Object-oriented land cover classification of panchromatic KOMPSAT-1 and SPOT-5 data

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***Abstract*—In this paper the use of an object-oriented classification approach for the identification of basic land cover types from panchromatic images is examined. Based on data recorded by KOMPSAT-1 and SPOT-5 the same classification procedure will be applied to both data sets and the results compared to a visual classification. Results show that a classifier which not only relies on the spectral values of individual pixels but rather on a number of features, calculated for previously identified image segments can be readily used for the semi-automatic classification of basic land cover types from panchromatic data. It is also robust enough to be able to analyze new data with minimal input by the user.**

classification, object-oriented, KOMPSAT-1, SPOT-5, panchromatic

I. Introduction

The spectral information of panchromatic data is very limited and even though they tend to have a higher spatial resolution they are seldom analyzed on their own by other means than visual image interpretation. In order to be able to make better use of the higher spatial resolution an image classification approach will be examined that not only relies on spectral values. It is based on previously identified image segments for which a large number of different features are calculated. These features are not only based on spectral data of these segments but refer to shapes, sizes, neighborhood, and so forth. An object-oriented classifier is then used to identify different land cover types. By applying a previously defined classification rule system each segment is assigned to specific class. This procedure will be applied to a subset of two panchromatic images, recorded at different spatial resolutions but covering the same spectral range. In order to examine the robustness of the classifier, the rules were developed for a satellite image and then applied to the second one, only adjusting those features, which directly refer to spectral values. Object-oriented classification has been applied in a number of studies using to multispectral high-resolution satellite data [1] and airborn scanner data [2].

II. Data and Study Area

The study area lies in Austria and covers parts of the Vienna Woods, an area protected since the 19th century. (see Fig. 1) Nevertheless, limited development is allowed to take place. The size of the study area is approximately 8 x 7 km².

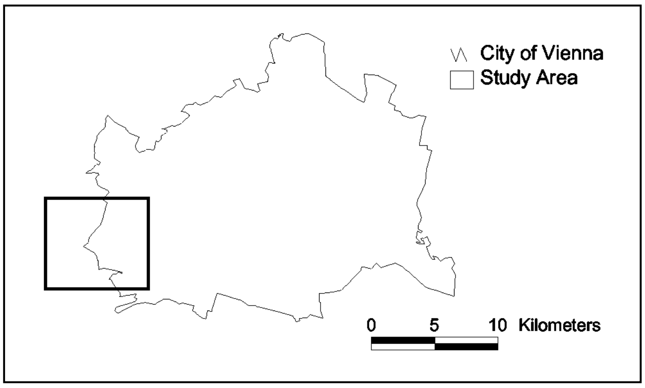

Figure 1. Study Area

Two panchromatic satellite images were available for this study. One was recorded by KOMPSAT-1 (Korean Multipurpose Satellite) in July 2002, the other by SPOT-5 (Satellites d'observation de la Terre) in August 2002. Their spatial resolutions are 6.6 m and 2.5 m respectively. The spectral resolution for both are 0.51-0.73 μm, with a radiometric resolution of 8 bit. KOMPSAT-1, launched in December 1999 is a part of a new family of satellites operated by the Korean Aerospace Research Institute (KARI). It is a push-broom scanner that orbits the earth in a sun-synchronous orbit at an altitude of 686 km and has a swath-width of 17 km.

SPOT-5, launched in May 2002 carries a number of cameras which record panchromatic and multispectral data at different spatial resolutions. It circles the earth in a sun-synchronous orbit at an altitude of 830 km. The data used in this study was created from two scenes, recorded simultaneously with a spatial resolution of 5 m –so-called supermode processing [3].

Fig. 2 shows the KOMPSAT-1 scene of the study area. It is widely covered with forest with numerous forest clearings. A motorway runs in the north of the image, urban areas are located in the northwest, northeast, along the motorway and in the southwest. Agricultural areas are located in the south and east.

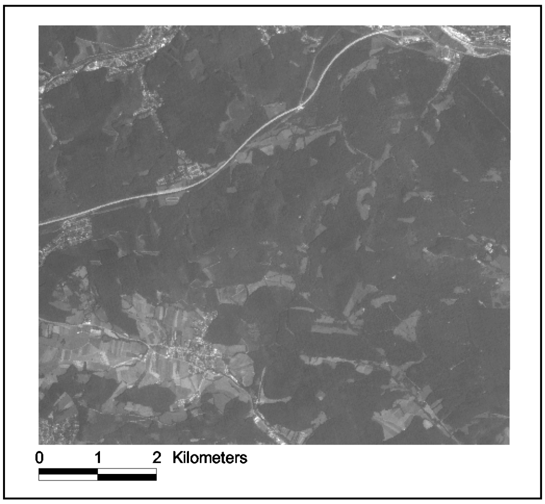

Figure 2. KOMPSAT-1 scene of study area

III. Object-Oriented Classification

The first step of the analysis is to identify image objects. This is done by using the multiresolution segmentation approach as implemented in the software package eCognition [4]. Aim is to divide the image into homogenous objects using the parameters scale, color, shape, smoothness and compactness. These parameters govern size, shape and spectral variation of each object. Single pixel objects are merged into bigger ones using an iterative procedure, resulting in objects with similar heterogeneity. Applying this procedure at increasing scales, building on the segmentation results of the previous scale, larger objects are created, whose borders are defined by those of the lower layers. In addition, segmentation can also be based on spectral differences alone, thus merging objects whose mean spectral values are below a defined threshold. For the following application both images were segmented separately into three layers. Layer one was segmented with a scale-parameter of 20, color 0.8 and shape of 0.2. For the second layer the spectral difference between neighboring segments was used (a difference of 1.5 for the KOMPSAT scene and 1 for the SPOT-scene). For the third level color was set to 1.

Classification was performed on all three levels. On level 1 only forest was classified on the basis of mean and standard deviation of each object. On level 2 streets were classified based on mean values and form parameters. A class called bright objects was classified on the basis of mean values. This was added to the urban class on level 3. Agriculture was also classified on level 2 based on area of objects and neighborhood to other agriculture objects. Forest clearing were classified on level 3 based on mean values and neighborhood to forest. Urban areas were classified on level three on the basis of standard deviation and proximity to other urban objects. As the classification rules can be applied for a specified number of cycles, neighborhood features can be used for the classification. Fig. 3 shows the classification results of the KOMPSAT data.

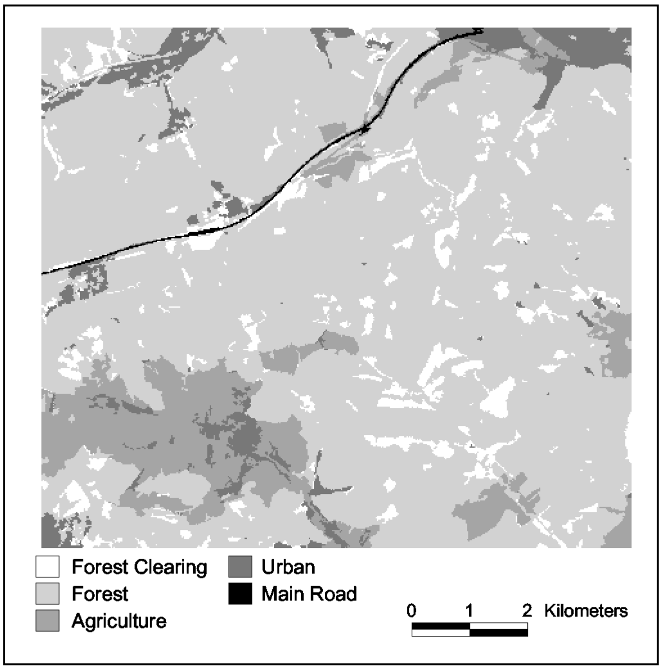

Figure 3. Classification of KOMPSAT-1 scene

Forest clearings are shown in white, forest in light gray, agriculture in medium gray, urban areas in dark gray and roads in black. When compared to the classification results of the SPOT-scene (see Fig. 4), similar patterns appear, although in some cases different classes have been assigned. This is especially the case for forest clearings, which are sometimes assigned to agriculture in the SPOT-scene and vice versa. In order to evaluate the overall performance, both classifications were compared to a visual classification of the segmented KOMPSAT-1 scene (see Fig. 5).

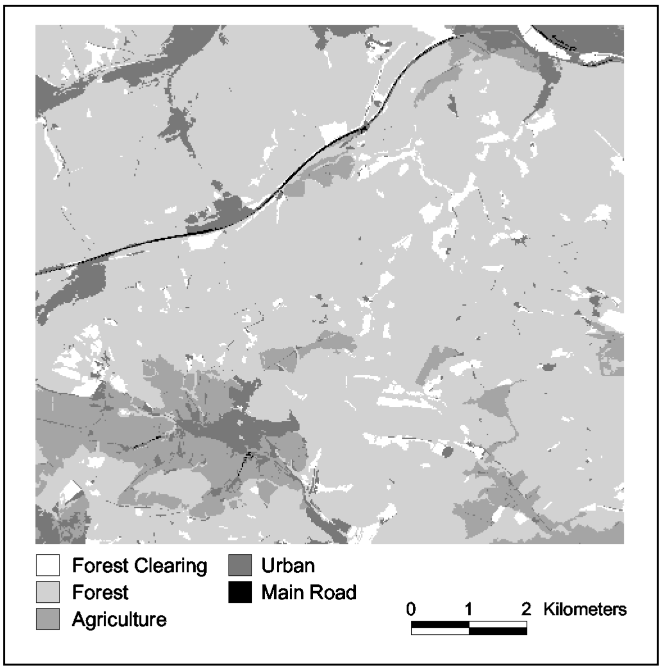

Figure 4. Classification of SPOT scene

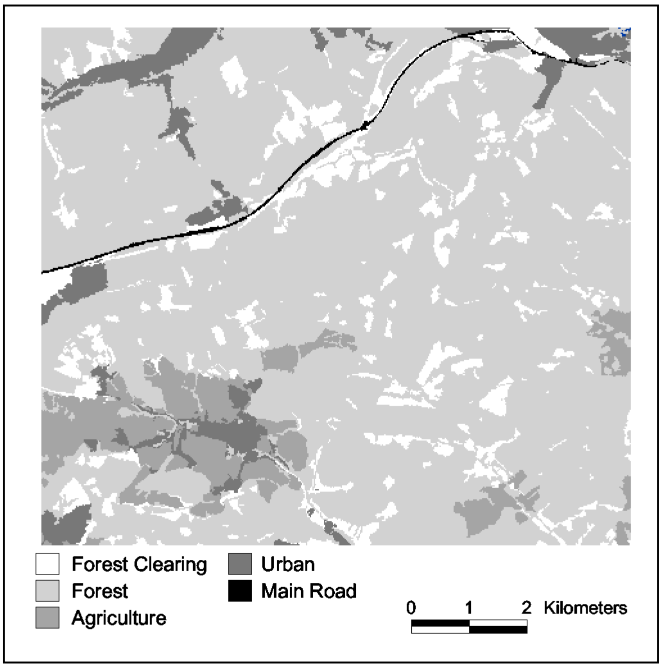

Figure 5. KOMPSAT-1 scene, classified by visual interpretation

The overall accuracy, when compared to the manual classification, is 89.9 % for the KOMPSAT-classification and 86.3 % for that of the SPOT scene. Forest has with over 90 % the highest producer's (probability that a sample from the classified image actually represents that class in the reference data) as well as user's accuracy (probability that a reference sample will be correctly classified) for both classifications. Agriculture has the lowest producer's accuracy of 63 % and open areas the lowest users accuracy for 52 % in the KOMPSAT classification. Urban areas have with 57 %the lowest producer's accuracy and forest clearings with 36 % the lowest user's accuracy in the SPOT classification. In both images the largest confusions are between agriculture and forest clearing as well as between forest and agriculture.

TABLE I. CONFUSION MATRIX OF KOMPSAT CLASSIFICATION (IN PIXELS)

KOMPSAT Classification	**Reference Data**						
	Urban	***Forest***	***Road***	***Forest Clearing***	***Agriculture***	***Sum***	***Producer's Accuracy (%)***
Urban	334,032	43,088	15,605	67,312	28,194	488,231	68.42
Forest	67,318	6,697,117	0	203,478	6,241	6,974,154	96.03
Road	855	1,002	31,420	2,408	0	35,685	88.05
Forst Clearing	33,510	83,160	1,138	516,074	6,663	640,545	80.57
Agriculture	66,568	111,027	701	196,547	648,249	1,023,092	63.36
Sum	502,283	6,935,394	48,864	985,819	689,347	9,161,707	
User´s Accuracy(%)	66.50	96.56	64.30	52.35	94.04		89.80

TABLE II. CONFUSION MATRIX OF SPOT CLASSIFICATION (IN PIXELS)

SPOT Classification	**Reference Data**						
	Urban	*Forest*	*Road*	*Forest Clearing*	*Agriculture*	*Sum*	***Producer's Accuracy (%)***
Urban	371,098	82,939	19,299	107,103	60,543	645,237	57.51
Forest	56,301	6,581,012	4,532	340,512	30,770	7,019,239	93.76
Road	4,334	841	19,707	1,020	77	25,998	75.80
Forest Clearing	10,761	133,526	1,107	363,619	26,864	535,117	67.95
Agriculture	59,789	137,176	4,219	173,565	571,093	936,116	61.01
Sum	502,283	6,935,394	48,864	985,819	689,347	9,161,707	
User´s Accuracy (%)	73.88	94.98	40.33	36.88	82.85		86.30

IV. CONCLUSION AND OUTLOOK

In this study two panchromatic images from KOMPSAT-1 and SPOT-5 were analyzed. An object-oriented classifier was used to identify five different land cover types (urban, forest, road, forest clearings and agriculture). In order to examine the robustness of the classifier, classification rules were developed for the KOMPSAT-1 scene and then applied to both data sets, only adjusting functions which refer to spectral values. The classification results were then compared to a visual classification of the KOMPSAT-1 scene.

The results show that an object-oriented classification approach not only allows a fast differentiation of basic land cover types, but can also be easily adapted to images recorded at different dates and with a different spatial resolution. The classification accuracy exceeds 86 % in both cases. As some classes are ambiguous (e.g. agriculture and forest clearing) some confusion still remains.

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