

Digital Harbor's Multi-Dimension Modeling and Presentation

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ABSTRACT With the fast growing digital measurement technology, we can obtain DEM directly from the digital video, overlap with the digital video texture to realize three-dimension terrain display. The spatial data contains not only three dimensions of the objects but also time, physical scale and other kinds of attributes, such as the ocean's water dimension and other ocean related attributes. Only multi-dimension data can completely and clearly describe spatial data and present a authorized and reliable geographic analyzing model which provides decision and application departments with a virtual platform that can supply a set of entirely managing and analyzing tools. Three outstanding characters of digital earth are spatial and temporal integration, networked and virtual reality. Geographic data stored in spatial databases can be characterized as multi-dimension, time-sensitive and bulk information.

KEY WORDS Spatia-Temporal Database, MutiDimensional Spatial Data, Visualization, Internet-GIS, VRML

1. Spatio Data's Different Model

The data of the GIS and the express pattern have changed from 2-dimension to 3-dimension, from the static state to dynamic state.

1.1. 2-dimension expressing of the spatio data

The GIS's purpose is processing the digital maps, and large volume of static 2-dimension maps. The data model of the 2-dimension expressing pattern include vector model, raster model and vector-raster mixed model. The vector model was developed from 1960's, and it's the data model which face to point, line and polygon geographic feature. The 2-dimension geometry coordinate of every kind of object which construct geographic landscape are linked by data list. The raster model express the geographic landscape through 2-dimension discrete gird. The raster data, on the one hand can process one by one point and block operate, which have the higher ability of the spatial analyzing and processing, on the other hand it can draw fast with shading. So base on the regular gird and irregular-gird, people can realize 3-dimension display of the earth surface.

1.2. 3-dimension express of the geo-data

Now, in the GIS and Computer Assist Design, real 3-dimension's pattern is adopt surface model, which object is constructed by vector edges and lines, depth clue displayed at raster surface by display chains, express the up-down relation among surfaces by hide and shade technology. Every change, which for geography stage, visual angles and light, must be discrete from new deeply chains and displaying buffer.

The homology of the surface model is body model, which is applied 3-dimension grid to draw

geographic stage, every space grid correspond one attributes value. One 3-dimension grid unit can be seen as a body element. The body element can be seen as the extending from the 2-dimension picture element to 3-dimension space. We reflect all of the material, color, texture or transparent that distributed by scalar quantity and vector geographic data which were collected by us. The body element picture has already become the important direction at science visual research and development because it can operate to data straightforward, and have the ability of real-time animation, and have the bigger advantage at calculation, and it wide used at medicine, fluid mechanics, limited element analysis, biology, CAD entity model.

1.3. Temporal express of the geo-data

The temporal research of geo-data is a hot research point in geographic information system fields. Langran, Barrera, Donna J. Peuquet etc. seperatly suggested and discussed the snapshot ways, mix ways and event ways to design event state data structure and database. In fact, people expand the definition of 2-dimension and 3-dimension data to 4-dimensions, which see the temporal as a coordinate axle, and called it as the 4-dimensions spatial. Between the temporal axle and the one dimension, two dimensions, three dimensions axle in euclid space has not only relation but also difference. At first, it has some attributes same as other axle. Pigot and Hazelton provided that the temporal axle is continuously, linear, orderly, it is for other axles. We can use temporal to forward calculate, backward calculate, but the temporal can't has branches. We can see many kind data including temporal in data model as

new data axle, but we should differently deal with them in practice.

2. Spatio-Temporal Data Model

In reality, geographic phenomenon varied as time goes by, such as tide and ocean current in some sea area varied in different time. GIS's space data model is an abstraction of the real world, it was defined as a set of co-related entities. Different abstraction of real world There are different data models because different surveying the real world, vector and grid data model are the two primary data model in up-to-date GIS software. Based on the two model, many experts build snap, temporal-spatial data models. However, for a long time, GIS only use to describe static or simple temporal-varied geographic phenomena, although theoretically it has powerful analyzing functions. The reason is that above time-space data model based on reality simplified methods and oversimplified presentation of geographic phenomena. As a result, GIS not only can't present complex geographic phenomena, ignore build-in relationship among these geographic phenomena but also limit the GIS's analyzing functions to some extent, especially in temporal-spatial analyzing functions, such as temporal-spatial entities evolvment, prediction and replaying, temporal-spatial based querying and searching is also very difficult. Recent years, GIS has introduced the concept of object-oriented from the computer programming. Many experts try to establish object-oriented data model, including temporal-spatial data model.

The spatio-temporal database is database system including temporal and spatial element. The temporal database was wild researched at 80's, and then got much achievement. Clifford provide the relation type historic database model at 1982. Afterward, Gadia provide the query language TempSQL, which can support double temporal database, and Snodgrass design the temporal database and query language Tquel at 1987. Spatio-temporal database was constructed by add temporal element at the basis of spatial database. The addition of temporal dimension enriched database containing. One side, it add the complexion at database management, on the other side, large volume of data provide a large stage for spatial and temporal analysis.

Temporal database has many kind of sorts. If bases on the ability of database process temporal, temporal database can be divided into historic database, roll database and double temporal database. Among them, the historic database only can deal with real time, roll database only can deal with database time, double temporal database can

deal with both two kind of time at the same time. Temporal database also can be divided based on above conception. When based on the database containing, temporal database can be divided into historic database, real-time database and forecast database. When based on the database structure, it can be divided into linear database, branch database and cycle database. When based on object, it can be divided into state-bases database and event-based database.

Spatia-temporal database model has two sorts, vector-based spatia-temporal database model and raster-based spatia-temporal database model, they derived based on the original vector data model and raster data model. The two model can deal with 8 kinds temporal and spatial change model: 1, Attribute suddenly change; 2, Attribute gradually change; 3, Positionsuddenly change; 4, Position gradually change; 5, Position and attribute suddenly change; 6, Position and attribute gradually change; 7, Attribute suddenly change and position gradually change; 8, Attribute gradually change and position suddenly change. In the most models, to deal with the gradually change through reduce the time granularity, and then divide the gradually change into many suddenly changes.

We have got large number of 2-dimension and 3-dimension spatial data by survey the earth, these data mostly are stored in relation database. According the amplification of data, the data has changed from characters and numbers to picture, image and sound etc multimedia data. It's very difficult that the ordinary database accomplish accessing, operating and analyzing large volume of data. A spatial object can be expressed by the follow function: $S=f(O,A,G,P,M,S)$, so the attribution function is $A=f(A1,A2...An)$, and so on, the other data dimensions can be expressed by function: $D=f(D1,D2...Dn)$. Because the attribute dimension can be extended no limited, we can add any attributes what we need. For example, when our subject is ocean, we must be interested in ocean special attribute, such as tide and wave. We can express the attribute by attribute function through the temporal model.

In order to implement temporal applications, non-temporal database systems need to be enhanced in three ways. First, the data structures have to be extended to record the time information. Second, new operations using the additional temporal semantic of data have to be provided in order to query and modify temporal data. Third, temporal constraints must be expressible. Usually, extending the data structures with time attributes does not cause any severe problems. When time-stamping data, two different time dimensions

can be distinguished. Valid time records time when data was true in reality. Transaction time records when data was stored in the system. To store valid time data, two additional attributes of a type data, VTS(Valid Time Start)and VTE(Valid Time End),can be added to non-temporal structures denoting the start and the end point of a valid time interval. The same can be done for transaction time.

With continued advances in the hardware technologies for on-line mass storage and the recent focus on data warehousing, the notion of On-Line Analytical Processing(OLAP)is attracting increasing interest. Reports indicate that traditional data models, such as the ER model and the relational model, do not provide good support for OLAP application. As a result, new data model based on a multidimensional view of data have emerged.

With the Object-Oriented technologies and Database technologies combined, the Object-Oriented Database technologies was born. In the Object-Oriented Database, every geo-entity is one object, every object own an unique ID to identify, and the ID is the base of object operation. Every object include attribute data, spatial-image data, static-image data, animation data and sound data. The temporal dimension can be processed as one attribute of the spatial data. It become a multidimensional database.

OODBMS allow the functionality of the system to be extended by classes, methods and/or functions. This feature can be use to add temporal classes and time functions which, together with the non-temporal operations already supported by the system, can be use to write temporal queries similar to those in proposed temporal relational data models.

We present nine advanced requirements that a multidimensional data model should satisfy: 1.Explicit hierarchies in dimensions; 2.symmetric treatment of dimensions and measures; 3.Multiple hierarchies in each dimension; 4.Support of correct aggregation; 5.Non-strict hierarchies; 6.Many-to-many relationships between facts and dimensions; 7.Handling change and time; 8.Handling uncertainty; 9.Handling different levels of granularity.

3.Development of Multidimensional GIS Running on Internet

For centuries, geographic data has been visualized and published in form of static maps and displays. However with the advent of GIS it becomes possible to make use of new electronical means for both, publishing and visualizing geographic data. Since most people are not educated to interpret

technical plans, publicly accessible data must be presented such, that they convey the contained information in an understandable way to a wide audience.

As for GIS software market of the 21th century, the following things have been point out:3-dimension geo-processing technologies, Internet-based application system development, distributed processing technologies for large volume of spatial information, real-temporal geo-data processing methodologies. Among them, research scope within Internet-based application system or Web-based GIS generally contains core parts of software development such as Internet application, large colume of spatial database handling, real-temporal spatial data processing, spatial data transfer and transformation and volumetric display of processing results. Therefore, commercial-bases requirement for these technologies is prevailed in world-wide level.

The internet offers existing opportunities for the distribution of spatial data and can geo-processing of the data on 2 and/or 2.5 dimensional land surface phenomena and topographic data until now but the demands for detailed 3 dimensional application are especially acute in the fields. So as to develop a 3-dimension GIS, the strategic linkage of Java and Virtual Reality Modeling Language should be first regarded. Because Java is an objected oriented interpreted language capable of running the Internet and the VRML is a 3D graphics standard for the Internet.

To visualize urban planing processes as realistic as possible, it is necessary to depict the real world in a three dimensional model. It should be possible to navigate through the three dimensional scene in a natural way, to give the recipient the most realistic impression possible. With the Virtual Reality Modeling Language(VRML), it is possible to create such virtual reality VR environments, which can be viewed and steered with ordinary WWW browser. Furthermore, VRML also offers some benefit to the visualization of terrain, as it is needed in classical cartography.

The VRML world can be controlled by the Jave applet using the so called External Authoring Interface(EAI). The EAI consists of a set of Java classes that allow to manipulate the VRML scene graph. It is possible to insert new objects into the scene, or to remove existing ones. Events from the VRML world can be caught and processed in the Jave applet, as new event can be generated and send to objects in the VRML scene. With a neat combination of VRML and Jave code, it is possible to generate and display new VRML scene and selected objects for taking data probes inside the

world. For interaction with the user, the Java applet opens up a separate window.

4.Conclusion

Spatio-Temporal Database and Multi-Dimensional Spatial Data Modeling is a new area in the Digital Earth field and it is key technology in Digital Earth. We present our viewpoint about how to model spatio-temporal model in this paper. This model can process any type geo-data and it will be wide use.

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