UNIT 17: SCANNING MAPS

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Context

Scanning is increasingly an effective means of automating spatial data. Traditionally, all spatial data was digitized manually by using a digitizing tablet or in some cases, keyed in by hand. However, in recent years, developments in hardware and software have made map scanning a viable tool for data automation. There are several different techniques that utilize map scanning as a means of recording spatial data. One method is to scan a map, and then use it as a background image for on-screen digitizing. Another method is to use sophisticated software to convert a scanned raster image into useable GIS data.

Example Application

A private GIS contractor specializing in creating spatial data has obtained a substantial contract with a neighboring county to convert all of the county maps into digital data. Since the maps are used continuously, the county has agreed to "lend" out the original paper maps only a few at a time and for no longer than a few days.

The strategy developed is to have several teams working on different layers at the same time. To avoid having to create extra working copies of the map and the expense of digitizing tablets, the company has decided to scan the maps in as images and then make multiple copies of these images for each team to digitize on-screen. This strategy really paid off when the company fell behind schedule and had to sub-contract some of the digitizing work to another company. With images copied to CD-ROM disks, the confusion of sending extra copies of paper maps was avoided.

Learning Outcomes

The following list describes the expected skills which students should master for each level of training, i.e. Awareness/Competency/Mastery.

Awareness:

Students should have an understanding of the potential applications of scanned maps. Students shall also possess a rudimentary understanding of the vocabulary associated with scanning in general.

Competency:

The learning goals of this section are to develop the ability to scan maps and to understand issues regarding spatial resolution and associated project application needs.

Mastery:

The learning goals of this section are for students to be able conceptually apply their understanding of map scanning to differing map scanning situations in different lab environments.

Preparatory Units

Recommended:

1. Unit 1
2. Unit 9
3. Unit 16

Complementary:

1. Unit 12
2. Unit 18

Awareness

Learning Objectives:

1. Students can define basic vocabulary associated with map scanning.
2. Students can explain procedures and operations involved with scanning.
3. Student can describe applications that would potentially benefit from map scanning.

Vocabulary:

- analog
- cell
- conversion
- coordinate system
- data format
- data quality
- digital
- digitizing
- dots per inch (dpi)
- drum scanner
- external conversion
- feed scanner
- flatbed scanner
- graphic file formats
- ground control points (GCP)
- georeferencing
- heads-up digitizing
- image processing
- image rectification
- image types (gray scale, black and white, color)
- internal conversion
- map scale
- mosaicing
- National Map Accuracy Standards
- optical character recognition (OCR)
- orthoimage GCP
- Photogrammetry
- Positional accuracy
- Raster data
- radial distortion
- root mean square error (RMSE)
- rubbersheeting
- scale
- scanning
- scale
- spatial resolution
- tagged-image file format (TIF or TIFF)
- vector/raster

Topics:

1. Unit Concepts

    1. Map scanning processes, image types, and file considerations.
    2. Considerations of desired spatial resolution as they relate to map scale.

3. Hardware and post processing considerations relating to digital image file output sizes.

    1. Desktop or flatbead scanner -- used for small appliations
    2. Drum scanner -- used in large format applications needing extreme accuracy
    3. Feed scanner -- primarily used for GIS purposes in large format applications

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Competency

Learning Objectives:

1. Students will be exposed to essential prerequisite information regarding the processes and considerations involved with scanning.

- The students will consider the two decisions that must proceed an map scan.
    - The image type needed as the result (i.e. grayscale or color).
    - The desired output resolution measured in dots per inch (dpi).

2. Students will be able to select and understand the implications of dpi selection as it relates to the output file size, and the desired spatial resolution requirements of the project.

- In any scanning software, selection of an appropriate dpi for the scan is in essence the determining factor of how many dots per inch the scanner will record.
- The more dots per inch, the more bits (binary digits) needed, and the larger the resulting image file.
- Generally, the limitation will be the possible scanning resolution of the scanner itself.
    - Sometimes the limit can be dependent on hardware issues and image file sizes.
    - Color scans (false or true), require a greater number of bits and therefore are greater in file size; the greater the dpi selection, the greater the spatial resolution and file size of the image.

1. Students will have a thorough understanding of basic image types (Unit 18).
2. Students should gain knowledge in image enhancement techniques:

- Contrast and Brightness
    - May be adjusted to preserve the highest degree of precision
- Gamma correction
    - The scanner analyzes a histogram based on the map's distribution along the gray or color scale.
    - Points are strategically placed along the histogram to isolate data types.
    - Scanner may then select the best areas to brighten or darken

1. Resolution considerations

- Resolution is the density of the raster image measuring the number of pixels within a given distance.
- Since inches are a common unit of measurement, dots per inch (DPI) is commonly used.
- Since a scan line is one pixel in length, feed scanners are most efficient at handling large map surfaces.
- The user must balance a reasonable resolution to match expected resolution and storage capacities.
  - A 100% (2X) increase in resolution yields a map image that is four times greater in physical storage size.
  - Use the following rule of thumb from the book GIS Data Conversion:
    - 200 dpi -- to view text and line art
    - 300 dpi to view most photographs
    - 400 dpi to view high quality orhophotos
  - With the above considerations, a 600 dpi scanner should more than suit most needs.

1. Scale and Accuracy

- Remember that a scanned map can be no more accurate than the original map.
- Accuracy refers to how correct the data is, while precision refers to the amount of detail present in the data. Using these rules, it is possible to have a scanned map that is very precise yet inaccurate.
- One way to control accuracy is to use the best possible maps as a source. Keep in mind that paper stretches as well as shrinks with changing humidity. A properly controlled environment might not be as important as previously thought. The best rule of thumb is to scan the maps in roughly the same temperature and humidity that they are stored and used in.

1. Map preparation

- Most people involved with scanning maps are interested in creating GIS data in geo-referenced coordinates. You may need to draft control points onto the map if they are not available on the printed media. It is easier to do this before the scan than after.
- Even with high resolution scanning, some features may not "show up" after scanning due to complex symbols, shading, or moir patterns. You may need to enhance the source map by drafting in difficult-to-see areas and lines.

- Use the following rules from the book GIS Data Conversion, page 286-287:
  - Never scan a map without control points
  - Never scan a dirty map
  - If you need to tape a map, use only the best available.
  - Never use petroleum based permanent markers. (These may destroy your scanner!)
  - Never draft with graphite
  - Avoid glossy finishes.

Mastery

1. Students will be able to use scanning operations to perform a map scan, and will consider the following list when at the scanner.

- *Scan at a default dpi unless specifics are known regarding the final desired spatial resolution or image file size.*
- *Scanning at 24-bit color even if the image being scanned is grayscale, this will provide the highest spatial resolution if it is required.*
- *Scan using the TIFF format unless other software specifics are known. Files using the TIFF format can be exportable from many packages.*
- *Post-scanning: Students will manage multiple scanned images in a logical way in order that they are readily accessible.*

2. Exercises should be performed by students at various dpi scanning resolutions to observe visual differences in the resulting imagery, as well as to experience file size issues associated with different image types and greater spatial resolutions.

Follow-up Units

1. Unit 1
2. Unit 9
3. Unit 14
4. Unit 16
5. Unit 18

Resources

[Outdated links have been removed.]

- The ESRI Arcscan site and a white paper dedicated to automated digitizing techniques.
- Hohl, Pat (Editor). 1998. GIS Data Conversion. Onword Press: Santa Fe, New Mexico. (ISBN: 1-56690-175-8)

- Image Acquisition Helpsheets from the University of Virginia Library

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