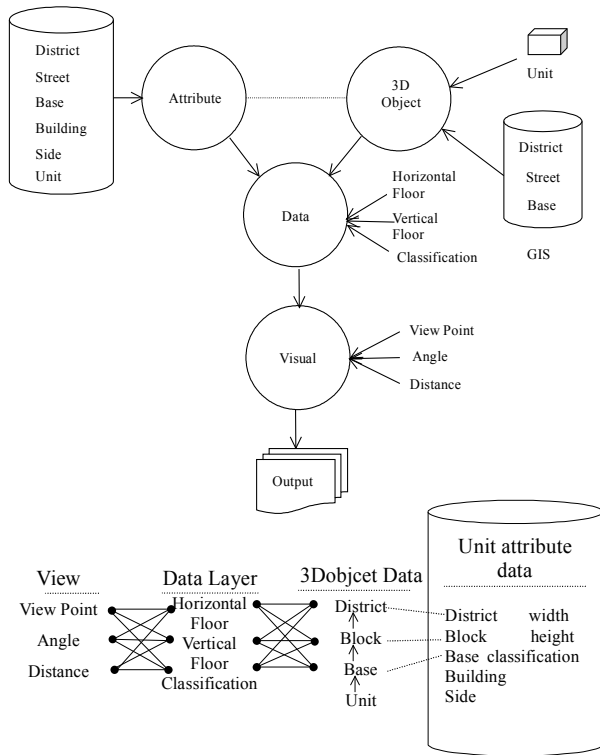
Figure 1, Simulation Concept

Figure2, simulation data concept

The basic urban spatial type of information whose "attributes" are unit, side, building, not only includes the information of their length, width, height but also includes their encoding and position relation which is acquired through on site investigation, and they are text type of information. "3D object" is the established concept as the basic unit of building and hierarchy; its contents are information of base, block, district. "Layer" is the concept of linking attribute information and 3D object information, and they divide into horizontal layer, vertical layer and classification. " View point" is the observable simulation concept of user; it includes view point, angle selection and distance.

2.2 Visualization concept

This study expresses 3D spatial urban mixed-use condition by 3D spatial computer visualization, and hopes to display a real mixed-use condition. Therefore, using 3D object layer transfer conception to proceed visual expression, using different city hierarchies to express different scale visual simulation. We divide whole urban environment into six parts to study; which are separated six hierarchies in simulation, they are district, block, base, building, side and unit.

2.3 Mixing degree calculation method

This study adapts the mixing degree calculation method used in "The study of the appropriate scale of land mixed-use in Taipei" (Chen Leon Chun); which takes mixed-use land as the connecting condition of different using units. Therefore the so called mixing degree refers to the percentage of connecting numbers of different type of using units compares to the connecting numbers between each unit [5]. The calculation method is as following:

A. If the using type of two connecting units (horizontal direction or vertical direction) is different, it is mixing use and calculates as one

$$\text{Mixing Degree}(\%)=\frac{\text{Mixing Connecting numbers of different using units}}{\text{Connecting numbers of all using units}}$$

mixing connecting. If those two units belong to the same using type, it isn't mixing connecting and calculates only one connecting.

B. The calculation of mixing degree is the percentage of the total connecting number of "different using units mixing connecting" (as numerator) divided by total number of "unit connecting"(as denominator) based on the above explanation.

But due to the above mixing degree calculation only considers the connecting numbers between each using unit, it is easy to have the same calculation result but the mixing condition is different. Although the mixing degree value of both of these two using units are 1, but the real mixing condition is different. (see figure 3).
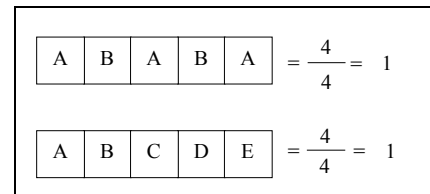

Figure 3, Original mixing degree calculation concept figure

Therefore, this study likes to provide a revised method, we not only calculate the mixing degree by connecting number but we also consider the types of using unit. It is using the original mixing calculation method times a coefficient; this coefficient comes from the percentage of "total number of using unit's types" divided by "total number of using units". The using condition of Figure 4 can reflects the difference in mixing degree after calculating by revised method.
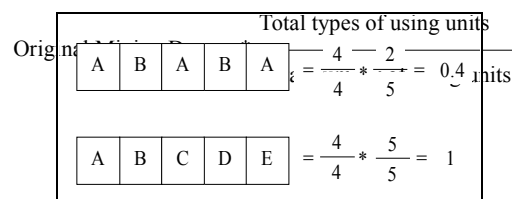

Figure 4, The revised mixing degree calculation figure

2.4 System structure

The system structure of this study focuses on building mixed-use function of urban 3D spatial model; it includes 3D object production of current condition simulation, 3D object production of regulation simulation, 3D object hierarchy transfer,

mixing degree calculation, regulation checking, using distribution and output display.

"3D object production of current condition simulation" refers to the production of 3D object by using the information investigated on real condition; they include current using condition, simple layout and floors. "3D object production of regulation simulation" refers to the production of 3D object by random number in accordance with the land use control regulation. "3D object hierarchy transfer" is linking the information of current condition simulation and regulation simulation then transferring information with the hierarchy concept. "Mixing degree calculation" is using mixing degree calculation to calculate the hierarchy transferred information of 3D object into mixing degree value of building or street. "Regulation checking" is using current regulation of law to proceed regulation checking on current condition information to better understand the condition of permitted use, permitted use with conditions and violating use. " Output display" is to display the processing result of each function.

3. System simulation operation

3.1 Procedure

This chapter describes the production procedure of using building mixed-use computer visualization system, it can divide into geographical drawing processing, current condition investigation, program write, 3D object production and computer visualization simulation.
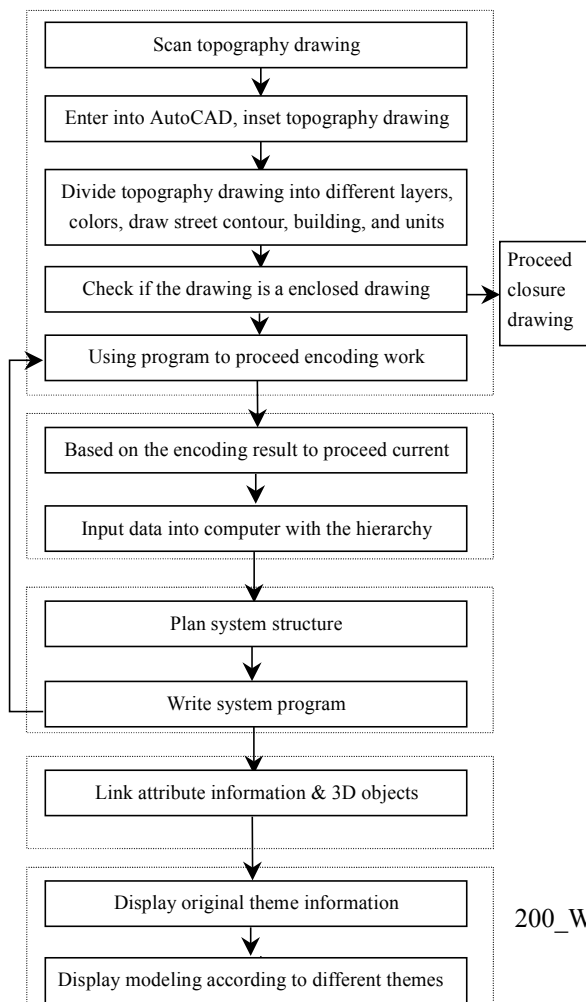
Figure 5, Procedure steps

3.2 Information classification and current condition investigation

The selection of current condition information classification is very influential to the mixing degree calculation result; there are tax business standard classification, land use district control regulation, business classification. This research adopts tax business standard classification and land use district control regulation as the mixing degree calculation classification base. [4]

When displaying the spatial unit, this research uses "land use district control regulation in Taipei City" as the base of using group. We give different colors to different spatial unit in accordance with the using group giving in the current condition information.

Regarding the current condition investigation, this research has completed the building current condition investigation in Asia World Commercial area, and the area of Dun Hua North Road, Nanking East road, Fu Hsing north Road and Chun Tzuen Road. (see figure 6). We also established the file in accordance with tax business standard classification and the classification of land use district control regulation in Taipei City.
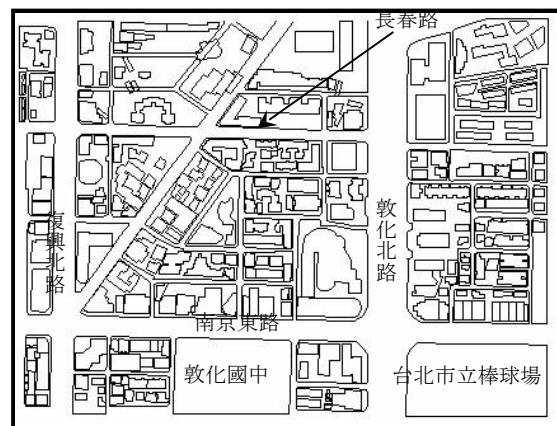
Figure 6, Simulation area layout

The current condition information investigation is to record the company name, address on each floor of each building and draw the conceptual floor plan of each building. After completing the information investigation, using the digital

Scan topography drawing

Enter into AutoCAD, inset topography drawing

Divide topography drawing into different layers, colors, draw street contour, building, and units

Check if the drawing is a enclosed drawing → Proceed closure drawing

Using program to proceed encoding work

Based on the encoding result to proceed current

Input data into computer with the hierarchy

Plan system structure

Write system program

Link attribute information & 3D objects

Display original theme information

Display modeling according to different themes

topography encoding result to process the information into the format as chart 1 with the hierarchy concept, and input them into the computer.
Chart 1, data input format

Block	Building	Unit	Floor	tax code	Usingname
1	1	1	-1	950200	Parking lot
1	1	1	1	535111	Kuo yu market
1	1	1	2	950100	House
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4.Current Research Result

4.1 Simulation result of current condition information

This chapter is to display the investigation result of original information, the displaying result is very similar to the exterior of original building, it can also simulate the void part of the building.
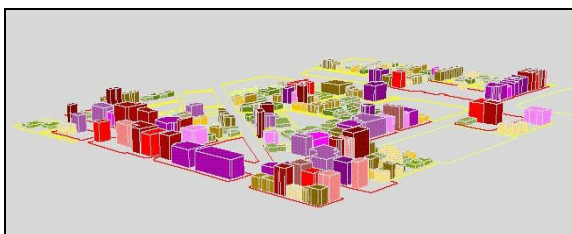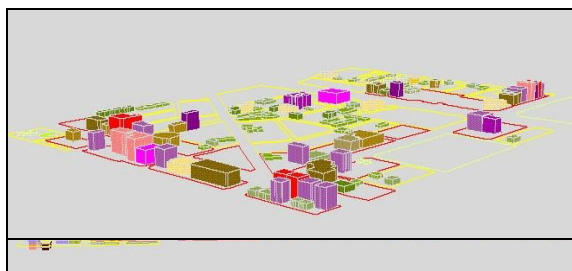

4.2 Simulation result of use behavior under the law

4.3 Simulation of mixing degree calculation

A. Horizontal mixing degree simulation

B. Vertical mixing degree simulation

C. Total mixing degree simulation

4.4 Simulation result of current condition information regulation checking

This part is using the land use district control regulation to proceed regulation checking on current condition information to understand which one is permitted use, which one is permitted use under certain condition, or violation use. The green color is permitted use, yellow is permitted use under certain condition and red color is violation use.

4.5 Simulation result of use distribution search

This part focuses on a certain type of use group to search its spreading condition on 3D spatial model.

5.Conclusion and Suggestion

This research is to study the subject and technology of building using mixing degree computer visualization by theory retrospect, conceptual modeling structure, system analysis and simulation operation to get the search result with actual case operation. This chapter has a further discussion on the research conclusion and possibility of continuous research, and the solid result of this research includes:

1. Constitute the "Building using mixing degree computer visualization prototype"
2. Guide an accessible method of linking 3D objects and attribute information.
3. Improvement of mixing degree calculation method.
4. Complete case operation simulation of current condition in Asian World commercial area in Taipei City.
5. Develop the urban visualized simulation method on the base of 3D spatial information.

The "Building using mixing degree computer visualization system" constituted by this research not only provides the output of text information but also displays its result with 3D spatial visual model. It is very helpful to the urban environmental quality evaluation, building mixed-use control, regulation checking of current condition use and regulation revision of land use district control. The general conclusion of this research are as following:

1. Linking of 3D object and attribute information

The establishment of data structure will influence the data link during computer visualization; it is the combination of data and CAD. This research resolved this problem with the concept of layer and hierarchy, using the data link function on CAD 3D spatial model, enhancing the computer visualization level, making it capable of linking to other related urban spatial information visualized model.

2. The application of urban environment hierarchy concept

The hierarchy concept can apply in constituting system's information, and the visual expression. The user can choose different scaled urban models to display according to different need of the studying subject. The division of urban environment hierarchy is not only beneficial to the function of display and analysis but also helpful to form the system simulation concept.

3. Computer visualization system

Through the mixing degree calculation, we can understand the 3D spatial land mixed-use condition and analysis its impact on environment. Therefore, computer visualization system is necessary for urban plan and design field, any related factor of building spatial unit's basic unit can use this concept to proceed visual modeling.

4. The urban simulation method based on 3D spatial information

The urban simulation method based on information of this research is very advanced and practical not only in urban planning's design quality but also very helpful to the management of city activities.

The future computer visual simulation could combine different urban spatial information and become an integrated tool. It can also consider several different urban spatial information and integrated with hierarchy of information. The integration of the urban spatial information allows planner using new analysis tool to consider the traditional planning problem, and will check the impact on environment.

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