Bharathidasan University , Tiruchirappalli, Tamil Nadu

Programme: M.Tech Geoinformatics
Course: Digital Image Processing

Unit: 1 INTRODUCTION TO DIGITAL IMAGE PROCESSING

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Digital Image Processing

Unit 1 **INTRODUCTION TO DIGITAL IMAGE PROCESSING**

M.Tech Geoinformatics
Course: Digital Image Processing

- Remote Sensing Process
- Analog to Digital data
- Digital image data formats
- Image processing system characteristics
- Initial statistical extraction: histograms, univariate and multivariate statistics
- Scientific visualization - Image Preprocessing: calculating radiance from DNs
- Atmospheric, radiometric and geometric correction.

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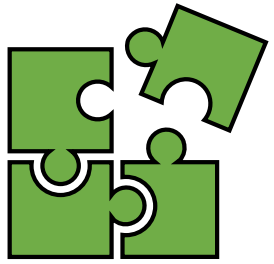
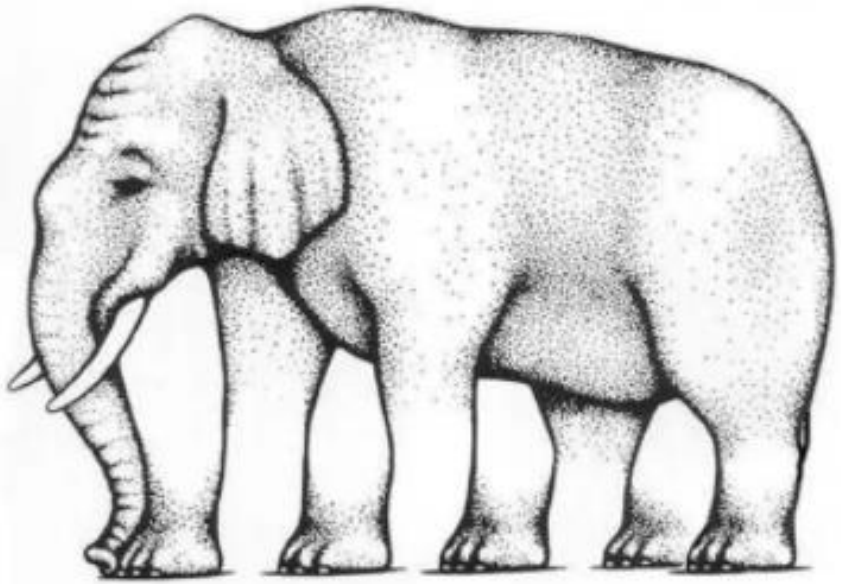
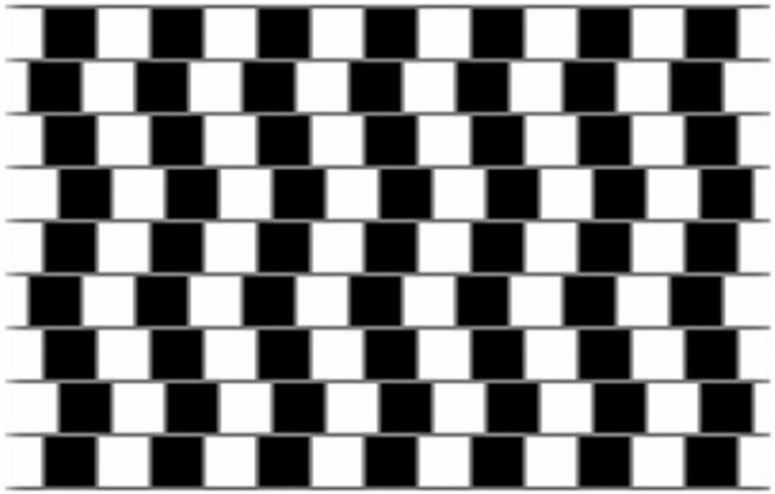
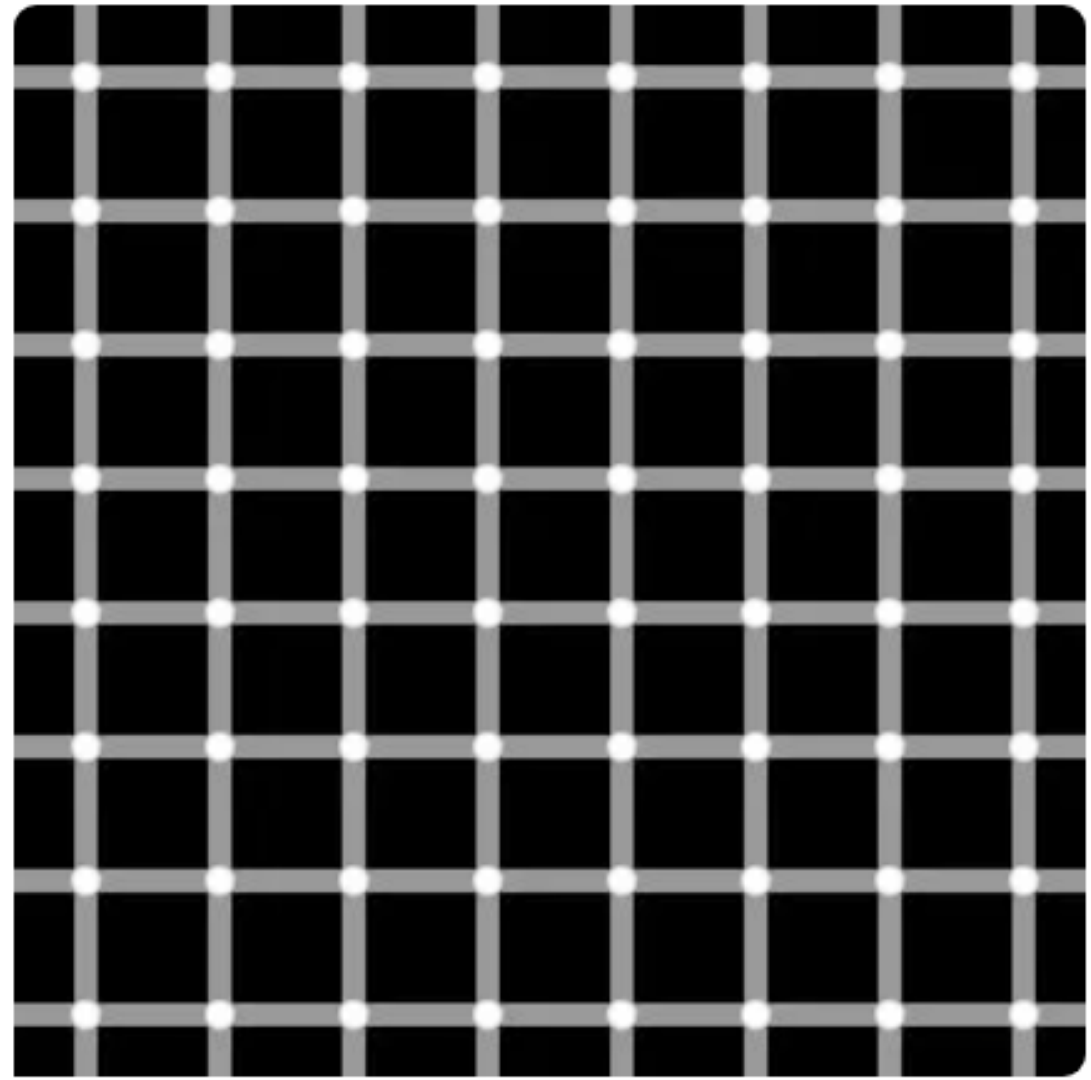








Public Domain Image

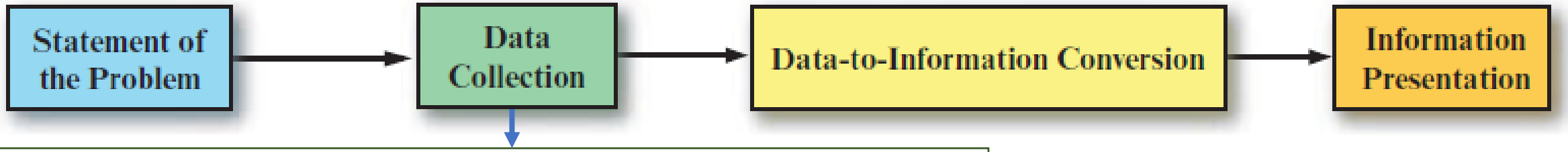
Remote Sensing Process

- **Formulate Hypothesis**
  (if appropriate)

- **Select Appropriate Logic**
  - Inductive and/or
  - Deductive
  - Technological

- **Select Appropriate Model**
  - Deterministic
    - Empirical
    - Knowledge-based
    - Process-based
  - Stochastic

Remote Sensing Process

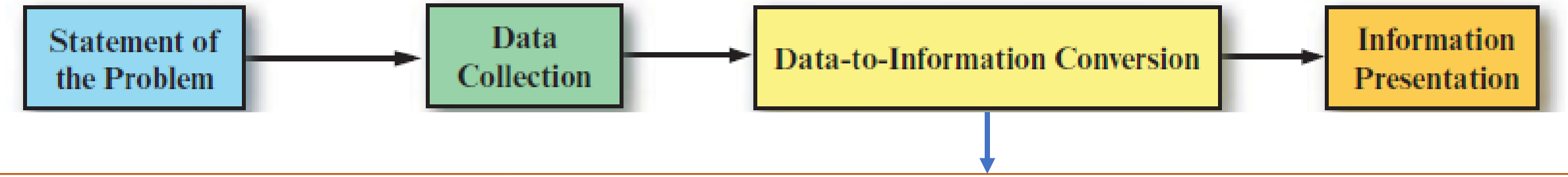


- ***In Situ* Measurements**
  - Field (e.g., x, y, z from GPS, biomass, reflectance)
  - Laboratory (e.g., reflectance, leaf area index)

- **Collateral Data**
  - Digital elevation models
  - Soil maps
  - Surficial geology maps
  - Population density, etc.

- **Remote Sensing**
  - Passive analog
    - Frame camera
    - Videography
  - Passive digital
    - Frame camera
    - Scanners
      - Multispectral
      - Hyperspectral
    - Linear and area arrays
      - Multispectral
      - Hyperspectral
  - Active
    - Microwave (RADAR)
    - Laser (LiDAR)
    - Acoustic (SONAR)

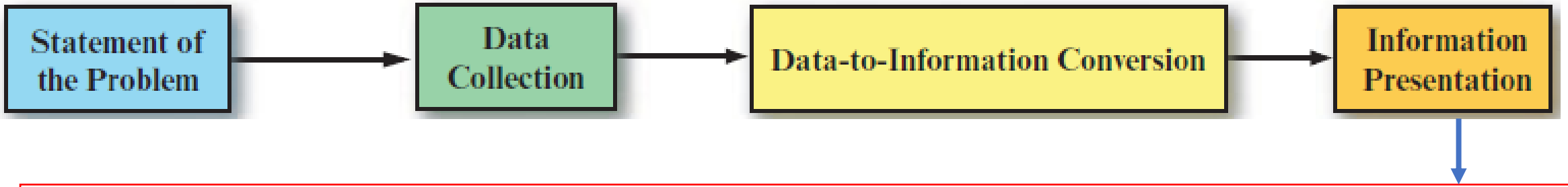
Remote Sensing Process



- **Analog (Visual) Image Processing**
  - Using the *Elements of Image Interpretation*

- **Digital Image Processing**
  - Preprocessing
    - Radiometric Correction
    - Geometric Correction
  - Enhancement
  - Photogrammetric analysis
  - Parametric, such as:
    - Maximum likelihood
  - Nonparametric, such as:
    - Artificial neural networks
  - Nonmetric, such as:
    - Expert systems
    - Decision-tree classifiers
    - Machine learning
  - Nonmetric, such as:
    - Expert systems
    - Decision-tree classifiers
    - Machine learning
  - Hyperspectral analysis
  - Change detection
  - Modeling
    - Using GIS data
    - Scene modeling
  - Scientific geovisualization
    - 1, 2, 3, and *n* dimensions

Remote Sensing Process

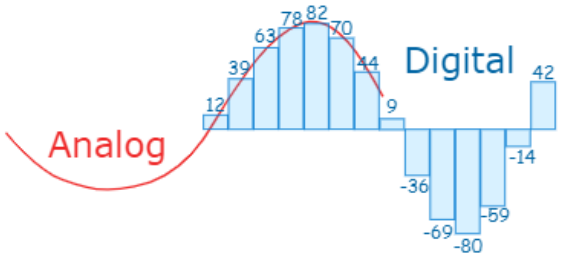


- **Image Metadata**
  - Sources
  - Processing lineage
- **Accuracy Assessment**
  - Geometric
  - Radiometric
  - Thematic
  - Change detection

- **Analog and Digital**
  - Images
    - Unrectified
    - Orthoimages
  - Orthophotomaps
  - Thematic maps
  - GIS databases
  - Animations
  - Simulations

- **Statistics**
  - Univariate
  - Multivariate
- **Graphs**
  - 1, 2, and 3 dimensions

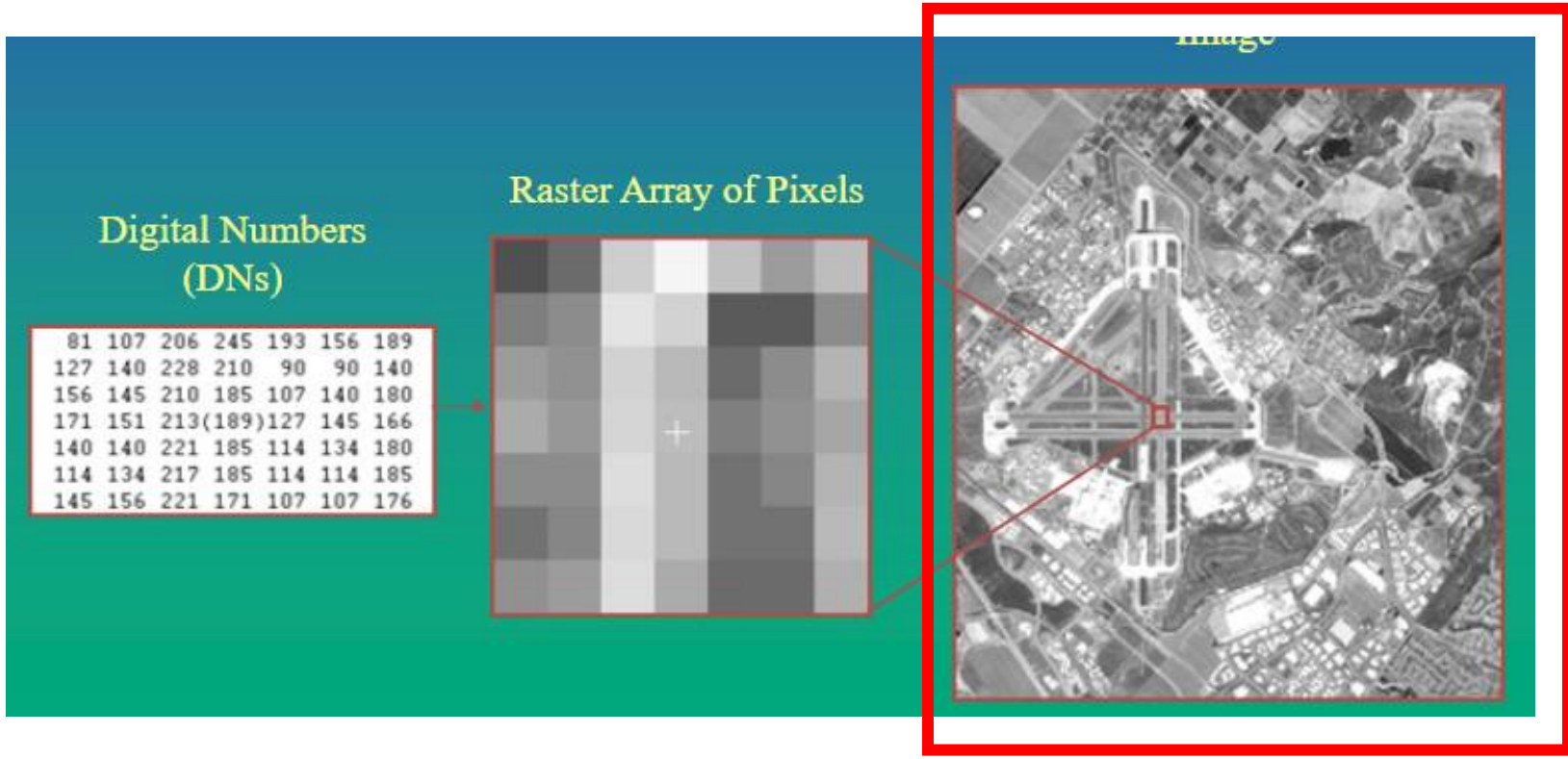
Analog and Digital



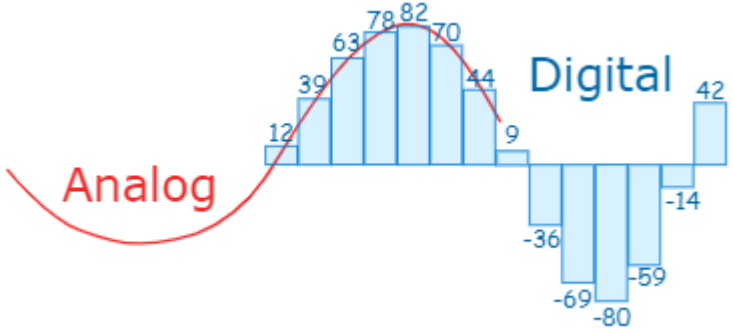
Analog (Visual) Image Processing

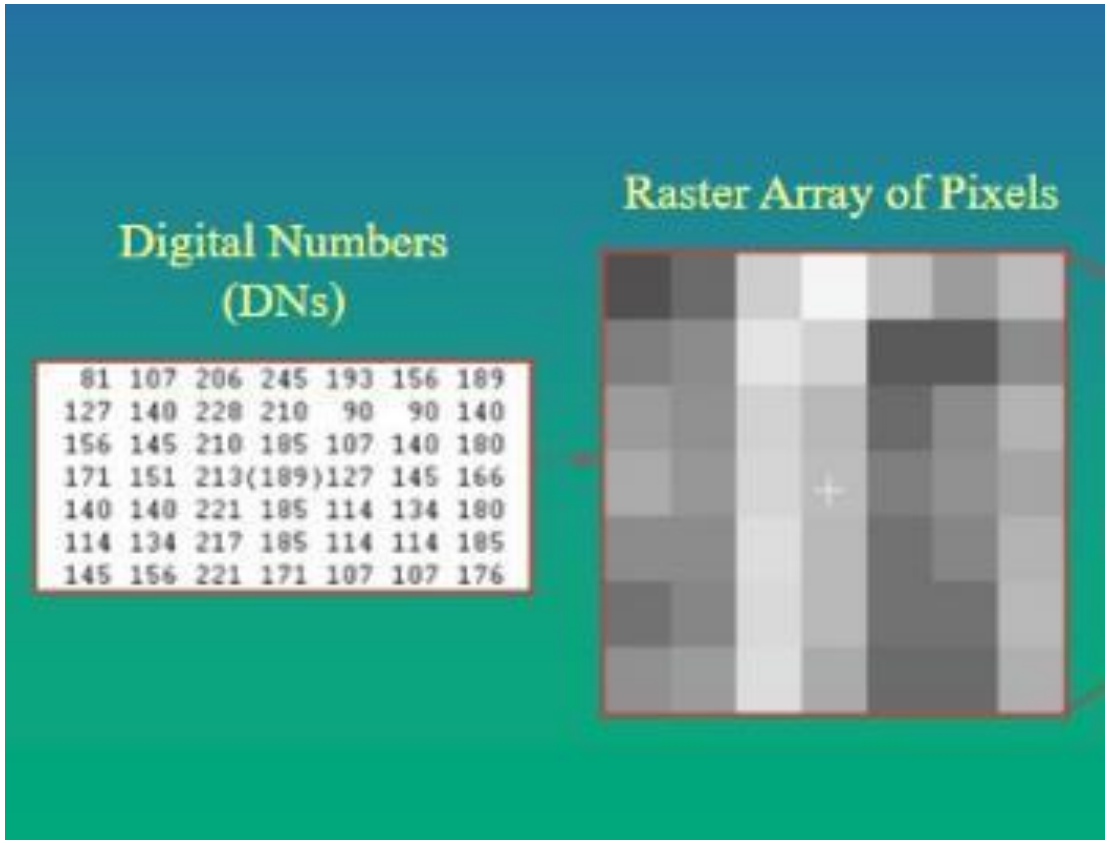
Elements of Image Interpretation

- Grayscale tone (black to white)
- Color (RGB = red, green, blue)
- Height (elevation) and depth
- Size (length, area, perimeter, volume)
- Shape
- Texture
- Pattern
- Shadow
- Site
- Association
- Arrangement



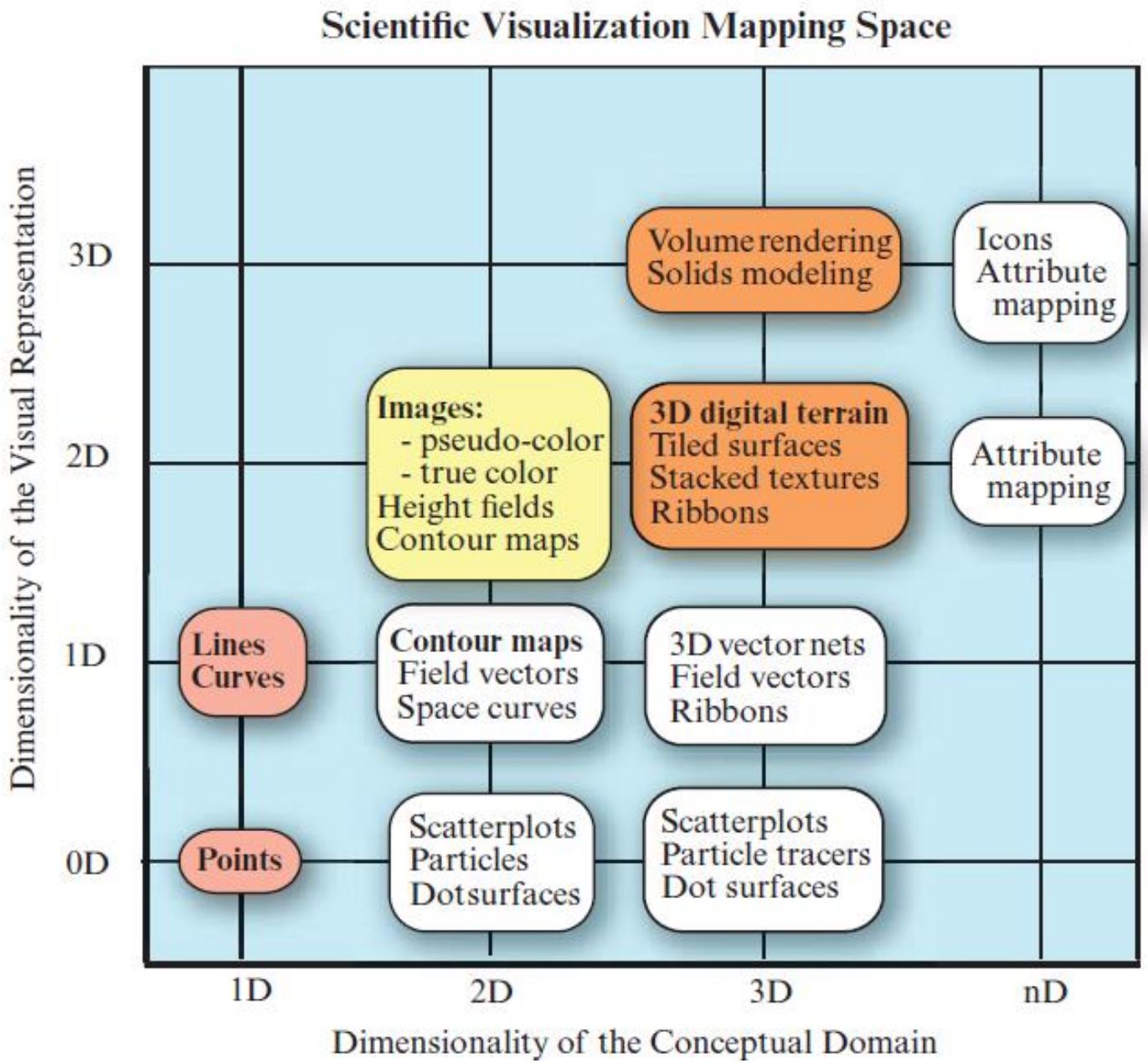
Analog and Digital



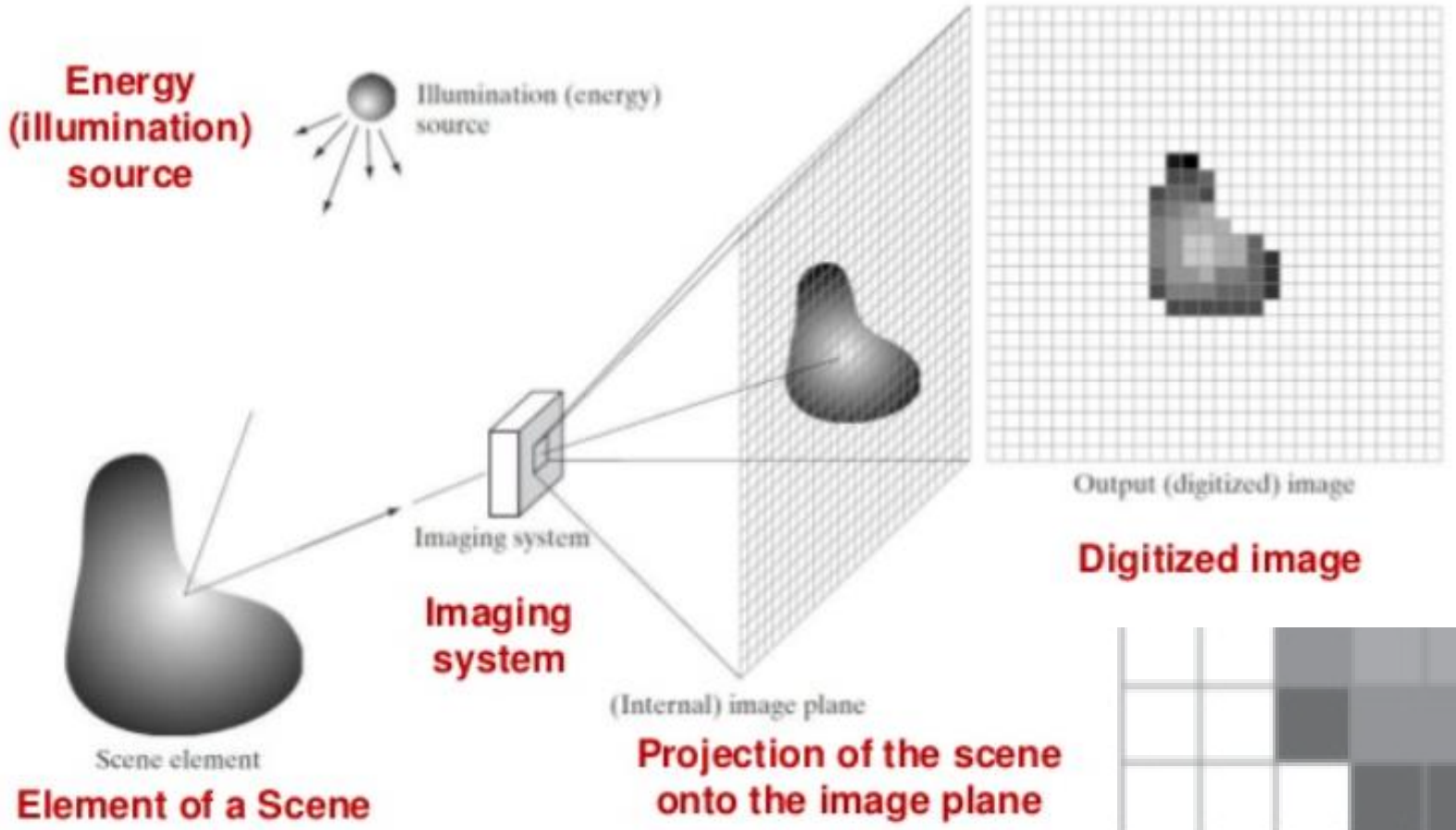


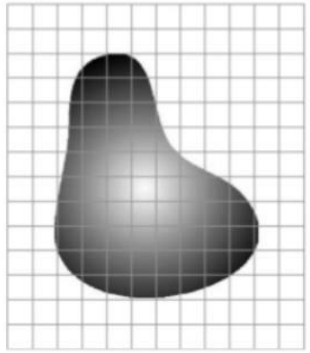
How the Elements of Image Interpretation Are Extracted or Used in Digital Image Processing

- 8- to 12-bit brightness values or scaled to surface reflectance or emittance
- 24-bit color look-up table display
  - Multiband RGB color composites
  - Transforms (e.g., intensity, hue, saturation)
- Soft-copy photogrammetry, radargrammetry, RADAR interferometry, LiDAR, SONAR
- Soft-copy photogrammetry, radargrammetry, RADAR interferometry
- Soft-copy photogrammetry, radargrammetry, interferometry, landscape ecology metrics, object-based image analysis (OBIA) segmentation
- Texture transforms, geostatistical analysis, landscape ecology metrics, fractal analysis
- Autocorrelation, geostatistical analysis, landscape ecology metrics, fractal analysis
- Soft-copy photogrammetry, radargrammetry, measurement from rectified images
- Contextual, expert system, neural network analysis
- Contextual, expert system, neural network analysis
- Contextual, expert system, neural network analysis

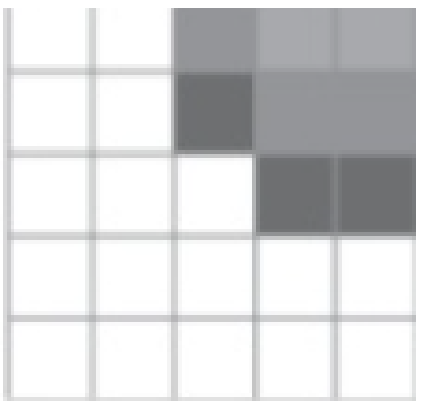

Scientific Visualization Mapping Space
Dimensionality of the Visual Representation
3D
2D
1D
0D
Volume rendering
Solids modeling
Icons
Attribute
mapping
Images:
- pseudo-color
- true color
Height fields
Contour maps
3D digital terrain
Tiled surfaces
Stacked textures
Ribbons
Attribute
mapping
Lines
Curves
Contour maps
Field vectors
Space curves
3D vector nets
Field vectors
Ribbons
Points
Scatterplots
Particles
Dotsurfaces
Scatterplots
Particle tracers
Dot surfaces
1D
2D
3D
nD
Dimensionality of the Conceptual Domain

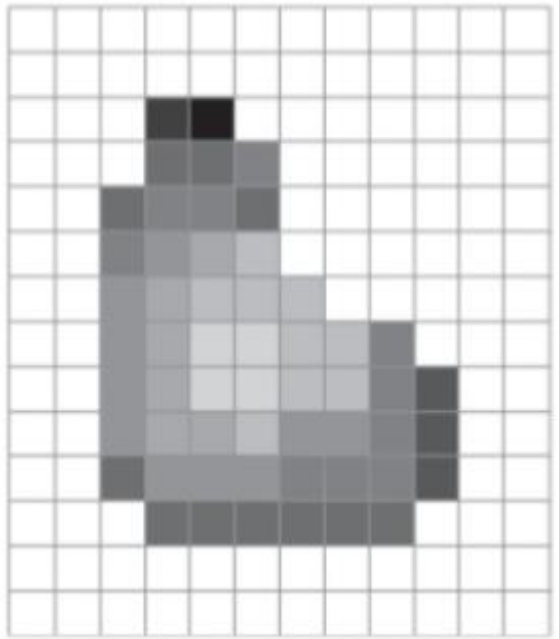
➢ Simple Image Formation Model:



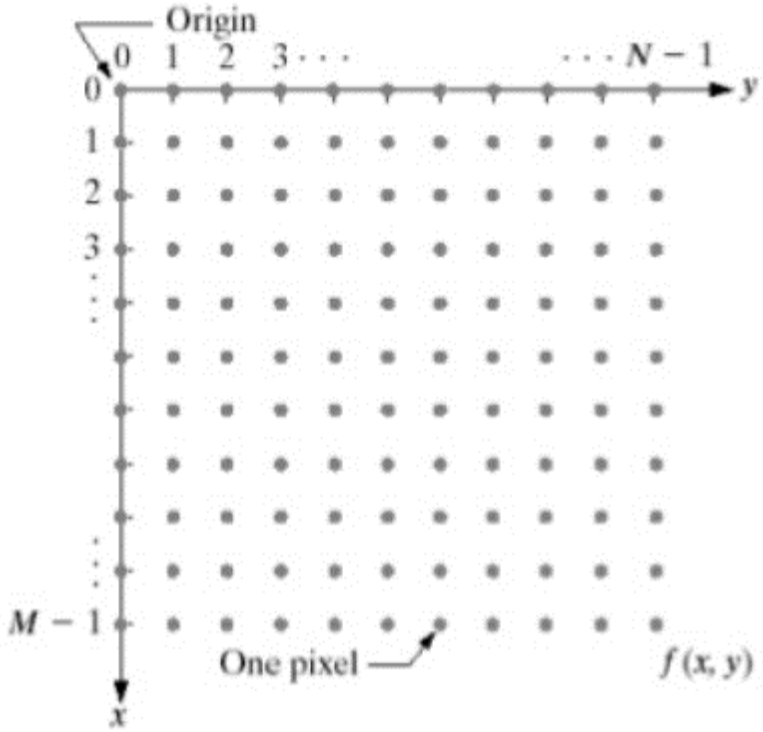


Continuous Image





Digital Image



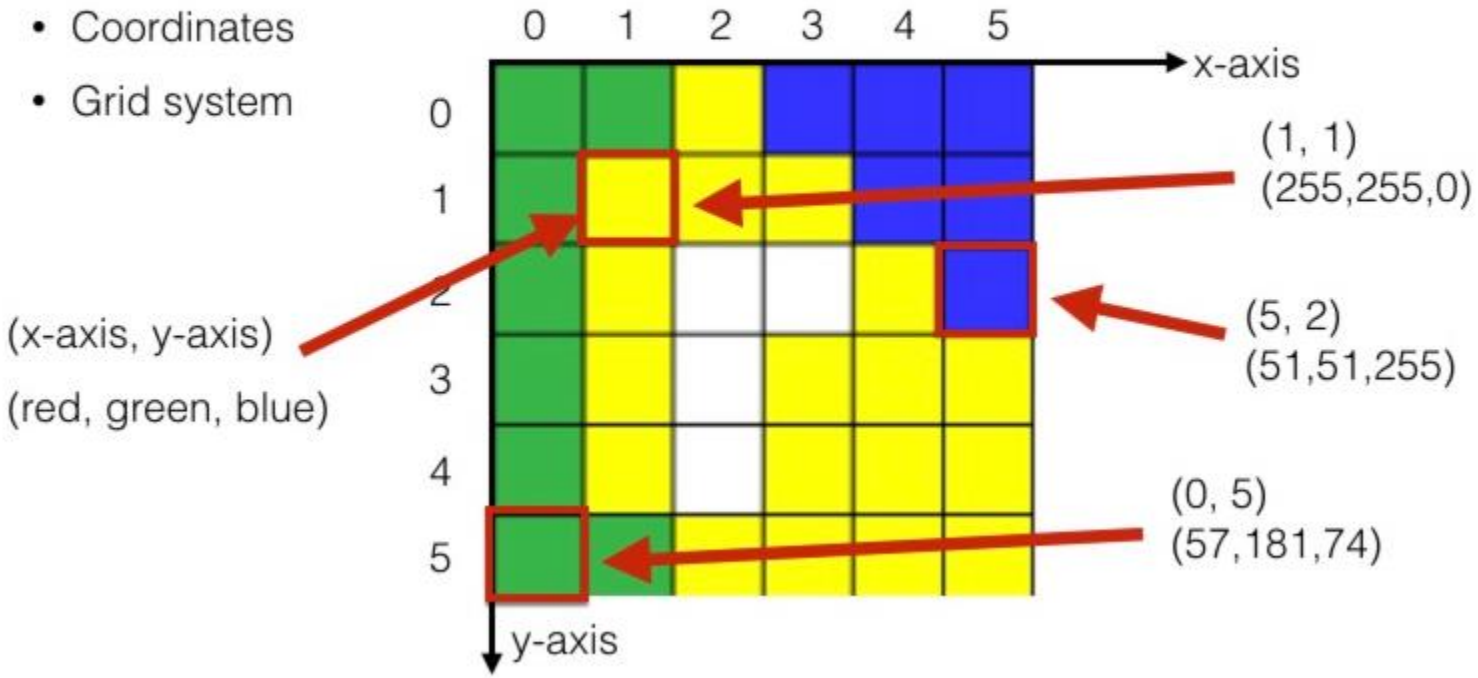
- A digital image is composed of M rows and N columns of pixels each storing a value
- Pixel values are most often grey levels in the range 0-255 (black – white)

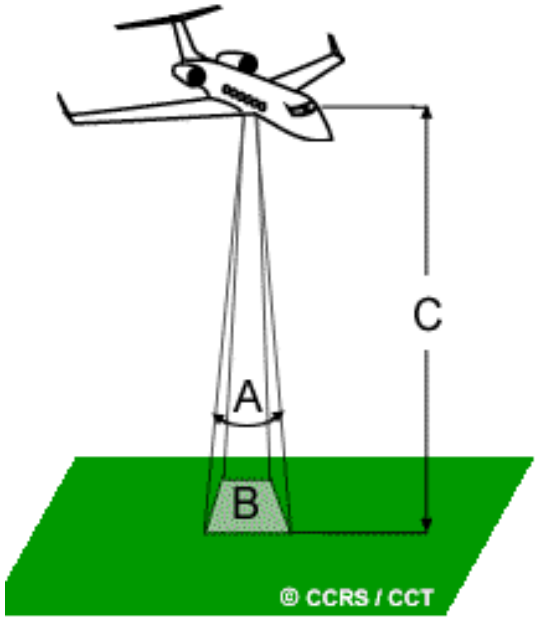
- **Spatial resolution:**
- It is a measure of the smallest discernible detail in an image.
- *Spatial resolution can be:*
  - *line pairs per unit distance, and*
  - *dots (pixels) per unit distance*
- Dots per unit distance is a measure of image resolution used commonly in the printing and publishing industry, expressed as *dots per inch (dpi).*
- For example:
  - Newspapers are printed with a resolution of 75 dpi,
  - Magazines at 133 dpi,
  - Glossy brochures at 175 dpi, and
  - Book page is printed at 2400 dpi.

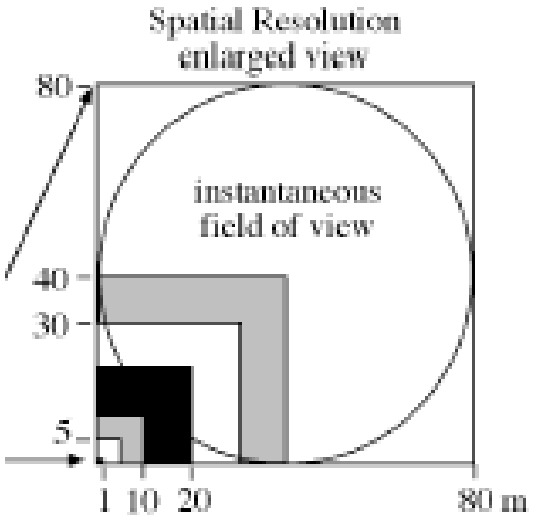
Number of Bits	Number of Intensity Levels
1	2
2	4
4	16
8	256
16	65,536

Understanding the pixel grid

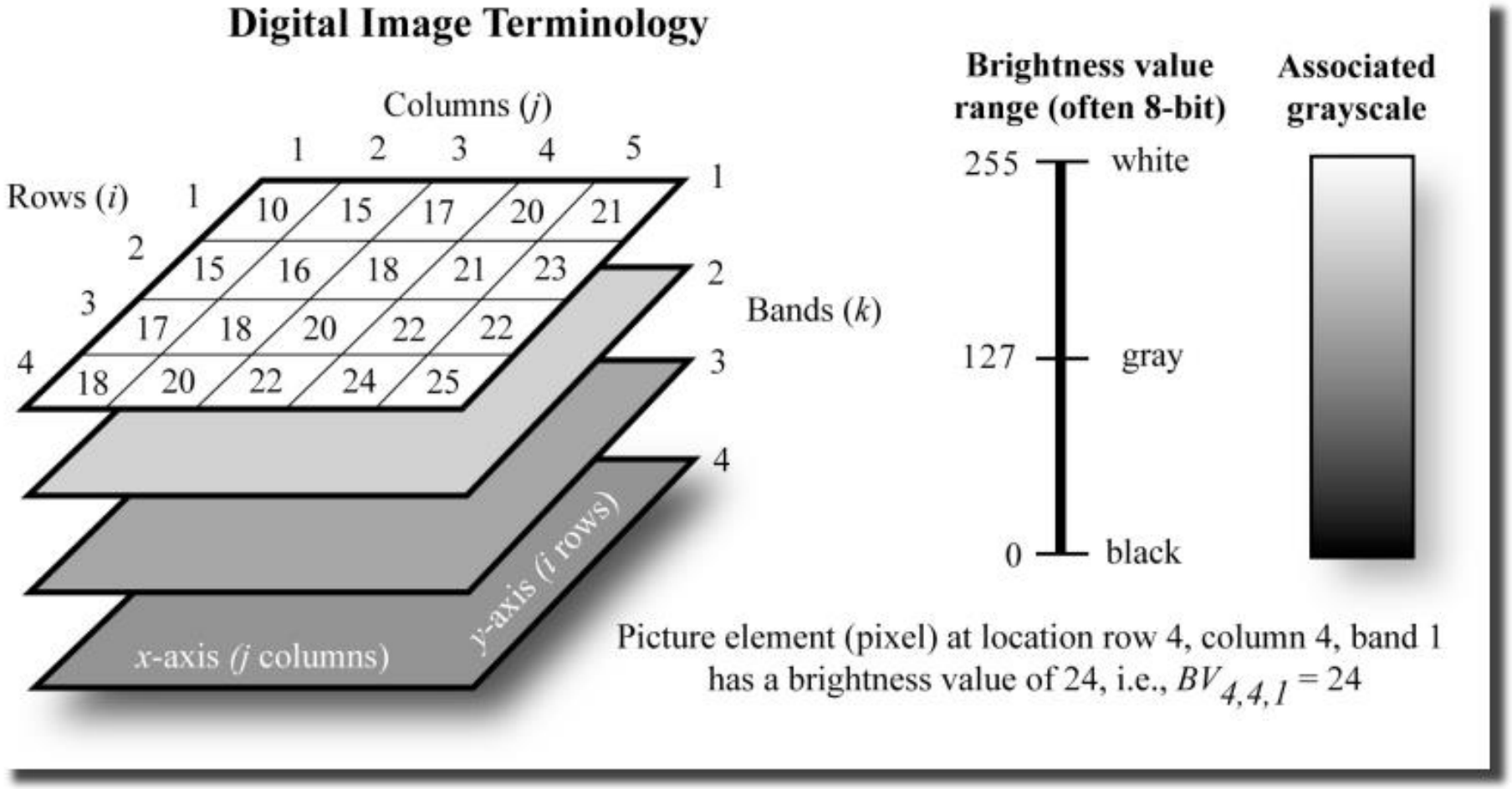
- Coordinates
- Grid system







Remote Sensing raster (matrix) data format

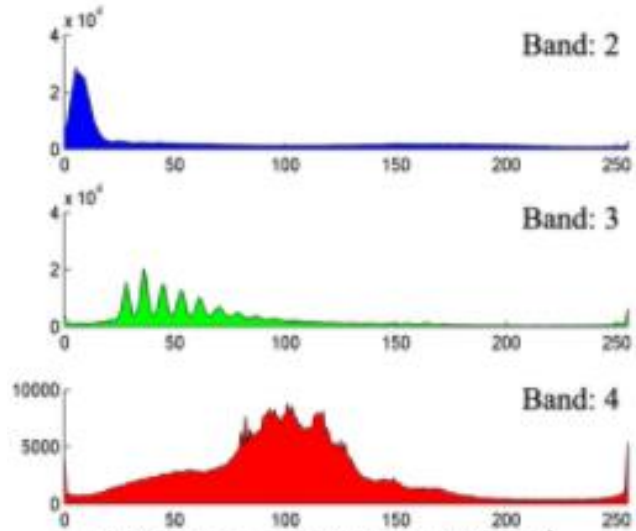


Jensen, 2004

Statistical description of images

- image histogram
- individual pixel values
- univariate descriptive statistics
  statistics derived from a single variable
- multivariate statistics
  statistics derived from multiple variables

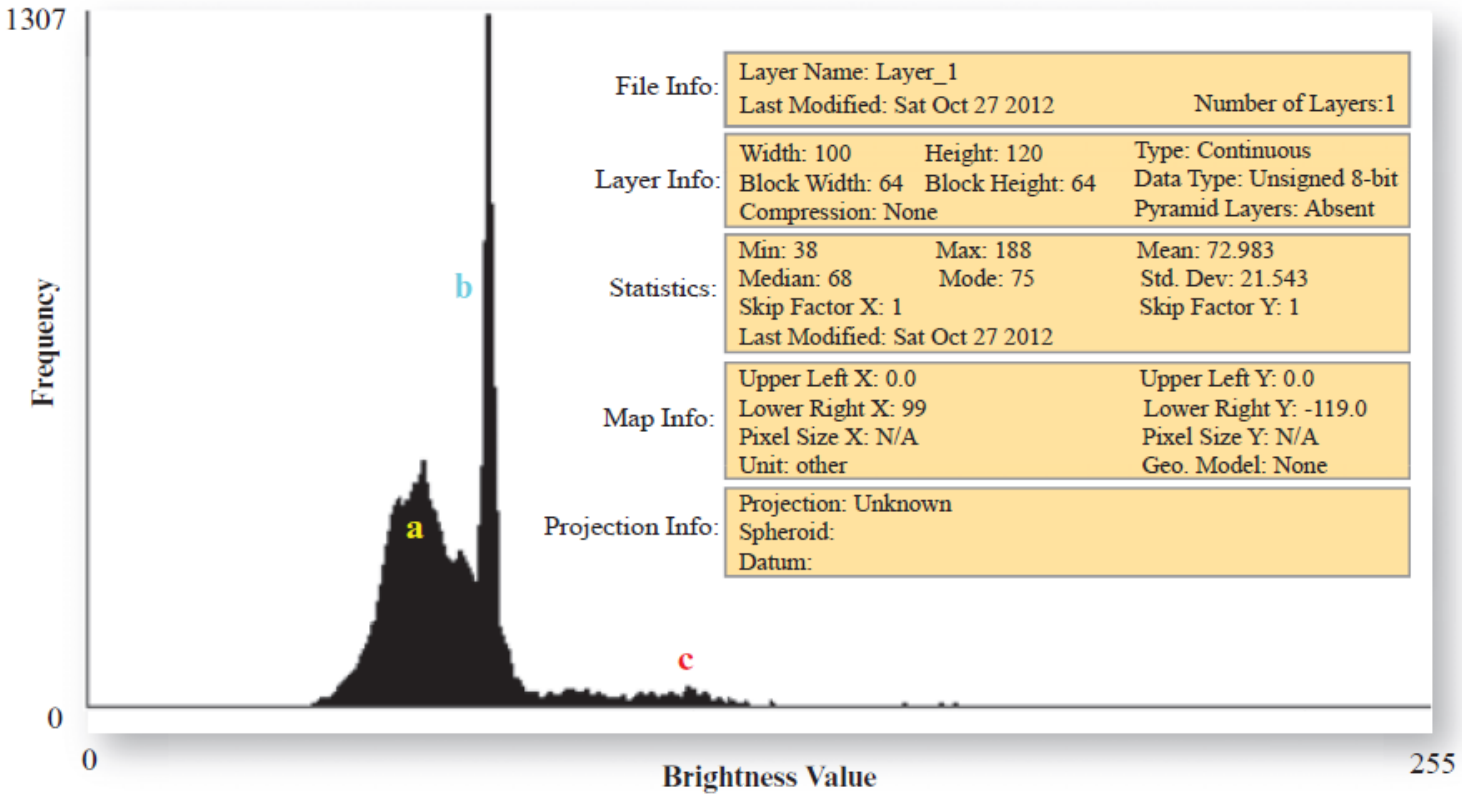
(b)HJ1A-CCD1



(d)Histogram(HJ1A-CCD1）

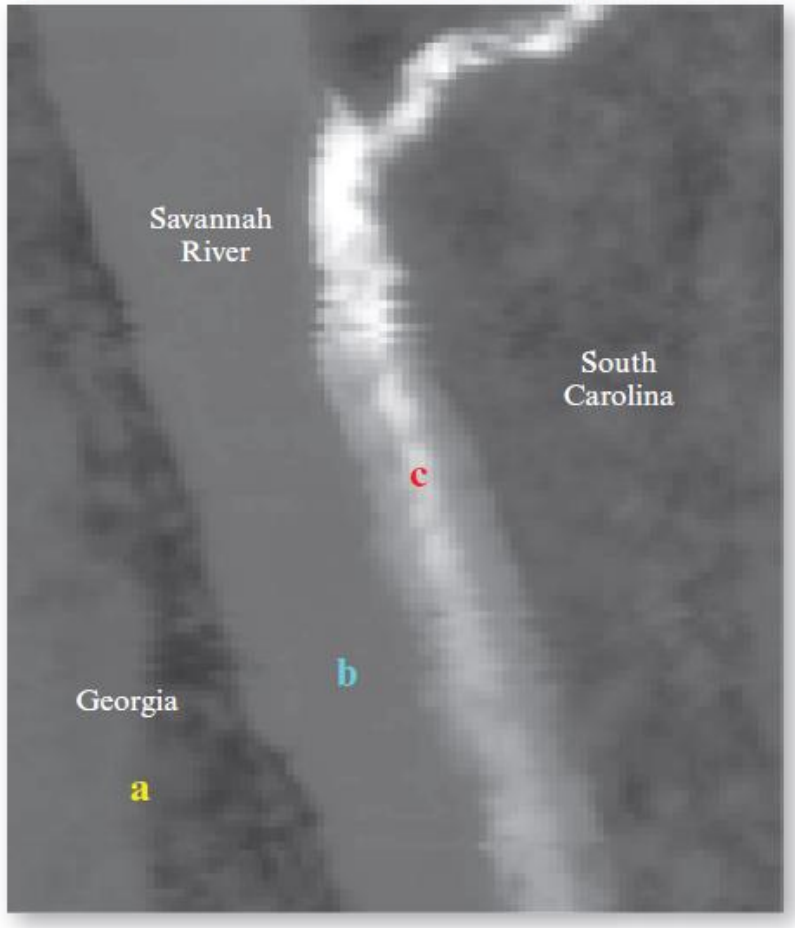
Image histogram

- The frequency of occurrence of individual or binned brightness values in an image



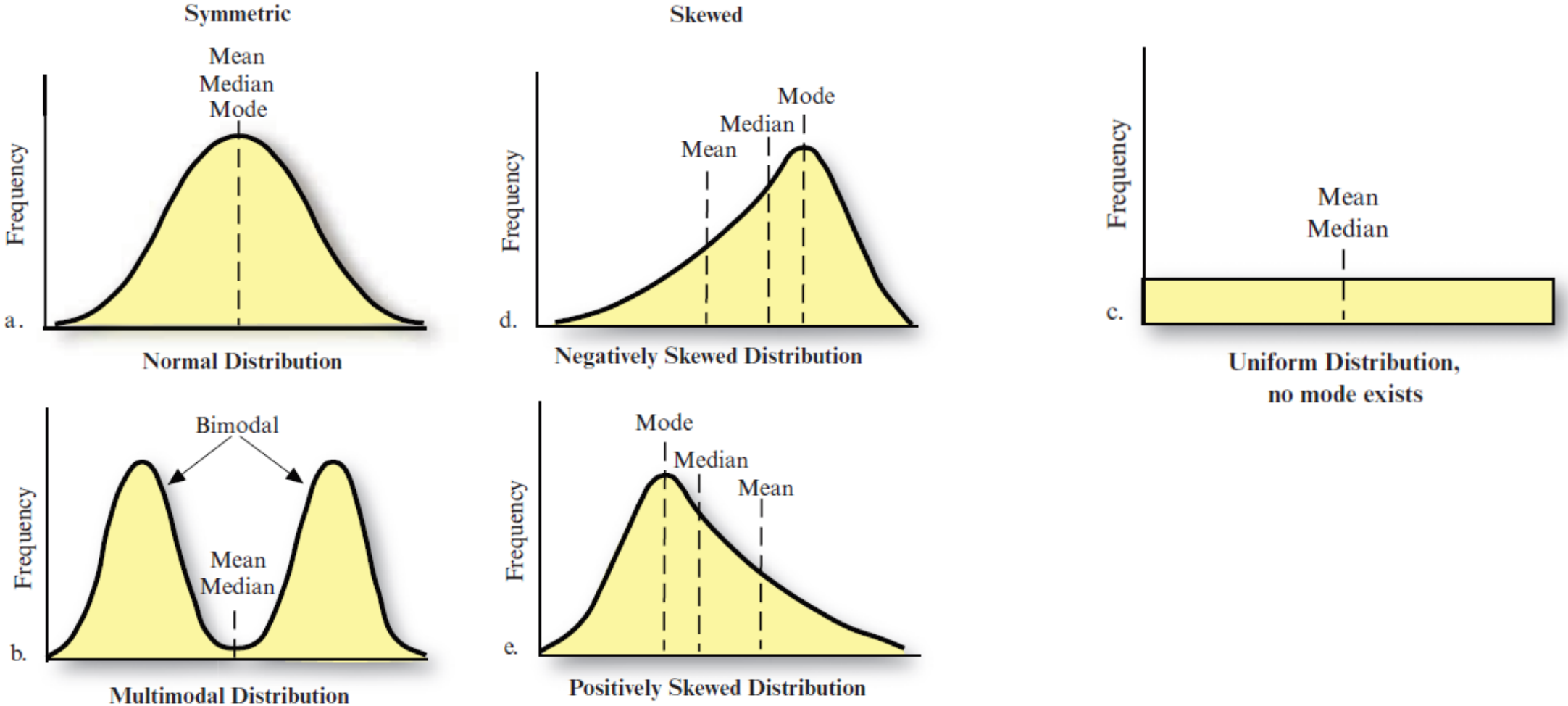
b. Histogram of the original thermal infrared data.

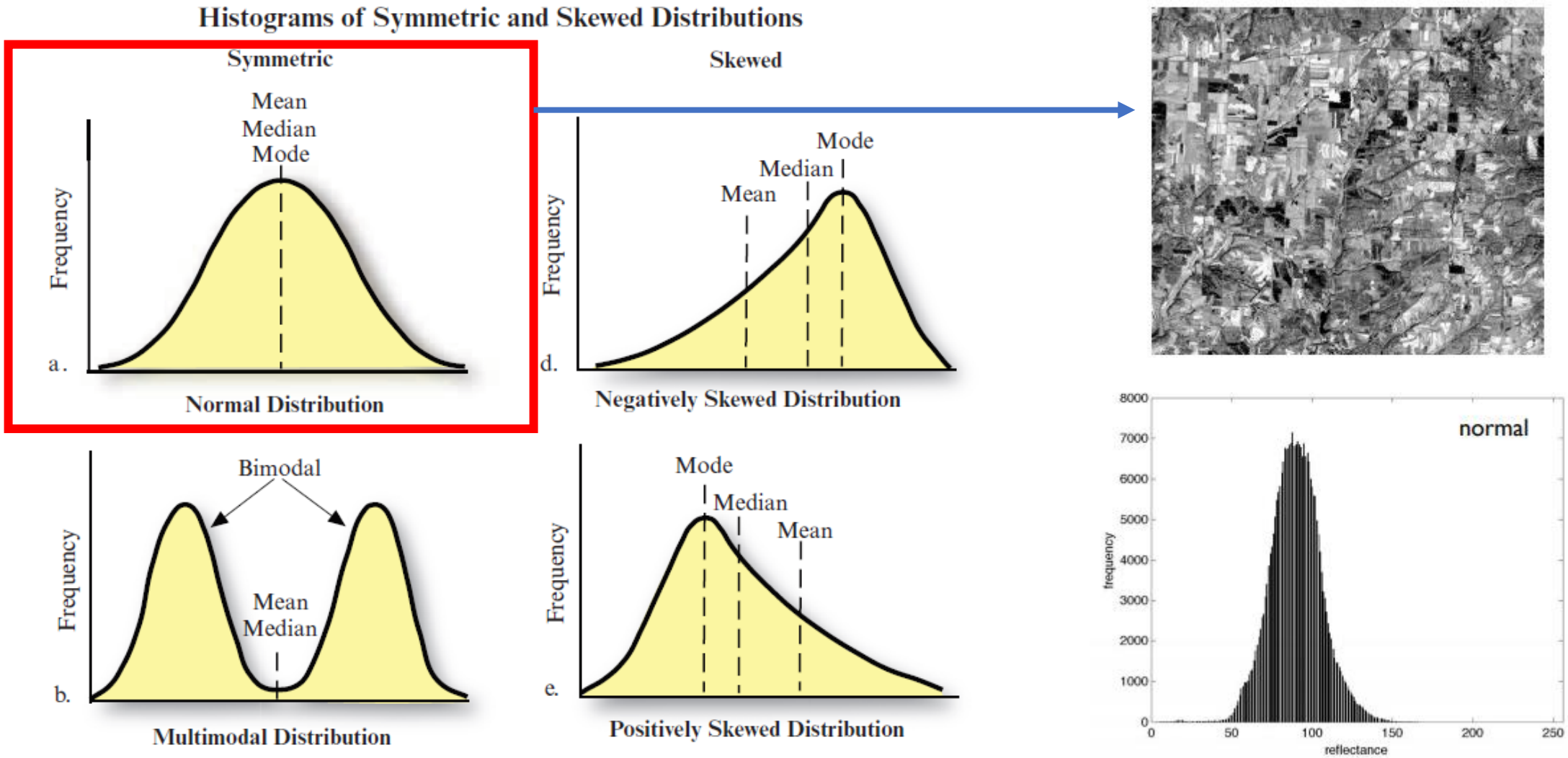
Histogram of Thermal Infrared Imagery of the Savannah River



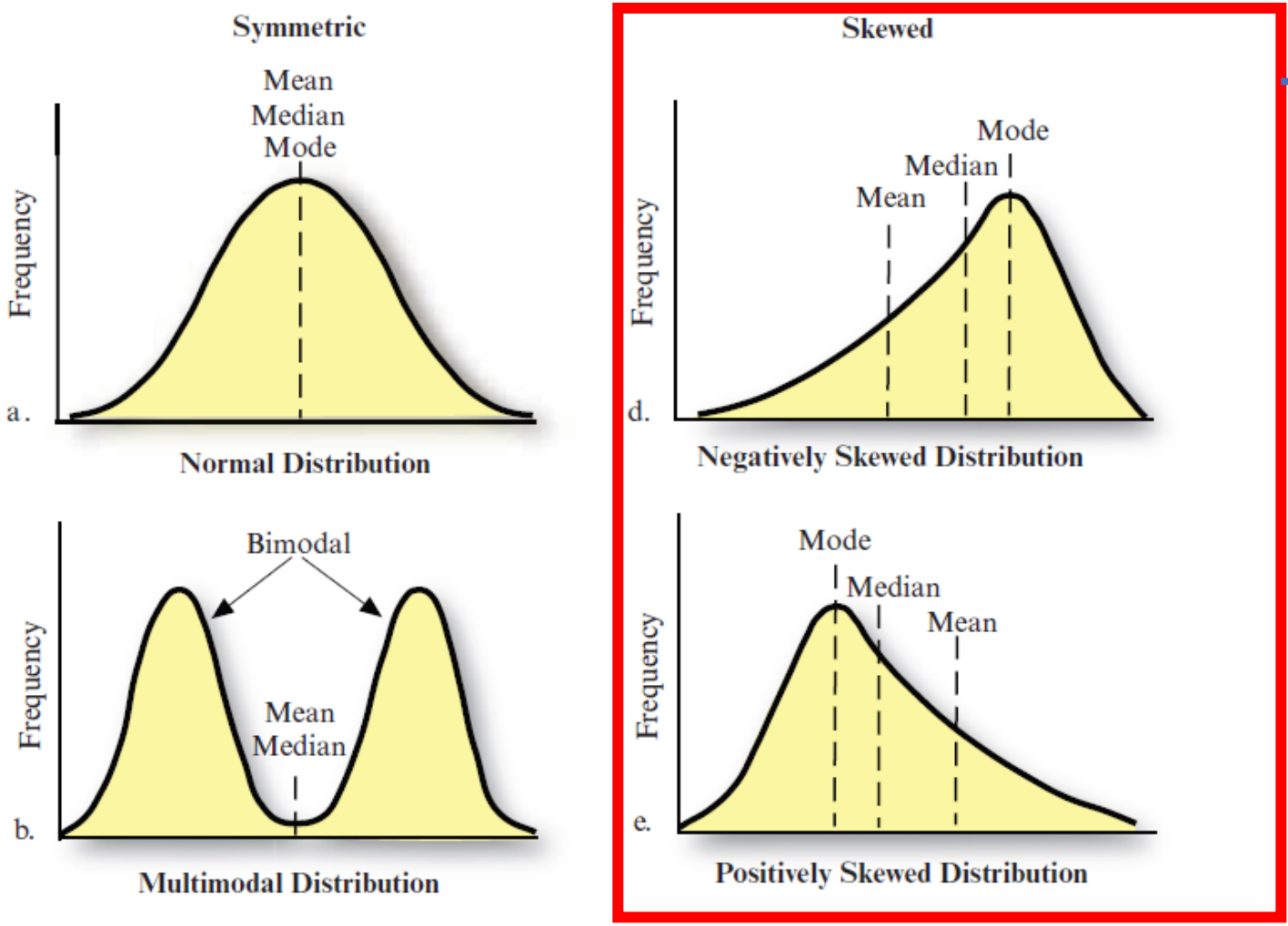
- Histograms provide a lot of information on images even without looking at the images themselves such as presence or absence of features, distribution etc.
- Histograms help evaluate images statistically e.g. normal, skewed, bimodal distribution
- Histograms are used in individual image enhancements
- Histograms are used in image classification
- Histograms are used in image segmentation
- Histograms help matching of images across time or space

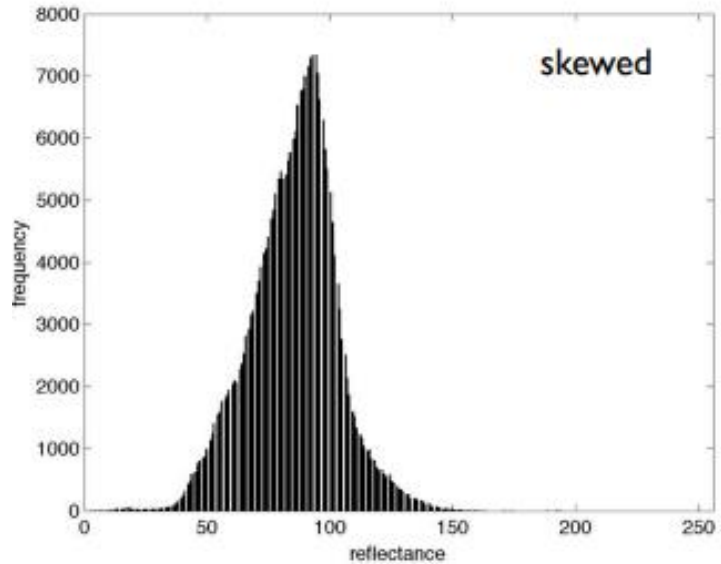
Histograms of Symmetric and Skewed Distributions



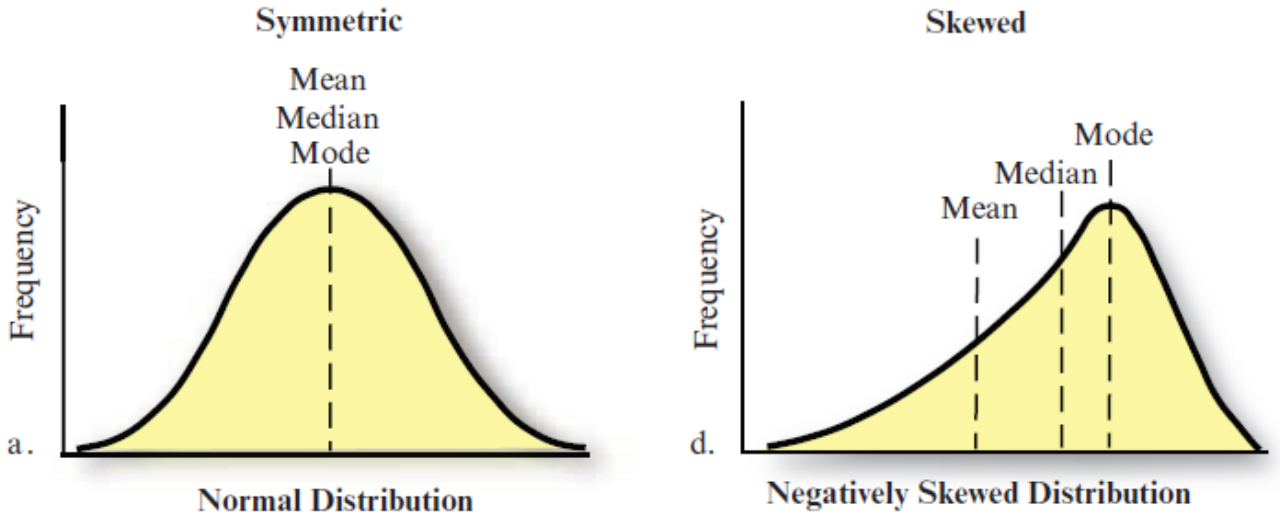

Histograms of Symmetric and Skewed Distributions
Symmetric
Mean
Median
Mode
Frequency
a.
Normal Distribution
Skewed
Mode
Median
Mean
Frequency
d.
Negatively Skewed Distribution
Bimodal
Frequency
Mean
Median
b.
Multimodal Distribution
Mode
Median
Mean
Frequency
e.
Positively Skewed Distribution
normal
frequency
reflectance
0
1000
2000
3000
4000
5000
6000
7000
8000
0
50
100
150
200
250

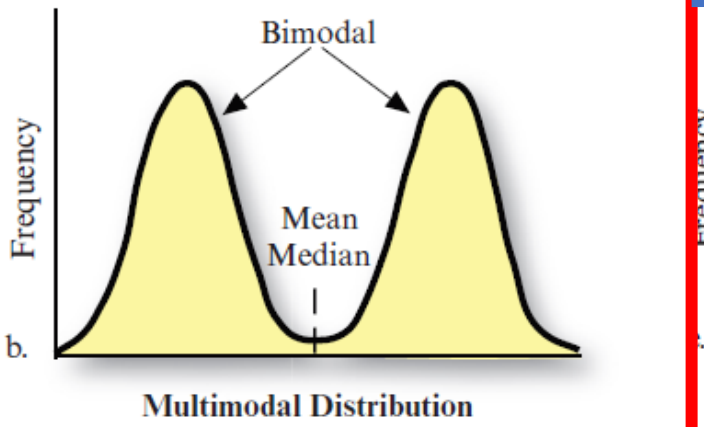
Histograms of Symmetric and Skewed Distributions

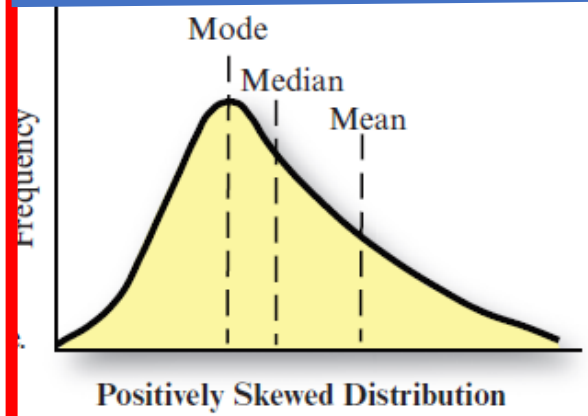


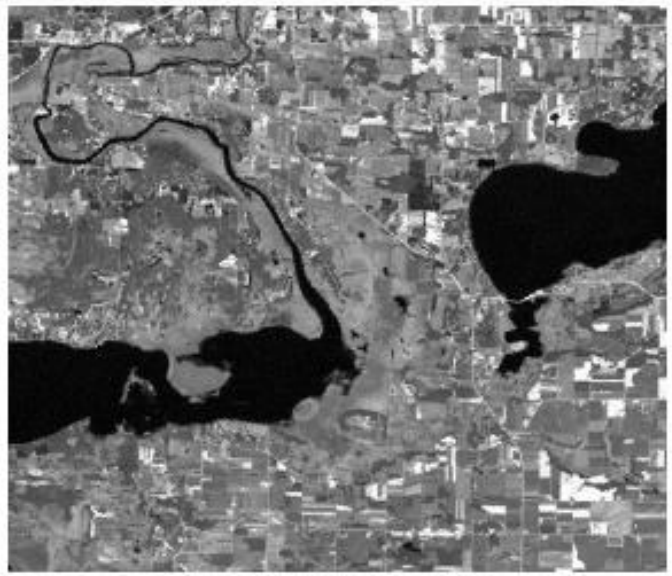


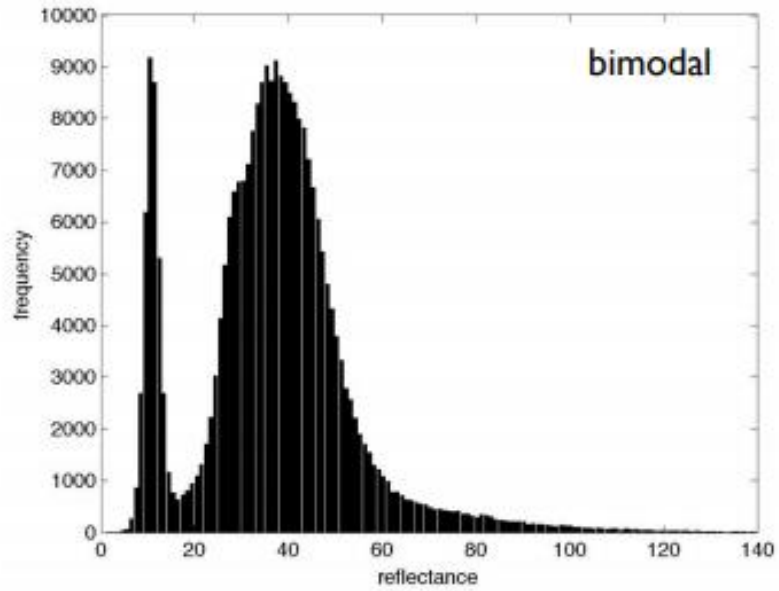
Histograms of Symmetric and Skewed Distributions



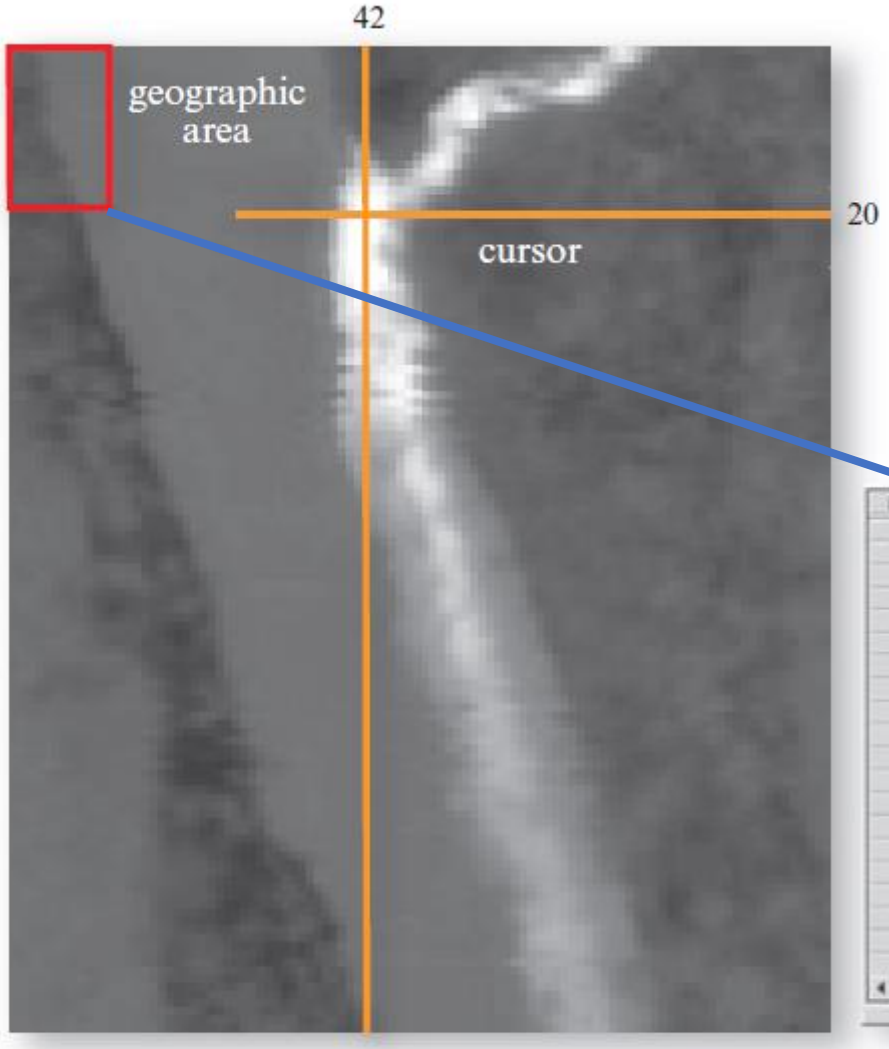




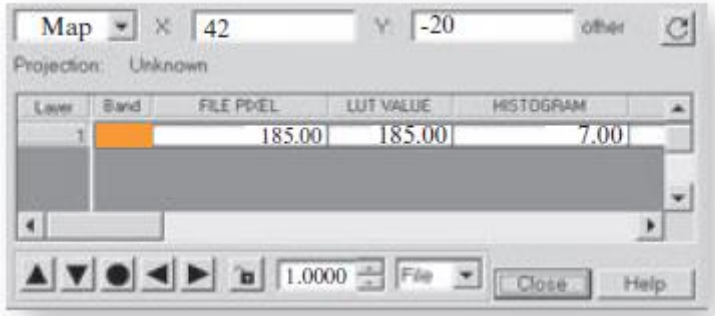




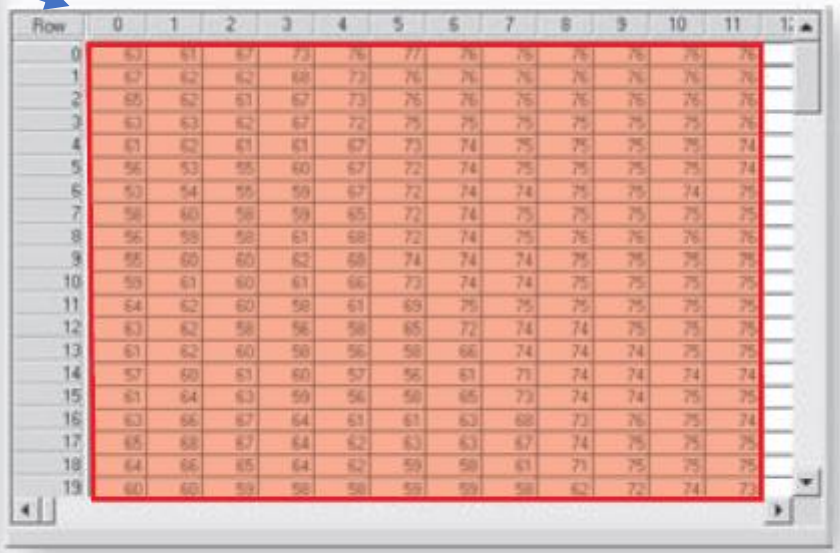
Individual Pixel Values



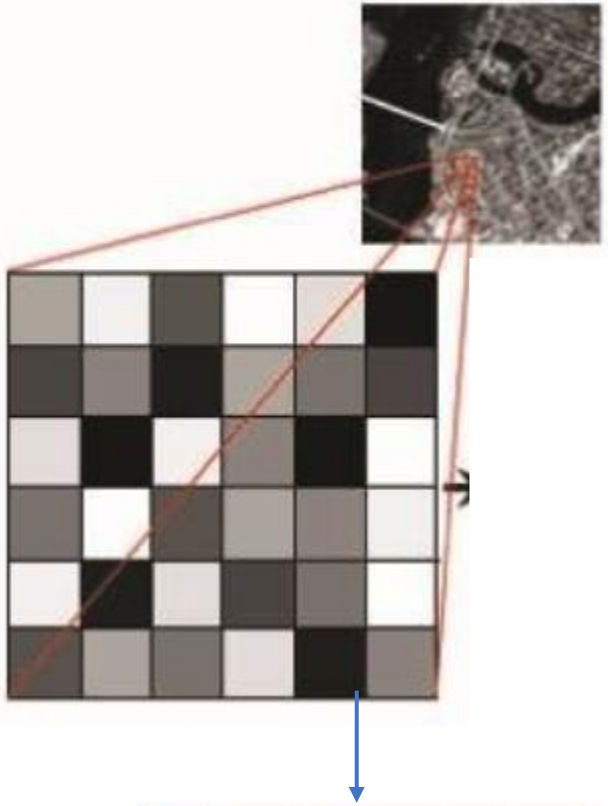
a. Nightime thermal infrared image of the Savannah River.



b. Individual brightness value extracted using the cursor.



c. Brightness values in a geographic area for an individual band.



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

Reference

Jensen, J. R., 1996, Introductory Digital Image Processing: A remote sensing perspective, 2nd Edition. NJ: Prentice-Hall

Jensen, J. R., 2015, Introductory Digital Image Processing: A remote sensing perspective, 4th Edition. Prentice-Hall

Thank You