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The System of Simulation of Forest Fire Spread and Assistant Decision-making Based on ArcGIS

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***Abstract*—The system realized the simulation of the forest fire spread and visualization of the three-dimensional images using the C# as the development language and ArcGIS as the development platform. It provided the simulation of the forest fire spread on the two-dimensional map and the displaying the real-time images transmitted by the GPS from the scene around the fire on the three-dimensional map in the same interface, combining the extension module-PixPoint costumed by the ESRI Company, which provided the reference for the decision-maker to fight fire.**

Keywords-ArcGIS, forest fire, spread simulation, assistant decision-making

I. INTRODUCTION

At present, the simulation and information management of the forest resources is increasingly being attached great importance in the countries with developed forest resources, such as Canada, the United States, Russia and so on.

The research about this field relatively started late in our country, especially in the field of two-dimensional simulation of forest fire and three-dimensional visualization. The existing three-dimensional simulation of forest fire is still at the exploratory stage. Beijing Forestry University simulated the spread of forest fire based on cellular automaton model of three-dimensional, which is different from the two-dimensional cellular in visualization [1]. Due to be extended to 3D space, the need of reflecting parameters' changes in the vertical direction, the division of cellular is complex. In the process of simulation running, it occupants too much space in the resources of memory, running slowly, so the effect of showing is not very good. On the other hand, Using OPENGL or VEGA renders to simulate forest fire in the area of computer images and graphics, the effects in three-dimensional display relatively are lifelike, but there is no real significance [2]. Simulation result is expected to help decision-makers to rescue rather than just be used in the performance of visual effects.

This paper discusses the visualization of the geospatial datasets on the basis of the simulation of forest fire spread on the two-dimensional map. The model selection and the study of fire spread about the simulation of forest fire on the two-dimensional map are almost mature. According to the location of the fire on the two-dimensional map, we should display the imagery of the corresponding region on the three-dimensional map.

II. DEVELOPER BASED ON ARCGIS

A. Selection of the Development Language.

The system selected the C# as the development language, C# is a simple, modern, object-oriented programming language, which deprived the C and C++ and in which Microsoft solved many issues which exited in the C++ for long time, for example, memory management and pointer. It supports garbage collection [3].

B. Selection of the Development Platform.

The system selected the ArcGIS as the development platform. ArcGIS is the one of widely used software in the World which was developed by the Environmental System Research Institute (ESRI) of the US. ArcGIS 9 increased the extension function, which represents mainly in the three-dimensional symbols, simulation of three-dimensional animation and spatial processing function of the three-dimension [4].

C. The development Way of the System.

ArcGIS Engine is a simple, application-neutral programming environment using ArcObjects, which are the building blocks of the ArcGIS software from ESRI. It offers the visual components that allow for rendering, interaction, and analysis with the underlying data, using three core mapping controls: MapControl, PageLayoutControl, and SceneControl. Developers can build customized GIS applications using simple interfaces to access the functions provided by ArcGIS. Embedding two-dimensional and three-dimensional controls into the same customized interface, at the same time, embedding the .NET windows control into edit and control the two maps simultaneously. The functions of the menu are implemented throughout the programming. For example the toolbar can contain navigational command that allow the user to zoom in, zoom out, or pan the map.

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Ⅲ. THE LOGICAL STRUCTURE OF THE SYSTEM

The system is mainly included three parts: the monitoring system of the forest-fire, the database system of information management of the forest fire and the decision-making system of management of the forest fire-proofing. The monitoring system of the forest-fire provides the quick locating, simulation of forest fire spread on the two-dimensional map and display function of the real-time images returned from the field on the three-dimensional map. The database system of information management of the forest fire improved the attribute data, spatial data and the pictures and images from the field .The two other systems read data from here. The decision-making system of management of the forest fire-proofing provides reference for emergency rescue and statistics of the population and area affected by the fire according to the simulation of forest fire spread and the real-time images transmitted from the field. The system logical structure is shown as follow in Fig.1.

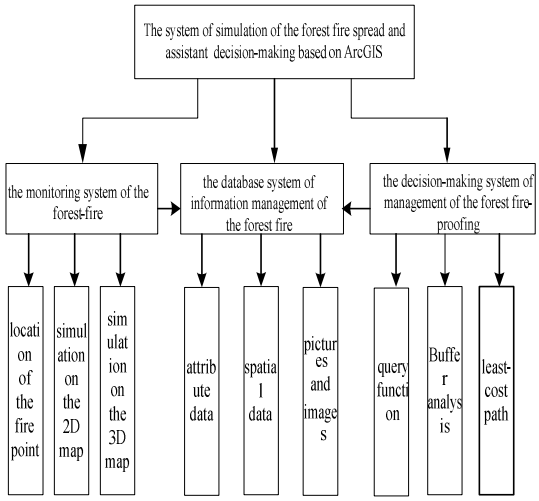

Figure 1. System logical structure

A. Support of the Database

The system adopts the newest database technology based on Geodatabase + ArcSDE, combining the two-dimension and the three-dimension scene of forest fire [5].

The contents of the database include attribute data, spatial data and picture and image data. Attribute data provides the properties information which scene required for the system, such as table related forest, includes name, address, latitude and longitude, area of the region, type of the vegetation, type of the trees and other information. It also includes the base information table related forest fire, such as time when forest fire occurred, address, latitude and longitude, fire risk level, wind speed and wind direction and so on. The spatial database provided spatial data for the system, points on the map represent regions and residents, lines are representative of administrative boundaries and the country region. After the fire, according to these data, we can know about the geographical environments and rescue teams, water resources, roads and rescue supplies around the forest fire. We can view these scenes from the pictures and images which took place before the fire, during the fire and after the fire, which contribute the decision-maker to rescue.

B. The Thought of Simulation of Forest Fire Spread

- The simulation of forest fire spread on the 2D map. The article introduces a cellular automata model to simulate the forest fire and predict its development trend on the two dimensional map. As the cell space is consistent with the grid space in the GIS and the CA model owns discreteness feature itself, the simulation system was easily realized using the C# and ArcGIS as the development tools. According to the resolution requirement, we set a group of square grid with the edge length of L focused on the area we studied, then chose a scientific CA rule with a series of influencing factors, for example the topographical factors such as slope, slope direction, forest categories and meteorological factors such as wind direction, wind strength, air temperatures and so on [6].

$$C_{i,j}^{t+1} = sC_{i,j}^{t} + (uG_{i-1,j}C_{i-1,j}^{t} + dG_{i+1,j}C_{i+1,j}^{t} + lG_{i,j-1}C_{i,j-1}^{t} + rG_{i,j+1}C_{i,j+1}^{t}) + 0.7(uG_{i-1,j-1}C_{i-1,j-1}^{t} + nG_{i-1,j+1}C_{i-1,j+1}^{t} + dG_{i+1,j-1}C_{i+1,j-1}^{t} + nG_{i+1,j+1}C_{i+1,j+1}^{t}) \quad (1)$$

In the formula above, the indexes in front of the each cell state, which will be read from the database, are stand for the weights of the influencing factors. When the fire happens, the system will annotate and flash the fire-position on the map. Before simulating, we divide the cell space into some cells and each cell has its own state, while the cell state at time t+1 is decided by the state itself and the eight adjacent cells at time t [7]. During the design, we define the influencing factors weights as variables and realize reading value from the database. The value of the influencing factors weights will update from time to time as the updating database, and realize the forest fire real-time simulation.

- The display of scene of forest fire on the 3D map. On the two-dimensional map, we can set a reasonable time period in which forest fire spread after the location of the fire point was determined. At the same time, make-decision can view the dynamic images which shoot throughout the camera around the forest fire in the three-dimensional map. The system developed the interface using the C# in the end, which contained

four parts: layout control window, two-dimensional display window, three dimensional display window and toolbar for operating the base function. User Interface is shown as the Fig.2.

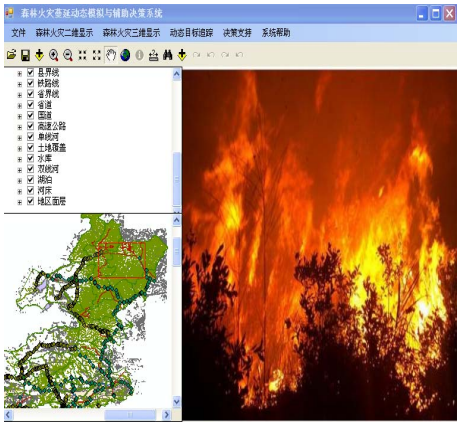

Figure 2. System interface

The system interface mainly includes four sections: layer control window, the map Eagle Eye, map window and basic function toolbar for operating the graphics by which users can perform typical visualization operations (zoom, rotation, and pan), layer control, query and other functions. Users can see a red rectangular box in the Eagle Eye view which tracks the display scope of the main view when moving the mouse in the window. The contents of the display are the real-time images related with fire from the scene. Function of the interface is mainly in simulation of forest fire spread on a certain area and dynamic visualization of GIS dataset about the forest fire. We can make the buffer analysis based the reasonable radius input according the location of the fire point and display the burned and unburned pictures and dynamic images around the area when simulation of forest fire spread based CA on the two-dimensional map.

- Data import of the three-dimensional real-time scene. Image import of the three-dimensional real-time scene using professional extensional tool module –PixPoint, customized for ArcGIS by the ESRI, PixPoint is a powerful collection of the digital image and management system., which storages automatically and management digital pictures and images with the geographical coordinates[8]. In the field of the fire, we can shoot the pictures and images throughout the cameras installed in the forest and ordinary digital camera, while using the GPS receiver or handset GPS to record the location data. We can shoot the scenes after the GPS receiver starts to record the track and the data shoot imports to the PixPoint model. Linking the every image with its location synchronously and increasing geographical coordinates for each image. Pixpoint inserts the GPS information to the original data of the images and incorporate the images to the geographical information database, while displaying on the three-dimensional window.

C. Decision-making System of Management in Forest –Fireproofing

The function of buffer analysis is mainly in the creating automatically buffer within a certain range around the fire point according the reasonable radius input by the decision-maker. We can make statistical analysis in the buffer and statistic the rescue site, road, distribution of the rivers to search for the best site. Similarly, we can circle the secondary disaster area affected by the forest fire and eliminate these hidden trouble. The best route analysis is mainly in the calculating the path by which all fire-fighting group and the supplies get to the fire area and the time crews demand, providing best fire fighting plans to the decision-maker and determine the final optimized program. The decision-maker assigns the fire-fighting group close to the fire or supplies to the fire field, saving the time and avoiding greater losses. The function of the measurement is mainly in the calculation the spatial distance between any two points, as well as the calculation of the fired area.

Ⅳ. CONCLUSION

The system implemented the real-simulation of the forest fire spread in the studied area combining the two-dimensional map and three-dimensional map, and combining the computer simulation and dynamic visualization of GIS dataset from the field, providing the reference for the decision-maker engages in the management of the forest fire. The decision-maker can view the spread display of the forest fire in the two-dimensional map, at the same time, calling and analysis the pictures and images in the fire field. The decision-maker makes decision-making according the villages, roads and dangerous sources and other buildings in the images around the fire.

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