SYSTEMS FOR THE INTEGRATION OF REMOTE SENSING AND GIS

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ABSTRACT:

The National Center for Geographic Information and Analysis, a consortium of the University of California at Santa Barbara, State University of New York at Buffalo, and University of Maine, has identified a number of key impediments to the effective use of geographic information and analysis. One of these impediments is the effective integration of remote sensing and geographic information systems. A number of authors have discussed both philosophical and practical reasons for the coupling of these two related areas, and efforts at NCGIA have resulted in a prioritized research agenda.

Available means to integrate remote sensing and GIS can be classified into at least three levels of systems integration, with different demands on both the system developers as well as the hardware components and the users. While there are clear benefits, in our view, of the highest level of system integration, these come with several kinds of associated costs.

KEY WORDS: Geographic Information Systems, Remote Sensing, Systems Integration

1. INTRODUCTION

The National Center for Geographic Information and Analysis was established in November 1988 as a five year effort to reduce key impediments to the use of geographic information and analysis, and augment the nation's supply of researchers and practitioners in participating disciplines (Goodchild, 1989). Research is organized around a series of initiatives which run for two or three years; the integration of remote sensing and geographic information systems was recognized as an important initiative from the Center's inception. The initiatives generally progress through a series of planning activities and workshops, through the presentation of research results at appropriate professional conferences (Estes and Star, 1991).

The remote sensing and GIS integration initiative identified a series of five areas which deserve priority attention (Star, Estes, and Davis, 1991). These are:

1. Institutional issues
2. Future computing environments
3. Data formats and access
4. Error sources and accumulation
5. Processing flow

Issues of systems and systems integration are of particular importance to the second, third and fifth elements of this list, and we return to them later.

2. SYSTEMS INTEGRATION

For the purposes of this paper, we consider the following model problem: a user is working with both remotely sensed data as well as datasets more commonly associated with geographic information systems such as parcel boundaries and soil characteristics. Thus, the user requires tools from both the remote sensing/image processing as well as the GIS domains.

A lack of systems integration for this user has been typical in the past. In this instance, which we arbitrarily define as level 0 integration, the remotely sensed datasets are processed on one computer system with stereotypical image processing software, and the results (for example, a land cover classification data layer) exported via physical medium transfer or network copy tools to a second computer, where GIS software and the additional data are resident.

A higher level of integration (level 1) involves remote sensing and GIS software being resident on the same computer, with local functions to convert data file formats between the two systems. Finally, at the highest level of integration (level 2), one imagines a single integrated software system, able to work with both remote sensing and GIS data and operations. This highest level of integration has been termed an integrated geographic information system, or *IGIS* (Ehlers, Greenlee, Smith and Star, 1991).

2.1 Level 0 Integration

When separate computers and software are used for the remote sensing and GIS phases of a project, there are both opportunities for local optimization, as well as additional costs for both system developers and users.

Display technologies for remote sensing and GIS have traditionally been different. Remote sensing systems have the requirement for true-color representation of large raster arrays: typically this translates into independent control of 8 bits per pixel each of red, green, and blue dynamic range (and thus, a color palette of potentially 2^{24} unique values), for an image area of 512x512 to 1024x1024 pixels. Additionally, a nondestructive overlay capability of 1 to 8 bits is normally required.

GISs, on the other hand, typically do not require such a wide range in color portrayal; 8 bits of color control (or 256 simultaneous colors) is generally adequate, particularly if the color palette from which the colors are selected are 12 bits or more deep. However, GISs can often benefit from the kinds of graphic accelerators that are common in the computer aided design field, since vector-like drawings and region filling are common. Thus, it appears that keeping these two systems at arm's length may permit the optimization of the respective graphic presentation functions.

In terms of costs, a single user in this environment will require competence in both sets of software, which are often from different vendors. File transfer and conversion, and thus, duplication of information, affects disk storage requirements as well as imposes a data management function on the user, and both of these may be significant in a given application.

2.2 Level 1 Integration

Today, it is much more likely that the remote sensing and GIS software systems are installed on a single computer. In a workstation environment, the trade-offs on the image display may be costly. 24 bit true color displays are still expensive, and few GISs make effective use of them. Some commercial suppliers of remote sensing software emulate 24 bit displays on 8 bit hardware, with varying degrees of success, and with varying costs in terms of performance and memory requirements.

However, many of the costs are still those of level 0 integration. Users still require knowledge of both software systems, file format conversions are still required (although media and network transfers are replaced with local file filters), and duplication of information remains a problem which must be managed by the user. One may also distinguish system environments where the remote sensing and GIS software are distinct and unrelated, from those where there is some coordination between the two.

There are both commercial systems from a single vendor which support this level of integration, as well as multi-vendor solutions. For example, in a coupled system, the GIS software and display functions may be set to control an overlay plane on the graphics device, while the remote sensing software and display functions control the underlying true color image display. In this kind of integration, software coordinates the display geometry between the GIS and remote sensing functions so that the GIS data layers properly overlay the remotely sensed imagery. These are clearly a step on the path to full integration of functionality and data, and a major benefit to the user when the costs of learning the two systems is not excessive.

2.3 Level 2 Integration

In a future environment, we believe remote sensing data and processing functions should be considered a component of a modern integrated geographic information system (Edwards, 1991). This by no means suggests that future GISs must be raster-based. However, in our laboratories the research projects now underway require the datasets, software tools, and approaches from both remote sensing and GIS in their conventional definitions.

This level of integration will clearly require more complex underlying software from the developers, since it must provide a wider functionality than now available, including both vector and raster data formats, categorical and continuous processing and statistical capabilities, object-like and field-like representations. While it will not reduce the requirements for users to understand the underlying information processing and extraction issues, it will significantly reduce training costs and potentially improve our productivity.

3. OBSERVATIONS

The computing environments of the near future are easy to forecast. They are networked, they are graphical, they have far more processing power than the systems of our past experience. However, the datasets we will try to examine will be larger and more heterogeneous, and the problems larger and more complex as well.

The workstations of the future will probably possess graphical subsystems with both vector enhancements as well as true color raster capabilities; we see such systems today albeit at often higher prices than practical for the average desktop system. The increasing reliance on various UNIX dialects may make it easier for the next generation of software developers to begin to create the integrated GISs of the future, at least in part since the costs of porting and optimizing code to many heterogeneous operating systems becomes unnecessary.

Issues of data formats and structures will need to be visited in the next generation of systems. It must be possible to place the burden of file format conversion on the systems, rather than on the users. The next generation of systems must also be able to provide an information management toolset for the user, in contrast to the file-oriented or directory-oriented systems we now use.

Finally, there are still many unsolved issued in the processing flow in an integrated geographic information system (Davis et. al., 1991). If a future system integrates the image processing and GIS functions now found separately, will they also facilitate tracing the lineage of derived datasets? Will they also assist us in documenting and quantifying the errors in our processing as they accumulate? And finally, will we have developed the knowledge and understanding to begin to use them effectively? The list of interesting research and applications areas is truly endless.

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