REMOTE SENSING: DIGITAL DATA

Chapter 04
Introduction to Remote Sensing
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Agenda

- Introduction
- Electronic Imagery
- Spectral Sensitivity
- Digital Data
- Data Formats
- Equipment for Digital Analysis
- Image Processing Software
- Internet

Introduction

- Image can be represented in digital form
- The pattern of image brightness constitutes an array of numbers recorded in digital mode
- Image is represented as numbers of brightness can be added, subtracted, multiplied and divided
- Digital format greatly increases our ability to display, examine, and analyze remote sensing data

Electronic Imagery

- A digital image is composed of many thousands of pixels
- Each pixel represents the brightness of an object, recorded digitally as a numeric value
- A numeric value separates for each of several regions of the electromagnetic spectrum

Electronic Imagery

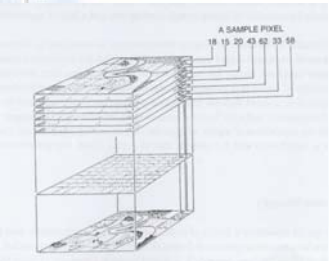

Figure 4.1 Multispectral pixels

Electronic Imagery

- Basic instruments to generate digital image:
  - Optical-Mechanical Scanners
    Physically move mirrors or lenses
  - Charge-Coupled Devices (CCD)
    Formed from light-sensitive material embedded in a silicon chip
- An alternative imaging technology is Complementary Metal-Oxide Semiconductors (CMOS)
  - Provide detail at low cost and low power requirement
  - Often used in camcorders and related consumer products

Electronic Imagery

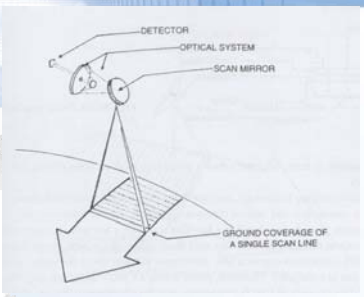

Figure 4.2 Optical-mechanical scanner

Electronic Imagery

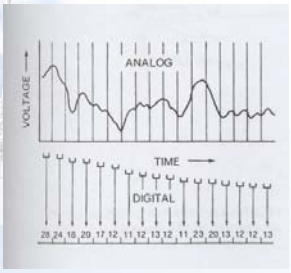

Figure 4.3 Analog to digital conversion

Electronic Imagery

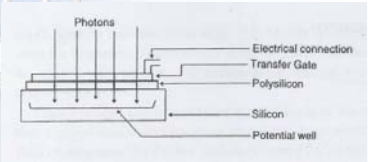

Figure 4.4 Charge-coupled device (CCD)

Electronic Imagery

- Optical sensors often use prisms and filters to separate spectral region
- Electronic sensors usually use diffraction gratings, considered more efficient because of their effectiveness, small size, and lightweight
- CCD can perform *pushbroom scanning* (generating an image from the filed of view forward along the path)

Electronic Imagery

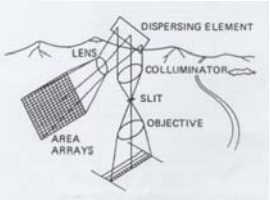

Figure 4.5 Diffraction grating and caluminating lens

Electronic Imagery

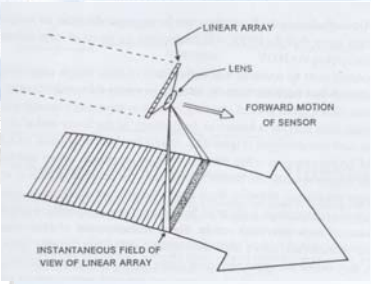

Figure 4.6 CCD used in superbroom scanning

Electronic Imagery

- The IFOV defines the smallest area viewed by sensor and establishes a lower limit for the level of spatial detail that can be represented in a digital image
- Noise is the result of the accumulated errors from various components of the sensor (and also noise in the atmosphere, the interpretation process, etc.)
- Instruments must be designed such their noise levels are small relative to the signal (brightness of the target)

Electronic Imagery

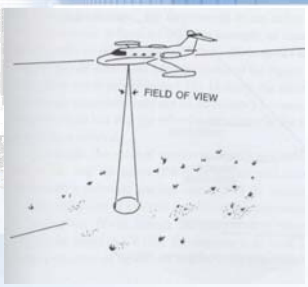

Figure 4.7 *instantaneous field of view* (IFOV)

Electronic Imagery

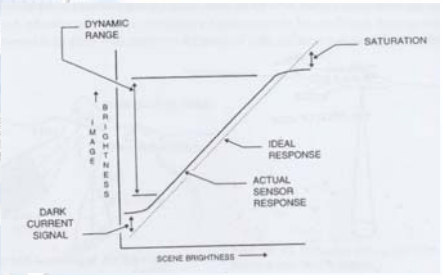

Figure 4.8 Dark current, saturation, and dynamic range

Spectral Sensitivity

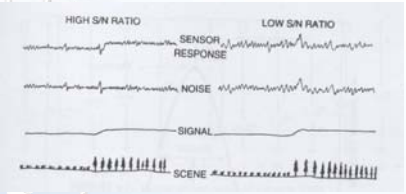

Figure 4.9 Signal-to-noise ratio

Spectral Sensitivity

- The various filters and diffraction gratings do not define discrete limit, spectral sensitivity varies across a specific defined interval
- The spectral sensitivity of an instrument is often specified using the definition of *full width, half maximum* (FWHM)
- FWHM forms a definition of *spectral resolution*, the narrowest spectral interval that can be resolved by an instrument.

Spectral Sensitivity

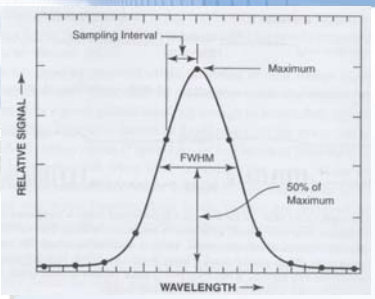

Figure 4.10 Full Width, Half Maximum

Digital Data

- Output from electronic sensors reaches analyst as a set of numeric values
- Discrete digital values for each pixel are recorded in a form suitable for storage on tapes or disks and for analysis by digital computer
- These values are popularly known as “digital numbers”, “brightness values”, or “digital count”
- These values do not record true radiances from the scene

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Digital Data

- The number of brightness values within a digital image is determined by the number of bits available.
- The 8-bit permits a maximum range of 256 possible values (0-255)
- Adding extra bits influences the sensitivity of the sensor and its capabilities for recording and transmitting data
- Design of remote sensing systems requires trade-offs between image coverage and radiometric, spectral, and spatial resolutions

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Digital Data

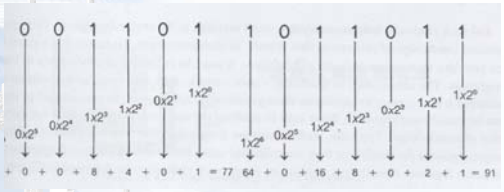

Figure 4.11 Digital representation of values in 7 bits

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Digital Data

TABLE 4.1. Terminology for Computer Storage

Bit	A binary digit (0 or 1)	
Byte	8 bits, 1 character	
Kilobyte (K or KB)	1,024 bytes	(2^{10} bytes)
Megabyte (MB)	1,048,576 bytes	(2^{20} bytes)
Gigabyte (GB)	1,073,741,824 bytes	(2^{30} bytes)
Terabyte (TB)	1,099,511,627,776 bytes	(2^{40} bytes)

Table 4.1 Terminology for Computer Storage

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Digital Data

- The brightness of radiation reflected from the Earth’s surface is measured as brightness (watts) per wavelength interval (micrometer) per angular unit (steradian)
- Thus the measured brightness is defined with respect to wavelength (i.e. “color”), spatial area (angel), and intensity (brightness)
- Radiances record actual brightness, measured in physical units, given as real values

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Data Formats

- Digital image analysis is usually conducted using raster data structures in which each image is treated as an array of values
- Each pixel is treated as a separate unit, which can always be located within the image by its row and column coordinates
- In most remote sensing analysis, coordinates originate in the upper left-hand corner of an image, and are referred to as rows and columns, or as lines and pixels, to measure position down and to the right, respectively

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Data Formats

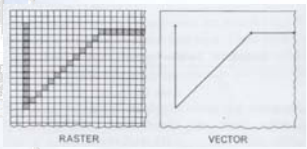

Table 4.12 Raster and Vector formats

Data Formats

- The alternative strategies for storing image data on digital remote sensing:
  - Band Interleaved by Pixel (BIP)
  - Band Interleaved by Line (BIL)
  - Band Sequential (BSQ)
  - Hierarchical Data Format (HDF)
  - Network Common Data Form (NetCDF)
- The "best" data format depends upon immediate context and often upon the specific software and equipment available

Data Formats

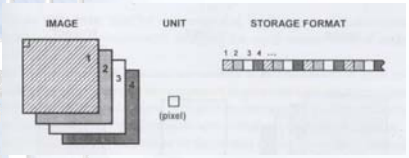

Figure 4.13 Band Interleaved by Pixel (BIP) format

Data Formats

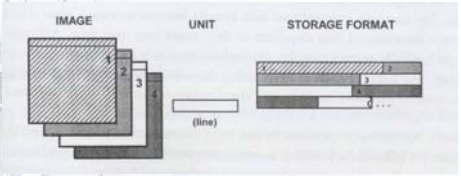

Figure 4.14 Band Interleaved by Line (BIL) format

Data Formats

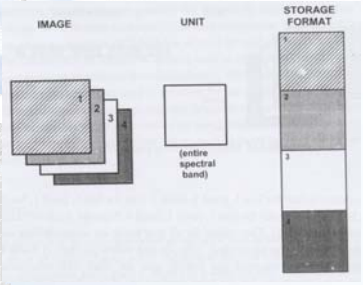

Figure 4.15 Band Sequential (BSQ) format

Data Formats

- Data compression reduces the amount of digital data
- Compression ratio compares the size of the original image to the size of the compresses image
- Data Compression:
  - Lossless compression (e.g. WinZip, etc.)
  - Lossy Compression (e.g. JPEG, etc.)
- For digital satellite data, lossless compression can be achieve ratios from 1.04:1 to 1.9:1
- For digitized cartographic data, ratio of 24:1

Equipment for Digital Analysis

- Digital analysis requires specialized equipment to record remotely senses images
  - Computers
  - Mass Storage
  - Image Display
  - Film Recorders and Color Printers
  - Advanced Image Display

Equipment for Digital Analysis

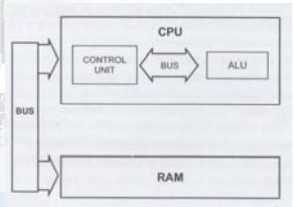

Figure 4.15 Schematic representation of the CPU

Equipment for Digital Analysis

- Mass Storage:
  - Hardisk (50-100 GB and more)
  - Floppy disk (1.44 MB)
  - Zip drive (100-250 MB to 2 GB)
  - CD-R (680 MB)
  - DVD (4.7 GB single-side)
  - Etc.
- Image Display:
  - Cathode ray tube (CRT)
  - Liquid crystal displays (LCD)
  - Plasma display
  - Etc.

Equipment for Digital Analysis

Name and designation	Color depth (bpp)	Screen size
Color graphics adapter (CGA)	2	320 × 200
Extended graphics adapter (EGA)	4	640 × 350
Video graphics array (VGA)	4	640 × 450
Extended graphics array (XGA)	32	1,024 × 768
Widescreen ultra extended graphics array (WUXGA)	32	1,920 × 1,600
Widescreen quad extended graphics array (WQEGA)	32	2,560 × 1,600

Table 4.2 Some graphics standards for computer display

Equipment for Digital Analysis

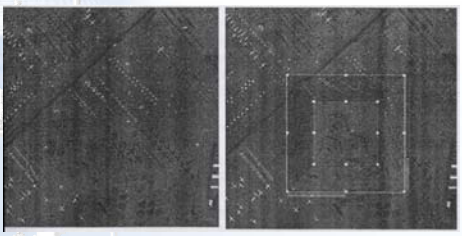

Figure 4.17 Example of “fisheye”-type image display

Equipment for Digital Analysis

Figure 4.18 Example of tiled image display

Image-Processing Software

- Digital remote sensing data can be interpreted by computer programs that manipulate the data recorded in pixels to yield information about specific objects (a.k.a Image processing)
- Some image-processing systems:
  - ER Mapper
  - EASI/PACE
  - ERDAS Imagine
  - GRASS GIS
  - IDRISI
  - Etc.

The Internet

- The internet is a network of computers connected by the world's telecommunication infrastructure
- The availability of the Internet has facilitated not only the acquisition of digital data, but also the equally troublesome task of searching indexes and archives to identity the appropriate coverage
- Technologies related to the internet:
  - FTP and Telnet, URL (www), search engines, Image Formats, Image viewers and online digital archives, etc.

Conclusion

- Remote sensing data is represented in digital form which easier to be analyzed and processed to get the required image
- Remote sensing requires specialized equipments (hardware) and related software, to collect the information, to perform image processing, and to display and store the image

References

- James B. Campbell, *Introduction to Remote Sensing -fourth edition*, The Guilford press, New York, 2007.