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Digital Image Processing

S. MADHUSUDHAN[1], R. VENKAT TARUN[2], KISHORE SARANGI[3]

[1, 2, 3] *U.G. Students of Department of Electrical & Electronics Engineering, Sasi Institute of Technology & Engineering, Tadepalligudem, West Godavari District, Andhra Pradesh, India.*

Abstract- The fundamental technical principles of digital image processing, with a focus on satellite image processing Image Rectification and Restoration, Enhancement, and Information Extraction are the three categories that all satellite image processing procedures fall into. The farmer is in charge of pre-processing raw image data in order to correct geometric distortion and calibrate the data. For the purpose of visual interpretation. It entails methods for enhancing the visual difference between scene elements. The goal of the information extraction procedures is to automate the identification of features in a scene by replacing visual analysis with quantitative techniques. This entails analyzing multi-spectral image data and applying algorithms. Land cover identification of each pixel in an image may be determined using statistically based decision procedures. The goal of the classification procedure is to group all pixels in a digital image into one of several different land cover groups or themes. Thematic maps of the land cover found in a picture can be created using this classed data.

I. INTRODUCTION

The most popular and practical method of conveying or distributing information is through pictures. It is said that a picture is worth a thousand words. Pictures provide information about item placements, sizes, and interrelationships in a clear and straightforward manner. They represent spatial data that we recognise as objects. Because of our intrinsic visual and mental talents, humans are good at extracting information from such images. Humans receive about 75% of their information in the form of pictures.

The analysis of photographs taken from an above perspective, including radiation not apparent to the naked eye, is being addressed in this context. As a result, the focus of our talk will be on the interpretation of remotely sensed images. These photographs are digitally represented. Brightness can be added, subtracted, multiplied, divided, and subjected to statistical manipulations when represented as numbers, which is not feasible when an image is displayed merely as a snapshot. Although digital analysis of remotely sensed data has been there since the beginning of remote sensing, the launch of the first Landsat earth observation satellite in 1972 ushered in a new age of machine processing (Cambell, 1996 and Jensen, 1996). Digital remote sensing data could previously only be evaluated in specialised remote sensing facilities. Because of the scarcity of digital remote sensing data and a lack of awareness for its attributes, specialised equipment and experienced persons needed to conduct routine machine analysis of data were not generally available.

II. DIGITAL IMAGE

Picture components (pixels) are normally situated at the junction of each row I and column j in each K band of imagery in a digital remotely sensed image. A number called a Digital Number (DN) or Brightness Value (BV) is associated with each pixel and represents the average radiance of a relatively tiny area inside a scene (Fig) A lower number denotes a lower average brightness. The area's radiance, and the high number indicates the area's high radiant qualities.

The size of this area has an impact on how well details in the scene are reproduced. The digital representation of a scene becomes increasingly detailed as the pixel size is lowered.

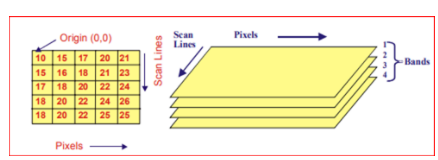


Figure: Structure of a Digital Image and Multispectral Image

III. COLOR COMPOSITES

When images collected in separate bands are displayed in image planes (other than their own) while showing the different bands of a multi spectral data set, the colour composite is referred to as False Color Composite (FCC). When creating colour components, a high spectral resolution is critical. A genuine colour composite requires image data in the red, green, and blue spectral regions. image processor frame buffer memory in bits of red, green, and blue. By inserting the infrared, red, green, and blue frame buffer memories in the red, green, and blue frame buffer memory, a colour infrared composite called a "standard false colour composite" is presented (Fig). Because vegetation absorbs the majority of green and red radiation yet reflects around half of incident energy, healthy vegetation appears in hues of red. Infrared radiation is a type of energy. Urban areas reflect an equal amount of NIR, R, and G, giving them a steel grey appearance.

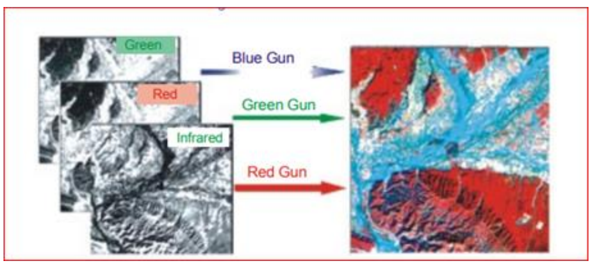
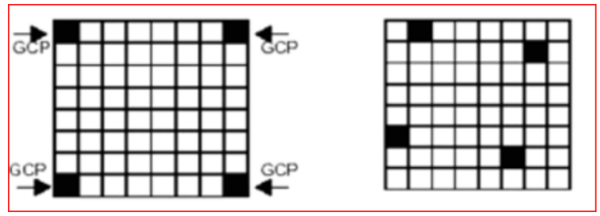


Figure: False Color Composite (FCC) of IRS : LISS II Poanta area

IV. IMAGE RECTIFICATION AND REGISTRATION

Geometric distortions appear as mistakes in a pixel's position in relation to other pixels in the scene as well as their absolute position inside a given map projection. If these geometric distortions aren't removed, any data taken from the image will be meaningless. This is especially true if the data is to be compared to other data sets, such as images or GIS data sets. Distortions can happen for a variety of causes.

Rectification is the process of rectifying an image geometrically so that it can be used. conform to a map, be depicted on a planar surface, or conform to other images (Fig). That is, it is the process of making an image's geometry Planimetric. When precise area, distance, and direction measurements from imagery are required, it is required. It is accomplished by employing a geometric transformation to transform data from one grid system to another.



V. IMAGE ENHANCEMENT TECHNIQUES

The quality of an image as perceived by a person is improved via image enhancement techniques. Because many satellite photos on a colour display provide insufficient information for image interpretation, these techniques are quite beneficial. There is no conscious effort to improve the image's integrity in comparison to some ideal form. Image quality can be improved using a variety of approaches. The most widely utilised techniques include contrast stretch, density slicing, edge enhancement, and spatial filtering. After the image has been adjusted for geometric and radiometric aberrations, image enhancement is tried. Image enhancing techniques are performed to each band of a multi spectral image separately.

- IMAGE FUSION TECHNIQUES:

The satellites cover various parts of the electromagnetic spectrum and record incoming radiation with various spatial, temporal, and spectral resolutions. The majority of these sensors have two modes of operation: multi spectral and panchromatic.

The panchromatic mode refers to observation across a broad spectral band (similar to a normal black and white photograph) and the monochromatic mode to observation over a narrow spectral band (similar to a typical black and white photograph). The observation in a number of relatively narrower bands is referred to as multi spectral (colour) mode. LISS III, for example, operates in the multi spectral mode in the IRS–1D. Green (0.52–0.59 m), red (0.62-0.68 m), near infrared (0.77–0.86 m), and mid-infrared (1.55–1.70 m) energy is recorded. PAN runs in panchromatic mode on the same satellite. Another satellite is SPOT. This uses a multi-spectral and panchromatic sensor combo. The multi spectral mode has a superior spectrum resolution than the panchromatic mode, according to the above facts.

The fusion of two or more separate images to create a new image is known as image fusion (by using a certain algorithm).

The following are the most often used Image Fusion Techniques:

1. IHS Transformation
2. PCA (Personal Computer Aid)
3. Brovey Transform is the third step in the Brovey Transform process
4. Substitution of Bands

VI. IMAGE CLASSIFICATION

Multi spectral data are typically utilised for classification, with the spectral pattern included within the data for each pixel serving as a numerical basis for categorization. That is, depending on their inherent spectrum reflectance and emittance qualities, various feature types display distinct combinations of DNs.

Traditional classification methods typically use two approaches: unsupervised and supervised. The unsupervised approach tries spectral grouping, which may have an ambiguous meaning for the user. After establishing them, the analyst attempts to link each group to an information class. Clustering is a term used to describe an unsupervised approach that produces statistics for spectral, statistical clusters. The image analyst oversees the pixel categorization process in the supervised approach to classification by providing numerical descriptors of the various land cover categories present in the scene to the computer algorithm.

VII. UNSUPERVISED CLASSIFICATION

Unsupervised classifiers do not use training data to make classification decisions. Rather, this class of classifiers consists of algorithms that evaluate unknown pixels in an image and group them into a number of classes based on the image values' natural groupings or clusters. When the values within a specific cover type are close together in the measurement space, and data from various classes is reasonably well separated, it works exceptionally well. The spectral classes that emerge through unsupervised classification are so named because they are based only on natural groups in picture values, and their identities are unknown at first. To determine the identification and informational value of the spectral classes, the analyst must compare the categorised data with some type of reference material (such as larger scale imagery or maps).

VIII. SUPERVISED CLASSIFICATION

Supervised classification is typically defined as the process of using known-identity examples to classify pixels with unknown identities. Pixels positioned within training zones are known identification samples. The training samples are pixels that are located inside these locations and are utilised to aid the classification algorithm in assigning specific spectral values to the relevant informative class.

The training stage of a typical supervised classification technique is depicted in Fig.

Selection of features

- Appropriate classification algorithm selection
- Smoothing after classification
- Evaluation of precision

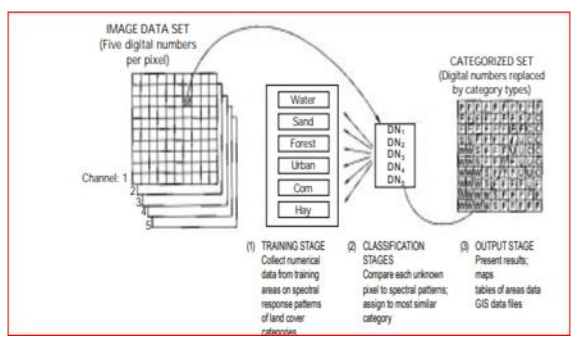


Figure: Basic Steps in Supervised Classification

IX. TRAINING DATA

Training fields are areas on a digital picture with a known identity that are demarcated by identifying the corner points of a rectangular or polygonal area using line and column numbers within the digital image's coordinate system. Of course, the analyst must be aware of the appropriate class for each region. The analyst usually starts by gathering maps and aerial images of the area to be Categorised. Following the standards indicated below, specific training areas are identified for each informational category. The goal is to find a group of pixels that appropriately depicts the spectral variation in each information region (Fig.a).

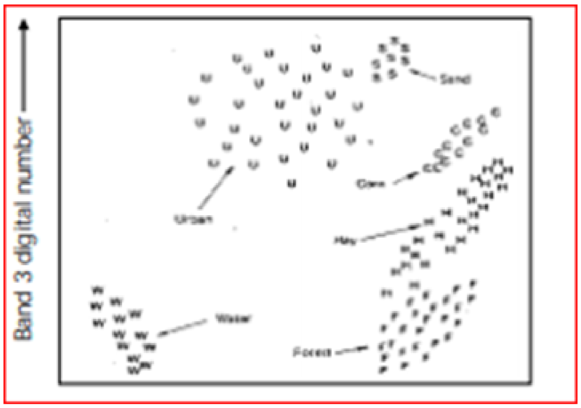


Figure a: Pixel observations from selected training sites plotted on scatter diagram

X. SELECTION OF APPROPRIATE ALGORITHM

To assign an unknown pixel to one of several classes, various supervised classification algorithms can be utilised. The nature of the input data and the desired output determine whether classifier or decision rule is used. The observed measurement vectors Xc for each class in each spectral band are assumed by parmetric classification algorithms. They are Gaussian in nature throughout the training phase of the supervised classification; that is, they are normally distributed. Such an assumption is not made by nonparametric classification algorithms. The parallelepiped, minimal distance, and maximum likelihood decision criteria are among the most commonly used classification algorithms.

- Classification Error Matrix

The development of a classification error matrix, also known as a confusion or a contingency table, is one of the most frequent ways of displaying classification accuracy. Error matrices compare the relationship between known reference data (ground truth) and the associated findings of an automated classification on a category-by-category basis. Square matrices are examples of such matrices. with the number of rows and columns equal to the number of categories being evaluated for classification accuracy. Table 1 is an error matrix created by an image analyst to determine how effectively a Classification has classified a representative selection of pixels utilised in the supervised classification training process. This matrix is the result of classifying the pixels from the sampled training set and listing the known cover types that were utilised for training (columns) vs the Pixels that were actually classified into each land cover category by the classifier (rows).

Table 1: Error Matrix resulting from classifying training Set pixels

	W	S	F	U	C	H	Row Total
W	480	0	5	0	0	0	485
S	0	52	0	20	0	0	72
F	0	0	313	40	0	0	353
U	0	16	0	126	0	0	142
C	0	0	0	38	342	79	459
H	0	0	38	24	60	359	481
Column Total	480	68	356	248	402	438	1992

Classification data Training set data (Known cover types)

Producer's Accuracy	Users Accuracy
W= 480/480 = 100%	W=480/485 = 99%
S = 052/068 = 16%	S = 052/072 = 72%
F = 313/356 = 88%	F = 313/352 = 87%
U =126/241l = 51	U =126/147 = 99%
C = 342/402 = 85%	C = 342/459 = 74%
H = 359/438 = 82%	H = 359/481 = 75%

Overall accuracy:

= (480 + 52 + 313+ 126+ 342 +359)/1992= 84%

W, water; S, sand; F, forest; U, urban; C, corn; H, hay

An error matrix encapsulates a number of aspects of categorization performance. For instance, the numerous classification errors of omission (exclusion) and commission can be studied (inclusion). The training set pixels sorted into the relevant land cover categories are positioned along the principal diagonal of the error matrix, as shown in Table 1. (Running from upper left to lower right). All of the matrix's non-diagonal elements indicate errors of omission or commission. Non-diagonal column elements (e.g., 16 pixels that should have been classed as "sand") are referred to as omission errors. Non-diagonal row items show commission errors (for example, 38 urban pixels + 79 hay pixels were incorrectly put in the corn category).

The error matrix can be used to calculate a variety of different metrics, such as overall classification accuracy. The total number of correctly identified pixels (sum of elements along the principal diagonal) is divided by the total number of reference pixels to arrive at this figure. Individual category accuracies can also be computed by dividing the number of correctly identified pixels by the number of correctly classified pixels. by the total number of pixels in the respective rows or columns in each category. The number of successfully identified pixels in each category divided by the number of training sets used for that category gives the producer's accuracy, which reflects how well the training sets pixels of a specific cover type are classified (column total). The number of correctly classified pixels in each category is divided by the total number of pixels classified in that category to determine user accuracy (row total). This image displays commission error and shows the likelihood that a pixel classified into a specific category on the ground actually represents that category.

It's worth noting that the table's error matrix suggests an overall accuracy of 84 percent. However, producer accuracy varies from 51% (urban) to 100% (water), while consumer accuracy varies from 72 percent (sand) to 99 percent (water). The training data is used to create this error matrix. If the findings are satisfactory, it means that the training samples are spectrally separable and that the classification is effective in the training areas. This contributes in the refinement of the training set, but says little about the classifier's performance elsewhere in the scene.

XI. KAPPA CO-EFFICIENT

Kappa analysis is a discrete multivariate accuracy assessment technique. The Khat statistic, which is a measure of accuracy agreement, is produced via Kappa analysis. The Khat statistic is calculated as follows:

$$\text{Khat} = \frac{N\sum^{r} x_{ii}(\sum x_{i} + {*}x_{+i})}{N^{2} - \sum^{r} (x_{i+} + {*}x_{+i})^{r}}$$

Where r is the number of rows in the matrix, xi denotes the number of observations in row I and column xi+ and x+i denote the marginal totals for row I and column I and N denotes the total number of observations.

CONCLUSION

Image Rectification and Restoration, Enhancement, and Information Extraction are the three main types of digital image processing for satellite data. The pre-processing of satellite data for geometric and radiometric relationships is known as image rectification. Image data is enhanced in order to display data efficiently for future visual interpretation. Digital classification is used to extract information, which is then utilised to create a digital themed map.

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