Multisensor Image Fusion for Enhanced Coastal Wetland Mapping

P. Shanmugam, Yu-Hwan Ahn, *S. Sanjeevi and Hong-Ryong Yoo
Korea Ocean Research and Development Institute, Seoul, 425-600, Korea
*Anna University, Chennai- 600 025, India
pshanmugam@kordi.re.kr

Abstract: The main objective of this paper is to investigate the potential utility of multisensor remotely sensed data for improved coastal wetland mapping. Five data fusion models , three algebraic models (Multiplicative (MT), Brovey (BT) and Wavelet transform (WT)) and two spectral domain models (Principals component transform (PCT) and Intensity-Hue-Saturation (IHS)) were implemented and tested over the multisensor data. The fused images were then compared based on visual and statistical approaches. The results show that the wavelet transform provides greater flexibility for combining optical data sets and has good potential for preserving the spatial and spectral content of the original images. However, this model yields poor information when combining optical and microwave data. Brovey transform is more reliable for fusing optical and microwave image data and yields improved information about different wetland features of the coastal zone.

Keywords: Remote Sensing, wetland, Fusion, Speckle

1. Introduction

The growing pressure on the coastal areas as a result of expanding population and increasing commercial, industrial, and other developmental activities has clearly indicated an urgent need to manage these areas in an optimal and judicious manner. In the recent years, the optical remote sensing systems have proven useful in providing information about the coastal wetlands at local and regional scales. However, one of the major limitations in the abilities of such sensors is that that it is very difficult to obtain cloud free imagery, especially in coastal regions that are frequently covered by clouds. In contrast, microwaves are capable of penetrating clouds and are actively sent by the antenna. It is independent of weather or day light (Genderen and Pohl, 1994). The combination of microwave and VIR data provides valuable tools for mapping such complex coastal wetland features with greater accuracy (Ramsey *et al*., 1998). On the other hand, thermal remote sensor provides information about emissivity of different surface features. Thus the combined use of such data sets visualizes the valuable additional information about different wetland features and shows the potential to overcome the cloud cover problems. Image fusion is one of the possibilities of combining disparate images to produce a new data set containing the characteristics of different input images (Genderen and Pohl, 1994). In the present study, the potential use of multisensor data is investigated using five fusion models for enhanced coastal wetland mapping of Tamil Nadu, southern India.

2. Study Area and Data Products

Three study sites including Pitchavaram, Vedaranniyam and Rameswaram are selected for this study. They are typical of mangrove ecosystem, mudflats and sand dunes respectively. All these study sites are situated on the southeastern coastal part of Peninsular India that include various wetland features such as mangroves, marsh, scrub, mudflat, aquaculture farms, salt pan, lagoon, coral reef, sand dunes, beach, and other associated land cover features such as agricultural vegetation, plantation and fallow lands etc. The use of single sensor data makes very difficult to discriminate these features. Thus, multisensor data such as IRS-1C/1D LISS-III, Panchromatic, Landsat-TM (including thermal) and ERS-2 SAR were assimilated and used in fusion models.

3. Fusion Models

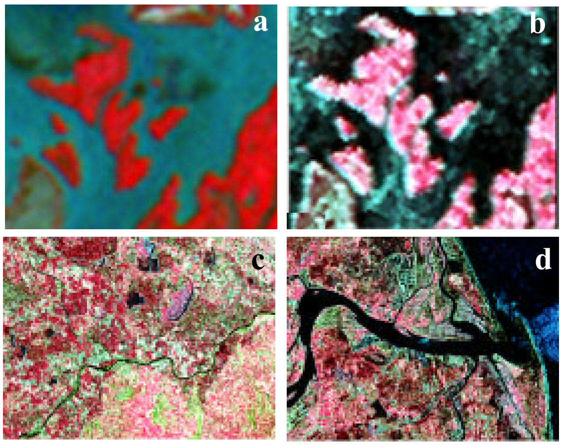
Fusion of data from different sensors has been published in several applications (Genderen and Pohl, 1994). The motivation behind data fusion is to generate an interpretation of the scene not obtainable with data from single sensor. In the present study, five fusion models implemented are Multiplicative Transform, Principal Component Transform, Intensity-Hue-Saturation, Brovey Transform and Wavelet Transform. The image data set was subject to each of the five data fusion models. More details concerning fusion techniques can be found in the thesis of Shanmugam (2002). The results of these techniques were compared based on visual and statistical approaches.

4. Radiometric and Geometric Correction

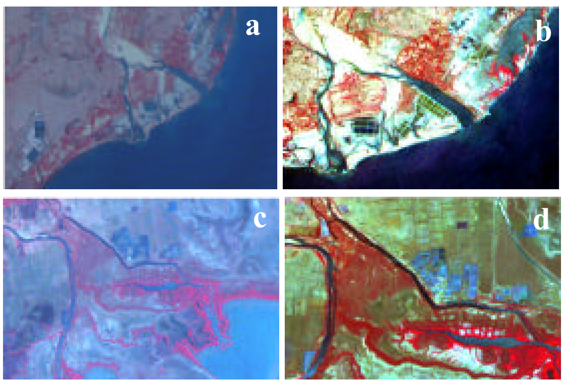
Radiometric and geometric corrections play an important role in satellite image analysis because of having various radiometric and geometric distortions arising during the image acquisition. It is understood that the LISS-III, PAN and TM are radiometrically corrected at ground station. Hence, no further radiometric correction was made for these data. In the case of SAR PRI data, a vertical antenna pattern of ERS-2 SAR causes distortions in radar pixel intensities in range directions. This correction was done in the data archival facilities at NRSA, India. Subsequently, 16 bit SAR data was converted to 8 bit data to be able to compare with 8 bit optical data. The speckle filtering algorithms were then implemented to remove the speckle noise present in the radar data. After necessary radiometric corrections carried out, the images were geometrically rectified and fused using fusion models.

5. Results and Discussion

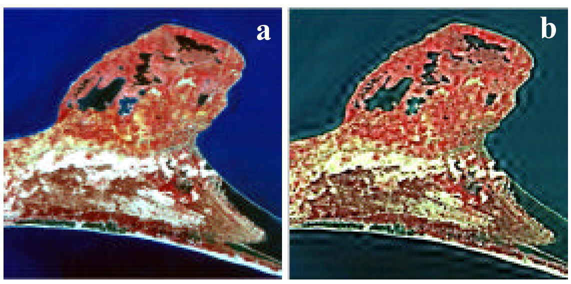
The visual comparison shows that a significant improvement in discriminating mangrove communities, marsh, mudflat, aquaculture farms, sandy areas and other associated cover features was achieved in the fused images (LISS-III and ERS-2 SAR) of the Pitchavaram study site (Figs. 1a-d). It is observed that largely *Rhizophora apiculata* species located on the margin of lagoon waters are of relatively low density, with extensive above root systems contributing to a large proportion of the biomass. In contrast, *Avicennia marina* just away from the water-land boundary has lower overall biomass than *Rhizophora apiculata* but the tree density is much greater than *Rhizophora apiculata*. The change in tonal variation as seen in Fig. 1b is mainly due to differing in radar backscatter (high backscatter from *Rhizophora apiculata* - dark red tone and low backscatter from *Avicennia marina* - light red). As the C- band of ERS-2 SAR is highly sensitivity to crown characteristics (number, density, size and orientation of leaves) and structure (architecture and heterogeneity), it results in high backscatter at co-polarization to increasing biomass of *Rhizophora apiculata* rather than *Avicennia marina.* In Vedaranniyam study site, it is worth noting that degradation of mangrove communities as a result of advancement of aquaculture farms was identified in the lagoonal areas near Muthupet. The optical fusion results in distinguishing different conditions of mudflats, marsh, saltpan, mangrove and plantation in Vedranniyam study site (Figs. 2a-d). In contrast, fusion of TM-VIR and TM-thermal data provides enhanced information about different vegetation communities (casuarine plantation, scrub and agricultural vegetation), soil moisture and coral reefs in the fused images of Rameswaram study site (Figs. 3a & b). These features are difficult to derive from the original VIR image data.



Figs. 1a-d. IRS-1D LISS-III (a) and fused images (b-c) of Pitchavaram study site



Figs. 2a-d. IRS-1C LISS-III (a & c) and fused images (b & d) ofVedaranniyam study site



Figs. 3a and b. Landsat-TM (a) and fused image (b) of Rameswaram study site

6. Conclusion

Multisensor image fusion provided enhanced information about different wetland features of Tamil Nadu coast. From this study, the wavelet transform is found to be appropriate for fusing LISS-III and PAN, and TM-VIR and TM-TIR image data while Brovey transform yields good information about different mangrove communities and other associated wetland features from optical and microwave image data. It was observed that the spatial and spectral details of several wetland features were found to be highly degraded when adopting other fusion models. We conclude with the potential use of fusion models and the complementary data sets for accurate mapping of complex coastal wetland ecosystem. The future work will focus on the use of different SAR systems (with multi-band and multi-polarizations) for improved coastal zone mapping.

References

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