Unit 18: SCANNING AIR PHOTOS

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Context

Scanning aerial photography into digital imagery can greatly assist GIS and CAD technicians by saving time and reducing potential errors. Digital imagery is used as a real world back drop for comparison and updates of vector or polygon data. The main purpose of scanning systems is to replace the task of automated tracing (digitizing), to assist in remote sensing applications (land use/land cover characterizations), as well as raster-based modeling. Visualization, through imagery, is an essential form of spatial analysis which allows for more informed decisions to be made. Imagery can greatly assist in a variety of project applications:

- *Erosion Control*
- *Land Use Planning*
- *Transportation Studies*
- *Environmental Modeling*
- *Natural Resource Management/Analyses*
- *Agricultural Monitoring*
- *Forest Inventories*
- *Urban Management*

Air photos are available in a variety of scales, decades of coverage, and for most regions, states, and counties. Perhaps the one limitation to aerial photography is the actual spatial coverage of individual photos (9-25 sq. miles vs. 1400-13,500 sq. miles for satellite scenes). This limitation can be handled in several ways; 1) scanned photo images can be merged or mosaicked in image processing software, or 2) if greater spatial coverage or higher spectral resolution is required for a project, then satellite imagery could be considered. Air photos are, however, relatively inexpensive compared to satellite imagery, have high spatial resolution, and are archived by numerous state, federal, and private agencies. For this reason, aerial photography is particularly well suited for pattern comparisons between seasons or over periods of time.

The following is an example of a project which may find scanning air photos useful, time saving, and cost effective.

Example Application

The USDA and SCS have expressed a need to quantify the extent to which agricultural land use has changed, both spatially and temporally, in the Southern Appalachian region. According to USDA statistics, the Southern Appalachian region has experienced a decline in farm acreage of

over seventy percent from 1950-1987. The SCS predicts a parallel reduction in associated agricultural soil loss during the period. This project will require the analysis of multiple years of air photo coverage to determine the extent of land use change and to ultimately to perform soil erosion modeling. A GIS environment would be the best way to manage and store the data for this project. For the entire region, it is expected that photo scale and relative quality will vary through the available years of coverage. Once the remote sensing analyst has determined availability, the GIS technician will be responsible for scanning the aerial photography into an image format that the GIS can import. Most GIS software packages are able to import a variety of formats, however, this should always be determined prior to scanning by the technician. The digital images should be organized and managed by the GIS technician in order that other GIS project staff may access them.

Proper data management and archive organization is essential since only subsets of the entire region can be processed at a given time.

Learning Outcomes

The following details the expected skills which students should master for each level of training (i.e. Awareness, Competency, Mastery).

Awareness:

Students should have an understanding of air photo scanning, potential applications of scanned images, spatial scale and file size considerations, and knowledge of image types and terminology.

Competency:

The learning goals of this section are to develop the ability to scan aerial photography and other images, 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 photo scanning to any number of scanning software packages in a number of different lab environments. Scanning software include: Adobe Photoshop, Kodak Photo Edge, Corel Draw, Aldus Photostyler, Kodak Photo CD, and an increasing number of others.

Preparatory Units

Recommended:

1. Lecture 1, Volume 1, Remote Sensing Core Curriculum
2. Lecture 12, Volume 1, Remote Sensing Core Curriculum
3. Unit 1 - Acquiring data
4. Unit 9 - Convert digital spatial data between formats,systems, and software
5. Unit 16 - Planning a scanning project
6. Unit 17 - Scanning maps

Complementary:

1. Lecture 2, volume 1, Remote Sensing Core Curriculum
2. Lecture 3, volume 1, Remote Sensing Core Curriculum
3. Lecture 6, volume 1, Remote Sensing Core Curriculum
4. Lecture 10, volume 1, Remote Sensing Core Curriculum

Awareness

Learning Objectives:

1. Students can define basic vocabulary associated with image scanning and remote sensing.
2. Students can explain procedures and operations involved with scanning.
3. Students can explain the importance of pre-scanning decisions and preparations.
4. If scanning software is available, students could perform a scanning project for importation into a GIS.
5. Student can describe applications that would potentially benefit from air photo scanning.

Vocabulary:

- analog
- binary digits (bits)
- digital
- dpi
- graphic file formats
- ground control points (GCP)
- image processing
- image rectification
- image types (gray scale, black and white, color)
- mosaicing
- orthoimage GCP
- radial distortion
- scanning
- scale
- spatial resolution
- vector/raster

Topics:

1. Unit Concepts

1. Air photo/image scanning processes, image types, and file considerations.
2. Considerations of desired spatial resolution as they relate to photo scale.
3. Hardware and post processing considerations relating to digital image file output sizes.
4. Sources and selection of remotely sensed data and graphic file formats.
5. GIS/Remote Sensing software exportation-importation

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 image 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.

3. Students will have a thorough understanding of basic image types.

- **Image types:**
    - **1-bit black and white** (each dot can be either be black or white)
        - 1-bit black and white scanning is rarely used for GIS or Remote Sensing applications. The image appears coarse due poor spatial resolution.
    - **8-bit grayscale** (each dot can be one of 256 gray shades)
        - An 8-bit image in grayscale does a pretty good job in terms of clarity for any black and white photo. Features can be recognized and detected.
    - **8-bit color** (each dot can be one of 256 colors)
        - 8-bit color is less "image" realistic than a 24-bit color image and can appear to be rather coarse or grainy at times. Features are typically less detectable to the human eye in these images than 8-bit grayscale.
    - **24-bit color** (each dot can be one of 16.8 million colors)
        - Although, 24-bit color scans provide high resolution photo-like images, they are typically too large to deal with effectively (note: compression formats can help, i.e. JPEG)

4. The students should consider dots per inch and scale determination as well.

- Below is a table of typical aerial photo scales (9 inch by 9 inch format) as they translate to pixel resolutions, and resultant image output file sizes.

air photo scale:	**10,000**	**24,000**	**40,000**			

kilometers across:	2.29	5.5	9.1	**scanned file size in pixels/Mbytes**		
DPI Scan	**Pixel size in meters**			**pixel width**	**color vs. greyscale in megabytes**	
150 dpi	1.7	4.1	6.8	1,350	5Mb	2Mb
300 dpi	0.8	2.0	3.4	2,700	21Mb	7Mb
600 dpi	0.4	1.0	1.7	5,400	83Mb	28Mb
1200 dpi	0.2	0.5	0.8	10,800	334Mb	111Mb

5. The student should have an understanding of the basic graphic file formats:

- There is a multitude of file graphic file formats available in software. Below are some examples of more commonly used formats. Vector formats relate mostly to map scanning whereas raster formats are typically used for aerial photographs.
- Acronym/extension Full Name Software Developer
- *Vector Formats*
    - CGM (ISO)
        - Computer Graphics Metafile
        - International Standards Organization
    - HPGL
        - Hewlett-Packard Graphics Language
        - Hewlett-Packard
    - DXF
        - Drawing Exchange File
        - Autodesk
- *Raster Formats*
    - TIFF
        - Tag Image File Format
        - Aldus Corporation
    - GIF
        - Graphics Interchange Format
        - CompuServe
    - PS & EPS
        - Postscript
        - Encapsulated Postscript
        - Adobe
    - PIC
        - Picture Format

        - Lotus (Corel)
    - BMP
        - Bitmap File Format

- The *TIFF* format is one of the most common formats used for scanning photographs. It is important for the student to make graphic file format decisions before scanning. Considerations will be made by the student regarding import/export formats the GIS or Remote Sensing software can accept.

NOTE: If the project intends to georectify the imagery or create orthoimages, additional considerations need to be made regarding radial distortions, and capture of the fiducial marks on the aerial photography (most scanners can only scan 8.5" wide which ***will not capture the fiducial marks***). Fiducial marks are necessary for ortho-rectification, so larger scanners are needed. Because the principle point (focal point) of a photograph is the most accurate, capture of the far periphery of a photo (particularly in areas with complex terrain/vertical relief) can affect geo-rectification and rubber sheeting processes later during image processing.

Mastery

Learning Objectives

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

- *Consult initially with Remote Sensing Analyst to confirm project needs.*
- *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.

NOTE: Although this unit deals with scanning processes, before beginning a project ask if the data agency provides the coverage pre-scanned. Increasingly, more agencies are archiving analog air photos by scanning them and in some cases mosaicing certain series. Some agencies offer scanning refined services that can also prove to be cost effective.

Follow-up Units

Suggested:

1. Lecture 2, volume 1, Remote Sensing Core Curriculum
2. Lecture 3, volume 1, Remote Sensing Core Curriculum

3. Lecture 6, volume 1, Remote Sensing Core Curriculum
4. Lecture 10, volume 1, Remote Sensing Core Curriculum
5. Unit 1 - Acquiring data
6. Unit 9 - Converting digital spatial data between formats, systems, and software
7. Unit 14 - Digitizing on-screen
8. Unit 16 - Planning a scanning project
9. Unit 17 - Scanning maps

Resources:

- Aerial Photography and Remote Sensing *[outdated link removed]* by Shannon Crum from The Geographer's Craft
- Remote Sensing Core Curriculum *[outdated link removed]* from the National Center for Geographic Information and Analysis (NCGIA)
- Image Acquisition Helpsheets *[outdated link removed]* from the University of Virginia Library
- ASPRS - American Society for Photogrammetry and Remote Sensing
- MAPPS - Management Association for Private Photogrammetric Surveyors
- Lecture Notes *[outdated link removed]* from The School of Tropical Environment Studies & Geography

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