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FUSION OF NIGHTTIME AVHRR DATA AND DAYTIME TM DATA FOR STUDYING COASTAL ENVIRONMNETS

Chada Narongrit * and Mitsuharu Tokunaga **

***Faculty of Agriculture, Natural Resource and Environment, Naresuan University, Phitsanulok, 65000, Thailand, E-mail: chada@nu.ac.th**
****Space Technology Applications and Research Program, School of Advanced Technologies, Asian Institute of Technology, Pathumthani 12120, Thailand, E-mail: tokunaga@ait.ac.th**

ABSTRACT- The co-registered 30 meters spatial resolution data of AVHRR imageries and TM imageries acquired over the western shoreline of the southern Thailand were fused for extracting coastal environments, particularly aquatic farming. The transformation methods, principal component (PC) and intensity-hue-saturation (IHS) methods were used to meet the objectives. The principal components (PC) images fused from day-nighttime AVHRR thermal infrared data and daytime TM thermal infrared data showed the highest eigenvalue compared with the components of daytime TM thermal infrared data only. Using the day-night infrared fused PC images as a spectral mapping band, the aquatic ponds along the coast can be well extracted. This proposed method of using nighttime AVHRR and daytime TM data fusion is useful to monitor the coastal aquatic investment in the coastal mangrove environments.

KEYWORDS- Data Fusion, Nighttime AVHRR Data, Daytime TM Data, Coastal Environments

INTRODUCTION

Since the remote sensing techniques have developed for monitoring the earth's surface and atmosphere, the multi-spectral, multi-spatial and multi-temporal data have used. To properly used these data, many data-fusion methods were proposed. In case of the classification of remotely sensed data, the data-fusion methods provide an improvement of the accuracy and a large number of classes.

There are many algorithms for enhancement of lower resolution imagery by combination of high-and low-resolution data. One commonly used procedure is the intensity-hue-saturation (IHS) transformation, in which three band spectral data (red, green and blue) at the lower spatial resolution are converted to intensity, hue, and saturation, after which intensity values are replaced by the higher resolution data values. Then the result is transformed back to the nominal red-green-blue. Such methods are useful in deriving an enhanced or "sharpened" image. However, method requires that the radiometric values of the high-resolution result agree with the lower resolution values of the original data so that the enhancement is apparent only at the highest spatial resolution. (Price, 1999, Niblack, 1986).

Our previous results showed that the use of nighttimes-derived AVHRR data as an additional band for land cover type classification is effective to improve an overall classification accuracy and to distinguish some land cover types based on landscapes in Thailand country. In this paper, we further developed a method relying on image based statistical relationships between the radiances in the low and high spatial resolution bands to fuse high spatial resolution data with additional day-nighttime spectral thermal data of low-resolution AVHRR data. The objectives of fusing different remotely sensed data were to effective visual display and to extract detailed features based on coastal topography.

TEST SITE

The study area locates in the western shoreline of Ranong province, Thailand. The analog topographic map (scale 1: 50,000) revised in 1979 and digital coverages scaled 1: 50,000 were used as references.

DATA AND METHODS

Co-registration

Two data set used in this study were the multi-spectral low-resolution images acquired in March 1997 by NOAA AVHRR sensor and the multi-spectral high-resolution images acquired in March 1995 by Landsat TM sensor. These two dataset were co-registered to the 30-meter spatial resolutions.

Principal Component

These registered low-and high- resolution images were transformed to the principal component (PC) images to fuse high spatial resolution data with additional lower spatial resolution data. The PC images were computed by correlation matrix because the data ranges differ greatly between bands. In this study, the generated PC images were categorized as two data sources: (1) from seven TM bands (hereafter called "TMPC") and (2) from ten bands of four TM thermal bands 4, 5, 6 and 7 and of six day-nighttime AVHRR thermal bands 3, 4, and 5 (hereafter called "THPC").

IHS Transformation

The spectral based merging using the intensity-hue-saturation (IHS) method was used to sharpen the low-resolution image. Because the nighttime thermal data have dominantly information of inundation-subjected lands, thus this experiment attempts to extract aquatic farms in coastal land. To improve the illustration of the image contrast enhancement, the THPC1i contained nighttime information was contrast stretched 0-255 with the intensity (I) image to aid in finding water boundaries and inundation-subjected lands.

LS-Fit Mapping

Using TM NDVI as a modeled band and TMPC1, 2, 3, and 4 (total 97% of eigenvalue) as predictor bands, the LS-Fit method was performed to compute two bands, the modeled band (TMmod) and the residual band (TMres).

RESULTS

As a single band shown in Figure 1, the fused THPC1 can be well discriminated water boundaries of canals, shrimp ponds and sea as well as mangrove forest and mountainous forest than a single TM thermal bands 4, 5, and 7, as well as TMPC1. The original thermal bands of TM and AVHRR acquired at daytime displayed water bodies as dark tone while the AVHRR acquired at nighttime displayed bright tone. The THPC1 image showed water areas in bright as same as nighttime AVHRR image but differencing from the original thermal TM and TMPC1 images. Considered on statistic analysis (Table 1), nighttime AVHRR LST showed greater negative correlation with daytime TM thermal bands of 4, 5, and 7 than with daytime AVHRR LST. Among the thermal bands of TM, nighttime AVHRR LST had stronger correlation with TM bands 4 and 5 than with band 7. According to statistic analysis shown in Table 1, THPC1 with 53 % of eigenvalues had negative correlation with TM band 4 (R 0.96), band 5 (R .95), and band 7 (0.82) as well as positive correlation with nighttime AVHRR bands 3 (R 0.67) and nighttime AVHRR bands 4 (R 0.68). With the positive correlation with nighttime AVHRR bands, THPC1 thus was bright in water areas as the nighttime ordinary images were. THPC1 was selected to illustrate the image contrast enhancement with intensity image to display the detailed information. By examination of enhanced THPC1 image, it is possible to find water areas where were not be well illustrated in TMPC1 as shown in Figure 1.

As RGB displaying in Figure 2, the transformed TMPC image did not illustrate well for build up, village farms, river, road, swamp mangrove and hilly forest (Figure 2a). The original TM NDVI band in red channel, the modeled TM NDVI band in green channel and residual TM NDVI band in blue channel can be enhanced details of those areas (Figure 2b). However, the instead of THPC1 image in blue channel can better distinguish swamp, river and road (Figure2c). This good visualization showed water areas in blue, mangrove swamps in purple, hilly mountains in yellow, village farms in green and roads network in browny purple. Comparison between the images deriving in this procedure and the original images, the inundation subjected lands such as shrimp farm, abandoned mine, mangrove swamp can be well mapped. The spectral mapping of the THPC1i image (Figure 3c) showed village farms in white, hilly forest in purple-cyan, and sea, river and pond in red. For mangrove, it can be divided into three zones in orange, yellow and green regarding to the distances of shore and river lines. The mangrove zone 1 was closed to the foreshore whereas the zone 3 was closed to the inner land. Moreover, this illustration was good to discriminate hilly non-mangrove forest from swamp mangrove forest in coastal land. The best depiction of THPC1i was stream network in the study area. The 24-bit color image of THPC1i was classified using the ISO-Data Unsupervised Method. The resulted image (Figure 4) showed corresponding to the checking topographic map scaled 1: 50,000.

CONCLUSIONS

The fused day-nighttime AVHRR-TM data and LS-Fit method showed good visual agreement for feature extraction of coastal covers with more illustrated obviously the submerged lands such as shrimp ponds, mining ponds, and swamp. The single spectral band (THPC1i) deriving from intensity enhancement of the fused day-nighttime AVHRR thermal data and daytime TM thermal data showed the best visual contrast enhancement of such lands. This finding is an efficient means to remote sensing applications on coastal zone management. This result was the preliminary study for fusing daytime and nighttime data to achieve more details of land features and their covers. Next, the experiment will be used the multi-temporal hyper-spectral MODIS data to monitor shrimp farming along the coastal Thailand.

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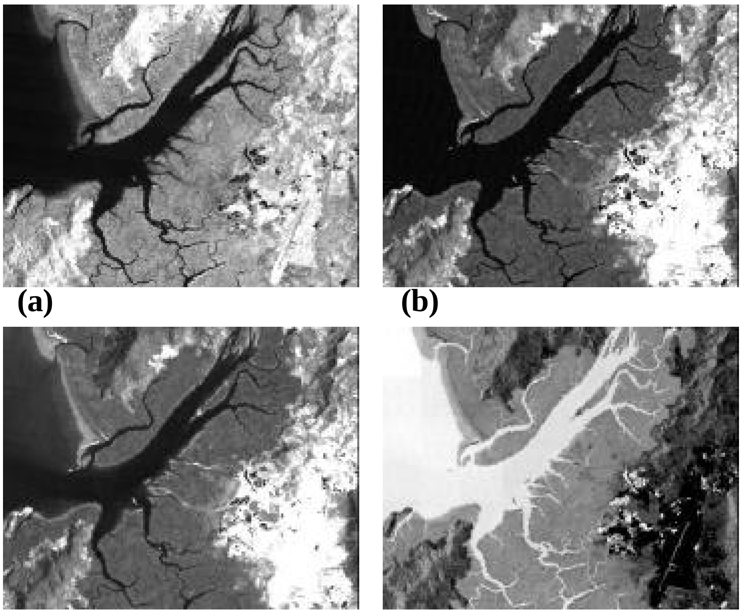
Table 1 Eigenvalues and Correlations of Transformed PC Bands

Sensors	PC	%Eigenvalue	Negative Correlation	Positive Correlation
TM	PC1	51	None	TM7 (0.97) TM5 (0.94), TM3 (0.78)
	PC2	38	TM4 (0.97), TM5 (0.93), TM7 (0.78)	None
TH (TM, AVHRR)	PC1	53	TM4 (0.96), TM5 (0.95), TM7 (0.82)	AVHRR3d (0.75), AVHRR3n (0.67), AVHRR4n (0.68)
	PC2	28	TM4 (0.78), TM5 (0.97), TM7 (0.78)	None



(d) (e)

Figure 1.
Thermal Infrared
Imageries of TM4 (a),
TM5 (b), TM7 (c),
TM PC1 (d) and
TH PC1 (e)

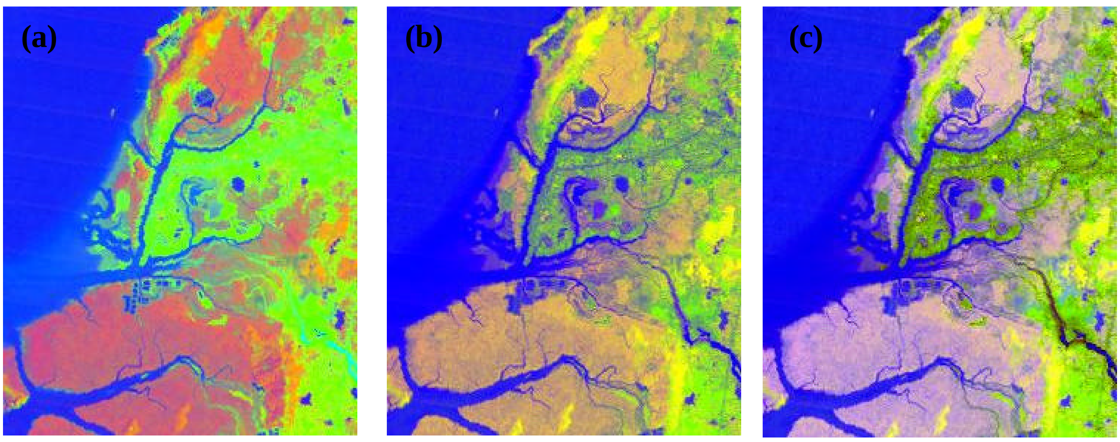


Figure 2 RGB Displayed Images: (a) TM NDVI, TM PC1, TM PC2,
(b) TM NDVI, TMmod, Tmres, (c) TM NDVI, TMmod, TH PC1i,

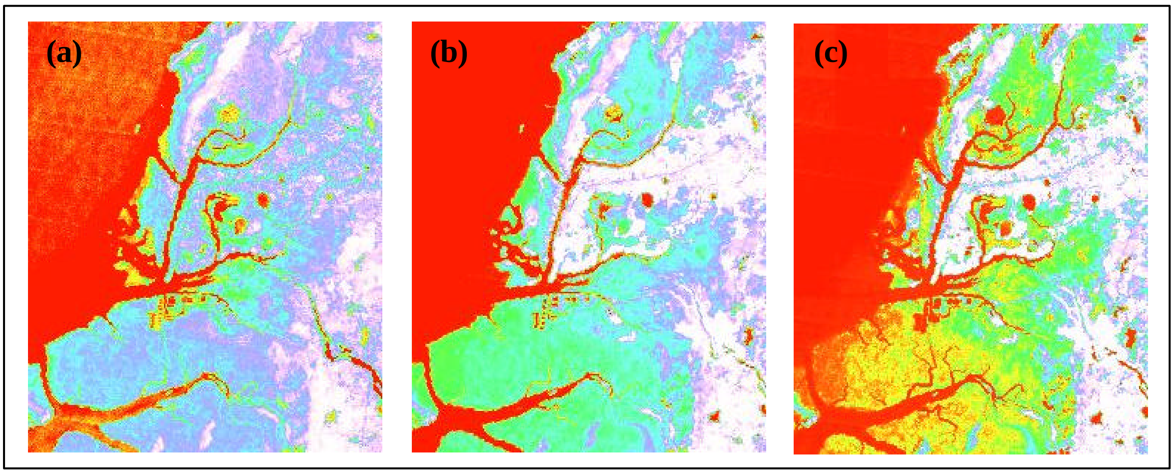


Figure 3 Spectral Mapping of (a) TMmod Band, (b) THmod Band, and (c) TH PC1i Band

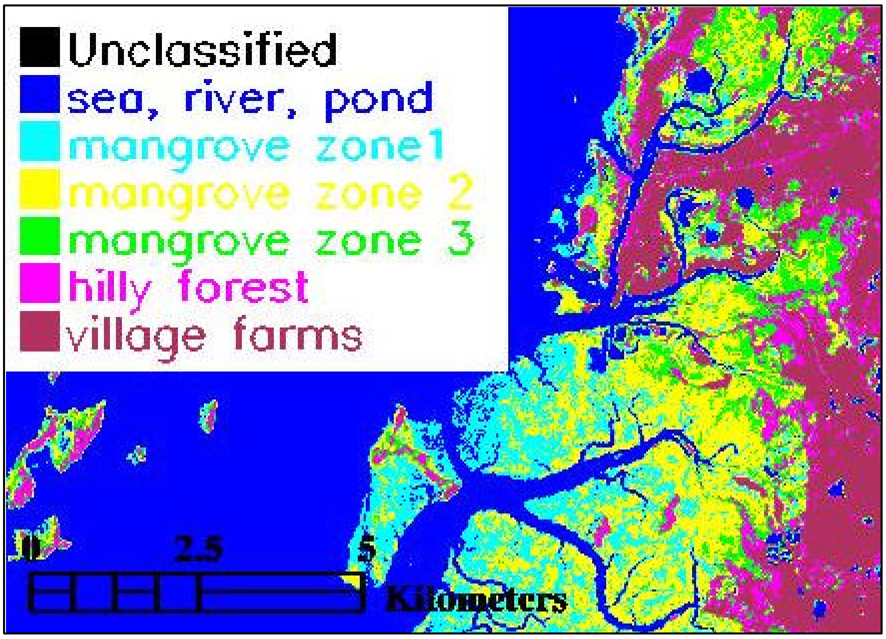


Figure 4 A Classified Image of HPC1i Using ISO-data Unsupervised Method