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AUTOMATED CHANGE DETECTION USING MULTIDATE SATELLITE DATA FOR FORESTRY APPLICATIONS

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Abstract *Change detection through remote sensing is process for determining and evaluating differences in a variety of surface phenomena over time. Detecting, describing and understanding changes in the physical and biological process that regulate the earth system is of considerable interest for ecologists and resource managers today. Here we have used the intensity-Hue-Saturation Transformation to normalise the intensity of the two data sets, in order to bring the illumination levels identical and differenced to depict the changes.*

INTRODUCTION

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (dates). Essentially, it involves the ability to quantify multi temporal data sets. Change detection is useful in many applications like land use change analysis, assessment of deforestation and afforestation, study of changes in vegetation phenology, etc. The visual interpretation of satellite data for change detection using sequential imagery is a difficult task and involves a fair amount of subjectivity. The digital nature of most satellite data makes it easy for computer aided analysis, but calls for preprocessing of data sets. In order to make a digital change assessment using multi temporal satellite data, the important factors which need to be considered while selecting the optimal data sets are:

- The multi-date data should belong to the same season or period,
- Data set should be cloud-free, and
- Data selected should have been acquired from sensors which are nearly similar in ground resolution and sensor spectral characteristics.

The selection of optimal data would facilitate in greatly reducing the inherent variations during the preprocessing among the multidate images.

STUDY AREA

For undertaking the pilot study for change assessment of the multi temporal data a 512×512 window has been selected covering parts of Midnapur district of West Bengal. The study area is so chosen that it is generally represented by gentle slopes and virtually devoid of any relief (more or less plain area). The data handling in the plain areas will initially facilitate in evaluating the efficacy of methodology to account the spatial changes that have occurred due to vegetation changes. Also the plain areas data handling does not pose shadowing problems. For this purpose we have selected LANDSAT TM data, Path 139 Row 44 quadrant No.4 date of pass 23.11.85 (Fig. 1a) and IRS –1A LISS-II data, path 19 row 52, subscene A1, date of pass 30.11.91 (Fig.1b).

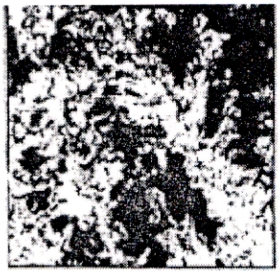


Fig. 1a L5TMP 139 R44 Q4
Date of pass 23.11.1985

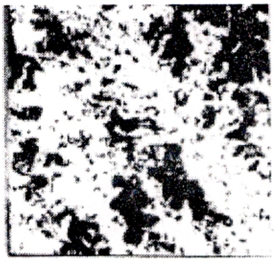


Fig. 1b IRS LISS II A1P 19 R 52
Date of pass 30.11.1991

OBJECTIVES

The objective of the study is to bring out land cover changes that have occurred from 1985 to 1991. The adoption of suitable methodology largely determines the precision of changes analysis. In order to obtain better accuracies, the multi-date satellite data was chosen, such that both the time frame data have similar solar elevation conditions as well as vegetative phenological conditions (maximum greenness).

Accordingly, Landsat TM data of 1985 and IRS-1AL-II A1 data of 1991 were selected for the month of November. Inspite of careful selection of data representing equal solar elevations, the data inherently possesses differential brightness, which could be due to varying illumination conditions prevailing at that time. The differential brightness normally results due to variations in Intensity, Hue and Saturation values of the features represented. However, the predominance of "Intensity" values largely determines brightness of the image in physical terms. Towards this an effort is made to simulate the intensity values of 1985 and 1991 by transformation of "RGB" to "IHS" and normalisation of "I" component equal for both the periods. The difference image generation between the periods and evaluating the procedure for its feasibility on automated Change Detection analysis using satellite data is attempted.

PREPROCESSING

Assuming, the spectral characteristics of both the sensors are nearly the same, but differ with respect to the spatial resolution and illumination conditions as they are acquired at two different dates, it becomes necessary to bring the illumination levels of the two data sets to nearly same level. This involves two steps:

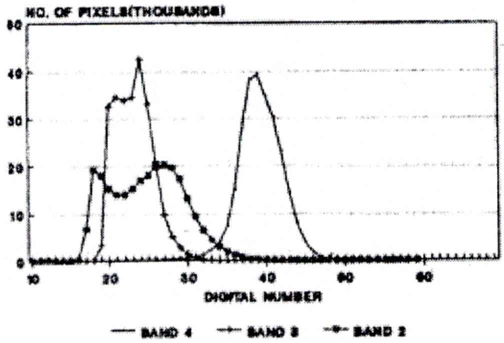
(a) Geometric registration of the two data sets is carried out by selecting control points properly distributed in the images for resampling and by using TM 1985 data as slave image. The image to image registration was achieved to subpixel accuracy using 2[nd] order polynomial transformation.

(b) In order to bring the illumination levels nearly identical, the data in "RGB" domain is transformed to "IHS" domain. The histogram of the intensity component of the first data is normalised to the intensity component of the second data set, and the normalised data in IHS domain is transferred back to RGB domain. Histogram normalisation is obtained by using the following algorithm:

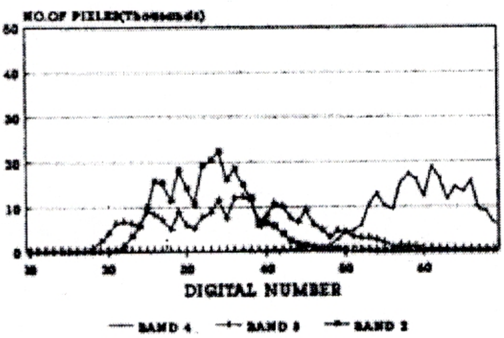
$$\text{O/P DN value} = S2/S1\,(\text{I/P DN value} - \text{Mean 1}) + \text{Mean 2} \tag{1}$$

where Mean 1, S1 and Mean 2, S2 are mean and standard deviation of the intensity component of the first and second data sets, respectively; and O/P is output pixel DN value. (Ingram et al., 1981)

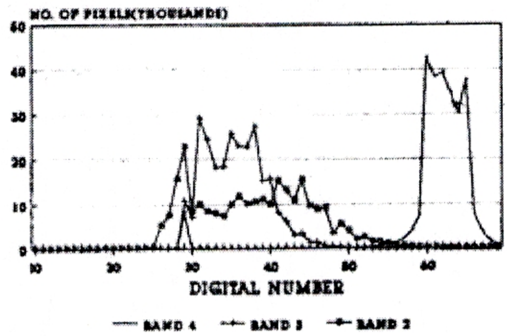
As per the procedure described above the histogram of TM, IRS and normalised IRS are generated and shown in the Fig. 2. It can be inferred from Fig.2 that histogram matching could be achieved for intensity band between TM and normalised IRS using the above algorithm.



(a) IRS histogram



(b) TM histogram



(c) Normalised IRS histogram

Fig. 2 Histogram of TM, IRS and normalised IRS

ANALYSIS

Since the intensity contributes to the brightness of the image, the difference in brightness features, specifically contribute the changes in the vegetal cover (Carper et al., 1990). In the process the information contained with respect to hue and saturation is preserved which is required for change detection.

In the present exercise, after subjecting the TM and IRS images to statistical normalisation using the intensity component, the output products were evaluated by computing the statistics of normalised IRS and L5 TM data. The statistics of normalised IRS and L5 TM data are shown in Table 1. The results clearly indicate that the mean and the standard deviation of normalised IRS intensity is almost identical to the TM intensity band.

Table 1 Statistics of normalised IRS and L5 TM data

1985		1991			
TM Standard		IRS Standard		Normalised IRS	
Mean	SD	Mean	SD	Mean	SD
60.03	6.75	37.75	8.095	59.986	7.057

IMAGE DIFFERENCING

There are several image differencing techniques used extensively for various application purposes (Singh, 1989). Predominant among them are classification of two time data and substraction of the images. Image differencing is accomplished by subtracting a pixel's DN value of one date from the corresponding pixel's DN value on another date. In order to obtain spatial differences between the dates, the following algorithm is used:

$$DX_{i,j} = \frac{X_{i,j}(t2) - X_{i,j}(t1)}{2} + 127 \qquad (2)$$

where X is pixel value band K; i is line; j is column; t1 is first date; t2 is second date; and DX is difference between the images.

The output image obtained after differencing from above is shown in Fig. 4.

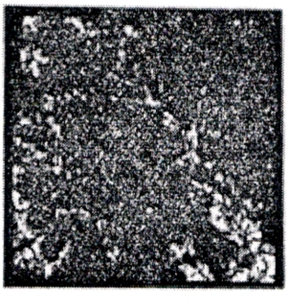


Fig. 3 Normalised IRS image

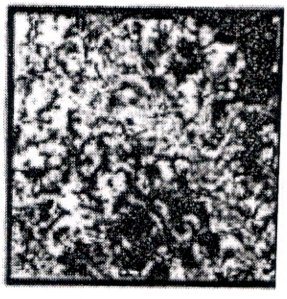


Fig. 4 Differenced image

CONCLUSIONS

When the L5 TM data of November, 1985 and IRS data of November, 1991 are compared in the raw FCC mode, the first distinguishable difference one would feel is the intensity variation. However, the physical observations of the raw images clearly show the increased spatial extent of plantations through afforestation (Figs. 1a and 1b). The intensity normalised 1991 (Fig. 3) data is brighter specifically in the vegetation part. This has resulted as the maximum proportion of the study area consists of vegetation and hence 'intensity' normalisation effected distinctly the vegetated area (mean changed from 37.75 to 59.986 and standard deviation from 8.095 to 7.057). The 'RGB' diffence image (Fig. 4) obviously as expected has low brightness since Intensity is attributed to 'RED' component of the image. This clearly indicates maximum change areas could only be seen in Greeen/Blue components. Thus, the change areas are seen in Bluish Cyan colour and least in Orange colour. The unchanged area are seen in Pink whereas the persistence of dull red colour is due to noise and change in the vigour of the forest growth. This is conspicuously seen in the plantation areas. Thus, the study clearly revealed the intensity normalisation based change detection procedure is efficient to account the afforestation/deforestation programmes. The methodology suggested here is recommended for monitoring of plantation programme in India.

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