B.Sc. GEOGRAPHY LAB MANUAL

5th Semester

MIDNAPORE CITY COLLEGE

MCC

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Prepared By
Pure & Applied Science Dept.
Geography

MIDNAPORE CITY COLLEGE

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DEPARTMENT OF PURE AND APPLIED SCIENCES
FIELD REPORT HANDBOOK AND LABORATORY MANUAL
BACHELOR OF SCIENCE (HONOURS)
IN
GEOGRAPHY
SEMESTER - V

PREFACE TO THE FIRST EDITION

This is the first edition of Lab Manual for BSc Honours in Geography (First Semester). Hope this edition will help you during practical. This edition mainly tried to cover the whole syllabus. Some hard topic are not present here that will be guided by responsive teachers at the time of practical.

ACKNOWLEDGEMENT

We are really thankful to our students, teachers, and non-teaching staffs to make this effort little bit complete. Mainly thanks to Director and Principal Sir to motivate for making this lab manual.

C11P: Research Methodology and Field Work Lab

Practical Record

1. Each student will prepare an individual report based on primary data collected form field survey and secondary data collected from different sources for either a rural area (mouza) or an urban area (municipal ward) based on cadastral or municipal maps to study specific problems.

2. The duration of the field work shall not exceed 10 days

3. The report should be hand written in English on A4 size paper in candidate's own words within 5,000 to 8,000 words excluding figures, tables, photographs, maps, references and appendices

4. A copy of the bound report, duly signed by the concerned teacher, should be submitted

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C12P: Remote Sensing and GIS Lab

1. Georeferencing of maps and images

2. Image enhancement. Preparation of reflectance libraries of LULC features across different image bands of IRS L3 or Landsat OLI data

3. Image classification, post-classification analysis and class editing

4. Digitisation of features. Data attachment, overlay and preparation of thematic map

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C11P: Research Methodology and Field Work Lab

'Learning outside the classroom is important for all young people if they are to connect with their local place, find a relevance for the classroom-based learning and develop a meaningful understanding of what environment really means.'

- **Turney, A. (2009)**

Fieldwork is learning directly in the real world outside the classroom and has a long tradition in geography. It is an essential ingredient of geography because it provides a 'real-world' opportunity for students to develop and extend their geographical thinking; it adds value to classroom experiences. Geography fieldwork is very much 'hands on'; when students are involved in fieldwork enquiries they are collecting primary data; formulating questions to investigate; seeking answers to their questions; and communicating their findings.

At the Bachelor of Science (Honours) level, a learner is expected to acquire tools, abilities and knowledge that will qualify him/her to teach, carry out research, and perform as a professional. The dissertation project in disaster management, **C11P: Research Methodology and Field Work Lab** seeks to partially fulfil this requirement. The purpose of this field work is to enable and encourage you to:

➢ Work independently and in-depth on a suitable theme of your own choice; and
➢ Produce a structured and documented piece of research work.

The dissertation project is worth two (02) credits of course work. This means that the dissertation work is near about four months process requiring about 40 study hours.

The dissertation process begins with the identification of topic and ends with the submission of a research document (including bibliographic references), which shows you have completed certain tasks. These tasks are:

➢ Identifying a specific problem
➢ Reading relevant literature
➢ Constructing a fieldwork framework
➢ Collecting and evaluating data
➢ Analysing and interpreting the data in reference to the main aims of the study

➢ Presenting the work in an extended and coherent form

This field work report is not expected to demonstrate a substantial original contribution in the field of research. However, it suffices to demonstrate research skills, though a well-organised and executed dissertation may result in useful and publishable findings.

The College encourages you to work independently on the field report. However, Academic Supervisor recognised by the Midnapore City College shall guide the field work.

every undergraduate student is required to prepare and submit an individual report based on primary data collected form field survey and secondary data collected from different sources for either a rural area (mouza) or an urban area (municipal ward) based on cadastral or municipal maps to study specific problems.

Every student should follow the following steps during their study to complete the individual report:

Pre-Field Stage

1. Sparking curiosity: Read the articles, watch the videos and choose a specific problem and write it in the form of a statement.

2. Selection of the study area: One mouza/municipal ward (Rural /Urban) is to be selected.

3. Setting up objectives of the study: Every study should have one main objective and several sub-objectives.

4. Setting of hypothesis: You can formulate at least one hypothesis on the basis of your objectives of study. However, it is not mandatory to formulate hypothesis to fulfil your study).

5. Collection of secondary data related to selected problem from reliable sources.

6. Creation of survey questions/survey schedule/questionnaire.

- must be relevant to the group's hypothesis
- must be able to help answer the group's hypothesis
- can be multiple-choice or open-ended

Field Stage

After selection of a specific problem and study area (mouza/municipal ward) the followings are to be done (The duration of the field work shall not exceed 10 days):

1. Plot-to-plot land use survey (Depending on Objectives).

2. Collection of primary data regarding the selected problem through in depth interview (with structured questionnaires/schedule - familiarity with local language of the study area is required) or by using geographical instruments.

3. Recording the primary information within an appropriate format.

4. Photographic evidences of field work as well as photos of important geographical features should be collected.

5. Collection of secondary data from the field during survey and it should be reliable sources.

EVERY STUDENT MUST FOLLOW THE FIELDWORK ETHICS DURING PRIMARY DATA COLLECTION.

Post-Field Stage

1. Classification and tabulation of data.

2. Preparation of map on cadastral plan (Depending on Objectives).

3. Preparation of maps and diagrams showing physiography, drainage, soil, forest, settlement, irrigation, cropping pattern, demographic characteristics etc.

4. Treatment of Data in tune with basic objectives

5. Correlation and analysis of data, maps, and diagram.

6. Analysis and Interpretation of results and Representation through Maps and Diagrams.

7. A report should be presented in a systematic way (see following Table).

TITLE OF THE FIELD REPORT

ACKNOWLEDGEMENT
PREFACE
CONTENT
LIST OF TABLES
LIST OF FIGURES
LIST OF PHOTOGRAPHES

CHAPTER I   INTRODUCTION
                 (Conceptual background, Reasons for the investigations, objectives, hypothesis)

CHAPTER II   GEOGRAPHICAL SETTING OF THE STUDY AREA
                 (Regional identity, location and environmental setting)

CHAPTER III   DATABASE AND METHODOLOGY
                 (Methods used to investigates each objectives/hypothesis, equipments used, choice
                 of techniques of sampling and field measurements)

CHAPTER IV   DATA ANLYSIS AND INTERPRETATION
                 (Interpretation of cartographic and statistical analysis of data)

CHAPTER V   CONCLUSION AND RECOMMENDATIONS
                 (Major findings from the study, difficulties faced in the present investigation, ideas
                 for future investigation)

                 BIBLIOGRAPHY
                 APPENDIX

The report should be hand written in English on A4 size paper in candidate's own words within 5,000 to 8,000 words excluding figures, tables, photographs, maps, references and appendices (Diagrams may be drawn in MS-Excel).

A copy of the bound report duly signed by the concerned teacher and should be submitted.

Some Ideas for Field Work

1. Physical Geography

➢ Influence of relief on settlement pattern

➢ Changes in slope and crow- section along a river

➢ Rock stability and slope failure

➢ Environmental impacts of landslides or of a thermal power plant or of surface mining

➢ Changes in cross-section and hydraulics on the two sides of a bridge across a river

➢ Change in slope, soil texture and land use away from an alluvial channel

➢ Variations in soil profiles along a slope

> Geomorphic mapping of a terrain in field
> Measurement, mapping and monitoring of a beach profile or of a bank profile
> Rainfall variability and irrigation
> Seasonal weather and cropping practices
> Environmental perception of people
> Study of environmental quality of rural and urban areas and so on.

2. Human Geography

> Industrial profile of a region
> Town size and quality of life
> Functional hierarchy of settlements
> Rank-size hierarchy of towns
> Size and spacing of towns
> City size distribution and economic development,
> Economic regionalisation of a country
> Urbanisation and social change
> Changes in the entropy of a settlement pattern
> Pattern of urban growth, Levels of urbanisation
> Demographic transition
> Trends of urbanisation
> Inter class mobility of towns
> Sub-urban housing boom
> Population redistribution in a metropolis
> A study of urban slums
> Population growth and productivity
> A study of rural-urban fringe or rural-urban migration,
> Crop diversification in a region
> Settlement growth and land use
> Family size and quality of living
> Growth poles and regional development
> Changes in occupational pattern of small and medium towns
> Consumer behaviour in the periodic markets
> A study of diurnal traffic flow along a highway
> Comparison of cultural landscapes of two areas

- ➢ Tourism potential of a region
- ➢ Agricultural or industrial landscape of a region and so on.

References

Turney, A. 'Living and Learning outside the classroom – fieldwork' in Mitchell, D. (ed) (2009) Living Geography: Exciting futures for teachers and students, Chris Kington Publishing.

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1. Georeferencing of Maps and Images

Georeferencing is the name given to the process of transforming a scanned map or aerial photograph so it appears "in place" in GIS. By associating features on the scanned image with real world x and y coordinates, the software can progressively warp the image so it fits to other spatial datasets. This manual will explain how to geo-referenced a raster image in Arc GIS, so it can then be used as an overlay or for digitizing purposes.

Georeferencing requires a spatially referenced dataset that will be used to provide locations on the scanned map with their associated coordinates. In this following example, we will match intersections represented on the scanned map with a shape file of city streets.

1. Click the Add Data button to bring up the Add Data window which allows you to browse to the folder and file location,

2. Click ADD to add the dataset to the Table of Contents.

3. Right-click on the name of the layer in the Table of Contents window, and select Label Features.
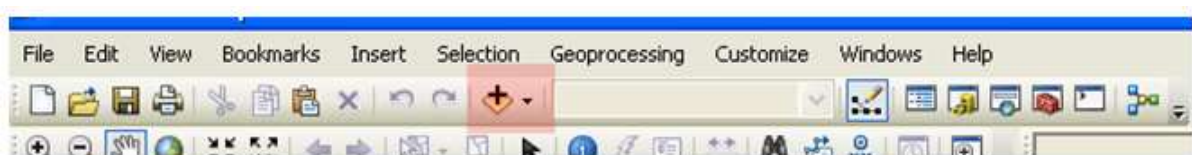
Figure 1

4.   Before   adding   the   raster   file   to   be georeferencedmakesuretoopenitinanimagevieweroreditortoensurethereis no excess areas which can often occur with scanned images.

For best results, the image should be rotated and cropped to so it is oriented in the right direction and areas outside the edge of the map sheet have been--removed. The image used in this manual (seen at left, below) is ready to be georeferenced.

Ready to be georeferenced   Rotate and crop before georeferencing
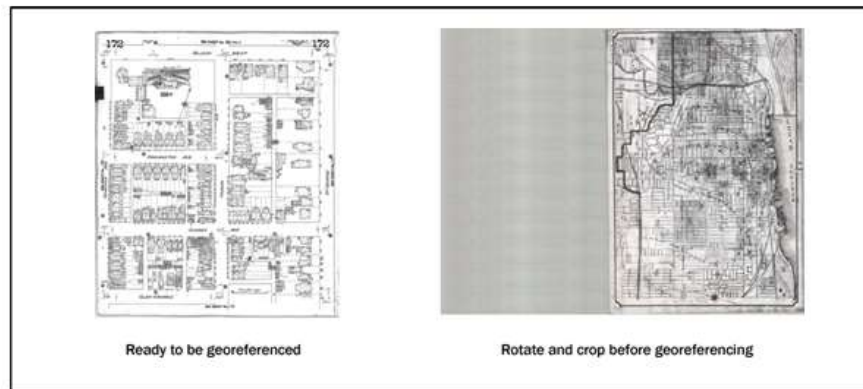
Figure 2

5. Use the Add Data button to add the scanned map image to the map document. If asked if you would like to build pyramids, click yes. Building pyramids improves the speed in which raster datasets load, and is optional.

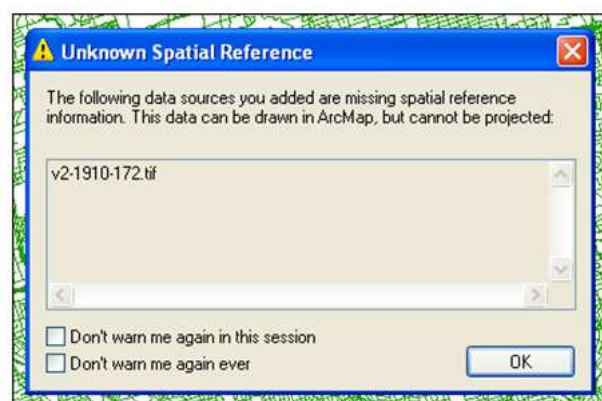You should receive the following warning message after adding the scanned image to ArcMap:

Figure 3

Note: The Georeferencing process in Arc GIS will solve the issue of missing spatial references. Click **OK**. Because Arc Map does not know where to locate this raster dataset, it will not display on the map, but will be visible in the Table of Contents.

6. Add the Georeferencing toolbar by going to Customize - Toolbars -Georeferencing.

The dropdown menu in the *Georeferencing* toolbar should display the filename of the raster file added to the map document.

Figure 4

Note: When multiple raster files are present in the Table of Contents, the dropdown menu controls which raster the Georeferencing tools will be targeting, therefore it is important to make sure that you have the correct raster selected.

7. You will notice that while the raster file appears in the Layers portion of the Table of Contents it is not immediately visible on the screen. To make the image visible click the **Georeferencing** button to the left of the dropdown menu, and select **Fit to Display** from the menu that appears.
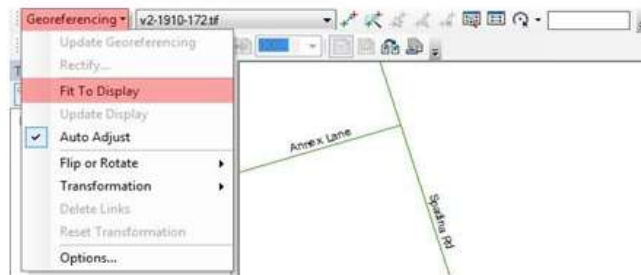
Figure 5

Note: The scanned map will appear with the data set as seen below, scaled to the extent of the current display – it should appear to be larger than the City of Toronto at the current zoom level.

Figure6

8. Use the Zoom tool to zoom in to the University of Toronto area in the road network file, shown here in the highlighted rectangle on the map below:

Figure 7

9. Use the **Zoom In, Zoom Out** and Pan Tools to approximately center on the map.

Figure 8

10. There are two methods in which you can bring the scales of both the digital map data and the scanned image more in line with each other.

The first is to use the same method as outlined in Step 9 (*Georeferencing > Fit to Display*).

The second is to use the **Rotate, Shift and Scale** commands located on the Georeferencing toolbar which allows for the manual transformation of the source layer.

Regardless of the method used, the end result should look similar to the second image below prior to moving on with the next steps in this tutorial.
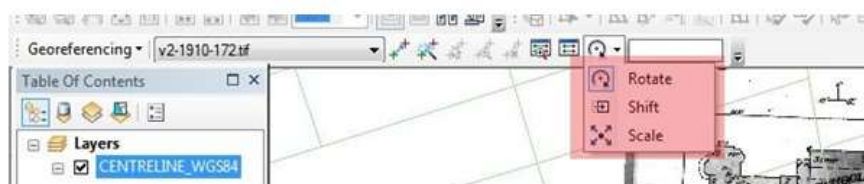
Figure 9

You can now begin to georeferenced the map.

11. In order to increase accuracy in selecting your control points it is best to turn on the **Vertex Snapping** option in the *Snapping* toolbar.

Figure 10

Of this toolbar is not initially available it can be added to the main screen via *Customize > Toolbars > Snapping* and can then be dragged and dropped into position as below.
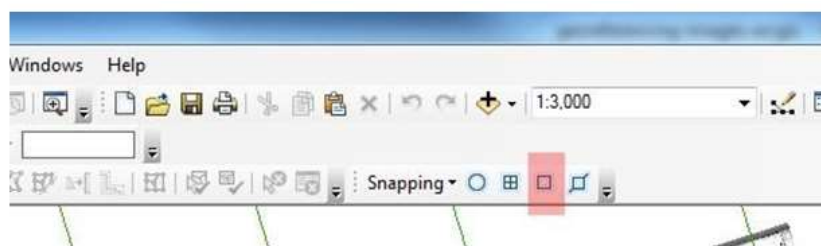

Figure 11

12. Another option which can be selected at this time is the **Auto-Adjust** option within the *Georeferencing* toolbar which automatically updates the display and adjusts the raster image with each new control point added. It is recommended that the Auto-Adjust option be selected for most GIS needs so that you can monitor the Georeferencing process in real time.
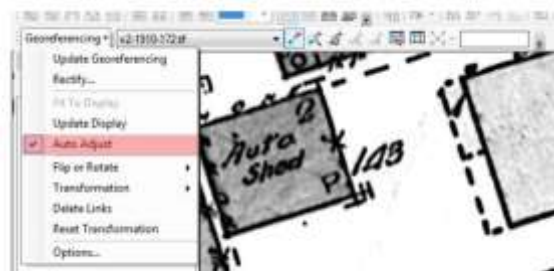

Figure 12

13. Click on the **Add Control Points** button in the Georeferencing toolbar. This tool allows you to associate points a scanned map or aerial image with their real-world spatial coordinates within your GIS.
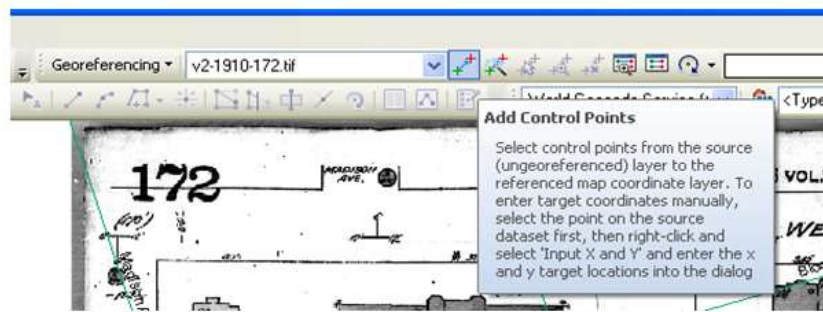
Figure 13

14. To add a Control Point to your map, first click on a location on the scanned map (a green 'plus' sign will appear as seen in the first image below), then click on the corresponding location in your street dataset to associate the two (a red 'plus' sign will appear as seen in the second image below). In this example, we will match the centre of the intersection of streets on the scanned map to the intersection of the same streets in our geospatial data, represented as line features in the spatial dataset. **Note that the lines in the middle of streets on the scanned map show the location of water pipes, not necessarily located at the centre of the inter section.**
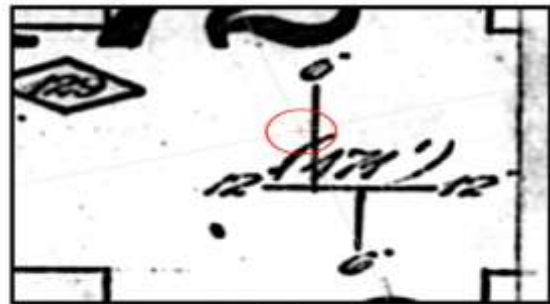

Figure 14

Figure 15

15. Continue adding control points until the raster image moves into place geographically, aligning itself with the digital data map. You will notice that after two control points were added the image automatically warped into position, in most cases several more control points should be added to increase the accuracy of the overlay. Select areas close to four corners of the map first, and then concentrate on your map area between the four corner points which should ensure that all points are georeference evenly.

16. If at any time you need to edit, save or delete any Control Points collected, this can be done by accessing the **View Link Table** button on the Georeferencing taskbar (highlighted in red below). This table displays the Control Point(s) information as well as the Transformation and Auto-Adjust options which control how the raster image responds to the addition of control points.

Figure 16

Each line represents a Control Point, a link between the raster image and the digital map data. Both the Source and **Map Points** can be edited by double-clicking on the values in the table. Clicking on the **Save** button allows the points table to be saved as a text file while the **Load** button allows for a set of control points stored in a text file to be loaded and edited. Saving a text file of your control points is strongly recommended

For images requiring many control points to georeference, periodically saving your control points to a text file allows you to come back to your work in case you are not able to finish it in one session.
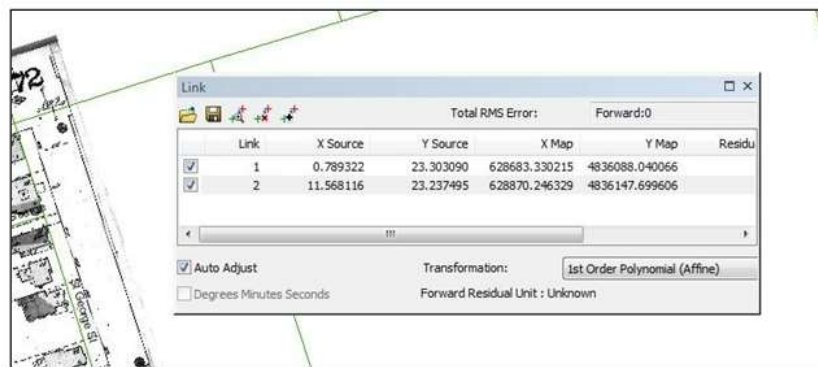

Figure 17

With the addition of control points at intersections and the auto-adjustment of the raster image to the digital dataset, your image should now look very similar to the image below:

Figure18

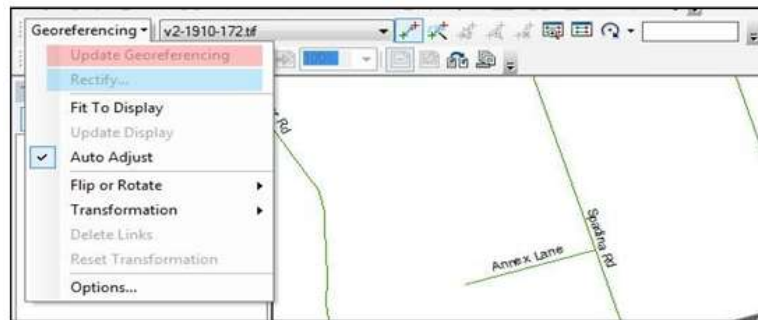17. Open the Georeferencing menu in the toolbar.

Figure 19

Using the **Update Georeferencing** tool will store the transformation information with the raster file, which can be internal or external depending on the type of raster dataset being used (i.e. for a the current raster dataset, that is a TIFF file, the transformation will be stored in what is known as a world file, with a .tfw or .tfwx extension).

18. Using the Rectify command will allow you to create a new raster dataset that is georeference using both map co-ordinates and spatial references which can be saved in a number of different formats (BIL, BIP, BMP, DAT,GIF TIFF, ESRI GRID, IMG, JPEG, JPEG 2000, PNG). This command can be useful if you wish to perform further analysis with the raster dataset or use it in an external program that does not recognize the external georeference information created in the ArcGIS world file (i.e. tfwx).

Note: Both functions can be accessed via the *Georeferencing* toolbar. For the **Rectify** option, another box will be displayed in which **Resample Type** and **Data Name**, **Location** and **Format** may be selected.

2. Image Enhancement, Preparation of Reflectance Libraries of LULC Features across Different Image Bands of IRS L3 or Landsat OLI Data

False Colour Composites (FCC)

Colour assignment for any band of a multispectral image can be done in an entirely arbitrary manner. The colour of a target in the displayed image does not have any resemblance to its actual colour. The resulting product is known as a false colour composite image. There are many possible schemes of producing false colour composite images. However, some scheme may be more suitable for detecting certain objects in theimage.

A very common false colour composite scheme for displaying a SPOT multispectral image is shown below:

R = XS3 (NIR band) G = XS2 (red band) B = XS1 (green band)

This false colour composite scheme allows vegetation to be detected readily in the image. In this type of false colour composite images, vegetation appears in different shades of red depending on the types and conditions of the vegetation, since it has a high reflectance in the NIR band as in the graph of spectral reflectance signature.

False colour composite multispectral SPOT image:
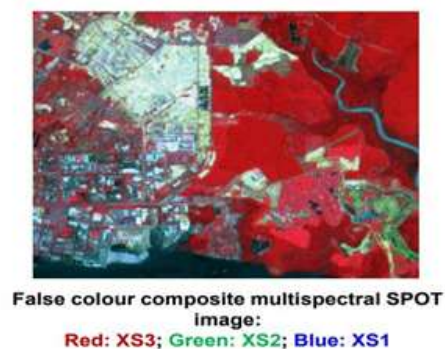**Red: XS3; Green: XS2; Blue: XS1**

Figure 20

Another common false colour composite scheme for displaying an optical image with a short-wave infrared (SWIR) band is shown below:

R = SWIR band (SPOT4 band 4, Landsat TM band5) G = NIR band (SPOT4 band 3, Landsat TM band 4)
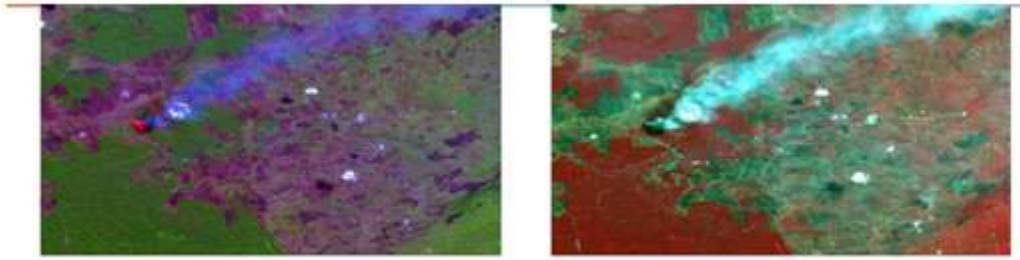B = Red band (SPOT4 band 2, Landsat TM band3)

Figure 21

Left image: Including the SWIR band: Red: SWIR band; Green: NIR band; Blue: Red band. In this display scheme, vegetation appears in shades of green. Bare soils and clearcut areas appear purplish or magenta. The patch of bright red area on the left is the location of active fires. A smoke plume originating from the active fire site appears faint bluish in colour.

Right image: Excluding the SWIR band: Red: NIR band; Green: Red band; Blue: Green band. Vegetation appears in shades of red. The smoke plume appears bright bluish white.

Image Enhancement

Image enhancement techniques improve the quality of an image perceived by a human. These are applied separately to each band of a multispectral image in order to display or visually interpret the data more effectively. The objective is to create "new" images from original raw data in order to increase the amount of information that can be visually interpreted from the data. Image enhancement is attempted after the image is corrected for geometric and radiometric distortions.
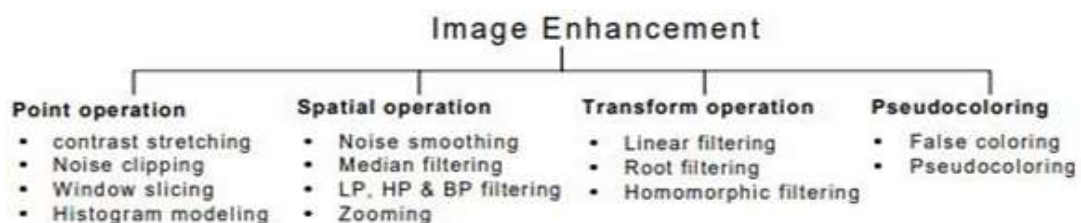

Figure 22

METHODS:

Image enhancement methods can be based on either spatial or frequency domain techniques.

Spatial domain enhancement methods:

- Spatial domain techniques are performed to the image plane itself and they are based on direct manipulation of pixels in animage.

- The operation can be formulated as g(x,y) = T[f(x,y)], where g is the output, f is the input image and T is an operation on f defined over some neighbourhood of (x,y).

- According to the operations on the image pixels, it can be further divided into 2 categories: Point operations and spatial operations (including linear and non-linear operations).

Frequency domain enhancement methods:

- These methods enhance an image f(x,y) by convoluting the image with a linear, position in variant operator.

- The 2D convolution is performed in frequency domain with DFT.

Spatial domain: g (x,y) = f (x,y)*h(x,y)

Frequency domain: G (w1, w 2) =F (w1, w 2) H (w1, w 2)

1. Enhancement by point processing

- These processing methods are based only on the intensity of single pixels.

Simple intensity transformation:

(a) Image negatives: Negatives of digital images are useful in numerous applications, such as displaying medical images and photographing a screen with monochrome positive film with the idea of using the resulting negatives as normal slides.

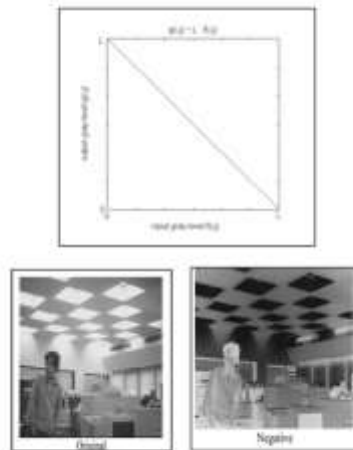Transform function T: g (x,y) = L - f(x,y), where L is the maximum Intensity.

Figure 23

(b) Contrast stretching: Low-contrast images can result from poor illumination, lack of dynamic range in the image sensor, or even wrong setting of a lens aperture during image acquisition. The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image being processed.
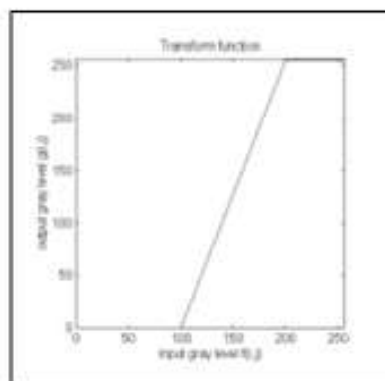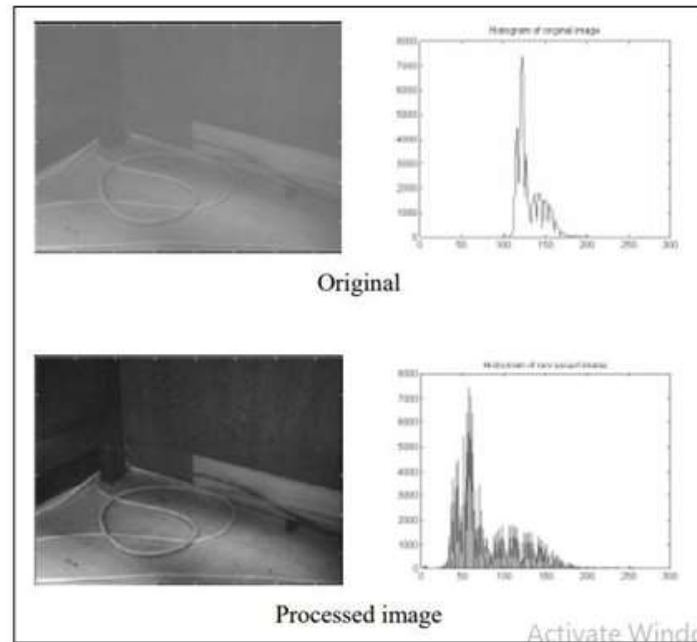

Figure 24

Figure 26

Special case: If r1=r 2=0, s1=0 and s 2=L-1, then it is actually a thresholding that creates a binary images.

(c) Compression of dynamic range: Sometimes the dynamic range of a processed image far exceeds the capability of the display device, in which case only the brightest parts of the images are visible on the display screen. An effective way to compress the dynamic range of pixel values is to perform the following intensity transformation function: $s = c \log(1+|r|)$ where c is a scaling constant and the logarithm function performs the desired compression.
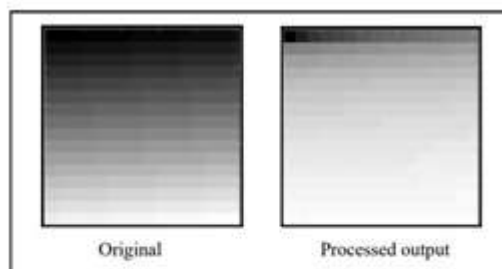

Figure 27

(d) Gray-level slicing: Highlighting a specific range of gray levels in an image often is desired. Applications include enhancing features such as masses of water in satellite imagery and enhancing flaws in x-ray images.

Histogram processing:

- The histogram of a digital image with gray levels in the range [0, L-1] is a discrete function p(r k)=n k/n, where rk is the kth gray level, n k is the number of pixels in the image with that gray level, n is the total number of pixels in the image, and k=0,1..L-1.

- P(r k) gives an estimate of the probability of occurrence of gray level rk.

- The shape of the histogram of an image gives us useful information about the possibility for contrast enhancement.

- A histogram of a narrow shape indicates little dynamic range and thus corresponds to an image having low contrast.
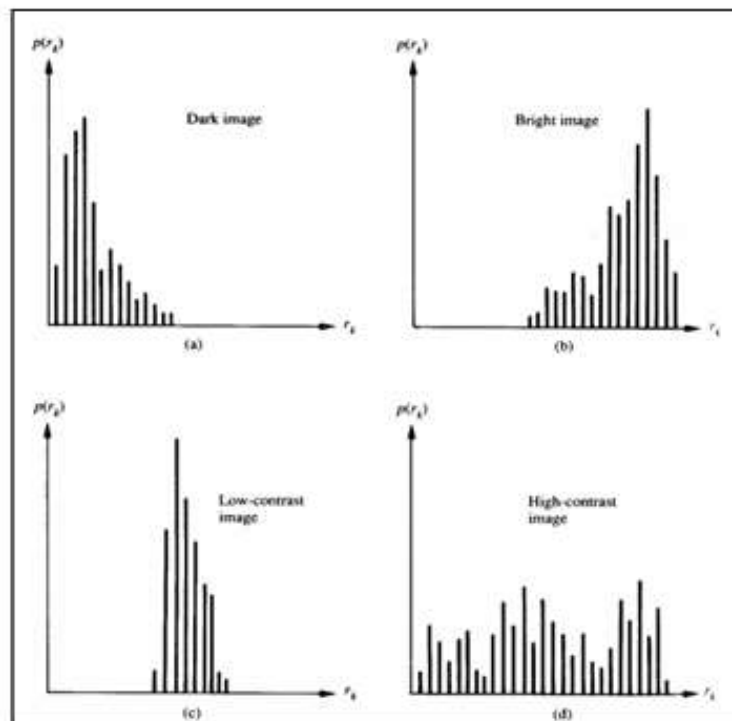
Figure 28

Spatial Filtering:

- The use of spatial masks for image processing is called spatial filtering.

- The masks used are called spatial filters.

- The basic approach is to sum products between the mask coefficients and the intensities of the pixels under the mask at a specific location in the image. (2D convolution) = $\sum \sum - - = - -$ d i d d d R(x, y) w(i, j) f (x i, y j) where (2d+1)X(2d+1) is the mask size, w(i,j)'s are weights of

the mask, f(x,y) is input pixel at coordinates (x,y), R(x,y) is the output value at (x,y).*

- If the center of the mask is at location (x,y) in the image, the gray level of the pixel located at (x,y) is replaced by R, the mask is then moved to the next location in the image and the process is repeated. This continues until all pixel locations have been covered.
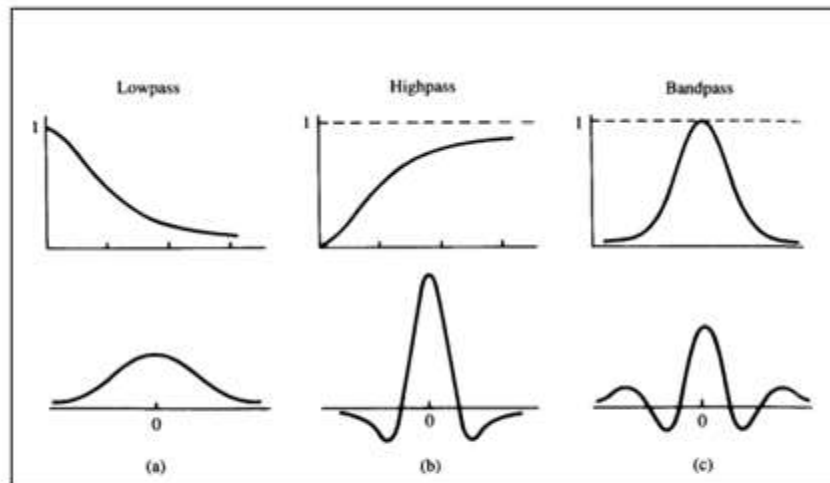

Fig: a) low pass   b) band pass   c) High pass filters

Figure 29

Smoothing filter:

- Smoothing filters are used for blurring and for noise reduction.

- Blurring is used in pre-processing steps, such as removal of small details from an image prior to object extraction, and bridging of small gaps in lines or curves

- Noise reduction can be accomplishing by blurring with a linear filter and also by non linear filtering.

(a) Low pass filtering: The key requirement is that all coefficients are positive. Neighbourhood averaging is a special case of LPF where all coefficients are equal. It blurs edges and other sharp details in the image.

(b) Median filtering: If the objective is to achieve noise reduction instead of blurring, this method should be used. This method is particularly effective when the noise pattern consists of strong, spike-like components and the characteristic to be preserved is edge sharpness. It is a nonlinear

operation. For each input pixel f(x,y), we sort the values of the pixel and its neighbours to determine their median and assign its value to output pixel g (x,y).
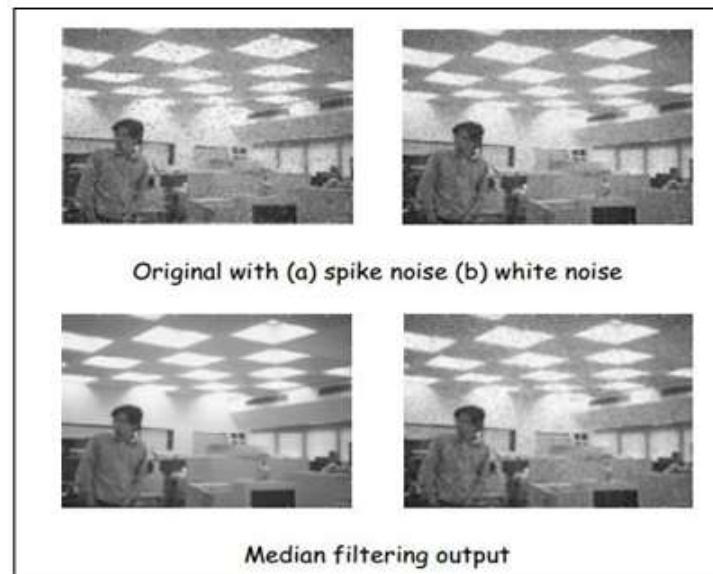

Original with (a) spike noise (b) white noise

Median filtering output

Figure 30

Low-pass filtering output
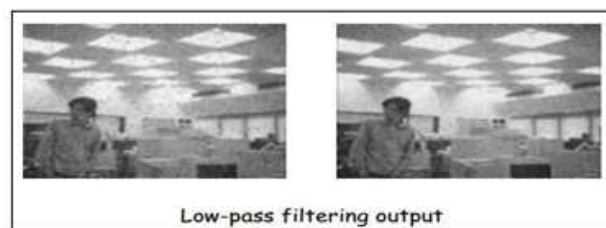
Figure 31

Sharpening Filters:

- To highlight fine detail in an image or to enhance detail that has been blurred, either in error or as a natural effect of a particular method of image acquisition.

- Uses of image sharpening vary and include applications ranging from electronic printing and medical imaging to industrial inspection and autonomous target detection in smart weapons.

(a) Basic high pass spatial filter: The shape of the impulse response needed to implement a high pass spatial filter indicates that the filter should have positive coefficients near its center, and negative coefficients in the outer periphery.

Example: filter mask of a 3x3 sharpening filter

$$\frac{1}{9}\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Figure 32

- The filtering output pixels might be of a gray level exceeding [0, L-1].

- The results of high pass filtering involve some form of scaling and/or clipping to make sure that the gray levels of the final results are within [0, L-1].

(b) Derivative filters: Differentiation can be expected to have the opposite effect of averaging, which tends to blur detail in an image, and thus sharpen an image and be able to detect edges. The most common method of differentiation in image processing applications is the gradient. For a function f(x, y), the gradient of f at coordinates (x', y') is defined as the vector.

$$\nabla f(x', y') = \begin{bmatrix} \dfrac{\partial f}{\partial x} \\ \dfrac{\partial f}{\partial y} \end{bmatrix}_{(x', y')}$$

Figure 33

- Its magnitude can be approximated in a number of ways, which result in a number of operators such as Roberts, Prewitt and Sobel operators for computing its value.

Enhancement in the frequency domain:

We simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter transfer function, and take the inverse transform to produce the enhanced image. Spatial domain: g(x, y) = f(x, y)*h(x, y) Frequency domain: G(w1,w2) = F(w1,w2)H(w1,w2) Low pass filtering

- Edges and sharp transitions in the gray levels contribute to the high frequency content of its Fourier transform, so a low pass filter smoothes animage.
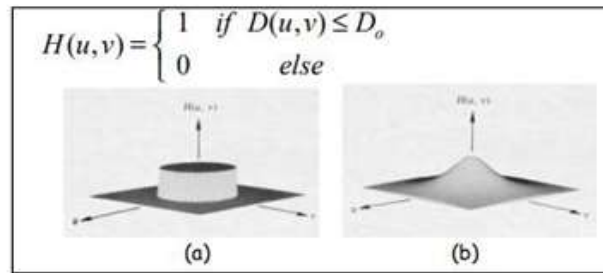
- Formula of ideal LPF

$$H(u,v) = \begin{cases} 1 & if\ D(u,v) \le D_o \\ 0 & else \end{cases}$$

(a)   (b)

Figure 34

High pass filtering:

- A high pass filter attenuates the low frequency components without disturbing the high frequency information in the Fourier transform domain can sharpenedges.

- Formula of ideal HPF function

$$H(u,v) = \begin{cases} 0 & if\ D(u,v) \le D_o \\ 1 & else \end{cases}$$

(a)   (b)

Figure 35

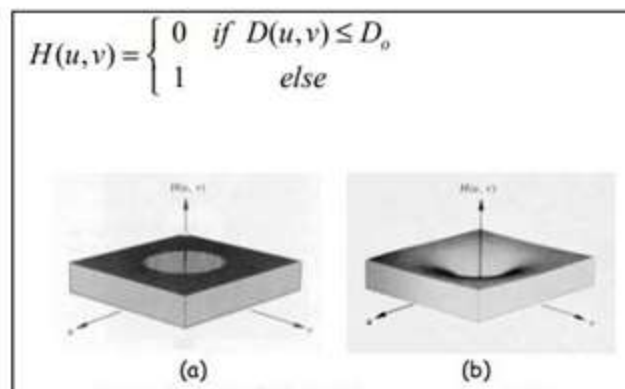### Pseudo colour image processing

- In automated image analysis, color is a powerful descriptor that often simplifies object identification and extraction from ascene.

- Human eye performs much better in discerning shades of colour than grayscale.

- A monochrome image can be enhanced by using colors to represent different gray levels or frequencies.

Gray level to colour transformation

- To perform 3 independent transformations on the gray level of any input pixel. The three results are then fed separately into the R, G, and B guns of a colour monitor.
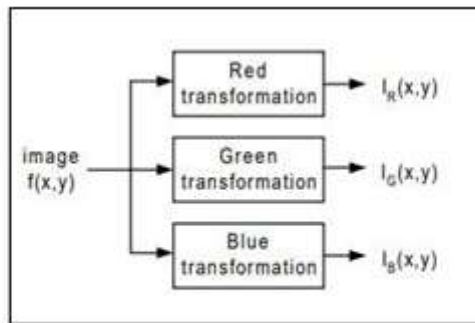

Fig. 36: Functional block diagram for pseudo-colour image processing

- This method produces a composite image whose colour content is modulated by the nature of the transformation functions.
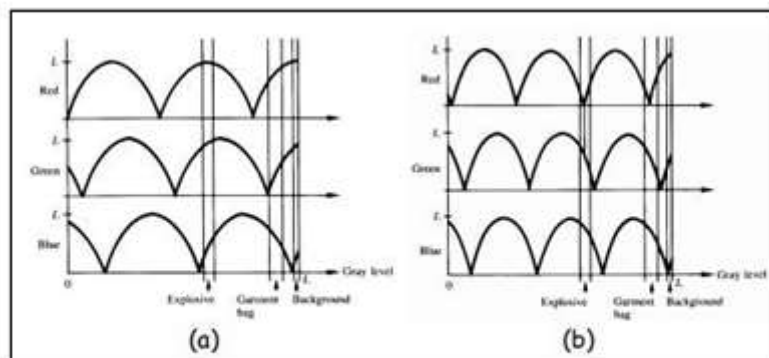
Fig. 37: Two examples of transformation functions

These sinusoidal functions contain regions of relatively constant value around the peaks as well as regions that change rapidly near the valleys.

- Changing the phase and frequency of each sinusoidal can emphasize ranges in the grayscale.

- A small change in the phase between the 3 transformations produces little change in pixels whose gray levels correspond to peaks in the sinusoidal (i.e. Case of I (x, y) I (x, y) I (x, y) R ≈ G ≈B).

Pixels with gray level values in the steep section of the sinusoids are assigned much stronger color content as a result of significant differences between the amplitudes of the 3 sinusoids caused by the phase displacement between them. (i.e. Case of I (x, y) I (x, y) I (x, y) R ≠ G ≠ B)
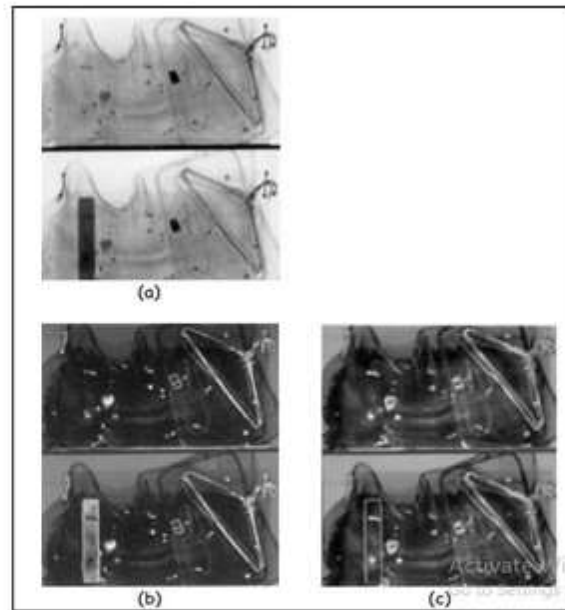
Pseudo-color enhancement by using the gray-level to color transformations. (a) Original image, (b) and (c) results obtained with transformation functions (a) and (b) respectively.

Figure 38

3. Image Classification, Post-Classification Analysis and Class Editing

The purpose of Image classification is to categorize all pixels in a digital image into different land use / land cover classes. Depending on the interaction between computer and interpreter during classification process, there are two types of classification. These two main categories used to achieve classified output are called Supervised and Unsupervised Classification techniques. Out of the two major methods of image classification, supervised classification is generally chosen when analysts have good knowledge of the area. In supervised classification, analyst select representative samples for each land cover class. The software then uses these "training sites" and applies them to the entire image. Supervised classification uses the spectral signature defined in the training set. There are many classification algorithms used in supervised classification such as maximum likelihood and minimum-distance classification. Supervised classification is based on the idea that a user can select sample pixels in an image that are representative of specific classes and then direct the image processing software to use these training sites as references for the classification of all other pixels in the image. Training sites are selected based on the knowledge of the user. The user also sets the bounds for how similar other pixels must be to group them together. These bounds are often set based on the spectral characteristics of the training area, plus or minus a certain increment. The user also designates the number of classes that the image is classified into. Many analysts use a combination of supervised and unsupervised classification processes to develop final output analysis and classified maps. The schematics of the steps used in supervised classification are given below.
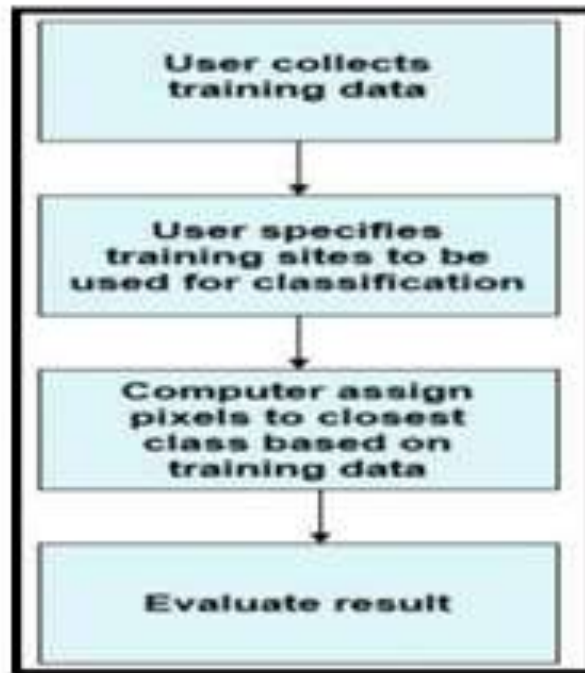
Steps of Supervised Classification

1. Training Data: Training fields are areas of known identity delineated on the digital image, usually by specifying the corner points of a rectangular or polygonal area using line and column numbers within the coordinate system of the digital image. The analyst must, of course, know the correct class for each area. Usually the analyst begins by assembling maps and aerial photographs of the area to be classified. Specific training areas are identified for each informational category following the key characteristics of training area. The objective is to identify a set of pixels that accurately represents spectral variation present within each information region.

2. Selection of Appropriate Classification Algorithm: Various supervised classification algorithms may be used to assign an unknown pixel to one of a number of classes. The choice of a particular classifier or decision rule depends on the nature of the input data and the desired output. Parametric classification algorithm assumes that the observed measurement Xe for reach class in each spectral band during the training phase of the supervised classification are Gaussian in nature i.e. they are normally distributed. Non parametric classification algorithm makes no such assumptions. Among the most frequently used classification algorithms are the parallelepiped, minimum distance, and maximum likelihood decision rules. An example of data samples is given below.
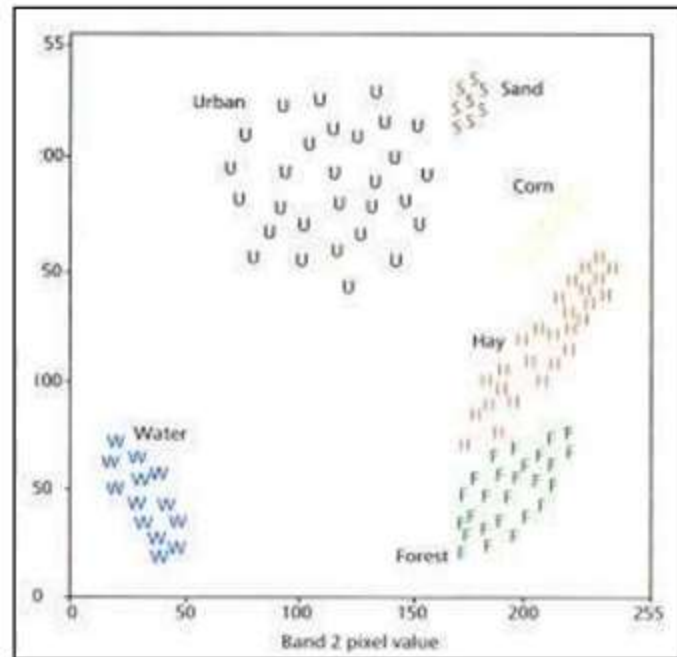
Algorithm

3. Parallelepiped Classification Algorithm: This is a widely used decision rule based on simple Boolean "and/or" logic. Training data in n spectral bands are used in performing the classification. Brightness values from each pixel of the multispectral imagery are used to produce an n-dimensional mean vector.
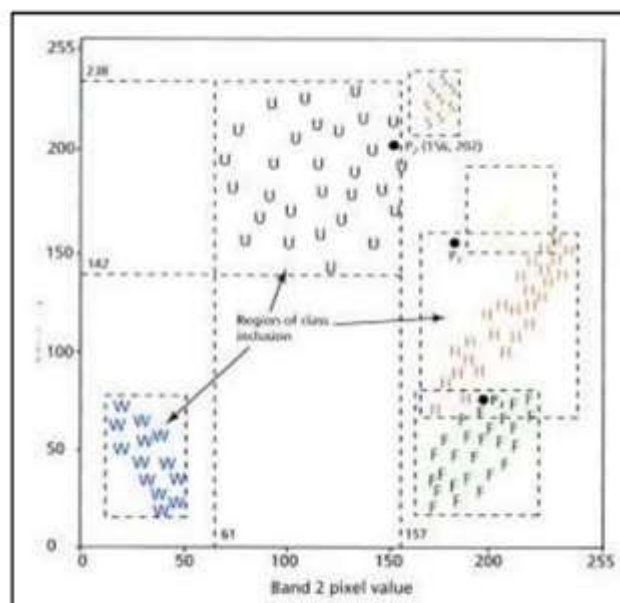
Parallelepiped Algorithm

4. Minimum Distance to Mean Classification Algorithm: This decision rule is computationally simple and commonly used. When used properly it can result in classification accuracy comparable to other more computationally intensive algorithms, such as the maximum likelihood algorithm. Like the parallelepiped algorithm, it requires that the user provide the mean vectors for each class in each band mck from the training data. To perform a minimum distance classification, a program must calculate the distance to each mean vector, mck from each unknown pixel (BVijk). It is possible to calculate this distance using Euclidean distance based on the Pythagorean Theorem.

The computation of the Euclidean distance from point to the mean of Class-1 measured in band relies on the equation:

$$\text{Dist} = \text{SQRT (BVijk - mck) 2 + (BVijl - mcl) 2}$$

Where, mck and mcl represent the mean vectors for class c measured in bands k and l. Many minimum-distance algorithms analyst specify a distance or threshold from the class means beyond which a pixel will not be assigned to a category even though it is nearest to the mean of that category.

When more than two bands are evaluated in a classification, it is possible to extend the logic of computing the distance between just two points in n space using the equation:

$$\text{n Dab} = \Sigma(\text{ai - bi})2 \text{ I}= 1$$
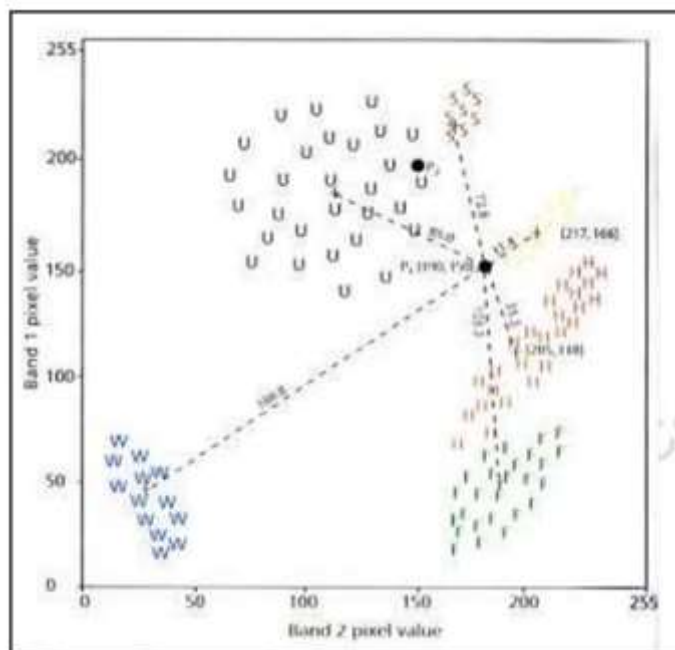
Minimum Distance to Mean Algorithm

5. Maximum Likelihood Classification Algorithm: The maximum likelihood decision rule assigns each pixel having pattern measurements or features X to the class c whose units are most probable or likely to have given rise to feature vector x. It assumes that the training data statistics for each class in each band are normally distributed, that is, Gaussian. In other words, training data with bi-or tri-modal histograms in a single band are not ideal. In such cases, the individual modes probably represent individual classes that should be trained upon individually and labeled 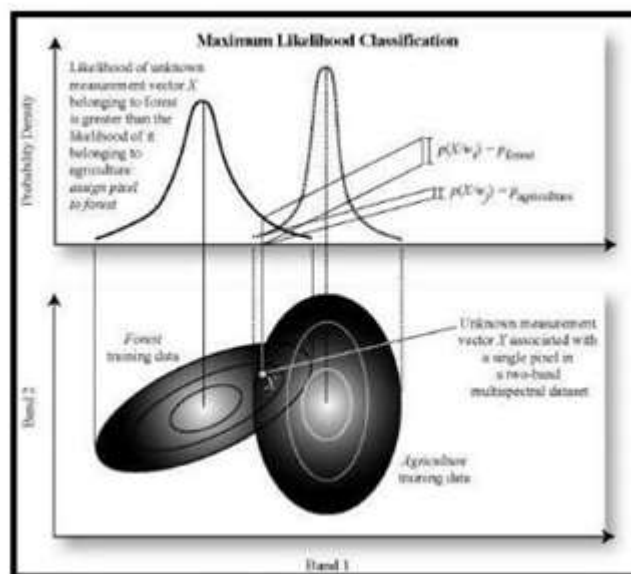as separate classes. This would then produce uni-modal, Gaussian training class statistics that would fulfil the normal distribution requirement. Maximum likelihood classification makes use of the statistics including the mean measurement vector, divergence, standard deviation and probability.

Maximum Likelihood Algorithm

6. Classification Accuracy Assessment: Quantitatively assessing classification accuracy requires the collection of some in situ data or a priori knowledge about some parts of the terrain, which can then be compared with the remote sensing derived classification map. Thus, to asses classification accuracy it is necessary to compare two classification maps 1) the remote sensing derived map, and 2) assumed true map. The assumed true map may be derived from in situ investigation or quite often from the interpretation of remotely sensed data obtained at a larger scale or higher resolution.

Unsupervised Classification

Introduction: Image classification refers to process of extraction of information from satellite image. The purpose of Image classification is to categorize all pixels in a digital image into one of several

land use classes or themes. In order to make use of the multitude of digital data available from satellite imagery, it must be processed in a manner that is suitable for the end user. For many projects this processing includes categorizing the land into its various use functions. Depending on the interaction between computer and interpreter during classification process, there are two types of classification.

These two main categories used to achieve classified output are called Supervised and Unsupervised Classification techniques unsupervised classification (commonly referred to as clustering) is an effective method of partitioning remote sensor image data in multispectral feature space and extracting land-cover information.

Compared to supervised classification, unsupervised classification normally requires only a minimal amount of initial input from the analyst. This is because clustering does not normally require training data. The process where numerical operations are performed that search for natural groupings of the spectral properties of pixels, as examined in multispectral feature space.

The clustering process results in a classification map consisting of m spectral classes. The analyst then attempts a posterior to assign or transform the spectral classes into thematic information classes of interest (e.g., forest, agriculture).

In unsupervised classification, the software does most of the processing on its own generally resulting in more categories than the user is interested in. This is the point where the user has to make decisions on which categories can be grouped together into a single land use category. In either case additional image processing may be used to determine which method is better for a given situation. It must be kept in mind that maps are simple attempts to represent what actually exists in the world and are never completely accurate. The image used for demonstration is Landsat 5 Thematic Mapper (TM) scene. Ground resolution for this image is 30 meters. Landsat TM records data in seven different bandwidths. These bandwidths cover parts of the visible, infrared, and thermal infrared regions of the electromagnetic spectrum are shown in following Table.

Bandwidths cover parts of the visible, infrared, and thermal infrared regions of the electromagnetic spectrum

Landsat 5 TM Band Descriptions(Jensen 2000)		
Band	Wavelength(µm)	Spectral region
1	0.45-0.52	Visible blue

2	0.52-0.60	Visible green
3	0.63-0.69	Visible red
4	0.76-0.90	reflective infrared
5	1.55-1.75	mid-infrared
6	10.40-12.50	thermal infrared
7	2.08-2.35	mid-infrared

Perry Lake Natural Color

This composition is a window from LANDSAT image. This scene is centered on Perry Reservoir located in Jefferson county, north eastern Kansas and is shown in natural color.

UNSUPERVISED CLASSIFICATION: IDEA

An attempt made to classify the various land uses in Idrisi was done using unsupervised classification techniques. Unsupervised classification techniques do not require the user to specify any information about the features contained in the images. This example was conducted using the ISOCLUST module in Idrisi. With ISOCLUST, the user simply identifies which bands Idrisi should use to create the classifications, and how many classes to categorize the land cover features into. Again, Landsat TM bands 1-5 and 7 were used. The resulting classified image is seen below.
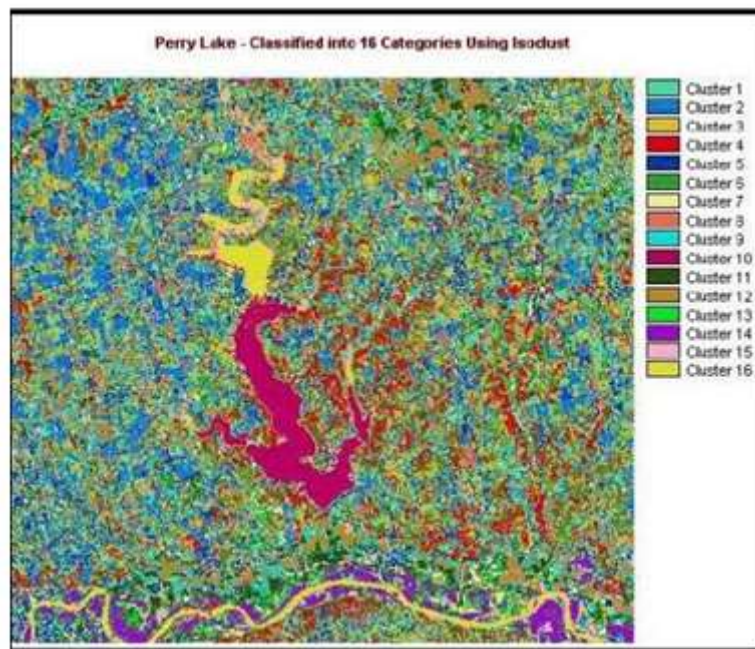
ISOCLUST of Perry Lake

(Source: http://academic.emporia.edu/aberjame/student/banman5/perry3.html)

At this point, the image is difficult to interpret. Looking to the image and classified output, decisions need to be made to convert spectral groups into feature or thematic classes. To make these decisions, other materials and knowledge of the area are useful. Ground truthing what is seen in the digital image with what was actually present at the time the image was recorded makes this task more efficient and more accurate. If this knowledge is not available, scientific reasoning may be used to group the various categories together into land use categories. In the demonstration example six land cover types were identified from the original 16 categories as shown in the image.
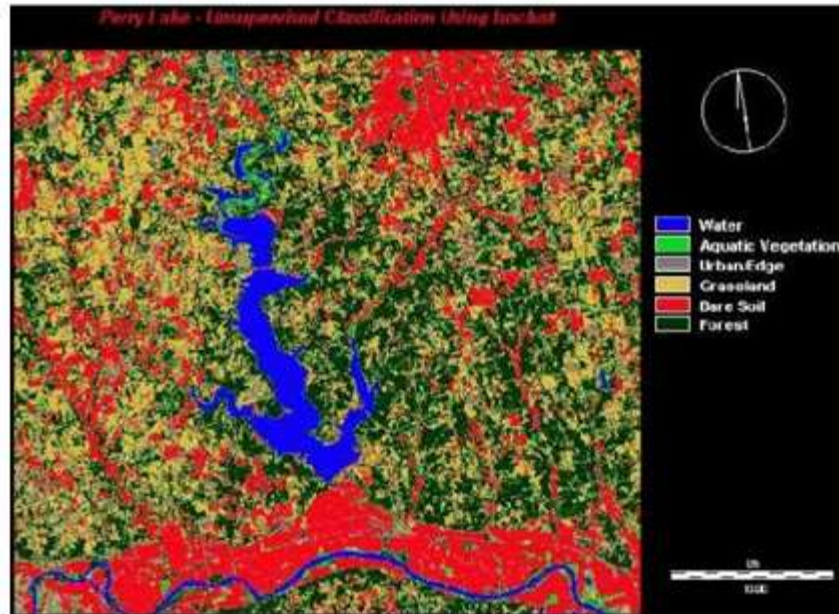
Classified Image with 6 Categories

There are two major methods of unsupervised classification.

Clustering

1. K-means clustering

2. Iso-data clustering

1. K-means: K-means is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed a priori. The main idea is to define k centroids, one for each cluster. These centroids should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest centroid. When no point is pending, the first step is completed and an early grouping is done. At this point we need to re-calculate k new centroids as barycenters of the clusters resulting from the previous step. After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new centroid. A loop has been generated. As a result of this loop we may notice that the k-centroids change their location step by step until no more changes are done. In other words centroids do not move any more. Finally, this

algorithm aims at minimizing an objective function, in this case a squared error function as in this equation.

The algorithm is composed of the following steps:

1. PlaceKpointsintothespacerepresentedbytheobjectsthatarebeingclustered.Thesepointsrepresent initial group centroids.
2. Assign each object to the group that has the closest centroid.
3. When all objects have been assigned, recalculate the positions of the K-centroids.
4. Repeat Steps 2 and 3 until the centroids no longer move. This produces a separation of the objects into groups from which the metric to be minimized can be calculated. Although it can be proved that the procedure will always terminate, the k-means algorithm does not necessarily find the most optimal configuration, corresponding to the global objective function minimum. The algorithm is also significantly sensitive to the initial randomly selected cluster centers. The k-means algorithm can be run multiple times to reduce this effect. K-means is a simple algorithm that has been adapted to many problem domains.

There are two schemes to use k-means to classify data.

Scheme-1: One method used is to separate the data according to class labels and apply k-means to every class separately. If we have two classes, we would perform k-means twice, once for each group of data. At the end, we acquire a set of prototypes for each class. When we have a new data point, we put all of the prototypes together and find which one is closest to the new data point. This prototype is associated with a class because the prototypes are created by clustering each class of data individually. The class of this prototype is taken as the class of the new data point. Scheme1of using k-means clustering to the training data in each class separately, using R prototypes per class.

♣ Assign a class label to each of the K × R prototypes.

♣ Classify a new feature vector x to the class of the closest prototype. Below is a result from the textbook using this scheme. There are three classes green, red, and blue. K-means is applied using 5 prototypes for each class. We can see below that for each class, the 5 prototypes chosen are shown by filled circles.
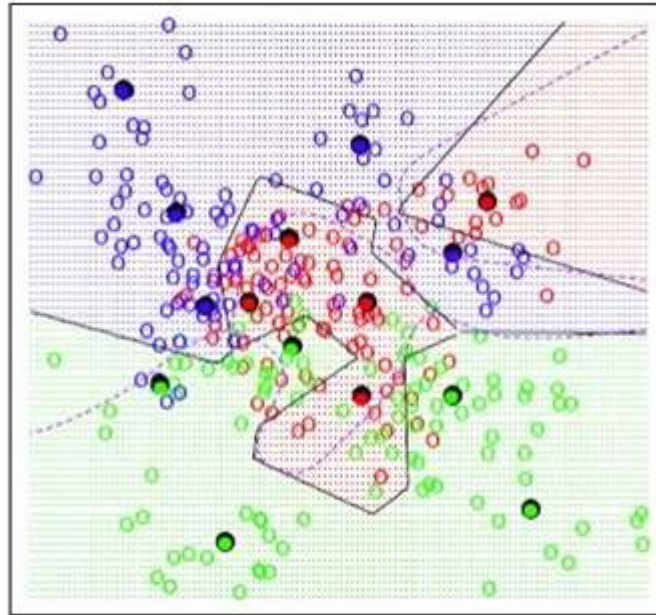
K-means clustering

(Source: https://onlinecourses.science.psu.edu/stat857/node/113)

According to the classification scheme, for any new point, among these 15 prototypes, we would find the one closest to this new point. Then, depending on the color code of that prototype, the corresponding class will be assigned to the new point. The black lines are classification boundaries generated by the k-means algorithm. Specifically, these are the classification boundaries induced by the set of prototypes based on the nearest neighbor. The decision boundary between any two prototypes based on the nearest neighbor rule is linear. Every prototype occupies some region in the space. The region around each prototype is sometimes called the voronoi region and is bounded by hyper planes. Because we have more than one prototype for each class, the classification boundary between the two classes is connected segments of the straight lines, which gives a zigzag look.

Scheme- 2: The second scheme of classification by k-means is to put all the data points together and perform k-means once. There's no guarantee that points in the same group are of the same class because we conduct k-means on the class blended data. To associate a prototype with a class, we count the number of data points in each class that are assigned to this prototype. The dominant class with the most data points is associated with the prototype. During the classification of a new data point, the procedure then goes in the same way as Scheme1.

Steps of Scheme 2:

♣ Apply k-means clustering to the entire training data, using M prototypes.

♣ For each prototype, count the number of samples from each class that are assigned to this prototype. Associate the prototype with the class that has the highest count.

♣ Classify a new feature x to the class of the closest prototype.

➢ ISODATA Clustering: The Iterative Self-Organizing Data Analysis Technique (ISODATA) represents a comprehensive set of heuristic procedures that have been incorporated into an iterative classification algorithm. Many of the steps incorporated into the algorithm are a result of experience gained through experimentation. The ISODATA algorithm is a modification of the k-means clustering algorithm, which includes a) merging clusters if their separation distance in multispectral feature space is below a user specified threshold, and b) rules for splitting a single cluster into two clusters.

➢ ISODATA is iterative because it makes a large number of passes through the remote sensing dataset until specified results are obtained, instead of just two passes.

➢ ISODATA does not allocate its initial mean vectors based on the analysis of pixels in the first line of data the way the two-pass chain algorithm does. Rather, an initial arbitrary assignment of all Cmax clusters takes place along an n-dimensional vector that runs between very specific points in feature space. The region in feature space is defined using the mean and standard deviation of each band in the analysis. This method of automatically seeding the original Cmax vectors makes sure that the first few lines of data do not bias the creation of clusters. ISODATA is self-organizing because it requires relatively little human input. Typical ISODATA algorithms normally require the analyst to specify the following criteria:

➢ Cmax: the maximum number of clusters to be identified by the algorithm (e.g., 20 clusters). However, it is not uncommon for fewer to be found in the final classification map after splitting and merging take place.

➢ T: the maximum percentage of pixels whose class values are allowed to be unchanged between iterations. When this number is reached, the ISODATA algorithm terminates. Some datasets may never reach the desired percentage unchanged. If this happens, it is necessary to interrupt processing and edit the parameter.

➢ M: the maximum number of times ISODATA is to classify pixels and recalculate cluster mean vectors. The ISODATA algorithm terminates when this number is reached. Minimum members in a cluster (%): If a cluster contains less than the minimum percentage of members, it is delete dand the member sare assigned to an alternative cluster. This also affects whether a class is going to be split (see maximum standard deviation). The default minimum percentage of members is often set to 0.01. Maximum standard deviation (σmax): When the standard deviation for a cluster exceeds the specified maximum standard deviation and the number of members in the class is greater than twice the specified minimum members in a class, the cluster is split into two clusters. The mean vectors for the two new clusters are the old class centers ±1 of standard deviation (σ). Maximum standard deviation values between 4.5 and 7 are typical. Split separation value: If this value is changed from 0.0, it takes the place of the standard deviation in determining the locations of the new mean vectors plus and minus the split separation value. Minimum distance between clusters means (C): Clusters with a weighted distance less than this value are merged. A default of 3.0 is often used. The below figure shows the schematic of iso-data clustering:
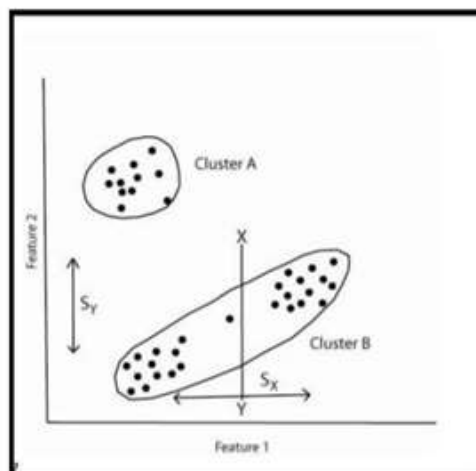
Iso-Data Clustering

Preparation of NDVI with Arc Map 10.3

NDVI computes the normalized difference vegetation index (NDVI) from a multispectral image or two selected image layers. The NDVI is a standardized index allowing you to generate an image displaying greenness (relative biomass). This index takes advantage of the contrast of the

characteristics of two bands from a multispectral raster dataset—the chlorophyll pigment absorptions in the red band and the high reflectivity of plant materials in the near- infrared (NIR) band.

To view the **Image Analysis** window, click **Windows** on the main menu and click **Image Analysis**.

If you are selecting a multiband dataset, you can specify which band will be used for the red and infrared inputs by doing the following:

Click the **Options** button on the **Image Analysis** window.

Click the **NDVI** tab.

Change the inputs for the **Red Band** and **Infrared Band**.

By default, the Red Band is 3 and the Infrared Band is 4. You may need to look at the metadata for your imagery to determine which bands to use. If, for example, you have a three-band color infrared image, the Infrared Band may be 1 and the Red Band may be2.

Optionally, check **Use Wavelength**.

This option will attempt to identify the correct bands to use if the wavelength information is in the dataset. If not, then the band numbers will be used.

Optionally, check **Scientific Output**.

The Band Arithmetic function will be used instead of the NDVI function, since the Band Arithmetic function will output values between -1.0 and 1.0. Whereas, the NDVI function will scale the values to a range of 0–200, which can easily be rendered with a specific color ramp or colormap.

Click **OK**.

Click a multiband raster, mosaic dataset, or image service layer in the Image Analysis window. Optionally, select two single-band raster, mosaic dataset, or image service layers in the table of contents. Click the NDVI button.

The output is added as a temporary layer to the table of contents. By default, a color map renderer is applied using a color map where green represents vegetation, unless the Scientific Output option is checked.

By default, the NDVI operation adds at least two functions to the temporary layer: the NDVI function and the Color map function.

Image Classification

Image classification refers to the computer-assisted interpretation of remotely sensed images. Procedures involved are treated in detail in the IDRISI Guide to GIS and Image Processing Volume 2 chapter Classification of Remotely Sensed Imagery. This section provides a brief overview. Although some procedures are able to incorporate information about such image characteristics as texture and context, the majority of image classification is based solely on the detection of the spectral signatures (i.e., spectral response patterns) of land cover classes. The success with which this can be done will depend on two things: 1) the presence of distinctive signatures for the land cover classes of interest in the band set being used; and 2) the ability to reliably distinguish these signatures from other spectral response patterns that may be present. There are two general approaches to image classification: supervised and unsupervised. They differ in how the classification is performed. In the case of supervised classification, the software system delineates specific land cover types based on statistical characterization data drawn from known examples in the image (known as training sites). With unsupervised classification, however, clustering software is used to uncover the commonly occurring land cover types, with the analyst providing interpretations of those cover types at a later stage.

Supervised Classification

The first step in supervised classification is to identify examples of the information classes (i.e., land cover types) of interest in the image. These are called training sites. The software system is then used to develop a statistical characterization of the reflectances for each information class. This stage is often called signature analysis and may involve developing a characterization as simple as the mean or the range of reflectance on each band, or as complex as detailed analyses of the mean, variances and covariance over all bands. Once a statistical characterization has been achieved for each information class, the image is then classified by examining the reflectances for each pixel and making a decision about which of the signatures it resembles most. There are several techniques for making these decisions, called classifiers. Most Image Processing software will offer several, based on varying decision rules. IDRISI offers a wide range of options falling into three groups depending upon the nature of the output desired and the nature of the input bands.

Unsupervised Classification

In contrast to supervised classification, where we tell the system about the character (i.e., signature) of the information classes we are looking for, unsupervised classification requires no advance information about the classes of interest. Rather, it examines the data and breaks it into the most prevalent natural spectral groupings, or clusters, present in the data. The analyst then identifies these clusters as land cover classes through a combination of familiarity with the region and ground truth visits. The logic by which unsupervised classification works is known as cluster analysis, and is provided in IDRISI primarily by the CLUSTER module. CLUSTER performs classification of composite images (created with COMPOSITE) that combine the most useful information bands. It is important to recognize, however, that the clusters unsupervised classification produces are not information classes, but spectral classes (i.e., they group together features (pixels) with similar reflectance patterns). It is thus usually the case that the analyst needs to reclassify spectral classes into information classes. For example, the system might identify classes for asphalt and cement which the analyst might later group together, creating an information class called pavement. While attractive conceptually, unsupervised classification has traditionally been hampered by very slow algorithms. However, the clustering procedure provided in IDRISI is extraordinarily fast (unquestionably the fastest on the market) and can thus be used iteratively in conjunction with ground truth data to arrive at a very strong classification. With suitable ground truth and accuracy assessment procedures, this tool can provide a remarkably rapid means of producing quality land cover data on a continuing basis. In addition to the above-mentioned techniques, two modules bridge both supervised and unsupervised classifications. ISOCLUST uses a procedure known as Self-Organizing Cluster Analysis to classify up to 7 raw bands with the user specifying the number of clusters to process. The procedure uses the CLUSTER module to initiate a set of clusters that seed an iterative application of the MAXLIKE procedure, each stage using the results of the previous stage as the training sites for this supervised procedure. The result is an unsupervised classification that converges on a final set of stable members using a supervised approach (hence the notion of "self-organizing"). MAXSET is also, at its core, a supervised procedure. However, while the procedure starts with training sites that characterize individual classes, it results in a classification that includes not only these specific classes, but also significant (but unknown) mixtures that might exist. Thus, the end result has much the character of that of an unsupervised approach.

4. Digitisation of Features. Data Attachment, Overlay and Preparation of Thematic Map

DIGITIZATION OF MAP/ TOPOSHEET/ FEATURES

Digitization is the process of converting analog data into digital data sets. In GIS context digitization refers to creating vector datasets viz., point, line or polygon from raster datasets. It is a way of tracing/recording geographic features in vector format from georeferenced images or maps. With the help of digitization we can create different set of layers Viz. Rivers, roads, schools, ward boundaries and building blocks from a single map; this process is known as Vectorization. Vector data is easy to edit, update and is more accurate as compared to raster data. Vector data is more efficient for GIS analysis. Due to these reasons Vectorization is the first step in many GIS projects.

Vector data is mainly of three types

1. Point: It consists of single points having (X, Y) coordinates, for example lamp posts, bus stops and postbox positions etc.

2. Line: It consists a series of (X, Y) coordinates in a sequence (from start node to end node with a number of vertices joining these two nodes). For example roads, power lines, ward boundaries and contours etc.

3. Polygon: It is a series of (X, Y) coordinates in a sequence closing a figure where first and last points are the same. For example lakes, building blocks, village blocks, ward areas and forests etc.

Shapefile

A shapefile is an Esri vector data storage format for storing the location, shape, and attributes of geographic features. It is stored as a set of related files and contains one feature class. Shapefiles often contain large features with a lot of associated data and historically have been used in GIS desktop applications such as ArcMap.

PROCEDURE:

Creating a new shapefile

1. Open ArcCatalog
2. Navigate to project folder
3. From the menu, click File>New>Shapefile
4. Give shapefile a name and select geometry (point, line or polygon), based on what type of features are trying to draw.
5. Use the Edit button to select the projected coordinate system WGS_1984_UTM_Zone_44N.
6. Click on ok to create shapefile.
7. Use the same projection for all map layers in a project in order to preserve accuracy.

Editing Shapefile

1. Add shapefile to ArcMap project
2. Open the Attribute Table of shapefile
3. Using the Attribute Table Options button, use the Add Field button to add fields you want to keep track of.
4. Optional: Set the symbology of your fields now. This will save time later when creating features.

Digitization

1. Open the snapping toolbar Via Customize Toolbars>snapping
2. Make sure snapping is turned on and that all types are active.
3. Editor -> start editing. Select which layer to edit (your new shapefile point, line or polygon). Select the task to perform (Create New Feature).
4. Select the editing pencil tool and click on, along, or around the features in a georeferenced and projected map you want to digitize or vectorize. You can zoom and pan to make this easier.
5. When finished drawing, right click and select Finish Sketch.
6. To edit the attribute table for the feature you just created click the Attributes icon on the Editor Toolbar.
7. All the editable fields for the feature you just created will appear. This way you can label your features as you create them.
8. When you're done creating features click on the Editor button on the Editor toolbar and select Save Edits, and then Stop Editing.

Note:

1. The symbology of the shapefile you just created can be manipulated.

2. Modifications to an existing layer can be made using the Modify Feature task, rather than Create New Feature. Using the Edit Tool individual vertices can be moved, added or deleted. Right-click the vertices with the edit tool to see all options available.

3. You can only edit the values in the Attribute Table of your shapefile while in Editing is turned on

4. However, you cannot create new fields in the Attribute Table while Editing is turned on. Create fields before starting an editing session.

RESULTS:

The different vector layers created using the given Toposheet are:

1. Point features/layers:
2. Line features/layers:
3. polygon features/layers:

CREATION OF THEMATIC MAPS

A "thematic map" is a type of map especially designed to show a particular theme connected with a specific geographic area. These maps "can portray physical, social, political, cultural, economic, sociological, agricultural, or any other aspects of a city, state, region, nation, or continent".

Thematic maps maps are further divided into two types,

a. Choropleth map

A map which uses differences in shading, colouring, or the placing of symbols within predefined areas to indicate the average values of a particular quantity in those areas.

b. Isopleths map

An isopleth map generalizes and simplifies data with a continuous distribution. It shows the data as a third dimension on a map, thus isopleth maps are more common for mapping surface elevations, amounts of precipitation, atmospheric pressure, and numerous other measurements that can be viewed statistically as a third dimension.

Types of Data

To create a thematic map using ArcMap you will need two kinds of data:

1. Spatial data: Displaying boundaries, roads, or some other geographic feature(s). Spatial data is georeferenced in a real world coordinate system and may contain limited attribute information associated with its features. Discrete geographic objects (as opposed to continuously varying variables, like elevation) are generally represented by one or more of three geometrical forms in a GIS:

> Points are used for showing occurrence or relative locations (rather than size or dimension), of features such as trees and fire hydrants, or (from a large scale perspective) buildings or cities.

> Lines, composed of connected points or nodes, can represent routes, pathways or boundaries, or for uses not requiring detailed polygons, such as rivers or roads.

> Polygons consist of a series of nodes and lines enclosing an area, representing things such as state boundaries, lakes, and tracts of land.

2. Attribute data: Descriptive information about a set of features and the information needed to create the "theme" in a thematic map. It can be a statistical data set collected through surveys, Census data, or any other information that describes the features represented in your spatial data set.

PROCEDURE:

1. Open new ArcMap and change the data frame properties to WGS_1984_UTM_Zone_44N.
2. Add the Georeferenced and projected Survey of India Toposheet which we have to digitize for thematic maps creation using Add icon.
3. Create point, line and polygon shape files using arc catalog
4. Editor -> start editing. Select which layer to edit (your new shapefile point, line or polygon). Select the task to perform (Create New Feature).
5. Select the editing pencil tool and click on, along, or around the features in a georeferenced and projected map you want to digitize and create point, line and polygon themes.
6. When finished drawing, right click and select Finish Sketch,
7. To edit the attribute table for the feature you just created click the Attributes icon on the Editor Toolbar.
8. All the editable fields for the feature you just created will appear. This way you can label your features as you create them.

9. Use the 'symbology' tab of the layer properties to modify the characteristics of the theme

10. When you're done creating features click on the Editor button on the Editor toolbar and select Save Edits, and then Stop Editing.

Note:

Application of symbology to thematic map:

Layer properties-> symbology

E.g.

1. Choropleth thematic map: Village theme, waterbodies theme, settlements theme etc.

 i. Legend Type: Graduated Color
 ii. Classification Field: Population/village name
 iii. Normalize by: <None>
 iv. Color Ramps: multicolor

2. Isopleths map: Contour, Drainage themes etc.

 i. Categories: Unique Value
 ii. Values Field: drainage/contour ID
 iii. Color Schemes: (don't change)
 iv. Then click Add All Values

RESULT:

1. Thematic maps created in a given Toposheet are:
2. Choropleth thematic maps: Village theme, water bodies theme, settlements theme etc.
3. Isopleth thematic maps: Contour, Drainage themes etc.

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<u>DISCLAIMER</u>

This self-learning material is based on different books, journals and web sources.