



FUNDAMENTALS OF DIGITAL IMAGE PROCESSING AND BASIC CONCEPT OF CLASSIFICATION

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ABSTRACT

We have to classify and analyze digital images for different study and purposes. Digital images are obtained from sources like camera, satellites, aircraft etc. Data obtained from satellites or aircraft i.e, the space based and remote sensing data needs to be corrected as they are usually geometrically distorted due to their acquisition system and the movements of the platform of aircraft. Processing and pre-processing are necessary for such correction prior to image classification. Image Processing is a technique which is used to enhance raw images received from cameras, satellites, space probes, aircrafts etc. and Digital image processing is the technique of processing images in the form of discrete digital brightness using digital circuits or digital computers. Image analysis and classification starts when processing and pre-processing ends.

Keywords: Air craft, Brightness, Distorted, Image, Processing, Space probe.

Contribution/ Originality

This paper contributes towards the concepts of digital image, digitization, image processing and classification. It complies originally about the stages of digital image processing and its application as well as its necessity.

1. INTRODUCTION

Digital image processing (DIP) can be defined as a transformation of an distorted image into a modified one which helps people to detect silent features without difficulty for interpretation necessary for image analysis in different study. It is an electronic data processing on a 2-D array of numbers known as pixel which is the numeric representation of any image [4]. The output of

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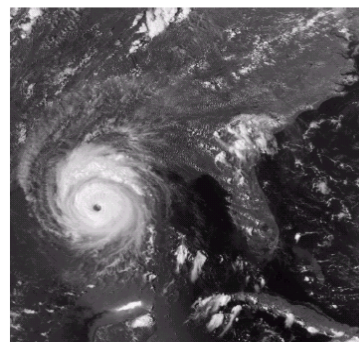
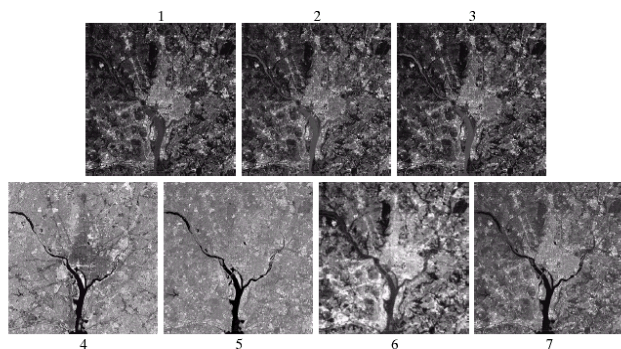
image processing can be an image or a set of characteristics related to the image. Digital Image Processing techniques are used to manipulate the digital images using computers. Image processing system includes treating images as 2d signal [5]. Image processing system consists of a source of image data, a processing element and a destination for the processed results. The source of image data may be a camera, a sensor, satellite, scanner, a mathematical equation, statistical data, the Web, a SONAR system, etc. The processing element is a computer, destination for the processed result, and the output of the processing may be a display monitor.

1.1. Field of DIP Application

Digital image processing techniques are used

- Geographic Information Systems (GIS)
- extensively to manipulate satellite imagery
- Meteorology
- Terrain classification
- Medical science etc.

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



1.2. Major Tasks

2 Major Tasks in Digital Image Processing

- pictorial information improvement for human interpretation
- data processing for storage, transmission and representation

2. OBJECTIVE

The objective can be summarized as follows:

- Image Correction to remove distortion, errors, and noise during data acquisition
- Image Enhancement to modify images or increases visual appearance and interpretability of imagery

- Information Extraction to classify pixels or neighborhoods of pixels on the basis of their spectral-radiometric temporal responses using computer

3. APPLIED IMAGE PROCESSING

Hardware and Software for Image Processing

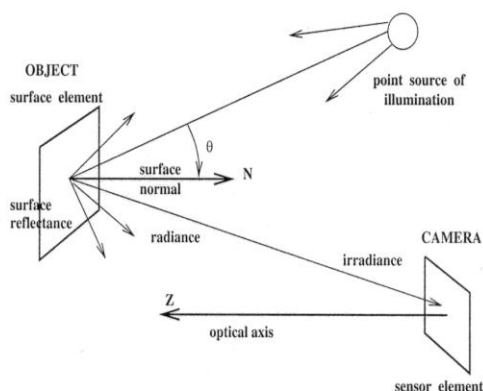
<p>Hardware</p> <ul style="list-style-type: none"> - Computer monitor - CD-ROM, ink-jet printer - Disk Drive - Internet connection - Scanner, digital camera 		<p>Software</p> <ul style="list-style-type: none"> - Photoshop - ERDAS Imagine - IDRISI, Arc View - MATLAB, Visual C++ - ENVI, ER Mapper etc.
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3.1. Image Concept

Image is a kind of language which expresses visual information to human being. Two types of images are- Analog & Digital .An analog image is continuous and indiscrete, the natural picture and a digital image is two-dimensional image having finite set of digital values, called picture elements or pixels. Digital image is composed of discrete pixels, or set of pixels each having associated integer brightness value which is called gray-level [1].

3.2. Pixel and Gray Level Concept

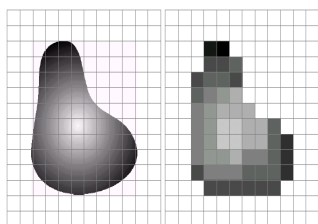
Image Formation



In other words, digital image is a data matrix or array of elements which are known as image pixels. Each pixel has an integer location and 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 [1].

A *real* image is formed on a sensor when an emitted energy strikes it with sufficient intensity to create a sensor output [1]. A digital image is formed as a 2-D function, $f(x, y)$, where x and y can be defined as spatial coordinates, & the amplitude of f at any pair of coordinates (x, y) which is called the intensity or grey level of the image at that point. The coordinates 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 [1].



Digitization

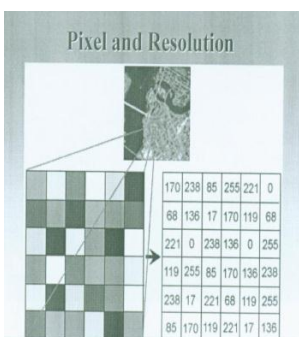
Digitization implies that a digital image is an *approximation* of a real scene Pixel brightness value which typically represents gray levels, colors, heights, opacities etc. [1]

Digitization accuracy

Resolutions express digitization accuracy.

They are of 2 types

- Pixel resolution
- Brightness resolution (color resolution)



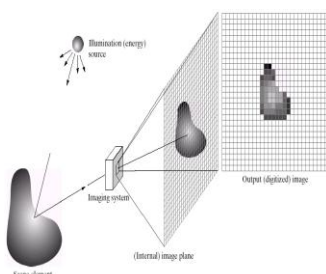
Pixel resolution expresses pixel sampling accuracy. They are of 2 types. Pixel resolution can be described by actual size of each pixel of a digital image, called Absolute resolution. Pixel resolution can also be described by the size of a digital image or the amount of pixels of the image, called Relative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

Brightness Resolutions expresses brightness quantization accuracy. Brightness resolution is also a kind of relative resolution because pixel brightness is quantized into finite number of gray-levels. It denotes total no. and data bits for gray-levels [2].

4. KEY STAGES OF DIG

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

4.1. Image Acquisition



An analog picture cannot be conveniently interpreted by a computer and thus an alternative representation; the digital image must be used. The objective of image acquisition is to convert an analog optical image into a digital image in a faithful manner as possible. Digital image acquisition is concerned with generation of 2D array of integer values representing the reflectance of actual scene at discrete special intervals [1]. This is accomplished by

- Sampling (Digitizing the coordinate values)
- Quantization (Digitizing the amplitude values)

Sampling 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 [1].

Quantization 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 [1].

4.2. 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 [1].

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 [2].

Image enhancement methods

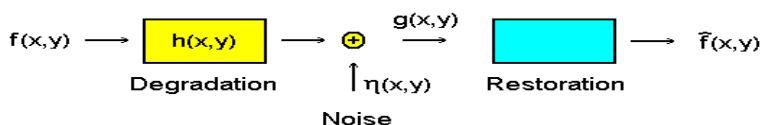
Image enhancement is the modification of an image to alter its impact on the viewer.

Image enhancement method includes:

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

4.3. 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 [3].

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 allows building output image pixel by pixel (warped) [4].

4.4. Image Pre-Processing

4.4.1. 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.

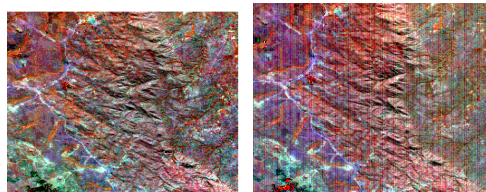


Image with nose

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 [3].

Absolute Radiometric (Atmospheric) Correction

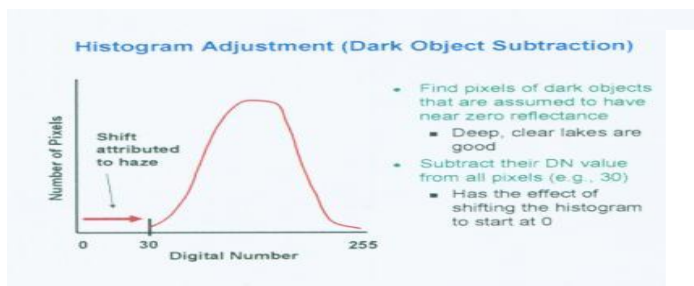
The general goal of absolute radiometric (atmospheric) correction is to turn the digital brightness values (or DN) recorded by a remote sensing system into scaled surface reflectance values [1].

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

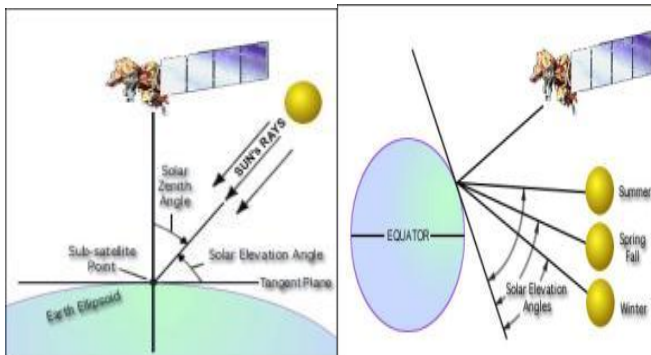


Dark object Subtract method can be applied for atmospheric scattering corrections to the image data [1].

4.4.2. 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 [2].

Scene Illumination



In satellite remote sensing, imagery acquired at different times of the year may be required (e.g., to study phenological cycle).These may require *sun elevation correction* and an *earth-sun distance*

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/\cos Zenith Angle [2].

4.4.3. 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 [2].

Sources of geometric distortion:

- **Sensor characteristics**
 - optical distortion
 - aspect ratio
 - non-linear mirror velocity
 - detector geometry & scanning sequence
- **Viewing geometry**
 - panoramic effect
 - earth curvature

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

• **Motions of the aircraft/satellite or target**

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

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 [2].

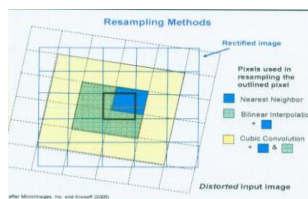
Rectification Method

This method includes Selection of Ground Control Points (GCP) that can be located on both the map and the image. In these equations (a and b) the unknowns are solved by determining the coordinates for a set of known locations known as ground control points (GCP's). They should be well defined, spatially small and well distributed over the entire image [2]



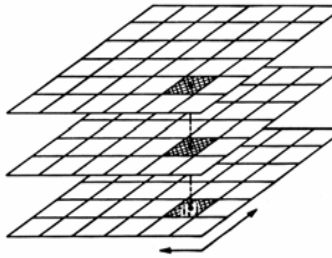
Resampling

This process calculates the new pixel values from the original digital pixel values in the raw and uncorrected image. There are three common methods for resampling of images which are as follows:



- nearest neighbor : this process assigns each corrected output pixel the value of the nearest input pixel
- bilinear interpolation :this process calculates the new output pixel value using interpolations from the four closest input pixels
- cubic convolution :this process interpolate a new pixel value from a larger neighborhood of 9, 16, 25 or 36 surrounding input pixels [4]

Image Registration



- This process applies the similar techniques as rectification for image to image and image to map overlays. It includes edge detection which is used for creating image outlines, giving areas with strong intensity contrasts. Edge detected image preserves the useful important structural properties filtering out unwanted things [4].

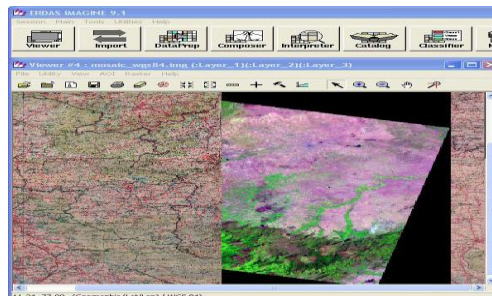
4.5. Segmentation

This process is used to subdivide an image into its component regions or objects. Algorithms of this process are based generally on one of the following 2 basic properties of intensity values

- discontinuity: to make partition of an image based on sharp changes in intensity (such as edges)
- similarity: to make partition of an image into regions that are similar according to a set of predefined criteria [4].

It should stop when the objects of interest in an application have been isolated.

Image mosaic



4.6. Image Classification

Image classification can be defined as the process of reducing an image to information classes. It is commonly used in photo interpretation, quantitative analysis. One of the main purposes of satellite remote sensing and digital image processing is to interpret the observed data and classify features for analysis. This process is usually applied to label each pixel to particular spectral classes and classes of interest - Information classes and Spectral classes [3]. There are 2 types of classification procedure - Supervised and Unsupervised [3].

4.6.1. Supervised Classification

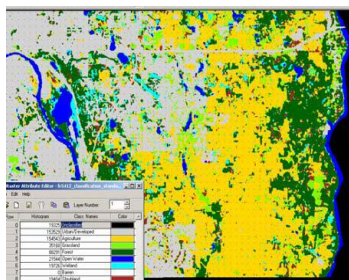
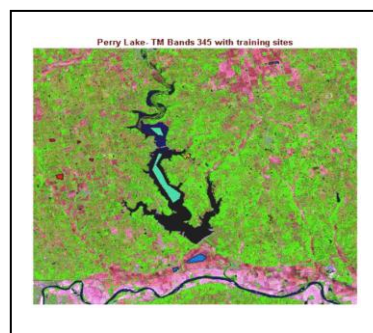
This type of classification is an essential tool which is used to extract quantitative information from remote sensing image. This process includes training. The analyst has to select groups of training sets (pixels) that are representatives for all classes of interest. This training dataset forms the basis for classification of the total image data. The algorithm classifies pixels with unknown identities using samples with known values. The user should procedure start the process by selecting and naming areas on the image corresponding to the classes of interest i.e, the information classes. The classification algorithm then will find out all other areas of similar class [3].

Procedure

Display the image in a single band or three-band combination.

- Acquire training sets.
- Choose the classifier type.
- Perform classification.
- Refine training sets.
- Derive the accuracy assessment measures [3].

- Supervised classification usually follows an iterative process too.



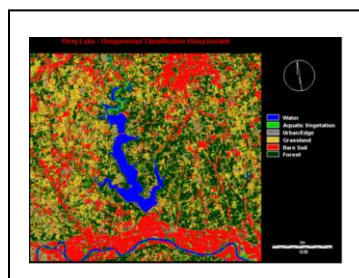
Training set is selected as the subset of the image, which contains a spectral class associated with a certain information class whereas the training data contains information from all spectral bands within the area indicated by the user or analyst. Most of the times, there are more than one spectral class for a given information class [3].

4.6.2. Unsupervised Classification

This type of classification approaches to use iso-data clustering .In this process, clusters of pixels based on their similarities in spectral information are automatically classified into classes of interest. The image is segmented into spectral classes automatically based on natural groupings of the data.

The classification procedure is as follows:

- User has to inputs some classification parameters.
- The algorithm proceeds by finding pixels having similar spectral properties.
- The user names each class after the classification



Spectral values of a given cover type are close together, whereas data of different classes are well separated. After the classification, the analyst labels all identified spectral clusters. Object Recognition & Representation is the final stage which gives the result of Digital image processing . [3].

5. CONCLUSION

Image Processing is necessary for different types of works like Land use study, numerical weather prediction, mapping etc. Digital Image Processing needs for digital images like space based and remote sensing data. It includes data operation which normally precedes for interpretation and further manipulation for analysis of the image data to extract specific information of interest. These operations aim to correct distorted or degraded image data to create a more faithful representation of the original scene which helps the user or analyst to detect information easily in a faithful manner. Preprocessing commonly comprises a series of sequential operations, including -atmospheric correction , normalization, radiometric & geometric correction, image registration representation etc.

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