CHAPTER 5: Elements of Visual Image Interpretation

REFERENCE: Remote Sensing of the Environment
John R. Jensen (2007)
Second Edition
Pearson Prentice Hall
Reasons why photo/image interpretation are powerful scientific tools:

- scale: aerial/regional perspective;
- three-dimensional depth perception;
- ability to obtain knowledge beyond our human visual perception;
- ability to obtain a historical image record to document change.
CHANGING OUR PERSPECTIVE
CHANGING OUR PERSPECTIVE
LA PARGUERA FROM A PLANE
LA PARGUERA FROM SPACE

Thematic Mapper
EVERYTHING IS ABOUT SCALES

PUERTO RICO FROM THE SHUTTLE
EARTH FROM SPACE
Three-dimensional Perspective:
Stereoscopic Image of St. Louis, Missouri

Three-dimensional Depth Perception
Obtaining Knowledge Beyond our Human Visual Perception


a. Green reflectance of an agricultural area in Saudi Arabia.
b. Red reflectance.
c. Near-infrared reflectance.
d. Color composite (RGB = near-infrared, red, green).
Historical Image Record and Change Detection Documentation

Remote Sensing Imagery as A Historical Record:
Informal City Demolition in Harare, Zimbabwe in 2005

a. QuickBird 61-cm image obtained on April 16, 2005.
b. QuickBird 61-cm image obtained on June 4, 2005.
<table>
<thead>
<tr>
<th>Element</th>
<th>Common Adjectives (quantitative and qualitative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x, y Location</td>
<td>• x, y image coordinates: column (x) and row (y) coordinates in an unrectified image</td>
</tr>
<tr>
<td></td>
<td>• x, y image map coordinates: silver halide crystals or panels in photograph or image are rectified to a map projection (e.g., UTM)</td>
</tr>
<tr>
<td>Tone/Color</td>
<td>• gray tone: light (bright), intermediate (gray), dark (black)</td>
</tr>
<tr>
<td></td>
<td>• color: HSB = intensity, hue (color), saturation, RGB = red, green, and blue, Munsell</td>
</tr>
<tr>
<td>Size</td>
<td>• length, width, perimeter, area (m²)</td>
</tr>
<tr>
<td></td>
<td>• small, medium (intermediate), large</td>
</tr>
<tr>
<td>Shape</td>
<td>• an object's geometric characteristics: linear, curvilinear, circular, elliptical, radial, square, rectangular, triangular, hexagonal, pentagonal, star, amorphous, etc.</td>
</tr>
<tr>
<td>Texture</td>
<td>• characteristic placement and arrangement of repetitions of tone or color</td>
</tr>
<tr>
<td></td>
<td>• smooth, intermediate (medium), rough (coarse), mottled, stippled</td>
</tr>
<tr>
<td>Pattern</td>
<td>• spatial arrangement of objects on the ground: systematic, unsystematic or random, linear, curvilinear, rectangular, circular, elliptical, parallel, concentric, serrated, stratified, layered</td>
</tr>
<tr>
<td>Shadow</td>
<td>• a silhouette caused by solar illumination from the side</td>
</tr>
<tr>
<td>Height/Depth</td>
<td>• z-elevation (height), z-bathymetry (depth), volume (m³), slope *, aspect *</td>
</tr>
<tr>
<td>Volume/Shape/Aspect</td>
<td></td>
</tr>
<tr>
<td>Site</td>
<td>• Site elevation, slope, aspect, exposure, adjacency to water, transportation, utilities</td>
</tr>
<tr>
<td>Situation Association</td>
<td>• Situation: objects are placed in a particular order or orientation relative to one another</td>
</tr>
<tr>
<td></td>
<td>• Association: related phenomena are usually present</td>
</tr>
</tbody>
</table>
Elements of Image Interpretation: Order and Methods of Search

Order
- Location
  - Tone/Color

Primary
- Size
  - Shape
  - Texture
- Pattern
  - Shadow
- Height
  - Depth
  - Volume
  - Slope
  - Aspect

Secondary
- Site
  - Situation
  - Association

Tertiary
- Methods of search

Spatial arrangement of tone/color

Complexity
- Higher
- Use of Collateral Data
  - Convergence of Evidence
  - Use of the Multi-concept
Elements of Image Interpretation - Tone and Color
Elements of Image Interpretation - Tone and Color

Green
Red
Near-infrared

Color composite
RGB = green, red, near-infrared
Elements of Image Interpretation - Tone and Color

- Green
- Red
- Near-infrared
- Mid-infrared
- True Color
- False Color
Elements of Image Interpretation - Size
Elements of Image Interpretation - Shape
Elements of Image Interpretation - Texture
Elements of Image Interpretation - Pattern
Elements of Image Interpretation - Shadow
Elements of Image Interpretation - Height and Depth
Elements of Image Interpretation - Site, Situation and Association
Methods of Search

- Use of Collateral Information
- Convergence of Evidence
- Use of the Multi-concept
Table 5-2. Collateral information often used in the interpretation of aerial photography and other remotely sensed data in the United States.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Collateral Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>General orientation</td>
<td>International Map of the World 1:1,000,000</td>
</tr>
<tr>
<td></td>
<td>National Geospatial-Intelligence Agency (NGA) 1:100,000, 1:250,000</td>
</tr>
<tr>
<td></td>
<td>USGS 7.5-min 1:24,000</td>
</tr>
<tr>
<td></td>
<td>USGS 15-min 1:63,360</td>
</tr>
<tr>
<td></td>
<td>Image browsing systems: Google Earth, Space Imaging, DigitalGlobe, SPOT</td>
</tr>
<tr>
<td>Boundaries or districts</td>
<td>USGS 7.5-min 1:24,000</td>
</tr>
<tr>
<td></td>
<td>USGS 15-min 1:63,360</td>
</tr>
<tr>
<td></td>
<td>Boards – state, county, city, school, fire, voting, water/ sewer</td>
</tr>
<tr>
<td>Cadastral</td>
<td>City and county tax maps</td>
</tr>
<tr>
<td>Geodetic control</td>
<td>USGS digital line graph – elevation</td>
</tr>
<tr>
<td></td>
<td>NGS – nautical and bathymetric charts</td>
</tr>
<tr>
<td>Forestry</td>
<td>USFS – forest stand information</td>
</tr>
<tr>
<td>Geology</td>
<td>USGS – surface and subsurface</td>
</tr>
<tr>
<td>Hazards</td>
<td>FEMA – flood insurance maps</td>
</tr>
<tr>
<td></td>
<td>USCG – environmental sensitivity index</td>
</tr>
<tr>
<td>Hydrology</td>
<td>USGS digital line graph – surface hydrology</td>
</tr>
<tr>
<td></td>
<td>NGS – nautical and bathymetric charts</td>
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<td></td>
<td>USGS – water-supply reports</td>
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<tr>
<td></td>
<td>USGS – stream gauge reports</td>
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<tr>
<td>Socio-economic</td>
<td>Bureau of the Census – demographic data</td>
</tr>
<tr>
<td></td>
<td>– TIGER block data</td>
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<tr>
<td></td>
<td>– census tracts</td>
</tr>
<tr>
<td>Soils</td>
<td>SCS, NRCS – soil taxonomy maps</td>
</tr>
<tr>
<td>Topography/bathmetry</td>
<td>USGS – National elevation dataset (NED)</td>
</tr>
<tr>
<td></td>
<td>NGA – digital terrain elevation data (DTED)</td>
</tr>
<tr>
<td></td>
<td>USCG – nautical and bathymetric charts</td>
</tr>
<tr>
<td>Transportation</td>
<td>USGS digital line graph – transportation</td>
</tr>
<tr>
<td></td>
<td>County and state transportation maps</td>
</tr>
<tr>
<td>Weather/atmosphere</td>
<td>National Weather Service – NEXRAD</td>
</tr>
<tr>
<td>Wetland</td>
<td>USGS – National Wetland Inventory maps</td>
</tr>
<tr>
<td></td>
<td>NOAA – Coastal change analysis program</td>
</tr>
</tbody>
</table>
WORKING WITH DIGITAL DATA

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PROCESSES AFFECTING THE REMOTE SIGNAL

- Satellite in Orbit
- Atmosphere
- Ocean Surface
- Land Surface
- Water Depth (m)
- Relative Depth of Penetration
- Reflection
- Absorption
- Scattering
- Incoming Sunlight
MEASURING THE RADIANCE

What we Measure

What we want

- Inherent Optical Properties of the Water
- Bottom Reflectance

From NEMO Overview
Nemo.nrl.navy.gov
Acquisition and reproduction of remotely sensed images

Element of an image

(x, y, value)

Direction of motion

Transmission to ground-station

Satellite

Sensor

Scanning

Scene

Resolution cell

Sunlight

\( R(\lambda) \)

Pixel coordinates

Grey shades or colour

Sensitivity

Where?

What?

How much?
DIGITAL IMAGING

Picture Elements

PIXELS
MULTISPECTRAL PIXELS
ANALOG TO DIGITAL CONVERSION

ANALOG

VOLTAGE

TIME

DIGITAL

28 24 18 20 17 12 11 12 13 11 23 20 13 12 12 13
SENSITIVITY OF THE SENSOR

DYNAMIC RANGE

IMAGE BRIGHTNESS

DARK CURRENT SIGNAL

SCENE BRIGHTNESS

SATURATION

IDEAL RESPONSE

ACTUAL SENSOR RESPONSE
SIGNAL TO NOISE RATIO (S/N)

HIGH S/N RATIO

SENSOR RESPONSE

LOW S/N RATIO

NOISE

SIGNAL

SCENE
SPECTRAL SENSITIVITY

- Sampling Interval
- Maximum
- FWHM
- 50% of Maximum

RELATIVE SIGNAL

WAVELENGTH
DIGITAL VALUES

- Each digital value is recorded as a series of binary values known as bits.

- A bit (a contraction of binary digit) is the basic unit of information in computing and telecommunications; it is the amount of information stored by a digital device or other physical system that exists in one of two possible distinct states.
DIGITAL VALUES

- Each bit records an exponent of a power of 2, with the value of the exponent determined by the position of the bit in the sequence.

- Example: A system designed to record 7 bits for each digital value. This means that seven binary places are available to record the brightness sensed for each band of the sensor.
A 7 BITS SYSTEM

Bit
A binary digit (0 or 1)

Byte
8 bits, 1 character

Kilobyte (K or KB)
1,024 bytes \((2^{10} \text{ bytes})\)

Megabyte (MB)
1,048,576 bytes \((2^{20} \text{ bytes})\)

Gigabyte (GB)
1,073,741,824 bytes \((2^{30} \text{ bytes})\)

Terabyte (TB)
1,099,511,627,776 bytes \((2^{40} \text{ bytes})\)
**Maximum Digital Values**

\[ \begin{align*}
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
2^0 & 2^1 & 2^2 & 2^3 & 2^4 & 2^5 & 2^6 & 2^7 & 2^8 & 2^9 & 2^{10} \\
\end{align*} \]

11 bits = 2048
From 0 to 2047

# Bits | MDV
---|---
1 | 2
2 | 4
3 | 8
4 | 16
5 | 32
6 | 64
7 | 128
8 | 256
9 | 512
10 | 1024
11 | 2048
RADIOMETRIC DIFFERENTIATION - Examination of any image acquired by remote sensing ultimately depends upon detection of differences in the brightness of objects and the features.

**Radiometric Resolution**: This is the sensitivity to small differences in the radiation of an observed object.

- MSS = 6 bits
- Landsat TM = 8 bits
- IKONOS = 11 bits
- ERS SAR = 16 bits
DATA FORMATS

RASTER

VECTOR
DATA FORMATS
Band Interleaved by Pixel (BIP)
DATA FORMATS
Band Interleaved by Line (BIL)
DATA FORMATS
Band Sequential (BSQ)
Hagamos Un Ejercicio
Ejercicio #1: Explorando La Parguera
Ejercicio 2: Identificar las diferencias entre la imagen visible y la imagen infrarroja de La Parguera.
Ejercicio 3: Principios de escala

- Examine el mapa topográfico del 1966 de La Parguera y determine su escala
- Interprete la escala en la parte inferior de la página.
Ejercicio 3: Principios de escala

- Use una regla y mida la distancia a través del área de estudio de oeste a este. ¿Cuántas pulgadas mide la distancia de oeste a este?
- Coloque la regla sobre la barra de escala que representa Kilómetros y determine:
  
  \[ X \text{ Kilómetros} = X \text{ pulgadas} \]

  ¿Cuántos Kilómetros mide a través del área de estudio de oeste a este?
Ejercicio 3: Principios de escala

➢ Repita las medidas a través del área de estudio de norte a sur y determine:

¿Cuántas pulgadas mide la distancia de norte a sur?
¿Cuántos kilómetros mide la distancia a través del área de estudio de norte a sur?
Ejercicio 4: Medidas de Área

- Utilice las medidas de distancia de norte a sur y de oeste a este y determine:

  ¿Cuál es el Área, del área de estudio, en pulgadas cuadradas?
  ¿Cuál es el Área, del área de estudio, en Kilómetros cuadrados?

Información: Área es la medida que se obtiene cuando se multiplica el largo por el ancho.
Ejercicio 5: Medidas de Distancia

- Seleccione los dos mismos puntos en las imágenes y determine la distancia en millas.