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Land cover mapping using high spatial resolution SPOT data over Penang Island, Malaysia

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ABSTRACT

Satellite digital imagery has proved to be an effective tool for land cover changes studies. The objective of this study is to demonstrate the effectiveness of SPOT imageries in changes detection over Penang Island, Malaysia. An understanding of land use/land cover at local with high resolution is important to prepare the latest data and can be used in many purposes. The neural network classifier was performed to the satellite images and the results were compared with four standard supervised classification techniques, such as the maximum likelihood, minimum distance-to-mean and parallelepiped. The land cover information was extracted from the satellite spectral bands using PCI Geomatica 10.1.3 image processing software package. Training sites were selected within each scene and four land cover classes were assigned to each classifier. The relative performance of the techniques was evaluated. The accuracy of each classification map was assessed using the reference data set consisted of a large number of samples collected per category. In this study, Kappa statistic and overall accuracy were calculated and compared for the supervised and unsupervised classification techniques. High overall accuracy (>90%) and Kappa coefficient (>0.90) was achieved by the neural network classifier in this study. This study indicates that land cover changes can be detected using remote sensing classification method of the satellite digital imagery.

Keywords: SPOT, Land cover, supervised classification.

1. INTRODUCTION

The availability of remote sensing data applicable for global, regional and local environment monitoring has greatly increased over recent years (Ehlers, et al., 2003). Availability of accurate and up-to-date land cover information is central to many resource management, planning and monitoring programs (Kasetkasem, et. Al., 2005). Remote sensing techniques appear as very useful tools in assessing such land cover information. Land cover mapping at coarse spatial resolution provides key environmental information needed for scientific analyses, resource management and policy development at regional, continental and global levels (Latifovic, et al., 2004).

The increasing availability of remote-sensing images, acquired periodically by satellite sensors on the same geographical area, makes it extremely interesting to develop the monitoring systems capable of automatically producing and regularly updating land-cover maps of the considered site (Bruzzone, et al., 2002). Many researchers used remotely sensed images in their land cover and land use studies [Tapiador and Casanova, (2003), Langley, et al., (2001), Shrestha and Zinck, (2001) and Friedl, et al., (2002)].

Satellite remote sensing methods, which can in principle be used to monitor very large areas in a reasonably short period of time, have notable potential for monitoring this high-latitude vegetation, although the techniques are in general less well established than at lower latitudes (Rees, et al., 2003). Information on land cover status at the regional scale is needed for natural resource management, carbon cycle studies, and modeling of biogeochemistry, hydrology, and climate. Satellite-based remote sensing products can meet these data needs in a timely and consistent manner (Boles, et. al., 2004).

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The main objective of this study is to evaluate the accuracy of each classification technique to classify the high spatial resolution digital satellite images. Three supervised classification methods were used in this study Maximum Likelihood, Minimum Distance-to-Mean, Parallelepiped and Parallelepiped with Maximum Likelihood Classifier Tiebreaker). Supervised classification of multispectral remote sensing imagery is commonly used for land cover determination (Duda and Canty. 2002). Parallelepiped with Maximum Likelihood Classifier Tiebreaker classifier was found to produce the best accuracy in this study.

2. STUDY AREA

The study area is the Penang Island, Malaysia within latitudes 5° 12' N to 5° 30' N and longitudes 100° 09' E to 100o 26' E. The map of the region is shown in Figure 1. The satellite image was acquired on 30 January 2006. The images were processed to level 2A (i.e., radiometric and geometric corrections performed) and projected to WGS84 Universal Transverse Mercator coordinate system with 10-m spatial resolution.

Fig. 1. Study area.

3. DATA ANALYSIS AND RESULTS

Our principal satellite imagery consisted of one Landsat TM image. All image-processing analysis was carried out using PCI Geomatica version 10.1.3 software at the School of Physics, University Sains Malaysia (USM). Land cover classification was accomplished in three steps. The first step in pre-processing was to apply a brightness correction technique to the digital images. The second step was to classify all the pixels in the digital images into land cover classes.

Training sites were needed for supervised classification. A total of 48 training sites were established in this study. The digital image was classified into three classes using all three visible bands and three infrared bands (Vegetation, Urban and Water). The final step is the accuracy assessment. The available ground truth data were used to derive an accuracy assessment analysis for the classified map. The accuracy of the classified map was determined using confusion matrix and Kappa coefficient. Kappa coefficient and overall accuracy results are shown in Table 1 and Table 2. The overall accuracy is expressed as a percentage of the test-pixels successfully assigned to the correct classes.

Accuracy assessment of coarse-resolution land cover products is a critical and challenging task, as these maps can overestimate or underestimate cover types due to the fragmentation and sub-pixel proportion of each cover type. As an alternative approach to field surveys, fine-resolution images and derived land cover maps have been used for validation of coarse-resolution thematic maps. In this study, validation was performed using the in situ data collected during the fieldwork in the study area. Many methods of accuracy assessment have been discussed in remote sensing literatures. Two measures of accuracy were tested in this study, namely overall accuracy and Kappa coefficient. The produced results in this study are shown in Table 1. Finally, the land cover map was generated (Figure 4).

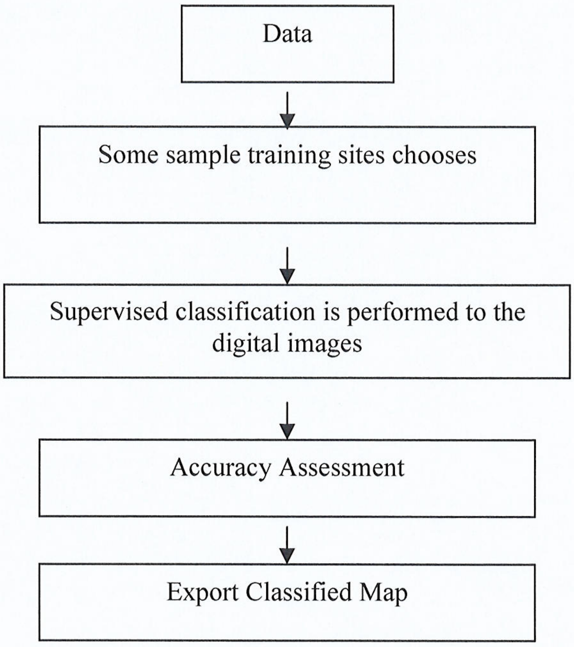

Fig. 2. Flow chart for data processing of the image.

Fig. 3. Raw satellite image.

Table 1. The Kappa coefficient for the image.

Classification method	Kappa coefficient
Maximum Likelihood	0.9025
Minimum Distance-to-Mean	0.8125
Parallelepiped	0.6120
Neural network	0.9236