THE HYPERMEDIA DATA MODEL BASED ON THE INFINITY IMAGE

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KEY WORDS  hypermedia data model; nodes; links; navigation; infinity RS image

ABSTRACT  This paper presents the hypermedia data model based on the infinity RS image information system we have developed. The hypermedia data model consists of different semantic units called nodes, and the associations between nodes are called links. This paper proposes three kinds of nodes (interior node, physical node and complex node) and two kinds of links (plane network structure link, hyper-cube network structure links). The hypermedia information system, based on the model and the basic data layer (the infinity RS image), represents a digital globe. An approach to the "Getting Lost in the Hyper-space" problem is presented. The approach using the hypermedia data model is an efficient way of handling a large number of RS images in various geographical information systems.

1 Introduction

The increasing usage of multimedia objects, such as RS images, scanned photographs, video recordings, texts and voice information, demands an efficient method to organize enormous information (Taylor, 1996). In two years, the satellite remote sensing industry will provide geographic information system (GIS) users with a significant new tool to create base-map and update their GIS databases with detailed information. This tool will be more and more useful when the satellite imagery with 1 m spatial resolution is used (Kevin, 1996).

Hypermedia technique is frequently used to deal with different media, and to organize the diverse and innumerable data in computers with very limited CPU speed and memory. The technique has been demonstrated to be an efficient way for processing a large amount of RS image data.

In this paper we present the hypermedia data model, which is based on RS image in GIS. Using the model concept, we can handle a large amount of RS image data efficiently with very limited computing power. We have developed the model with three kinds of nodes: interior node, physical node and complex node to organize the infinity image.

2 Image information

It is said that "Rapid updating is key to build a GIS". Satellites can acquire images from large areas in a matter of seconds and return within days to collect more images. More and more data need to be managed. But how can we organize the data efficiently? With the increase of resolution, the volume of an image becomes larger. We must work out a new approach to solve the problem.

2.1 Image interior nodes

In an information system, semantic units called nodes and associations between nodes referred to as links organize hypermedia (Berk and Davlin, 1990). The size of node must be small (Wang Pu, 1996). Satellites provide huge amounts of geographic data in the form of images, which will take up a very large file memory on a map unit basis. So
the map's file must be divided into many small blocks, which are named as image interior node (or hidden node), and association between blocks referred to as interior links. It is better to display a node in more than one page of screen and less than two pages of screen (Wang Pu, 1996). The form is as follows

$$S_s < N_i < 2 \times S_s$$  \hspace{1cm} (1)

where $S_s$ is the size of a screen; $N_i$ is the size of an interior node.

2.1.1 The data model of image interior nodes

The separating technique is used in the management of interior-nodes. A new file data structure is adopted. It only brings an increasing number of logical nodes, but the number of physical nodes will not increase. This is a very important technique. The change of data structure is as follows:

![Image Data Structure](image.png)

The physical nodes mentioned above represent RS image files, which are referred to the file unit. Using interior node structure has changed the original image data structure. This kind of data model makes the size of physical file not relate to the memory. It is available to establish an ultra-large RS image library.

2.1.2 Interior node’s link model

The relationship among interior nodes can be established by interior links. It will let you navigate arbitrarily. The structure is designed as the plane network structure model. Fig. 2 shows interior-nodes and their links. Each node connects with eight neighboring nodes and is accompanied by eight links. All of the links are in double directions, which will ensure travel in all directions.

In Fig. 2, the rectangle block represents an interior node whose size is determined by the user. It is better to ensure that one node can be shown in one screen and no more than two screens. The links among nodes are double-direction links. The nodes and links constitute a plane network structure model. In a certain system, this kind of structure is relatively simple and fixed. The number of nodes, which is only decided by the size of a physical file and the approach of split can not be added. This structure allows user to roam everywhere on the map continuously and smoothly in a special order, but it does not allow the user to jump from a node to another non-neighboring one. For example, in Fig. 2, the user can not jump from node 13 to node 42 directly. This is just like the navigation in the virtual terrain, but the difference is that the user need not choose the road, as the user is allowed to travel at either accelerated speed or slow speed in this hypermedia system.

![Interior Nodes and Links](image2.png)

2.1.3 Dynamic dispatching technique among interior nodes

In hypermedia information system, a large number of documents can be handled. In fact, we need to work on partial documents, because the screen does not show the whole document at one time, but a part of it. According to formula (1), we know that it might even happen that we need to work on 4 interior nodes at the same time. The principle of dynamic memory dispatching is used. First, we establish a topology relationship of the neighboring nodes and encode them along matrix order (see Fig. 3). Then we must forecast the number of the following nodes. Those nodes are calculated in terms of node numbers and the current direction of the node movement (see also Fig. 3 and Fig. 4). The algorithm can ensure that no more than four interior nodes are being active, i.e., at most there are four nodes being shown on the screen at the same time.

In Fig. 3, each little block represents an interior node. The lines represent the relationship of interior
nodes, which are named interior links. In Fig. 4, the shadow means a screen area. The number of active nodes will be changed from one to four when we navigate from area A to area B. The processing is dynamic, which enable us to get a seamless image easily.

The special file data structure decides a special control among the files. Thus this model has an advantage that the processing is not limited by the memory size. That is to say, no matter how large the image files are, we can also navigate everywhere continuously and smoothly.

2.2 Image physical nodes

A basic physical unit in hypermedia data structure is called image physical node.

2.2.1 The relationship between physical nodes and interior nodes

A physical node is combined with a set of interior nodes. The relationship can be described as follows

\[ C, a = \{n, r\} \]  

where \( C, a \) is a physical node; \( n \) interior nodes; and \( r \) the links among interior-nodes.

2.2.2 The link model of physical node

The link model is the same as the interior model, but the shape and the map projection must be corrected. In Fig. 5, a block represents a physical file, which is called a physical node (for example f22). From Fig. 5 and Fig. 6, we find that there are some differences between physical nodes and interior nodes. The physical node has the following attributes:

1) Each size of the RS image can be different. That is to say, the size of the physical node is uncertain.

2) In the coding matrix, a lack of the node is allowed.

3) Adding and deleting nodes is allowed.

4) Adding and deleting links is allowed.

For example, in Fig. 6, f24 is a new node; there are five nodes around it, so we must add five links when we add the physical node f24.

2.2.3 Seamless RS image library

It is very important to establish a seamless RS image library, which can make the virtual terrain visible on the screen. As shown in Fig. 7, if there are four active physical nodes at the same time, it is easy to realize the seamless geographic database. The dynamic dispatching principle is the same as what we used in the interior nodes.

2.3 Image complex nodes

The dynamic dispatching principle used for physical nodes is similar to that for interior nodes. All of the physical nodes can be completely connected. Sets of physical nodes constitute a huge complex node.
Supposing the physical node is a part of the earth, a complex node will represent the whole earth. We want to roam in the globe along each direction. We will go anywhere we expect to. We hope that it is entirely suitable for us to travel on the screen like in the virtual terrain. Interior nodes, physical nodes, complex nodes and their links can completely demonstrate a virtual world on the screen, but sometimes in order to get detailed or sketch information, we must establish maps of different scales (or images of different resolutions). The pyramid structure seems to be effective for storing and organizing images for such usage. A traditional example for image organization is presented in Fig. 8.

The basic assumption is that an image space of city area is delimited by a rectangle. From Fig. 8 we obtain:

1) Maps (images) with the smallest scales (or resolution) form the base of the pyramid.
2) Each scale (resolution) corresponds to a pyramid level.
3) The maps (images) at the upper level include the maps (images) at the lower level.
4) Neighboring maps (images) at the same level are connected and form (structure of) a network links structure.

5) All the image levels will constitute a hypermedia RS image library.

In hypermedia information system, the complex node is a huge one, which is composed of a set of physical nodes. All the complex nodes are connected by hyper-cube network structure link. Such nodes and links are organized as a hypermedia data model. It is an information system, which is illustrated in Fig. 8. It is different from traditional pyramid map model, shown in Fig. 9.

In Fig. 9, if the number of complex nodes is n in the system, there are \( n - 1 \) pointers to point to the other nodes. In fact, the number of links increases with that of nodes

\[
L = \sum_{i=1}^{n} n = n^2 - n
\]

where \( L \) is the total number of links; \( i \) is the number of level.

Assume that there are \( N \) complex nodes in a system. If one node is added, then \( N \) links must be added at the same time. So the links will increase with nodes in square.

This kind of model is called hyper-cube network structure model. It has "thinking" and "jumping" functions. Links represent the relationship of spatial data. For example, if a system is composed of 7 nodes, the model is shown in Fig. 10.

It can be clearly found that if we want to arrive node 1 from node 6, there will be many paths to choose. We can do directly from node 6 to node 1, or we can navigate to node 3 first then to node 1, or we can navigate to node 4 first then to node 1, etc. Controlled by interior nodes, physical nodes and complex nodes, this model is entirely suitable for us to navigate on the computer screen just like in the nature.

Comparing Fig. 9 with Fig. 10, we name each lev-
el (or layer) data in Fig. 9 a huge complex node, and the number of complex nodes are equal to that of levels (or layers). It is unlimited in theory, but sometimes there is no need of more levels (or layers) in practice. Then we get the Fig. 10. The complex linking relationship constitutes a hypermedia data model. Thus we can suppose that the earth is represented by a large number of RS images, those data can be organized by the hypermedia data model and a form of digital earth can really be obtained.

![Fig. 10 Hyper-cube network link model](image)

3 Navigation

Hypermedia integrates diverse media in a very elegant and simple fashion. Each relation among information units (nodes) is implemented with pointers. This technique has some properties which need to be critically evaluated. The most well known effect is "Getting Lost in the Hyper-space". That is to say, while navigating such a map, the perspective and context can get lost. In order to solve the problem of "losing", we will give the following suggestion.

1) Add a small navigation view window named as navigator, which will make the position visible. If the navigation is among interior nodes or among physical nodes, this technique is applicable. The image located in the small view window is an abstract of the physical nodes.

2) The interior nodes and the physical nodes are connected with plane net links, which do not allow direct "jumping", but allow regular navigating. That is to say, we decide that the querying for position in interior is linear.

3) Make use of tools to help navigation. In order to support "jumping" among complex nodes, we can set up a set of layer scale status bars, toolboxes and icons. For example, in Fig. 10, if the current position is in node 6, and we want to come back to node 1, the best way is that we have a label of node 1, and then click it.

4) Content and spatial relations must be synchronized when we integrate diverse media. That is because the same data (object) are represented in two different ways (image or vector).

5) On the basis of graphic querying, technique itself is a very good method to control the problem of "losing", it ensure the querying and label visible. In fact, we had made use of above method to establish a city RS image library. It is very important to have a good navigation tool not only in thematic navigation but also in spatial navigation.

4 Conclusion

The use of 1 m resolution RS image representing a seamless terrain and establishing a visible city information system will result in vitality and information increasing highly. The hypermedia data model can be effectively used to manage RS image information.

We combined the logical structure with physical structure, and developed the hypermedia system to process RS image effectively. The system consists of interior nodes, physical nodes, complex nodes, plane network links, and hyper-cube network links. The advantage of the data model is that it can provide an efficient way for processing large quantity of image data within current hardware capacity. We think that in the near future hypermedia model will be widely used in spatial information system. Hopefully, the future spatial information systems will be based on the hypermedia concept.

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