# GEO-INTELLIGENCE INSIGHT

IMAGE ANALYSIS FOR FASTER RESULTS, DEEPER INSIGHTS AND BETTER DECISIONS FOR SECURITY AND DEFENCE. GOVERNMENT AGENCIES RESPONSIBLE FOR PROVIDING GEO-INTELLIGENCE FACE A GROWING CHALLENGE. COMPUTATIONAL POWER AND IMAGING CAPABILITIES HAVE INCREASED VASTLY, YET, HIGHLY SKILLED IMAGE ANALYSTS ARE A LIMITED AND SCARCE RESOURCE.

As the burden on them grows, intelligence can often be overlooked and valuable data may 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. What appears to be background objects may now be targets. Any area of the world could suddenly become the region of utmost interest and increasingly fast delivery of geo-spatial information is required to support decision making.

**The challenge: how to extract relevant information in a timely manner from the growing number of images**

Image analysis and information extraction is the primary bottleneck in geo-intelligence. Today, data is rapidly accessible from multiple sources such as SAR, LIDAR, pan-chromatic, multi-spectral and hyper-spectral sensors mounted on satellite and aerial platforms and information can be distributed quickly and securely. Information extraction, however, remains largely a manual task conducted by the image analysis experts. Attempts to automate image analysis and information extraction have been continuing for decades. Yet, fundamental advances in automated image analysis remained

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 can a computer duplicate what goes on in the brain of an analyst?

### Extracting intelligence from images by emulating human cognitive processes

The human mind is phenomenally proficient in extracting pertinent information from any given data. One of the most interesting and innovative developments in technology is the cognition network, a technology which emulates human cognitive methods and implements them in a computer-based system. 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.

### Assistance in defense and security operations

There are three vital areas where the automation of image analysis, based on emulating the human cognitive process has already proved to be a strategic advantage. These areas revolve around rapid mapping and feature extraction, change detection, as well as assisted target detection and recognition.

Governments, commercial entities and research organizations around the world have already used this new technology and it plays an important role in international projects such as GMES (Global Monitoring of Environment and Security), NGA's STAR (Synergistic Targeting Autoextraction and Registration) Program and RIUGV (Remote Imaging for Unmanned Ground Vehicle).

*Rapid mapping and feature extraction* supports time critical missions in unfamiliar territory and is fundamental for both military and humanitarian operations. The imagery and data required is typically provided by remote sensing from satellites, aircraft or unmanned aerial vehicles (UAVs). Timely automated information extraction from this data was simply not possible until now. The cognition network technology, however, has proved to be successful in rapid mapping. It combines powerful, automated vectorization with highly efficient semi-automated tools, able to deliver a detailed and reliable drivability map for large areas in a matter of hours.

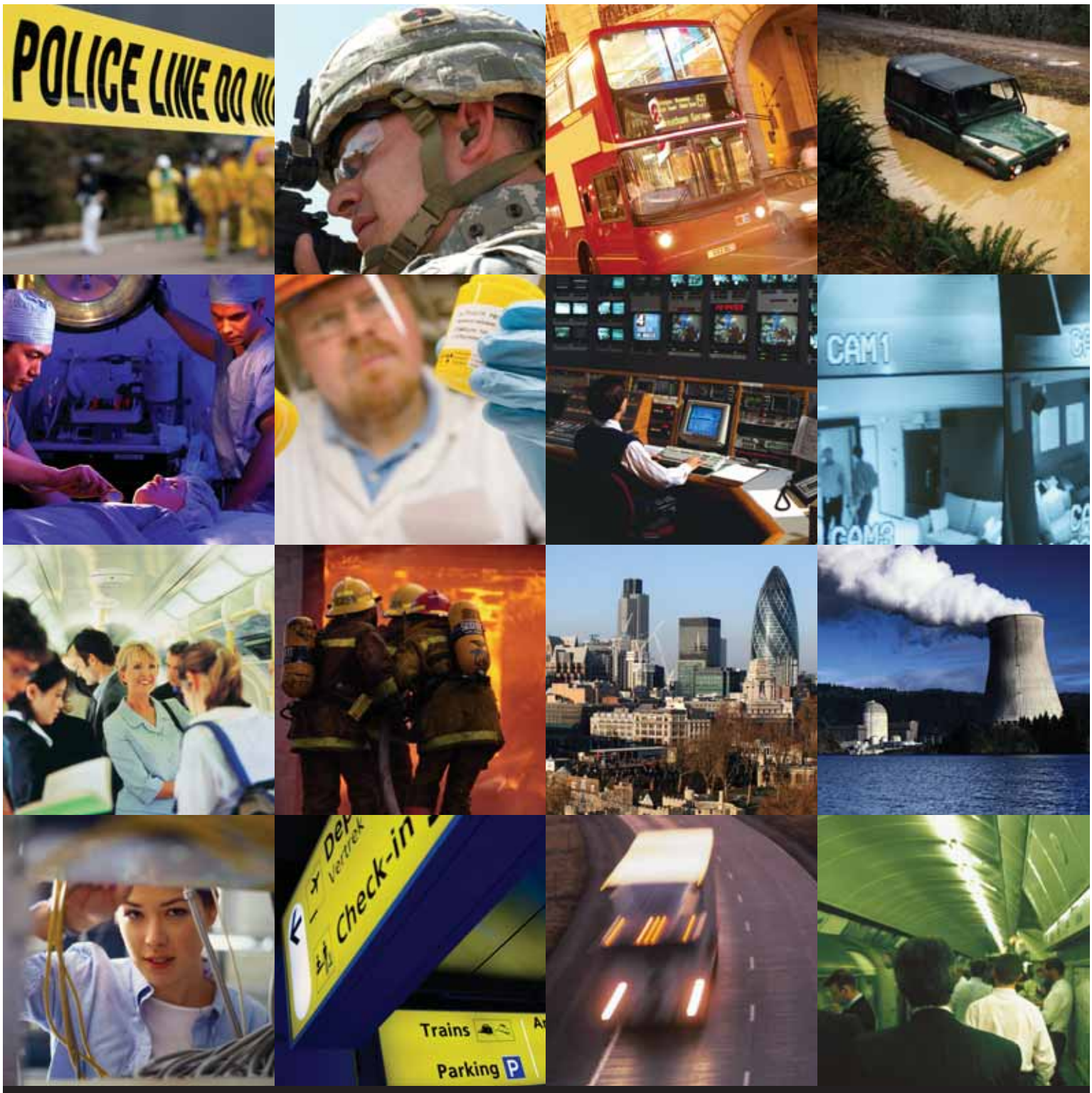
First image of the area under study.

In the area of terrain mapping for unmanned vehicles, Lockheed Martin Missiles and Fire Control have used the cognition network technology to develop an automated feature extraction and object detection application for unmanned vehicle navigation. In field tests conducted by the US Army Tank Automotive Research and Development and Engineering Center (TARDEC) at Fort Knox, unmanned vehicles successfully followed a combined off-road / on-road route for the first time. They relied on automatically generated terrain data and object detection from space-borne imagery.

The cognition network technology is flexible enabling maps to be generated using whatever remote sensing data is available. Basic features can be extracted from panchromatic satellite imagery and single channel SAR data and also advanced 3D feature categorization is possible using multi-spectral imagery, LIDAR or advanced SAR.

*The detection of terrain and land cover changes* is one of the most important and time-critical mapping tasks. 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. The urgent need for automated change detection can be met by the object-based rather than pixel-based technology which provides an intelligent comparison of data and information.

An example for the requirement for automated change detection was the damage assessment in Falludjah. In 2004, the US attacked targets in the city of 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 geo-database.

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Second image taken at a later date.

*The detection and recognition of objects* is an essential task of geo-intelligence. It is necessary to analyze the entire situation based on the relation of objects to each other. This is possible via a multi-scale object network which explores the image, the objects it contains and the relations between them simultaneously on multiple levels.

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 the cognition network technology. It handles the ambiguities and variations arising from sensors, different operating conditions and vague models. The results are transparent and reproducible and provide a high degree of consistency. Fully automated detection can be incorporated in the upstream process of image triage. Recognition is supported by providing multiple attributes including object shape, relative and absolute object position and classification confidence.

As with all technologies, it is vital that any new solution integrates easily into existing environments and processes. Only if this is "given" will it result in a complete intelligence process that maximizes the combined value of intelligence from all sources. The seamless interoperability between applications for land, sea and air can contribute to unique image-based situation awareness.

## Conclusion

Not surprisingly, an increasing number of organizations are looking for solutions and technologies for automated image analysis. With the help of new technologies, such as the cognition network technology, the workflow and effectiveness of imagery analysts can be efficiently supported enabling rapid extract of accurate information. Definiens AG provides its global customer base with Definiens Cognition Network Technology®, a patented software, built on an open, standards-based architecture. Definiens solutions are highly acknowledged by industrial and government customers in security and defense in USA, Canada, Asia and Europe as well as partners in international projects as GMES (Global Monitoring of Environment and Security), GMOSS (Global Monitoring for Security and Stability), RIUGV (Remote Sensing for Unmanned Ground Vehicle). Its applications can be developed with a fast and modular method and offer a massively scalable solution that help organizations achieve results faster, gain deeper insights and ultimately make better decisions.

Author: **Prof. Gerd Binnig is,** *Founder and Head of Research, Definiens AG. Prof. Binnig and colleague Prof. Heinrich Rohrer - were awarded the Nobel Prize in physics for their work in scanning tunnelling microscopy.*

Analysis and identification of areas where changes have occurred.

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