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Fundamentals of Digital Image Processing and Classification

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ABSTRACT

Remotely-sensed data obtained from satellites or aircraft are usually geometrically distorted due to the acquisition system and the movements of the platform. Preprocessing of satellite images prior to image classification and change detection is essential. Image Processing is a technique which is used to enhance raw images received from cameras and sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-to-day life for various applications. Digital image processing is the technique of processing images in the form of discrete digital brightness quantities by means of using digital circuits or digital computers.

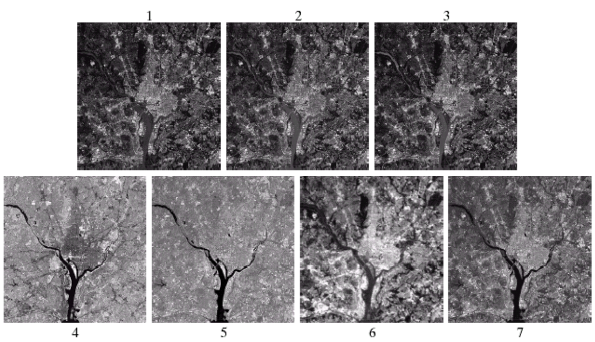
Introduction

Digital image processing can be thought of as a transformation of an image into a modified image from which human can detect silent features without difficulty for interpretation necessary for image analysis. In other words, Digital image processing is an electronic data processing on a 2-D array of numbers known as pixel which is the numeric representation of an image .Image processing ends and image analysis start.An image processing system consists of a source of image data, a processing element and a destination for the processed results. The source of image data may be a camera, a scanner, a mathematical equation, statistical data, the Web, a SONAR system, etc.

- The processing element is a computer.
- The destination for the processed results i.e,
- The output of the processing may be a display.

Application of DIP:

- Geographic Information Systems (GIS)
- Digital image processing techniques are used extensively to manipulate satellite imagery
- Meteorology
- Terrain classification
- Medical science
- etc.

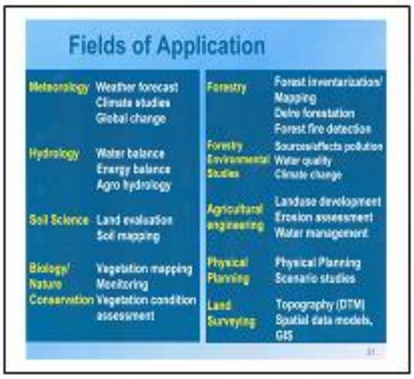


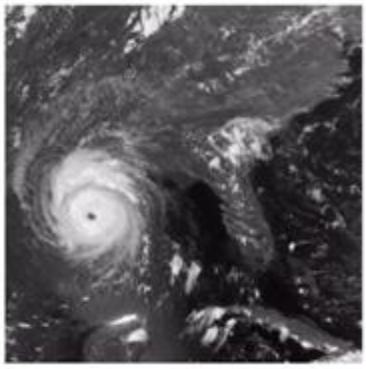
Major tasks of Digital Image Processing:

Digital image processing focuses on two major tasks

– Improvement of pictorial information for human interpretation

– Processing of image data for storage, transmission and representation





Objective:

It can be summarized as :

- Image Correction -compensates distortion, errors, and noise during data acquisition
- Image Enhancement -improves or increases visual appearance and interpretability of imagery
- Information Extraction - uses the computer to classify pixels or neighborhoods of pixels on the basis of their spectral-radiometric temporal responses (DN's

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Applied Image Processing:

Hardware and Software for Image Processing:

Hardware
- Computer monitor
- CD-ROM, ink-jet printer
- Disk Drive
- Internet connection
- Scanner, digital camera

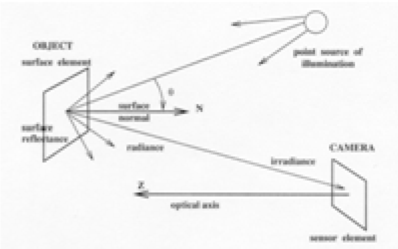
Software
- Photoshop
- ERDAS Imagine
- IDRISI, Arc View
- MATLAB, Visual C++
- ENVI, ER Mapper etc.

Image Concept:

Human senses include vision, hearing, touching, smelling and tasting. Vision is the most important way of information exchanges of human being. Image is a kind of language which expresses visual information. Two types of images are- Analog & Digital .Natural picture is continuous and indiscrete, called analog image or continuous image. A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels. A digital image is composed of discrete pixels, or set of pixels each having associated integer brightness value which is called gray-level.

Pixel and Gray level concept:

Image Formation



Digital image is a data matrix or array of elements which are known as image pixels

Each pixel has an integer location or address (row number and column number). The integer value is proportional to the brightness at the spatial point of the pixel. The accuracy of pixel brightness is quantized in number of bits or gray-levels.

A *real* image is formed on a sensor when an energy emission strikes the sensor with sufficient intensity to create a sensor output.

Image Formation as a 2-D function, f(x, y), where x and y□Can be defined are spatial (plane) coordinates, & the amplitude of f at any pair of coordinates (x, y) is called the intensity or grey level of the image at that point when x, y, and the amplitude values of f are all finite, discrete quantities, we call the image a digital image which is obtained by digitization of analog image.

D*igitization*

D*igitization* implies that a digital image is an *approximation* of a real scene Pixel brightness value typically represent gray levels, colors, heights, opacities etc.

Digitization accuracy

Resolutions express digitization accuracy.

They are of 2 types

– Pixel resolution

– Brightness resolution (color resolution)

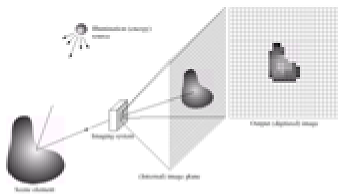
Pixel resolution expresses pixel sampling accuracy. They are of 2 types. Pixel resolution can be described by actual size of each pixel of a digital image, called Absolute resolution. Pixel resolution can also be described by the size of a digital image or the amount of pixels of the image, called Relative resolution.

Brightness Resolutions expresses brightness quantization accuracy. Brightness resolution is also a kind of relative resolution because pixel brightness are quantized into finite number of gray-levels. It denotes total no. and data bits for gray -levels.

Key stages of Digital Image Processing

1) Image acquisition 2) Image enhancement 3) Image restoration 4) Image pre-processing 5) Segmentation 6) Object recognition 7) Classification

Image acquisition



<u>**Sampling**</u> means measuring the value of an image at a finite number of points normally corresponds to the extent of the no of pixels in both vertical and horizontal directions .<u>**Quantization**</u> is the representation of the measured value at the sampled point by an integer. The number of gray levels in the equally spaced gray scale is called the quantization or gray scale resolution of the system.

Digital Image enhancement:

Image enhancement makes the interpretation of complex data easier for the operator.

Fewer errors are made, more subtle features can be detected, and quantitative measurements are facilitated. The goal of digital image enhancement is to produce approached image that is suitable for a given application.

Image enhancement tasks

Image reduction, image magnification, transect extraction, contrast adjustments (linear and non-linear), band rationing, spatial filtering, Fourier transformations, principal components analysis, texture transformations, and image sharpening etc.

Image enhancement methods

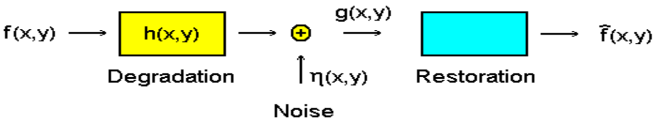
Image enhancement is the modification of an image to alter its impact on the viewer.

Image enhancement method includes:

1) Contrast enhancement 2) Density slicing 3) Frequency filtering 4) Band rationing

Image restoration

The objective of Image Restoration is to highlight fine details in the image which were suppressed by the blur. The goal of image restoration is to improve a degrade image in some predefined sense. Schematically this process can be visualized as



where f is the original image, g is a degraded/noisy version of the original image and $\tilde{f}$ is a restored version. Image restoration removes a known degradation.

The distortion may be specified by locating control points and identifying their corresponding control points in an ideal. The distortion model then made transformation between these control points to generate a special warping function which allow to build output image pixel by pixel (warped).

Radiometric Correction:

Radiometric correction improves the fidelity of the DN's that constitute an image.

Radiometric Corrections used for

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

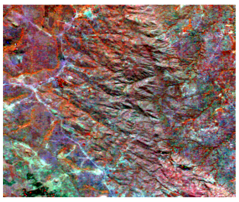
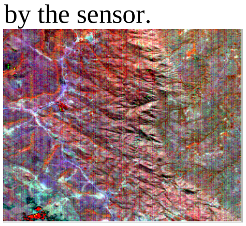



Image with nose Radiometric Corrected

Types of radiometric correction

- Atmospheric error correction (external error)
- Topographic error correction (external error)
- Detector error or sensor error (internal error)

Atmospheric correction attempts to quantify (i.e., remove) the effect of the atmosphere at the time an image was acquired.

Absolute radiometric (atmospheric) correction:

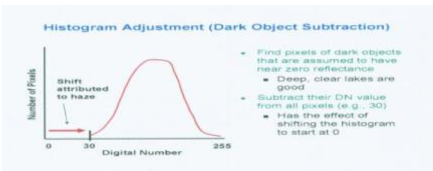
The general goal of absolute radiometric (atmospheric) correction is to turn the digital brightness values (or DN) recorded by a remote sensing system into scaled surface reflectance values.

Relative radiometric (atmospheric) correction:

When required data is not available for absolute radiometric (atmospheric) correction, we can do relative radiometric (atmospheric) correction. Relative radiometric correction may be used to

– Single-image normalization using histogram adjustment
– Multiple-data image normalization using regression

Single-image normalization using histogram adjustment

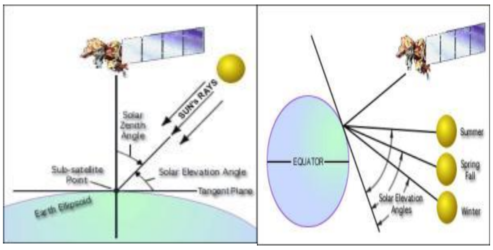


Dark object Subtract method can be applied for atmospheric scattering corrections to the image data.

Topographic correction

Topographic slope and aspect also introduce radiometric distortion (for example, areas in shadow)The goal of a slope-aspect correction is to remove topographically induced illumination variation so that two objects having the same reflectance properties show the same brightness value (or DN) in the image despite their different orientation to the Sun's position.

Scene Illumination



In satellite remote sensing, imagery acquired at different times of the year may be required (e.g., to study phonological cycle).These may require sun elevation correction and an earth-sun distance correction. Sun elevation correction accounts for the seasonal position of the sun relative to the earth.

Solar Elevation Angle: the angular elevation of the sun above the horizon Solar Zenith Angle: The angular deviation from directly overhead (or complement of elevation). Corrections: DN/Sin Elevation Angle or DN/Cosine Zenith Angle

Geometric Correction

Both aerial photos and satellite imagery have geometrical errors. Satellite imageries usually have many more errors than aerial photos. Geometric correction is necessary to pre process Remote Sensing data so that individual picture elements (pixels) are in their proper planimetric (x, y) map locations. 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).Geometrically corrected imagery can be used to extract accurate distance, polygon area, and direction (bearing) information.

Sources of geometric distortion:

• Sensor characteristics

-optical distortion
- aspect ratio
- non-linear mirror velocity
- detector geometry & scanning sequence

• Viewing geometry

- panoramic effect
- earth curvature

• Motions of the aircraft/satellite or target

- attitude changes (pitch, roll, etc.)
- position variations (altitude etc.)
- earth rotation

Distortions appear as:

- changes of scale over the image
- irregularities in the angular relationships among the image elements
- displacement of objects in an image
- occlusion of one image element by another

Levels of Geometric corrections

1) Registration 2) Rectification (geo-referencing) 3) Geocoding 4) Ortho- rectification

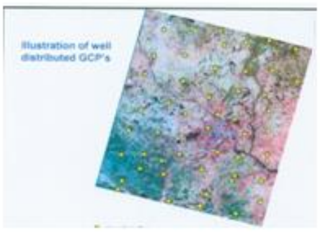
Geometric Correction is done for Conversion of the data to real world coordinates. This is carried by analyzing well distributed Ground Control Points (GCPs).This is done in two steps as follows:

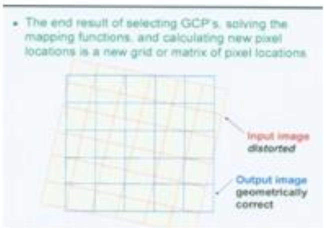
Geo-referencing (rectification) which involves the calculation of the appropriate transformation from image to terrain coordinates and Geocoding which involves resampling the image to obtain a new image in which all pixels are correctly positioned within the terrain coordinate system.

Rectification method

It includes, **Selection of Ground Control Points (GCP).** The unknowns in these equations (a and b) are solved by determining the coordinates for a set of known locations called ground control points (GCP's)GCP's are features that can be located on *both* the map and the image; they should be:

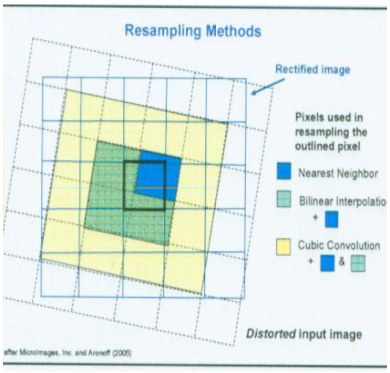
- well defined
- spatially small
- well distributed
  over entire image





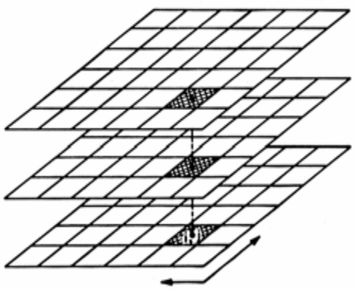
Resampling:

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 neighbor --assign each corrected output pixel the value of the nearest input pixel
- bilinear interpolation -- calculate the new output pixel value using interpolations from the four closest input pixels
- cubic convolution -- interpolate a new pixel value from a larger neighborhood of 9, 16, 25 or 36 surrounding input pixels

Image Registration



Registration applies the same techniques as rectification for image to image and image to map overlays. It includes edge detection which is used to create image outlines, giving areas with strong intensity contrasts. Edge detected image Filters out useless information and Preserves the important structural properties.

Segmentation:

Segmentation is to subdivide an image into its component regions or objects. It should stop when the objects of interest in an application have been isolated. Segmentation algorithms generally are based on one of 2 basic properties of intensity values

- discontinuity : to partition an image based on sharp changes in intensity (such as edges)
- similarity : to partition an image into regions that are similar according to a set of predefined criteria.

Image mosaic:

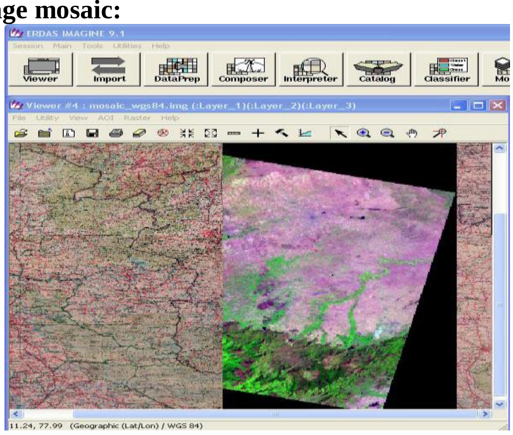


Image Classification

One of the main purposes of satellite remote sensing is to interpret the observed data and classify features. Image classification can be defined as the process of reducing an image to information classes. Image Classification is commonly used in photo interpretation, quantitative analysis, which uses computer to label each pixel to particular spectral classes and classes of interest

• Information classes:
• Spectral classes:

There are of 2 broads of classification procedure:

- Supervised and
- unsupervised

Supervised Classification

The supervised classification is the essential tool used for extracting quantitative information from remotely sensed image data. In this method, the analyst has to select groups of training pixels that are representative parameters for all class of interest. This step is called training .This training dataset forms the basis for classification of the total satellite image. Using samples with known identities (i.e., assigned pixels to information classes), the algorithm classifies pixels with unknown identities. The procedure starts by the user selecting and naming areas on the image, which correspond to the classes of interest. These classes correspond to information classes. The image classification algorithm will find all similar areas.

Procedure:

Display a single band or three-band combination.

– Acquire training sets.
– Choose the classifier type.
– Perform classification.
– Refine training sets.
– Derive the accuracy assessment measures.

• Supervised image classification usually follows an iterative process

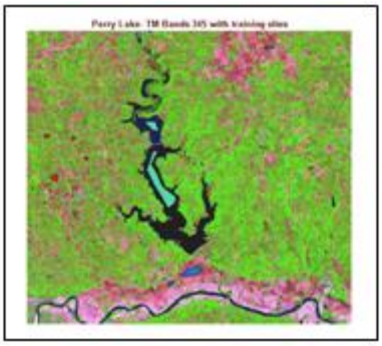
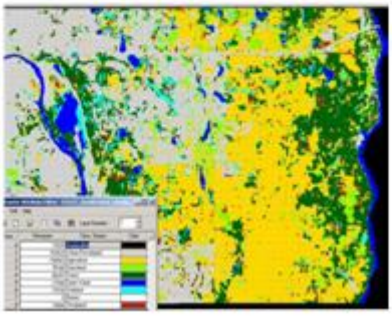


Image Classification



A training set is subset of the image, which the analyst believes contains a spectral class associated with a certain information class. The training data contains information from all spectral bands within the spatial area indicated by the analyst. Most of the times, there are more than one spectral class for a given information class

Unsupervised Classification

In unsupervised classification approach, isodata clustering will be used, in which clusters of pixels - based on their similarities in spectral information - are automatically classified into the desired number of categories. The image is automatically segmented into spectral classes based on natural groupings found in the data. Classification procedure s as follows:

– The user inputs some classification parameters.

– The algorithm proceeds by finding pixels with similar spectral properties.

– After the classification, the user names each class (i.e., the user relates the spectral classes to the relevant information classes).

Basic premise: Spectral values within a given cover type are close together, whereas data in different classes are comparatively well separated. Identified classes are 'spectral classes' not cover type/information classes. The analyst labels identified spectral clusters after the classification. Object Recognition & Representation is the final stage of which gives the result of Digital image processing task.

Conclusion:

Digital Image Processing is necessary for different types of works like Land use study, numerical weather prediction, mapping etc. It includes data operation which normally precedes further manipulation and analysis of the image data to extract specific information. These operations aim to correct distorted or degraded image data to create a more faithful representation of the original scene. Preprocessing commonly comprises a series of sequential operations, including -atmospheric correction or normalization,, radiometric & geometric correction, image registration and masking (e.g., for clouds, water, irrelevant features).

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