GEOGRAPHIC APPLICATIONS FOR SATELLITE DATA

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EXTENDED ABSTRACT

Computer graphics, pattern recognition, and image processing are essential ingredients in the design of systems for utilizing remote sensing data for geographic purposes. The number and quality of satellite imaging sensors is increasing steadily. Thousands of specialized systems for geographic data processing are in current use to help us cope with the resource-related social and economic problems facing us. Some digital terrain models encompass the entire globe. Many countries are developing integrated planning systems. Smaller units of government struggle with databases for transportation networks, land-use, water and mineral rights, soil-type, or recreation areas. Even small towns are rationalizing and computerizing their cadastral records to augment tax collection. The direct and only mildly distorted view of the Earth afforded by satellite imaging systems provides a valuable source of up-to-date information for many of these endeavours.

LANDSAT-D, launched in July 1982, carries both a four-channel multispectral scanner similar to those on LANDSAT 2 and 3, and a thematic mapper with 30-meter resolution and seven narrower spectral bands. Because on-board data storage has proved unreliable, either direct transmission to earth-receiving stations or satellite relay stations are used to transmit the image data at up to 300 megabits per second. Both photographic and digital data products are available from several national and international processing centers which correct distortions introduced by the sensor systems with varying degrees of success, but the utilization of photographs so far greatly outpaces the utilization of digital images.

The digital images are located approximately using ephemeris data from tracking stations. Geometric distortions resulting from changes in satellite position, altitude, attitude and view angle are removed. Radiometric correction based on on-board and celestial calibrations sources compensates for sensor and electronic anomalies and for changes in illumination. Images may also be precision-corrected with reference to a library of easily-detected ground-control points whose position is accurately known, and resampled to standard map projections. Other optional enhancement processes include haze removal and contrast stretching.

Geographic analysis may be viewed primarily as a data-reduction process: a vast amount of data is reduced to a few elements that can be assimilated by human decision makers. The bulk of the data is, in many applications, satellite image data. A single multispectral LANDSAT-D thematic mapper frame contains over 100,000,000 bytes, more than most entire non-image geographical databases. Fortunately, an increasingly wide range of image processing technologies can be applied to geographical analysis as systems originally designed only for pattern recognition or image processing are expanded to perform the entire gamut of operations needed for data integration and analysis. As with any new technology, there are many technical, economic, and conceptual barriers to wide-scale use.

The conflict between the high-resolution but infrequent coverage necessary for some applications and the lower-resolution, frequent coverage needed for others remains unresolved. Image data is still not generally available in a form that facilitates direct correlation with other geographic sources of information such as topographic maps. The analysis of satellite images is evolving slowly from ad hoc methods of utilizing spatial and temporal context to artificial intelligence oriented procedures of hierarchical scene analysis. Feature representations more abstract than Euclidian vector spaces offer some hope of combining structural and decision-theoretic methods of classification. The estimation of expected classification error rates is becoming more sophisticated and rigorous, but useful finite-sample results for non-parametric distributions appear unobtainable.

Current developments in computer science should be gradually assimilated by the geographic and remote sensing community. Software engineering techniques reduce the effort necessary to develop and maintain complex image processing systems. Computational geometry provides efficient algorithms for

two-dimensional searching and sorting and may eventually pave the way for the development of geographic information retrieval systems. Focus on concrete computational complexity allows meaningful comparison of algorithms and data structures. Reductions in the costs of digital storage and of high-quality raster devices facilitate the display of combined image and vector information. Advances in parallel computer architectures, commercial database technology, and man-machine communications are also in principle applicable to the design of systems for geographic analysis, but the differences between geographic analysis and business-oriented tasks are sufficiently significant to preclude rapid progress.

The current shift to microcomputer-based image-analysis facilities is a step towards more interactive and qualitative utilization of satellite data. The wide availability of such systems and their expected success in meeting many local needs will no doubt foster additional interest in digital satellite image data. However, in view of the immense amount of data that will have to be processed to approach our long-term goal of a complete and always up-to-date inventory of the world's major resources, research on highly automated, quantitative methods must also continue and expand.

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KEYWORDS:

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