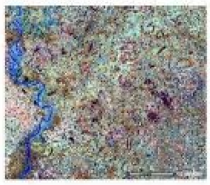
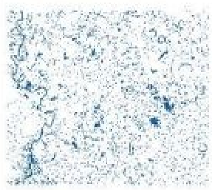
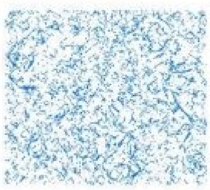
BEYOND THE SQUARES

Object-based Image Analysis







Looking at a satellite image one sees squares (i.e. pixels) representing landscape, although the actual shapes of roads, rivers, lakes, forest and nature reserve might more accurately be represented by lines, circles or irregularly shaped polygons. Over recent years earth observation has become an important data source, while image interpretation has been limited to squares the features of which are spectral variables: colours and invisible radiance determined by reflection-absorption behaviour of landscape objects as observed by satellite sensors.

As we view an image our eyes register its spectral characteristics (colour) and shape, the location of an object and its relationship to others in its immediate neighbourhood. We use all this information to decide what type of object it is. Traditional image analysis detects only spectral information, leaving shape, location and neighbourhood unconsidered. Objects of interest represented by pixels of 20 to 30 metres make them too small for us to recognise their shapes. The new generation of sensors, however, records images at a resolution of a few decimetres, increasing the number of pixels representing an object and allowing shape recognition.

OBIA
Object-based image analysis (OBIA) involves pixels first being grouped into objects based on either spectral similarity or an external variable such as ownership, soil or geological unit. Many variables may be determined, categorised as spectral, shape and neighbourhood. Examples of spectral variables are mean value and standard deviation of a specific spectral band; shape variables include size, perimeter and compactness; neighbourhood variables indicate, for example, the mean difference of an object compared to darker ones. Each object is also part of a ‘super-object', obtained by combining several neighbouring objects into one larger, and each can be subdivided into smaller objects: ‘sub-objects'.
Using OBIA, knowledge on a landscape may be included by introducing rules. When a group of trees, grass and water is found in the neighbourhood of dense housing it is likely to belong to a city park. In contrast, a group of trees surrounded by many others probably belongs to a forest. It is possible to make this distinction with OBIA, but not using traditional spectral image analysis. In general, OBIA provides increased accuracy and detail for classification purposes.

River Analysis
OBIA can also provide reliable products where traditional image analysis fails totally; for example, when spectral properties are indistinct. A study of the Ganges-Brahmaputra Delta in Bangladesh and India provides a clear illustration. Images immediately reveal how the landscape results from rivers meandering towards the sea. Over time there has evolved a complex of active and fossil meanders. In addition to the river channels one sees a finely scaled pattern of abandoned meanders filled with water or sediment or overgrown with vegetation, but always retaining the characteristic meandering shape. Whereas the spectral signatures of the (fossil) meanders do not unify them, their shape reveals their identity. Figures 1 to 3 of the Ganges-Brahmaputra illustrate this complex pattern, and where OBIA proves superior to spectral image analysis.

Land Use
Another example of innovative use of OBIA is in land use classification. ‘Land use' describes the function of an area, whereas ‘land cover' describes its physical appearance. There is no unique relationship between land use and land cover, so several land-cover classes may correspond to a single land-use class, and vice versa. For example, the land-cover class ‘Grass' can correspond to land-use classes such as agriculture, recreation, residential, or transportation; the land-use class ‘Residential' may include land-cover classes such as roof tiles, grass, and trees.
Land cover is responsible for the reflectance recorded in an image and it is difficult to deduce land-use information from images using traditional spectral image analysis. However, using OBIA to first subdivide an image into objects representing ownership, it becomes possible to create sub-objects based on spectral similarity and representing small land-cover patches that together fill in the ownership parcel. Analysis of spectral and shape characteristics of sub-objects enables land-use classification from images.

Stand Density
OBIA also opens up perspectives in cases where imagery and applications are not geared to one another. Take for example image-based estimation of stand density, an important forest inventory parameter reflecting number of trees per hectare. Traditional stand-density estimation techniques typically operate at stand level and rely on identification of individual trees by searching through the image at local

maxima: tree crowns. For each stand local maxima representing tree tops are then counted, yielding an estimation of stand density. Such an approach places great demands upon spatial resolution because each individual tree crown has to be identified. With degrading image spatial resolution small tree crowns become blurred, resulting in an underestimation of stand density.

Textural Character

In contrast, the spatial resolution of an image may be found suitable when tree shape deviates, as is the case of the doughnut-shaped common olive tree. Here the risk with local maxima techniques is localisation of several maxima on the same tree leading to systematic overestimation of stand density.

OBIA offers a solution by identifying tree groups as image objects and deducing the number of trees from textural characteristics. Stand density is thus no longer based on individual tree identification, but relies on small-area statistics characterising local texture. Such an object-based approach offers an additional advantage: judgment can be passed regarding within-stand density (semi-continuously).

The OBIA approach is very enlightening when applied to forest stands that are heterogeneous in age, species composition and spatial distribution of tree trunks (like many forest stand in Flanders, Belgium). Rather than working at stand level, OBIA offers the chance of working with objects corresponding to areas smaller than actual management units, providing a more reliable estimation of tree density.

OBIA Community

About a decade ago came launch of the first software package specialising in object-based image analysis: a revolutionary development in the remote sensing world that led to improvements within a wide field of applications. Over the past few years more packages have been developed, both specialised, and modules of existing image-analysis software.

An OBIA community is also emerging. In 2006 the first OBIA conference was held in Salzburg, Austria; in 2008 a second, renamed Geographic OBIA (GEOBIA) to distinguish it from medical applications, was held in Calgary, Canada; and the third will take place in Ghent, Belgium, in summer 2010. If your curiosity has been aroused, GEOBIA 2010 offers a great opportunity to immerse yourself in the world of object-based image analysis.

Further Reading

Blaschke, T., 2009. Object-based image analysis for remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing. doi:10.1016/j.isprsjprs.2009.06.004.