Land Cover Classification Over Penang Island, Malaysia Using SPOT Data

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***Abstract*- Land cover analysis plays an important role in many environmental applications nowadays. Land cover classification is one of the primary objectives in the analysis of remotely sensed data. SPOT can provide a high spatial resolution land cover map with 10 m resolution. The objective of this study is to assess the capability of SPOT scene for land cover mapping. A frequency based contextual classifier was applied to the multispectral satellite images in this study. Contextual classification is employed when neighbouring pixels are taken into account. The land cover information was extracted from the digital spectral bands using PCI Geomatica 10.1.3 image processing software package. The frequency based contextual classifier was performed to the satellite image and the result was compared with three standard supervised classification techniques, such as the maximum likelihood, minimum distance-to-mean and parallelepiped. Training sites were selected within each scene and accuracy assessment was carried out in this study. Training sites were selected within each scene and land cover classes were assigned to each classifier. The relative performance of the techniques was evaluated. The accuracy of each classification map was assessed by referring to a large number of samples collected per category. High overall accuracy (>85%) and Kappa coefficient (>0.85) was achieved by the frequency based contextual classifier in this study. Finally, a land cover map was generated using the frequency based contextual classifier over Penang Island, Malaysia.**

***Keywords*- Remote Sensing, Classification, SPOT**

I. INTRODUCTION

Remote sensing can be used in the various purposes. In the past few years, there has been a growing interest in the used of remote-sensing systems for a regular monitoring of the earth's surface [1]. 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 [2]. The availability of remote sensing data applicable for global, regional and local environment monitoring has greatly increased over recent years [3]. Land cover is a fundamental parameter describing the

Earth's surface. With sufficient calibration, a land cover map can be used to identify spatial patterns of physical quantities such as carbon storage or vegetation cover as well as more abstract phenomena such as land use. Land cover maps can also be used to generate spatial estimates of input parameters for assessment of biodiversity, land use dynamics, and biosphere–atmosphere interaction. Furthermore, a time series of land cover maps of the same region can be used to identify temporal changes in surface properties that may be related to natural or anthropogenic disturbances [4]. Remote sensing techniques appear as very useful tools in assessing such land cover information.

Many researchers used remotely sensed images in their land cover and land use studies [5], [6], [7] and [8]. The main objective of this study is to evaluate the frequency based contextual classifier technique to classify the high spatial resolution digital satellite imagery.

II. STUDY AREA

The study area is the Penang Island, Malaysia within latitudes 5o 12' N to 5o 30' N and longitudes 100o 09' E to 100o 26' E. The map of the region is shown in Fig. 1. The satellite image was acquired on 30 January 2006. The image was 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

III. DATA ANALYSIS AND RESULTS

All image-processing tasks were carried out using PCI Geomatica 10.1.3 digital image processing software at the School of Physics, Universit Sains Malaysia (USM). Fig. 2 shows the raw satellite image. The frequency based contextual classifier performs classification of multispectral imagery using a grey level reduced image and a set of training site bitmaps. The frequency based contextual classifier performs the second of two steps in frequency-based contextual classification of multispectral imagery. It inputs a grey level vector reduction image (must be 8-bit layer) and a set of training site bitmap layers, and creates a classification image under the specified output window. Each input bitmap can be assigned a unique output class value for the classification image. The contextual classifier uses a pixel window of specified size around each pixel.

The aim of the classification analysis is to categorize all of the pixels into same classes. Basically, the process can be divided into three steps, the pre-processing, data classification and output. For the first step of pre-processing, one satellite image was chosen for land cover classification. For the second step of data classification, the satellite image was processed using PCI Geomatica 10.1.3 software package. Supervised classifications operate in three basic steps: training, classification and accuracy assessment. Training sites were needed for supervised classification. Training data sets were established using polygons. They were delineated by spectrally homogeneous sub areas, which have, class name given. Once the training sites and classes were assigned, the images were then classified using the four supervised classification methods (Maximum Likelihood, Minimum Distance-to-Mean, Parallelepiped and frequency-based contextual).

The SPOT satellite image was classified using three supervised classification and a frequency-based contextual classification methods with a set of the training data set. The digital satellite image was classified into 3 classes namely vegetation, Urban and Water. The available ground truth data were used for accuracy assessment analysis of the classified map. The accuracy of the classified map was determined using confusion matrix and Kappa coefficient.

Accuracy assessment was carried out to compute the probability of error for the classified map. A total of 200 samples were chosen randomly for the accuracy assessment. 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. In thematic mapping from remotely sensed data, the term accuracy is used typically to express the degree of 'correctness' of a map or classification [9]. The produced results in this study are shown in Table 1 and Table 2. The classified land cover map was shown in Fig. 3.

Fig. 2 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
Frequency-based contextual	0.9287

TABLE 2
THE OVERALL CLASSIFICATION ACCURACY FOR THE IMAGE.

Classification method	Overall classification accuracy (%)
Maximum Likelihood	92.36
Minimum Distance-to-Mean	81.21
Parallelepiped	60.29
Frequency-based contextual	95.76

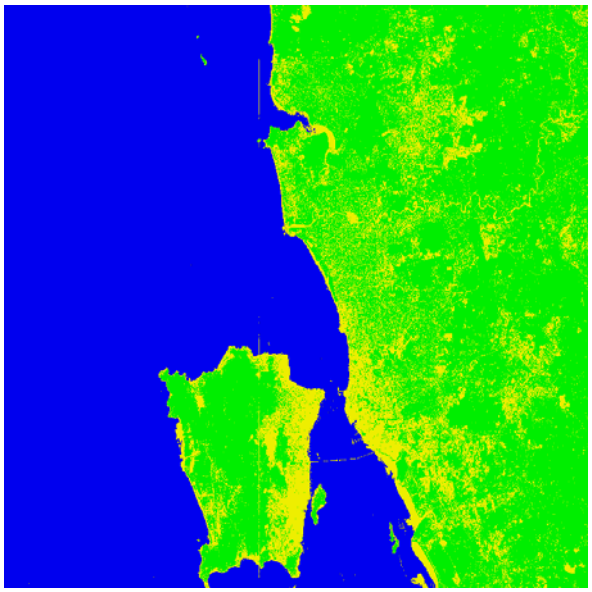

Fig. 3 The classified image obtained from frequency based contextual classifier (Light Green = vegetation, yellow = Urban and Blue = Water).

IV. CONCLUSION

From the three classified map, frequency based contextual classifier gives a good result for land cover mapping. The satellite imagery can be used to provide useful data for planning and management. The application of the SPOT satellite image for land cover mapping produced reliable and accurate results.

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REFERENCE

[1] Bruzzone, L. and Prieto, D. F., 2002, A partially unsupervised cascade classifier for the analysis of multitemporal remote-sensing images. Pattern Recognition Letters, 23, 1063–1071.

[2] Latifovic, R., Zhu, Z. L., Cihlar, J., Giri, C. and Olthof, I., 2004, Land cover mapping of North and Central American-Global Land Cover 2000, Remote sensing of environment, 89, 116 – 127.

[3] Ehlers, M., Gahler, M. and Janowsky, R., 2003, Automated analysis of ultra high resolution remote sensing data for biotope type mapping: new possibilities and challenges, ISPRS Journal of Photogrammetry & Remote Sensing 57 (2003) 315– 326.

[4] Fernandesa, R., Fraser, R., Latifovic R., Cihlar, J., Beaubien, J. and Du, Y., 2004, Approaches to fractional land cover and continuous field mapping: A comparative assessment over the BOREAS study region. Remote Sensing Of Environment, 89, 234-251.

[5] Tapiador, F. J. and Casanova, J. L., 2003, Land use mapping methodology using remote sensing for the regional planning directives in Segovia, Spain. Landscape and Urban Planning, 62, 103-115.

[6] Shrestha, D. P. and Zinck, J. A., 2001, Land use classification in mountainous areas: integration of image processing, digital elevation data and field knowledge (application to Nepal). JAG, 3(1), 78-85.

[7] Langley, S. K., Cheshire, H. M. and Humes, K. S., 2001, A comparison of single date and multitemporal satellite image classifications in a semi-arid grassland. Journal of Arid Environments, 49, 401–411.

[8] Friedl, M. A., Mclver, D. K., Hodges, J. C. F., Zhang, X. Y., Muchoney, D., Strahler, A. H., Woodcock, C. E., Gopal, S., Schneider, A., Cooper, A., Baccini, A., Gao, F. and Schaaf, C., 2002, Global land cover mapping from MODIS: algorithms and early results. Remote Sensing of Environment, 83, 287–302.

[9] Foody, G. M., 2002, Status of land cover classification accuracy assessment. Remote Sensing and Environment, 80, 185–201.