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Urban Planning Support System Based on Three Dimensional GIS

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Abstract

In this study, the theory of technology analysis and decomposition of the 3-D (three dimensional) visualization of GIS (Geographic Information System) are analyzed, it divides the 3-D visualization of GIS into virtual reality technology, and it presents situation and development trend of 3-D visualization of GIS. It studies the urban model of 3-D data acquisition and processing, the classification of urban 3-D space information data and summarization of the characteristics of urban 3-D spatial data are made, and the three dimensional terrain data, building plane and building elevation data access, building surface texture are also analyzed. The high resolution satellite remote sensing data processing technology and aviation remote sensing data processing technology is studied, and the data acquisition and processing technology of airborne 3-D imager also are introduced This paper has solved the visualization of 3-D GIS data model and visual problem in the construction of the 3-D terrain and expression of choice of buildings, and it is to find suitable modeling route, and in order to provides a reference basis in realization of 3-D visualization of GIS. Visualization of 3-D model of the theory and method are studied in the urban construction, according to the 3D visualization in GIS and it proposed the two kinds of 3-D visualization model of GIS technology.

Keywords*: urban Planning, support system, three dimensional, GIS, visual*

1. Introduction

Modern computer technology provides important technical support for massive information storage, management and processing in the field of urban planning. As the limitations of the traditional two-dimensional GIS in the data structure and form, thus the three-dimensional visualization of GIS now gradually play an important role and become an important part of digital city construction [1-3]. Three-dimensional visualization is an important part of 3-D GIS; it is also the difference of feature between 3-D GIS and 2-D GIS. The digital research of three-dimensional geographic information system of city, and the applying of 3-D visualization and information query and management technology in the construction of digital city, will lead the design of urban landscape situation and planning be based on 3-D physical model expression and in 3-D space form [4]. It can makes the policy-makers, designers, and users have a vivid and intuitive understanding and more profound understanding and about the present situation of urban landscape planning and the design blueprint, thus it can broaden the urban planning, design, and the perspective of management, and make the design of city planning, infrastructure more scientific, it has important significance for urban sustainable development research [5-7].

2. Key Techniques in the 3-D Visualization of GIS

Research of 3-D visualization of GIS technology, is the precondition of its application in urban planning. 3-D visualization technology involves three-dimensional, visualization and GIS. Therefore, the 3-D visualization of GIS can be looked as the combination of three kinds of technology, which has the function of 3-D visualization of geographic information system; its core part is the geographic information system. In this paper, the concept of 3-D visualization of GIS includes so-called 2.5D-GIS, VR and GIS, and can achieve a deeper interaction of 3-D GIS. Urban 3-D GIS have gained the attentions of people, but its planning application is limited [7-10].

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In auxiliary planning process, the limitation of three-dimensional geographic information system is the perspective of virtual reality, bring the person is a kind of visual effect, the GIS data management, analysis of data and query functions are covered. So the 3-D visualization of GIS in the urban planning should provide comprehensive information to the users, and should support the urban planning process. Compared with real entity 3-D city model, three-dimensional urban geographic information system is equals to 3-D city model+project information + efficient data storage and management, planning and analysis functions [11-13].

If from computer-aided decision-making level of intelligence to understand the GIS in urban planning, it can be understood as the following three levels, the first level is the spatial database, it is the basic requirements space to search; The second level is based on the spatial database application system, based on the spatial analysis, such as auxiliary city planning and design (CAD) based on GIS, the urban planning office automation (OA), etc.; Third level is on the basis of the first two levels of expert system (ES), Decision Support System, Decision Support Systems, etc., such as urban planning and management expert system, etc [14-15].

Many researchers have been developed 3-D GIS prototype system, thus leads the application of the 3-D GIS technology in the field of mineral resources administration, digital city and many other fields. Kavouras and Masry from the Canada's university of New Brunswick developed the evaluation of mineral resources and mining of 3-D GIS prototype system in 1987. Rostock University, university of Stuttgart, Germany research institutions now make the joint research of 3-D GIS in the application of digital city model. The spatial objects of city are classified and digital urban simulation system is established, the infrastructure of the urban (including houses, roads, green space, etc.) can easily be queried, analyzed and displayed.

Because the GIS involves very wide knowledge, including astronomy, geography, geology, urban construction, environmental assessment, etc., while at the same time, the GIS is a new edge discipline, it relates to graphics, management science, computer science, disciplines of surveying and mapping science and so on. Experts from different fields can make study of true 3D GIS according to characteristics of their own discipline. The three dimensional visual geographic information system is just shown as Figure 1, it involves digital orthography map (DOM), digital terrain model (DEM), digital line draw diagram (DLG) and digital raster graph (DRG). The system combines the 3-D visualization technology, visual reality and virtual reality technology, and reappear the real situation of the management environment, all managed objects are put into a true three-dimensional world, and fulfill the sense of “What you see is what you get”, just as shown Figure 2

Figure 1. VRMap Interface

Figure 2. The Solution of IMAGIS

3. Acquisition and Processing of Urban 3-D Data

As known that the data is the basis of GIS, the space information data of urban three dimensional have different types, the information acquisition and processing of the data has its own characteristics, so the research of data acquisition and processing method of 3-D city model is very necessary.

3.1. Three Dimensional Space Information of City

Urban residential environment is relatively concentrated areas on the earth's surface; they are also the necessary production and living space for urban people. Urban space is based on the surface, and extends into the air and underground slightly, thus it is the three-dimensional space. As a result, the urban space can be divided into three parts, the surface, the ground and underground, accordingly urban terrain can be divided into surface terrain, ground objects on the ground.

3.2 Classification of 3-D Spatial Information Data

The 3-D visualization GIS of the city can be summarized as six categories: landscape, vegetation, drainage, roads, residents and state. And the important position is the landscape and residents. Therefore, the three-dimensional space of the city planning information can be summarized as 3-D terrain, 3-D buildings and surface texture image data. In the 3-D visualization of GIS, the landscape is represented in the form of the digital elevation model (DEM) performance, residents is represented by the 3-D buildings.

Digital map is the concentrated reflection of multi-source data. Digital map is stored on computer hard disks, floppy diskettes, optical disks or tapes in the digital map, its content is represented through digital data, it needs to use specialized computer software for the digital display, read, search, modification, analysis and output. The data of city present situation and the urban planning are in the form of digital map data stored in the database. Digital map types mainly have: digital line graph (DLG), digital raster graph (DRG), digital orthogonal projection map (DOM), digital elevation model (DEM) and digital building model, digital pipeline model and panel data, etc.

Digital line graph (DLG) is to abstract space entities directly with points, lines and plane, and adopts the coordinates to describe the location and shape of it. DLG is the images after scanning and geometric correction, it is the vector data file of the quantization, and it can be conveniently amplified and superposition of roaming, query, retrieval, measurement, map, facilitate stratification, and it can be able to quickly generate thematic map.

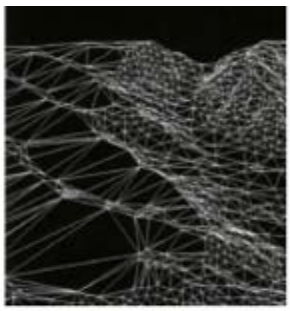

Figure 3. Digital Elevation Model

Figure 4. Digital Raster Map

Figure 5. Digital Orthophoto Map

Digital raster graph (DRG) is all sorts of paper medium scale topographic map and professional digital products. It is the data file after scanning, geometric correction and color correction, formed on the content, geometric accuracy and color consistent with the topographic map of raster. DRG data can be used as a background reference or other geographic information revision, it can also be used in the integration with DOM and DEM data, and thus derive the new visual information, so as to extract the updating map data as Figure 3.

DEM digital elevation model (DEM) is the elevation value matrix with specific rules of projection plane and with interval level of space, the level interval of DEM is according to the landscape and the DEM application can be converted to contour map.

Perspective, profile, and various thematic data as shown in Figure 4. Numerical projective map applies the digital aerial photograph and high-resolution satellite remote sensing image data, through geometric correction and mosaic operation, and generate a certain scope projective data. It also has the image of geometry precision of map and image features.

Compared with the traditional line drawing, DOM has rich information, express intuitive features, can also and the traditional line drawing phase composite, and form the various thematic map, and take it as a graphical analysis of the background layer. Combined with the DOM and DEM, the terrain information more intuitive, can reflect the surface condition as shown in the Figure 5.

Digital model building often is produced by the two cases in general. One is the using of 3-D modeling software, such as 3 D MAX, CAD technology, which is often used in architectural design and planning and design of this modeling method. The second method is to use the point, line and surface information in the existing GIS systems and the height of building and thus establish three-dimensional model directly. In 3-D building surface texture map, it can achieve the realistic result.

4. Three Dimensional Spatial Data Access

4.1. Acquisition of 3-D Terrain Data

Digital 3-D terrain data can be divided into vector data and raster data. Vector data is generally divided into three classes of point, line, surface; it mainly refers to the contour vector, vector, vector geographic elements, terrain feature points, and thread box or discrete lattice representation of digital elevation model (DEM). The Terrain visualization is the study of DEM display, simplify and simulation and so on, the DEM data is the basis of 3 D terrain model. Due to the visual unity and scalability of digital 3 D terrain mainly depends on the quality and accuracy of DEM, so the vector data and raster data are the most important part in DEM.

Now in the three-dimensional model of the city, there are several obtaining methods of DEM.

1. Using the 2-D GIS in the DEM, as the model through the measured elevation points of irregular triangle net (Triangulated Irregular Network, TIN) and thus the precision is the highest, but the disadvantage is that speed of access and update is too slow.

2. Through the digital photogrammetric system, the aerial photography can be formed, this kind of access is limited by scanning resolution and measuring method, precision of mapping will be affected, but the access speed will be improved.

3. As the direct scanning airborne laser scanning system obtains the information through the subsequent processing. Its advantage is that it can directly measure the ground elevation, without human intervention and has fast automatic data processing ability; its access speed is very quickly. The weather has little influence on it; its shortcoming is low accuracy, and needs the special processing algorithm.

4. Through synthetic aperture radar (SAR) digital elevation model can be obtained. Advantage is that no matter the night or the day and the influence of the weather, it resolution is high, but the cost of data acquisition is very high, now it is not easy to be promoted in the actually application.

4.2. Remote Sensing Data Acquisition Method of 3D Urban Data

Urban 3-D remote sensing information is one of the spotlights; the remote sensing technology of getting urban 3-D remote sensing information becomes one of the hot issues of research. Urban 3-D remote sensing information can be widely used in urban planning and design, the monitoring of urbanization, the modernization of the city management, city buildings. The three-dimensional information is also one of the key information of virtual city. At present because of the economic and social development of city, the speed of change also is accelerated, many applications needs efficient urban 3D information. The development of “digital city” requires obtaining city information more efficiently. The using general methods and means such as artificial ground surveying, aerial survey need to invest a lot of manpower, material, slow speed, while the effect is not satisfactory, and it does not match with the urban development speed. Therefore, the traditional method is difficult to meet the application requirements. Using satellite remote sensing and airborne remote sensing can obtain high resolution data; airborne 3-D image can reflect accurate real-time three-dimensional position and spectrum of ground information, and it can guarantee acquisition of 3-D structure information complete in a short time, thus it can meet the needs of the fast urban development.

4.3. Modular High Resolution Satellite Remote Sensing Data Processing

The application of high resolution satellite remote sensing data in city has just started, because the development of high resolution satellite remote sensing is in recent years, such as IKONOS, SPOT, QUICKBIRD and the successful launch and operation of commercial satellites. When the IKONOS satellite launch to orbit in the autumn of 1999, it opened a new era of space imaging. The high resolution imaging reconnaissance satellite is only dedicated to the military field. But, with the launching of satellite, anyone can order black and white image taken from 681km high space with 1m resolution. These images are transmitted in digital way, sometimes you can get in a few hours. Urban planners can use it to determine where to build new roads; high-resolution satellite data can play an important role in urban planning, map update, its processing can according to satellite data processing method and airborne remote sensing data processing method, the processing method as shown in Figure 5.

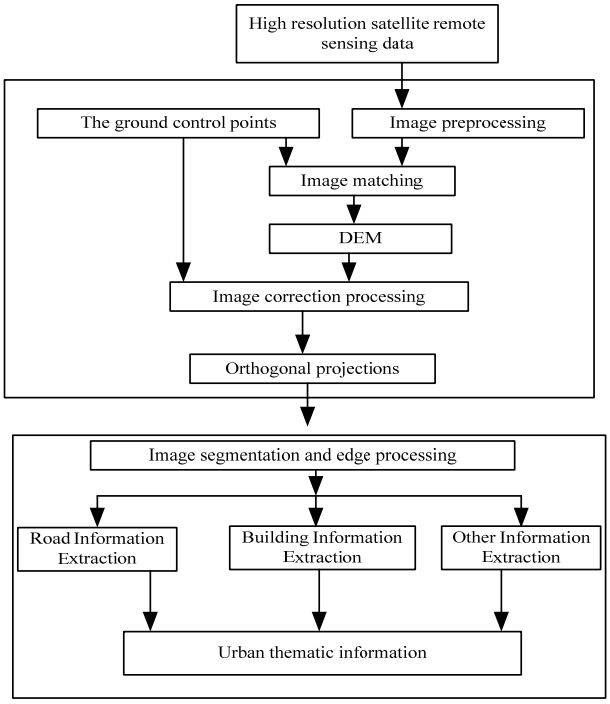

Figure 5. Satellite Remote Sensing Data Processing

4.4. Data Acquisition and Processing of Urban Airborne 3D Imager

Airborne 3-D imager is a kind of laser scanning and imaging system, it is consisted of four main parts, the GPS receiver, position measurement device (INS), scanning laser rangefinder and scanning imaging. GPS can obtain precise three-dimensional of 3-D imager position in the air; Attitude measurement device can measure 3-D imaging posture parameters in the air; Scanning laser rangefinder can measure precise distance from the 3D imager point to ground. According to the principle of geometry the three-dimensional position of the laser can be calculated. The remote sensing image can get through the scanning imager synchronization of the ground at the same time. The scan imaging and scanning laser rangefinder shares one scanning optical system and form the scanning laser range and the combination of imaging sensors, so it can ensure the laser ranging points of ground strict with spot point in the image matching. In the processing of image, it takes the 3D position of the laser as control points in the precise correction of remote sensing images, so it can provide fast projective figure. The laser ranging points can also be used to generate DTM quickly. The process is as shown in the Figure 6.

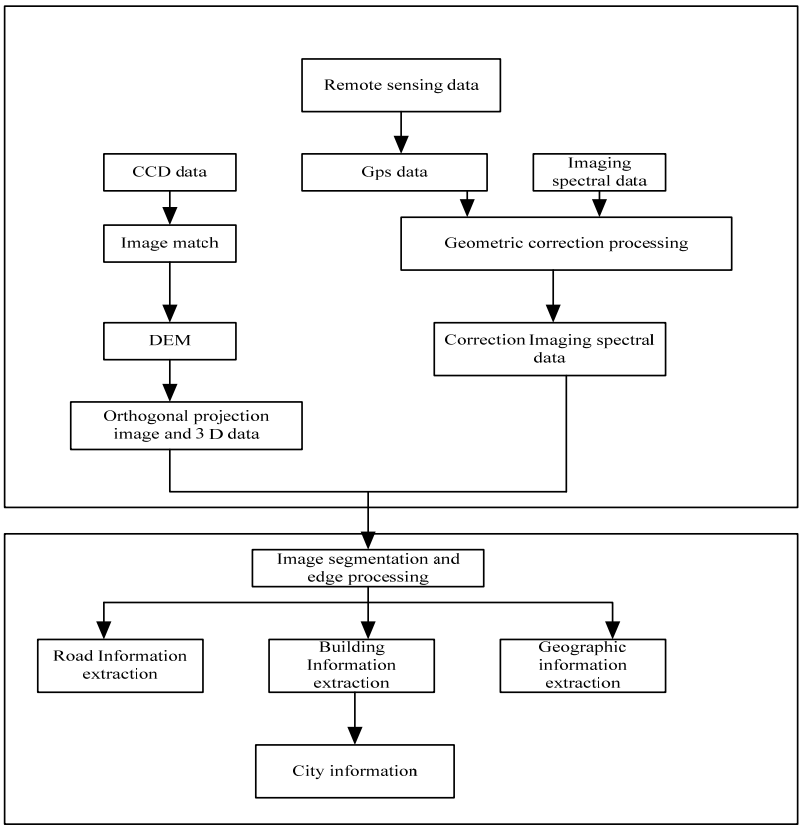

Figure 6. Remote Sensing Image Process of the City Informations

5. Urban Planning Based on the GIS

If we want to use 3-D visualization of GIS in the urban planning, the interactive planning support system is necessary. 3-D visualization of GIS urban planning support systems (PSS) design is discussed in the below.

5.1. Urban Planning Support System Based on 3-D Visualization of GIS Workflow

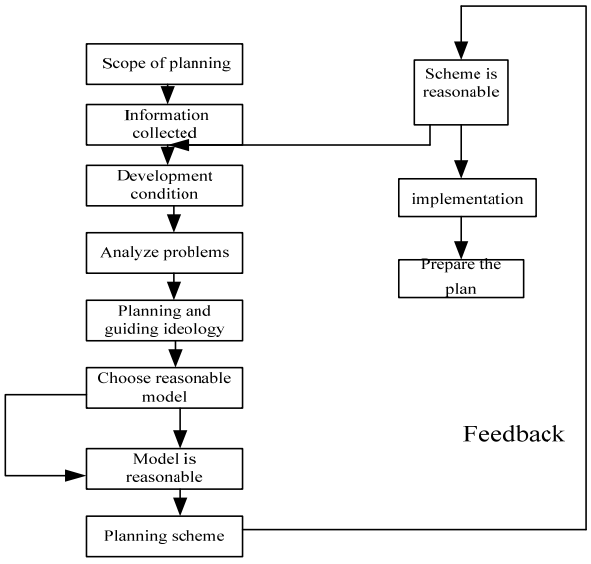

Figure 7. Urban Planning Support Working Process of Based on the GIS System

Urban planning is complicated system engineering. The situation is very complex, and there are a lot of space information and uncertain information, in the planning process, it will encounter a lot of semi-structured and unstructured problems. The whole planning has the characteristics of a comprehensive, long-term and variability; so the aided planning system of 3-D visualization of GIS must always be used in the whole process of urban planning. The working process of the system is as shown in Figure 7.

5.2. Principles of Urban Planning Support Systems based on 3-D visualization of GIS

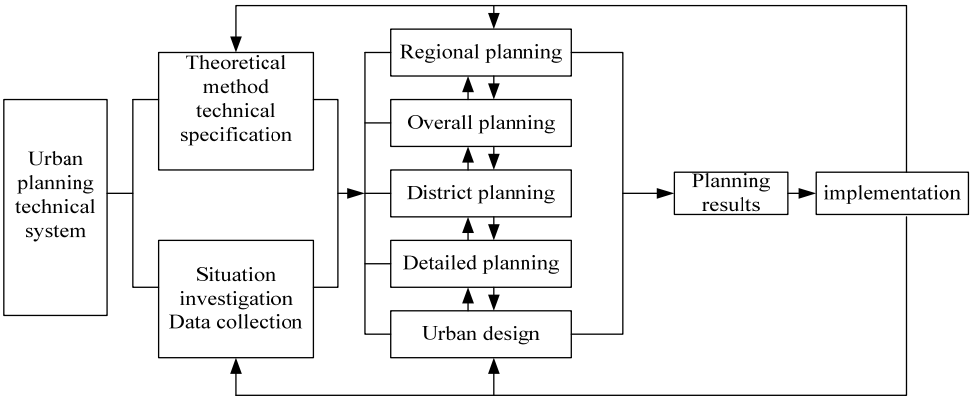

Figure 8. Urban Planning Technical System Structure

System design goal is determined by tasks of planning support system. The urban planning technical system is based on regional planning, overall planning, zoning, detailed planning, engineering design. These five levels are layer upon layer, step by step, according to the theory of city planning; aim to achieve the coordinated development of urban economy, society and environment. Urban planning technical system structure as shown in Figure 8.

Urban design is a bridge between urban planning and architectural design, it is departure from the whole city, and makes a comprehensive design in particular to a city district, a street or a center. Its purpose is to improve the quality of urban environment, improve people's quality of life, and provide the most convenient and comfortable to the people, and brings the person with beautiful enjoyment.

Therefore, 3-D visualization of GIS auxiliary planning support system must adapt to establish requirements of planning, and provide scientific and effective tools and instruments achieving the planning goal. Planning support system of 3- D visualization of GIS is based on the database and takes it as the core, it makes the joint management of query, analysis and display of data, and combined with urban planning and design content, it provide assistance for urban planning.

6. Conclusion

This study focuses on 3-D visualization of GIS technology and its application in urban planning

1. In this study, the theory of technology analysis and decomposition of the 3 D visualization of GIS are analyzed, it divides the 3-D visualization of GIS into virtual reality technology, 3-D visualization technology and GIS technology, it also discussed from 2.5 D to 2-D GIS, the GIS to 3 D visualization of GIS key technology development process, present situation and development trend of 3-D visualization of GIS.

2. It studies the urban model of 3-D data acquisition and processing, the classification of urban 3-D space information data and summarization of the characteristics of urban 3-D spatial data are made, and the three dimensional terrain data, building plane and building elevation data access, building surface texture are also analyzed. The high resolution satellite remote sensing data processing technology and aviation remote sensing data processing technology is

studied, and the data acquisition and processing technology of airborne 3D imager also are introduced

3. This paper has solved the visualization of 3 D GIS data model and visual problem in the construction of the 3D terrain and expression of choice of buildings, and it is to find suitable modeling route, and in order to provides a reference basis in realization of 3D visualization of GIS. Visualization of 3D model of the theory and method are studied in the urban construction, according to the 3D visualization in GIS and it proposed the two kinds of 3 D visualization model of GIS technology.

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