URBAN LAND USE SPECTRAL USING HIGH RESOLUTION IMAGERY AND GIS APPROACH IN SUSTAINING URBAN PLANNING SPATIAL DATABASES

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Abstract: Remote sensing technology is useful for urban planning due to its capability in examining detailed spectral characteristic of urban land uses. This study attempts to review a relevant studied have been done in identified an appropriate spectral for urban land use using high resolution remote sensing images and GIS approach. The detailed spectral for urban land uses consist of residential, industrial and commercial in metropolitan and city center urban hierarchy will be discussed. The segmentation techniques through object oriented and the use of field measurement was highlighted, at once demonstrates the usability of such infrastructure to facilitate further progress of remote sensing and GIS application in urban planning in Malaysia. Finally, a discussion of the needs for further research is presented.

Keywords : Land use spectral, high resolution, Remote sensing, GIS and urban planning

1. Introduction

High resolution imagery satellites, such as IKONOS, QuuickBird, OrbView-3 and EROS-B1 are revolutionizing the extracting the urban land use particularly in the urban area where satellite imagery has rarely been used in the past. Currently, the interpretation of high-resolution satellite images is carried out manually by visual interpretation. The information of accessibility very high resolution satellites increases on land cover at local to national scales (Aplin et al., 1999). There are a variety of earth observation satellites in orbit capable of imaging objects on the earth with various degrees of resolution (Hart and McCleave , 2002). The category of satellite imagery is following: (Table.1)

A number of high resolution imaging satellites have been increased since it was launched in the year 1999 (Table.2). The width of the array provides coverage across the satellite track, whilst the motion of the satellite provides coverage along the track. This method of collecting is in contrast to “staring” or “spinning” sensors. A “staring” sensor points to an area and instantaneously collects images of the area covered by the array. “Spinning” sensors rotate as they collect data of an area.

Table .1: Spatial Classification of Satellite Imagery Resolution

Resolution (m)	Level of Image	Examples
≥300m	Very Low	NOAA (Oceanographic and Weather)
≥300m< 300m	Low	Landsat MSS
≥3m< 30m	Medium	Landsat TM, SPOT
≥0.5m< 3m	High	Quickbird, IKONOS

There are four advantages have been identified Li (1998) namely (i) Provide the highest resolution satellite data available to the civilian mapping community which could then be better than small scale aerial photography. (ii) Comprise an extremely long camera focal length of ten meters for capturing terrain relief information from satellite orbit. (iii) Include fore, nadir and after looking linear CCD arrays supplying in-track stereo strips. (iv) Have a base-height (sensor baseline vs. orbit height) ratio of 0.6 and greater, which is similar to that of aerial photographs.

Remote sensing is very useful for the production of land use and land cover statistics which can be useful to determine the distribution of urban land. The remote sensing technique for developing land use mapping is very useful and it is considered as a detailed way to improve the selection of areas designed for agricultural, urban and/or industrial areas of a region (Selcuk, 2003). Some studies show that a reduction in the accuracy with which different urban land uses can be distinguished in such images, relative to that obtained using coarser resolution data (Haack et al., 1987 & Martin et al., 1988). However , the spatial resolution of the sensor increases, individual scene elements (e.g., buildings, roads, and open spaces) begin to dominate the detected response of each pixel; therefore, the spectral response of urban areas as a whole becomes more varied, making consistent classification of land use problematic (Gastell Etchegorry, 1990). In recent years urban remote sensing has proved to be a useful tool for cross-scale urban planning and urban ecological research. Remote sensing in urban areas is defined by nature as the measurement of surface radiance and properties connected to the land cover and land use.

High spatial resolution means higher level of information contents that favour to better accuracy. It is important to understand the high spatial resolution remote sensing concept in order to know the advantages of using remotely sensed data in remote sensing applications, especially in extracting the urban land use. High resolution satellite imagery is a unique source of spatial data. It is not only imagery providing a graphic representation of an area but also can be used for feature extraction for mapping, digital elevation model creation and change monitoring over a period of time. Various studies anticipate that the higher spatial resolution remote sensing sensor to be developed in order to increase the mapping accuracy of remote sensing studies (Innes and Koch, 1998; Franklin, 1994; Li and Strahler, 1992). The urban remote sensing community has had access to imagery from very high spatial resolution sensors such as the digital imaging payloads onboard IKONOS and DigitalGlobe's QuickBird satellite systems since 1999.The launching of two commercial high spatial resolution earth observation remote sensing satellites, namely IKONOS (spatial resolution 4 m for multispectral and 1 m for panchromatic band) and Quickbird (spatial resolution 2.4 m for multispectral and 60 cm for panchromatic band) during the year 1999 and 2001 respectively. High spatial resolution imagery provides a closer view of smaller objects while low spatial resolution imagery provides a farther view of larger objects.

Table 2: High Resolution Satellite Image for urban spectral

Satellite	Spatial resolution	Life expectancy	Launch	Company/Country	Panchromatic	Multispectral
IKONOS	1.0(panchromatic) 4.0m (Multispectral)	> 8.5 years	24/9/1999	Geoeye (US)	0.45-0.90 microns	#1: Blue 0.45-0.52 #2: Green 0.52-0.60 #:3Red 0.63-0.69 #4: Near IR0.76-0.90
EROS A	1.8m (panchromatic)	10 years	5/12/2000	ImageSat (Israel)	0.5-0.9 microns	None
Quickbird	0.6-072m (panchromatic) 2.442.88m (Multispectral)		18/10/2001	Digitalglobe (US)	0.45-0.90 microns	Blue:0.45-0.52 Green:0.52-0.60 Red:0.63-0.69 Near IR:0.76-0.90
Orbview - 3	1.0m (panchromatic) 4.0 m (Multispectral)	At least 5 years	26/6/2003	Geoeye (US)	0.45-0.90 mocrons	0.45-0.52 0.52-0.60 0.625-0695 0.76-0.90
EROS B	0.7m (panchromatic)	10 years	25/4/2006	ImageSat (Israel)		
Resurs DK-1 (01-N5)	1.0m	3 years	15/06/2006	NTs OMZ (Russia)		
KOMPSAT-2	1.0m	-	28/07/2006	Korean Aerospace Research Institute (KARI) (Korea		
IRS Cartosat 2	1.0m	-	10/01/2007	India		
Worldview 1	(panchromatic only 0.50m at Nadir	7.25 years	18/09/2007	Digitalglobe (US)	Panchromatic only	
GeoEye-1	0.41m	7 years	2008	Geoeye (US)		
WorldView -2	0.5m	7.25 years	01/07/2008	Digitalglobe (US)		
EROS C	0.7m	10 years	21/03/2008	Israel		
Pleiades-1	0.7m	5 years	2009	France		
Pleiades-2	France 0.7m	5 years	5 years March 2011	France		

High spatial resolution means higher level of information contents that favour to better accuracy. It is important to understand the high spatial resolution remote sensing concept in order to know the advantages of using remotely sensed data in remote sensing applications, especially in extracting the urban land use. High resolution satellite imagery is a unique source of spatial data. It is not only imagery providing a graphic representation of an area but also can be used for feature extraction for mapping, digital elevation model creation and change monitoring over a period of time. Various studies anticipate that the higher spatial resolution remote sensing sensor to be developed in order to increase the mapping accuracy of remote sensing studies (Innes and Koch, 1998; Franklin, 1994; Li and Strahler, 1992). The urban remote sensing community has had access to imagery from very high spatial resolution sensors such as the digital imaging payloads onboard IKONOS and DigitalGlobe's QuickBird satellite systems since 1999.The launching of two commercial high spatial resolution earth observation remote sensing satellites, namely IKONOS (spatial resolution 4 m for multispectral and 1 m for panchromatic band) and Quickbird (spatial resolution 2.4 m for multispectral and 60 cm for panchromatic band) during the year 1999 and 2001 respectively. High spatial resolution imagery provides a closer view of smaller objects while low spatial resolution imagery provides a farther view of larger objects.

In the case of high spatial resolution, the inherent effectiveness of spatial information have somehow ensured 'busyness' or variation in a 'class of target' hence preprocessing such as texture analysis need to be carried out prior to information extraction (Schowengerdt, 2007). On the other hand, the high spectral resolution such as found in hyperspectral data often face "Rayleigh phenomenon" and problem in selecting optimum bands from the voluminous data set. "Rayleigh phenomenon" refers to the fraction of light scattered are sensitive with the narrow bands and sometimes give false information in interpreting the target object (Borengasser et al., 2007).

Remote sensing of urban areas reflects the power of using multiple sources of satellite imagery with geographic information system and the expertise of urban areas. Urban remote sensing applications have substantially benefited from the high spatial resolution characteristics of commercial satellite image data and the ensuing ability to monitor smaller features of interest in complex urban environments (Donnay et al. 2001).The satellite remote sensing is monitoring with high speed, accurate and efficient (Li Yingcheng et al). It not only gives the amount and location of the change information of land use, but can also be used to check the data supplied by local government. It gives the administrators with scientific assistance in the macro managing, planning and utilizing the land resource. It is also an important means in constructing the system of national land use dynamic monitoring.

The availability of high and very high resolution sensors the interest for using remote sensing data for urban application was increased on facilitating (Ehlers 2002), and identification of urban objects, such as individual buildings and details of road networks (Brussel et al. 2003). The relationship between the spatial resolution of remote sensing data and land use/land cover is that developed by Anderson et al. (1976) (Table 3).

Table 3: Land use classification levels (Anderson et al. 1976)

Level	Resolution (m)	Example of class
I	≤100	Built-Up urban
II	≤20	Residential, Industrial, commercial etc
III	≤5	Single family Units, Apartments, etc.
IV	≤1	Additional information e.g condition of the building

Tatem (2004) described that the advance of using Very High Resolution Radiometer (AVHRR) for urban land use mapping. Moreover, recent research has identified a number of different approaches for data acquisition and for land-use characterization and analysis which utilize remote sensing imagery as source data in the derivation of spatial data sets with high temporal and spatial resolution (Hall et al, 1995). A major problem in urban area remote sensing from space is the heterogeneity of the urban environment. This environment typically consists of built-up structures (for example, buildings, and transportation nets), several different vegetation cover types (parks, gardens, and agricultural areas), bare soil zones, and water bodies (Barnsley et al, 1993). In order to record accurately this complex spatial assemblage, high spatial sensor resolutions are required (Welch, 1982).

The development of the IKONOS satellite (with 1 m panchromatic and 4 m multispectral resolution) such data were not continuously available from civilian space-borne systems. Several studies have demonstrated the high potential of digital remote sensing data as source information specifically useful for analysis of the urban and suburban environment: urban land-use and infrastructure mapping and monitoring (Barnsley et al, 1993; Henderson and Xia, 1997; Jensen and Cowen, 1999; Meaille and Wald, 1990). High spectral variation within any land-cover class often decreases the classification accuracy. The huge amount of data storage and severe shade problem in fine spatial resolution image give rise to challenges for selection of suitable image processing approaches and classification algorithms over a large area. Last but not least, high spatial resolution imagery is much more expensive and requires much more time to implement data analysis than medium spatial resolution image data.

2.0 Characteristics of urban land use spectral

Urban is a fairly complex concept. It is a function of (1) sheer population size, (2) space (land area), (3) the ratio of population to space (density or concentration), and (4) economic and social organization. Urban environments are characterized by different types of materials and land cover surfaces. Urban land use spectral is possess a high spectral heterogeneity (Ben-Dor et al. 2001, Roberts & Herold 2004). They are characterized by a large diversity of materials such as human-made features, vegetation, soils, and others. spectral signatures is usually based on spectral libraries. These libraries contain pure spectral samples of surfaces, including a wide range of materials over a continuous wavelength range with higher spectral detail, and additional information and documentation about surface characteristics and the quality of the spectra (i.e., metadata). The multispectral applications of satellite imagery must be assessed when looking at the practical use of satellite imagery. The availability of colour information in this instance would assist feature definition in that it would be easier to locate objects featuring a contrasting colour such as roofs, trees, green areas and water surfaces. An option in such an instance would be to use pan-sharpened images, which are created by merging the colour information in a multispectral image with the higher spatial resolution of a panchromatic image (Gianinetto et al, 2005). A particular point to note is that the complexity of a scene directly affects the selection and success of an automatic procedure for detecting building features (Chen et al, 2001). This can be due to the variety of spectral responses available in close proximity in an area, such as from roof tops, roads and garden vegetation in the Central Business District of a city.

Particularly note is the determination that the spectral resolution of high resolution commercial satellite imagery is inadequate for extracting ground cover information based on typical pixelbased classification techniques. This scheme divides urban land uses into four hierarchical levels and provides an approximate indication of the sensor resolution required for a given land use/land cover classification. Although this scheme continues to be useful for many remote sensing users, it is primarily concerned with general land use and land cover classes. In contrast, the more recent work of Jensen and Cowen (1999) incorporates other aspects and categories, including hierarchical object classes.

Table 3: detection of land use component in high resolution imagery

Land use component/types	**Types of sensor**	**Band**	**Reference**
Urban area	Landsat 7 ETM	Band 3,4 5	*Dengsheng Lu & Qihao Weng (2005)*
Un-built area/ vegetation area	Landsat 7 ETM	Band 3,4 5	*Dengsheng Lu & Qihao Weng*
Road	Landsat 7 ETM	Band 3,4 5	*Dengsheng Lu & Qihao Weng*
Residential	Quickbird II	Between 4 ,3 and 2	*Asmat,A & Zamzam,S.Z (2011)*
Industrial	Landsat 7 ETM	Band 3,4 5	*Dengsheng Lu & Qihao Weng*
Water bodies	Landsat 5	Band 1, 4 & 7 / Band 1, 2 & 3	*Dengsheng Lu & Qihao Weng*

3.0 Methodology to extract the spectral using remote sensing and GIS techniques 4.0

The number of operational high-resolution satellite has increased significantly nowadays. The obtained images provide more and more detail about land and water surfaces and hence permit to observe. Remote sensing of urban spectral is particularly challenging. A single image from a high-resolution satellite provides a huge amount of information that needs to be reduced for analysis and interpretation. Many researchers have studied classification methods for satellite images. The land surface objects (e.g., buildings/roofs, roads) have a small spatial extent. Given this large amount of spatial heterogeneity most analyses in urban areas have relied upon aerial photography as a data source. Recent advances in spaceborne systems, such as IKONOS and QUICKBIRD provide cost effective alternatives to aerial photography. IKONOS provides 4 m multispectral data, the minimum spatial resolution of 5 m considered necessary for accurate spatial representation of urban materials such as buildings and roads (Jensen and Cowen 1999).

3.1 Object-Based Classification

The alternative approach is to consider image objects made of homogeneous clusters of adjacent pixels with meaningful geometric and other spatial properties. These clusters assure a much richer and more powerful working environment throughout the classification process (Blaschke and Strobl 2001). Objects generated through segmentation can be classified using two different classification methods: (1) classification based on samples and (2) classification based on the integration of prior external knowledge stored in rule bases**.** Classification starting from image objects rather than individual pixels can utilize spatial and geometrical properties as well as relationships among objects. Blaschke and Strobl (2001) make a case for the use of segmentation algorithms to delineate objects based on contextual information in an image**.** Using textural information and additional characteristics like the size or shape of the objects the per-pixel classification process is complemented by a new image processing technique. In particular, information from high resolution images is being aggregated at multiple levels of detail, resulting in hierarchical sets of homogenous regions according to the given application semantic. Object-based classification techniques are a new and innovative approach, especially for applications handling human-made features.

In the realm of urban remote sensing there are several applications demonstrating that object-based approaches are superior to per-pixel analysis especially when urban land cover classes, as airport, roads, etc., are to be separated (e.g. Darwish et al. 2003 & Hofmann 2001). In comparison to most natural environments the built environment is characterized by sharp, discrete boundaries and a high frequency change of different surfaces with similar reflectance properties. Anthropogenic features can be reproduced rather unambiguously in an object-based environment through an iterative segmentation process. Shadowed areas for example can be characterized by specific relationships to neighboring objects and the shape of an object may help in discerning between a roof and a road of similar reflectance. Object-based image analysis combines GIS functionality and remote sensing techniques by working with polygonal, homogeneous clusters instead of single pixels.

The most recent techniques for object extraction and classification typically use spectral information from individual pixels in conjunction with information on the texture, shape, color and/or height properties of the objects of interest (Thurston 2002). A multi-resolution, multi-sensor approach using such characteristics is a feature of some recent work. For example, Ehlers (2002) uses a hierarchical approach that combines existing GIS data with elevation data and multispectral imagery, obtained simultaneously from the TopoSys II system, to develop methods for object. (Hofmann 2001) analyzed that based on spectral and spatial resolution two different levels of detail can be examined (1) the detection of single shacks or (2) the location of entire informal settlements and their boundaries. The study area is a part of Cape Town (South Africa), is characterized by several different forms of settlement areas. The first step was an image enhancement by applying a principal-component pan-sharpening method. Next, multiple hierarchical image object levels were created in eCognition. The smallest level of image segments reveals single houses, while the top-most level represents entire settlement areas or parts thereof. The result was improved by using inheritance mechanisms and form criteria. Textural information described by reflectance and shape of lower-level objects helps to identify and classify different types of settlement areas. Hofmann argues that the object-based approach is well suited to detecting the complex structures of informal settlements. Especially when working with enhanced high resolution satellite imagery, image segmentation identifies ‘real-world’ objects that show a typical texture according to the different types of settlements.

The object-based image analysis is to work on homogenous image objects rather than on single pixels. Using spectral and spatial information the pixels are merged into homogenous groups (segments, image objects). After segmentation the features of generated objects are used for image interpretation and subsequent classification. Thus the user's knowledge can be integrated into image processing and the potential set of target classes can be extended. Object-based classification utilizes external knowledge by means of a rule base.

4.0 Conclusion

In conclusion this study has reviewed and examined all aspects of the development and application of high resolution satellite imagery. The successful implementation of the extracting of high resolution satellite imagery is a significant technological around the world. Therefore, in order to derive accurate urban classifications it is necessary to utilize data acquired by high spatial resolution sensors. High resolution satellite imagery is a unique source of spatial data. It is not only imagery providing a graphic representation of an area but also can be used for feature extraction for mapping, digital elevation model creation and change monitoring over a period of time. Further developments within the field of remote sensing and the allied mapping sciences of GIS and cartography, including the increasingly available commercial, high spatial resolution imagery, should enhance the ability to learn and understand more aspects of urban places and populations. Besides that Morphing physical remote sensing with social sciences appears to be the current trend in studies of urban land use planning.

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