UNIT 2

18CEO407 T

Applications of Remote sensing

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Visual interpretation

Elements of image interpretation

- Image analysis requires explicit recognition of eight ***elements of image interpretation*** that form the framework and understanding of an image
  - Shape
  - Size
  - Tone
  - Texture
  - Shadow
  - Site
  - Association
  - pattern

7.4 Interpretation Elements

The following eight elements are mostly used in image interpretation; size, shape, shadow tone, color, texture, pattern and associated relationship or context.

(1) **Size**:

A proper photo-scale should be selected depending on the purpose of the interpretation Approximate size of an object can be measured by multiplying the length on the image by the inverse of the photo-scale.

(2) **Shape:**

The specific shape of an object as it is viewed from above will be imaged on a vertica photograph. Therefore the shape looking from a vertical view should be known. For example the crown of a conifer tree looks like a circle, while that of a deciduous tree has an irregula shape. Airports, harbors, factories and so on, can also be identified by their shape.

(3) **Shadow**:

Shadow is usually a visual obstacle for image interpretation. However, shadow can also give height information about towers, tall buildings etc., as well as shape information from the non-vertical perspective-such as the shape of a bridge.

(4) **Tone**:

The continuous gray scale varying from white to black is called tone. In panchromatic photographs, any object will reflect its unique tone according to the reflectance. For example dry sand reflects white, while wet sand reflects black.In black and white near infrared infrared photographs, water is black and healthy vegetation white to light gray.

(5) **Color:**

Color is more convenient for the identification of object details. For example, vegetation types and species can be more easily interpreted by less experienced interpreters using color information. Sometimes color infrared photographs or false color images will give more specific information, depending on the emulsion of the film or the filter used and the object being imaged.

(6) **Texture**:

Texture is a group of repeated small patterns. For example homogeneous grassland exhibits a smooth texture, coniferous forests usually show a coarse texture. However this will depend on the scale of the photograph or image.

(7) **Pattern**:

Pattern is a regular usually repeated shape with respect to an object. For example, rows of houses or apartments, regularly spaced rice fields, interchanges of highways, orchards etc., can provide information from their unique patterns.

(8) **Associated relationships or context**:

A specific combination of elements, geographic characteristics, configuration of the surroundings or the context of an object can provide the user with specific information for image interpretation.

Shape

- The outline of a feature
  - Important to note that shape depends on perspective
  - Overhead perspective, introduces scale effect

Size

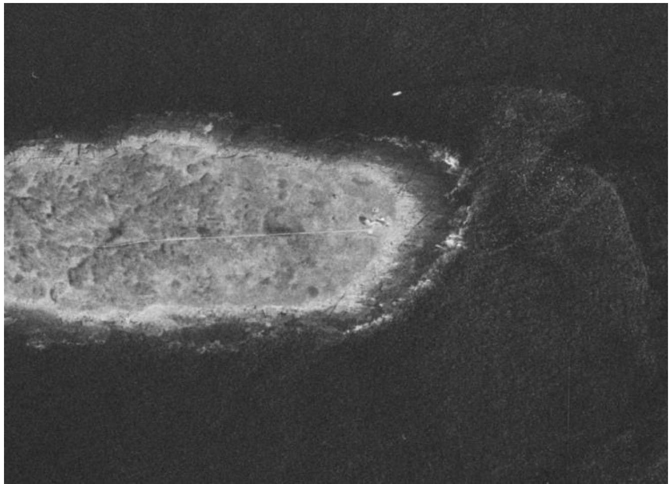
- The first to the dimensions of a feature
- ***Relative size*** determined by comparing the object with familiar nearby features
- ***Absolute size*** refers to the use of the aerial image to derive measurements

Tone

- Refers to the average brightness of an area or, in the case of color imagery, to the dominant color of the region
  - Depends on the nature of the surface in the ankles of observation and illumination.
  - Smooth surfaces behave like ***specular reflectors***, they tend to reflect radiation in a single direction
    - These features may appear bright or dark
  - Rough surfaces behave this ***diffuse reflectors***.
    - Scatter radiation in all directions.
    - A peer is medium gray tones

Texture

- Refers to the variation in tone over a surface or the apparent roughness of the surface as seen in the photo
- Created by micro shadows in small irregularities in the surface.



Shadow

- Refers to large distinctive shadows that revealed the outline of a future as projected onto a flat surface.
  - – Depends on the nature of the object, angle of illumination, perspective, and slope of the ground surface

Site

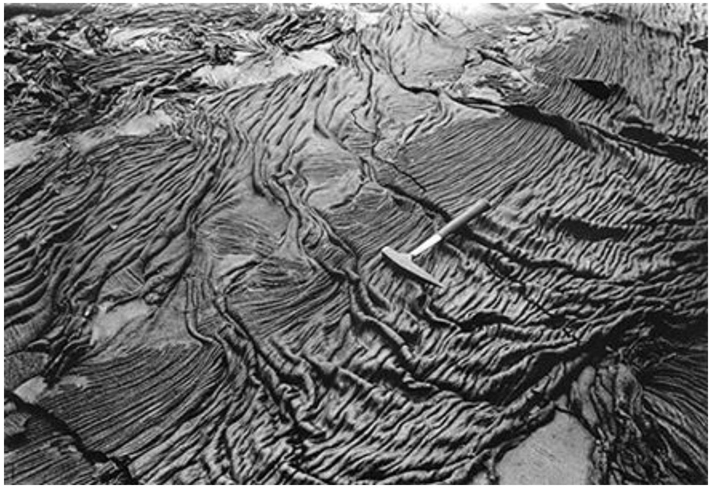
- Refers to a futures position with respect to topography and drainage.
  - Some things occupy a distinctive topographic position because of their function
    - Sewage treatment facilities at the lowest feasible topographic position.
    - Power plants located adjacent to water for cooling

Association

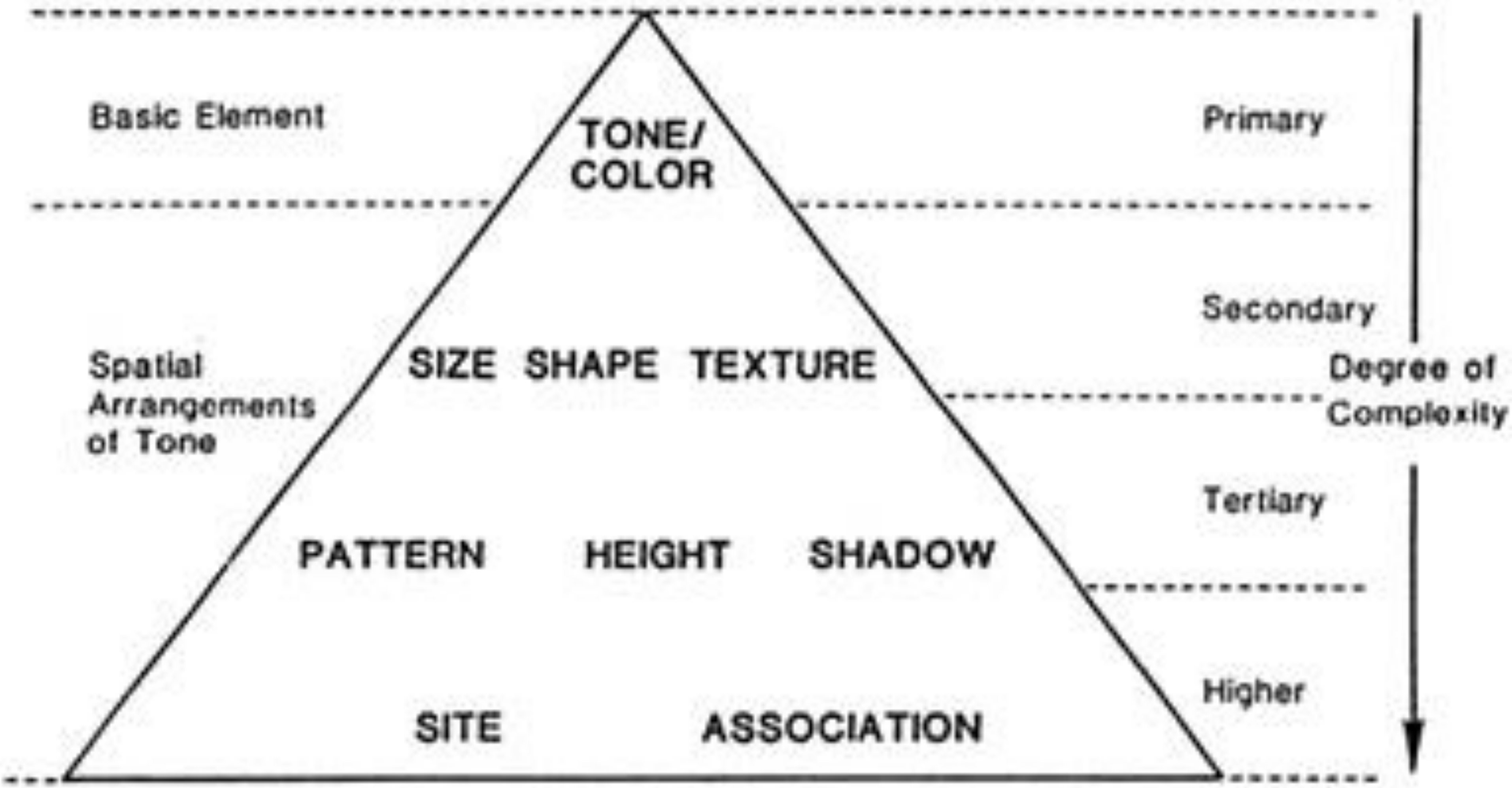
- Association refers to the distinctive spatial interrelationships between features
  - Schools often associated with athletic fields.
  - Large parking lots often associated with malls

Pattern

- Refers to distinctive arrangement of features
  - Orchards have trees plant can rows
  - Mobile home parks have rectangular buildings arranged in rows



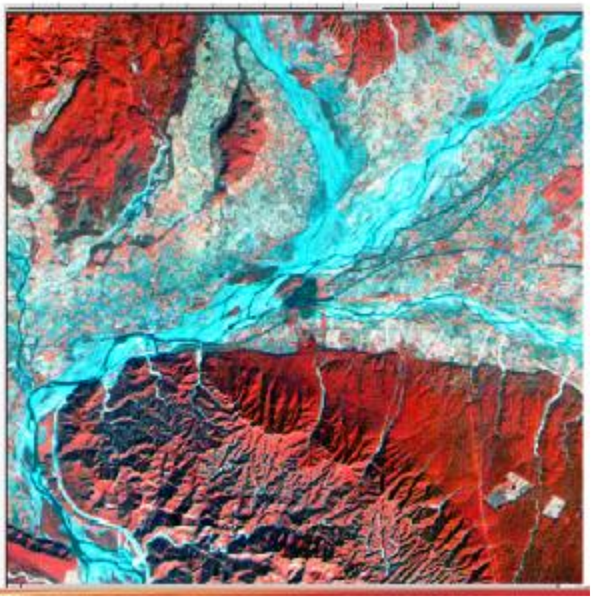
PRIMARY ORDERING OF IMAGE ELEMENTS FUNDAMENTAL TO THE ANALYSIS PROCESS

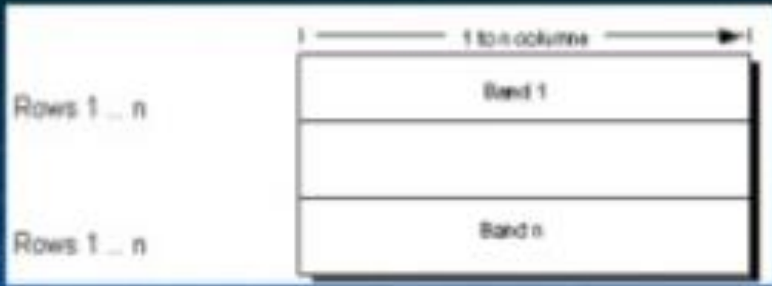


What is an Image ?

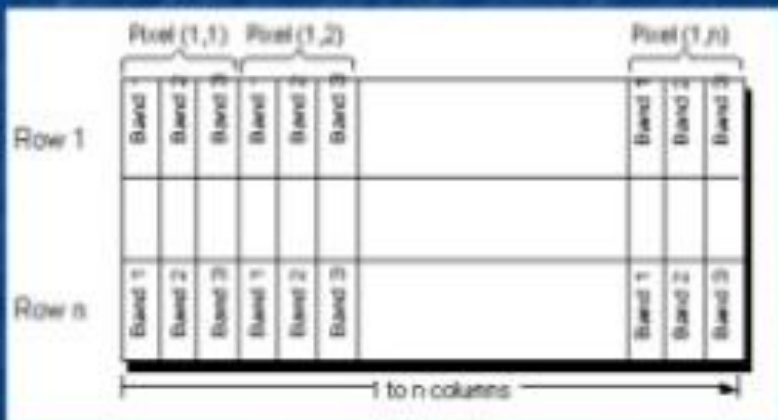
- **An IMAGE** is a Pictorial Representation of an object or a scene.
- Forms of Images
  - Analog
  - Digital



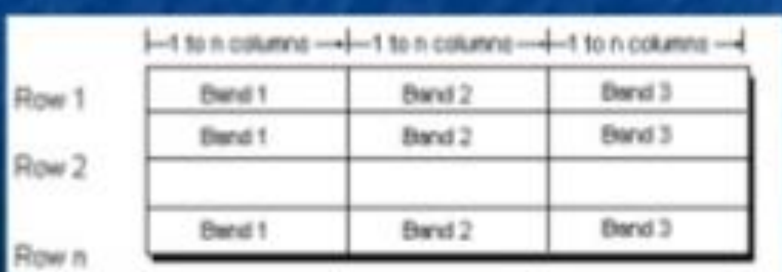




- Band sequential (BSQ) format stores information for the image one band at a time. In other words, data for all pixels for band 1 is stored first, then data for all pixels for band 2, and so on.



- Band interleaved by pixel (BIP) data is similar to BIL data, except that the data for each pixel is written band by band. For example, with the same three-band image, the data for bands 1, 2 and 3 are written for the first pixel in column 1; the data for bands 1, 2 and 3 are written for the first pixel in column 2; and so on.



- Band interleaved by line (BIL) data stores pixel information band by band for each line, or row, of the image. For example, given a three-band image, all three bands of data are written for row 1, all three bands of data are written for row 2, and so on, until the total number of rows in the image is reached.

Distortion of remote-sensed images

There are 2 types of distortion:

- Radiometric distortion

  The brightness of the pixel is affected

  - by differences between sensors
  - by the atmosphere

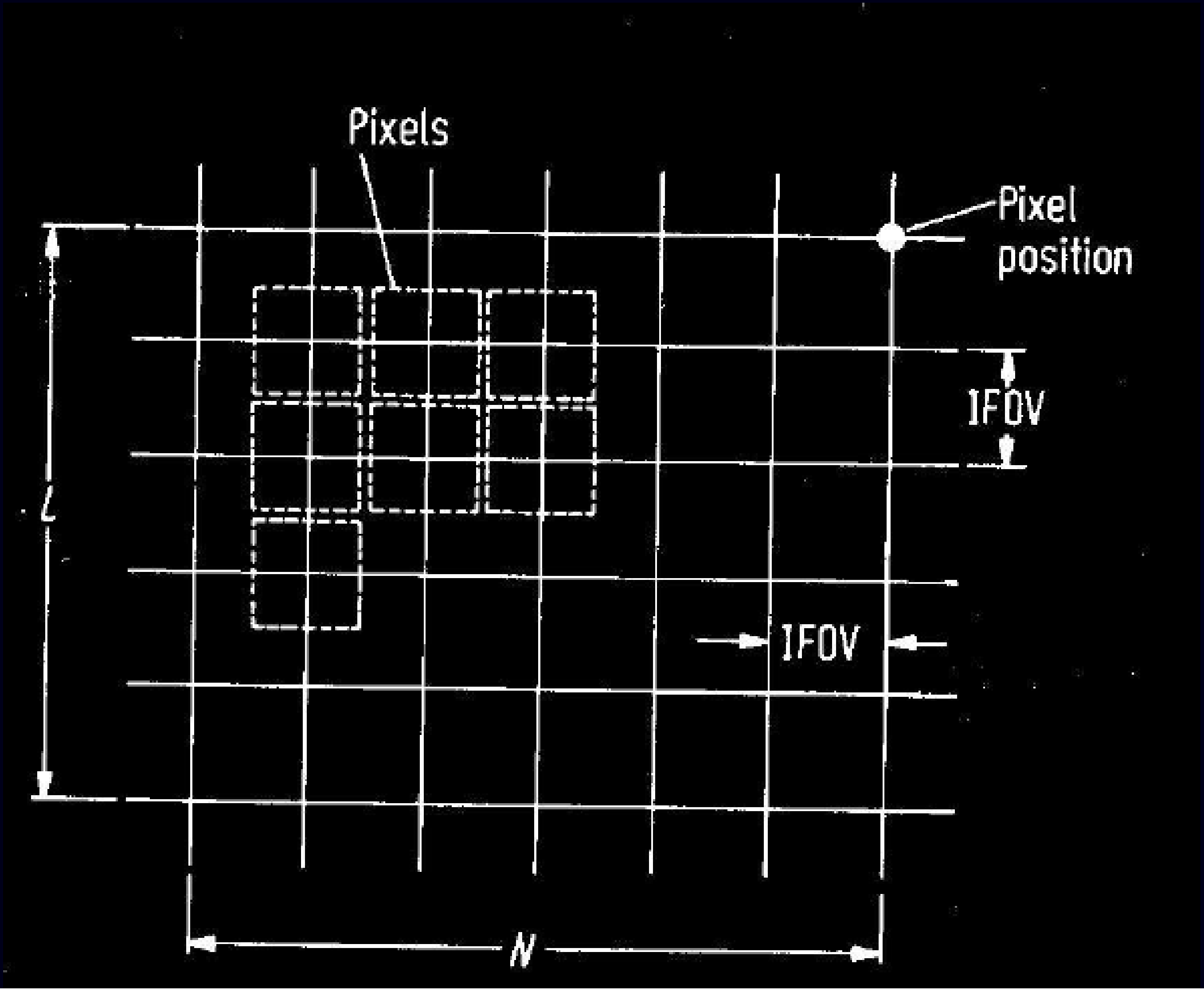
- Geometric distortion

  - The pixels are different shapes
  - . . . and different sizes . . .
  - . . . and in different places . . .
  - . . . from what you would naturally assume

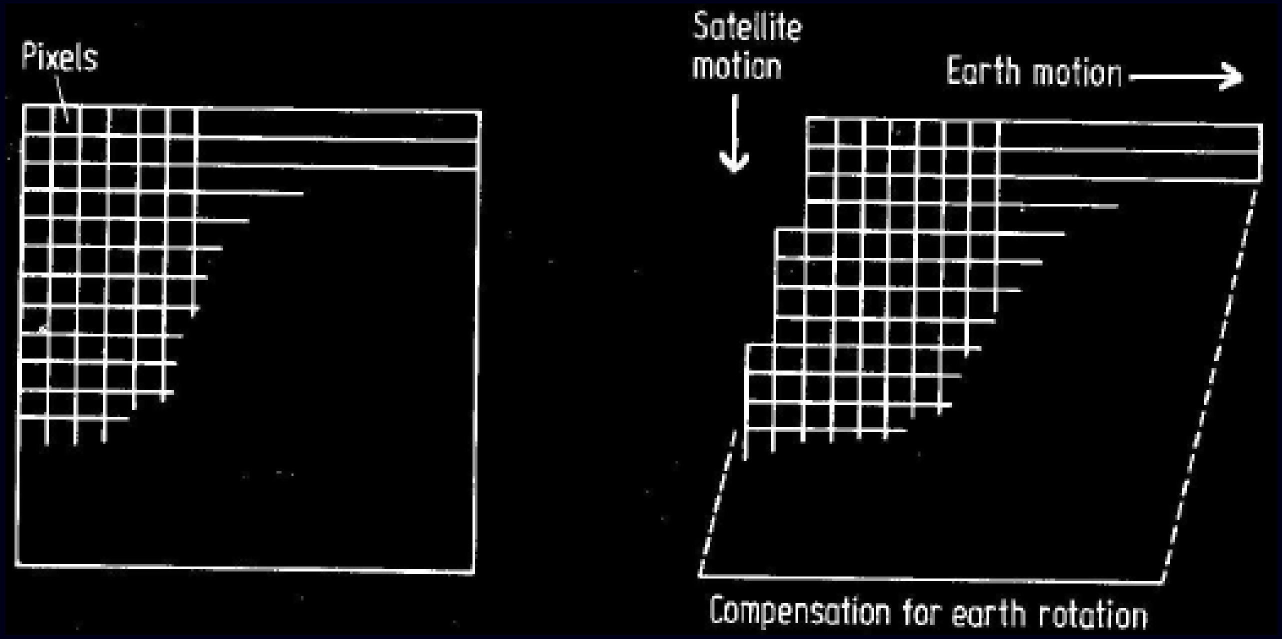
Types of geometric distortion

- Earth rotation
- Panoramic distortion
  - Further affected by Earth curvature
- Scan time skew
- Platform variations of
  - Height
  - Velocity
  - Attitude
    - Pitch
    - Roll
    - Yaw
- Aspect Ratio Distortion

Displaying an image

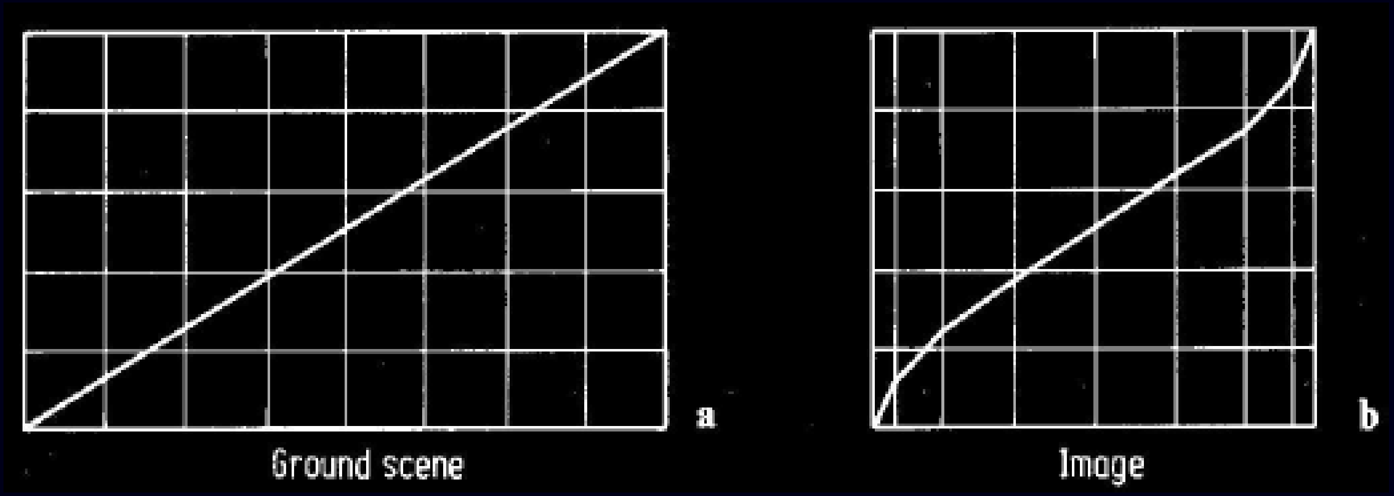


Earth Rotation



- Landsat MSS:
  - Standard image is 185 km square
    - and consists of 2340 scan lines
  - Distortion of whole image is about 10 km.
    - Which is about 4.6 m per scan line

Panoramic distortion: S-band effect

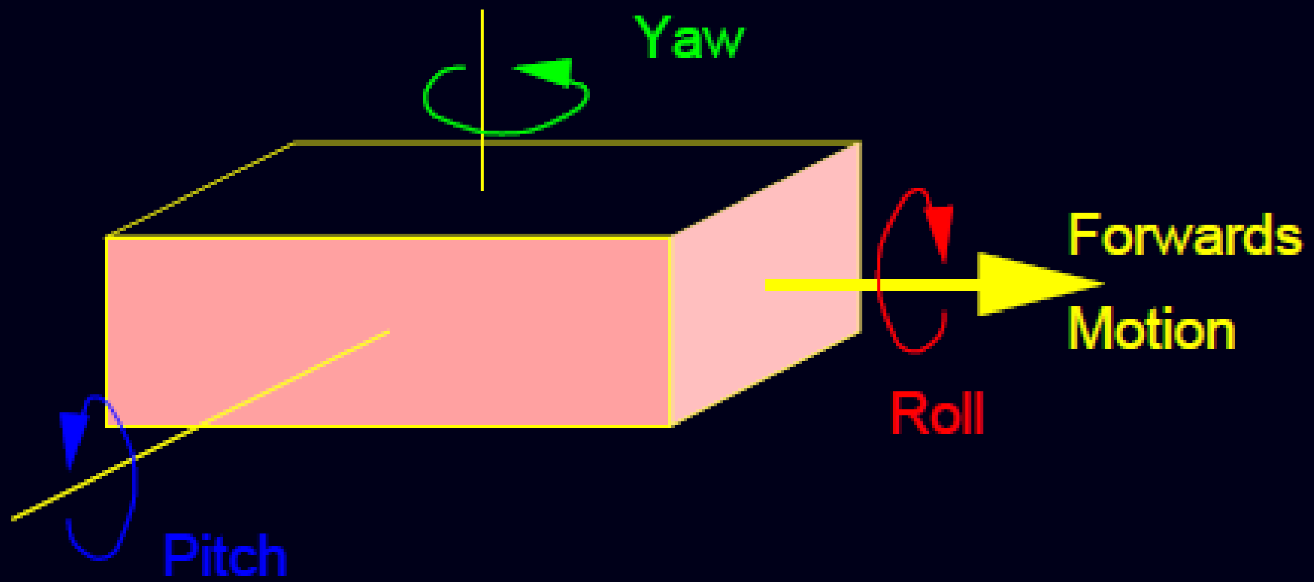


Small for SPOT, LANDSAT: $\theta = 7.5°$: edge pixels 2% bigger

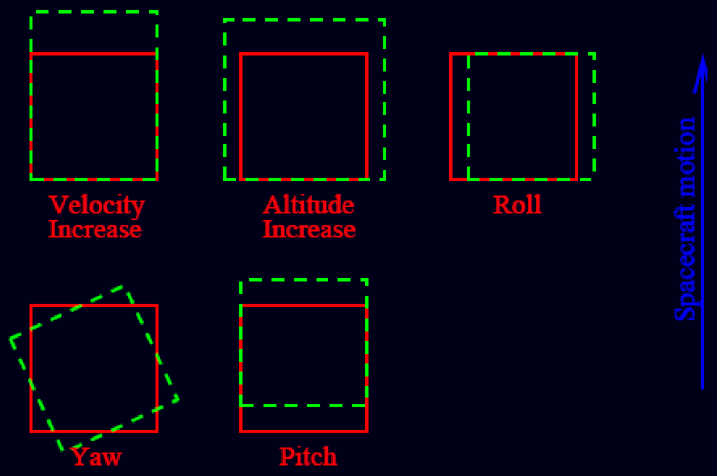
Large for AVHRR

Very large for aircraft instruments $\theta = 40°$: edge pixels 70% bigger

Attitude



Effects of instant attitude variations



Effects of slow attitude variations

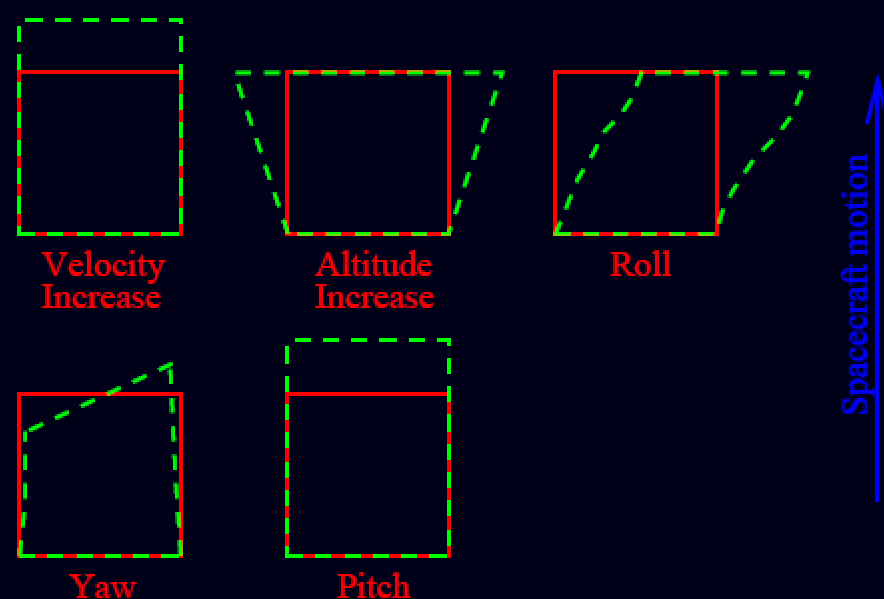


IMAGE ENHANCEMENT

Image Enhancement

Process of making an image more interpretable for a particular application.

Enhancements are used to make it easier for visual interpretation and understanding of imagery.

In raw imagery, the useful data often populates only a small portion of the available range of digital values.

Attempted after image is corrected for distortions. May be performed temporarily or permanently.

Enhancement Types

- **Point Operations (**Contrast enhacement, histogram equalization etc)
  - Modification of brightness values of each pixel in an image data set independently. (radiometric enhancement**)**
  - Brings out contrast in the image
- **Local operations** (Filtering techniques)
  - Modification of pixel values based on the values of surrounding pixels. (spatial enhancement)
- **Image Transformations (Ratioing, PCA, Image merging etc)**
  - Enhancing images by transforming the values of each pixel on a multiband basis (spectral enhancement)

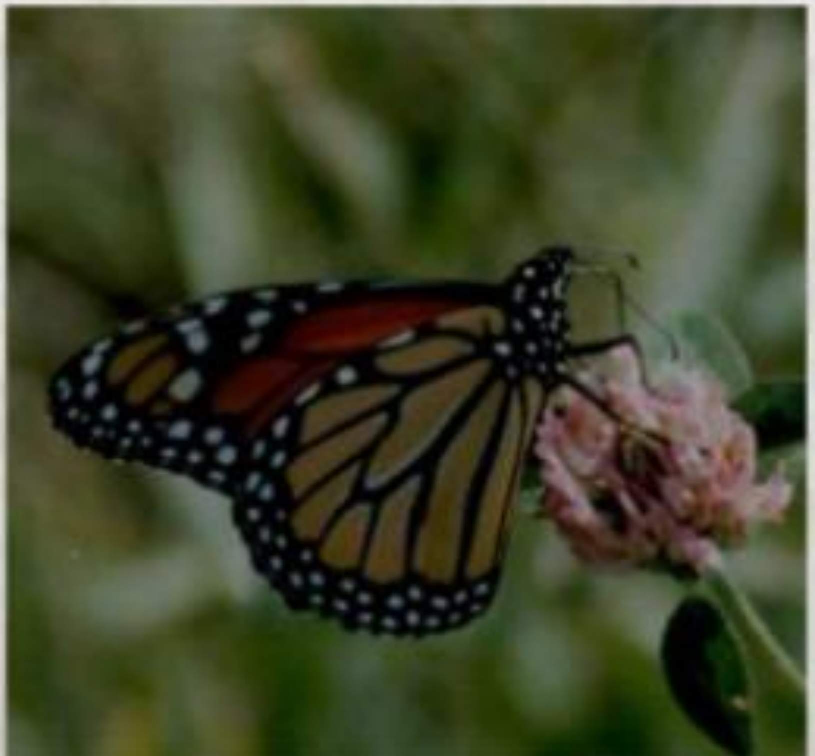
CONTRAST STRECHING

RECORDING AND DISPLAY DEVICES OPERATES OVER 128/256 GREY LEVEL IMAGES

INTENTION IS TO EXPAND THE NARROW RANGE OF DISPLAY LEVEL

OUTPUT ACCENTRIATES THE CONTRAST

- **Linear strech**
- **Histogram equlaisation**
- **Special stretch**



a. image with poor contrast

b. Image enhancement by contrast stretching

LINEAR STRECHING

EXPAND THE RANGE OF IMAGE LEVELS (60-158) TO FILL THE RANGE OF DISPLAY LEVLES (0-255)

DN' =(DN-MIN/MAX- MIN) * 255

Where, DN' = output image pixel value

DN = original pixel value

MIN = Minimum value in the image value (60)

MAX = Maximum value in the image (158)

Contrast Enhancement

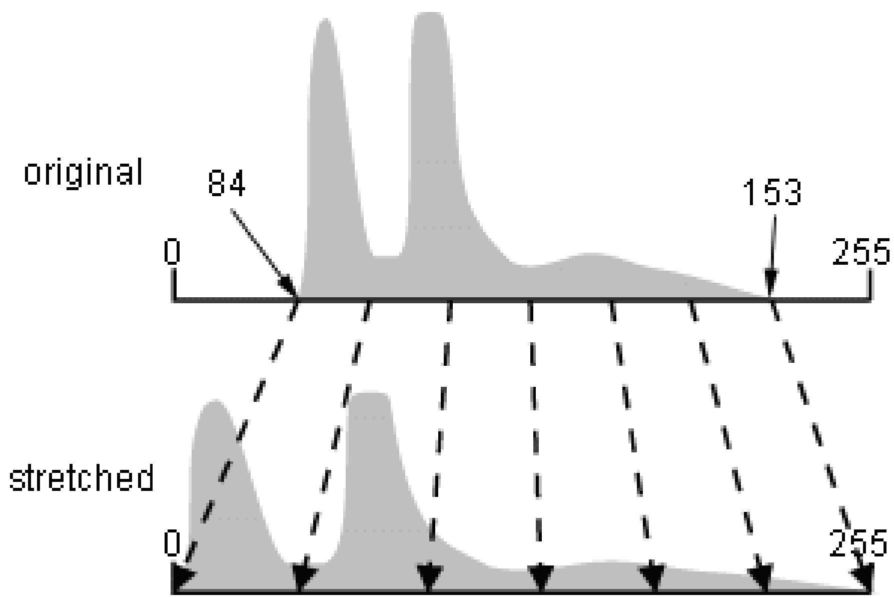
- **Expands the original input values to make use of the total range of the sensitivity of the display device.**
- The density values in a scene are literally pulled farther apart, that is, expanded over a greater range.
- The effect is to increase the visual contrast between two areas of different uniform densities.
- This enables the analyst to discriminate easily between areas initially having a small difference in density.

Types

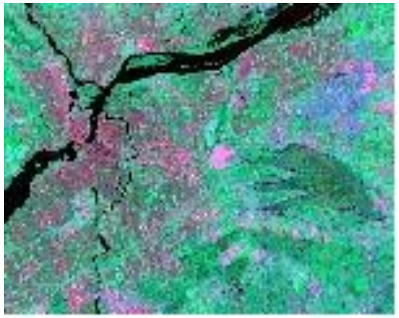
- Linear - Input and Output Data Values follow a linear relationship
- Non Linear- Input and output are related via a transformation function $Y = f(x)$

Linear Contrast Stretch

- A DN in the low range of the original histogram is assigned to extreme black, and a value at the high end is assigned to extreme white.
- The remaining pixel values are distributed linearly between these two extremes



$$Y = (X - X_{min}) / X_{max} - X_{min}) * 255$$

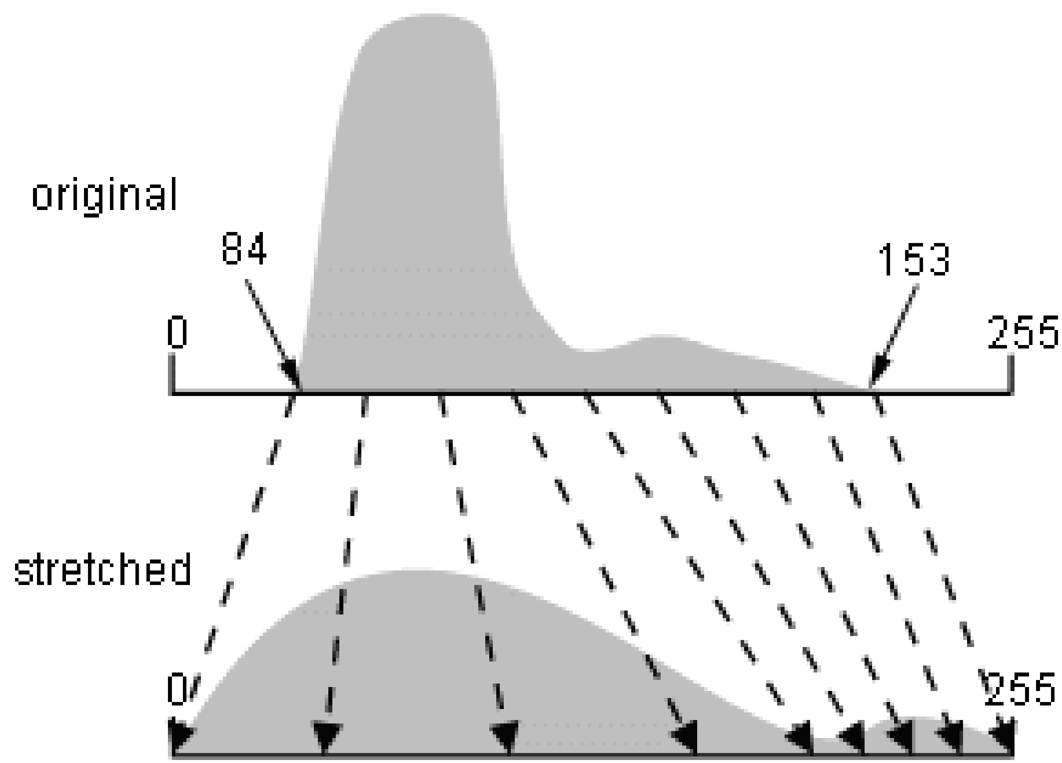


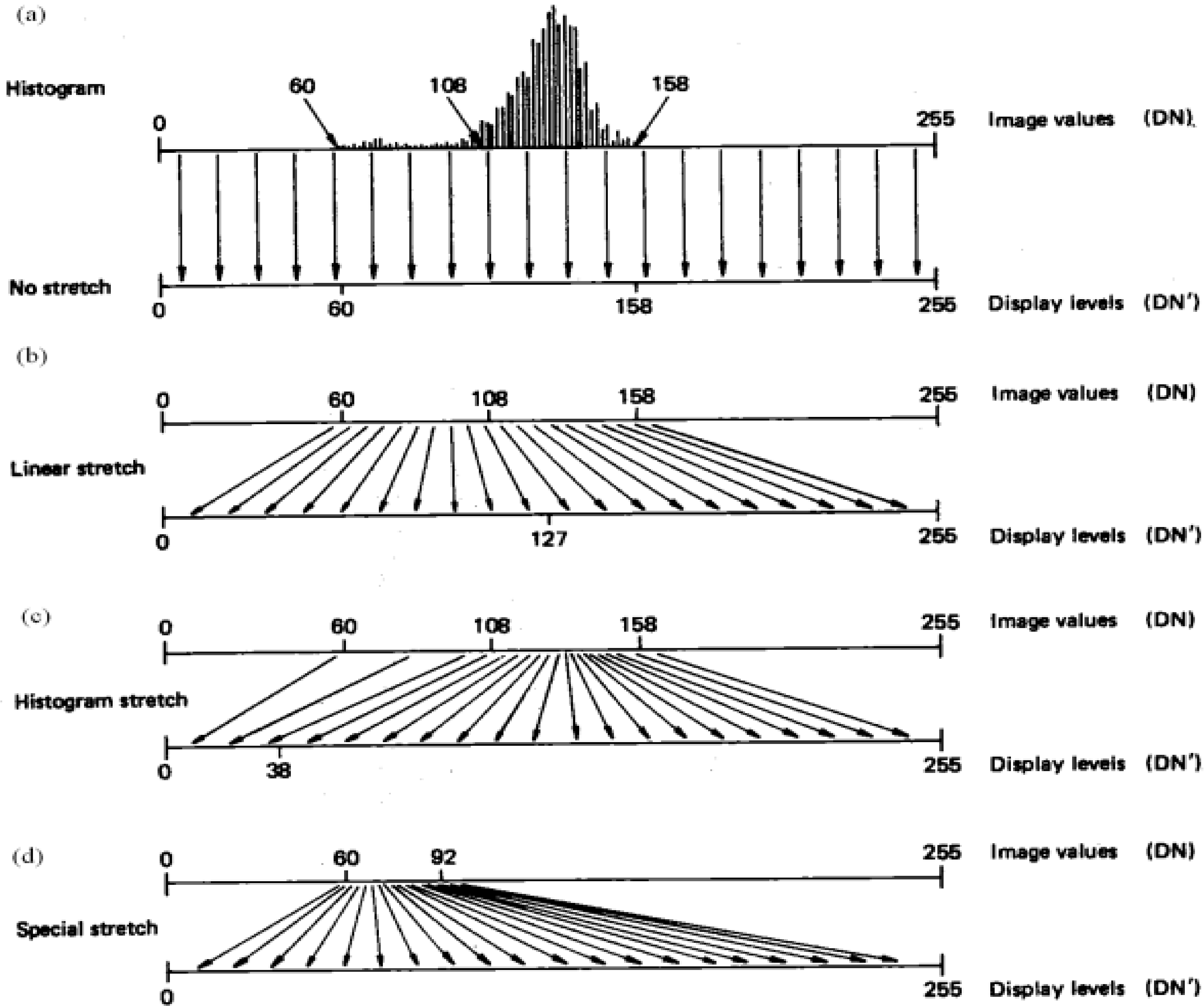
Histogram Equalisation

- In this technique, histogram of the original image is redistributed to produce a uniform population density.
- This is obtained by grouping certain adjacent gray values.
- Thus the number of gray levels in the enhance image is less than the number of gray levels in the original image.
- Contrast is increased at the most populated range of brightness values of the histogram (or "peaks").
- It automatically reduces the contrast in very light or dark parts of the image associated with the tails of a normally distributed histogram.

It assigns more display values (range) to the frequently occurring portions of the histogram.
In this way, the detail in these areas will be better enhanced relative to those areas of the original histogram where values occur less frequently.

In other cases, it may be desirable to enhance the contrast in only a specific portion of the histogram.




(a)
Histogram
60
108
158
0
255
Image values (DN)
No stretch
0
60
158
255
Display levels (DN′)
(b)
0
60
108
158
255
Image values (DN)
Linear stretch
0
127
255
Display levels (DN′)
(c)
0
60
108
158
255
Image values (DN)
Histogram stretch
0
38
255
Display levels (DN′)
(d)
0
60
92
255
Image values (DN)
Special stretch
0
255
Display levels (DN′)

SPATIAL FILTERING TECHNIQUES

- **EMPHASIS OR DEEMPHASIS** IMAGE DATA OF VARIOUS SPATIAL FREQUENCIES
- **HIGH SPATIAL** FREQUENCY (**ROUGH**) – ROADS, FIELD BORDERS
- GREY LEVEL CHANGES ABRUPTLY OVER RELATIVELY SMALL NUMBER OF PIXELS
- **LOW SPATIAL** FREQUENCY (**SMOOTH**) – WATERBODIES,AGRICULTURE BODIES

FILTERS

- LOW PASS FILTER (3*3 WINDOW AVERAGE)

- HIGH PASS FILTER (ORIGINAL DN – LOW PASS FILTER)

- SOBEL FILTER –
- DIAGONAL,HORIZONTAL,VERTICAL

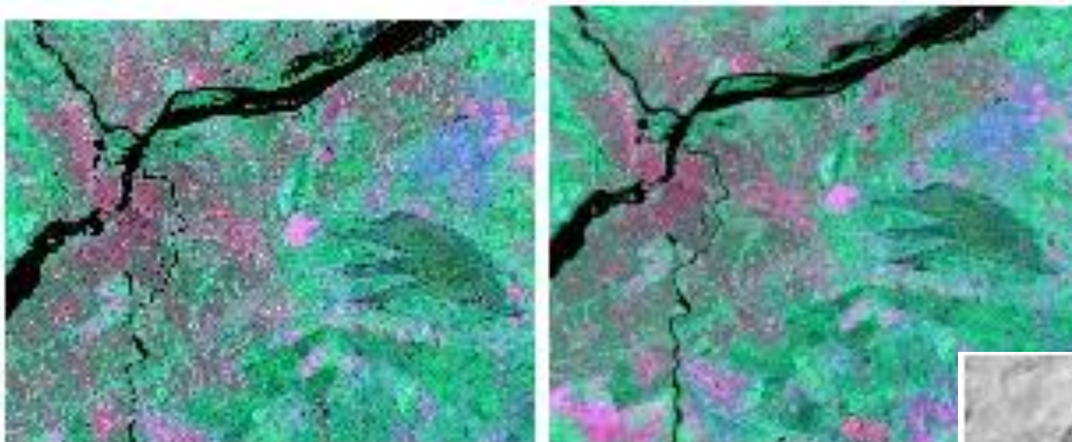
A **low-pass filter** is designed to emphasize larger, homogeneous areas of similar tone and reduce the smaller detail in an image. Thus, low-pass filters generally serve to smooth the appearance of an image. Average and median filters, often used for radar imagery are examples of low-pass filters.

High-pass filters do the opposite and serve to sharpen the appearance of fine detail in an image. One implementation of a high-pass filter first applies a low-pass filter to an image and then subtracts the result from the original, leaving behind only the high spatial frequency information.

Directional, or edge detection filters are designed to highlight linear features, such as roads or field boundaries. These filters can also be designed to enhance features which are oriented in specific directions. These filters are useful in applications such as geology, for the detection of linear geologic structures.

Filter Types

- Low Pass Filters
- block high frequency details
- has a smoothening effect on images.
- Used for removal of noise
- Removal of “salt & pepper” noise
- Blurring of image especially at edges.
- High Pass Filters
- Preserves high frequencies and Removes slowly varying components
- Emphasizes fine details
- Used for edge detection and enhancement
- Edges - Locations where transition from one category to other occurs



Low pass filtering

High pass filtering

Low pass filtering

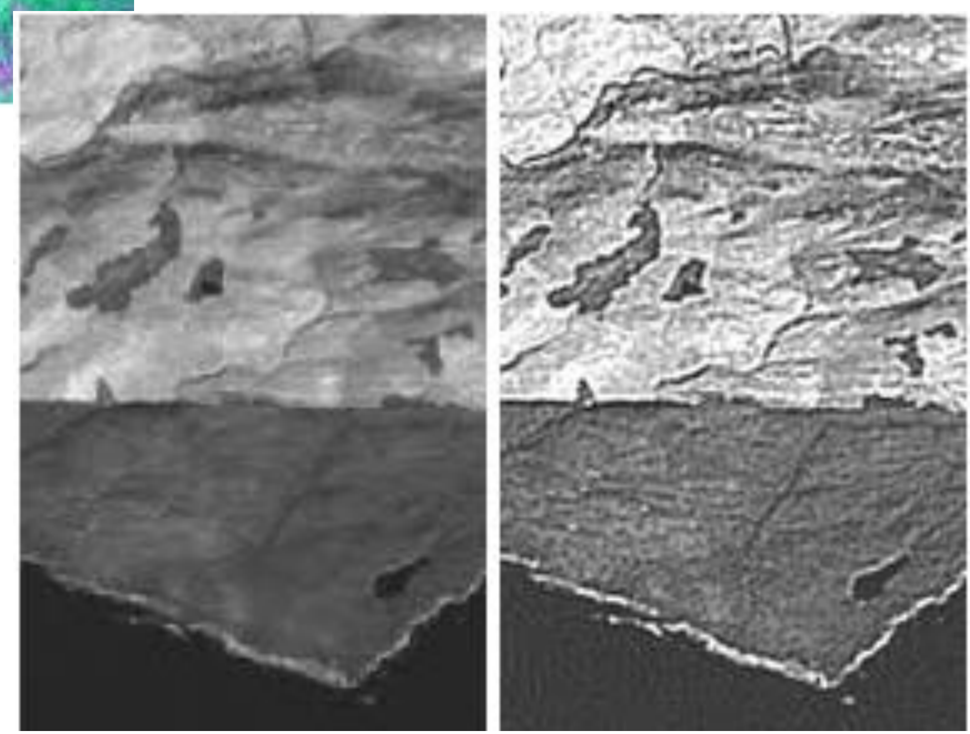


Image Division/spectral ratioing

- The most common transforms applied to image data.
- On a pixel-by-pixel basis carry out the following operation
  - Band1/Band2 = New band
  - Resultant data are then rescaled to fill the range of display device
- Very popular technique, commonly called **'Band Ratio'**

Mathematically $BV_{i,j,r} = BV_{i,j,k} / BV_{i,j,l}$

Where

$BV_{i,j,k}$ Brightness value at the location line i, pixel j in k band of imagery

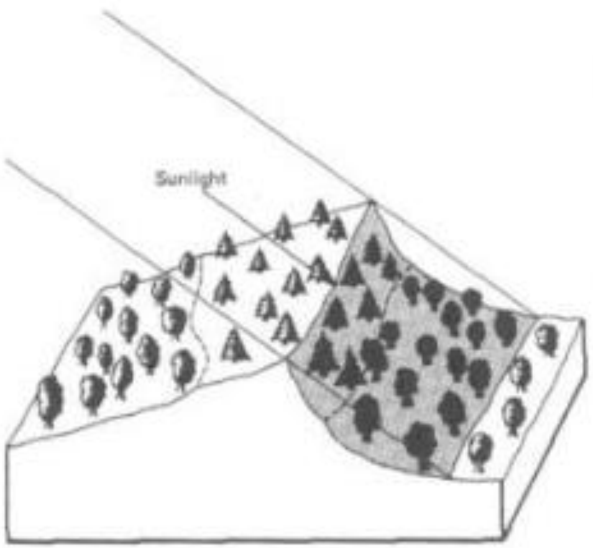
$BV_{i,j,l}$ Brightness value at the same location in band l

$BV_{i,j,r}$ Ratio value at the same location

(Note: If Denominator is 0 (zero) then Denominator BV is made 1)

Application of Ratios

- Undesirable effects on recorded radiances (e.g. variable illumination) caused by variations in topography.
  - Sometimes differences in BV's from identical surface material are caused by topographic slope and aspect, shadows or seasonal changes
  - These conditions hamper the ability of an interpreter to correctly identify surface material or land use in a remotely sensed image.
- Ratio transformations can be used to reduce the effects of such environmental conditions



To reduce topographic effect

Landcover/ Illumination	Digital Number		Ratio
	Band A	Band B	
Decidous			
Sunlit	48	50	.96
Shadow	18	19	.95
Coniferous			
Sunlit	31	45	.69
Shadow	11	16	.69

Image Ratioing

- Concept
  - Date 1 / Date 2
  - No-change = 1
  - Values less than and greater than 1 are interpretable
  - Pick a threshold for change
- Pros
  - Simple
  - May mitigate problems with viewing conditions, esp. sun angle
- Cons
  - Scales change according to a single date, so same change on the ground may have different score depending on direction of change; I.e. 50/100 = .5, 100/50 = 2.0

Change Detection

source: CCRS website, CANADA

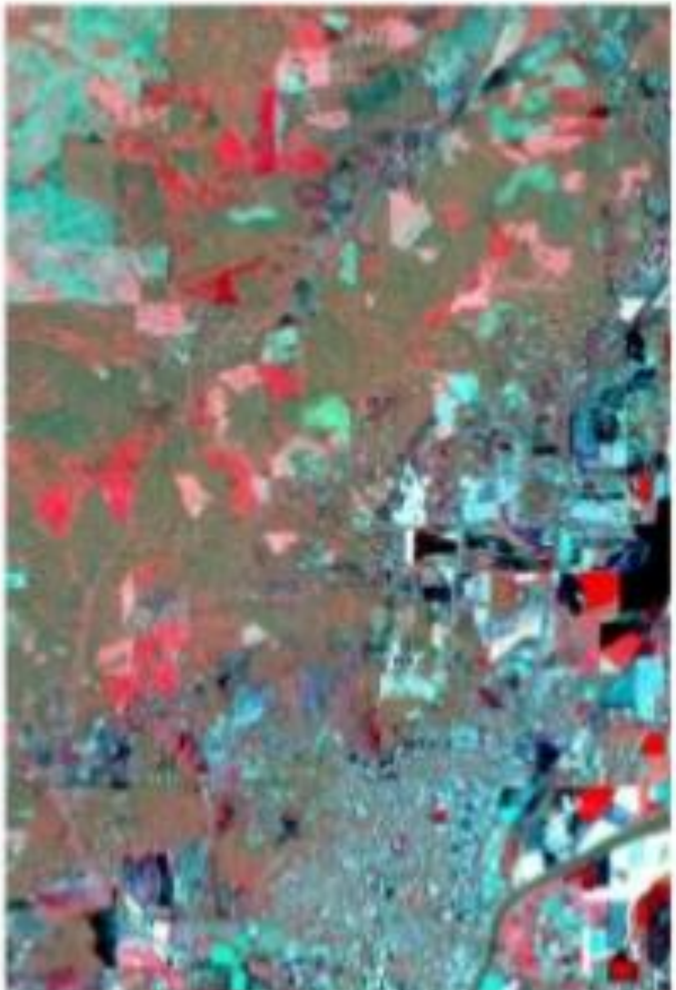


Image Difference (TM99 – TM88)

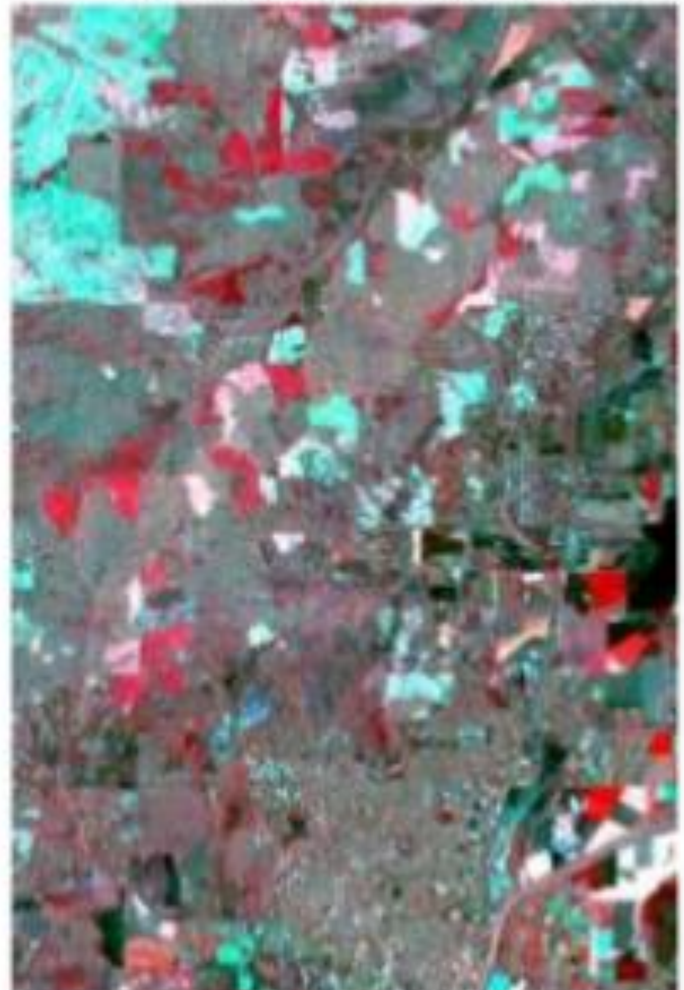


Image Ratio (TM99 / TM88)

Principal Component Analysis (PCA)

- Different bands of multispectral data are often highly correlated and thus contain similar information.

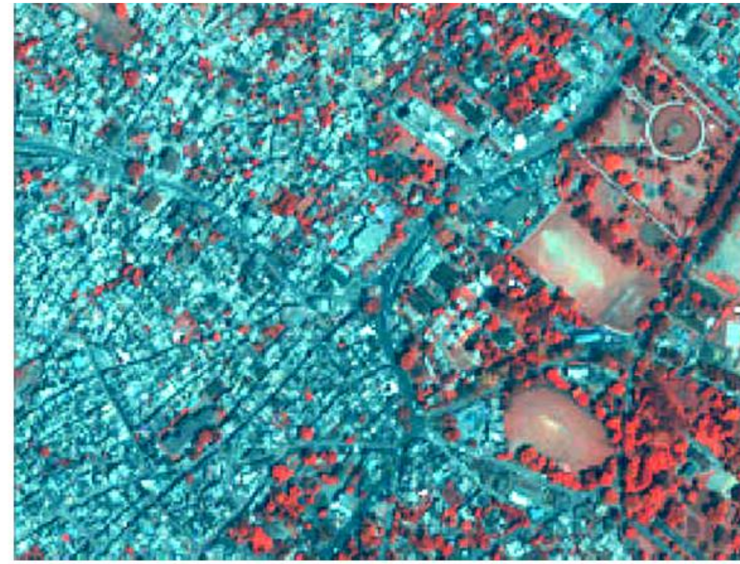
- We need to Transforms the original satellite bands into new “bands” that express the greatest amount of variance (information) from the feature space of the original bands

- PCA is accomplished by a linear transformation of variables that corresponds to a translation and rotation of the original coordinate system.

IMAGE FUSION/IMAGE MERGING

- Most of the sensors operate in two modes: multispectral mode and the panchromatic mode.
- The panchromatic mode corresponds to the observation over a broad spectral band (similar to a typical black and white photograph) and
- the multispectral (color) mode corresponds to the observation in a number of relatively narrower band.
- Usually the multispectral mode has a better **spectral resolution** than the panchromatic mode.
- Most of the satellite sensors are such that the panchromatic mode has a better **spatial resolution** than the multispectral mode,
- Better is the spatial resolution, more detailed information about a landuse is present in the imagery
- **To combine the advantages of spatial and spectral resolutions of two different sensors, image fusion techniques are applied.**

Panchromatic Image - 1 m spatial resolution, IKONOS



Multispectral Image - 4 m spatial resolution, IKONOS

Merged PAN+ Multispectral

Multi-temporal data merging

- Same area but different dates $\rightarrow$ composites $\rightarrow$ visual interpretation
  - e.g. agricultural crop
    - NDVI from Landsat-7 ETM+
      - March 7 $\rightarrow$ blue
      - April 24 $\rightarrow$ green
      - October 15 $\rightarrow$ red
    - GIS-derived wetland boundary $\rightarrow$ eliminate the interpretation of false positive areas
  - Enhance the automated land cover classification
    - Register all spectral bands from all dates into one master data set
      - More data for classification
      - Principal components analysis $\rightarrow$ reduce the dimensionality $\rightarrow$ manipulate, store, classify, …
  - Multi-temporal profile
    - Fig 7.54: greenness. (t_p, σ, G_m, G_0)

Multi-sensor image merging

- Multi-sensor image merging

  IHS multisensor image merger of SPOT HRV, landsat TM and digital orthophoto data

- Multi-spectral scanner + radar image data

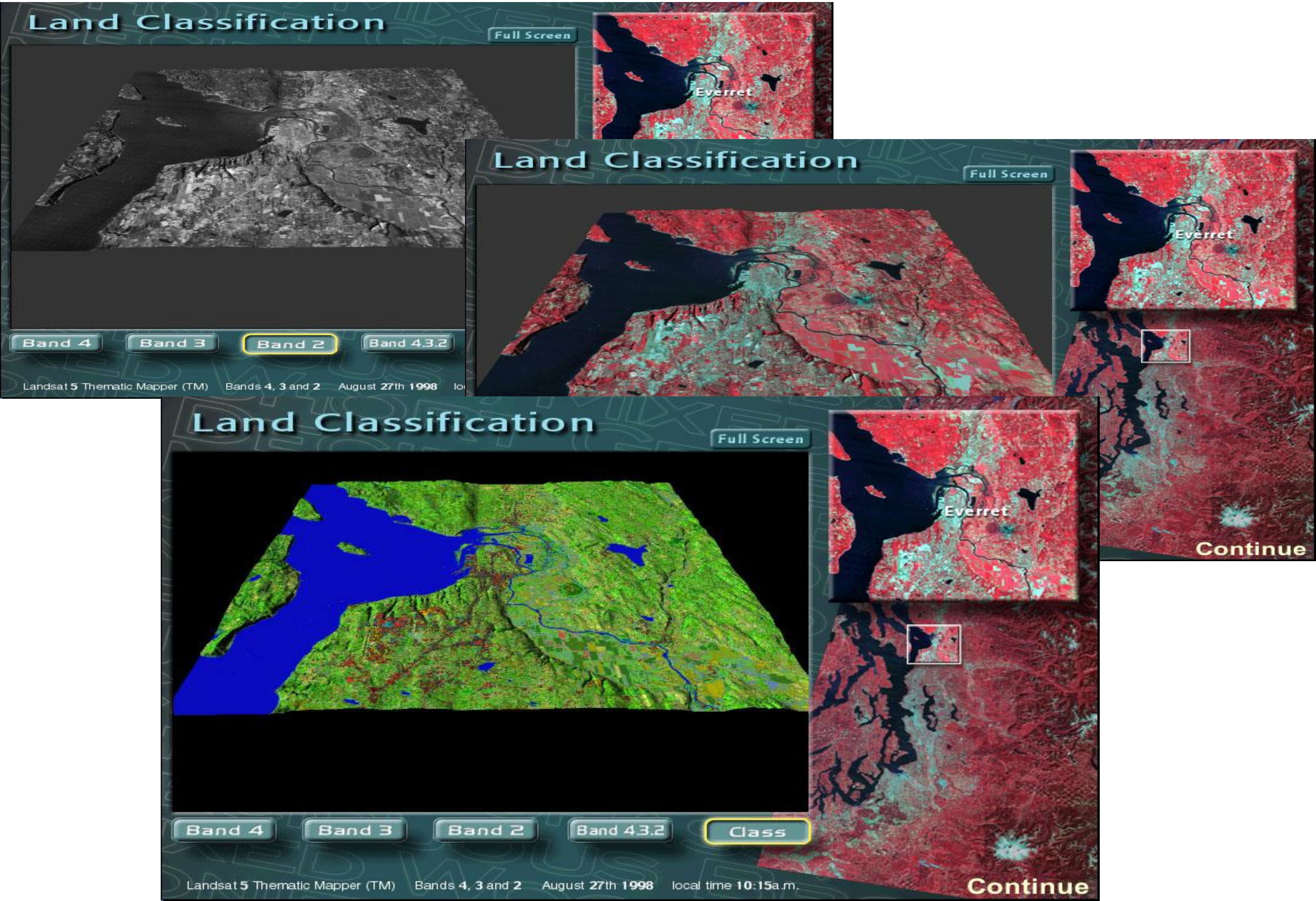
IMAGE CLASSIFICATION

- Why classify?

- Make sense of a landscape
  - Place landscape into categories (classes)
    - Forest, Agriculture, Water, etc

- Classification scheme = structure of classes
  - Depends on needs of users

Image Classification



What is a Classified Image

- Image has been processed to put each pixel into a category
- Result is a vegetation map, land use map, or other map grouping related features
- Categories are defined by the intended use of the map
- Can be few or many categories, depending on the purpose of the map and available resources

TRAINING STAGE

It is to assemble a set of statistics that describe the spectral response pattern for each land cover type to be classified in a image.

REQUIREMENTS

- **To make classification automated**
- **Close interaction between image analyst and image data.**
- **Requires substantial reference data**

- **Through knowledge about the geographic information of the study area. Quality of training process determines the success of classification.**
- **Training set determines the shape, size, location and orientation of clouds of points for each land cover.**
- **For best result the training data must be both representative and complete.**
- **E.g. Water – Clear Water**
- **Turbid water(Various turbidity classes etc.)**

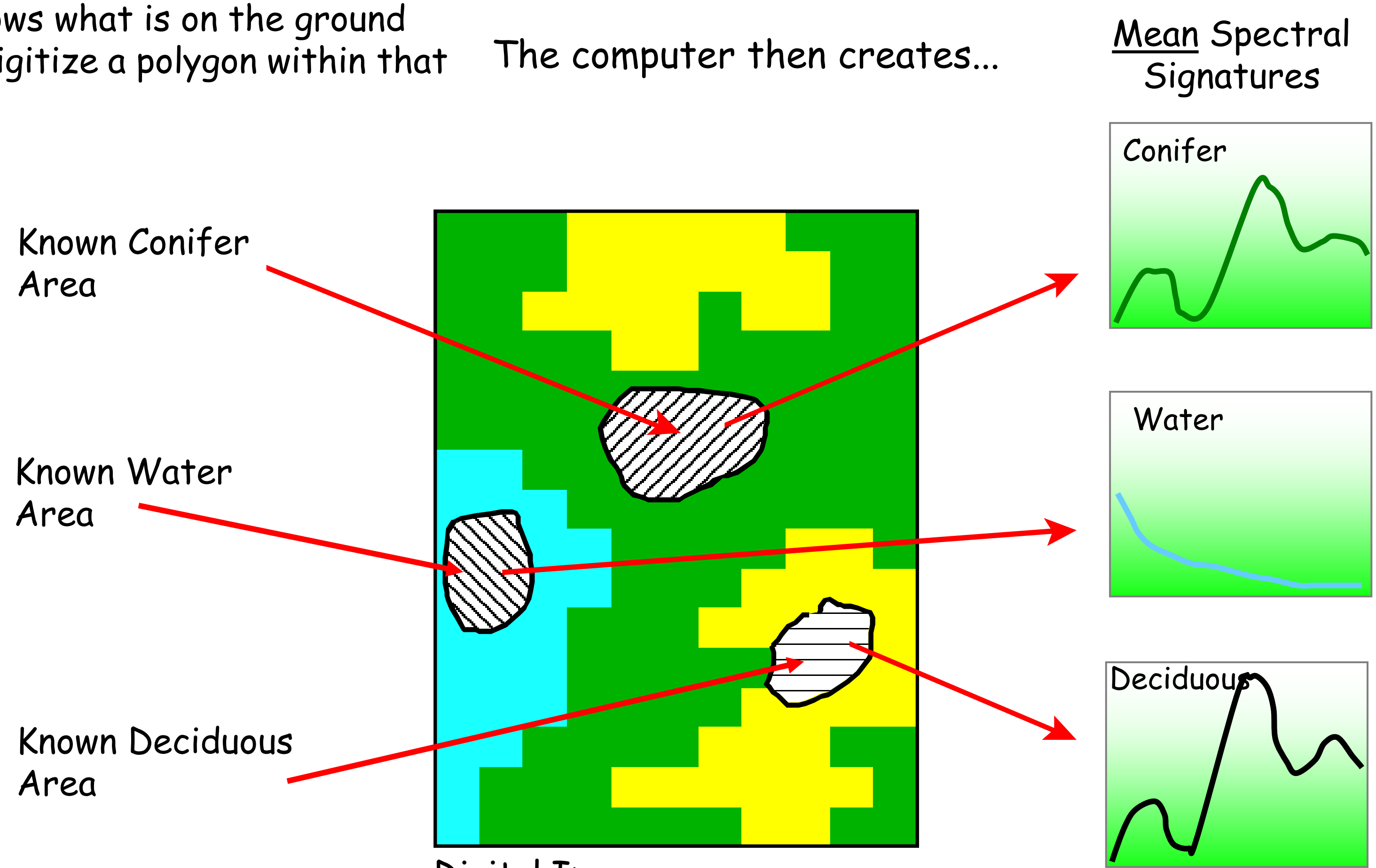
TRAINING AREA LOCATIONS

- ❖ Enlarge the image.
- ❖ Uniform tonal area (smooth) for various shades demarcated using the cursor.
- ❖ All DNs in the training area are derived.
- ❖ Mean Vector and covariance calculated.
- ❖ Minimum (n+1) number of pixels needed for ‘n’ number of bands.
- ❖ Usually 10 n to 100n pixels are used.
- ❖ For each training sets several sites throughout the scene selected i.e. 20 locations of 40 pixels data sets rather than 1 location 800 pixel data.
- ❖ Then distinctive spectral separability between various classes are evaluated.

Supervised Classification

Supervised classification requires the analyst to select training areas where he/she knows what is on the ground and then digitize a polygon within that area…

The computer then creates…



Digital Image

SUPERVISED CLASSIFICATION.

Classification stage

Scatter plot using two band data for the training area training data set.

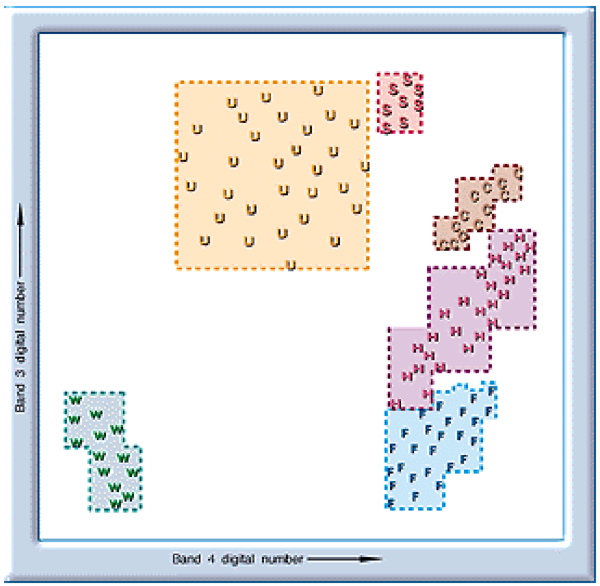
TYPES

Minimum Distance to Mean Classifier

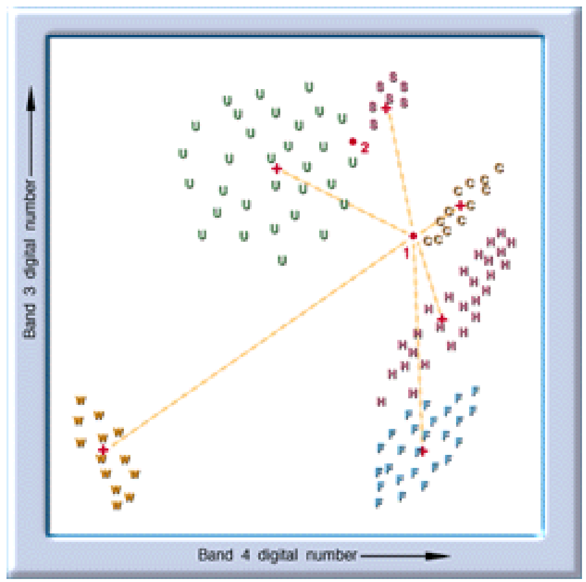
Parallelepiped Classifier

Gaussian Maximum Likelihood Classifier

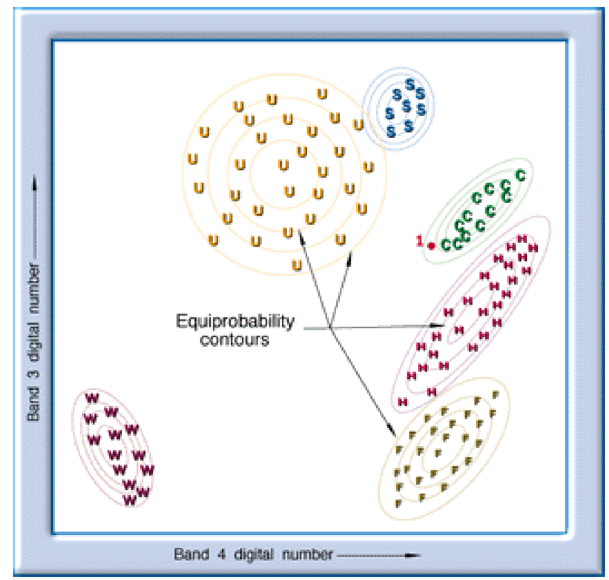
Decision Rules
in Spectral Feature Space



Parallelpiped



Minimum Distance to Means



Maximum Likelihood (Discriminant Analysis

Minimum Distance & Maximum Classifier

Training set scatter plot

Mean DN Calculation for each class and plot.

Find the distances from unknown pixel to all mean values.

Minimum Distance class/category is assigned to unknown pixel.

Advantages & Disadvantages in MD & MC

Mathematically simple & computationally efficient.

Insensitive to different degrees of variance in the spectral response data

So not widely used – where **spectral classes are close**.

Minimum Distance & Maximum Classifier

Training set scatter plot

Mean DN Calculation for each class and plot.

Find the distances from unknown pixel to all mean values.

Minimum Distance class/category is assigned to unknown pixel.

Advantages & Disadvantages in MD & MC

Mathematically simple & computationally efficient.

Insensitive to different degrees of variance in the spectral response data

So not widely used – where **spectral classes are close**.

MAXIMUM LIKELIHOOD CLASSIFIER

Quantitative evaluation of variance and covariance

Assumption Training data set is normally distributed

Under this assumption - each category described by

Mean Vector

Covariance Vector

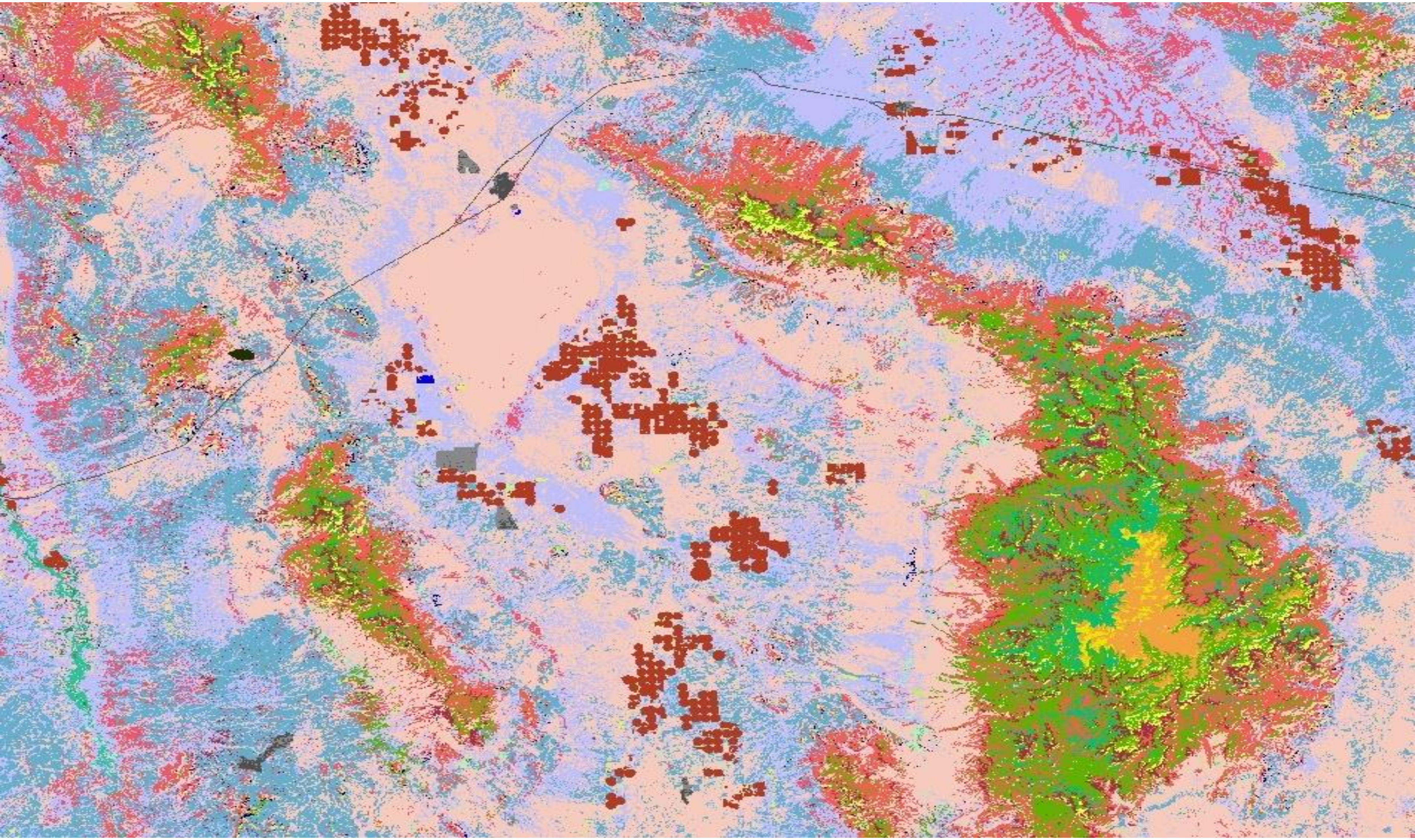
Computate – statistical probability

Three dimensional curve preparation

Band A DN
- Two Horizontal axis
Band B DN

Probability – Vertical Axis

Land Cover Classification

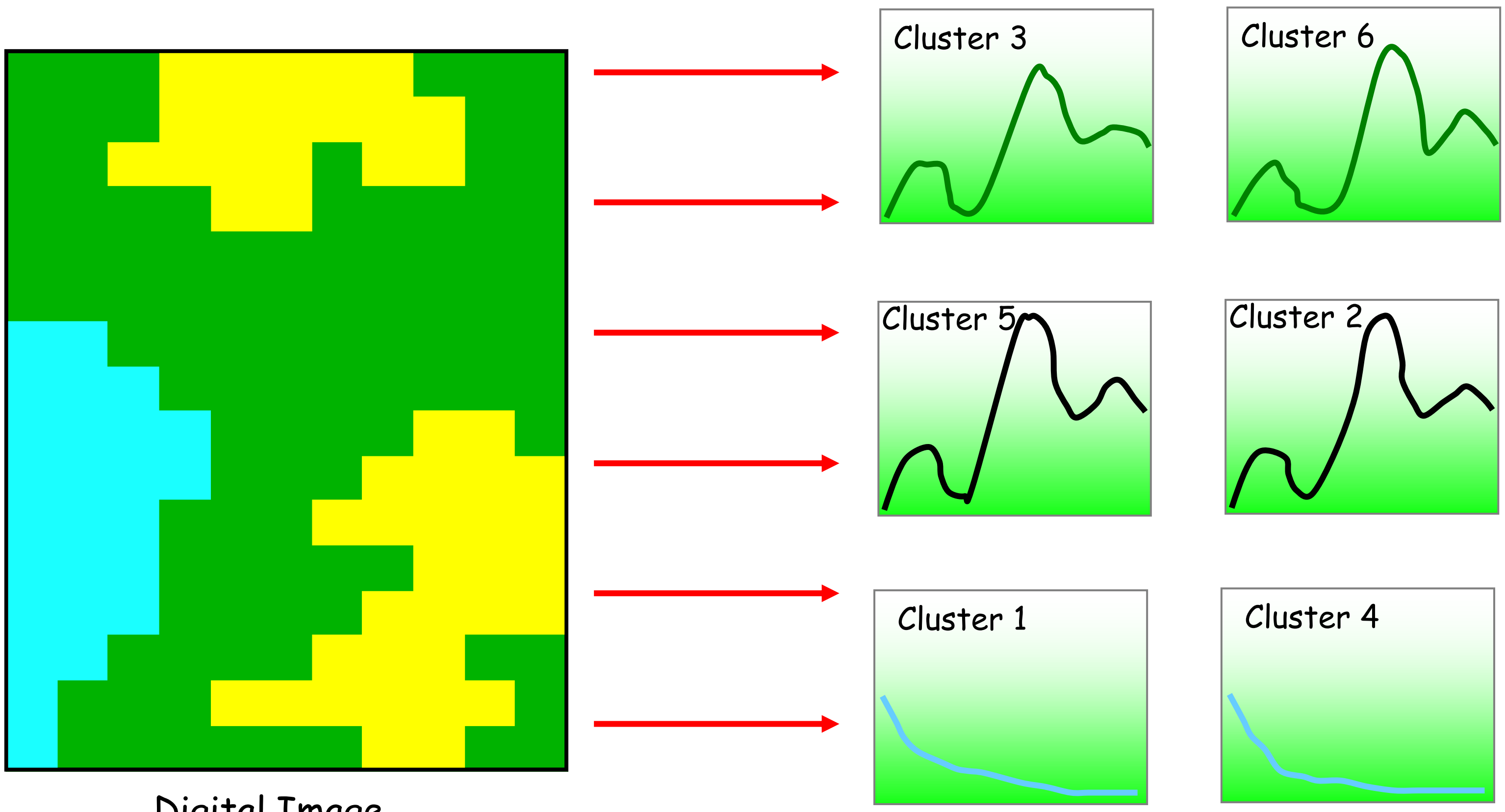


Defining the pieces that make up the puzzle

Unsupervised Classification

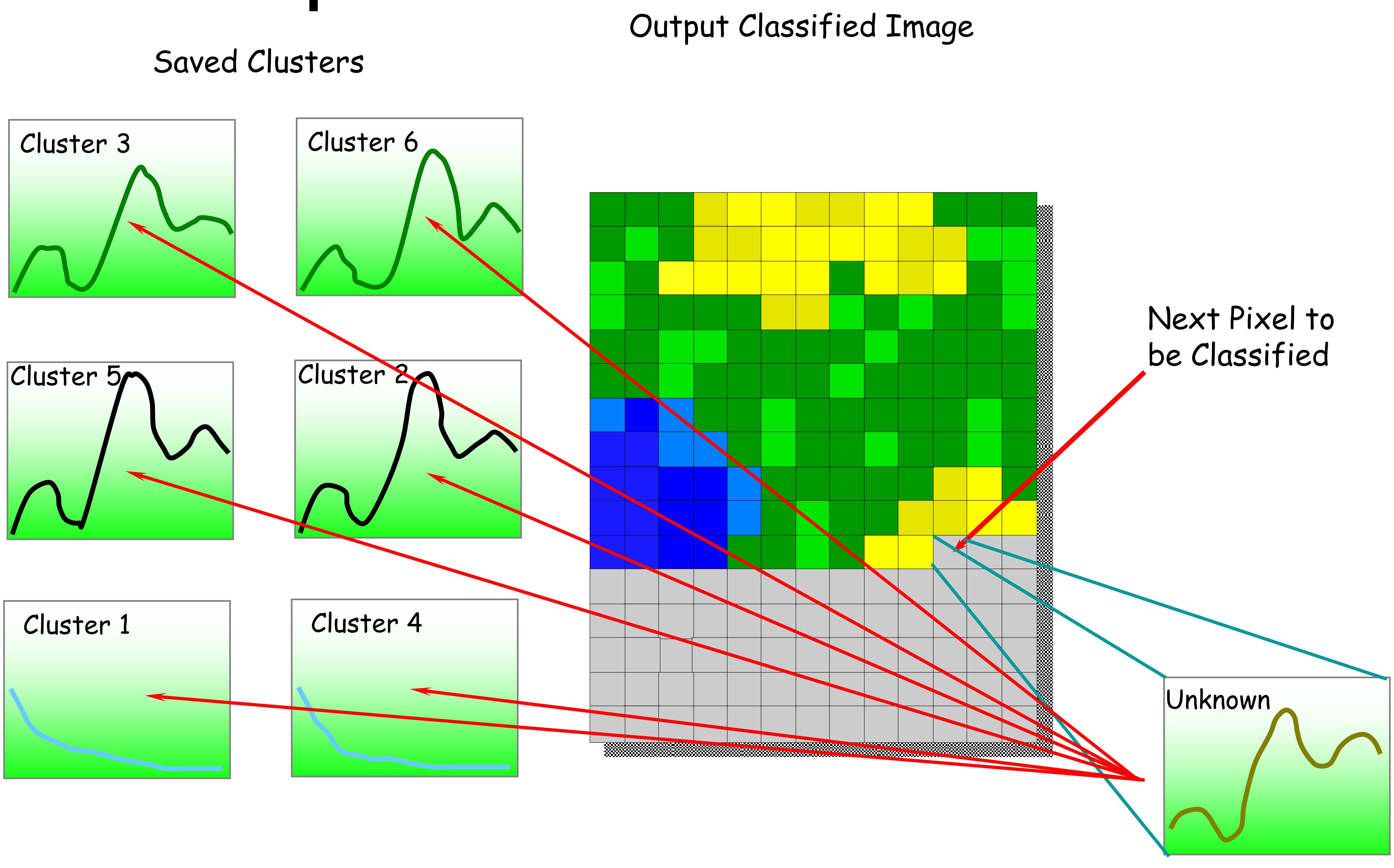
The analyst requests the computer to examine the image and extract a number of spectrally distinct clusters…

Spectrally Distinct Clusters



Digital Image

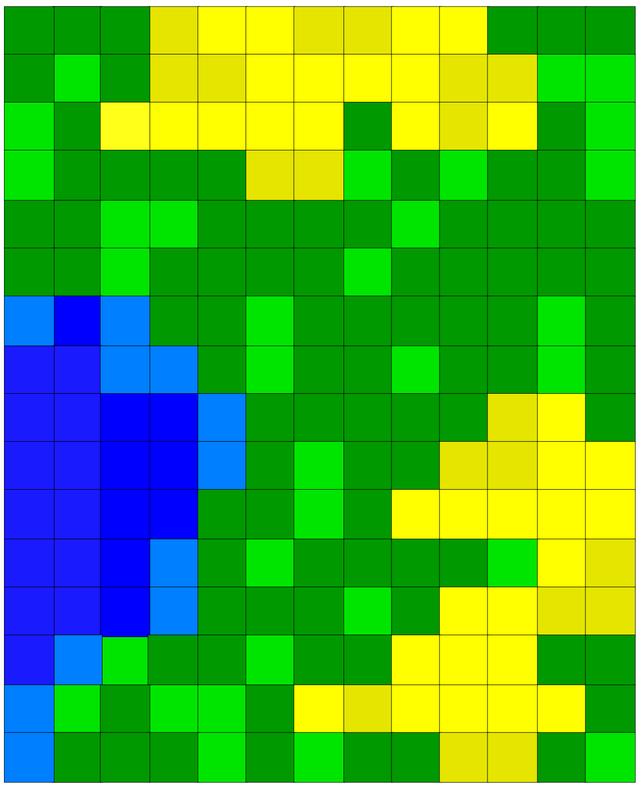
Unsupervised Classification



Unsupervised Classification

The result of the unsupervised classification is not yet information until…

The analyst determines the ground cover for each of the clusters…



??? → **Water**

??? → **Water**

??? → **Conifer**

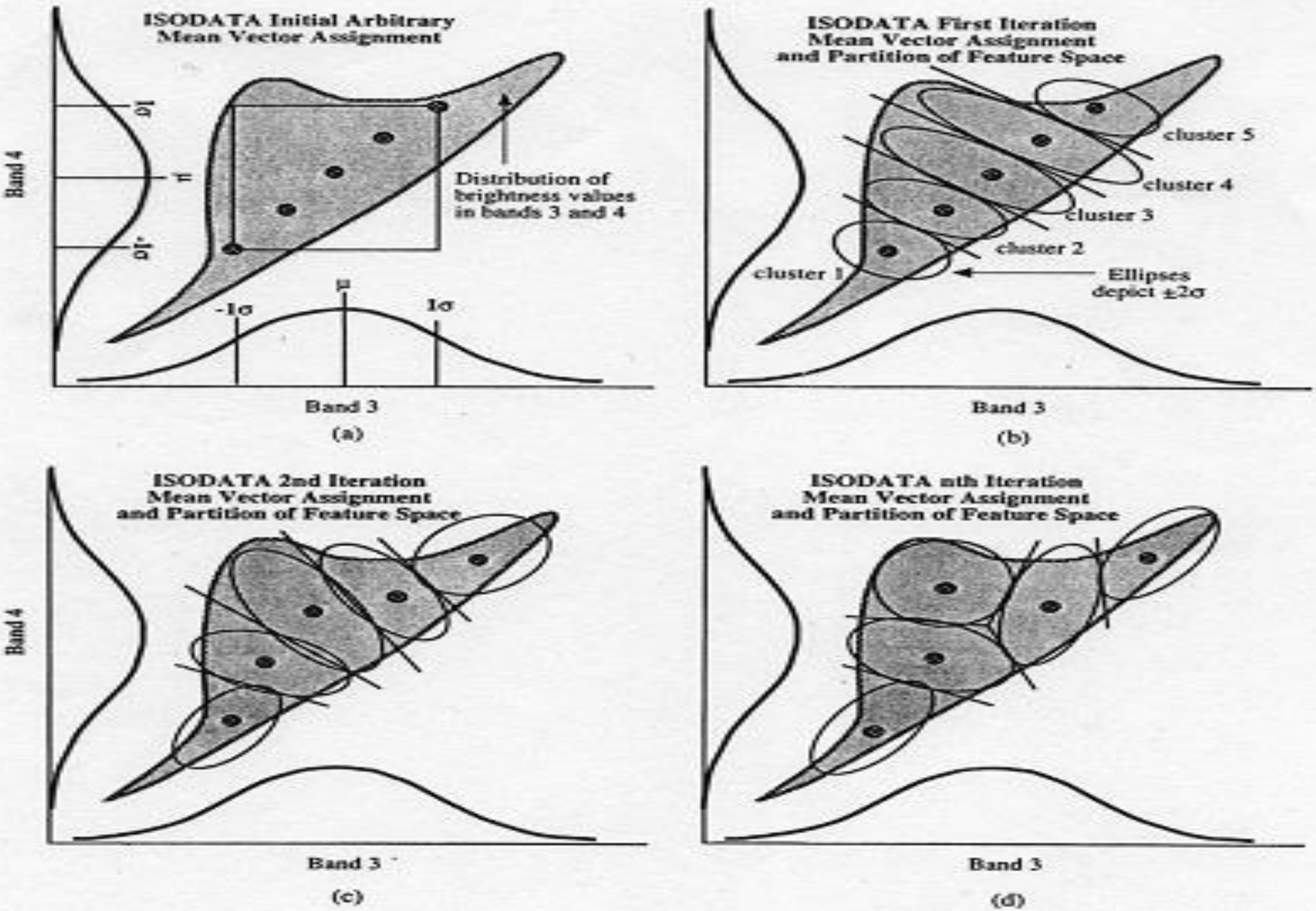
??? → **Conifer**

??? → **Hardwood**

??? → **Hardwood**

ISODATA Procedure

- Arbitrary cluster means are established,
- The image is classified using a minimum distance classifier
- A new mean for each cluster is calculated
- The image is classified again using the new cluster means
- Another new mean for each cluster is calculated
- The image is classified again...



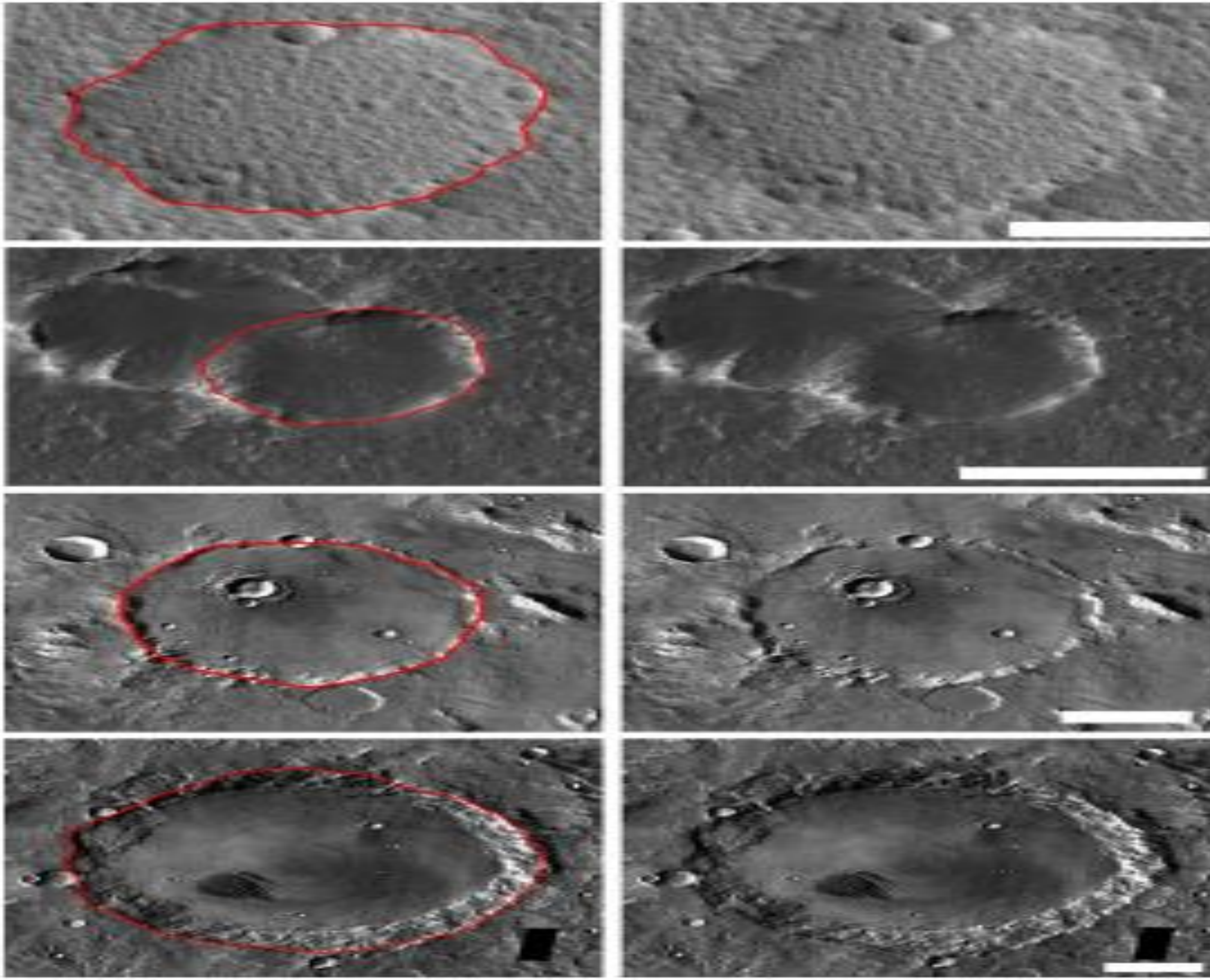
ISODATA Initial Arbitrary
Mean Vector Assignment
Band 4
1σ
μ
-1σ
Distribution of
brightness values
in bands 3 and 4
-1σ
μ
1σ
Band 3
(a)
ISODATA First Iteration
Mean Vector Assignment
and Partition of Feature Space
cluster 5
cluster 4
cluster 3
cluster 2
cluster 1
Ellipses
depict ±2σ
Band 3
(b)
ISODATA 2nd Iteration
Mean Vector Assignment
and Partition of Feature Space
Band 4
Band 3
(c)
ISODATA nth Iteration
Mean Vector Assignment
and Partition of Feature Space
Band 3
(d)

Pattern recognition is the process of classifying input data into objects or classes based on key features. There are two classification methods in **pattern recognition**: supervised and unsupervised classification

Pattern Recognition

- Change detection in an image sequence
  - Detecting abnormal patterns/shapes
  - Detecting changes in motion patterns
- Classification, retrieval, recognition
  - Faces, objects, activities, handwriting,…
- Shape analysis, matching
  - Learning statistical models for shapes of groups of points or of continuous contours, their dynamics over time
  - Matching: shape classification

Fig. 1. (a)(b)-Lunar image with craters



Shape Analysis: Shape is a geologically important characteristic of rocks. However, the shape of a rock is a complex property that can be difficult to describe precisely. A great deal of geological work has been conducted on classifying and categorizing the general appearance of microscopic particle grains with respect to various properties [1-5], and the same basic concepts remain applicable when scaled to the macroscopic realm of Martian rocks. In particular, the concepts of sphericity and angularity provide indicative measures of a rock's shape that could be used by a rover to obtain valuable information about the specimen's geologic origins and history [7].

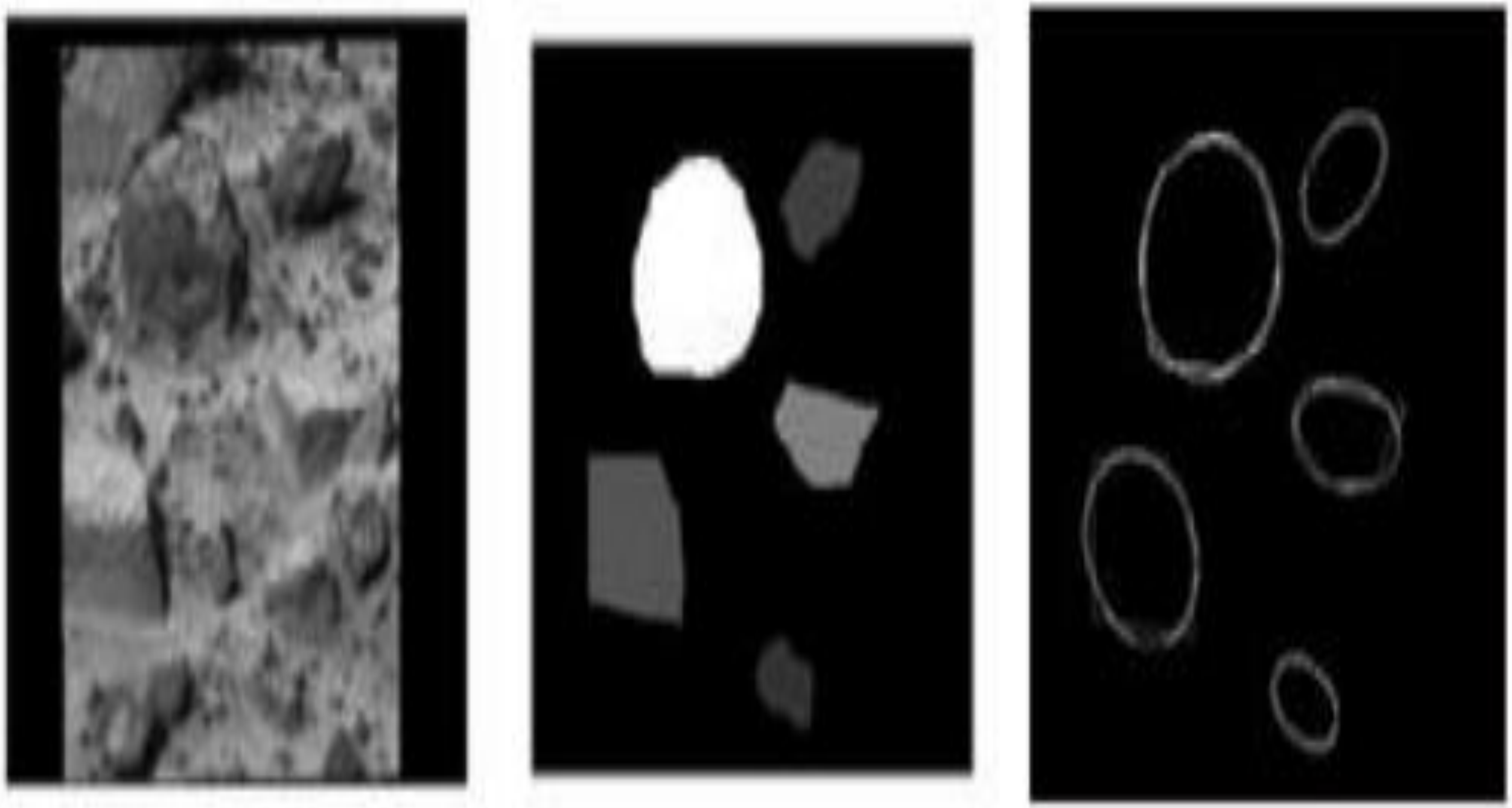


Figure 1 a) Original image taken from the Mars Pathfinder landing site, b) rocks identified from image, c) ellipses fitted to rock outlines.

CHANGE DETECTION

- In general, change detection involves the application of **multi-temporal** datasets to quantitatively analyze the temporal effects

- Change detection can be defined as the process of identifying differences in the state of an object or phenomenon by observing it at different times. This process is usually applied to Earth surface changes at two or more times.

- understanding **relationships** and interactions to better manage and use resources

- Change detection is **useful in many applications** such as land use changes, habitat fragmentation, rate of deforestation, coastal change, urban sprawl, and other cumulative changes

Change Detection

Change detection applications:

1. Deforestation assessment,
2. Vegetation phenology
3. Urban expansion
4. Damage assessment
5. Crop stress detection
6. Snow melting

…

Change Criteria

Before a change detection technique is applied, the analyst has to define what is considered to be a change.

Considerations before implementing change detection

- Before implementing change detection analysis, the following conditions must be satisfied:
  i. precise registration of multi-temporal images;
  ii. precise radiometric and atmospheric calibration or normalization between multi-temporal images;
  iii. selection of the same spatial and spectral resolution images if possible

Good change detection research should provide the following information:

i. area change and change rate
ii. spatial distribution of changed types
iii. Change trajectories of land-cover types
iv. accuracy assessment of change detection results.