Definiens Developer

Has the world become more complex in the last few years? If we think of the „world“ in terms of the earth as a holistic system, it’s unlikely. But when it comes to our approach to asking questions about our world and generating relevant answers, then definitely yes. The latest generation of image data reflects this new complexity and demands solutions for effectively interpreting the huge flood of information and the high degree of detail available to us.

In the remote sensing field, the call for image data of an increasingly higher resolution has been heard. Today, the problem revolves around the evaluation of this vast amount of available image information and gaining value from it. The EU/ESA GMES initiative (Global Monitoring for Environment and Security), for example, relies on the use of image data for the observation of system flows and process chains, from maritime ecosystems to social security, from ship detection to vulnerability mapping. In addition, all ranges of scales are covered, from examinations in medicine and pathology to earth observation. It’s no wonder that the Nobel Laureate in Physics Dr. Gerd Binnig, the inventor of the scanning tunneling microscope, has developed the basic concept of the Definiens product range. His development opened up a new approach to image interpretation and was a significant co-determinant in the image processing paradigm shift.

Context matters” – Definiens takes a stand on its homepage. Context, it maintains, has to be captured using spatial concepts, and this requires bridging the gap between GIS and remote sensing. This bridge has been built successfully in recent years by object-based image processing. The approach has initiated a methodological paradigm shift, which is currently in the consolidation phase.

What Can the Software Do?
One core functionality of the Definiens product range is the segmentation and detection of spatial units. Fundamentally, segmentation covers two complementary procedures, namely aggregation (summarizing detailed information to units) and disaggregation (splitting into sub-units).

Data Handling and Integration
Definiens’ flexible data gateway enables completely different types of data to be loaded, which certainly includes image data, but also all kinds of raster data such as an elevation or surface model. In addition, vector data can be loaded as thematic layers, although these are converted into an internal raster representation. The key to integrating geo-data continues to be geo-referencing, but the „enforce fitting“ option („correct fit cannot be guaranteed“) can also be selected. The possibility of selecting a subset through the entry of coordinates or the interactive selection in a preview window has been maintained as is the allocation of alias names to individual channels and data layers. Descriptive names should be assigned at the beginning, since they facilitate working with information layers significantly. A current project can be modified at any time: For example, it is possible to remove individual channels or to load additional thematic layers or metadata into the active scene. Images with a „resample factor“ (e.g., 50 percent of the resolution) can also be loaded. Metadata can also be read in and co-administered as features in a proprietary format. The specific aggregation of loaded channels and additional data layers is referred to as „scene“ in Definiens Developer. This is important when working with rule sets, since there are separate features specific to scenes (e.g., total number of objects formed). The management of attribute data or (vector-based) geo-data is organized using tables.

Graphical User Interface
Definiens Developer boasts an advanced, comfortable and stable user interface (Fig. 1). Depending on the primary tasks, four layouts of windows and GUI elements are preset (load and manage data, configure analysis, review results, develop rule sets). The often laborious rearrangement of the numerous windows to find an optimum position is no longer necessary. As before, it is possible to move windows and change their size as desired, but the „expand“ and „contract“ buttons make this job easier.

All processes, including comprehensive segmentation algorithms, can be terminated efficiently using „cancel“, which opens a window warning from a premature interruption of the running process. Before comprehensive, complex processes are launched, the Process Profiler should be used to identify any loops that may be very time-consuming. For highly advanced, automated processes, the indication of the average processing time per object will provide valuable input for a cost/benefit analysis.

Class Modeling
The central goal of all image analysis software is classification. In Definiens Developer, the aforementioned, almost revolutionary, development is primarily the com-
bination of segmentation algorithms with rule-based classification procedures. As compared to „conventional understanding“ (see also GeoBIT Snapshot eCognition 4, May 2005), the sequence of segmentation and classification should no longer be conceived as a linear procedure, but as a cyclic process, which can best be described by the term class modeling (Fig. 2). However, as before, boundaries are provided using segmentations, whereby new units are created over and over again using temporary class assignment and spatial referencing of generated objects, until the final image objects are delineated and classified completely. Class assignment is achieved via a rule-based system, whereby rules can be created using „Cognition Network Language“ (CNL) or „samples“. Although, for pragmatic reasons, sharply defined class boundaries are primarily used in work with rule sets, the fuzzy classification known from eCognition is still possible and continues to be an adequate approach to „soft“ classification. The „Feature View“ is a powerful tool for displaying the numerous object properties and their value ranges graphically. The image objects are presented in the scene in a color gradation, based on the value of the relevant feature. This tool offers valuable help when searching for distinctively appearing objects. However, in the work with samples, it only offers visual control. Feature Space Optimization is an analytical instrument for assessing the suitability of individual features when selecting representative class samples.

Cognition Network Language

Not only has the name of the software changed with the launch of Definiens Developer: A completely new concept has been introduced, in particular the software structure. Process algorithms that in previous versions were only available to developers are, as of version 5, also available to the general user. They are embedded in a „process tree“ allowing for an automatic sequential processing of these algorithms arranged by the user. A real modular programming language has been developed through an extension of these algorithms by control structures (loops and branches) and the possibility of using variables. With the so-called „Cognition Network Language“ (CNL), the user has been provided with structures which offer a multitude of new options related to object-based image analysis - but which also move the responsibility toward the user and away from a more isolated approach.

As an example, we would like to mention „multi-resolution segmentation“: In eCognition (up to version 5), this segmentation algorithm was an indispensable entry point to generate and classify image objects. In Definiens Developer, this segmentation algorithm is only one out of many - although, without doubt, the most important one. Now, the software not only offers many additional segmentation algorithms, but also the option of addressing individual image objects directly via CNL. In this way, objects can be summarized pursuant to specifically defined rules, split within object domains and, on principle, specific segmentation routines can be implemented (Fig. 3).

To avoid the necessity of programming again and again frequently used code parts of rule sets programmed in CNL, the software now offers the possibility of importing and exporting „snippets“. These snippets can be used in rule set development via drag and drop. Rule sets programmed in CNL can also be exported as a whole and transferred to other images. However, for the automated application to n images, a Definiens eCognition® Server license is necessary (see also Product Lines and Extension Levels).

Accuracy Assessment

To evaluate the quality of a classification, there are several methods of accuracy assessment, which all refer to the class assignment of the formed objects. To be differentiated are „best classification“ (the class with the highest membership value) and „classification stability“ (the reliability of the classification) as well as the presentation of error matrices. However, the accuracy assessment does not cover the type of delineation (adequacy of drawn boundaries, generalization, etc.).

Manual Object Editing

Definiens Developer offers a range of editing options for manual optimization of objects or their delineation (Fig. 4), consisting of a series of digitization tools for removing („object merge“) and adding („object split“) boundaries, and for changing the label.

Image Pre-processing

Definiens Developer 7 is a first step towards pixel-based image pre-processing. Some of the filter algorithms such as edge detection filter or convolution filter can now be applied directly as process algorithms; several useful and convenient image pre-processing stages have been integrated in this way. However, it cannot replace a complete image processing software comprising all steps of image pre-processing.

In addition to this extended functionality enabled by integrating established methods, the new version also aims to offer better interaction of the software with existing structures. These include, for example, extended data importing and enhanced shape file exporting, a Software...
The two poles are Definiens Developer, which is a development environment, and Definiens Viewer used to visualize and review results. The range of desktop tools is completed by Definiens Architect, a tool for configuring tailor-made applications, and Definiens Analyst, an analysis application that interacts with Definiens eCognition® Server.

Definiens eCognition® Server is the powerful heart of the entire Definiens Enterprise Image Intelligence™ Suite and has been designed primarily for environments processing massive data throughput. Through parallel processes adapted to each other and so-called „tiling“ (virtual tiling of large scenes), the user can edit complex scenes, for example, with pan-sharpened SPOT mosaics. This allows for fully automated workflows of (batch) processing of huge data volumes.

Definiens Extension for ArcGIS now also provides the physical bridge between remote sensing and GIS for ArcGIS users. However, it is not a „full version“ offered as an extension. It can be compared best with the overall functionality of Definiens Analyst and supports the application of existing rule sets for performing image analysis.

The licensing model of the Definiens Developer software is based on a flexible modular structure (FlexLM), whereby the floating licenses managed by a server can be temporarily activated and deactivated as workstation licenses.

**User Guidance and Help**

The software comes with advanced tutorials, a user guide and a description of all process algorithms. Regular webinars (online seminars) on various topics are offered, and the website includes links to scientific papers and case studies. Problems are discussed.

**Product Lines and Extension Levels**

The Definiens product range is offered by functionality and application fields: The two poles are Definiens Developer, which is a development environment, and Definiens Viewer used to visualize and review results. The range of desktop tools is completed by Definiens Architect, a tool for configuring tailor-made applications, and Definiens Analyst, an analysis application that interacts with Definiens eCognition® Server.

**Wish List**

These are the authors’ most important proposals for improving Definiens Developer

1. An online library would be helpful for exchanging CNL program codes. It could help meet the demand of many research institutions for sharing rule sets.
2. The start of a process chain with „insert child“ is slightly technocentered. Dragging processes to another hierarchy is also somewhat cumbersome. There should be an option to append new rule sets at the bottom or at the top.
3. An undo function in manual editing mode would be desirable.
4. For the Multiresolution Segmentation algorithm it is worth considering designing shape optimization independent of spectral homogeneity and separating the two aspects from each other.
5. The entire software is built on a strict object hierarchy (common boundaries). Introducing scale-specific, generalized delineations should be considered in order to account for the increasing generalization at lower mapping scales.
6. The implemented region-based segmentation algorithms could be rendered „more intelligent“ so that, e.g., geographical features with heterogeneous spectral properties but regular structures are „recognized“ immediately. It should be possible to suppress (optionally) sliver objects in spectral transition areas.
7. The classification using the class hierarchy with fuzzy values is still possible, but the process tree tempts the user into following a highly procedural image analysis sequence. It would be practical to offer the fuzzy allocation as a distinct process.
8. The integration of spatial concepts would be conceivable to improve the accuracy assessment (comparison of automated object delineation with manual digitization).
9. In metadata management, geo-data standards or at least XML support would be desirable.
The Centre for Geoinformatics (Z_GIS) has created teaching materials on the general theoretical background of object-based image analysis (OBIA), which are available from the authors of this article on request. The Resource Center on the Definiens homepage is the place to find scientific publications discussing the object-based approach of image analysis. The proceedings of the 1st International Conference on Object-based Image Analysis (OBIA 2006) are available online at http://www.commission4.isprs.org/obia06.

**Conclusion**

Definiens Developer sets new standards in automated image analysis. Its comprehensive possibilities and the almost unlimited usability of object properties as well as the combination of processes offer numerous new options for intelligent image understanding. But they also mean more responsibility on the part of users and experts. From the technical standpoint, transferability across different scenes is excellent. It is a fact that Definiens Developer is a significant step in analyzing and understanding complex image content. Whether the software is really better, faster, more efficient and more precise than human cognitive power or is, at best, able to „see“ what the human eye captures, has to be based on an evaluation of concrete cases.

**Editors**

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**Cooperation with Z_GIS**

The Centre for Geoinformatics Salzburg (Z_GIS) is the interdisciplinary centre for research and further education within the overall Department of Geoinformatics at Salzburg University. Z_GIS stands for innovative and applied research and development. In cooperation with GIS-Business, the Centre publishes its reviews of programs appearing in „Snapshot“. 