Remote Sensing Image Processing

-Pre-processing
-Geometric Correction
-Atmospheric correction
-Image enhancement
-Image classification

Division of Spatial Information Science
Graduate School Life and Environment Sciences
University of Tsukuba

Prof. Dr. Yuji Murayama
Surantha Dassanayake

Pre-processing

- This includes data operation which normally precede further manipulation and analysis of the image data to extract specific information.
- These operations aims to correct distorted or degraded image data to create a more faithful representation of the original scene.
- Pre-processing functions are generally grouped as Radiometric or Geometric corrections

Radiometric Corrections

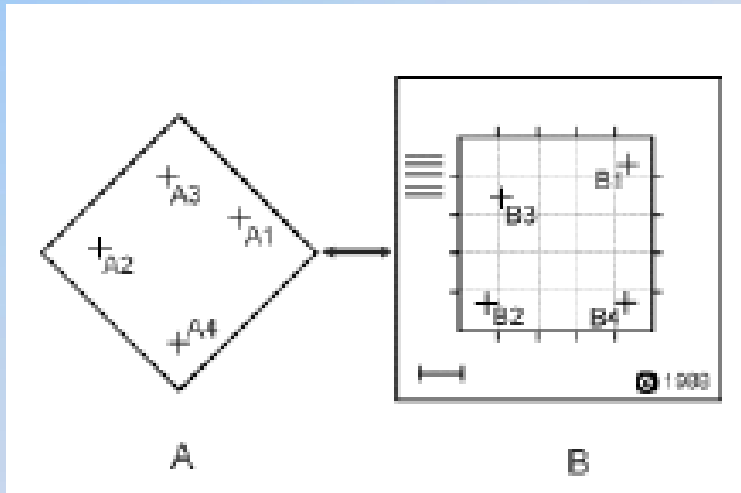
- Radiometric corrections include correcting the data for Sensor Irregularities and Unwanted Sensor or Atmospheric Noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor.

Geometric Corrections

- Geometric corrections include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface.
- Sources of distortions are
  - Variation in the altitude
  - Altitude & Velocity of the sensor platform
  - Earth curvature
  - Atmospheric refraction
  - Relief displacement and
  - Nonlinearities in the sweep of a sensor’s IFOV

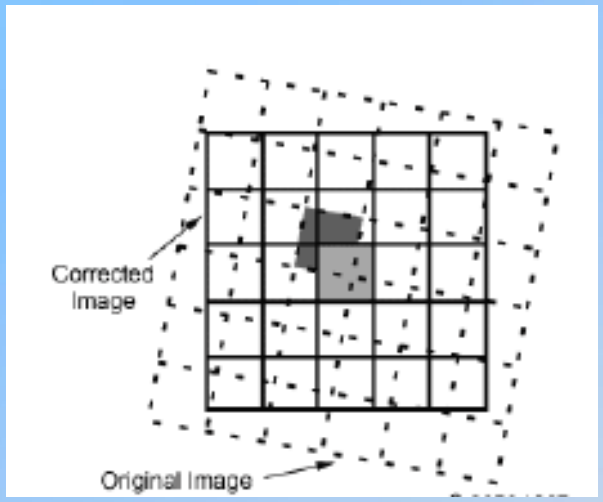
Geometric Correction Contd..

- Conversion of the data to real world coordinates are carried by analyzing well distributed Ground Control Points (GCPs).
- This is done in two steps
  - Georeferencing : This involves the calculation of the appropriate transformation from image to terrain coordinates.



Geometric Correction Contd..

- Geocoding :This step involves resembling the image to obtain a new image in which all pixels are correctly positioned within the terrain coordinate system.



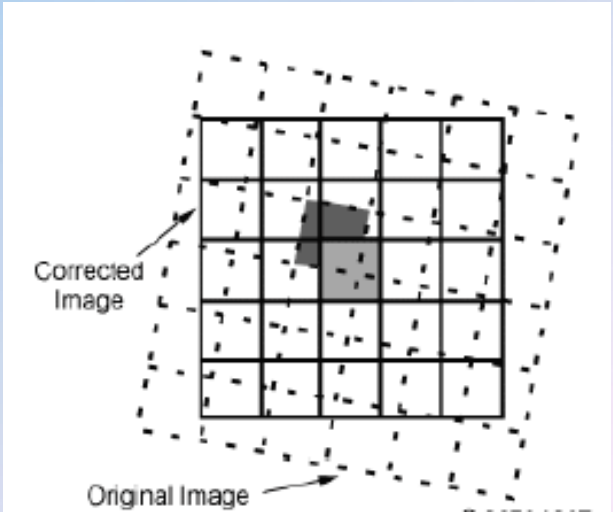
Resampling is used to determine the digital values to place in the new pixel locations of the corrected output image.

Resampling

- The resampling process calculates the new pixel values from the original digital pixel values in the uncorrected image. There are three common methods for resampling.
  - Nearest Neighbourhood, Bilinear Interpolation, and Cubic Convolution.

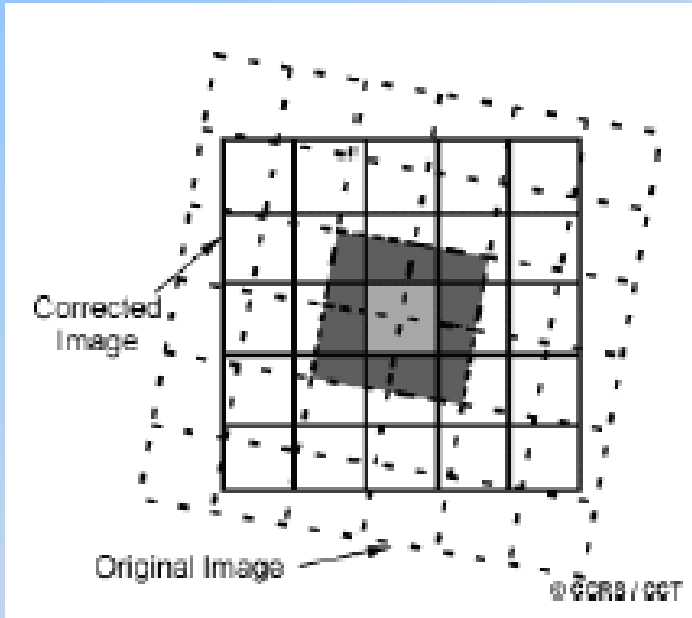
Nearest Neighbourhood

- Nearest neighbour resampling uses the digital value from the pixel in the original image which is nearest to the new pixel location in the corrected image.
- This is the simplest method and does not alter the original values, but may result in some pixel values being duplicated while others are lost.
- This method also tends to result in a disjointed or blocky image appearance.



Bi-linear interpolation

- Bilinear interpolation resampling takes a weighted average of four pixels in the original image nearest to the new pixel location.
- The averaging process alters the original pixel values and creates entirely new digital values in the output image.



Cubic Convolution

- Resampling goes even further to calculate a distance weighted average of a block of sixteen pixels from the original image which surround the new output pixel location.

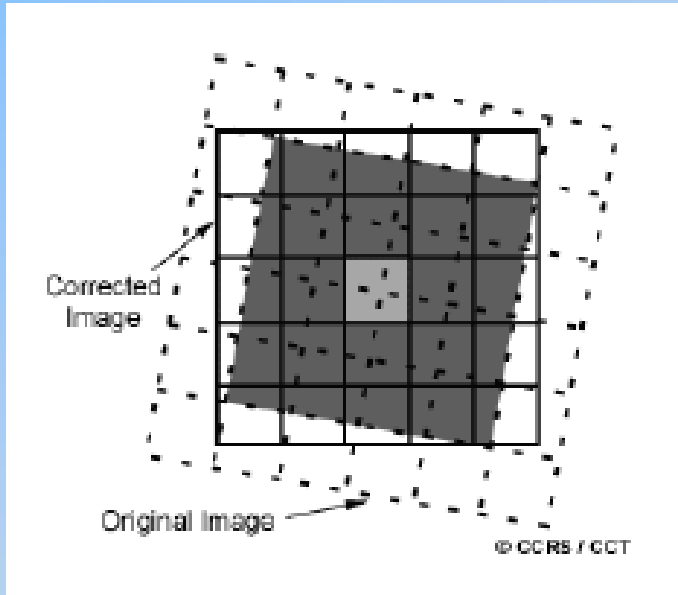


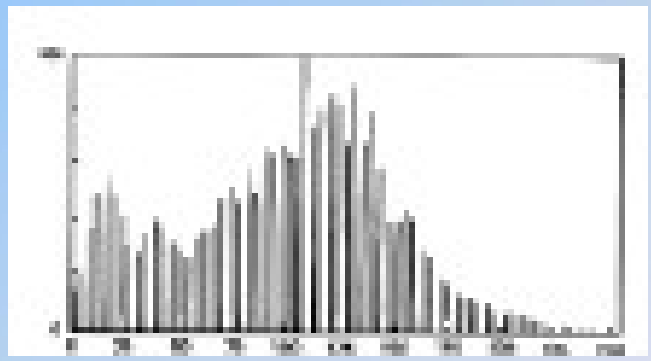
Image Enhancement

Image enhancement is the modification of an image to alter its impact on the viewer. Most enhancement operations distort the original digital values.
Image enhancement methods are:

- Contrast enhancement
- Density slicing
- Frequency filtering
- Band rationing

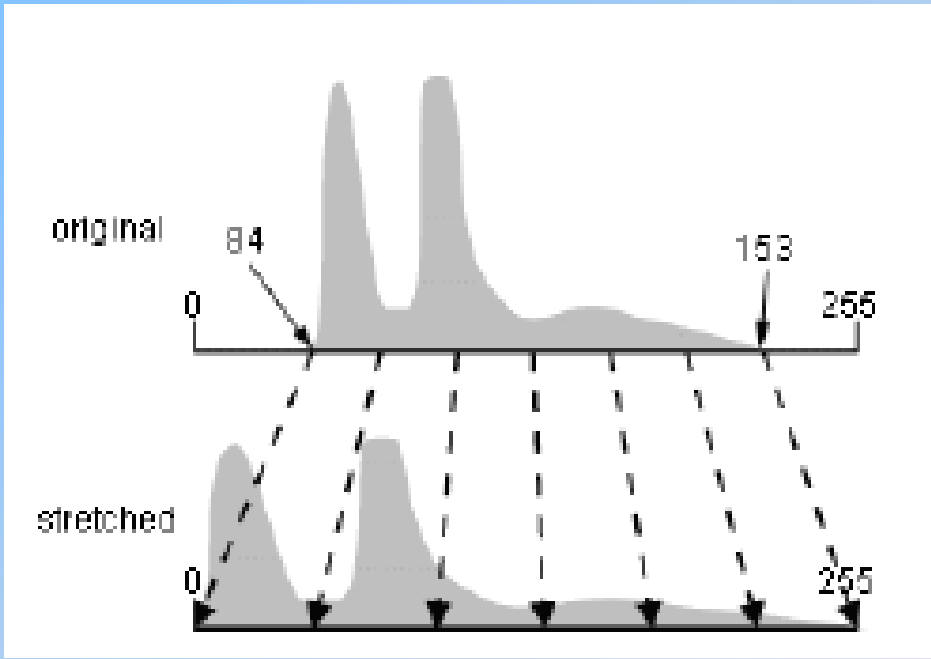
Contrast Enhancement

- In raw imagery, the useful data often populates only a small portion of the available range of digital values (commonly 8 bits or 256 levels).
- Contrast enhancement involves increasing the contrast between targets and their backgrounds.
- The key to understanding contrast enhancements is to understand the concept of an **image histogram**.

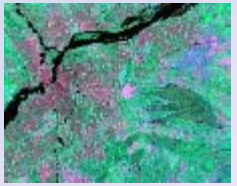


Linear contrast stretch

- The simplest type of enhancement is a linear contrast stretch. This involves identifying lower and upper bounds from the histogram and applying a transformation to stretch this range to fill the full range.



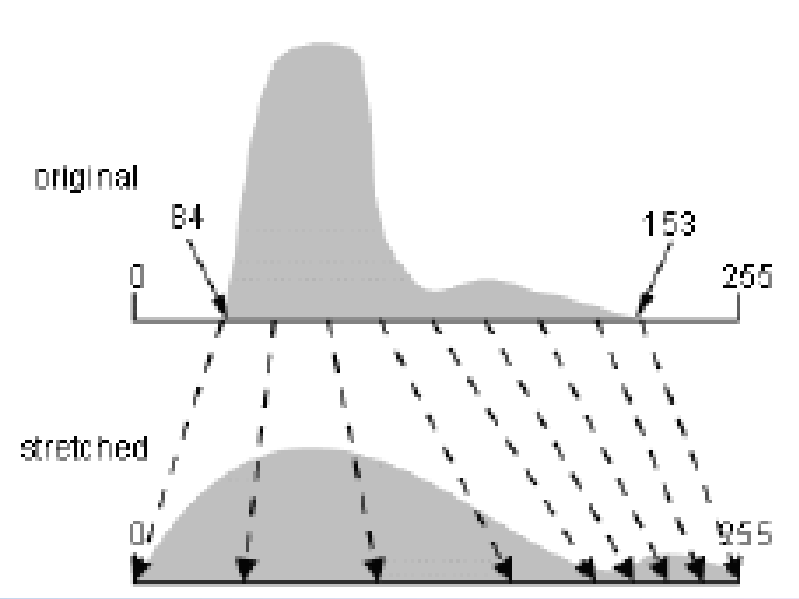
before



After

Histogram-equalized stretch

- A uniform distribution of the input range of values across the full range may not always be an appropriate enhancement, particularly if the input range is not uniformly distributed.
- In this case, a histogram-equalized stretch may be better.

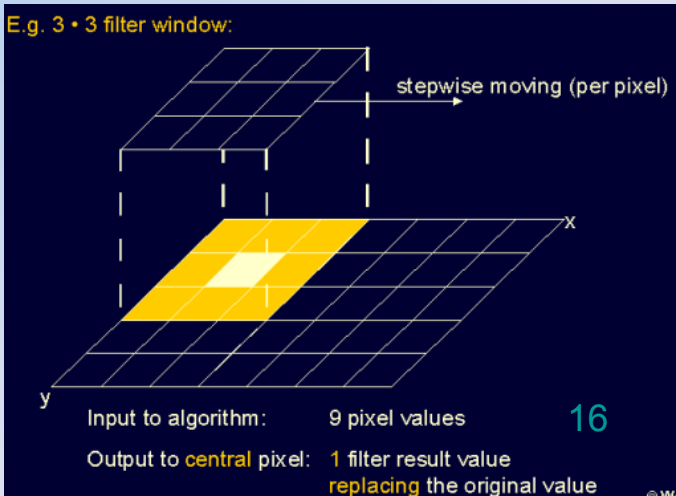


Density slicing

- Density slicing is an enhancement technique whereby the DNs distributed along the x axis of an image histogram are divided into a series of analyst specified intervals or slices.
- All of DNs falling within a given interval in the input image are then displayed at a single DN in the output image.

Spatial Filtering

- Low pass filter
  - A low-pass filter is designed to emphasize larger, homogeneous areas of similar tone and reduce the smaller detail in an image.
  - This serve to smooth the appearance of an image.
  - Low pass filters are very useful for reducing random noise.
  - Example. Average & Median filters



Median filter

f1	f2	f3
f4	f5	f6
f7	f8	f9

Ex.

23	7	8
5	25	20
12	40	35

Median filter : 9 pixel values were ordered.

f4 f2 f3 f7 **f6** f1 f5 f9 f8

Pixel value f6 is now assigned to centre pixel.

High pass filter

- High pass filters do the opposite and serve to sharpen the appearance of fine detail in an image.
- Directional, or edge detection filters are designed to highlight linear features, such as roads or field boundaries.

Band Rationing (Spectral)

- Image division or **spectral ratioing** is one of the most common transforms applied to image data. Image ratioing serves to highlight subtle variations in the spectral responses of various surface covers.
- Healthy vegetation reflects strongly in the near-infrared portion of the spectrum while absorbing strongly in the visible red. Other surface types, such as soil and water, show near equal reflectances in both the near-infrared and red portions.
- Thus, a ratio image of Landsat MSS Band 7 (Near-Infrared - 0.8 to 1.1 mm) divided by Band 5 (Red - 0.6 to 0.7 mm) would result in ratios much greater than 1.0 for vegetation, and ratios around 1.0 for soil and water.

Image Transformation

- Image transformations typically involve the manipulation of multiple bands of data, whether from a single multispectral image or from two or more images of the same area acquired at different times (i.e. multitemporal image data).
- Basic image transformations apply simple arithmetic operations to the image data.
  - Image addition
  - Image subtraction

Fields of Application

Meteorology	Weather forecast Climate studies Global change
Hydrology	Water balance Energy balance Agro hydrology
Soil Science	Land evaluation Soil mapping
Biology/ Nature Conservation	Vegetation mapping Monitoring Vegetation condition assessment
Forestry	Forest inventarization/ Mapping De/re forestation Forest fire detection
Forestry Environmental Studies	Sources/effects pollution Water quality Climate change
Agricultural engineering	Landuse development Erosion assessment Water management
Physical Planning	Physical Planning Scenario studies
Land Surveying	Topography (DTM) Spatial data models, GIS

References :

Remote Sensing for GIS Managers by Stan Aronoff

http://www.ciesin.org/TG/RS/RS-home.html

http://rst.gsfc.nasa.gov/

http://www.cmis.csiro.au/rsm/intro/