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CLASSIFICATION OF SATELLITE FUSED DATA FOR LAND USE MAPPING IN DEVELOPMENT PLAN

Norzailawati Mohd Noor[1]
Kulliyah Architecture and Environmental Design,
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
Alias Abdullah[2]
Kulliyah Architecture and Environmental Design,
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
Mazlan Hashim[3]
Faculty of Geoinformation Sciences and Engineering,
UNIVERSITI TEKNOLOGI MALAYSIA

Abstract
Land use mapping in development plan basically provides resources of information and important tool in decision making. In relation to this, fine resolution of recent satellite remotely sensed data have found wide applications in land use/land cover mapping. This study reports on work carried out for classification of fused image for land use mapping in detail scale for Local Plan. The LANDSATTM, SPOT Pan and IKONOS satellite were fused and examined using three data fusion techniques, namely Principal Component Transform (PCT), Wavelet Transform and Multiplicative fusing approach. The best fusion technique for three datasets was determined based on the assessment of class separabilities and visualizations evaluation of the selected subset of the fused datasets, respectively. Principal Component Transform has been found to be the best technique for fusing the three datasets, where the best fused data set was subjected to further classification for producing level of land use classes while level II and III pass on to nine classes of detail classification for local plan. The overall data classification accuracy of the best fused data set was 0.86 (kappa statistic). Final land use output from classified data was successfully generated in accordance to local plan land use mapping for development plan purposes.

Keywords: Data fusion, classification, remote sensing, land use mapping, development plan

[1] Assistant Professor, Department of Urban and Regional planning, Kulliyah Architecture and Environmental Design, International Islamic University Malaysia;
[2] Professor, Department of Urban and Regional planning, Kulliyah Architecture and Environmental Design, International Islamic University Malaysia. e-mail: dralias@iium.edu.my;
[3] Professor, Institute of Geospatial Science & Technology, Faculty of Geoinformation Sciences and Engineering, Universiti Teknologi Malaysia

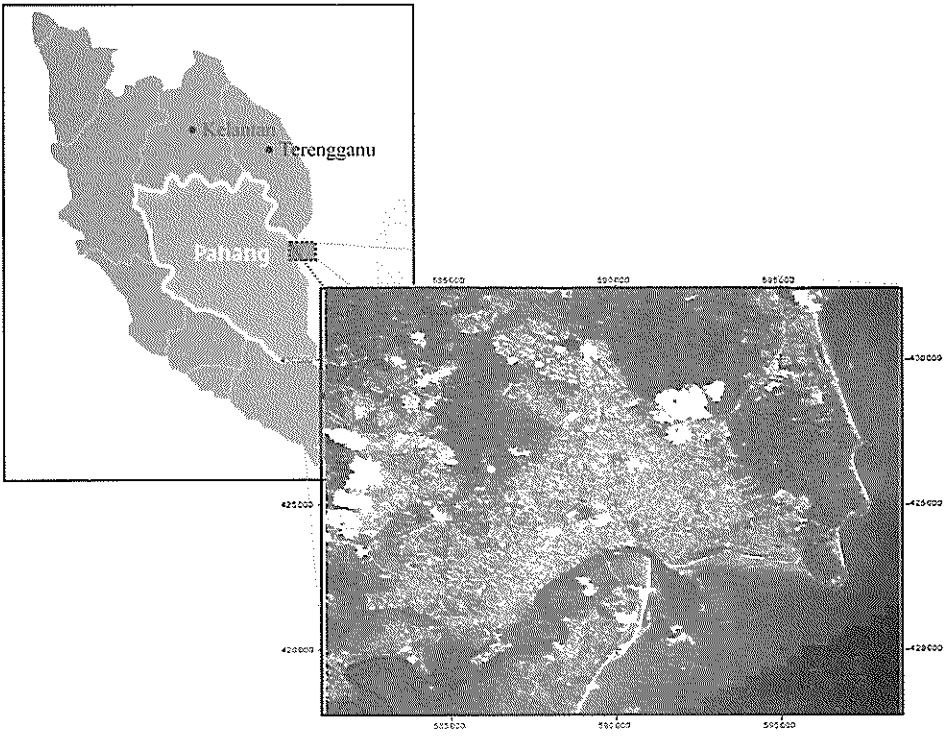
INTRODUCTION

Satellite Image fusion aims at the generation of a single image from multiple image data for the extraction of information of higher quality (Pohl, 1999). Parallel with this development, emphasis on techniques that guarantee a better image for classification in urban/regional is urgently needed. In remote sensing, fusing high resolution multispectral images becomes popular since it can produce high spatial resolution multispectral images which can meet the requirement of classification of land use for development plan purposes. There are many types of fusion techniques which already tested by previous researcher and various image fusion and algorithm have been proposed which included three types of methods used in this study respectively (refer Pohl, 1999). In the context of the needs of urban/regional planning aspect, the fusion techniques determination is becoming very crucial in providing a better image with complete information in one solution. Fusion of multi sensor data becomes promising, through combining registered images generated by different imaging systems, images fusion can produce new images with more complete information that are more suitable for vision perception, object detection and automation target which can be utilized fully to produce a better classification for land use mapping purposes (Li et al, 2005) which currently not fully explored in Malaysian perspectives.

When we look at the effective planning, land use maps are of vital importance in the development of urban planning especially in developing countries. Section III in Malaysia Town and Country Planning Act 1976 (Act 172) states that land use map was crucially necessary for the preparation of development plan. The development plan generally defines as a blueprint document to guide development along the desired line for a particular horizon year. It has been practiced into tiered hierarchy of National Physical plan, structure plan, local plan and special area plan which utilized the small to big scale maps which also required the low to high resolution imagery in remote sensing perspective. In accordance, the land use map was considered as the base map to generate the other maps and also used as spatial tools to predict the future development. That was the requirement in development plan to fulfill the answer of stakeholders who used this detailed maps on clarifying land use in their own lot and make any objection or suggestion for the proposal plan.

The objective of this study is to map land use to be utilized in development plan using fused image sets of IKONOS, SPOT panchromatic and LANDSAT TM which derived from using (a) PCT (b) Wavelet Transform and; (c) Multiplicative approach. The study area is located in Kuantan district ($03^{0}52N,103^{0}17E$ and $03^{0}45N,103^{0}23E$) southeast of Pahang state, Malaysia. It covers about $14ha^{2}$ classes made of mainly built up areas such as residential, industrial, commercial, institution, and recreational areas and un-built features such as agriculture, forest, vacant land and water bodies.

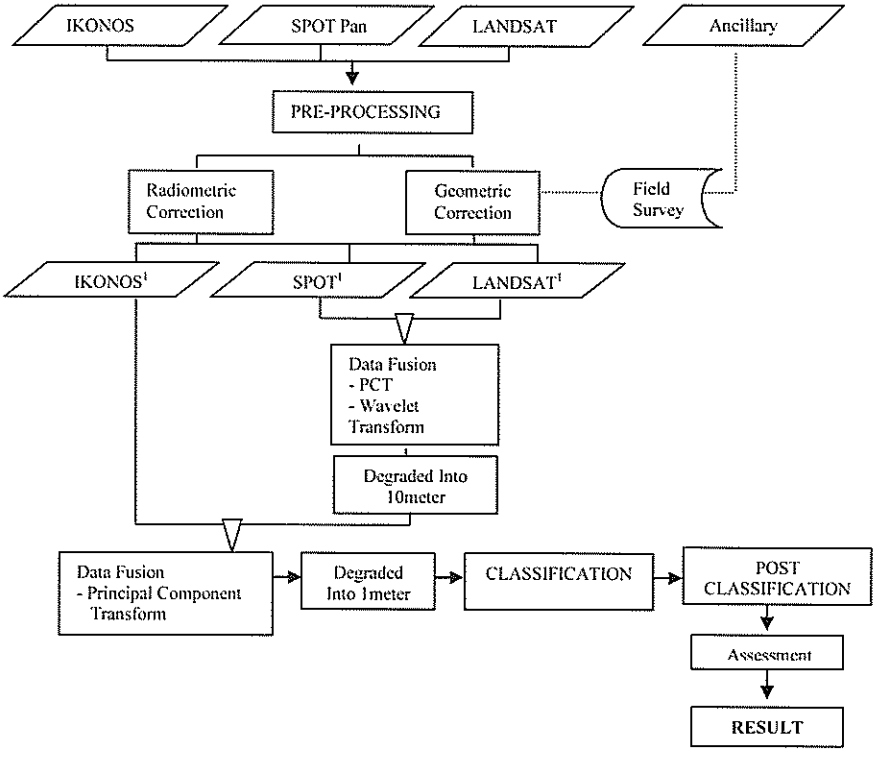
Figure 1: Location of Study Area



MATERIAL AND METHOD

Three image sets used in this study were acquired in 2004 and provided by the Malaysian Centre of Remote Sensing (MACRES). The ancillary information to support these imageries were also collected from secondary sources which include road network, urban map and topographic map. This information was uses as guidance and parameter during pre-processing image. LANDSAT TM, SPOT Panchromatic and IKONOS were geo-referenced using image to map approach using 2nd order polynomial transformation function, and later resampled with the nearest neighbor interpolation. The image to map procedures have been applied to the IKONOS, SPOT panchromatic and LANDSAT TM image using a set of ground control point area which appear in the same place both in the imagery and known location in corresponding map as ancillary in rectification process (Figure 2).

Figure 2 : Methodology employed in this study



Apart from the geometric correction, radiometric enhancement was also performed. The atmospheric correction was applied to LANDSAT TM to remove noise that was caused by the atmospheric effect to the image. This situation must be considered properly because the serious atmospheric attenuation may have impact on classification accuracy within a scene if it varies significantly. While the SPOT panchromatic image is also subjected to image enhancement, it can to contribute more to enhance spatial element into the kernel output. We used cost model approach to remove this error to attain a good result.

Three data fusion approach was conducted using ERDAS Imagine software package, table 1 shows the process performed to the different images of SPOT Panchromatic and IKONOS. For this study, image of 1 meter, 10 meter and 30meter were used to merge with double data set to get a better

image with more spatial details. These techniques involve the Principle Component Transform, Wavelet transform and Multiplicative.

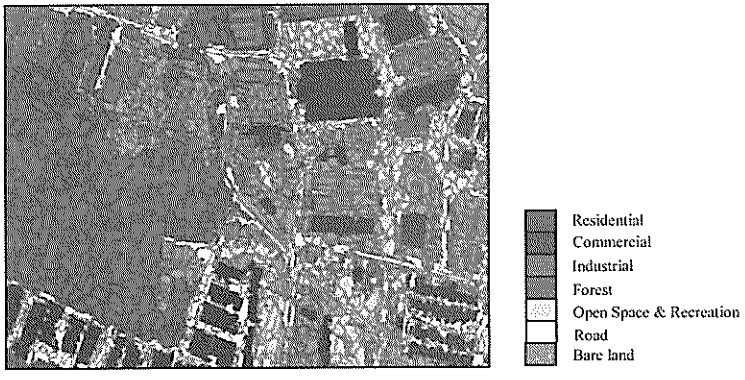
Table 1 : Data Fusion techniques examined

Process	Original Data Fused/ Resolution	Technique #	Result Band/Resampled Grid
1st fusing process	LANDSAT TM /(30m) and SPOT Pan/ (10m)	PCT	6/10m
		Wavelet Transform	6/10m
		Multiplicative	6/10m
2nd fusing process	LANDSAT TM/(30m) + SPOT Pan/(10m) and IKONOS (1m)	PCT	6/1m
		Wavelet Transform	6/1m
		Multiplicative	6/1m

Note :
PCT – Principal Component Transform

The result of final fused image from Principal Component Transform has been classified further in classification stage. The supervised classification techniques have been chosen for this study. The Ecognition software that supports different supervised classification techniques and different method to train and build-up knowledge have been used for this classification of image object (Blaschke, 2010). Post classification was employed in GIS software which merged on vector data to produce a land use map for local plan requirement through K-mean classification approach. The assessment on statistical validation has been performed to assess the accuracy of output for this study (figure 3).

Figure .3 : A section of the study area showing the classification.



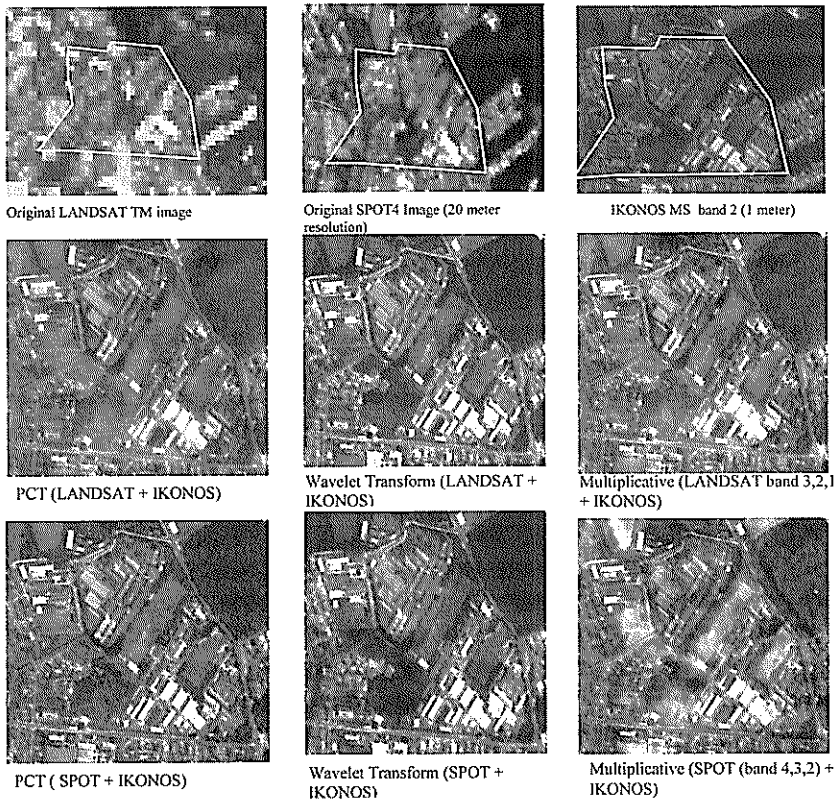
RESULT, ASSESSMENT AND DISCUSSION

Result and Assessment

The result of data pre-processing shows all data sets have been successfully corrected. All the three images set were fused to be transformed to local mapping coordinate system with RMSE 0.5 pixels. Results of three fusion techniques are shown in Figure 3. The visual comparison method is used to assess all the fusion techniques. The fusion of IKONOS and SPOT images allows a segregation of land use for level I when Principal Component Transform (PCT) was used. Level II and some of level III classes are well enhanced. Similar result of fused is obtained in the LANDSAT TM and IKONOS image set. Visual images interpretation show that merged image of LANDSAT TM/IKONOS and SPOT4/IKONOS depicted better spatial and spectral detailness (figure 4). Building, roads and crossroad can be identified easily from the merged image sets compared to the original data. Information content for LANDSAT TM improved significantly by merging LANDSAT TM and IKONOS.

The spectral reparability among land use was also carried out for the derived merged data sets. Best average separabilities among land use classes are fused in the PCT merged data set (Table 2). Using the ground truth gathered from field verification,the result of classification has been tested on paired sample t-test for reliabilities. Table 3 summarizes the analysis which clearly shows the reliability of the classified urban local plan using fused image set. The correlation shows the ability of the result to maintain correlation image classes using 95% confidence level. This result obtained 37.80 for standard error mean. It reveals that 0.995 values capable to maintain excellent correlation.

Figure 4 : Parts of result of fused imaged and originals subject of 300 x 300 Pixels.



Two types of assessment performed in this study were data set fusion and data classification. A total of 10 classes identified from ground truth in-situ survey were used in the analysis using divergence technique. This measurement can be considered as an priori estimate of the likelihood of correct classification between groups of different feature combinations. Table 2 shows that principal component transform was the best technique of 1862/2000 for classes separabilities using three best combination for each image sets.

Table 2: Summary of divergence analysis carried out within fused image set against original image set

Image Sets	Average Divergence
Original LANDSAT	1913
Principal Component Transform fused set	1862
Multiplicative approach fused set	1810
Wavelet Transform fused set	1729

Table 3 : Reliabilities of fused image classification for deriving land use map by significant test (T-test) of the result obtained.

	Paired Differences					Correlation
	No.Of Class	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
				Lower	Upper	
Pair 1 Existing - Image	11	125.35	37.80	-84.2108	84.2108	.995

The fused output of this study is shown in Figure.5. The land use map was edited using post processing GIS approaches.

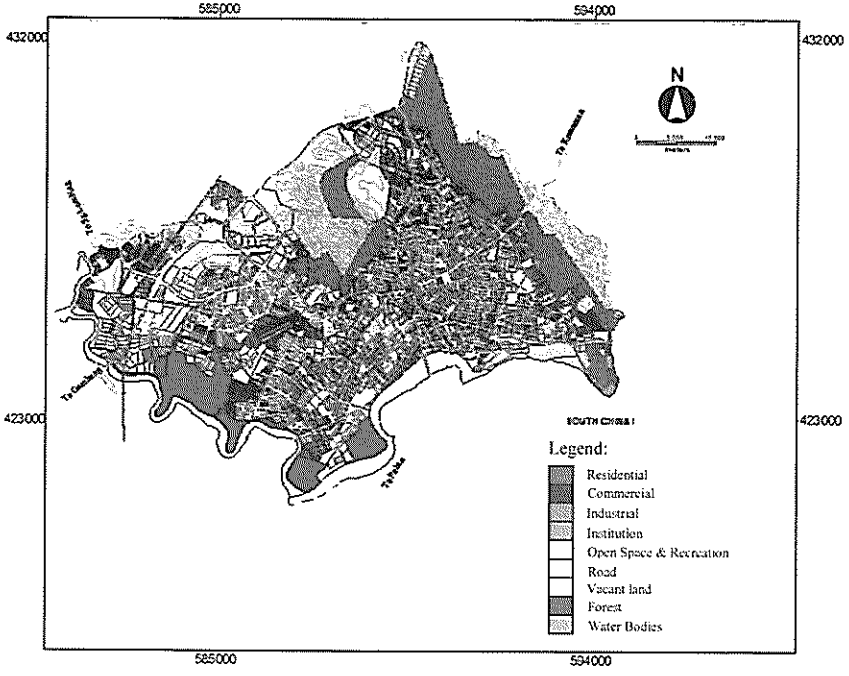


Figure 5 : Classified Fused Image Derived using PCT

The result of this study clearly indicates that, data fusion is one of the important elements in producing a detailed land use classes of the urban local plan. Merging process must consider the spatial interaction to issues on radiometric integrity. However, the result of Wavelet Transform and Multiplicative shows poor color fidelity

(incomplete retention of multispectral information). In adittion, the assessment for this study, requires more appropriate mathematical approaches because the result was very complex due to the different sources of data involved and other factors to guarantee the accuracy of the results. The post processing strategy has proven to be particularly effective for generating interclass boundaries. The necessary object was not detected during the fusion and classification process that compensate from the GIS database in a coarse manner. This study indicated the utilization of remote sensing imagery fulfilled the demands required in town planning fields particularly on land use mapping for development plan. The strength aspect of: (1) frequent/continuous update of the information database; (ii) collection of information in areas, where due to the economic and geographic context it would be difficult to gather the appropriate data (especially in developing countries); and (iii) reduction of the information input and extraction shows the potential of remote sensing in town planning.

Finally, for this study we also have presented a preliminary result on the study of fusion of multisensor image for land use mapping for urban and regional planning. The main aim of the research was to compare the performances of different data fusion techniques for enhancement of different surface features and evaluate the features obtained by the fusion techniques in terms of separation of urban land use classes to be utilize in mapping for development plan purposes. Specifically, three fusion techniques which consist of Principal Component Transform, Wavelet Transform and Multiplicative were examined. Although fusion method demonstrated different result, detailed analysis of each image revealed that image obtained by the PCT fusion applied in this study. The assessments also indicated the PCT is an adequate approach for merging LANDSAT TM, SPOT and IKONOS in producing a detailed land use mapping for development plan purposes.

CONCLUSION

Field of urban planning may be thought of as a process for determining appropriate future action through a sequence of choices. To make these choices uncertain conditions, planners need to collect comprehensive information about the past, the present and the future. The relationship between planning and remote sensing techniques, it can be agree that land use classification is more detailed using remote sensing tools and provides planners with new direction to implement their work efficiently especially in handling base-map in development plan process. However, the implementation of innovative technology such as remote sensing, involves far more than hardware and software decision. This study of fusion between type of satellite imageries is one alternative to show the effectiveness of remote sensing into urban planning application. We still are seeking the implementation rest on thorough and systematic evaluation encompassing planning, operational, organizational, institutional, personnel, financial

and technical aspects to develop these tools broadly in the planning field, as well as developing the technology for planning and management purposes.

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