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Developing a Raster Profile for the Spatial Data Transfer Standard

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ABSTRACT. The Spatial Data Transfer Standard (SDTS) was designed to transfer both vector and raster data sets. In the early development of the SDTS, the designers recognized that there was a need to transfer raster data in addition to the more challenging vector data. As a result, the SDTS includes a "raster module" that accommodates a variety of raster data structures and formats. A raster profile is being developed that will exercise a selected subset of SDTS capabilities in order to provide a simple-to-use transfer of complete raster data sets.

KEYWORDS: raster, spatial data, standards

Introduction

During the decade of Spatial Data Transfer Standard (SDTS) developments, many advancements were made in hardware and software that are used for spatial analysis (e.g. image processing and geographic information systems). Some systems can now efficiently and directly process both raster and vector data using an integrated data model. This has placed new requirements on the raster transfer process. To facilitate this process, a raster profile for the SDTS is being developed.

It is apparent that many users are spending excessive time and effort dealing with the problems of geographic referencing and registration. This situation is often aggravated by poorly documented data sets, inconsistent terminology, and incomplete transfer of ancillary georeferencing information. As users of geographic information and image processing systems attempt to process spatial data in both raster and vector form, a simple but more complete raster transfer process is needed.

Objective

The objective of the raster profile is to provide an SDTS-prescribed method for encoding and transferring raster data. The U.S. Geological Survey (USGS) requires such a profile to distribute data such as Digital Elevation Models, Digital Orthophotos, and remotely sensed images.

The design of the raster profile will take advantage of the existing Topological Vector Profile (Fegeas, 1992), and will use it as a model for all commonly defined SDTS modules (e.g. data quality terminology, data set lineage, and geographic referencing).

A goal of the raster profile is to integrate raster data sources with SDTS data that are transferred in vector form.

USGS Requirements for a Raster Profile

The development of an SDTS raster profile will involve the participation of Federal agencies, State and local governments, the private sector, and academic institutions that have a vested interest in implementing the SDTS for raster data transfers. The actual process to accomplish this activity will be similar to that for developing the vector profile: design of a prototype profile, test and demonstration of sample data sets and software, refinement of the profile, and FIPS approval.

At this point, however, a prototype raster profile has not yet been defined. Therefore, this paper will focus on known requirements for a raster profile from the perspective of the USGS.

Digital Elevation Models

The USGS has been distributing raster elevation data as Digital Elevation Models (DEM) for more than 15 years (USGS, 1990). DEM's are typically referenced to the Universal Transverse Mercator projection, or directly to latitude and longitude, and are made up of a regularly spaced set of elevations. These DEM's contain a complete set of georeferencing information in the header records. The information in the DEM header should be preserved in the raster profile transfer process.

Provision should also be made for inclusion of additional information that can be provided to assist in making appropriate use of the DEM (e.g., accuracy as determined during validation procedures or an indication of the source of the DEM (Gestalt Photo Mapper, scanned hypsography, or digital profiles)). This provision will require additional research by the data provider, in this case the USGS.

As expressed in a DEM, elevation (referred to as altitude by the SDTS) values will typically require a 16-bit (two byte) signed integer binary data representation.

Digital Orthophotos

The USGS is working cooperatively with the U. S. Department of Agriculture to implement a national interagency digital orthophoto program. The product of this program is a digitized photo from the National Aerial Photography Program digitized at 25 microns. The digital image will then be geographically registered to a standard map projection to create a Digital Orthophoto Quadrangle (DOQ) (USGS, 1992). The result will require an 8-bit unsigned byte (range 0-255) to represent each monochromatic brightness value (pixel) that corresponds to a 1-meter square on the ground.

As with DEM's, provision should be made to include the header information that accompanies each DOQ. The DOQ header carries sufficient information to satisfy SDTS data quality, lineage

and georeferencing requirements.

For color images that can be scanned with filters, multiband data sets will be required. The SDTS allows for virtually any organization, including the commonly used Band Interleaved by Line, and Band SeQuential. One or both of these band organization methods will be chosen for the raster profile.

Remotely Sensed Images

Data transfers of remotely sensed data will require the capability to transfer unsigned (8-bit) byte data. This capability will also accommodate most digitally enhanced data and classification results (classes ranging from 0-255). The raster profile will not provide a mechanism for transferring images of complex numbers (e.g. Fourier transforms), real valued data (e.g. some aeromagnetic data), or some raw remotely sensed data (e.g. raw Advanced Very High Resolution Radiometer data that require 10 bits).

Multispectral scanner data will require multiple bands. Often these data sets contain 4 to 7 bands, but some data sets can contain as many as 224 bands (e.g. Advanced Visible and Infrared Imaging Spectrometer). Also, remotely sensed data are often transferred as a geometrically registered time series, and this increases the number of coregistered bands. The raster profile will require a decision on the maximum number of bands allowed in a single transfer.

To facilitate the registration of raster data with other data sources (and profiles), a geographic referencing procedure will be required for data transferred with the raster profile. This may require resampling of raw sensor data to a rigorously defined map projection and the confinement of errors to subpixel accuracy. Further discussion and a foundation for geographic referencing requirements can be found in the report of a NASA sponsored workshop held in 1977 (Simonett, 1978).

The raster profile will not be used for raw sensor (non-georeferenced) data. Because many existing image file formats do not require these data, the raster profile will be limited to data sets that have received this additional work. The extra effort of the data provider will be more than balanced by the reduced effort for many users.

A major new source of remotely sensed data is expected to be encoded using NASA Earth Observing Systems specifications that are currently under development. NASA probably will adopt the Hierarchical Data Format as a transfer standard (Suresh, written commun., 1992). The raster profile could provide a future option for these data, but only if they have been geographically registered.

Summary of USGS Raster Profile Requirements

In the interest of file size and processing efficiency, the raster profile will require binary encoding schemes that are more efficient than character codes. Software encoding and decoding routines will need to be added to the existing SDTS support routines and ISO 8211 (FIPS 123) tools.

The raster profile should transfer unsigned byte data for DOQ and most remotely sensed data. For DEM's, 2-byte integer data will be necessary. The raster profile will not require the inclusion of binary encoding of real-valued (i.e. floating point) data sets. For nonimage portions of the transfer (e.g. headers and data quality), character encoding of floating point values will be needed, as allowed by the standard.

The raster profile will transfer of complete raster images and will not employ tiling techniques that could speed up access and allow windowing operations, but increase data structure complexity.

Image compression techniques are efficient and are becoming standardized. The raster profile should transfer data using a "lossless" compression method (e.g. LZW) as described by Welch (1984), or a higher compression "lossy" method (e.g. JPEG), as described by Wallace (1991).

Future Plans for the Raster Profile

To promote the prototype profile and provide well-documented examples to the user community, several data sets will be generated and distributed using the raster profile. Planned inclusions from the USGS are: a DOQ sampler of data in compressed and uncompressed form, remotely sensed AVHRR biweekly composites on CD-ROM, and (or) an AVHRR companion disk that contains data in both raster (DEM, remotely-sensed, and ancillary data) and vector (DLG format ancillary data) form. Sample data sets from other sources of raster data will also be generated for the raster profile test and demonstration period.

For the raster data transfer process to be both complete and simple, it is necessary to provide users with software, documentation, and some assistance. To date, software subroutine libraries have been developed and are being tested for the vector profile. It is planned that additional routines for the raster profile will be written.

In a recent session at an SDTS Implementation Workshop in Reston, Virginia, the plans for a raster profile were discussed among a group of about 20 people. A mailing list was established for a group of about 65 users, system vendors, and data providers. If you would like to be added to this list or would like to participate in the development of the raster profile, contact Janette Cascio, USGS, 526 National Center, Reston, VA 22092.

Planned milestones for developing an SDTS raster profile are as follows:

Raster profile interest group technical exchange meeting		Winter 1992
Design of a prototype raster profile		Spring 1993
Creation of sample data sets and software		Spring/Summer 1993
Test and Demonstration period	(six months)	ends Fall 1993
Completion of raster profile		Winter 1993
Submission to NIST for FIPS approval		Winter 1993

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Biographical Sketch

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