Advanced land use classification using polarimetric high-resolution SAR

Polarimetric multifrequency high-resolution E-SAR data was used to map an agricultural terrain in southern Germany. Using the object-oriented approach of Definiens eCognition an advanced rule base was defined to classify different basic land use classes and several crop types. The overall accuracy reached 86 %. This is comparable to a result derived from hyperspectral data using a similar concept.

Test site

The test site covers a 3,1 km by 2,3 km area near Alling located in the northwest of Munich. It is a mainly flat area on a fluvial terrace and represents a typical rural landscape with heterogeneous agricultural land use, grassland, forest and small villages. Main crop types are cereals (summer and winter barley, wheat, rye), corn and potatoes on relatively small fields (0,05 - 1,5 ha).

Dataset

The radar data (see fig. 1) were acquired with the airborne E-SAR system of the German Aerospace Centre (DLR) on June 16th 2000 (6 a.m.) and are part of the investigations of the project TerraDew (1) at the Friedrich-Schiller-University Jena (FSU). The SAR images were processed at DLR including polarimetric calibration, multilooking (2-3 m resolution) and geocoding. The computation of the radar backscatter coefficients, i.e. calibration, was carried out at FSU. In this study the following bands and polarisations were used: X-HH, X-VV, C-VH, C-VV, L-HH, L-VV and L-HV. No speckle filtering was necessary on these multilook images to achieve optimum segmentation results with Definiens eCognition. FSU carried out intensive fieldwork and the collection of ground truth for validation purposes.

Method

Objectives of this work are to classify the radar data with the object-oriented image analysis software Definiens eCognition and to differentiate land use very detailed, e.g. discrimination of different cereals.

As a first step, image objects are extracted by a knowledge-free automatic segmentation of the imagery. The patented segmentation technique of Definiens eCognition creates a hierarchical network of image objects in different scales, which represents the image information in different spatial resolutions simultaneously. The resulting objects have as attributes not only spectral statistics but also shape information, relations to neighbouring objects and texture. Texture is derived from the distribution of sub-objects in the hierarchical network. With this information a fuzzy classification of the image objects can be performed.

Rule base design

Figure 3 shows the concept of the classification. Three different levels of image objects have been created representing different scales. In level 1, very small image objects represent buildings or trees. They are used for subsequent feature extraction. Large ob-

Figure 1: E-SAR data of the test site Alling (June 16th 2000-6 a.m.), RGB composite L-HH, C-VV, L-VV.
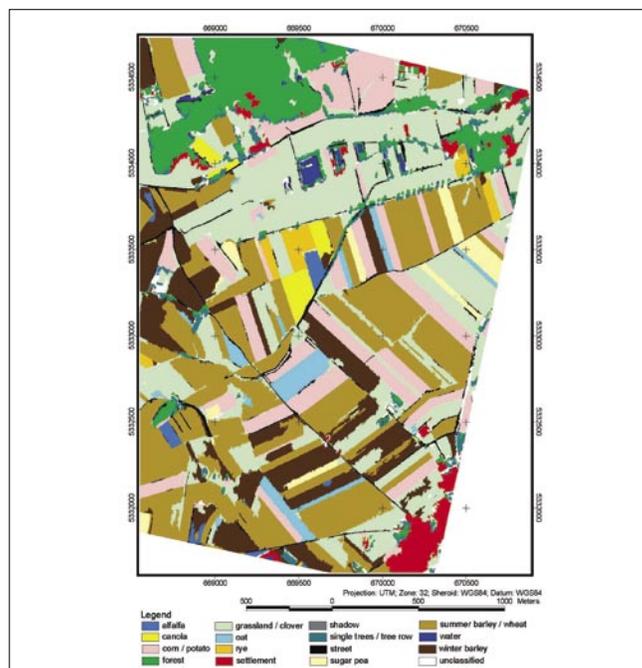

Figure 2: Object based classification result.

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jects on level 3 are classified as settlements if their sub-objects on level 1 have a high contrast. This feature is a powerful texture measure provided by the multiscale approach of Definiens eCognition, which makes it possible to examine texture based on sub-objects.

Level 2 is the main classification level. First, classified settlement objects in level 3 are transferred to level 2. Secondly, a fuzzy rule base, using spectral- and shape-information and class related features, classifies the remaining objects. In the available high dimensional feature space, grassland and crop types were easier classified using samples and the Nearest Neighbor classifier than by describing them with user-defined membership functions. However, membership functions are used to model local knowledge for classification
refinement, e.g. the assumption that areas completely or nearly completely surrounded by winter barley belong to winter barley.

Verification of the result

Ground truth was collected from 118 crop fields and over 50 grassland areas during the E-SAR overflight. In addition, settlement, water and forest areas have been digitised from aerial photomaps for verification purposes. The classification accuracy was only evaluated on fields, which were not used as training samples. The crop types alfalfa and canola were excluded from accuracy evaluation, because the number of fields was not representative. The classification accuracy for most of the remaining classes is very satisfying. The analyses of the users- and producers accuracies show that rye and clover obtain the lowest accuracies. Rye is confused mostly with wheat and clover with grassland. Because of its thematic similarity a mixed class „grassland/clover" was created. Settlement areas are also classified with high accuracy although some forest areas were misclassified as settlement. Definiens eCognition offers the opportunity to examine the quality of a classification not just with a confusion matrix but also to analyze the degree of membership to a specific class and its class-separability. This gives additional information: despite the high classification accuracies the separation of corn and potato respective summer barley and wheat is very low. Since it was an objective to create

a stable rule base that can be applied to datasets with similar characteristics these classes had to be grouped in a superior class called „corn/potato" and „summer barley/wheat". This was easily achieved in the Groups Hierarchy. The final classification result is shown in figure 2.

Summary

The presented study demonstrates the capability of multifrequent and multipolarimetric airborne SAR data in combination with the object-oriented image analysis approach of Definiens eCognition to classify land use very detailed with emphasis on agriculture. In contrast to a study with a conventional pixel-based classification the presented results show more homogenous fields, that are ready to use in Geographic Information Systems (GIS) and the classification accuracy was improved by more than 15 % (2). Parallel to this study, hyperspectral data of the HyMap™-sensor have been classified at the same test site (3). The work shows similar results, and in addition the possibility to distinguish between different forest types and to better separate forest and settlement data. However, the SAR system has important advantages due to its all-weather capabilities.

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Class	producers accuracy	users accuracy
Clover	45,9 %	93,0 %
Corn	98,3 %	97,4 %
Forest	96,5 %	94,5 %
Grassland	94,8 %	88,0 %
Oat	100 %	90,1 %
Potato	99,7 %	97,2 %
Rye	13,8 %	46,4 %
Settlement	77,6 %	93,4 %
Sugar pea	100 %	99,4 %
Summer barley	83,4 %	89,2 %
Water	90,6 %	100 %
Wheat	87,5 %	63,5 %
Winter barley	84,6 %	79,7 %
Overall accuracy	86,2 %	
Kappa Index	84,0 %	

Table 1: classification accuracies

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