Digital Data and Binary Numbers

1. Digital Data
2. Binary numbers
3. How digital data is displayed on the monitor
4. Color
5. Data formats
Digital Remote Sensing Data

- Matrix of rows and columns
- Each pixel has a value
  - corresponds to brightness range of the color in each array
Binary Numbers

100111000

101001
193 = 100 + 90 + 3

<table>
<thead>
<tr>
<th>Hundreds</th>
<th>Tens</th>
<th>Ones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

193 is really \((1 \times 10^2) + (9 \times 10^1) + (3 \times 10^0)\) = 100 + 90 + 3

Binary numbers are 'base two digits'

\[
\begin{array}{ccc}
2^2 & 2^1 & 2^0 \\
0 & 1 & 1 \\
\end{array}
\]
Binary numbers are 'base two digits'

\[ 7 = 4 + 2 + 1 \]

<table>
<thead>
<tr>
<th>$2^2$</th>
<th>$2^1$</th>
<th>$2^0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Binary number = 111

\[ 3 = 0 + 1 + 1 \]

<table>
<thead>
<tr>
<th>$2^2$</th>
<th>$2^1$</th>
<th>$2^0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Binary number = 11

- Each column represents one “bit”

<table>
<thead>
<tr>
<th>$2^2$</th>
<th>$2^1$</th>
<th>$2^0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

- “8-bit image” stores 8 bits for each pixel (from 00000000-11111111)

\[ 2^8 = 256 \text{ (grayscale)} \]
“Additive color”

- Red, Green, and Blue are primary colors, all others can be made from them
- Yellow is not yellow, it is a combination of red and green

True Color

- Adds Red, Green, Blue arrays (each are 8 bits) together
- “24-bit image”
But data collected from sensors not in 0-255 values, so must be converted.

Signed vs. Unsigned

<table>
<thead>
<tr>
<th>Number Type Name</th>
<th>No. of Bits</th>
<th>Minimum Possible Value</th>
<th>Maximum Possible Value</th>
<th>Other Names, Abbreviations &amp; Symbols in Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsigned Byte</td>
<td>8</td>
<td>0</td>
<td>255</td>
<td>Byte</td>
</tr>
<tr>
<td>Signed Short Integer</td>
<td>16</td>
<td>-32,768</td>
<td>32,767</td>
<td>Short, I2, Integer*2</td>
</tr>
<tr>
<td>Signed Long Integer</td>
<td>32</td>
<td>-2,147,483,648</td>
<td>2,147,483,647</td>
<td>Long, I4, Integer*4</td>
</tr>
<tr>
<td>Single Precision Floating Point (SAR image)</td>
<td>32</td>
<td>-3.403*10^{38}</td>
<td>3.403*10^{38}</td>
<td>Single, R4, Real*4</td>
</tr>
</tbody>
</table>

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24-bit “true color” display

Each screen pixel is represented by three groups of eight pixels, for a total of 24 bits.

Blue | Green | Red

Pixels on the computer screen:

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Photoshop color picker shows the R, G, B components that make “yellow.”
2 ways to convert:

1. **Linear Mapping**
   
   Take numerical range of data for each of the three colors and create a linear map (equal class intervals)

   ![Linear mapping – equal class intervals](image)

   Problem: if you have outliers, image will be really dark or really light.

2. **Equalization** (equal class frequencies)
   
   Produces image with more contrast

   ![Non-linear mapping – equal class frequencies](image)
3 types of images can be stored and seen on the computer:

1. **Color images**

   a) **Natural color images:**
   Red, green, blue bands represent these actual colors as we see them

   b) **False color images:**
   assign three bands that do not represent actual green blue and red

   c) **Pseudocolor image:**
   one band, values range from 0-256 and levels of values are assigned a color on a look up table.

2. **Grayscale images**

   - One single band
   - Has all colors, but colors have same values (127, 127, 127)
3 types of images can be stored and seen on the computer:

3. Labeled/classified images

- pixels’ value represents a tag that indicates a property
- used for landcover, e.g.: 1=ag., 2=water, etc.

Data Formats
Data format

Describes the way that data is written to storage

Usually contain:

1. Metadata (description about the data: projection, scan lines, pixels per line)
   
2. Image Data
   - pixel values of each band, arranged band by band
File compression

Lossy vs. Lossless

**Lossless**: preserve all data  
- can always obtain original data  
- file size may not be compressed that much

**Lossy**: loses some information in compression (JPEG)  
- smaller file sizes, easy sharing  
- cannot obtain original data

8888883333

**Lossy**: 83

File compression

quadtree: as a 2-D compression scheme  
- image must be square and length must be a power of 2.

If many homogeneous areas, file will be compressed  
If many non-homogeneous areas are there, file may be much larger
*System Processing:
need to take info collected from sensors and turn into usable format

- remove noise
- correct for pixel misalignments from sensors (called geometric correction in Ch.4)
- pixels relocated (projected) (Chapter 4)
- image geometry corrected
determined by orbital height,
direction of motion