EARTH CASE STUDY

IKONOS imagery classified with Definiens eCognition for a flood damage assessment

Recently, dramatic river flooding has occurred in several regions of the world: Bangladesh (1988), Rhine and Meuse (Netherlands, Belgium and Germany, 1995), Oder (Czech Republic, Poland and Germany, 1997), Yorkshire and Midlands (UK, 2000), Alps and Po (Italy, 2000) and Mozambique (2001). Damage caused by a flood can be determined by combining land use maps with flood depth maps. Using depth damage curves for each land use item, the damage can be determined as a mathematical relation of the depth of the water to the percentage damage to the land use class involved. Valuation data of land use classes can put a monetary value to the damage. Land use maps are readily available in different classification systems and scales throughout Europe. A constraint is that these land use maps are not interchangeable, while flood events occur many times at the transnational level. Land use maps can also be produced using satellite imagery, which is interchangeable. With the launch of IKONOS-2 in September 1999 one meter resolution images became available, and with this kind of data it is possible to distinguish those urban and suburban objects needed for a damage assessment

Data and Methods

The study was executed in the villages of Itteren and Borgharen and their surroundings in the south of the Netherlands. The area lies north of Maastricht between the river Meuse and the canal Julianakanaal and consists of a residential area together with farmers' fields and an industrial area, covering about 16 km^2, see figure 1. In January 1995 severe flooding occurred in this area. For this study a one-meter panchromatic sharpened multispectral IKONOS-2 image was used with blue, green, red and near infrared bands. In order to perform a damage assessment each possibly damaged element had to be identified on the satellite image and put into a land use classification system. These elements, like roads, buildings and arable land, are very diverse in space and spectrum. Recent experience has shown that pixel-based approaches for classification of remote sensing data are not very suitable for the analysis of very high-resolution images. Important semantic information necessary to interpret such an image is not represented in single pixels, but in grouped pixels, presented in meaningful image objects, and their mutual relations. Definiens eCognition uses a region-merging technique for segmentation. The different applications of the four spectral bands are crucial to creating homogeneous objects for the different land use classes and were either included or excluded in the segmentation process, depending on their functionality. Various levels were created, each emphasising the specific characteristics of the objects. The size of the objects was determined with the scale parameter. The colour parameter and shape parameter were used to emphasise either colour or shape of the objects. From the land use and land cover classification system followed the classes which needed to be extracted from the IKONOS-2 image. The class hierarchy was the knowledge base in Definiens eCognition. It contained all the classes of the classification system and allowed organising them hierarchi-

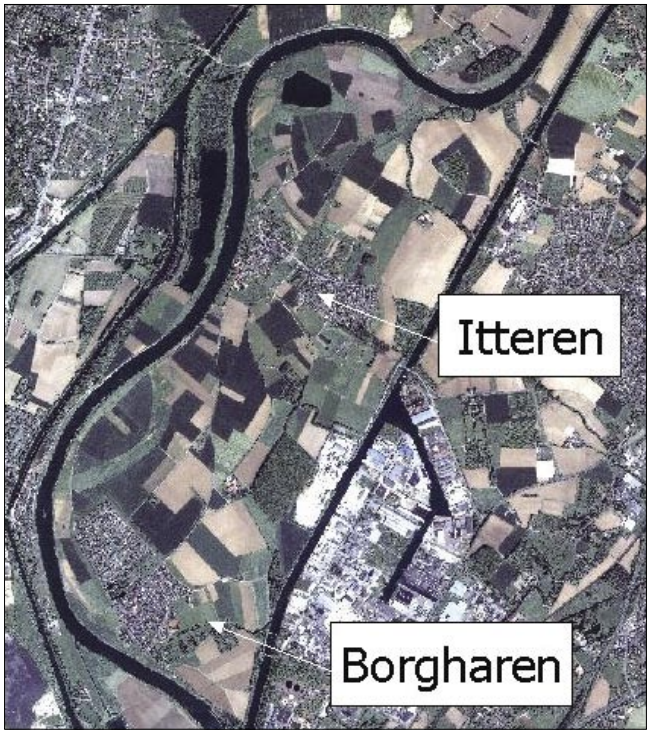

Figure 1: IKONOS-2 image

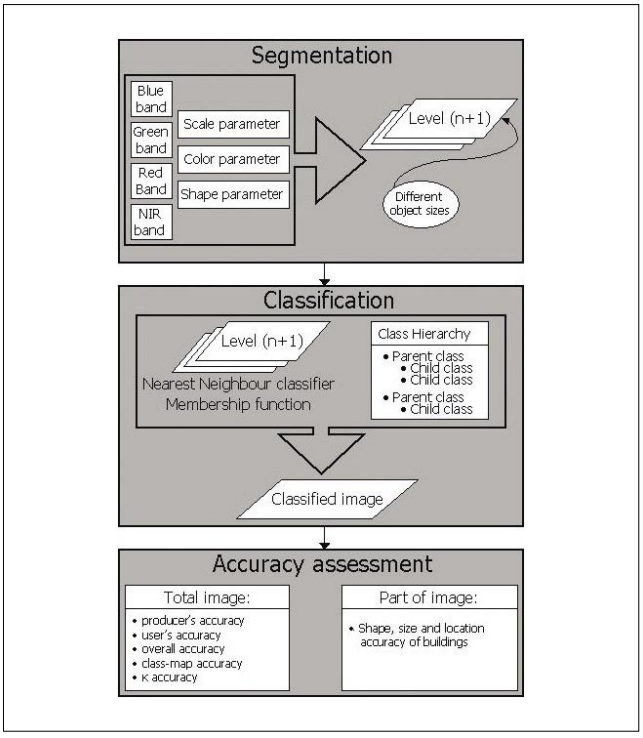

Figure 2: Entire classification process

cally. This hierarchy distinguished between the passing down of class descriptions from parent to child classes on the one hand (inheritance) and meaningful semantic grouping on the other. Prototype segment samples were chosen for each class in the class hierarchy to classify with nearest neighbour. Suitable features and expressions to describe the classes were formulated using membership functions, thus fine-tuning the spectral and spatial signature of each class. Subsequently the entire IKONOS-2 image was classified.The ground truth data used to make the supervised classification were: a scanned topographic map, two classified Landsat TM images for discriminating the various agricultural land use types, and the IKONOS-2 image itself. The quality of the damage assessment also depends on the quality of the classification; therefore, the classification was subjected to an accuracy assessment with the use of an error matrix. The river flood damage was determined using depth damage curves derived in the Netherlands for the different land use classes referring to the price level of 1995, see figure 3.

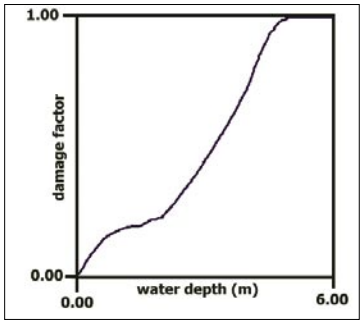

Figure 3: Depth damage curve

Results

The overall accuracy of the classification is 0.74. The KHAT accuracy is 0.70, indicating a reasonable classification, see figure 4. However, regarding the class map accuracies, the urban classes residential building, garden, road, and industrial company are confused with each other and have in general a class map accuracy of 0.50. Regarding the total area of residential buildings classified this is approximately in agreement with the ground truth data. However, location and shape vary a lot. Related to these data it was possible to make a damage assessment. Damage was calculated using depth damage curves and a water depth map (figure 5), see table 1.

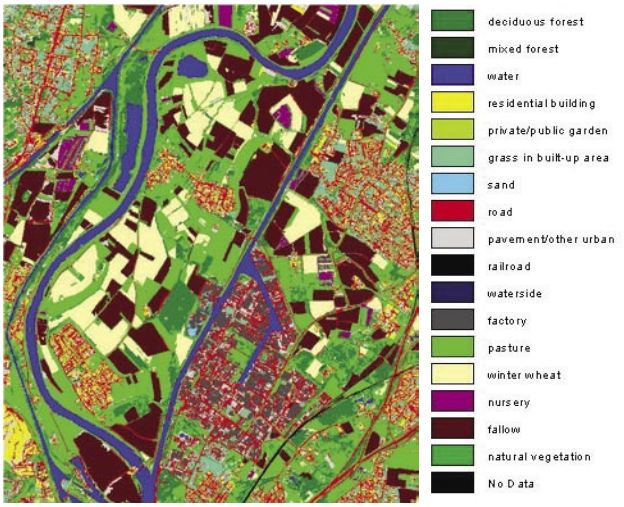

Figure 4: IKONOS-2 classification

Conclusions

Classification with Definiens eCognition of high-resolution images such as IKONOS-2 has the advantage of a huge amount of features for defining a class. Besides the spectral features, spatial features like area, length and width of objects really make a difference. Moreover, the ability to use relational features is very helpful, like relations to neighbouring objects or to objects from other levels with finer or courser segments. In the class hierarchy the classes are defined in a very logical and comprehensive way.

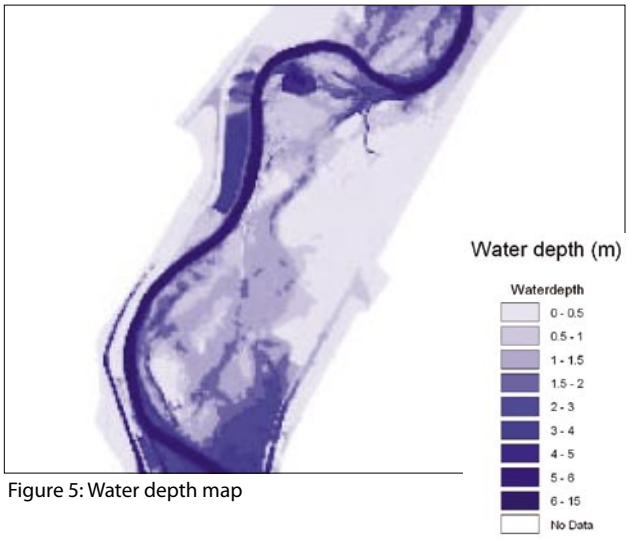

Figure 5: Water depth map

Land use classes	Damage in Euro
Residential building	66625248.80
Private/public garden	1252348.02
Grass in built-up area	68.20
Pavement/other urban area	313576.59
Water side	80634.24
Road	2650343.32
Railroad	0.00
Factory/agency	314739.34
Pasture	36500.29
Winter wheat	109625.46
Nursery	646916.68
Fallow	0.00
Natural vegetation	0.00
Deciduous forest land	0.00
Mixed forest land	0.00
Water	0.00
Total amount of damage (€)	**72,030,000.95**

Table 1: Calculated damage

All these characteristics of Definiens eCognition really reduce the complexity of assessing a classification of high-resolution images.

Author

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