eCognition
OBJECT ORIENTED IMAGE ANALYSIS

Mapping urban areas in the Santa Barbara South Coast using Ikonos data and eCognition

Introduction

New data resources from high spatial resolution satellite sensors like Ikonos or Quickbird, and innovative concepts in image analysis have the potential for improving mapping and analysis of urban land use structures and related dynamics. Considering the high amount of spatial detail in those types of data and the land cover heterogeneity of urban areas it is more difficult to apply traditional digital image analysis algorithms to derive thematic information. The object-oriented image analysis approach provides a new and innovative avenue in the analysis of high spatial resolution (2.5 m – 4 m) sensors that represent urban land cover objects such as houses, roads and vegetation patches in a number of adjacent pixels. However, the geometry of the targets (e.g. three dimensional roof structures and topography) and the heterogeneity of the objects themselves (e.g. roads with cracks or fillings) result in distinct spectral variation within these areas of homogenous land cover (image objects). Furthermore, satellite sensors like Ikonos and Quickbird are limited in their spectral resolution especially evident in urban area remote sensing. The widely known spectral complexity of urban land cover materials results in specific limitations in the separation of built up and non-built up materials, of roofs and roads and of different roof types (Herold et al. 2002). Accordingly, the image classification should include additional spatial and contextual characteristics as additional level of information in land cover type separation and mapping the complex urban environment. In previous studies object-oriented techniques using the eCognition Software system have shown their potential to consider and approach the problems raised in the image classification process (Blaschke & Strobl 2001) and provide more detailed and accurate mapping products. In this context we explore and present our experiences with the software system eCognition in analyzing multi-spectral Ikonos data for object-oriented urban land cover mapping in the Santa Barbara South Coast area (California, USA), which includes three adjacent urban areas covering over 350 sq km.

Datasets and Processing

The dataset consists of seven individual multi-spectral Ikonos images (4 m spatial resolution) acquired in April and May 2001. The preprocessing of the data included the geometric correction and the normalization of atmospheric effects to provide a consistent and calibrated dataset covering the entire Santa Barbara South Coast area. The first step in object-oriented analysis with eCognition is the image segmentation to extract meaningful image objects (e.g. roads, houses, swimming pools etc.) with the parameters Scale 8, Color 0.7/Shape 0.3, Smoothness 0.4/Compactness 0.6. Given the size of Ikonos mosaic (over 500 MB), the segmentation required a fair amount of processing time and sophisticated computer hardware. However, significantly less computing power was needed for the following image classification and analysis based on the segmented image objects. Figure 1 indicates the distinct representation of individual building structures, the spatial homogenizations of segmented image objects, and the additional object information provided by eCognition.

Classification

The classification in eCognition was implemented as hierarchical system with Level I classes: water, built up, vegetation, and bare land surfaces. The Level I classes were separated using spectral information (nearest neighbor distance), except for bare soil/beach/bare rock areas, which were constrained by a minimum object size to avoid confusion with specific roof types. Another minimum size rule was applied for water bodies to include another separation criterion to shadows and swimming pools. The Level II built up class, roofs, and transportation areas, were separated using spectral and shape information. Usually road image objects are determined by a linear structure whereas buildings have more compact shapes. We used the length/width ratio of objects to represent this feature in the classification process. Figure 2 shows the comparison of the final results of the classification to a false color composite, and digital data layers of buildings and roads. The overall land cover pattern of vegetation, buildings, and roads are well represented in the classified map. The land cover categories appear as homogenous objects due to the object-oriented approach used for classification, providing a sophisticated and accurate representation of the real world structures. The accuracy assessment was performed applying independent field reference data that considered one image object as one reference point. The error matrix of the final aggregated classification result (shown in Table 1) indicates a very accurate classification for green vegetation, water bodies and swimming pools. Good results are shown for light roofs that confuse with roads (esp. light concrete roads), and red tile roofs that obviously mix with bare soil and non-photosynthetic vegetation (NPV). The lowest accuracies can be found for dark roofs and roads that confuse with each other. Some parts of the roads appear as smaller individual objects and are classified as roofs due to their shape and vice versa as both classes are not distinctively separated based on their spectral characteristics.

Conclusion

The software system eCognition has proven its excellent concepts for improved mapping of urban areas from remote sensing data. Given the sensor capabilities of high spatial resolution satellite systems and the spatial and spectral complexity of the urban environment image segmentation and object-oriented classification provide a superior approach in deriving detailed land cover information. eCognition was able to handle a large dataset and derive an accurate and comprehensive mapping product. The results strongly encourage the application of the derived land cover map in studies analyzing spatial urban structure, socio-economic characteristics and transportation infrastructure as part of a research project funded by U.S. Department of Transportation, Research and Special Programs Administration (OTA# DTRS-00-T-0002).

References:

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Figure 1: NDVI image subset (top), segmented image derived from IKONOS in channel 4,3,2 color composite (middle) and length/width ratio of the segmented image objects.

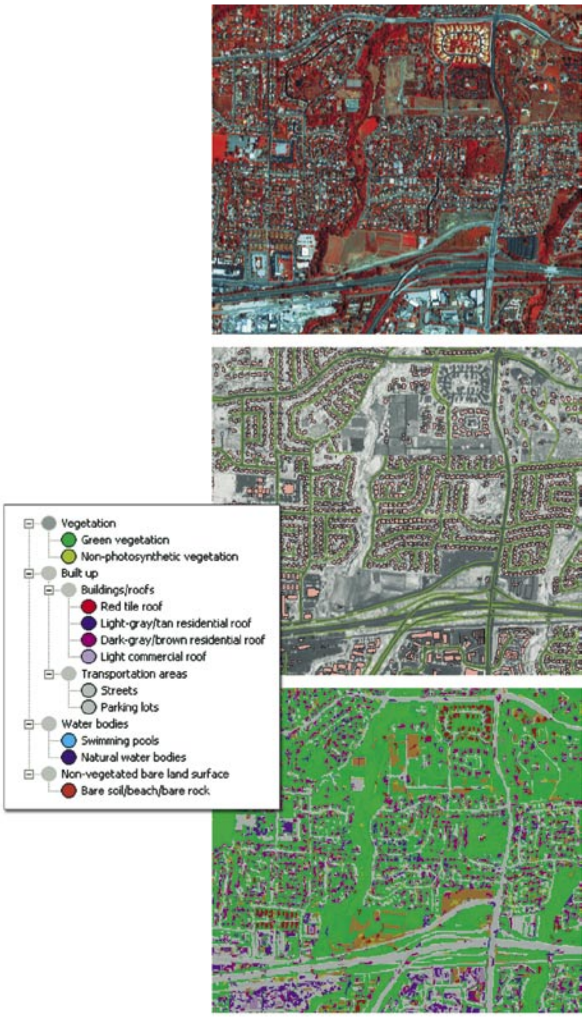

Figure 2: eCognition classification result (bottom) compared to IKONOS false color composite (top) and digital data representing house and roads overlaid the NDVI (middle).

User/Reference Class	Green Veg.	Red Tile Roof	Light Roofs	Dark Roofs	Streets/Parking Lots	Swim. Pools	Water Bodies	Bare Soil /NPV	Sum
Green Vegetation	103	2	0	6	8	0	1	3	123
Red Tile Roofs	0	109	0	2	2	0	0	25	138
Light Roofs	0	0	87	0	3	0	0	1	91
Dark Roofs	0	4	0	82	18	0	1	8	113
Streets/Parking Lots	2	1	13	20	86	2	4	7	135
Swimming Pools	0	0	0	0	0	51	0	0	51
Natural Water Bodies	1	0	0	0	1	0	67	0	69
Bare Soil/Non-photosynthetic veg.	2	13	2	8	9	0	0	72	106
Sum	108	129	102	118	127	53	73	116	826
Accuracy									
Producer	0.95	0.84	0.85	0.69	0.68	0.96	0.92	0.62	Overall
User	0.84	0.79	0.96	0.73	0.64	1.00	0.97	0.68	0.79

Table 1: Classification error matrix