The Research on Spatial Process Modeling in GIS

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ABSTRACT The functionality of spatial process analysis is the foundation of GIS's comprehensive application . To realize such a goal. it is desirable that not only the data model of GIS can represent the datasets needed by spatial process models, but also GIS is able to do multitemporal spatial analysis. But most of current GISs are static in essence, they cannot represent temporal information and temporal topology, and have not rich functionality of multitemporal analysis. Based on this point of view, a GIS spatial processes modeling system(GSPMS) is proposed , which extends current GIS, supports the whole life cycle of an GIS spatial process modeling and supports integration of models, GIS and other computer systems. This paper first describes the conception of spatial process and spatial process modeling. And then the conception framework for GIS spatial processes modeling system is investigated and a graph representative method for the framework architecture is introduced. At last the functions of GSPMS and its supporting technologies are discussed.

1. INTRODUCTION

Every thing on the earth is related eternal developed, being the system and being the entity of the process on the same time , which is the inhering character of the material . The realization of GIS , the acquisition , process,storage,analysis and representation of the information relate with spatial problem not only correlate with the spatial model of the special field, but also is a problem of the spatial process. The spatial process analysis function is the fundament of the orientation of abroad application of GIS.

The essence of the current GIS software and application system which mainly orient to the management of the spatial information and the query request, is static.(liu, 1999). To realize of the flexible spatial analysis function , the following factors is fundamental : the spatial process model can be represented by the GIS model , the GIS sup port the multi-tense spatial analysis ,and the most important is the dynamic GIS system structure which is the GISspatial process modeling system issued in the paper. Process modeling is one of the important research aspect in the software engineering. With the support of software tools, the accurate process management ,control,and the process improvement can be realized through the formalization of the software process and the simulation of the process. The technology is widely used in the software engineering domain and the enterprise process engineering(Law, 2002). The introduce of the process modeling in GIS will do well to the development of the high-quality GIS application system. The platform of dynamic spatial process modeling will be the main research orientation of future GIS.

2. THE CONCEPT OF THE SPATIAL PROCESS MODEL

1.1 Process and Process Model

The concept of process is widely used in many domain, generally it indicate the sequence of the action involved in the system life circulation. ISO and IEEE defined the concept of the software process(ISO, 1995 IEEE, 1991]. The software process is a sequence of the relative process in the software life circulation. The process is the aggregation of the action, the action is the aggregation of the mission. Through the mission , the input will become the output . The action which styles such as artificial action,automatic action,batch process action,automatic batch process and combination action etc, is the undivided work unit in the process. The execution of the action can be sequent ,iterative, collateral ,nested or be triggered under certain condition.The process model is the abstract description and definition of the process, it includes all the important process details. It can be formalized ,or half-formalized(even be un-formalized).

2.2 The Spatial Process Model

The spatial process model is the abstract des cription and definition of the information analysis,management and the representation process those adopted in certain spatial problem. One example of spatial process - the lose of the natural environment is summarily showed in figure 1(Wu, 2001). The process has such input as sampling of the elevation,the sampling of the soil ,satellite image,the sampling of the vegetation and precipitation record. With the analysis process such as the rebuilding of the digital elevation,the analysis of gradient and slope ,spatial interpolation, integrating the special mathematics model such as soil erode, vegetation evolvement and precipitation , the process can predict the situation of the precipitation,the erodibility of the soil and the variety of the vegetation cover.

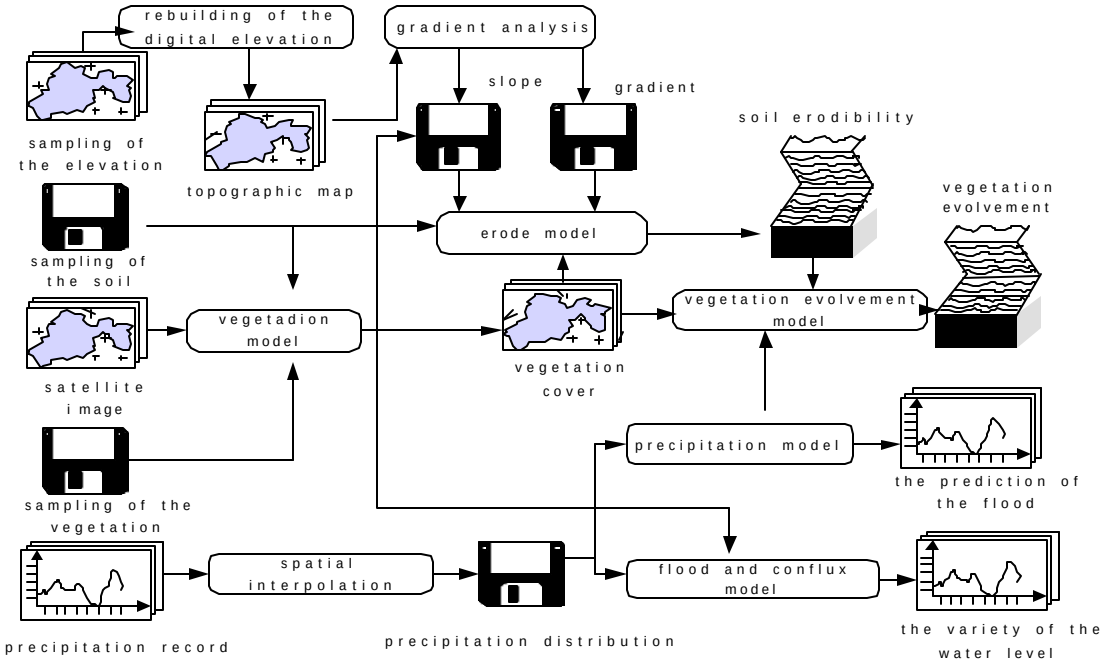

Figure 1, The spatial process model of the lose of the natural environment[G.Alonso]

The spatial process model can be divided into spatial analysis process model,spatial decision process model and spatial dynamic process model. The spatial analysis process is also named "Cartographic Model" which simply integrate the spatial analysis commands of GIS, dealing with the structured GIS spatial data. Such process doesn't need any special knowledge. The spatial decision process can resolve such problem as region plan ,resource allocation which related with the spatial action. In general, involved with multi-target and multi-restriction ,the spatial decision process is a complex process which integrate structured , half-structured and non-structured knowledge. It must integrate the expert knowledge , information management technology and effective mutual means. The spatial dynamic process model such as the variety of the soil utility, the prediction of the flood, the soil erode model is the dynamic geographic and environment simulation which established in the GIS frame. It can serve for the resource management and scientific research. It require that GIS can manage, query, analysis geographic information, realize the dynamic simulation of the geographic and environment process in the multi -domain. Thus, the model should express the time variant and space-time topographic effectively and support the visualization and control of simulation process.

2.3 The Conception Framework for GeoProcess Modeling

In narrow sense, GeoProcess Modeling refer to the process of the establishment of the spatial process model. However, in the view of the project, the broad GeoProcess Modeling not only include the process of the establishment of the spatial process model, but also include the reduction and representation of the example according to the specific spatial problem , and the whole process of executing and improving the model. The conception framwork for GeoProcess Modeling is showed in figure 2.

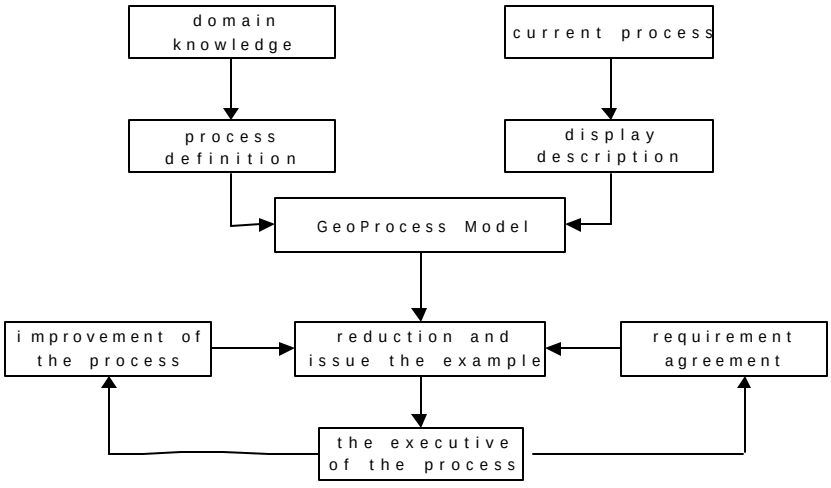

Figure 2,The conception framwork for GeoProcess Modeling

The understand of the domain of the spatial question is the precondition of the GeoProcess Modeling. The following question should be clear: What spatial problem to be resolved? Which spatial and non -spatial information are needed? How can we understand and deal with these information effectively according to the knowledge and experience we have. The answer to the question above is the knowledge about the spatial problem. The knowledge can represent in structured and non-structured style. The former one is named "Procedural Knowledge" which can be described in special domain model and can be realized through the automatic action. The rear one is named "Declarative Knowledge" which is essentially qualitative , experimental,and can not be expressed in fixed program. It is realized by the mutual artificial action in the

process. The definition of the process is the establishment of the process model of the spatial problem based on the relative domain knowledge. In the other case, the description of the process is ambiguous and non-formalized, display the current process in the apparent way will be the best solution.

The above two obtained spatial process model is the abstract description and definition of the process, is the static parameterized description of the process of the specific spatial problem, with the representation of t he aggregation of a sequence of actions and missions. When it come to resolve the specific problem, the parameter need exampled and those unnecessary and impossible parts of missions and actions should be removed.. Thus, after reduction and issue the example, the executable process is obtained. The specific agreement of the problem is the foundation of the reduction of the model. With the participation and control of the human being, the process modeling is executed in the GeoProcess Modeling system. The validity of the model can be tested and the shortage of the model can be found for the improvement.

3. THE FUNCTION REQUEST OF GEOPROCESS MODELING SYSTEM AND KEY TECHNOLOGY

3.1 The Function Request Of GeoProcess Modeling System

(1) GeoProcess Modeling Language The GeoProcess Modeling language is the key component of The Function Request Of GeoProcess Modeling System. The language can describe any given complex geographic spatial process and have enough semantic element. The language should be visualized, formalized, easy-understood, structured, can be nested and support sub-process reused. What's more the language should allow the definition and registration of the exterior object , allow the introduction of the exterior object in the practical system to avoid the mutual-operation problem.

(2) GeoProcess Modeling Simulation The validity, maturity and the correctness of the Process Model can be improved . There are two ways: static check and the dynamic GeoProcess Modeling simulation. The static check examine the correctness of the syntax and the maturity of the structure according to the modeling language. The dynamic GeoProcess Modeling simulation simulate the execution of the process model under certain initial condition and input condition, examine the output and capability standard of the system. simulation is the most important approach of model certification and improvement.

(3) GeoProcess Modeling Control The GeoProcess Modeling is one of the Stream-Like information management process without the devotion of material. With the support of the software and hardware , and the interference of human being , the transformation, analysis and the management of the input data is automatic or half-automatic done. The sufficient, accurate and valid information is handed out for the spatial decision. Thus , the valid GeoProcess Modeling control should be established . The system should supply the convenient mutual interface , support the halt and resume of the action under the distributed network-parallel calculative environment, satisfy the complex request of the geographic spatial process.

(4) GeoProcess Modeling Management The research domain of GeoProcess Modeling should include the process modeling development and the process modeling management. The process modeling development include the acquirement of the request, the edition of the request agreement, the definition of the process, the reduction of the process and issue the example, the simulation of the process and the execution of the process ,etc. The process modeling management not only exist in all the time of the above process, but also exist in the evolvement of the model improvement. The impetus of the improvement of the model come from many factors such as the variety of the request, the improvement of the technology, the

improvement of the function and the model reuse. All these result in many problems such as allocation management,version control,Lineage tracking and Change propagation.

3.2 The Key Technology of GeoSpatial Modeling System

(1) The storage and manage ment technology of data The main target of the storage and management technology of data is data model,data structure and DBMS(Data Base Management System). The data model is the concept model ,is the abstract representation of the real world. The basic spatial data model are: basic element model,the model based on object,network model and field model. The data structure is the realization of the data in the information system. The current data structure include raster structure, vector structure and integrated structure. The DBMS realize the storage,management and control of the real data. The R -E DB is the mainstream. The Object-Oriented technology will be used in DBMS. The data storage and management technology which satisfy the GeoSpatial Modeling system should organize and manage the spatial and non-spatial information effectively,express the time variantand other time-space relation ,support the management and analysis of the multi-time-space. It should also support the expression of the spatial variant of 3 dimension .

(2) The Spatial Data Analysis Technology The Spatial Data Analysis Technology is the kernel technology of the realization of the analysis of GeoSpatial process modeling. Different GeoSpatial process modeling need different Spatial Data Analysis Technology. In general, the Spatial analysis process modeling is used in the traditional spatial analysis, dealing with the spatial data and output the proper result. The key is the spatial mathematics based on different GeoSpatial process modeling. In spatial decision process modeling, the useful information is usually obtained after the data mining. The resources of the data are spatial, non-spatail ,so the analysis is issued after the integration of the prediction model and the decision model . The key in the analysis of Spatial dynamic process modeling is multi -time-space data analysis which require the support of time-variant and the expression and management of the time-space topographic. In recent years, the technology of spatial data analysis develop rapidly. The development of the mathematics methods such as Spatial Topography, Optimization method, chart provide the new approach for the spatial data analysis. The spatial data mining provide the approach to obtain unknown information from the vast and numerous data. The research on the multi-time-space data model and relative mathematics will realize the multi-dynamic GIS.

(3) Network Technology With the development of the network, especially the Internet, the transformation and share of theinformation have changed greatly. All the profession related with information strive to be the first to utilize the network technology. The InternetGIS is viewed as one of the most import aspect of the development of GIS(Korte, 1997). Inthese year, the Web GIS emerge in endlessly. They are great restriction in the aspect of information organization and management in the across platform and distributed network. Many network GIS technology such as Open GIS ,distributed Component,distributed database maturate gradually. The realization of the integrated GIS spatial process modeling system(GSPMS) based on the trans-platform network will come to truth with the advance of the speed of the network.

(4) Visualization and Virtual Reality technology Visualization in Scientific Computing is the theory, method and technology to display and mutual process the data produced in the scientific process(Lock, 1992). With the development of the technology, the visualization not only include the visualization of the scientific computing data but also include the visualization of the engineering computing data and the

visualization of the surveying data, etc. The visualization and the virtual reality syncretize gradually (Andries, 2000). In traditional GIS, the output of data process is represented in the static 2D or 2.5D graph or tables(Ri,2001). With the extension of the GIS application, the visualization and virtual reality technology will be used widely. In Geospatial process modeling system, it is the necessary tool for dynamic process simulation, control and man-machine conversation. The VRML is one of the extendable and open 3D visualized language which support the 3D display of data and process. With VRML, the user can create the 3D world integrate text, image and animation, just like what he feel in the real world.

(5) Object-Oriented Technology Object–Oriented technology include object-oriented computer programmer language, object-oriented software component, object-oriented software design method, object-oriented database etc. The prevalent object-oriented programmer language are C++, Small Talk, C# etc. The object-oriented software component be accepted by the software industry are COM/DCOM of Microsoft, JavaBeans of SunSoft and CORBA of OMG. There are three styles are adopted in the research of object-oriented database: to fortify the object-oriented function in the traditional DBMS ,to fortify the data base function in the object-oriented programmer languages, to develop brand new object-oriented database. The UML(Unified Modeling Language) and Unified Software Development Process have integrated the goodness of all object-oriented methods and become the factual standard of software engineering. The object-oriented understand and describe the system from the inherent character of object , emphasize the object in the system and the relationship among the objects should reflect the problem domain and the relation, thus provide the strong support for the software engineering and is favourable to the software reuse and development. It make the crackless integration of spatial process modeling system and other system possible.

4. CONCLUSION

In the paper, the concept of spatial process and GIS spatial process modeling are described, the framework of spatial process modeling system is issued and the analysis of the function request and the main support technology is brought forward. The research of the GeoSpatial process modeling is still in the stage of exploration. The function is realized in the second-development of GIS software platform. The application is still staying in the simple spatial analysis process and the spatial process simulation in some specific domain. However, the GeoSpatial model analysis function is the foundation of the wide GIS application. With the development and maturity of relative technology, the integrated GIS spatial process engineering environment which based on the spatial process modeling system will be one of the important future in the development of GIS.

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