

Definiens in Defense and Security

Deeper insights
Faster results
Better decisions

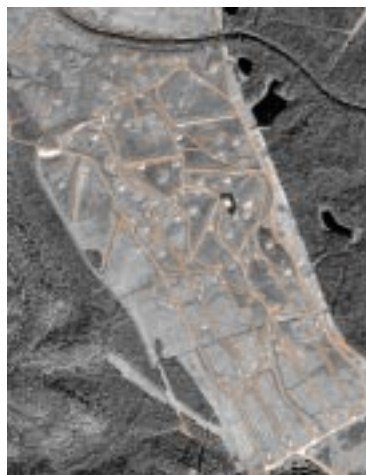


Image Analysis in Defense & Security

Agencies responsible for providing geo-intelligence face a growing challenge: how to extract relevant information in a timely manner from a growing number of images.

Expert image analysts are a finite resource. As the burden on them grows, intelligence can often be overlooked and valuable data can be archived without ever being analyzed. The consequences fall in the field, where opportunities to improve missions are missed and people and material are exposed to unnecessary dangers.

With the open trade of military equipment between nations and the cooperation of various task forces, the challenge facing image analysts in both target recognition and feature extraction has become even harder.

Similarly the changing emphasis from 'war' to 'terrorist attack' means that the variety and difficulty of mapping tasks has increased. Background objects may now be targets. Any area of the world could suddenly become the region of utmost interest and increasingly fast delivery of geospatial information is required to support decision making.

The analysis bottleneck

Image analysis and information extraction is the primary bottleneck in geo-intelligence. Data can be rapidly provided from multiple sources and information can be distributed quickly and securely.

But information extraction remains largely a manual task conducted by experts.

Automated image analysis

Attempts to automate image analysis and information extraction have been continuing for decades. But despite increases in computational power and imaging capabilities, fundamental advances in automated image analysis have been limited.

The heart of the problem is that for any image there may be many plausible interpretations: it requires great experience to determine the correct interpretation with confidence. The difficulties take the form of varied shading and colors, partially-hidden objects, identifying targets from vague indicators and determining three-dimensional depth from two-dimensional projections.

Experienced image analysts resolve these ambiguities with a high degree of accuracy. But how can a computer duplicate what goes on in the brain of an analyst?

"For future analysts who will face information overload, it is imperative to find ways to reduce the time required to screen imagery as well as assist them in queuing images for examination."

**Dr. Keith Littlefield,
former Director of
Innovation at NGA**

Definiens Cognition Network Technology[®]

Definiens Cognition Network Technology[®] has been developed by Gerd Binnig, the 1986 Nobel Laureate for Physics and his team. It emulates human cognitive processes, extracting intelligence from images.

The technology examines pixels not in isolation, but in context. It builds up a picture iteratively, recognizing groups of pixels as objects. Just like the human mind, it uses the color, shape, texture and size of objects, as well as their context and relationships, to draw the same conclusions and inferences that an experienced analyst would draw.

The result is the world's leading solution for fast, accurate geo-spatial information extraction from any kind of remote sensing imagery.

Definiens' Approach

Definiens' technology can create highly automated feature extraction, target detection and recognition applications for all modern remote sensing instruments including SAR, Lidar, panchromatic, multispectral and hyperspectral sensors mounted on satellite and aerial platforms.

The technology even correlates image analysis with a variety of intelligence sources to provide greater insight and generate reliable image based information for situation awareness.

Definiens' technology assists defense and security operations in three vital areas:

- **Rapid Mapping and Feature Extraction:** Highly automated mapping provides a fast, accurate and up-to-date overview of remote terrain which assists in the planning of military or humanitarian aid operations.
- **Change Detection:** Broad area change detection identifies changes over any period of time helping, for example, to assess damage after disasters, monitor reconstruction or track targets.
- **Assisted Target Detection and Recognition:** Definiens' technology determines not only the geo-position, shape and dimensions of objects but other attributes like the relation of objects to each other. These attributes help greatly to speed up identification and recognition.

DEPLOYED AROUND THE WORLD

Definiens' applications are used by governments, commercial entities and research organizations around the world and play an important role in international projects such as GMES (Global Monitoring of Environment and Security), NGA's STAR (Synergistic Targeting Auto-extraction and Registration) Program and RIUGV (Remote Imaging for Unmanned Ground Vehicle).

Rapid Mapping and Feature Extraction

Rapid mapping and feature extraction supports time critical missions in unfamiliar territory and is vital for both military and humanitarian operations.

The imagery and data required is usually provided by remote sensing from satellites, aircraft or unmanned aerial vehicles (UAVs). Until now, a timely automated information extraction from this data was simply not possible.

However, Definiens Cognition Network Technology® has demonstrated major success in rapid mapping. Powerful, automated vectorization is combined with highly efficient semi-automated tools delivering, for example, a detailed and reliable drivability map for large areas in a matter of hours.

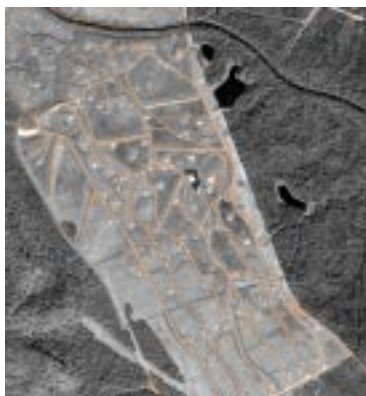
Example: Terrain mapping for unmanned vehicles

In a joint project with Lockheed Martin Missiles and Fire Control, Definiens developed an automated feature extraction and object detection application for unmanned vehicle navigation.

Field tests conducted by the US Army Tank Automotive Research and Development and Engineering Center (TARDEC) at Fort Knox were the first time that unmanned vehicles successfully followed a combined off-road / on-road route relying on automatically generated terrain data and object detection from space-borne imagery.

The flexibility of the technology allows maps to be generated using whatever remote sensing data are available. Basic features can be extracted accurately from panchromatic satellite imagery and single channel SAR data. Advanced 3D feature categorization is possible using multispectral imagery, Lidar or advanced SAR.

Automated feature extraction from IKONOS imagery and metadata for rapidly updateable multi-scale mobility maps



A IKONOS satellite imagery with road center lines



B Basic land cover polygons



C Basic land cover polygons (detail)

Change Detection

The detection of terrain and land cover changes is one of the most important and time-critical mapping tasks.

There is an urgent need for automated change detection. The challenge is to differentiate a large number of non-relevant changes from the relatively few critical changes with as few false alarms as possible. Usually, the imagery is acquired by different sensors, under different lighting conditions and in different seasons, which make the simple and direct comparison of data impossible.

Because Definiens Cognition Network Technology® is object-based rather than pixel-based it can provide an intelligent comparison of data and information giving an extremely efficient and accurate change detection for land cover and targets.

Example: Damage assessment in Falludjah

In 2004, the US attacked targets in the city Falludjah from the air. By comparing two IKONOS images, one before the campaign and one after, it was possible to identify precisely which buildings had been damaged and destroyed. The damaged buildings were captured as attributed polygons, ready for input into a geodatabase.

The damage assessment application was developed in a very short amount of time by reusing the modular ruleware which had already been developed for a rapid mapping application.

Damage assessment in Falludjah, 2004



A Falludjah, September 12, 2004



B Falludjah, November 24, 2004



C Vector layer: distorted buildings

Target Detection and Recognition

The detection and recognition of objects is an essential task of geo-intelligence. Simple image analysis alone is not enough; it is necessary to analyze the entire situation based on the relation of objects to each other.

Definiens' multiscale object network explores the image, the objects it contains and the relations between them on multiple levels.

So, for example, a ship could be identified as a small ship in the neighborhood of a large cargo vessel (same level) or as an unexpected type of ship within the military area of the harbor (first super-level) which itself is part of a specific harbor (second super-level).

Fuzzy Logic is integrated as a core classification method within Definiens' technology. It handles the ambiguities and variations arising from sensors, different operating conditions and vague models. The results are transparent and reproducible and provide an extremely high degree of consistency.

Example: Assisted submarine detection and recognition

A US Government agency assessed Definiens' technology for submarine detection and recognition based on panchromatic satellite imagery (QuickBird). Four major advantages of Definiens' technology emerged from the study:

- The submarine detection application works with black-and-white imagery which is the major image source for intelligence.
- The application works with commercially available imagery.
- Fully automated detection can be incorporated in the upstream process of image triage.
- The application aids recognition by providing multiple attributes including object shape, relative and absolute object position and classification confidence.

The results can be stored in a geodatabase and exported to a freely configurable html report for rapid transmission from experts to decision makers, speeding up the decision making process.

ANALYSIS

Type of Data:	QuickBird, panchromatic
Location:	Quingdao
Imaging Conditions:	Very good
Diesel electric submarines:	5
Nuclear submarines:	0



Within the panchromatic satellite imagery (QuickBird) five vessels are detected as image objects and categorized as diesel submarines (red objects). The result is ready to be used in a geodatabase to monitor statistical movements in the area and to detect anomalies.

Object ID	Classification	Confidence	Length (m)	X center (Px)	Y center (Px)	Snapshot
1	Diesel Submarine	1.0	67	284	456	
2	Diesel Submarine	0.9	61	272	229	

The object attributes, classification, confidence of classification, object length and object position are automatically exported together with a snapshot of the object and an object ID in a spreadsheet.

The Definiens Edge

Definiens Cognition Network Technology® surpasses every other automated image analysis system today across nine different criteria delivering faster results, deeper insights and better decisions.

Deeper insights

Definiens handles complex real world situations.

The multi-scale object network can explore an image, the objects in it and the relations between them simultaneously on multiple levels. The technology can even detect anomalies due to the constellation of targets, like cars queuing up in a line in front of a building. At the same time, the Fuzzy Logic handles uncertainties due to sensors, varying operating conditions and vague models.

Definiens fully supports a multi-source environment.

Definiens' technology interprets all types and combinations of modern spaceborne and airborne sensors including panchromatic, multispectral and hyperspectral optical imagery, infrared, LIDAR, single channel, multifrequency and multipolarimetric SAR.

Definiens extracts, measures and quantifies data directly.

Definiens' powerful data structures allow extraction of exactly the relevant data at the right time significantly reducing complex and time consuming post processing. The measurement and quantification can be fully automated delivering accurate, consistent results.

Faster results

Definiens' applications can be developed in a fast and modular way.

Applications can be developed rapidly by combining existing ruleware modules. Complex tasks can be addressed with the full power of Definiens Cognition Network Technology®, which in turn creates ruleware that can easily be reused in other situations.

Definiens' applications identify the most important images and the areas of interest within them.

Definiens' applications perform automatic image triage, directing the attention of image analysts to the key areas of interest on the most important images. The technology is massively scaleable, making it capable of automatically processing large numbers of high resolution images.

Definiens enables analysts to extract accurate information more efficiently.

User friendly interfaces support the workflow of imagery analysts, enabling them to integrate additional data and imagery, and ensure high interoperability with GIS. For example, smart object-based editing greatly speeds up the review and upgrade process of automatically derived information.

Better decisions

Definiens provides reliable information for decision making.

The easy-to-use knowledge base creates a fully transparent extraction process. The deterministic approach ensures all results are fully reproducible while the fuzzy classification provides the detection confidence for each object.

Definiens integrates image intelligence across existing processes.

Definiens' technology integrates easily into any intelligence environment. As a result, it supports end-to-end intelligence processes maximizing the combined value of intelligence from all sources. The seamless interoperability between applications for land, sea and air and between feature extraction and target recognition contributes to an unparalleled image-based situation awareness.

Definiens will continue to lead the field.

The unique patented software, built on an open standards-based architecture, represents a new paradigm in automated image analysis. Gerd Binnig and his team continue to lead the research and development at Definiens, ensuring that the technology will remain at the forefront of enterprise image intelligence.

Definiens Cognition Network Technology® offers a massively scalable technology to meet the challenges of automated and assisted feature extraction, change detection and target recognition.

If you are interested in learning more about how Definiens' technology could address the challenges you face, please contact us at info@definiens.com or visit our web site at

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Understanding Images

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