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Opening Lecture

Synergy of Photogrammetry, Remote Sensing, and GIS

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ABSTRACT

The status of the GIS field, computer hardware and software, and various GIS-related technologies, including telecommunications, are briefly reviewed. Then the impacts of these developments on data collection and use, including remote sensing, and photogrammetry and some recent work on the Spatial Data Production System (SDPS) are discussed. Some applications of these technologies, both conventional and novel, are enumerated. The paper concludes with some remarks on the future of these technologies and the possible future of photogrammetry as a profession.

1. INTRODUCTION

As more and more spatially referenced information of all kinds is put directly into geographic information systems (GIS) instead of being inscribed on hard copy maps, GISs are becoming the ultimate repositories of spatial information and the information source from which both hard copy maps and other kinds of cartographic displays are derived.

As the capabilities of remote sensing continue to expand and diversify, remote sensing and photogrammetry are increasingly the means by which new information for GISs is collected and through which the updating of existing GISs is performed. So remote sensing and GISs are becoming ever more tightly connected by the process of photogrammetry.

Partly as a result of these technical developments and partly as a result of the important fundamental connections between them, increased synergy is developing among remote sensing, photogrammetry, and GIS, forming what I shall call in this paper a “Technology Triad” of great importance to many fields.

2. THE STATUS OF THE GIS FIELD

The readers of this paper are well aware of the current state of the technology in both remote sensing and photogrammetry, but, because of my close association with GIS, I would like to make a few points about the current status of GIS technology, the third leg of the Technology Triad.

GIS technology is now about twenty-five years old and in its fifth generation of development. The GIS business is growing at somewhere between 15% and 25% each year and, globally, GIS firms are probably selling more than three billion dollars (U.S.) worth of GIS-related goods and services each year. At present there are probably more than 500.000 users of GIS technology worldwide. That the number will be more than 2 million by the end of this decade, and by the 2020 there may be 50 million GIS users or more. In ten years GIS displays of various kinds will be about as common as paper maps are today. Low end automated mapping software is already sold in retail markets in many countries. Ten years from now a full function GIS is likely to be as inexpensive as a word processor is today, perhaps 200 U.S. dollars in 1997.

3. COMPUTER HARDWARE AND SOFTWARE TECHNOLOGY

The trend is clearly toward extremely inexpensive computer hardware for GISs in the future; this may take the form of “zero cost” hardware, or of hardware with very few technical limitations (e.g., of memory size, speed, etc.), or of some combination of these two.
Important developments in software, especially object-oriented approaches, improved graphic user interfaces, and database management systems have been occurring and have helped produce the rapid growth in GIS in recent years.
GIS hardware/software represents a small enough investment that many public and private organizations can now easily afford the entry price for GIS technology.

4. STANDARDS AND “OPEN GIS”

In recognition of the capabilities of modern hardware and software, increasing efforts are being made to create and adopt standards for GIS technology, beginning with data (e.g., interchange formats and metadata) and interoperability. The move to standards, open systems, and interoperability is already irreversible: it will be increasingly easy to exchange spatial data and to select freely among hardware and software capabilities in doing GIS work. The ability of GISs to integrate divers data will increase in the years ahead.

5. SPATIAL DATABASE ENGINES

Until recently, GIS technology usually provided software for managing spatial referencing data (e.g. x,y coordinates or grid references), and made use of conventional relational DBMS (RDBMS) software to manage non-spatial (attribute) data. Now it is possible, using spatial database engine technology, to combine spatial referencing data with conventional data in a single database managed by existing RDBMS software.
This technology is especially useful where a large conventional database resides on a mainframe computer (server) which is accessed by a large number (hundreds) of user’s computers (clients). By optimizing special GIS software for queries (both conventional SQL and spatial queries), while including some capabilities for spatial analysis, spatial database engines provide a great deal of GIS functionality combined simultaneous client users.
This technology makes it possible to rapidly access spatially referenced information over telecommunications networks.

6. TELECOMMUNICATIONS

Improved networking for GIS use depends on improvements in telecommunications technology, such as fiber optics. It is particularly important that telecommunications permit higher data transfer rates, especially to support transmitting images, graphics, and large databases over long distances. Conversion to fiber optic cables is occurring in many areas at the present time.
Proposed private sector systems of low orbit communications satellites may make wireless communications available around the world and also permit extremely high (2 MB/sec) data transfer rates.
While improvements in both these areas will likely be incremental because of the enormous size of the installed telecommunications base and the high costs of upgrading or replacement, telecommunications are improving quite rapidly in many parts of the world, with impacts on GIS use which will be revolutionary.

6.1 Global Networking

By making it possible to link computer users virtually anywhere on earth with providers of spatial information, the Internet is further expanding the use of GIS data. Recent GIS software developments make it extremely easy for Internet user to quickly create maps interactively without knowing anything about GIS technology and to make use of GIS technology without even being aware they are doing so. Already some spatial databases are available to users throughout the world; spatial data utilities may become common in the years just ahead.

7. IMPACTS ON DATA COLLECTION

These increases in GIS use are fueling an apparently insatiable demand for new, high resolution information for spatial databases. Technological developments, combined with this demand, are rapidly changing the way in which ground data are collected. The most important portable data capture instruments available at present are probably based on Global Positioning System (GPS) technology, which is providing spatial referencing for many kinds of newly acquired data. It is estimated by industry groups that sales of GPS receivers alone will exceed five billion dollars (U.S.) Per year by the year 2000.

For about the last decade, developments in the ultraminiaturization of measuring instruments have been proceeding in a number of fields, including the electronics industry, health care fields, scientific research, and the like. As a result, a new class of measuring instruments are just beginning to be available. These instruments are extremely small, rugged, automated, and relatively inexpensive. So-called “data loggers” are an early example of the class. These instruments promise to automate the collection, storage, and transmission of many kinds of ground data without much need for human intervention.

These developments are likely to greatly enrich the kinds of information available to users, and greatly reduce the costs of information which previously required labor-intensive laboratory work.

8. REMOTE SENSING AND PHOTOGRAMMETRY

As readers of this pare are well aware, developments in the first two legs of the Technology Triad, remote sensing and photogrammetry, have been keeping pace with those in these related technologies. The variety of sensing arrays, satellite platforms, and processing capabilities continues to grow rapidly. Many countries are now in the satellite imaging business, including the U.S., Russia, India, Canada, Japan, and others.

Particularly important at the present time is the movement in several countries toward the commercialization of satellite remote sensing based on commercial launch vehicles and commercial satellites and commercial satellite networks. If these ventures are financially successful, imagery with resolutions down to 1 meter become widely available for much of the earth.

9. THE SPATIAL DATA PRODUCTION SYSTEM (SDPS)

One technical response to these developments is the Spatial Data Production System, an “end-to-end” production system for spatial data from imagery.

ESRI and a team of three companies, Raytheon E-Systems, GDE Systems, Inc., and the Environmental Research Institute of Michigan (ERIM), are developing a system for the production from high resolution satellite imagery of digital and hard-copy data, including all types of large scale (1:25,000 to 1:100,000) maps.

The development of the SDPS began more than a year ago. The U.S. National Imagery and Mapping Agency (NIMA, formerly the Defense Mapping Agency), selected Raytheon E-Systems as one of several firms to demonstrate means to provide several of NIMA's products: cartographic source, digital imagery, digital geographic data, and high volume hard copy map production.

Data generation begin with Raytheon E-Systems receiving the imagery and reviewing it to make sure that its quality meets defined standards and that it covers the area appropriate for the intended product. E-Systems performs image source geopositioning and preparation by ingesting the imagery which is received on tapes, and converting it from its original format (National Technical Means [NTM], SPOT, Landsat, etc.) To National Imagery Transfer Format (NITF), including reduced resolution data sets, using conversion, interpolation, and filtering processes designed for this purpose.

The processed imagery, along with terrain data extracted from the imagery by GDE Systems, Inc., is passed to ERIM for the development of the Controlled Image Base (CIB) product, an imagery product created by mosaicking and rectifying the image; the image is resampled to the required resolution (ground sample distance) and geocoded for ease of use. ERIM produces CIB data by using its heritage software product, which is known as ERIPS Image Processing software.

From the same satellite imagery preprocessed by Raytheon E-Systems, GDE Systems extracts not only terrain data but also feature data by using its SOCET SET photogrammetric software, which is capable of both monoscopic and stereoscopic data extraction. Using the automated in interactive terrain extraction, the GDE Systems team members collect a gridded terrain model and convert it to Digital Terrain Elevation Data (DTED) Level to comply with NIMA product specifications. The GDE team members send the DTED Level 2 data to ERIM for CIB production and to ESRI for use in Vector Smart Map (Vmap)) Level 2 and Topographic Line Map (TLM) production. GDE Systems also uses the feature and extrction tools of SOCET SET to collect physical, cultural, vegetation, and hydrographic features from the imagery.

ESRI is responsible for core database operations and for providing the data finishing capabilities for the SDPS. At the heart of the these activities is a digital geographical database; the data in the database can be selected, symbolized, scaled, generalized, and so on, in order to create a variety of cartographic products. The database operations result in the creation of digital Vmap Level 2 data, which are in Vector Product Format ((VPF). The terrain and feature data are also used to produce TLM files (fully symbolized with all marginal data, screens, and area patterns). These TLM files are then used to produce fully composed color separation materials for printing. ESRI's ARC/INFO is being used for the database operations, the manipulation of the digital vector data, and the cartographic operations associated with the print-ready negatives.

10. NEW PATTERNS OFDATA COLLECTION AND USE

If these various technical developments do occur, if the commercial demand for GIS data expands as predicted, and if a premium continues to be paid for newly collected data which are interpreted rapidly, then it is likely that approaches to collection spatially referenced data will make increasing use of high resolution satellite imagery, soft copy photogrammetry, and various client server approaches to supplying users with spatially referenced information over networks like the internet. It is also likely that attempts will be made to reduce dependence on ground surveys, field work, and other labor intensive approaches to data collection and interpretation.

10.1 Data costs

Despite the improvements in technology, data will continue to be the most expensive part of any GIS, when the real costs of the data gathering - not just the purchaser access costs - are considered. It is

unlikely that this will change in the foreseeable future, even as the total cost of GISs (including data) continues to fall.
Attempts will continue to be made to reduce the unit data costs through marketing data to larger numbers of users by means of the Internet, data utilities, and other approaches.
As a result of these efforts, any new users will come into the data market because they will be able to find the limited amount of data which they really need at a reasonable cost. As the unit cost of data falls and as they see opportunities to resell their data to others, large institutional users (corporations and governments) will expand the size of their databases.

10.2 Public access to information

If the costs of data do fall, if GIS user interfaces become more user-friendly, and if the use of networks, including global networks, increases, then it will become easier for private citizens to make use of spatially referenced information, and new patterns of information use of information are likely to develop, rather unlike those we now observe.

10.3 Impact of increasing use of spatially referenced information

Although GIS technology has been around for more than two decades, organizations and individuals are just now beginning to change the way they do things in response to the impact that GIS technology has on and the life of private citizens, significant changes are likely to occur in all our lives.

11. APPLICATIONS OF THESE TECHNOLOGIES

In the last twenty-five years a number of applications of remote sensing, photogrammetry, and GIS have become widespread; these include systems for dealing with:

- Land Information
- Natural Resources
- Municipalities and Regions
- Environment
- AM/FM
- Transportation Networks
- And others

11.1 Less conventional applications

In recent years the combination of all the rapid technological changes mentioned above has produced a growing number of less conventional applications of the Technology Triad. In these applications the capabilities of the Triad are being stretched to their limits; technical applications which were once reserved for the extremes of military combat are increasingly converging with civilian applications.
These recent applications have included, for example,

- Rapidly or continually assessing the effects of disasters which have affected wide areas (wildfires, floods, earthquakes, hurricanes)
- Rapidly or continually assessing the effects of accidents on the environment (tanker spills of oil, ...)
- Enhancing agricultural productivity down to the level of the individual farmer’s field
- Evaluating the surface condition of complete systems of roads, railroads, etc.

- Locating illegally dumped hazardous wastes
- Responding to uncontrolled settlements surrounding major their world cities
- Global climate and regional meteorological modeling
- Locating refugees and the sites of massacres; supporting human rights investigations
- Locating and identifying violations of international treaties.

In each of these applications the Technology Triad plays an essential role.
As more and more organizations, business, and, ultimately, individual people, make use of the information generated by the Technology Triad, the range of new applications will continue to increase, probably in ways which none of us can now foresee.

11.2 Global environment and development

Perhaps the greatest challenge now facing humanity is that of simultaneously developing the earth while protecting the global environment.
Many organizations involved in development, at local, regional, national or international levels, already make use of the Technology Triad. The development of urban areas, agriculture, transportation, trade, infrastructure, natural resources, and industry can all be assisted by the judicious use of these three technologies, often in a more comprehensive and effective way than by other means.
The developments which are occurring in the Technology Triad will increasingly make it possible for emerging nations to plan their national development and simultaneously preserve their environments. No other technologies are more important to this process than the Technology Triad.

12. THE IMPACT OF CHANGING TECHNOLOGY ON THE PROFESSIONAL

ESRI was founded nearly thirty years ago in 1969. At that time the vision for the company was to create a group of people who could make use of the new techniques in automated cartography to help various organizations do a far better job of things like environmental planning.
By about 1985 that vision changed as it became possible to supply others with GIS technology which they could use without direct help from ESRI staff. Instead of doing the work for others, we were supplying technology which allowed them to do the work for themselves. As a result, the last dozen years have been very exciting for us as our technology reached some quarter of a million users.
It seems possible that increasing automation in remote sensing and photogrammetry may follow that same pattern. Just as GPS technology is making accurate position location available to millions and changing the way that surveyors think about what they do, automation in photogrammetry and the wider public availability of remote sensing information may alter the way in which professionals in these fields see their work.
In whatever new forms it takes on, I am convinced that the Technology Triad will have an increasingly important role in the overall development of the Information Age.

13. THE FUTURE OF REMOTE SENSING, PHOTOGRAMMETRY, AND GIS

The future of the Technology Triad of remote sensing, photogrammetry, and GIS is bright. As these three technologies continue their rapid development, their costs continue to fall, the quality of their products improve, their user community expands, and the mix of their applications is enriched, the applications of the Technology Triad will expand beyond our imaginings.

It will be an exciting time, as the promise of these technologies is fulfilled.