STUDY ON GIS DATA DIRECTLY INTEGRATED INTO IMAGE PROCESSING

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ABSTRACT The basic properties to be dealt with, when considering initially the research needs related to the integration of remote sensing (RS) information into a geographic information system (GIS), are many-sided. The primary combination of remote sensing and GIS is mainly realized by the transforms of data structure. Because of its own limitations, there is an urgent need to investigate the integration of RS and GIS in higher levels. In this paper, we discuss the different types of combinations of RS with GIS, and propose that GIS data should be directly brought into image processing from the beginning. A tentative idea of how to use the method of granularity to study the common processing unit of RS and GIS is described. The example for the determination of granularity of spatial data processing related to run-length-code line is also given.

1 Introduction

The basic properties to be dealt with, when considering initially the research needs related to the integration of remote sensing (RS) information into a geographic information system (GIS), are many-sided: 1) the ability to simultaneously view image data and GIS vector information; 2) some common neighborhood operations that are applied to GIS/RS data sets; 3) a vertical analysis that allows the user to add numerical attributes of a number of independent GIS/RS variables into a resulting analysis variable; 4) direct input from digital cartographic databases, CAD systems, or photogrammetric data files.

For embodying the properties described above in a readily usable form, remote sensing and GIS data have to follow specified data structures. Raster and vector data structures are clearly two main members in the set of spatial data structures\(^{[1]}\). Raster format is simply to make data arranged as regularly spaced, equal-sized grids; vector data maintain the true shape of a polygon using a series of vertices connected by straight lines. In some applications raster format is more effective than vector one, whereas in other occasions vector format is more effective than raster one. Much work has been devoted to overcoming technical obstacles in joining raster and vector data structures, and it is a general idea that data would need to be converted between them.

The integration of remote sensing information into GIS occurs in the conversion from vector to raster or from raster to vector, it requires the low cost, but, unfortunately, there may be significant limitation because of much time, low efficiency and need for intimate knowledge of the data structures, and it is difficult to serve some functions needed for raster and vector data structures' occurring simultaneously.
For example, on a request for region growing\textsuperscript{[2]}, some conditions may be found

\begin{align}
\Delta Y &< \epsilon_1 \\
D / \min \{P_1, P_2\} &> \epsilon_2 \\
D / C &> \epsilon_3
\end{align}

which $P_1$ and $P_2$ are the perimeters of two adjacent regions $R_1$ and $R_2$; $C$ is the length of common boundary; $D$ is a part of $C$; $\Delta Y$ is the difference of the attributes in the areas separated by $D$; $\epsilon_1$, $\epsilon_2$ and $\epsilon_3$ are parameters. If formulas (1), (2) and (3) are satisfied, regions $R_1$ and $R_2$ may be merged (see Fig. 1).

Examining the several conditions described above, we can note that formula (1) should be applied in remote sensing image processing system, and formulas (2) and (3) require a GIS environment. With the growing of regions, it is inevitable that data would need to be converted between raster and vector formats. Today remote sensing system and GIS mainly deal with raster and vector data structures separately. As formulas (1), (2) and (3) are essentially applied synchronously, continued developments should lead to joint analysis of remote sensing and GIS data, and the developments capable of handling multiple data structures and supporting complex spatial analysis.

2 Integrating approaches of remote sensing and geographic information systems

It has been debated that which of raster and vector is the most effective, from the viewpoints of storage efficiency, processing efficiency, and ability to capture the essence of geographic space for an application. There may be no clear answer to this debate. It seems appropriate to note that the main difference between them relates to the degree to which the spatial entities of interest are explicit in the data.

In general, raster remote sensing image allows the investigator to measure and monitor surface electromagnetic wave variation in which most objects and the spatial interrelationships between them are implicit. In practice, there are many poorly understood tradeoffs in coupling remote sensing data to existing thematic maps. Maps use points and lines to represent selected features of the environment in a generalized fashion, but the objects such as individual polygons, lines and points within an image are typically unknown.

The integration of remote sensing information into a GIS occurs naturally in a raster GIS because both data structures are approximately the same. Integration into a vector system requires somewhat more effort, but it has been recently achieved by several GIS and remote sensing vendors. When one is storing a large amount of image data related to some applications into a spatial database system, it is not possible to process the data and to obtain polygonal representations of all objects that will be of interest to users in advance. On the other hand, it might be of great value in such a system to have a vector representation of certain important objects. For this application, one needs to design a system with both raster and vector capabilities, as well as tools to interrelate them. Especially, as in Fig. 1, we need to process both raster and vector simultaneously.

As described above, while a spatial information system may have several data structures, the system could be extended in several ways which correspond to the following different properties (see Fig. 2):

1) The structure information $R$, background information $C$ and result $A$ are derived mainly from remote sensing image;

2) The structure information $R^*$, background information $C^*$ and result $A^*$ are derived mainly from GIS data;

3) Existing GIS incorporates with remote sensing data, and it is inevitable that data would need to be
converted between raster and vector formats;

![Diagram](image)

**Fig. 2** Procedure associated with the remote sensing and GIS data analysis

4) The integration of remote sensing information into a GIS occurs in a raster GIS or GIS data directly merging into image processing;

5) Integration into a vector system, and GIS has used data generated directly from remote sensing in part;

6) There is no difference between remote sensing data and GIS data in a uniform system.

Now, we have come at least to the extent of carrying out the properties 3) by using vector to raster conversion or raster to vector conversion. The properties 4) and 5) are further request for us to improve integration of remote sensing and GIS. It is the eventual aim to realize the property 6).

3 Finding common processing unit of RS and GIS

The following basic actions must have been completed before common processing unit of RS and GIS can be created (see Fig. 3):

![Diagram](image)

**Fig. 3** Illustration of GIS data directly putting into image processing

1) Granularity Selection

The purpose of granularity selection is to make the operation on a given information agglomeration by adjusting the number of components so that they contain, reduce or increase the extent of detailed information and thus create a new relation. The eventual aim is to find some administrative levels of information spaces, which provide a common processing unit of RS and GIS.

2) Interrelationship analysis

When the data is aggregated from separated sources which are remote sensing image and GIS data, each application program must be rewritten to accommodate the new placement of structures. Then, clearly, there is a group of interrelations between remote sensing image and GIS data associated with the common processing unit which must be selected to meet the needs of the application programs.

3) Variables for the integrated processing of remote sensing image and GIS data

The intersection of remote sensing image and GIS data can contain information pertaining to the integrated processing of the indicated part from the common processing unit. To make it possible for a variable to be a member of several sets of remote sensing image and GIS data, conceive of a segment to link individuals of the same population together.

4) Execution module generation

Before the integration of remote sensing and GIS, there are two separate execution modules. For GIS data directly put into image processing it has to deal with a common execution module based on the granularity, interrelationship and variables mentioned above.

4 Example and conclusions

It is often necessary to restrict activity which an application program or user can perform while processing the spatial data. Restrictions in overall type of activity, from the most to the least restrictive, are:

- No details
- Give the details in part
- Give all the details

These restrictions can be used to find common processing unit of RS and GIS on the basis of granularity selection. Given one line, for example, some common processing unit for spatial data analysis can be extracted from it.
For each line, the start point, the length of the line are stored. A data structure called a tile graph can be created in terms of the run length encoding lines. An example that illustrates free space partitioned into tiles is given in Fig. 4. As shown in the figure, the free space is partitioned into five areas \( i, j, k, m, n \) by two run length encoding lines \( l_1 \) and \( l_2 \) parallel to the X axis. Splitting of the background occurs at those points that, with respect to the Y axis, are local maximum and minimum vertices of obstacles. "split points" are points where one tile splits into two or, alternatively, where two tiles join to become one.

![Fig. 4 Example of run length encoding lines and tiles](image)

Let us examine how a split point might be obtained from the integration of remote sensing and GIS. The first action is to determine what is the common processing unit of RS and GIS corresponding to some granularity. In fact, in our opinion, for the run length encoding lines mentioned above to be useful, which can be handled more efficiently with simple processing, they should be appropriate.

It must be made clear whether structures in the split points search are directed to the processing or are to be converted into either remote sensing manner or GIS manner. The procedure used to manipulate data is directed to the structures, which is extended from raster structure (see Fig. 5 (c)).

We call the structure as hyper-raster structure. It appears in Fig. 5 (a) as a raster structure, and in Fig. 5 (b) as a vector structure. They are combined into a hyper-raster structure in Fig. 5 (c). The numbers in Fig. 5 (c) reflect the data from remote sensing, and the asterisks reflect the data from GIS.

![Fig. 5 Illustration of integration of remote sensing and GIS](image)

Three kinds of works may occur in the data processing: 1) image data analysis, which deals with the numbers in Fig. 5 (c); 2) GIS data analysis, which deals with the asterisks in Fig. 5 (c); 3) data analysis using integrated GIS and remote sensing data. To find the split points we may use all the processing described above. Therefore, on the granularity related to the run length encoding lines and tiles, we may embody the integration of remote sensing and GIS.

References

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