GIS-based Visual Perception Analysis of Urban Natural Landscape for Urban Planning Supporting: A Case Study of Jinzishan Hill Region

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In this paper we present a GIS-based system prototype in evaluating visual perception quality of natural landscape within urban environment. Through a case study, we demonstrate the entire procedure which includes data modification, model making, viewshed and view sensibility analysis as well as design aiding presentation of this system. This system prototype offers a calculatable and visulizable technique to evaluate the visual quality of urban natural landscape in either actual situation or planning future. Furthermore, we collaborate with local professional organization in a real urban site study to preparing regional planning instruction items by means of this system.
Keywords: *GIS; urban natural landscape; visual perception; viewshed; Jinzishan.*

Introduction

In reason of traditional culture, most of old Chinese cities are designed in an urban context style collaborating with natural landscape. These planning principles can provide high visual quality in addition to other urban function. But modernization of Chinese cities had ruined such unique strategies. Furthermore, it also caused the neglect of natural visual landscape in urban planning practice as well as the lack of supporting methodology system. The reason is the deficiency both in recognition of visual value of urban natural landscape and its cooperative methodology in environment sustaining. This reality has become a great challenge for current China planners.

Reacting to such problems, a GIS-based system prototype for evaluating visual perception quality of natural landscape within urban environment is presented in this thesis. The production of this system operation is quantified spatial information for further development controlling. It can support planners in decision making in order to keep urban tradition and recognition.

Procedure

Figure 1 illustrated the proposed system design in a framework. GIS idea are introduced in analysis methodology as well as modeling. GIS software also served as technical solution.

Primal data processing

In current China city planning field, the digitalized terrain maps are mostly produced by CAD system. DWG or DWN are the most familiar formats. We select AutoCAD, which is the first choice of CAD platform in more than 90% China planning professional field, as the basis tool in raw data processing. Relief maps and planning drawings are combined together to create blueprint. Simplicity, layer adjusting and open-ended for further modification is general principles of the primal data processing.

3D conversion

3D conversion of terrain and buildings modeling is operated in ArcView GIS software for constructing a triangulated irregular networks (TINs). In this research, two kinds of TINs model, which are terrain TINs and

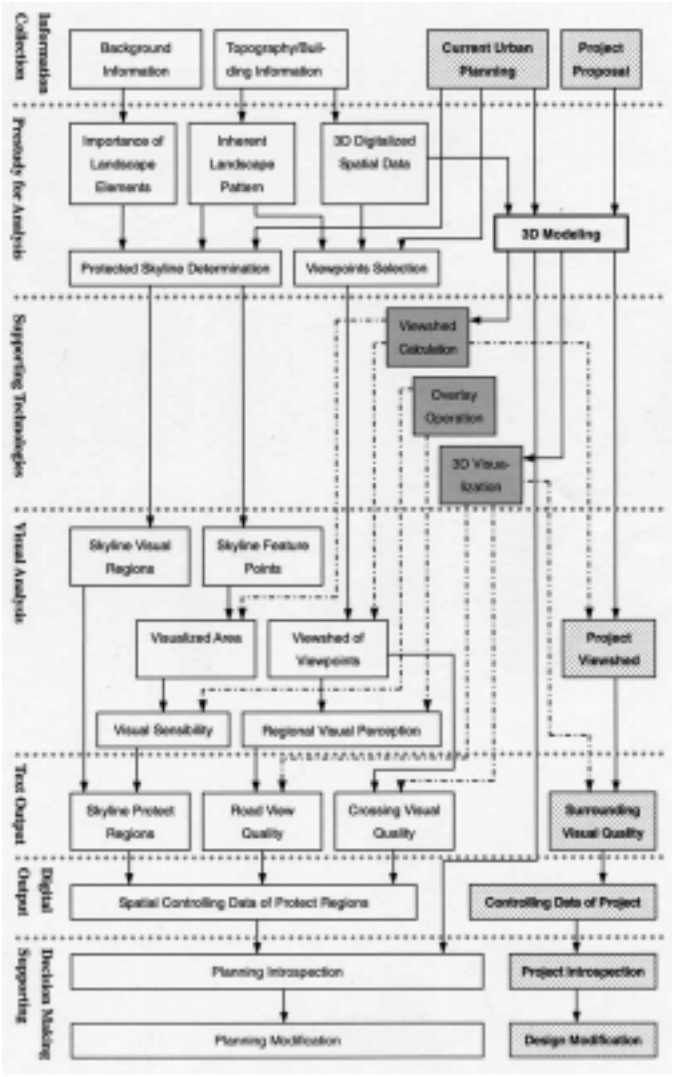

Figure 1. Diagram of the system prototype framework

integrated TINs of typology and buildings, are employed in the analysis for different purposes. 3D Analyst extension of ArcView GIS also offers the function to modifying existing TINs with new spatial data. This utility supports the flexibility of spatial modeling for potential alteration.

Vieshed Analysis

Viewshed calculation in this research is operated through simulating human visual perception by means of introducing human optical parameters. According to the visual characters of anthropometry data from

Tilley (1993), following values are adopted in parameters setting: visual height and target height in 1.6m, horizontal view angle in 360°, angle of depression in 35°, angle of elevation in 25°.

After settle the visual characteristic factors through dialogue box, particular viewpoint can be fixed in 3D position. Then the software automatically computes the visible and invisible areas of this viewpoint base on the topography and building models. Consequences of the calculation are illustrated by precise vector data in 2D polygon features. According to the principle of intervisibility, which states that visibility is determined in two ways either from the site or to the site, the same technique can be employed inversely in calculating the scope in which can witness a certain spatial point.

Overlay analysis

Overlay analysis of thematic maps is a traditional method in planning. Through manual or automatic function provided by ArcView GIS software, common visible area of the proposed viewpoints can be illustrated by overlaying visible areas of different viewpoints. Since the common area can be visible from numerous points, the development in this scope will affect the visual perception quality of all viewpoints. In this research, the term “visual sensitivity” is introduced to evaluate such effect through the statistic in quantity of visual absorption. A landscape in high visual sensitivity means that it can absorb more vision from surrounding area. Therefore, higher sensitivity means the area is very susceptible in landscape change Meanwhile, the scenery with a low sensitivity rating can withstand a lot of development without losing its quality (Hanna, 2000).

Simultaneous 3D simulation

The significant of simultaneous 3D simulation is offering direct perceived object vision to interpret the 2D maps data in urban design procedure. Especially for semi-professional or unprofessional participants, such as in government management of China or public participation program of urban planning, the 3D object images act as the main tool of information communication. In this research, a script program by Lane (Sep 1998) is introduced to present the simultaneous 3D simulation. Other than still perspective images, this program also provides real-time dynamic vision of any trail within the study area (Figure 2).

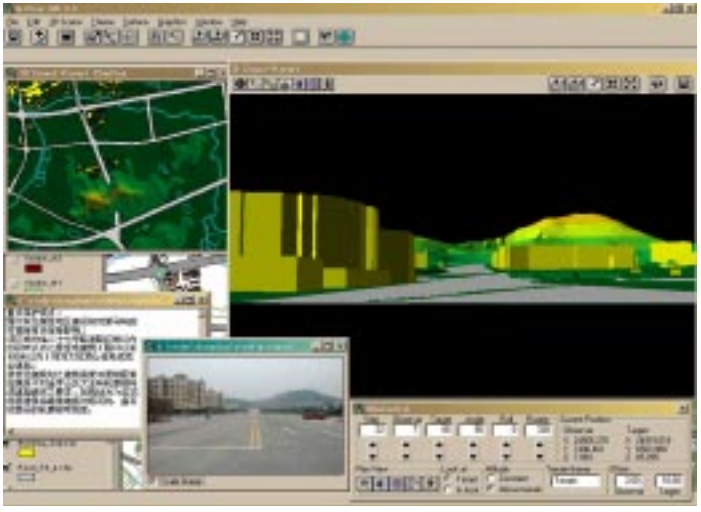

Figure 2. Simultaneous 3D simulation and integration of other information expressions

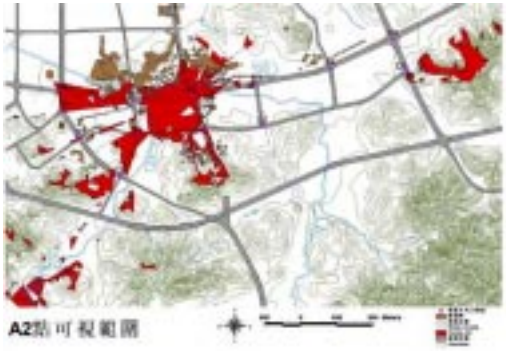

Figure 3. (left) Visible area from viewpoint A2 (intersection of Qiwandao and Bo'ailu)

Figure 4. (right) Integrated visible scope of viewpoint b4, b5 and b6 of Bo'ailu

Integration of other information expressions

ArcView GIS software offers functions in hot link of spatial information with related references. Photos, text instructions, planning sketches or even other digital format media can be integrated to provide supporting information for design or communication (see Figure2).

Data output

ArcView GIS 3.2 or upper versions provides "Shape DXF Converter" tool to handle the vector data exchanging. Shape files which symbolize spatial information thematic maps can be transferred to DXF format for further application in other CAD system or software.

Case study

A case study has been conducted for evaluating the developed system. The case is in Zhongshan city, Guangdong Province of China. Jinzishan hill region, which is the site picked by collaborating discussion of research team and local government, locates on the edge of the city built-up area (Zhongshan Planning Bureau and Zhongshan Planning and Design Institute, 1998). Jinzishan is the prominent landscape element of the surrounding environment. Its landmark situation in urban structure has been recorded in the county annals within recent three centuries (He, 2001).

Visual quality evaluation of road crossing

Through viewshed calculations, viewshed maps indicates visible areas and visual impact objects of viewpoints (Figure 3). By reviewing the viewshed distribution as well as the essential visual impact assessment (VIA) principles (Yeomans, 1986), planners can evaluate the visual perception quality of natural landscape at intersections of surrounding roads within the hill region. To control the keypoints view in urban planning, visual resources, especially urban natural landscape, of every crossing are recorded in accuracy as the fundamental for surrounding development. In the past, this kind of planning and analysis are only based on manual operation or even guessing.

Integrated visual perception of linear space of road: Bo'ailu and Qiwandao

Bo'ailu and Qiwandao are two urban arterial roads in the study area. The Qiwandao is just opposite to the massif and the other passes through the best visual perception area of the region. Combine with 3D dynamic visualization, integrated visual perception through overlying visible scope of viewpoints along a road partitions the whole road according to different quality of natural landscape visibility and visual sensitivity (Figure 4). Such reference is helpful in making planning instructions for development alongside the roads.

Figure 5. Partition of scopes with best visual perception to Jinzishan skyline (irregular shapes in darker color of the above center) and the west peak (left irregular shapes in darker color). This image also indicates the districts with particular vision angle to skyline for symbolizing visual perception quality (circles and colored crescent shapes).

Visual perception of Jinzishan skyline.

By reviewing the visual sensitivity areas of typical feature points of Jinzishan skyline, we designate its integrity, continuity and identifiability in vision from surrounding. In addition, consulting human visual ergonomics (Tilley, 1993) and psychology of visual landscape perception (Higuchi, 1983), limits of horizontal and vertical view angles are introduced to define visual perception quality of the skyline. Visual scopes of skyline perception that view angel to the skyline is from 30°to 70°in horizontal are defined as in valuable visual perception. For vertical angels, 5°, 9°and 20°is the critical values to control visual quality of the massif skyline. Overlaying these scopes with visual sensitivity results, potential high quality visions can be accurately positioned for planners' reference.

Conclusion

A report of the Jinzishan hill region's natural visual landscape is presented to Zhongshan Planning Bureau. The most valuable content of this report is the evaluating tables of various vision positions including key viewpoints, road sections, and surrounding developing districts. Information in these tables integrates visible natural landscape description, visual landscape quality evaluation, and the referenced planning instruction (He, 2001). Decisions of the system prototype design and its practical operation are reviewed by specialists in urban planning and management from the Zhongshan Planning Bureau. They declare that this system can be in great value in China planning practice, especially benefit to the examination and approve program of new development planning or projects. On the other hand, they also indicate that complicacy in handling operation procedures and deficiency in user-friendly interface will restrict the system's practical application. Furthermore, the proposed system prototype is employed in an architecture design evaluation. That project locates in the case study area. The validity and utility of this system is highly recommended by the participating experts and academicians.

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