Like a Jigsaw Puzzle

New modeling approach transforms imaging technologies

Researchers are improving the performance of technologies ranging from medical CT scanners to digital cameras using a system of models to extract specific information from huge collections of data and then reconstructing images like a jigsaw puzzle. The new approach is called model-based iterative reconstruction, or MBIR.

"It's more-or-less how humans solve problems by trial and error, assessing probability and discarding extraneous information," said Charles Bouman, Purdue University's Michael and Katherine Birck Professor of Electrical and Computer Engineering and a professor of biomedical engineering.

MBIR has been used in a new CT scanning technology that exposes patients to one-fourth the radiation of conventional CT scanners. In consumer electronics, a new camera has been introduced that allows the user to focus the picture after it has been taken.

In medical CT scanners, the reduction of radiation exposure is due to increased efficiency achieved via the models and algorithms. MBIR reduces "noise" in the data, providing greater clarity that allows the radiologist or radiological technician to scan the patient at a lower dosage, Bouman said.

"It's like having night-vision goggles," he said. "They enable you to see in very low light, just as MBIR allows you to take high-quality CT scans with a low-power X-ray source."

Researchers also have used the approach to improve the quality of images taken with an electron microscope. New findings are detailed in a research paper being presented during the Electronic Imaging 2013 conference in San Francisco this week.

Traditionally, imaging sensors and software are designed to detect and measure a particular property. The new approach does the inverse, collecting huge quantities of data and later culling specific information from this pool of information using specialized models and algorithms.

Purdue, the University of Notre Dame and GE Healthcare used MBIR to create Veo, a new CT scanning technology that enables physicians to diagnose patients with high-clarity images at previously unattainable low radiation dose levels. The technology has been shown to reduce radiation exposure by 78 percent.

"If you can get diagnostically usable scans at such low dosages this opens up the potential to do large-scale screening for things like lung cancer," Bouman said. "You open up entirely new clinical applications because the dosage is so low."

A CT scanner is far better at diagnosing disease than planar X-rays because it provides a three-dimensional picture of the tissue. However, conventional CT scanners emit too much radiation to merit wider diagnostic use.

The research to develop Veo has been a team effort with Ken Sauer, an associate professor of electrical engineering at Notre Dame, in collaboration with Jean-Baptiste Thibault, Jiang Hsieh and Zhou Yu. Thibault and Yu worked on the technology as graduate assistants under Bouman and Sauer and both currently work for GE Healthcare.

In the electron microscope research, MBIR was used to take images of tiny beads called aluminum nanoparticles.

Improved resolution could help researchers design the next generation of nanocomposites for applications such as fuel cells and transparent coatings.

MBIR also could bring more affordable CT scanners for airport screening.

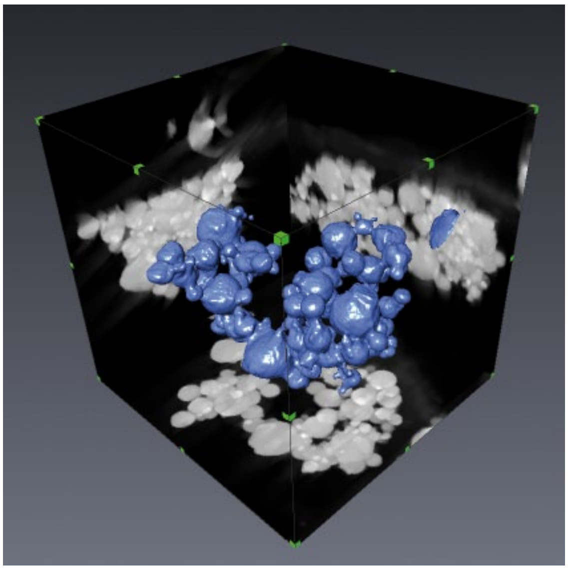

Fig. Researchers are improving the performance of technologies ranging from medical CT scanners to digital cameras using a system of models to extract specific information from huge collections of data and then reconstructing images like a jigsaw puzzle. Here, the method is used to create a high-resolution 3-D electron microscopy reconstruction of aluminum nanoparticles, aiding efforts to design nanocomposites for applications ranging from fuel cells to transparent coatings. (Source: Purdue University, US Air Force Research Laboratory and Carnegie Mellon University)

In conventional scanners, an X-ray source rotates at high speed around a chamber, capturing cross section images of luggage placed inside the chamber. However, MBIR could enable the machines to be simplified by eliminating the need for the rotating mechanism.

Future research includes work to use iterative reconstruction to study materials. Purdue is part of a new Multi-University Research Initiative funded by the U.S. Air Force and led by De Graef. Researchers will use the method to study the structure of materials, work that could lead to development of next-generation materials.

http://spie.org/electronic-imaging.xml