CHAPTER 4: DIGITAL IMAGERY
Total Radiance is converted to digital values at each pixel in the images. Then digital values are calibrated to radiance (or reflectance) values at different wavelengths (or bands).
Acquisition and reproduction of remotely sensed images

Element of an image
pixel
( x, y, value)

Direction of motion
Satellite

Transmission to ground-station

Sensor

Scanning
Scene

Resolution cell

R(λ)

Sunlight

Pixel coordinates

Grey shades or colour

Where?

What?

How much?

Sensitivity
Un megapíxel (Mpx) equivale a 1 millón de píxeles. Usualmente se utiliza esta unidad para expresar la resolución de imagen de cámaras digitales convencionales. Por ejemplo, una cámara que puede tomar fotografías con una resolución de \(2048 \times 1536\) píxeles se dice que tiene 3.1 megapíxeles \((2048 \times 1536 = 3.145.728)\).

| 0.3 | 640 x 480 |
| 1.2 | 1280 x 960 |
| 2.0 | 1600 x 1200 |
| 3.0 | 2048 x 1536 |
| 5.3 | 3008 x 1960 |
| 6.3 | 3088 x 2056 |
| 11.1 | 4064 x 2704 |
MULTISPECTRAL PIXELS
Figure 4.2. Optical-mechanical scanner. Whereas a linear array (a) acquires imagery line by line as its field of view slides forward along the ground track, an optical-mechanical scanner (b) oscillates from side to side to build coverage pixel by pixel as the field of view progresses forward.
ANALOG TO DIGITAL CONVERSION
INSTANTANEOUS FIELD OF VIEW (IFOV)
FIGURE 4.5. Dark current, saturation, and dynamic range.
FIGURE 4.6. Examples of sensors characterized by high and low gain.
FIGURE 4.7. Signal-to-noise (S/N) ratio. At the bottom, a hypothetical scene is composed of two cover types. The signal records this region, with only a small difference in brightness between the two classes. Atmospheric effects, sensor error, and other factors contribute to noise, which is added to the signal. The sensor then records a combination of signal and noise. When noise is small relative to the signal (left: high S/N ratio), the sensor conveys the difference between the two regions. When the signal is small relative to noise (right, low S/N ratio) the sensor cannot portray the difference in brightness between the two regions.
Each digital value is recorded as a series of binary values known as **bits**.

- A **bit** is the smallest possible unit of information.

- It can be in one of two states –
  - off (0) or on (1).

**Example:** A system designed to record 2 bits for each digital value. This means that two binary places are available to record the brightness sensed for each band of the sensor. The possible combinations are four.
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.
MAXIMUM DIGITAL VALUES

1 + 2 + 4 + 8 + 16 + 32 + 64 + 128 + 256 + 512 + 1024

1 2 4 8 16 32 64 128 256 512 1024

# Bits | MDV
---|---
1 | 2
2 | 4
3 | 8
4 | 16
5 | 32
6 | 64
7 | 128
8 | 256
9 | 512
10 | 1024
11 | 2048
12 | 4096

11 bits = 2048
From 0 to 2047
### TABLE 4.1. Terminology for Computer Storage

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Value</th>
<th>Binary Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit</td>
<td>A binary digit (0 or 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Byte</td>
<td>8 bits, 1 character</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kilobyte (K or KB)</td>
<td>1,024 bytes</td>
<td>(2^{10} bytes)</td>
<td></td>
</tr>
<tr>
<td>Megabyte (MB)</td>
<td>1,048,576 bytes</td>
<td>(2^{20} bytes)</td>
<td></td>
</tr>
<tr>
<td>Gigabyte (GB)</td>
<td>1,073,741,824 bytes</td>
<td>(2^{30} bytes)</td>
<td></td>
</tr>
<tr>
<td>Terabyte (TB)</td>
<td>1,099,511,627,776 bytes</td>
<td>(2^{40} bytes)</td>
<td></td>
</tr>
</tbody>
</table>
**KEY CONCEPTS OF REMOTE SENSING**

**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
- ERS SAR = 16 bits
FIGURE 4.12. Band interleaved by pixel format. In effect, each band is subdivided such that pixels from the several bands are collected together and written to digital storage in neighboring positions. Pixels from each band are intermingled as illustrated.
FIGURE 4.13. Band interleaved by line format. Lines of pixels from each band are selected, then written to digital storage such that the lines for separate bands are positioned in sequence. Lines from each band are intermingled as illustrated.
FIGURE 4.14. Band sequential (BSQ) format. The structure of each band is retained in digital storage—all pixels for each band are written in their entirety before the next band is written. There is no intermingling of pixels from separate bands.
FIGURE 4.15. 742 band combination.

FIGURE 4.16. 451 band combination.
FIGURE 4.19. Schematic representation of the loss of visual information in display of digital imagery. (a) Often the brightness range of digital imagery exceeds the ability of the image display to represent it to the human visual system. (b) Image enhancement rescales the digital values to more nearly match the capabilities of the display system.
LINEAR STRETCH

FIGURE 4.21. Linear stretch spreads the brightness values over a broader range, allowing the eye to see detail formerly concealed in the extremely dark or bright tones.
LINEAR ENHANCEMENT
FIGURE 4.22. Histogram equalization spreads the range of brightness values but preserves the peaks and valleys in the histogram.
HISTOGRAM EQUALIZATION
FIGURE 4.23. Density slicing assigns colors to specific intervals of brightness values. See also Plates 3 and 15.
DENSITY SLICING
Read Chapter 4 and answer the review questions 1, 6, and 8 (at the end of the chapter).