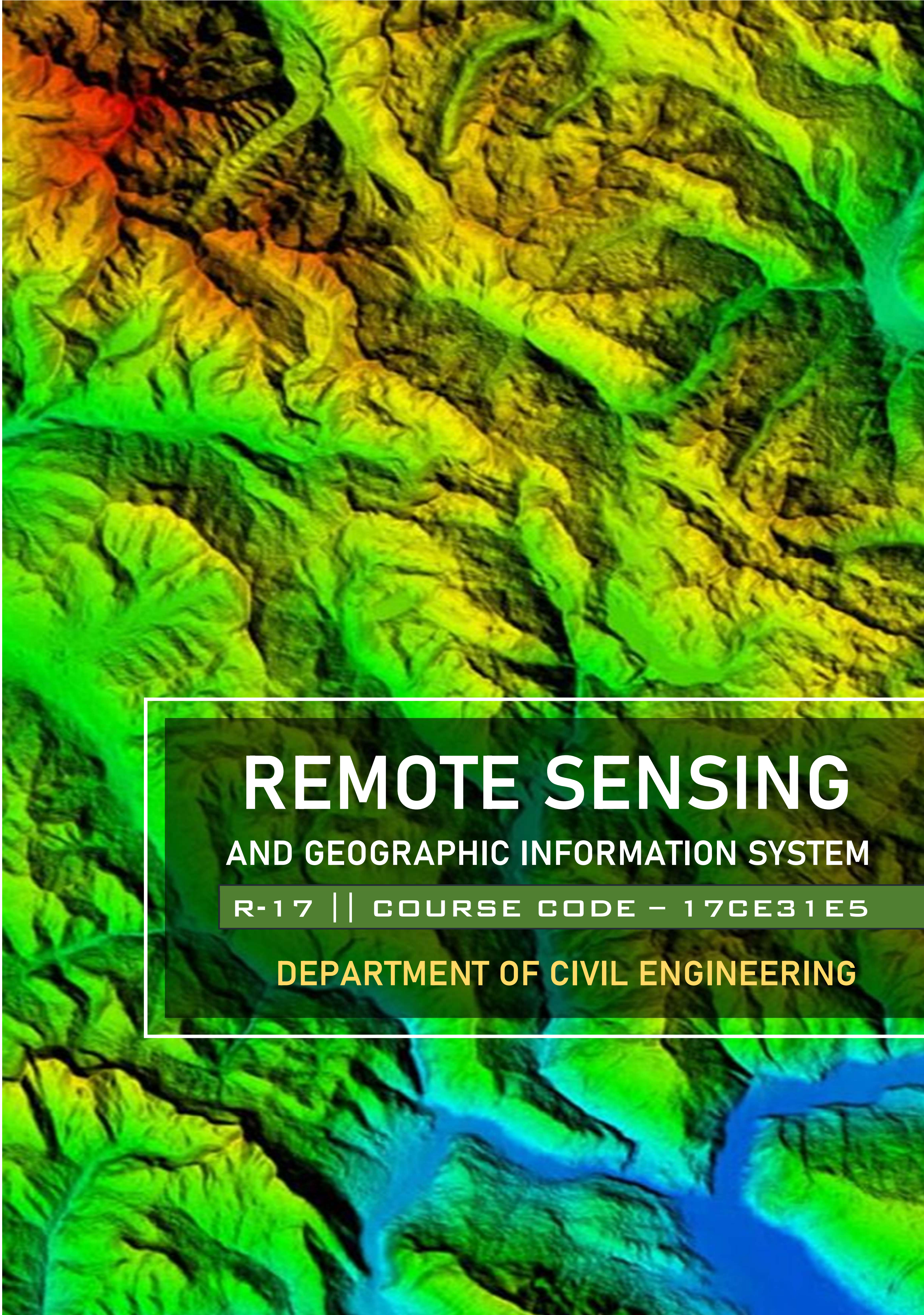


REMOTE SENSING

AND GEOGRAPHIC INFORMATION SYSTEM

R-17 || COURSE CODE – 17CE31E5

DEPARTMENT OF CIVIL ENGINEERING

MODULE – III

DIGITAL IMAGE PROCESSING

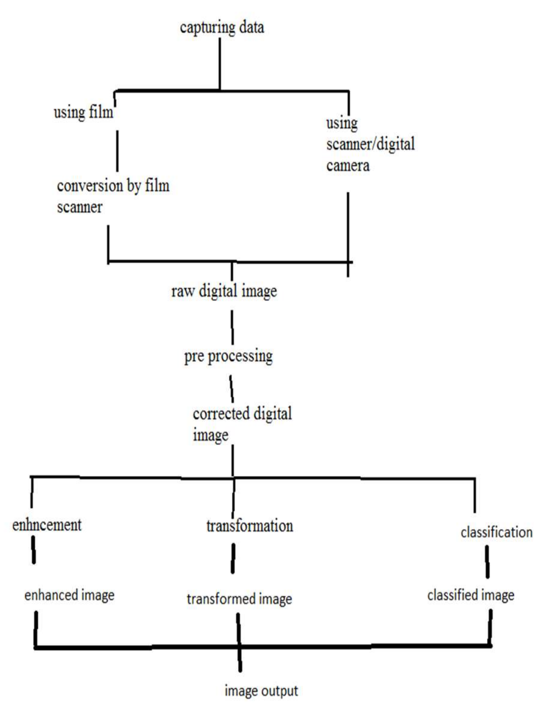
Course objective	To understand the principles of spatial analysis.
Content	**IMAGE PROCESSING:** Introduction – Overview – Preprocessing – Radiometric Correction – Geometric correction – Rectification – Enhancement techniques – Contrast stretch – Edge enhancement – Filtering techniques – Classification techniques – Supervised and unsupervised classification.
Course outcome	Understand about various methods of corrections applied to data to ensure maximum credibility and accountability to the data collected.

Digital image processing:

Digital image processing is a collection of techniques for the manipulation if digital images by computers.

Ultimate goal of this process is to extract information from an image that is not readilty available in its original form.

Digital image process:



Pre-processing:

- Remotely sensed data generally contains flaws or deficiencies.

- The correction of deficiencies and the removal and the removal of falws present in the data called pre-processing.
- In pre-processing it optimizes atmospheric correction, sun-illumination geometry, surface induced geometric distortion, spacecraft velocity and altitude variations, effect of earth rotation, loss of specific scan lines etc.,
- The entire pre-processing techniques involved in remote sensing may be categorized into 2 broad categories:

1. **Radiometric corrections**
2. **Geometric corrections**

Apart from these some other pre-processing may be necessary.

1) RADIOMETRIC CORRECTIONS:

- The energy registered by the sensor on-board aircraft or spacecraft, will not be exactly equal to that emitted or reflected from the same object observed from short distance.
- This is due to atmospheric conditions such as fog or aerosols, sensor's response etc.,
- They represent the commonly encountered error that alters the original data by including errors.
- Before analysis of remote sensing images, it is essential that these error types are identified and removed to avoid error propagation.

Three types of radiometric correction:

1. Detector response calibration
    - De-stripping
    - Removal of missing scan line
    - Random noise
    - Vignetting removal
2. Sun angle and topographic correction
3. Atmospheric correction

Detector response calibration

De-striping:

If a detector goes out of adjustment – that is , it provide readings consistently greater than or less than the other detectors for the same band over the same ground cover. Also occurs due to improper data recording and/or transmission.

Striping was common in early Landsat-MSS data due to variations and draft in the response over time of the six MSS detectors. The 'drift' was different for each of the six detectors, causing the same brightness to be represented differently by each detector. Stripes are not constant data values, they are patterns of lines with consistently high or low DNs. Removal of these strips is known as de-striping.

A common method of de-striping entails a construction of histograms for each detector of the problem band, i.e., histograms generated for the six Landsat -MSS. Then the means and standard deviations are calculated for each of the six histograms. The detectors can then be effected by adopting one sensor as a standard and adjusting the brightness of all pixels recorded by each other detector so that their mean brightness and standard deviations match those of the standard detector.

Removal of missing scan lines:

Line dropout occurs when a detector either completely fails to function, or becomes temporarily saturated during a scan. Creating a horizontal streak is usually corrected by replacing the bad line with a line of estimated data files values, which is based on the lines above and below it. Loss of one line is replaced by averaging the two neighbouring lines. If two lines are lost, the first line lost is recovered by repeating the subsequent line. If three consecutive lines are lost, the first lost line is recovered by repeating the previous line and the third lost is recovered by repeating the subsequent line. Second line is replaced by the average of the first and third line. Lost lines should not be recovered in the case of more than three consecutive line losses.

Random noise removal:

Specially stripes are systematic noise. Noises may appear on an image, which are not arranged in a systematic manner. Noise and suppressed by spatial filtering marked differences in DN from adjacent pixels, pixels can be replaced by substituting an average value of the neighbouring DNs.

Vignetting removal :

Fringe area in the corners is darker when compared with the central area is called vignetting. Effect can be experienced in the aerial photo. Photography, vignetting is also called as aerial trend. Lens shade that is the wrong size for the focal length being and using a portable vignette, because lens hoods that are used are not wide enough. Vignetted can be expressed by cos n, where n is the angle of a ray .

Sun angle and topographic correction:

Sun spot together with vignetting effects can be corrected by estimating a shading curve by Fourier analysis to extract a low frequency component appears due to topographic relief and can be corrected using the angle between the solar radiation and the normal vector to the ground surface.

Atmospheric correction:

Radiation is absorbed or scattered by the atmosphere during transmission the reflected or emitted radiation from the target is also absorbed or scattered by the atmosphere before it reaches a sensor. Ground surface receives the direction of solar radiation but also sky light, or scattered radiation from the atmosphere, the amount of path radiance varies from band to band. Atmospheric corrections is used to remove these effects. Radiance received at a sensor above the atmosphere and the radiance leaving the ground surface .Data are not considered as errors, they are a part of the signal received by the sensing device to remove atmospheric effects for scene matching and change detection analysis developed to correct atmospheric effects.

(a) Using the radioactive transfer equation usually determined for the radioactive transfer equation, aerosol density in the visible and near-infrared (NIR) region and water vapour density in the thermal infrared region should be estimated, the absorption or scattering effects are required for the measurement of the composition and reflectance profile of the atmosphere model is then compared to the image.

(b*)* Using ground-truth data atmospheric correction can be made by comparison between the known value of the target and the image data (output signal) can only be applied to the specific site with targets or a specific season.

(C*)* Other methods a special sensor to measure aerosol density or water vapour density is utilized together with an imaging sensor for atmospheric correction.

2) Geometric Correction of Remotely Sensed Data

Collection from airborne or space-borne sensors often contain systematic and non-systematic geometric errors arise from the earth curvature, platform motion, relief displacement, non-linearties in scanning motion, the earth rotation, etc ephemeris known internal sensor distortion characteristics. By matching image coordinates of physical features recorded on the image geographic coordinates of the same features collected from a map or using global positioning system.

Systematic Correction:

Those effects that are constant and can be predicted in advance. Mainly three types,

***Scan skew*:** Forward motion of the spacecraft during the time of each mirror sweep.

The ground swath scanned is not normal to the ground track.

Known mirror velocity variation: Velocity variation are used correct the minor distortion to the velocity of the scan mirror not being constant to finish of each scan.

Cross-track distortion: generally occur in all the un restored images acquired by the across-track scanners .A scan line at constant time intervals. Width of a pixel is proportional to the tangent of the scan angle either margins of the scan line that compresses the pixel. Geometric distortion can be theoretically or systematically avoided.

Non-systematic Correction:

Transform from a geographic coordinates system to an image coordinates determined with given coordinates of GCPs using the least square method. Depends on the order of the polynomials and the number and distribution of GCPs.

The earth's surface is spherical, use flat maps to represent the transform the coordinates on the spherical surface to a flat sheet using map projection. Sensed images are not maps. It has the scale and projection properties of a given projection, is essential.

Two types of image non-systematic corrections .The correction of digital images ground coordinates using GCPs collected from maps or collected from ground using GPS. The GCPs are collected from ground .Image-to-ground georeferencing. The GCPs are collected from an existing map, then the process is generally referred as images-to-map georeferencing.

Fitting of the coordinates system of one image to that of a second image of the same area. Matching the coordinate systems of two digital images with one image acting as a reference image and the other as the image to be rectified. A projection or geographic coordinate system is not necessarily involved. Many applications of remote sensing image data require two or more images of the same geographic area, acquired at different dates or by different sensors, to be processed together.

Coordinate Transformation

The technique of coordinates transformation is useful for geometric correction with GCPs. Involve rearrangement of the input pixels onto a new grid. Equations are used to convert the source coordinates to rectified coordinate. Transformation, the relationship between the pixel coordinate system and the image coordinate system can be defined.

Selection of transform formulae: depending on the geometric distortions, the order of polynomials is determined. Maximum of third-order polynomials is sufficient for existing remote sensing images.

Selection of GCPs: The number and distribution of GCPs influences the accuracy of the geometric correction. The number of control points should be more than the number of unknown parameters in polynomial equations because the errors are adjusted by the least-square method. The distribution of control points should be random, but almost equally spaced including corner areas. About ten to twenty points that are clearly identified both on the image and the map or ground should be selected the accuracy of geometric correction is usually represented by the standard deviation

Are differences between the input pixels of the uncorrected image output pixels of the corrected image and n is the number of pixels. The accuracy should be usually within ±1 pixel. The error is larger than should be rechecked, the formula should be reselected.

Resampling and Interpolation

Resampling is used to determine values to place in the new pixel locations of the corrected output image. The spacing of the output grid is chosen according to the pixel size required in the corrected image and need not be the same as that in the original geometrically distorted image .Which pixel of the input image to be placed where in the output image. Input and output grids are not similarly oriented. The location of output pixels derived from the control points. To establish the geometry of the output image and its relationship to be input image. This transformation can be achieved by different resampling methods to determine the pixel locations in the corrected image. Pixel value should be chosen for placement of a pixel on the

new grid. Each resampling method employs a different strategy to estimate values at output grid for given known values for the input grid.

1. **Nearest neighbour**: The nearest neighbour approach uses the value of the closest input pixel for the output pixel value. To determine the nearest neighbour, the algorithm uses the inverse of the transformation matrix to calculate the image file coordinates of the desired geographic coordinate.

ADVANTAGES:

Methods of resampling tend average surrounding values.

Original data are retained. To compute and therefore fastest to use.

DISADVANTAGES:

Rough appearance relative original unrectified other values may be duplicated.

Values 13 and 22 are lost while values 14 and 24 are duplicate .

2. **Bilinear interpolation:** output sell value by calculating the waited average of the four closest input cells based on distance

ADVANTAGES:

Nearest neighbour resampling is reduced . Image look smooth.

DISADVANTAGES:

Original data and reduces contrast by averaging neighbouring.

Computationally more expensive than nearest.

3. **Cubic convolution**: The weighted average of the nearest sixteen pixels to the output pixel .Similar to bilinear interpolation but the smoothing effect caused by the averaging of surrounding input .

ADVANTAGES:

Image looks smooth , smoother than bilinear interpolation.

DISADVANTAGES:

Original data and reduces more expensive than nearest neighbour resampling.

Miscellaneous pre-processing:

Braking out a portion of a large file into one or more smaller files. Image files contain areas much larger than a particular study area. Helpful to reduce the size of the image file to include only the area of interest. Multi-space spectral data, in some cases may not require all of the available bands removal of spectral band is required; this is known as spectral

sub setting. Approaches not only eliminate the extraneous data in the file, speed up processing due to the smaller amount of data to process. Area in which we are interested may span several image files. TO combined images to create one large file is called mosaic king.

IMAGE ENHANCEMENT

Conversion of the image quality to a better and more understandable level for future extraction or image interpolation. Radiometric corrections for illumination, atmospheric influences, and sensor characteristics may be done prior to distribution of data to the user. The image enhancement techniques are applied either to single-band images or separately to the individual bands of a multi-band image set.

So that the result is more suitable than the original image for a specific application operations change the value of each individual pixel independent of all other pixels, local operations change the value of individual pixels in the context of the values of neighbouring pixels.

Image enhancement techniques change the original DN values permanently.

Enhancement are performed for better interpolation of images by means of a human interpreter.

IMAGE REDUCTION:

Generally exceeds the screen resolution of our computer screen. lower than the number of pixels generally present in an image .Result the computer screen cannot reduce the visual representation of the image .

An image containing 5,160 rows by 6,960 columns, be reduced so that every other row and every other column (i.e., n=2) can be selected. Reduction would create a sampled image containing only 2,580 rows by 3,480 columns.

Dataset would contain only 25% of pixels found in the original scene. Sample 2x integer reduction is often still too large to view on most screens. Small enough, the date must be sampled more intensely. Image sampled at 10x reduction, meaning every tenth row and tenth column of the image is sampled, although the resampled image at this scale contains only 1% of the original data, small enough to view the entire scene within the screen. A resampled has obviously lost many of its original pixels, not contain adequate data for image interpolation.

IMAGE MAGNIFICATION:

Image magnification is often referred to as zoom in.

Improve the display-scale of the images for enhanced visual interpolation.

Match the display-scale of another image. Pixel in the original image is usually replaced by an n* n block of pixels all of which have the same DN values as the original input pixels. An example of the logic of a 2x magnification. This form of magnification doubles the size of

each of the original pixel values. Analyst can specify a floating point magnification rate such as 2.75x.

COLOUR COMPOSITING:

A colour image can be generated by compositing three selected bands of multi-band images with the use of three primary colours. colour images may be depending on the selection of three-band images and the assignment of the three primary colours .

Two methods of colour composite additive colour composite subtractive colour composite. Colour composite uses three light sources of three primary colours, subtractive colour composite uses three pigments of three primary colours.

Device has three colour guns multi-spectral images generally contain more than three spectral bands. But we can view a maximum of three bands of any multi-spectral images at a time ,the human eye cannot detect any region of colour other than RGB. This implies that several bands of multi-spectral images are invisible to the human being. True colour combination is a combination when image captured in blue band is passed through the blue colour gun of display device, green band through the green colour gun, and red band through the red colour gun, in case of IRS LISS-111/LISS-4 there is no blue band and it is not possible to generate true colour composite

We use various colour combination to facilitate the visual interpretation of an image. Combination other than true colour combination are known false colour combination.

Invisible infrared band is visible by obtaining red colour tones and the image may highlight some features, were not clearly identifiable in true colour composition.

Composite with the assignment of blue colour gun to the green band, green gun to the red band, and red gun to the NIR band is very popular and it is called infrared colour composite.

Not only created from a single multi-spectral image set. Images from different dates are also used for change detection. Generally by passing single bands of imagery from different dates through the RGB colour gun. To identify changes between images from two different dates. Land-cover change that is responsible for the change in reflectance in the selected bands will appear bright red or cyan, areas with little or no change will appear in grey shades in case of decrease in reflectance value changes will appear in cyan colour instead of red.

TRANSECT EXTRACTION:

A transect is a straight line between any two user-specified points within an image. Pixels that lie on the transect can be used to measure DNs and displayed to compare spectral or spatial differences. The x-axis contains the distance in pixels and the y-axis, the raw pixel values. Each graph contains a unique distribution. Transect at band 3 and notice that spectral differences that colour along the transect in this band much greater than in other bands. A study as this may be important in determining optimal bands for further analysis.

CONTRAST ENHANCEMENT

Range of reflectance values collected by a sensor may not match the capabilities of the colour display monitor. The range of reflectance values collected by a sensor may not match the capabilities of the colour display monitor.

Range of brightness values present on an image is referred to as contrast. Stand out more clearly making optimal use of the colour intensities available on the display or output device. Look-up table is a pre-set function in a computer that while changing the contrast, original brightness values do not change; computer stores the changed brightness values in the LUT and utilizes these values to display the image.

Changing the range of values in an image in order increase contrast. Might have a range of brightness values between 40 and 90. Is stretched to a range of 0-255, difference between features are enhanced. for construction in the rural sensed imagery with a much lower contrast as opposed to urban areas concrete, asphalt, and fertilized green vegetation may be more prevalent.

Understand contrast enhancements is to comprehend image histogram graphical representation of the brightness values comprise an image histogram is a statistical representation of the range of tones from dark to light and associated number of pixels for each tone for an image.

Horizontal axis of a histogram range of all possible brightness values. vertical axis is the number of pixels associated with each brightness value.

Histogram can convey whether the lighting is harsh or flat. Histogram can also describe the amount of contrast. It is a measure of the difference in brightness between light and dark areas in a scene.

LINEAR CONTRAST ENHANCEMENT

When the values in the original image are expanded uniformly to fill the total range of the output device, the transformation is called linear contrast stretching. If DN is the Digital Number of the pixel, DNst is the corresponding DN in the enhanced output image, DNmax and DNmin are the maximum and minimum DN values in the original image, the linear contrast stretching can be graphically.

In the contrast stretched image the light tone areas appear lighter and the dark tone areas appear darker. The variation in the input data, now being displayed in a wider range, thus becomes easily differentiable.

From the histogram of the original image it can be observed that though the DN values ranges from 60 to 158, number of pixels having DN values in the range 60-90 are very less. Nevertheless, in linear stretching equal number of display levels are assigned to these

ranges. Consequently, for the higher values not many display levels are available. In other words, the number of display levels available for different DN ranges are not in proportion to the number of pixels having DN values in the range. To solve this problem, non-linear contrast stretching has been used.

Linearly expands the original digital values into a new distribution. Range of colour resolution of the display device can be utilized.

MAIN METHODS:

MINIMUM-MAXIMUM STRETCH: Original minimum and maximum values of the data are assigned to a newly specified set of values that utilize the full range of available brightness values of the display set unit minimum brightness values of 45 and maximum value of 205. Image is viewed without enhancements, values of 0-44 and 206-255 are not displayed. Spectral differences can be detected by stretching the minimum value of 45 to 0 and the maximum value of 205 to 255.

Old minimum value to the new minimum value, old maximum value to the new minimum value. Old intermediate scaled proportionately between the new minimum and maximum values. Digital image-processing systems have built-in capabilities that automatically expand the minimum and maximum values to optimize the full range of available brightness values. linear mapping between input and output, maximum and minimum values is a value between 0 and 255, stored in a look-up table is obtained in real form, it is rounded to nearest integer.

SATURATION STRECHES: Similar to the minimum-maximum linear contrast stretch expect this uses specified minimum and maximum values lie in a certain percentage of pixels. Reside at two ends of a histogram, a reasonable amount of brightness values.

These tails of the histogram trimmed the remainder part of the histogram is enhanced more prominently. Main advantage of percent linear contrast stretch. Outside the defined are mapped to either 0 or 255.

Content of the pixels that saturate at 0and 255 is lost, remainder part of histogram is more enhanced compared to minimum-maximum linear stretch.

AVERAGE AND STANDARD DEVIATION STRETCH: It is similar to percent stretch. A standard deviation from the mean is often used to push the tails of the histogram beyond the original minimum and maximum values. Can be applied for determining the minimum and maximum values for such stretch. The standard deviation can be multiplied by any number.

PIECEWISE STRETCH: Distribution of a histogram in an images is bi-or tri-modal, stretch certain values of the histogram for increased enhancement in selected region of brightness values.

Piecewise linear contrast enhancement involves the identification of a number of linear enhancement steps that expands the brightness ranges in the modes of the histogram.

A series of small min-max stretches are set up piecewise linear contrast stretch is a very powerful enhancement procedure, values of 0 and 255 at a contrast level of intensity. Several breakpoints, that increase or decrease the contrast of the image for a given range of values are defined.

NON-LINEAR CONTRAST ENHANCEMENT :

Linear contrast stretch is not appropriate .Contrast enhancement involves histogram conversion through the use of an algorithm .Histogram conversion is the conversion of the histogram of original image to another histogram. One major disadvantage is input image can have several values in the output image, original scene lose their correct relative brightness values. Major non-linear contrast enhancement techniques are:

- Histogram equalization
- Histogram normalization
- Reference stretch
- Density slicing
- Thresholding
- Logarithmic, power law or Gaussian stretch

HISTOGRAM EQUALIZATION:

One of the most useful forms of the task of histogram equalization is to transform a any shape to a histogram has the same frequency along whole range of DN. All pixel values of the image are distributed, approximately an equal number of pixels to each of the output brightness values is increased at the most populated range of brightness values. Reduces the contrast is very light or very dark parts of the image. Separate pixels into distinct groups. Bins are used to group ranges of data values together for better manageability. Bin function is provided to serve as a data reduction tool.

Perform histogram equalization, the pixel values of an image area reassigned certain number of bins , simply numbered sets of pixels . Pixels are then given new values .Total number of pixels in the image is divided by the number of bins. Input range of 3 to 7 is stretched to the range of 1 to 8 .Data values at the tails of the original histogram are grouped together values 0 through 2 all have the output values of 0 .Loss of the dark and bright characteristics usually associated with the tail pixels. Histogram equalization may hide much of the necessary information. Group pixels that are very dark or very bright into very few gray scales. Normal distribution of a histogram is actually a bell-shaped distribution. Most values are at or near the middle, more extreme are rarer. It involves the fitting of the observed histogram to a normal or Gaussian histogram. Pixels with same brightness value would be reallocated to other different brightness values, in order to form a normalized histogram. As a result, same objects or objects having similar brightness values may appear different on the image.

Reference stretch known as histogram matching or histogram specification. Process of determining a lookup table that converts the histogram to one image to same resemble the histogram of another .Data of the same scene or adjacent scenes that were captured on separate days, or are slightly different because of the sun angle or atmospheric effects. useful for mosaicking or change detection good results with histogram matching, the input images should have similar characteristics.

Density slicing forward form of enhancement results from the DN’s of different values within a specified range or interval single value of converting the continuous grey tones of an image into a series of density intervals or slices, each corresponding to a specific digital range are then displayed either as uniform grey tones or as colours. some details of the image is lost, the effect of noise can also be reduced by using density slicing . Image may be segmented, sometimes contoured into sections of similar grey level. Method works best on single-band images. Especially useful when a given surface feature has a unique and generally narrow set of DN values. This yields a simple map of the distribution of combined DNs. Several features each have different values, then several grey-level slices may be produced.

Thresholding type of image enhancement segments the image DNs into two distinct separated by a threshold DN. Thresholding produces binary output with sharply defined spatial boundaries.

Power law

Application of power law executes the stretching in an opposite way. Power-law contrast stretching generally uses the following form.

$DNst = c\ DN^{n}$ (4)

where c and n are positive constants.

While using the power functions, higher values are expanded to a wider range. This enhances information contained in the higher DN values, whereas the lower DN values are compressed.

Logarithmic or Gaussian stretch

In logarithmic stretching, curves having the shape of the logarithmic function are used for rescaling the original DN levels into the wider output range.

General form of logarithmic stretching uses the following form.

$DNst = c \log (1+DN)$

where c is a constant.

in logarithmic stretching,

FILTERING AND EDGE ENHANCEMENT

1. Introduction

Spatial feature manipulations are the processes which help to emphasize or deemphasize data of various spatial frequencies. The term spatial frequency represents the tonal variations in the images such that higher values indicate rough tonal variations whereas lower values indicate smoother variations in the tone.

Spatial feature manipulations are generally local operations where the pixel values in the original image are changed with respect to the gray levels of the neighboring pixels. It may be applied to either spatial domain or frequency domain. Filtering techniques and the edge enhancement techniques are some of the commonly used local operations for image enhancement.

Filtering Techniques

Filtering is the process by which the tonal variations in an image, in selected ranges or frequencies of the pixel values, are enhanced or suppressed. Or in other words, filtering is the process that selectively enhances or suppresses particular wavelengths or pixel DN values within an image.

Widely used approaches to digitally filter images are convolution filtering in the spatial domain.

Convolution filter

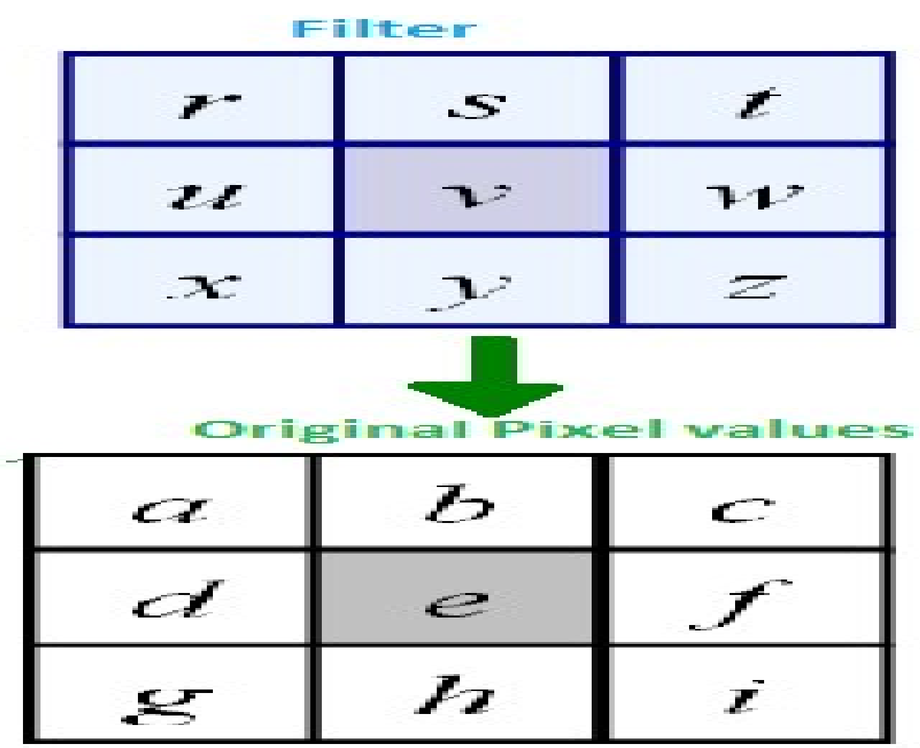
Convolution filter is one of the most commonly used filters in image enhancement in the spatial domain. In convolution filter, the filter mask is called convolution mask or convolution kernel. The convolution kernels are square in shape and are generally of odd number of pixels in size viz., 3x3, 5x5, 7x7 etc.

The kernel is moved over the input image for each pixel. A linear transformation function involving the kernel coefficients and the pixel values in the neighbourhood selected is used to derive the modified DN of the pixel at the centre of the kernel, in the output image. Each coefficient in the kernel is multiplied by the corresponding DN in the input image, and averaged to derive the modified DN value of the centre pixel.

For example, the filter shown in Fig. 1 is a convolution filter of kernel size 3x3. DN value of the centre pixel in the input image is e. The modified DN value is obtained as given below.

$ep = (e.v + a.r + b.s + c.t + d.u + f.w + g.x + h.y + i.z)/9$

fig 1



Based on the elements used in the matrix and the procedure used for calculating the new digital number, different digital filters are developed for different purposes. Using different kernels, different type of enhancement can be achieved. For example, high pass and low pass filters are special types of convolution filters, which emphasize the high frequency and low frequency features, respectively.

Types of filters

1. Low pass filter
2. High pass filter
3. Edge enhance filter
4. Adaptive filter

Someother statistical filters

1. Mode filter
2. Median filter

Low pass filter

Low pass filters are also called averaging filters as the filter output is the average pixel value of all the pixels in the neighbourhood. When such filter is applied on an image, it will replace every pixel with the average of the surrounding pixel values. Thus, the low frequency values in the image are highlighted after filtering. Low pass filter reduces the effects of noise component of an image.

1	1	1
1	1	1
1	1	1

Low pass

-1	-1	-1
-1	8	-1
-1	-1	-1

High pass

High pass filter

High pass filter, on the other hand, enhances the high frequency values in an image. Accordingly, in the resulting image, low frequency values are de-emphasized. When above high pass kernel is used on a set of pixels in an image, a relatively low values is surrounded by higher values, the low value gets lower, as following

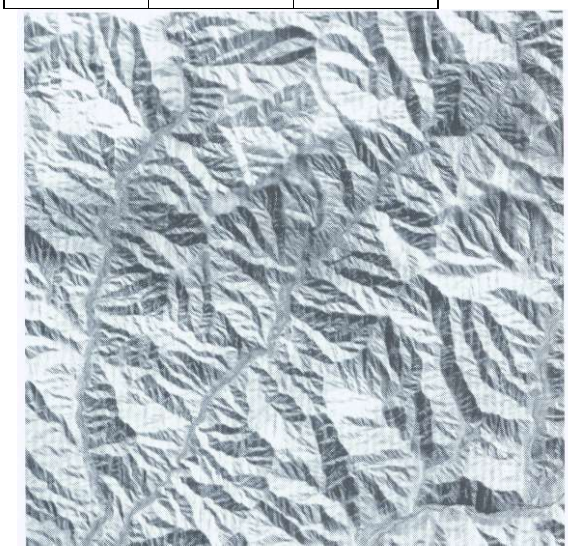
204	200	197
201	106	200
198	200	209

208	200	197
201	8	200
198	200	209

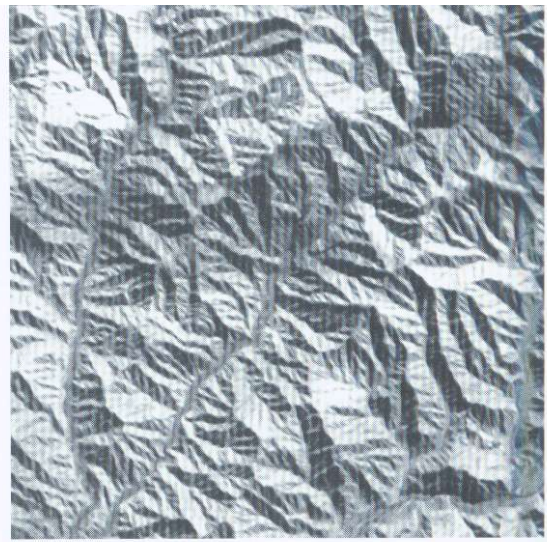
Inversely, when the kernel is used on a set of pixels in which a relatively higher value surrounded by lower values, the high value become higher.

64	60	68
61	125	69
58	60	68

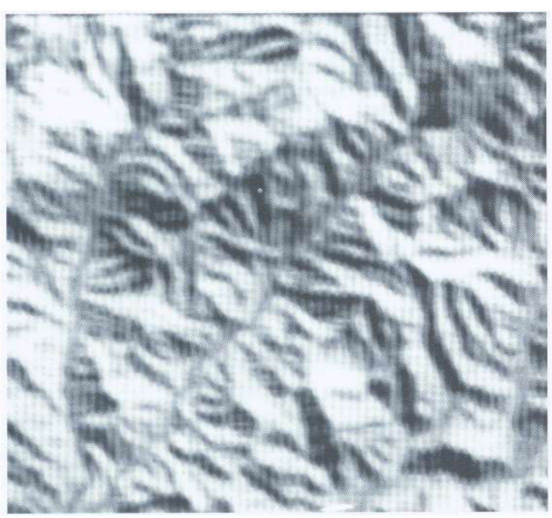
64	60	68
61	188	69
58	60	68



originalimage



3x3 low pass



11x11 low pass

high pass

Edge enhance filter

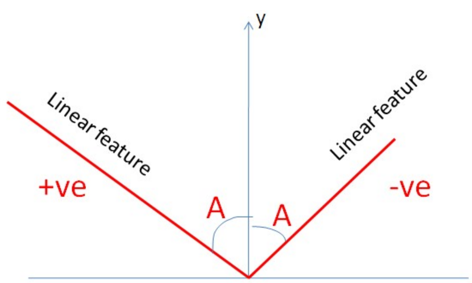
Edges in the images are generally formed by long linear features such as ridges, rivers, roads, railways, canals, folds and faults. Such linear features (edges) are important to geologists and Civil Engineers. Some linear features occur as narrow lines, whereas some edges are marked by pronounced differences that may be difficult to be recognized. Such narrow linear features in the image can be enhanced using appropriate filtering techniques.

Linear features such as shore line and the river banks are extracted using the edge enhancement and edge detection algorithms. Digital filters used for edge enhancement in images are of two broad categories: 1. Directional filters 2 Non-directional filters

Directional filters will enhance linear features which are having specified orientation (say those oriented to 300 North) whereas non-directional filters will enhance linear features in almost all orientations.

Directional filter

Directional filter will enhance linear features with a specific orientation (direction). Direction in which the edges are to be enhanced is specified in degrees with respect to North. Angles within the North-East quadrant are considered with negative sign and those falling in the North-West quadrant are considered with positive sign.



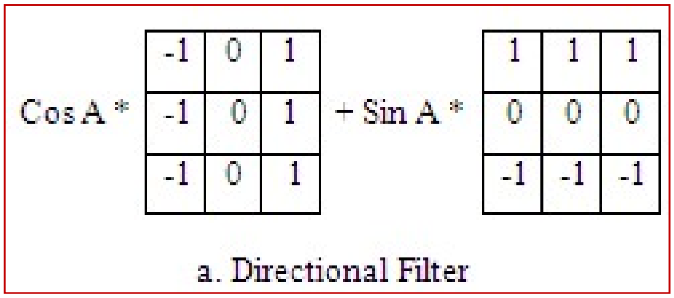
Concept of orientation angle of the linear features as used in directional filter

Directional filters consist of two kernels of size 3x3 pixels, which are referred as left and right kernels. Both left and right kernels are moved over the original image and the pixel values are multiplied using the kernel coefficients. The values obtained for the nine pixels within the filter mask are added up for each kernel separately. The value added up for the right kernel is multiplied by Sin(A), where A is the angle specified. Similarly, the value the directional filter also enhances the linear features in directions other than the specified direction. In this example the filter passing through the N45^{o}W direction also enhances linear features that tend obliquely to the direction of filter movement. As a result, many additional edges of diverse orientations get enhanced.

-1	0	1
-1	0	1
-1	0	1

1	1	1
0	0	0
-1	-1	-1

Left kernel right kernel



a. Directional Filter

Non-directional filter:

Pewitt gradient, Sobel and Lapalaican filters are some of the examples of nondirectional filters.

Prewitt gradient and Sobel gradients

Prewitt gradient and Sobel gradients are used to estimate the digital gradient in an image, and are useful for edge detection. Sobel filter enhanced the higher values, whereas the lower values are compressed. The kernels of these filters when moved over an image highlight the higher gradients corresponding to edges and make the lower values smooth.

Laplacian Filter

Laplace filter is also useful in edge enhancement. It helps to detect sharp changes in the pixel values and hence enhances fine edges.

A first order derivative simply shows the difference in the pixel value for adjacent. Laplacian filter is a non-directional filter based on the second spatial derivative of the pixel values.

During edge enhancement using Laplacian filter, the kernel is placed over 3x3 array of original pixels and each pixel is multiplied by the corresponding value in the kernel. The nine resulting values are summed and resultant kernel value is combined with the central pixel of 3x3 array. This number replaces the original DN of central pixel and the process is repeated for all the pixels in the input image.

Laplacian filter will enhance edges in all the directions excepting those in the direction of the movement of the filter (i.e., linear features with east-west orientation will not get enhanced).

Adaptive filter

Adaptive filter have kernel coefficient's calculated for each window position based on the mean and variance of the original digital number in the image. Here we use re-defining a high-pass filter as the sum of a collection of edge sharpening kenels.

Following is one example for high-pass filter

-1	-2	-1
-2	12	-2
-1	-2	-1

This filter can be re-written as sum of the eight edge-sharpening kernels as follow.

Mode filter

This filter primarily used to clean up the thematic or classified images for presentation purpose. This filter computes the mode of the class values with in the filer window surrounding each pixel.

5	4	3
3	5	2
3	4	2

Filtered pixel of above filter window (2,2,3,3,3,4,4,5,5,) is 3.

Median filter

The median filter is better way to reduce speckle(spot). This filter operates by arranging all DN values in a sequential order within the window that we define. The pixel of interest replaced by the value in the centre of thus distribution (median). This filter useful in removing random noise and speckles than a simple average filter. This filter can also applied to drop-out line(missing scan line) removal.

5	1	7
8	2	4
6	9	3

Here (1,2,3,4,[5],6,7,8,9) 5 is the median of filter. Thus center value of the window (2) replaced by meadian value.

IMAGE CLASSIFICATION:

- Image classification is the process of sorting pixels into finite number of individual classes or categories of data, based on their DN values.
- Classification of remotely sensed data is used to assign corresponding levels with respect to groups with homogenous characteristics, with the aim of discriminating multiple objects from each other within the image.
- Classification is the most popularly used information extraction technique in digital remote sensing.

- First for any image classification, the computer system must be trained to recognize patterns in the data. Training is the process of defining the criteria by which these patterns are recognized.
- Training can be performed with either a supervised or an unsupervised classification.
- A human analyst attempting to classify features in an image uses the elements of visual interpretation. Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands.
- Image classification, can be performed in two different approaches:
    - Supervised classification.
    - Un-supervised classification.

Supervised Classification:

- For supervised classification, we first start with specifying an information class on the image. An algorithm is then used to summarize multi-spectral information from the specified areas on the image to form class signatures. This process is called **supervised training.**
- The spectral characteristics of pixel digital numbers within each of the land cover types can be used to generate multivariate statistical parameters for each of the training sites.
- As the supervised classification methods are based on statistical concepts, this classification is also termed as per-point or per-pixel classification.
- Supervised classification is performed with a set of target classes in mind. In a supervised classification, an analyst identifies homogenous representative's samples of different surface cover types of interest in the imagery.
- The selection of appropriate training areas is based on the analyst's familiarity with the geographical area and knowledge of the actual surface cover types are present in the image.
- Supervised classification is usually appropriate when we need to identify relatively few classes, when we selected training sites that can be verified with ground truth data, homogenous regions that represent each class.
- By identifying patterns, we can instruct the computer system to identify pixels with similar spectral characteristics and to assign the pixels into respective class to which it has maximum similarity.
- Supervised classification is much more accurate for mapping classes, but largely depends on the cognition and skills of the image analyst.

Unsupervised Classification:

- One of the differences between a supervised and an unsupervised one is the ways of associating each spectral class to an information class.
- Unsupervised classification process involves algorithms in which spectral values of pixels are grouped first, based solely on the numerical information in the data to generate spectral classes (clusters), and is then matched by the analyst to information classes.
- For unsupervised classification, an algorithm is first applied to the image and some spectral classes (clusters) are formed. This process is known as **unsupervised training.**
- The image analyst then tries to assign a spectral class to the desired information class.
- Unsupervised training is more computer-automated. It enables us to specify some parameters that the computer uses to uncover statistical patterns that are inherent in the data.
- These patterns do not necessarily correspond to directly meaningful characteristics of the scene, such as contiguous, easily recognized areas of a particular land-cover. They are just clusters of pixels with similar spectral characteristics.
- Unsupervised training is dependent upon the data itself for the definition of classes. This method is usually used when not much is known about the data before classification.
- Unsupervised classification is useful only if the spectral classes can be appropriately interpreted and identified.
- If we want the classes to be determined by spectral distinctions that are inherent in the data so that we can define the classes later, then the application is better suited to unsupervised training.
- Unsupervised training enables us to define many classes easily, and identify classes that are not in contiguous, easily recognized regions.