FUNCTIONS FOR A MULTIMEDIA GIS

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ABSTRACT

Geographical information systems (GIS) include a number of standard functions that allow one to perform spatial queries and operations. New technologies and methodologies suggest new functions bringing the time dimension and providing more realistic representations for spatial objects. Such technological and methodological developments include: the manipulation of digital video and sound offered by digital multimedia technologies; and the use of pictures in addition to numbers in multidimensional simulation. The creation of GIS functions allowing for multimedia simulation capabilities is proposed in this paper. These functions are based on extensions of common cellular automata rules and video and audio operations. A preliminary implementation of such functions was achieved using a simple hypermedia system. This system emulates a multimedia GIS. To illustrate the use of the proposed functions a fire propagation model was developed.

INTRODUCTION

Geographical information systems (GIS) include a number of functions that allow one to perform spatial queries and operations. New technologies and approaches suggest the development of new functions taking into account the dynamic nature of spatial objects and providing more realistic views of spatial phenomena.

Those technological and methodological developments include: digital interactive multimedia technologies offering the manipulation of digital video and sound; and multidimensional modelling considering pictorial entities and operations.

New GIS functions based on these developments are suggested herein. They were designed to enable the manipulation of images (understood as sets of pictorial entities), video and sound. These multimedia functions could complement the more traditional GIS operations in a multimedia GIS.

A prototype of such a multimedia GIS, including only the image and sound components, was implemented following an object oriented view in the form of a hypermedia document. An application to the modelling of forest fire propagation illustrates the use of the proposed functions.

FOUNDATIONS FOR A MULTIMEDIA GIS

Multimedia Technologies and GIS

The use of interactive digital multimedia technologies have the potential to offer more realistic representations of spatial objects and bring the time dimension to GIS. What is multimedia computing? Interactive digital multimedia computing is the operation of computers that can simultaneously incorporate full motion video, graphics, sound, and eventually tastes, smells and textures. During this operation, the user can not only view, but can interact with and manipulate all parts of the system in real time (Fox, 1991).

Multimedia documents are typically based on large streams of data and have a non-linear structure. The large streams of data result from the adding of video and audio and can only be handled through compression and decompression mechanisms. The non-linear structure comes from the typical representation of a multimedia document as a graph where each node contains information (text, images, video or sound). The nodes are connected by links, which help the user to move from one node to another. This is the classical structure associated to hypertext (Nielsen, 1990).

There are two important types of standards for digital multimedia (Fox, 1991): low-level coding or compression standards for data streams and hardware processing; and higher level standards for network and software operation. For the conceptual design of a multimedia GIS, the higher level standards are more relevant. These include the MHEG and the HyTime standards (Markey, 1991). MHEG provides an object-oriented view of how interactive digital multimedia systems operate. HyTime standardizes all details regarding document structure, hypermedia synchronization and timing (Fox, 1991).

A multimedia GIS may be then designed as an object-oriented data base, connected to a HyTime engine that uses the MHEG specified objects. This system will include the typical GIS functions (retrieval, classification, measurement, overlay, neighborhood and connectivity operations) as well as functions designed to operate with multimedia objects such as images, video and audio objects.

Proposed Functions for a Multimedia GIS

The proposed functions for a multimedia GIS were designed to facilitate the use of a GIS for dynamic spatial simulations and the realistic observation of spatial objects and phenomena.

In such a GIS, spatial objects may be seen as pictorial entities (pictographs, signs or symbols) described by their color, position, size and shape. These pictorial variables may be numerically decoded or not.

Following earlier work by Camara et al., 1990, it is possible to define a set of dynamic functions that enable the spatial simulation of such objects based on extensions of cellular automata principles. These functions establish the behaviour of each object and the interaction rules between each pair of objects.

Four types of behaviour may be considered: movement, expansion, retraction and decay. Features of any of these types of behaviour include the definition of the movement, expansion, retraction or decay's direction and probability of occurrence.

Interaction rules consist of: neutralization, where both objects are eliminated; reproduction, where a third object can be created; transformation, where the two objects are replaced by another object defined at the user's will; no contact, where the two objects meet but immediately return to their initial positions; no change, where the two objects meet but nothing happens; and assimilation, where the two objects are replaced by two other objects defined by the user. These rules may be defined as a set of deterministic or stochastic functions in a GIS.

Simulations of spatial phenomena using these functions may be stored in digital video format using compression if needed. This synthetic video may be then manipulated using typical video operations (i.e., transitions, zooming in and out, special effects) and may be combined with natural video. These operations may also be translated into another set of multimedia GIS functions. A third set of functions is related to the use of audio through the activation of background stereo sound, sound icons and even music to create movement and illustrate point scenes.

Table 1 provides a systematic view of the proposed three sets of multimedia functions for a GIS.

Table 1
Multimedia functions for a GIS

Images	Video	Sound
• Movement • Expansion • Retraction • Decay • Neutralization • Reproduction • Transformation • No change • Alteration	• Transitions • Zoomings • Special effects	•Activation of background stereo sound • Illustration of point scenes

APPLICATION
A prototype that applies the concepts described above was developed using both an objected-oriented orientation and an overall hypermedia coordination. Implemented on Hypercard, to includes two modules: the geographical module and the pictorial module.

Both modules are based on a main screen (Fig. 1) that contains two types of areas: the simulation area and the operational area. The simulation area occupies most of the screen. Several different layers of information such as an aerial photography, a land use map, an elevation map, or a grid with pictorial objects can be displayed in this area. The operational area has several icons that can be activated or selected to perform operations related with the layer currently shown.

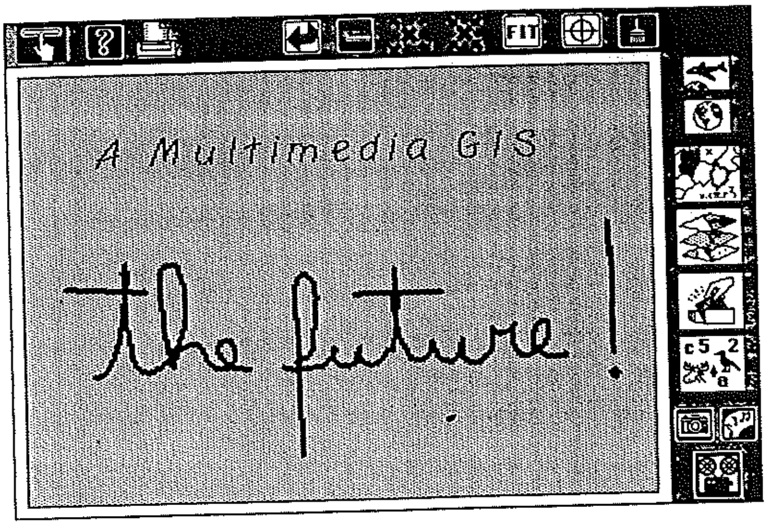

Fig.1. Main screen for a Multimedia GIS

The geographical module
The geographical module includes most of the functionalities of a traditional GIS added with some new functions. It contains different layers of information corresponding maps (fig. 2), and/or aerial photographs (Fig. 3).

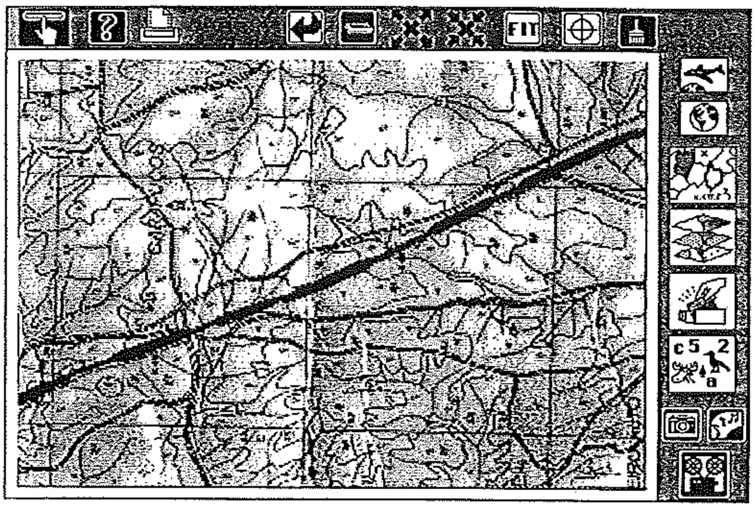

Fig. 2. Map layer

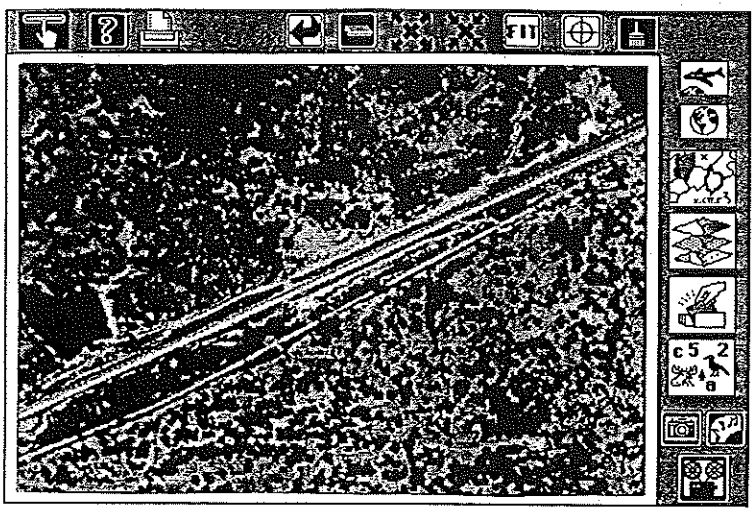

Fig. 3. Aerial photograph layer

GIS operations like zooming or editing graphic files can be done over those layers of geographic information. It is possible to perform graphical and attribute searches These searches can also include the visualization of ground photographs characterizing the selected elements or areas existing on the geographical layer. The possibility of associating sound in the system is also explored. A "database of sounds" was created providing the user with the possibility to have sounds corresponding to the objects selected on the layer loaded on the screen.

The geographical module has acess a pictorial module where the simulation of spatial phenomena uses the multimedia functions described above.

The pictorial simulation module

The pictorial simulation module is responsible for the simulation process. The layer of this module is a grid with pictorial objects defined by the user and representing the simulation problem (Fig. 4). These objects, previously drawn and present in the operational area are selected based on background layers.

In the example of a forest fire model, icons representing two different tree species (pinus and oaks) were imposed over the areas where these forestal occupation existed (confront Figs. 3 and 4). Also, an icon representing water was imposed over a river area. An icon representing the fire and two icons (one for each specie) representing the burned forest were also defined (Fig. 4).

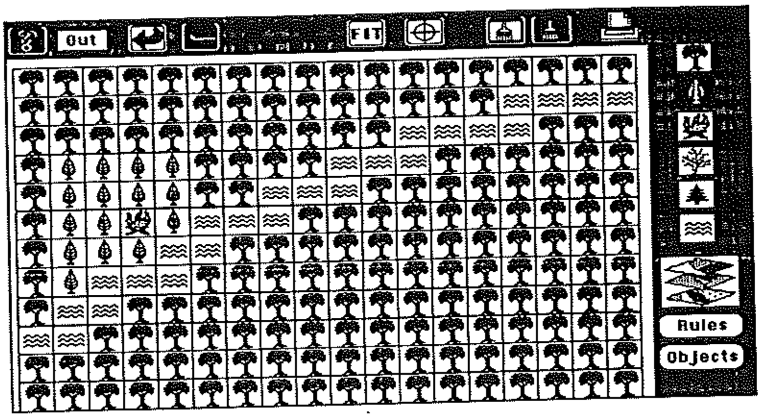

Fig. 4. Object layer

Using a layer with a topographical map (Fig. 2), a grid layer with the surface elevations was created with the appropriate elevations for each grid rectangule. After defining these two layers (the object's layer and the elevation's layer based on Fig. 2), the behaviour of each object (Table 2) and the rules (Table 3) to be applied when any two objects interact were described.

Table 2
Behaviour of objects for the forest fire model

Objects	Behaviour	
Oaks	-------------	
Pinus	-------------	
Fire	Expansion	
	Over oaks background	
	To higher elevation	
	Prob. N: 0.1	Prob. NW: 0.25
	Prob. NE:0.02	Other directions: 0.0
	To same elevation	
	Prob. N: 0.2	Prob. NW: 0.3
	Prob. NE:0.05	Other directions: 0.0
	To lower elevation	
	Prob. N: 0.3	Prob. NW: 0.4
	Prob. NE:0.1	Other directions: 0.0
	Over pinus background	
	To higher elevation	
	Prob. N: 0.3	Prob. NW: 0.45
	Prob. NE:0.1	Other directions: 0.0
	To same elevation	
	Prob. N: 0.4	Prob. NW: 0.35
	Prob. NE:0.1	Other directions: 0.0
	To lower elevation	
	Prob. N: 0.35	Prob. NW: 0.5
	Prob. NE:0.15	Other directions: 0.0
Burned oaks	-------------	
Burned pinus	-------------	
River	-------------	

Table 3

Rules for interacting objects in the forest fire model

Relations	Rules
	Transformation
	Transformation
	No change
Other interactions	No change

The propagation of a forest fire depends on two types of factors: internal and external (Ferreira and Silva, 1987). The internal factors are: the composition of the forest material, which causes its combustibility; the forest specie, which affects its flammability; and the overall development of the forest population, which determines the amount of combustible existent material. The external factors are meteorological and environmental factors that determine the flammability of the propagation of a forest fire.

In this example, a fire starts in a pinus area and propagates through a pinus and oak's area. The wind direction and speed are translated into probabilities that affect the behaviour of the object "fire". It was considered a predominant N-NW direction for the wind.

The different layers (map, aerial photograph) are constantly updated through the simulation process with the information from the pictorial layer. Therefore, the user can select any layer during the simulation run and visualize the effects of the fire propagation in the landscape. The new scenario resulting from simulation can be presented using animation and sounds activated using the "sound data base".

SUMMARY AND CONCLUSIONS

Multimedia technologies will enable GIS to afford the time dimension and more realistic representations of spatial objects and phenomena. The foundations for a multimedia GIS based on object oriented data bases, hypermedia coordination and multimedia functions including image, video and sound manipulation are proposed herein. A prototype developed on Hypercard running a multimedia fire simulation model illustrates the potential applications of such a GIS.

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