Remote Sensing and DIP
(Module-2)

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Digital Image Data Formats

- Understanding existing digital data formats is essential before the data can be processed.
- There are four major data formats used:
  - Band Interleaved by Pixel (BIP) Format
  - Band Interleaved by Line (BIL) Format
  - Band Sequential (BSQ) Format
  - Run-Length Encoding Format

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Band Interleaved by Pixel Format (BIP)

- This format treats pixels as the separate storage unit.
- It is practical to use if all bands in an image are to be used.
- This format may be awkward to use if only certain bands of the imagery are needed.

Figure 2-3.1 Band Interleaved by Pixel Format (BIP)

Line 1	Pixel 1	Band 1	Line 1	Pixel 2	Band 1	Line 1	Pixel 3	Band 1
Line 1	Pixel 1	Band 2	Line 1	Pixel 2	Band 2	Line 1	Pixel 3	Band 2
Line 1	Pixel 1	Band 3	Line 1	Pixel 2	Band 3	Line 1	Pixel 3	Band 3
Line 1	Pixel 1	Band 4	Line 1	Pixel 2	Band 4	Line 1	Pixel 3	Band 4

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Band Interleaved by Line Format (BIL)

- Just as the BIP format treats each pixel of data as the separate unit, the BIL format is stored by lines.
- It is a useful to use if all bands of the imagery are to be used in the analysis.

Figure 2-3.2 Band Interleaved by Line Format (BIL)

Line 1	Band 1	Line 1	Band 2	Line 1	Band 3	Line 1	Band 4	
Line 2	Band 1	Line 2	Band 2	Line 2	Band 3	Line 2	Band 4	
Line 3	Band 1	Line 3	Band 2	Line 3	Band 3	Line 3	Band 4	
Line 4	Band 1	Line 4	Band 2	Line 4	Band 3	Line 4	Band 4	

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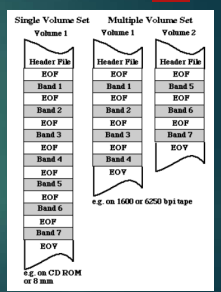
Band Sequential Format

- The band sequential format requires that all data for a single band covering the entire scene be written as one file.
- Many researchers like this format because it is not necessary to read serially past unwanted information if certain bands are of no value, especially when the data are on a number of different tapes.



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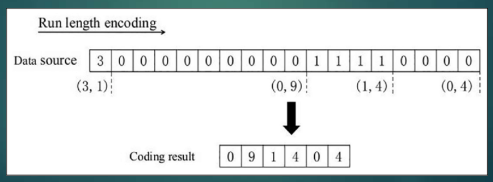
Run-Length Encoding

- Run-length encoding is a band sequential format that keeps track of both the brightness value and the number of times the brightness value occurs along a given scan line.



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Standards of Data Formats

- LGSOWG (Landsat Ground Station Operators Working Group) or Super Structured Format
- Fast Format
- GeoTIFF (Geographic Tagged Image File Format)
- HDF (Hierarchical Data Format)
- IMG: developed by ERDAS for Imagine
- GRID: developed by ESRI
- JP2: JPEG 2000, developed by JPEG group

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Basic Image Statistics

- Image statistics provide valuable information necessary for displaying and analysing remote sensor data
  - Univariate Image Statistics
  - Multivariate Image Statistics

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Univariate Descriptive Image Statistics

- Minimum
- Maximum
- Range (Max – Min)
- Mean
- Median
- Mode
- Variance
- Standard Deviation

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- **Mean:** is the arithmetic average and is defined as the sum of all observations divided by the number of observations.
- **Median:** is the value midway in the frequency distribution.
- **Mode:** is the value that occurs most frequently in a distribution.

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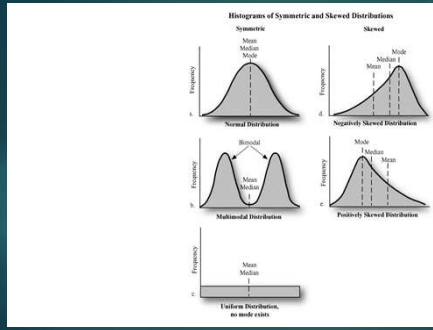

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- **Variance:** is the expectation of the squared deviation of a random variable from its mean, and it informally measures how far a set of (random) numbers are spread out from their mean.

$$var_k = \frac{\sum_{i=1}^{n}(BV_{ik} - \mu_k)^2}{n-1}$$

- **Standard deviation:** is the positive square root of the variance.

$$s_k = \sqrt{var_k}$$

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Multivariate Image Statistics

- **Covariance:** is a measure of the degree to which returns on two variables move in tandem.

$$cov_{kl} = \frac{\sum_{i=0}^{n}(BV_k - \mu_k)(BV_l - \mu_l)}{n-1}$$

- **Correlation:** is a mutual relationship or connection between two or more bands.

$$r_{kl} = \frac{cov_{kl}}{s_k s_l}$$

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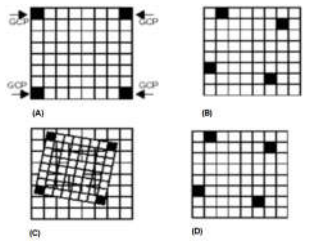
Georeferencing and Rectification

- It is a process of transforming an uncorrected, raw image from an arbitrary coordinate system into a map projection (geographic) coordinate system Namely, image pixels are positioned and rectified to align and fit into real-world map coordinates.



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Reasons for Georeferencing and Rectification

- Due to inherent geometric distortions, aerial and satellite images generally need to be geocoded before they can be used in geo-scientific analysis
- Data fusion: overlay a number of different images of the same area to combine their bands containing data into a single image dataset. The individual images must be georeferenced to a compatible coordinate system
- Comparing images for change detection
- Creating composite image maps
- Making measurements
- Mosaicking images

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Correction of Geometric Distortions

- Geometric distortions are often systematic (predictable) and may be identified and corrected using pre-launch or in-flight platform ephemeris (ie, information about the geometric characteristics of the sensor system and the Earth at the time of data acquisition) Geometric distortions in imagery can be corrected through analysis of sensor characteristics and ephemeris data. Three types of corrections
  - Rigorous orthorectification
  - Image-to-map rectification
  - Image-to-image co-registartion

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Rigorous Orthorectification Process

- Orthorectification corrects local and global distortions by modeling imaging geometry (the position and attitude of sensor or camera) and terrain topography. It is a more accurate form of rectification
- All georeferencing and rectification methods require selection of GCPs, although orthorectification process needs relatively fewer GCPs
- Orthorectification of Digital Aerial Photos
- The following information is required: 1) Pre-launch or in-flight space-borne platform ephemeris data (altitude, velocity, attitude at the time of data acquisition) 2) Sensor viewing geometry 3) Digital Elevation Model (DEM)

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- **Image-to-Map Rectification**:

This procedure is commonly used to rectify remotely sensed data to a standard map projection whereby it may be used in conjunction with other spatial information in a GIS to solve problems

- **Image-to-Image Co-registration**

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Ground Control Points

- Ground control points are also known as tie points, tick points, conjugate points in other contexts
- Candidate features for GCPs
  - Locations that can be easily and clearly identified and precisely located are good candidates to be chosen as control points
  - Visible, small, stable, permanent, and well-defined landmarks

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Ground Control Point (GCP) Acquisition

- The distribution of tic points should be fairly uniform across your study area
- The number of GCPs required depends on the terrain, the size of the image, and the rectification method and the order of mathematical equation utilized. The greater the terrain variations and geometric distortion, the more GCPs that are required
- The geographic coordinates of ground control points are often determined from topographic map, ground survey, or GPS measurement
- GCP Link File Format

Point	Xi_image	Yi_image	Xi_state	Yi_state
1	1655	2693	35537794799	102116525559
2	1500	2986	35525079185	102140797149
3	2152	2859	35578729998	102130937236

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Polynomial Method

- The Polynomial method model distortions by fitting a polynomial mathematical function through Ground Control Points. It does not require knowledge of the sensor geometry or how the image was captured
- A polynomial is essentially a mathematical equation which links the uncorrected raw image to the georeferenced database based on the input ground-control points
- Rectification Type: Linear (Affine), Quadratic or cubic polynomial
- Generally, for moderate distortions in a relatively small area of an image (e.g., a quarter of a Landsat TM scene), a first-order, six-parameter, affine (linear) transformation is sufficient to rectify the imagery to a geographic frame of reference
- You should select at least twice as many points as the number required

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Error of Georeferencing and Rectification

- A least squares fit method is used to fit the transformation parameters
- At least one ground control point more than the minimum required is needed to generate an RMS error
- Root Mean Squared Error is a statistical measure of the error between the calculated coordinates of a GCP from the fitted polynomial equation and the measured (true) coordinates of the GCP from GPS, topographic map, or a georeferenced image
- The polynomial will not transform every GCP with 100 per cent accuracy and it is important before the full rectification proceeds to ensure that the errors are within acceptable limits
- The RMS error value for each GCP affects and is affected by other GCPs

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Resampling Method

- When georeferencing (geocoding) and rectification is performed, the output grid (image) will commonly have different cell (pixel) size, orientation, and coordinates from those in the input image. To determine the DN values for cells (pixels) in output grid (image), the resampling (intensity interpolation) process is required
- Resampling is the process of determining new values for output pixels after geometric transformation of input image It is based on the original image
- The three resampling techniques commonly used: nearest neighbor assignment, bilinear interpolation, and cubic convolution

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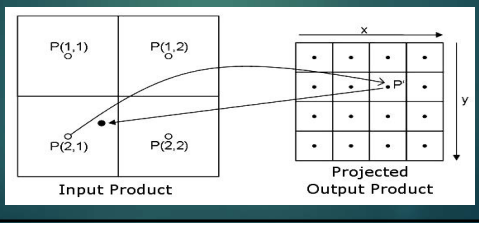
Nearest Neighbor

- Nearest neighbor interpolation simply assigns the value to a pixel that is closest to * as shown



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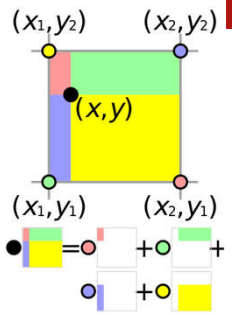
Bilinear Interpolation

- In this geometric visualisation, the value at the black spot is the sum of the value at each coloured spot multiplied by the area of the rectangle of the same colour, divided by the total area of all four rectangles.



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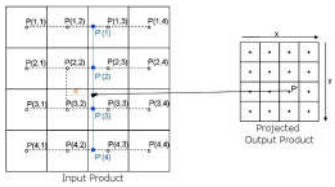
Cubic convolution Interpolation

- Cubic Convolution looks at the 16 nearest cell centers to the output and fits a smooth curve through the points to find the value.



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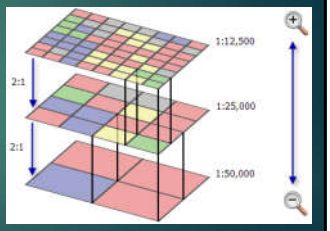
Raster Pyramids

- Pyramids are used to improve display performance.
- They are a downsampled version of the original raster dataset and can contain many downsampled layers.
- Each successive layer of the pyramid is downsampled at a scale of 2:1.



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Any Questions?

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