Design and implementation of spatial analysis module for forestry ecological engineering monitoring system

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Abstract. Spacial Analyst(SA) is the core technology of GIS and it’s also the technology which is different from other information systems. In this paper, the design of spatial analysis module is a sub-module of forestry ecological engineering monitoring system. In view of the forest is dispersed, vast and dynamic, the long-term characteristic, this paper designs its functions include digital terrain analysis, spatial characteristics of geometric analysis, statistical analysis, etc., and briefly introduces the method and technical requirements of realization of each function module, the result is suitable for resourceful forestry workers are applied in the spatial data processing and analysis.

1. Introduction
The monitoring and evaluation technology of national forestry major ecological engineering is to integrate the application system on the technical platform of unified planning and design to provide technical support for information resource sharing and technology sharing in the construction of forestry major ecological engineering. This technology can release project information regularly, submit project progress dynamic monitoring, plan the project, and can also benefit evaluation and decision. Extensive forestry ecological engineering management and monitoring to provide technical support and services. Thus, it serves for the planning, management, monitoring, evaluation, analysis and decision making of major forestry ecological engineering construction in China.[1]

Each information system depending on the object to the function of GIS have different needs and focus on, for the forestry ecological engineering monitoring system, in view of the forest is dispersed and vast in terms of spatial distribution, dynamic in time distribution, and has the characteristics of long-term growth period, the key lies in data acquisition, modeling, spatial analysis and decision analysis. This paper focuses on the design and implementation of spatial analysis module.

Is the core technology of GIS spatial analysis and GIS is unique, the analysis of forest monitoring helps to the GIS decision makers and decision, for the current situation of ecological environment construction and the demand to provide accurate and reliable and the dynamic change of indicator and surface data, for the planning, statistical analysis, which provides the basis for evaluation and auxiliary decision-making, reduce the cost of research and management.
2. Module function analysis and design

2.1. The module objectives

The spatial analysis module designed for forestry ecological engineering monitoring system should lay more emphasis on spatial superposition analysis, buffer analysis, digital terrain analysis and so on, besides inherits the basic function of spatial analysis of common geographic information system.

This space analysis module is designed as a tool to solve the geographical space problems. Using this module to solve the spatial problems, we should first spatialize and model the problems, and then solve the problems to make decision analysis.

2.2. Module Functions

Spatial Overlay Analysis: When the data files of concentrated polygon elements in the same area and the same scale are overlaid, the statistical analysis of attributes of polygon or polygon range with various attributes is produced. For example, by superimposing a soil map on a forest map, the soil type of each forest area can be determined and the area of a certain type of soil can be counted.

Digital terrain analysis: a digital representation of changes in the continuity of spatial relief. Its main contents include: contour line generation and analysis, topographic elements generation and analysis, sectional map analysis, three-dimensional display and calculation, etc.

Buffer analysis: Buffer analysis is to study point, line and surface entities based on GIS database and automatically establish buffer polygons within a certain range around them. There are three types of buffer: one is the buffer based on the point element, usually with a point as the center of a circle and a certain distance as the radius of the circle. The other is the buffer zone based on the line element, the polygon of the parallel strip with the line as the central axis and a certain distance from the central axis. Thirdly, based on the buffer of polygon, the new polygon can be generated by extending inward and outward for a certain distance. Buffer zone analysis is widely used in the analysis of returning farmland to forest and forest management. For example, the delimitation of natural forest reserves around rivers and lakes, the demarcation of the core areas and buffer zones of nature reserves, etc.[3]

Spatial statistical analysis: due to the original nature of the data stored by GIS, users can extract and analyze the data according to different purposes to obtain the required information. Spatial variables in the same or different research areas are compared and corrected, and new features of GIS data, such as spatial model, spatial generalization, spatial association, spatial clustering and classification, are explored and developed.

2.3. The functional structure of the module

![Figure 1. Figure with The functional structure of the module](image)

2.4. Technical route of module development
This system adopts object-oriented component development, using ESRI company's functional component Arc Object (AO) as the development platform, using Visual Basic programming environment, directly embedded GIS functions to achieve the various functions of GIS, while using ADO to achieve the program and the underlying database communication.

It should be noted that AO is not an independent application product, but a software development kit attached to ArcGIS Desktop product. ArcGIS Engine includes a development kit for building custom applications. ArcGIS Engine embeds GIS functions in applications by adding controls, tools, menu bars and object libraries to the development environment. For example, a programmer could build an application that includes an ArcMap thematic map, some mapping tools from the ArcGIS Engine, and other custom features. ArcGIS Engine development package includes three key parts: controls, toolbars and tools, object library.

Controls are an integral part of the ArcGIS user interface that you can embed and use in your applications.

A toolbar is a collection of GIS tools used in applications to interact with map and geographic information.

The object library is a collection of programmable ArcObjects components, including a range of libraries from geometry to mapping, GIS data sources, and Geodatabase. Using these libraries on Windows, UNIX, and Linux platforms, programmers can develop a wide range of customized applications, from low-level to advanced.

3. The realization of spatial analysis function

3.1. The realization of spatial superposition analysis
The data and files of two or more groups of polygons in the same area and the same scale are superimposed through the superposition analysis, and polygons with multiple attributes are established according to the intersection points of the boundary of the two groups of polygons or the statistical analysis of the attribute characteristics of the range of multilateral rows is carried out. For example, the land use status map of afforestation demonstration area and afforestation planning and design map are analyzed by three-dimensional superposition, so as to more intuitively understand the changes of afforestation small class attributes before and after afforestation, and the changes of land types before and after afforestation.

Engine provides you with a powerful object library. In terms of spatial overlap analysis, Engine provides IBasicGeoProcessor interface, which includes CLIP, DISOLVE, MERGE, UNION, INTERSECT and other members.

For example, the realization of the function of dissolve. According to the basic concept of dissolve, we know that the operation of dissolve is to merge the adjacent polygons with the same value of the fusion field and eliminate the common boundary. Before undergoing fusion operation should be specified by the user to merge fields, we adopt the way of choice, namely the user on a specified data layer integration analysis, the data layer of all property fields are reflected in the design of the combobox, users can according to need in combobox drop-down list, select the required property field into blue, then the system will according to user selection for IBasicGeoprocessor. Disolve operation, to achieve fusion (dissolve) function. Figure 1 shows the comparison before and after fusion. In this operation I have selected the fusion field as SUB_REGION.

Users can achieve the objective simplification of complex polygons by integrating a certain attribute field of a certain data layer, so as to make corresponding decision and analysis. As shown in the image above, the fusion field is SUB_REGION and according to the fused layer we can see that the data layer has changed from more than 500 polygons to more than 10 polygons. Each polygon is combined from the polygons that have a common attribute under the common SUB_REGION attribute field.

The implementation of functions such as CLIP, MERGE, UNION and INTERSECT are also in the same interface as DISOLVE, and the interface should be as simple and clear as possible during the
design to make it clear to users.

3.2. The implementation of buffer analysis function
The iToLogicalOperator interface provides buffer function in ArcGIS Engine. The system design idea is that when the user selects a certain point, line or plane entity in the layer and highlights it, the user specifies the buffer radius and the buffer style (to establish a buffer in, to establish a buffer out or to establish a buffer in both directions), and finally realizes the function of generating a buffer through itoLogicalOperator.Buffer.

Buffer analysis is widely used in ecological monitoring system. For example, in forestry planning, the cutting area of the forest needs to be planned according to a certain depth from the river to prevent soil erosion; In the evaluation of wildlife protection, the range of activities of many animals is always limited to a certain range of habitat (rivers, caves, nests). In each of these cases, you need to create a buffer of some range along these points, lines, and surfaces. Buffers are new polygons that do not contain origin, line, or plane elements.[3]

3.3. The realization of digital terrain analysis function
This function includes spatial interpolation analysis, slope and slope aspect analysis, topographic slope analysis, 3D topographic display and analysis, watershed analysis, etc. Engine provides DTM analysis module -- GRID model analysis and TIN model analysis. The Grid model analysis function can be used to complete the local "Grid three-dimensional map rendering" of the forest area, which can visually display the terrain and landform of the demonstration area. On this basis, the registration and superposition of topography and afforestation types can be realized to reflect the spatial distribution of forestland after afforestation. In addition, the TIN model analysis can be used to complete the local "slope analysis map" of the forest area, and superimposed with the afforestation class. The slope distribution of each afforestation class can be seen, providing information for tree species selection, afforestation construction and other work.

4. Conclusion
Through the design of the spatial analysis module of forestry ecological engineering monitoring system. This paper has realized the transformation of complex and original information into graphical spatial information. And also it enhances the objectivity and correctness of analysis and decision making, and it provides a better basis for decision making and management of forest resources management.

Acknowledgments
This paper is one of the stage research results of the Center for Web Front-end Development and Research of Yunnan Open University.

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