EVALUATION OF HYBRID DATA GENERATED USING IRS - 1C PAN AND LISS III FOR URBAN LANDUSE MAPPING AND LANDUSE / LANDCOVER ANALYSIS

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ABSTRACT

The present study evaluates five methods namely; Principal Component analysis, Determinant analysis, Filtering technique, IHS transformation and Radiometric method for optimally combining the high resolution IRS -1C PAN data and multispectral IRS LISS III data. The study area is part of Jodhpur city and surroundings covering 5 km x 5 km area. IRS-1C PAN and LISS III of 1996 were used for the analysis. The hybrid data thus generated was visually and statistically analysed. The outputs were evaluated for urban landuse mapping and landuse/ landcover analysis. IHS method and radiometric method provide the best results from all type of analysis.

INTRODUCTION

The availability of data from multisensors onboard a common platform has led the investigators to investigate various methods for merging of multisensor data. The merged output optimally combines the best from different sets of input data. A high resolution data is usually acquired in one band with large band width. Multispectral data has more bands with less resolution and narrower band width. In the present scenario IRS - 1C data with its better spatial resolution provides the basic input for various applications. Urban landuse mapping particularly requires high resolution data. IRS -1C PAN with its 5.8 m resolution is of particular reference. Urban sprawl, urban landuse and zoning applications are of particular significance in view of the large increase in the urban population and subsequent growth in urban areas. IRS-1C LISS III data with 23 m resolution is widely used in resource applications.

An hybrid output of these two can be used in variety of applications. Combination is also useful in multispectral classification where the linear details of PAN can increase the positional visibility of classified output.

The process of merging should not deteriorate the original spectral and spatial characteristics of the input data. The present study deals with the comparison of the five methods of merging IRS -1C PAN and LISS III data.

STUDY AREA

The study area is part of Jodhpur city and surroundings with extent of 5 km x 5 km. Two test sites are selected for the analysis. The first site is dominated by urban landuse and contains residential units, fallow land, industrial area, plantations, park, playground, etc. The second test site has various landuse / landcover categories viz. agricultural land, fallow land, waste land etc.

DATA SET

IRS 1C PAN (spatial resolution 5.8 m) and IRS -1C LISS III (spatial resolution 23 m) data pertaining to path 92 and row 53 for part of Jodhpur city were used. Date of pass for PAN was 26.02.96 and for LISS III was 28.01.96.

METHODOLOGY

Registration and Resampling

IRS 1C PAN data was georeferenced with respect to SOI toposheets. LISS III data was registered with PAN by selecting ground control points which are clearly visible on both the data sets. The well distributed points were submitted for least square regression analysis using second order transformation model to relate both the data sets. The residual error of the model was brought below one by selecting good control points. LISS III data was resampled to 5.8 m by using nearest neighborhood technique. One composite output was generated with PAN an band 1, LISS IIII band 2 as band 2, LISS III band 3 as band 3 and LISS III band 4 as band 4.

Merging

Merging of multi sensor data requires either direct use of PAN band as one band in band triplet for making FCC or transformation of multispectral data in to new coordinate system where intensity is one axis. The determinant analysis and filtering techniques come under first way of merging where as PC technique, radiometric method and HSI techniques fall under second way of merging. In second method, the intensity channel is replaced by PAN channel. After inverse transformation the merging process is completed.

Intensity I is a function of pixel values of multispectral bands.

$I_i = f_1 \{N_1, N_2, \ldots N_n\}$ $i = 1,2,\ldots n$ (1)

Where N_i ($i = 1,2,\ldots n$) is the pixel value in different bands.
The intensity channel calculated for PAN channel will have same value as pixel.

$N_p = I_p$ (2)

Replacing I1 by Np we get,

$N_iN = F_i^{-1} (I_p, I_2, \ldots I_n)$ (3)

where N_iN is the pixel value of the merged image.

Determinant analysis : In this method the band triplet which accounts for greatest possible variance found from the original variance - covariance matrix by selecting three bands with the largest diagonal elements was found out.

The four band data (PAN, VIS - G, VIS - R, and NIR) was submitted for variance - covariance analysis and correlation matrix calculation. Table 1 shows the statistics for test site 1 and 2.

Table 1 : Scene Statistics

Band	Mean	Standard Deviation
	SITE 1	
PAN	151.42	16.84
B2	102.20	11.38
B3	77.62	12.61
B4	70.78	9.32
	SITE 2	
PAN	165.77	16.47
B2	107.75	12.85
B3	87.37	16.99
B4	86.19	8.65

The band triplet that provides the ellipsoid of maximum volume was computed by ranking in order the determinants of each 3x3 principal subset of original data set. The best combination obtained from determinant analysis was L3 B4, PAN, and L3 B2.

Filtering technique : A specially designed high pass kernel of size 3 x 3 was applied to PAN data. The kernel used was given below

-.25	-.25	-.25
-.25	+2.0	-.25
-.25	-.25	-.25

From the filtered PAN band another channel was created which contains 70% of the filtered image and 30% of the raw image. This combination has reduced the noise creating frequency components in filtered PAN image. The high frequency components which has spatial information were added to all the bands of IRS LISS III.

Principal Component analysis : In this method, IRS LISS III data was submitted to principal component analysis. From PC analysis it was found that for site 1 PC1 contains 87.54%, PC2 contains 15.96% and PC3 contains 2.51% information and for site 2 percent information content is 85.03%, 13.78%, 1.18% respectively. PC1 which is nothing but the intensity channel with information from all the LISS III bands was replaced by PAN band. The mean and standard deviation of PC1 was calculated and the PAN band was stretched to have same standard deviation (17.5) and mean (127). PC1 was replaced by this stretched PAN band. Using Martyn Tailor enhancement the channels were converted back to RGB space.

IHS transformation : Three input channels of lower spatial resolution data i.e. IRS LISS III were transformed in IHS space. The Intensity channel is calculated by

$$I_i = (N_1 + N_2 + N_3) / 3 \quad (4)$$

THE PAN data was stretched to have mean and standard deviation of Intensity channel. The image was brought back to original space .

Radiometric technique : This technique takes into account the spectral bandwidth over which the data is acquired. If we see the band width of IRS-1C PAN and LISS III then a lot of overlap is seen.

Table 2 : Spectral bandwidths of IRS

Sensor	Bands No	Band width
LISS III	B2	0.52-0.59
	B3	0.62-0.68
	B4	0.77-0.86
PAN		0.50-0.75

From the table it is clear that the PAN data is collected over large band width hence its value can be obtained by linear combination of multispectral image. Again from the table the observation can be made regarding the overlap bandwidths. B4 does not have any band overlap with PAN. Hence to maintain the radiometry of the data, linear combination of B2 and B3 only was replaced by PAN.

ANALYSIS

Visual

Visually the outputs were compared with each other for identification of level III urban landuse categories. Plate 1 shows the merged outputs. The merged output generated by IHS method and radiometric analysis rovide the best clarity. All the level III urban landuse details are clearly depicted on the output. These two products maintain the standard FCC mode in the merged output along with outputs generated by filtering and determinant methods. The output generated by PC method is also clear but the colour scheme is changed. Vegetation appears in green and different categories of settlement appear in shades of magenta. Linear deatils are more prominant in IHS and radiometric method. Filtering method tends to break the linear features, in addition to introduction of salt and paper appearance.

Statistical

The IRS LISS III bands and PAN band were individually studied to see the dynamic range.

Study of individual bands : Table 3 shows the variance - covariance between individual raw bands.

Table 3A : Statistical characteristics of site 1

Band	PAN	L3 B2	L3 B3	L3 B4
PAN	283.69			
L3 B2	153.16	129.51		
L3 B3	168.99	133.76	159.02	
L3 B4	73.51	48.75	60.28	87.02

Table 3B : Statistical characteristics of site 2

Band	PAN	L3 B2	L3 B3	L3 B4
PAN	271.44			
L3 B2	180.69	165.26		
L3 B3	235.71	210.63	288.96	
L3 B4	-5.89	-13.45	-33.55	74.83

From the table it is clear that PAN band has maximum variance for both the test sites. L3 B4 (Infra red) has the least covariance with PAN data. PAN data has maximum correlation with L3 B3 (Visible red) followed by L3 B2 (Visible green). VIS - G and VIS - R are also correlated with more covariance for both the sites. If we plot the spectral response for various urban categories then we find that the spectral response of dominant categories (residential, Industrial, Open ground etc) is more or less same in VIS - G and VIS - R and hence the correlation.

Study of merged bands : DN values for major six cover types in the study area for test site 1 were plotted for raw LISS III bands and for the bands generated by other four methods (Fig. 1). Output generated by determinant method was not compared visually as it retains raw bands. DN values were found out for points as well as sample areas and average was plotted. The categories chosen are open land, grass, residential, industries, water bodies and hillocks. The graphs clearly indicate that all the methods introduce some shift in gray values. The spectral response curve behaves in the manner identical to raw bands for IHS and filtering techniques. Radiometric method has introduced positive shift in the gray values of two bands.

Post processing algorithms

Post processing techniques like classification, ratioing etc. were done on the merged outputs of different methods for site 2 which contains agricultural categories. The study area was divided in four categories viz. crop land, fallow land, scrub land and settlement. Training site acquisition was done over raw LISS III band and the same training sites were used for all the merged outputs.The table 4 shows the landuse / landcover statistics for the raw LISS III band and the merged outputs. Plate 2 shows the classified outputs generated for all merging methods. White color indicates category 1, dull white indicates category 2, gray color shows category 3 and black is for category 4 and unclassified areas.

The analysis of classified output reveals that, all the merged outputs can be subjected to classification and other post processing algorithms. Classified output generated using IHS and Radiometric method showed maximum correlation with each other.

DISCUSSION

In the study PAN band replaced the intensity channel generated by various methods. All the methods distorted the spectral characteristics but the spectral trend remained same in IHS and filtering methods. Radiometric method gave good visible output along with IHS method. Although the post processing algorithms can be applied on all the outputs, the outputs generated by radiometric and IHS technique were better. All the level III details are cleary seen on the outputs. Hence IHS method and radiometric method provide the best result for merging of IRS-1C LISS III and PAN data.

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Table 4 : Classification statistics of merged outputs

Method / Category	Raw	RAD	PC	FILT	IHS	DET
Category 1	17.41%	18.22%	20.32%	17.39%	18.26%	18.84%
Category 2	35.71%	43.94%	41.92%	38.34%	39.45%	41.06%
Category 3	20.70%	19.65%	19.71%	17.91%	16.59%	20.55%
Category 4	16.54%	14.95%	15.93%	22.27%	22.47%	13.21%
Un classified	9.64%	3.24%	2.13%	4.09%	3.23%	6.34%

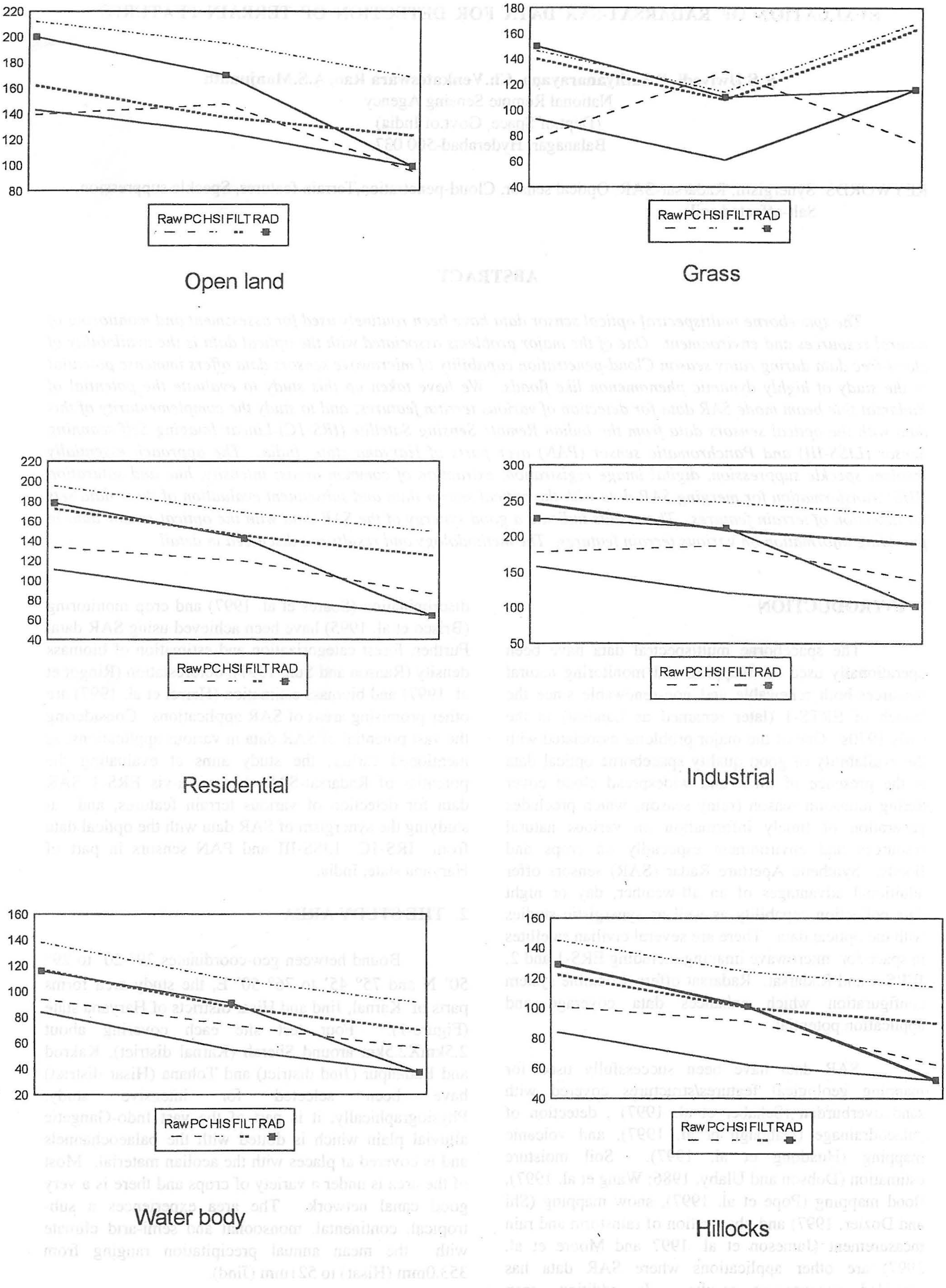

Fig. 1 Spectral Response Curves