eCognition and hyperspectral HyMap™ data allow advanced land use classification

Hyperspectral HyMap™ data were used to map an agricultural terrain in southern Germany. Using the object-oriented approach of eCognition an advanced rule base was defined to classify different basic land use classes and several crop types. The overall accuracy reached 83 %. The results are compared to a classification derived from multifrequency multipolarisation E-SAR data using a similar concept.
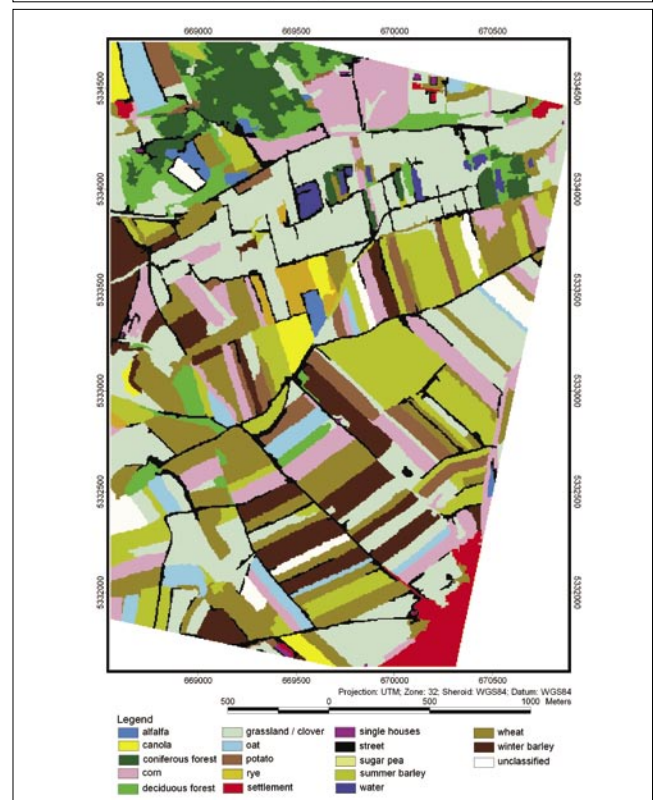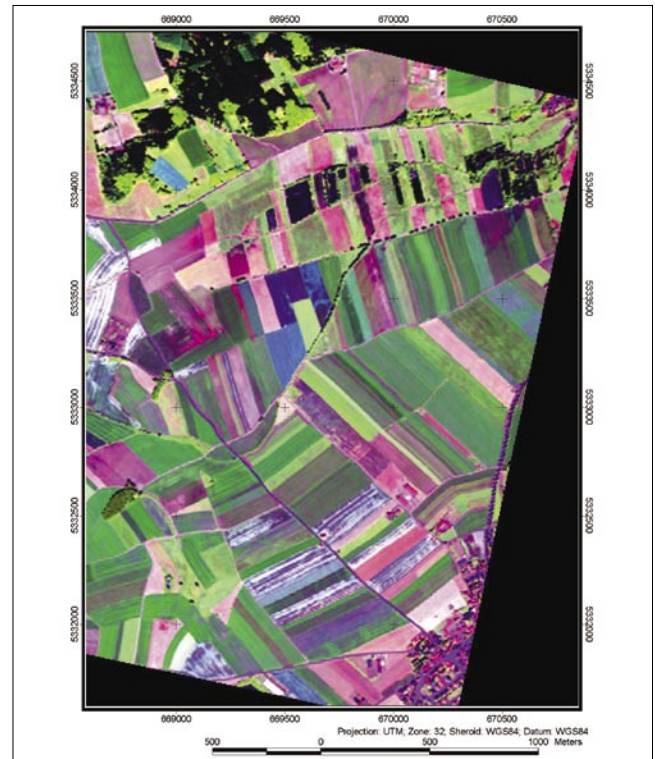
Test site

The test site covers a 3.1 km by 2.3 km area near Alling located 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 dataset used was acquired by the HyMap™ sensor on June 20th 2000 and was kindly provided by the German Remote Sensing Data Centre (DFD). The HyMap™ data consists of 126 bands covering the 0.44 - 2.5 mm spectral region. The spatial resolution is 5 m.

Pre-processing by Friedrich Schiller University Jena (FSU) included geocoding and data compression using a principle component analysis. No atmospheric correction was applied due to clear weather conditions during the overflight and the following nonquantitative classification analysis. For geocoding 100 ground-control points were selected to correct a subset of approximately 3.3 by 3.8 km with a „rubber sheeting" algorithm. The first four principle components, representing 98.8 % of the total variance, were used for further image analyses.
Rule base design Parallel to this study polarimetric SAR data were evaluated (3) and a similar rule base was used for both approaches for reasons of comparison. In both cases, three levels of image objects were generated representing different scales. Small objects on level 1 have meaningful spectral features, e.g. buildings are characterized by a high fourth principal component. Shape features are more relevant for higher levels. Hierarchical and local dependencies can be addressed, because eCognition not only creates the objects, but builds a multi-resolution network of these objects. Thus in this rule base neighboured buildings in level 1 are aggregated by classification based segmentation to parts of settlements an object in level 3 is assigned to class settlement, if a certain number of its sub-objects in level 1 are classified as buildings classifications of level 1 and 3 are transferred to level 2.

Level 2 is the main classification level. First objects are assigned to buildings as described above, then streets and water bodies are identified using fuzzy sets defined by membership functions on spectral and shape features. The remaining agricultural and forest objects are separated in 11 land cover classes using a

Legend
alfalfa | grassland / clover | single houses | wheat
canola | oat | street | winter barley
coniferous forest | potato | sugar pea | unclassified
corn | rye | summer barley
deciduous forest | settlement | water

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fuzzy approach of nearest neighbour classification. The results are refined using knowledge about spatial dependencies, which can be represented by fuzzy sets on the neighbourhood relations between objects on the same scale.

Verification of the result

Extensive ground truth was collected within the scope of the TerraDew(2) project by FSU some days before the HyMap™ overflight. With this, forty percent of the whole area was used to validate the result. The classification accuracy was only evaluated on fields which were not used as trainings samples. The crop types alfalfa and canola were excluded from accuracy evaluation, because there were too few fields in the test site for reliable results. The classification accuracy for most of the classes is very satisfying, especially considering the high number of classes (see table 1). Classes like rye or clover had low results due to spectral ambiguities. Because of its thematic similarity a mixed class „grassland/clover" was created.
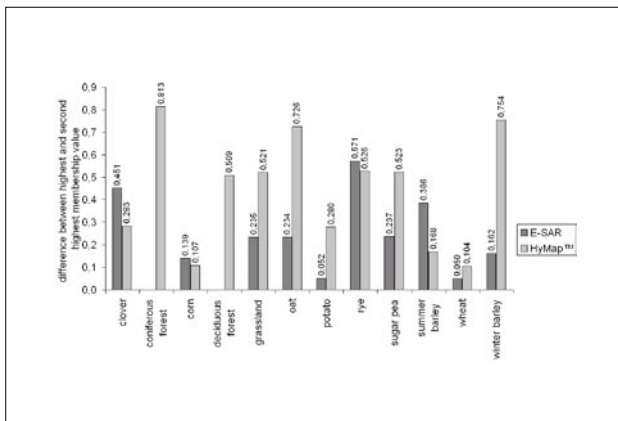

Figure 3: Comparison of E-SAR and HyMap™ classifications using the difference between best and second best class assignment

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

Though the overall accuracy of 83 % is somewhat below the result based on E-SAR data (86 %), some improvements could be achieved: it was possible to distinguish reliably between more land use classes and obtain higher class separation for most of these classes. The class separation was analyzed using the membership values of the fuzzy classification output. These values express the degree of membership of an object to all considered classes. The val- ues range from 0, representing no member-ship, to 1 repre-senting full membership. For the final („crisp") classification result (see figure 2) the class with the highest membership value is assigned to the object. The closer the difference between the highest and second highest membership value to 1, the more stable the classification. Figure 3 shows that most of the classes in the HyMap™ classification have higher differences to their next possible class, thus resulting in a more stable classification compared to the E-SAR result. For example, the assignment to potato and wheat differs by more than 0.1. In the E-SAR classification, classes with a difference below that were fused with the next possible class, thus resulting in the mixed classes „corn/potato" and „summer barley/wheat", which could be reliable separated in the HyMap™ classification.

Summary

The presented study demonstrates the suitability in classifying hyperspectral data with the object-oriented image analysis approach of eCognition. A high number of different land use classes, in a mostly agricultural area, could be distinguished. In comparison to another study with polarimetric E-SAR data(1) the overall accuracy is 3 % lower but more classes with a higher separability could be classified.

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References

(1) MÜLLER, A. (2001): eCognition - Advanced land use classification using polarimetric high-resolution SAR. - eCognition application notes, Vol. 2, No. 6, September 2001. http://www.definiens-imaging.com/down/notes/6-2001.pdf.

(2) SCHMULLIUS, C. & M. HEROLD (2000): TerraDew - Investigations about the Temporal Effects of Dew on Multifrequency and Multipolarimetric DLR E-SAR Radar Backscatter Signals. BMBF-Foerderkennzeichen: 50EE0035, Friedrich - Schiller - University Jena, Remote Sensing Unit, Institute of Geography.

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