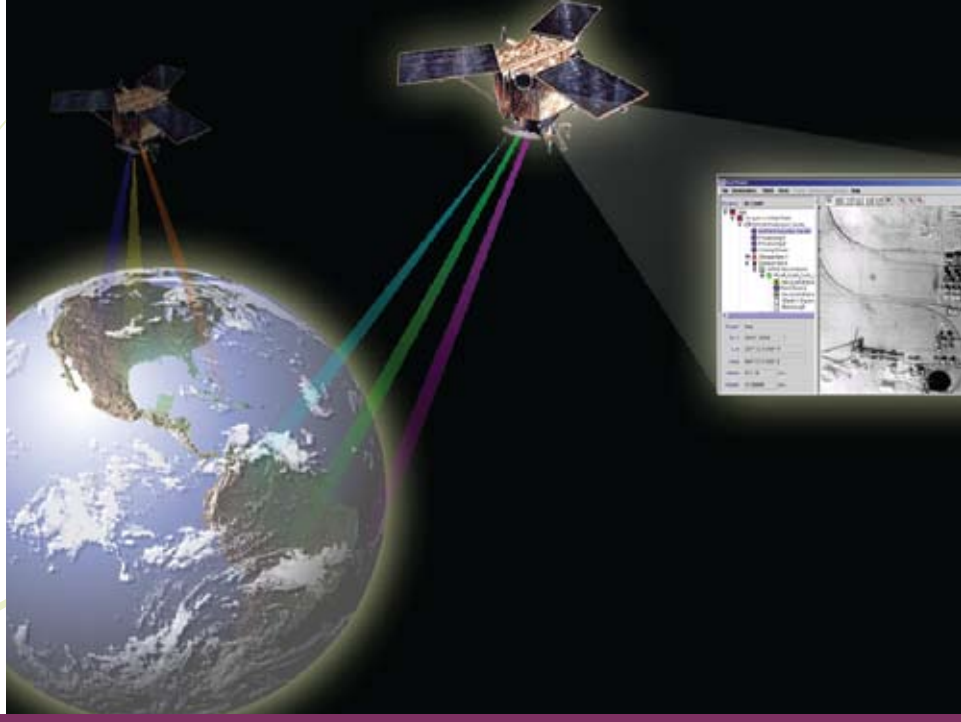
An LDRD Success Story



National Nuclear Security Administration's
Lawrence Livermore National Laboratory

Fast

The Image Content Engine (ICE) reduces the amount of time that human analysts need to spend searching massive volumes of overhead imagery for specified objects of interest. In the defense and intelligence communities, this problem is known as broad-area searching.

Unique

According to the various defense and intelligence agencies, no off-the-shelf products or even prototype systems other than ICE exist to provide useful computer assistance to human analysts in broad-area imaging searching.

Flexible

- The ICE architecture can run on different computing platforms and operating systems.
- ICE can search for a specific structure or for one that suggests an object.
- The algorithms in the ICE software library can be chained together in pipelines configured through a graphical user interface.

A High-Speed, Accurate Tool for Analysis of Visual Intelligence

The Problem

Today's massive volumes of visual data from satellites and other remote-sensing platforms far exceed the capabilities of human analysts to analyze and interpret data in a timely fashion.

The Solution

The Image Content Engine (ICE), funded by the Laboratory Directed Research and Development Program (LDRD), searches image data and automatically extracts image features—such as manmade structures—and then allows the user to interactively search the results. In short, ICE performs image-analysis triage, getting the eyes of the human analyst on the highest priority images.

ICE Basics

- Developed under a three-year LDRD project launched in 2003, ICE is a computer-aided image-extraction system designed primarily to increase the speed and accuracy of overburdened analysts who search satellite photos and other visual intelligence.
- As with many LDRD projects, Livermore's ICE team is a multidisciplinary one comprising engineers, computer scientists, and physicists.
- ICE leverages the world-leading technology in data mining at Lawrence Livermore National Laboratory.

ICE Capabilities

- ICE can detect specific types of objects, such as particular types of buildings or vehicles.
- ICE can detect objects of interest even amid distracting background clutter.
- Extracted features are vectors representing attributes of image tiles, regions, and shapes.
- ICE can reduce more than one week of intensive analytical work into a few hours.
- Users can interactively specify decision thresholds.

About LDRD

The Laboratory Directed Research and Development Program (LDRD) is LLNL's primary mechanism for funding cutting-edge R&D to enhance the Laboratory's scientific vitality. Established by Congress in 1991, LDRD collects funds from sponsored research and competitively awards those funds to forward-thinking, potentially high-payoff projects aligned with Laboratory missions.

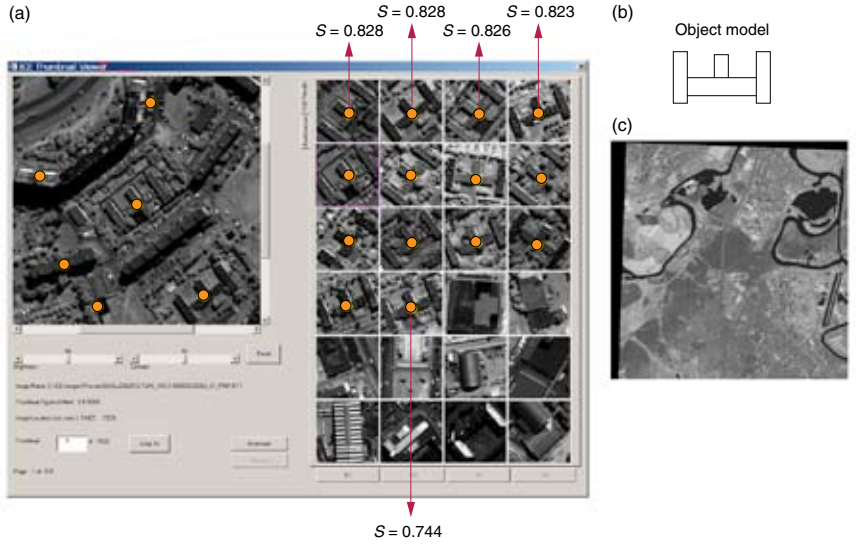
Livermore's multidisciplinary ICE team comprising computer scientists, engineers, and physicists.

The Future of ICE

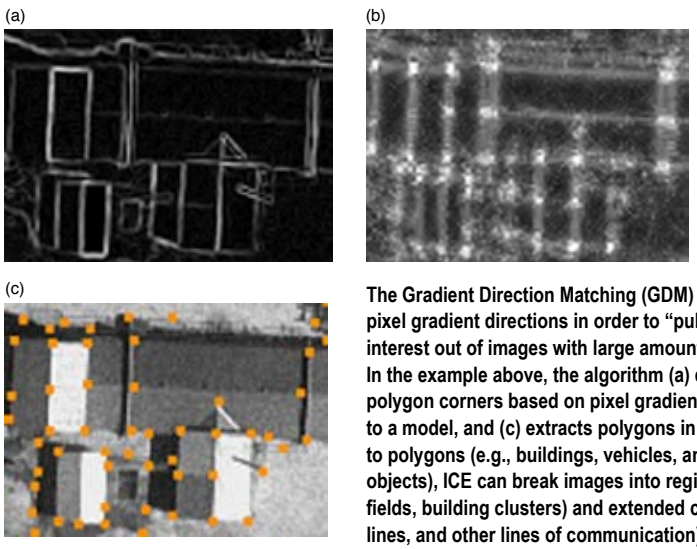
Other possible applications include:

- Detection and characterization of defects in advanced laser optics by searching for diffraction ring patterns and other indirect evidence of defects.
- Automatic extraction of data generated by the Large Aperture Synoptic Survey Telescope, which will generate thousands of high-resolution digital images each day once it comes online.

ICE has also laid the foundations for the Predictive Knowledge System (PKS)—also the subject of a major LDRD project—which correlates visual, audio, and other sensor data for nuclear nonproliferation and homeland security applications.



First, (a) on the ICE interface, the user specifies the images to search and the (b) object to search for. Features are extracted as vectors representing attributes of image tiles, regions, and shapes. The user views the results—a list of thumbnails of the closest matches to the specified model. Objects with the highest similarity appear at the top. The user can (c) select a thumbnail and capture it as a vector or even submit it as a new search for objects similar to objects in the thumbnail.



The Gradient Direction Matching (GDM) algorithm compares pixel gradient directions in order to "pull" specific objects of interest out of images with large amounts of visual clutter. In the example above, the algorithm (a) detects 90-degree polygon corners based on pixel gradients, (b) matches them to a model, and (c) extracts polygons in the image. In addition to polygons (e.g., buildings, vehicles, and other manmade objects), ICE can break images into regions (forests, plowed fields, building clusters) and extended curves (roads, power lines, and other lines of communication).

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