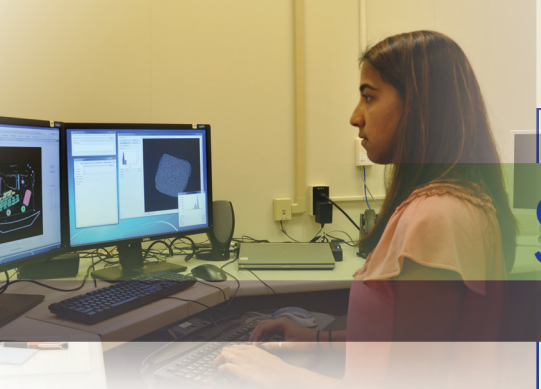
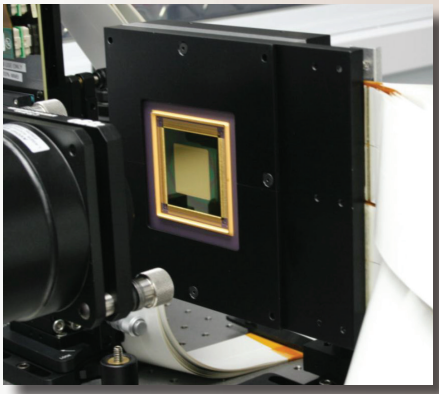


Signal and Image Sciences

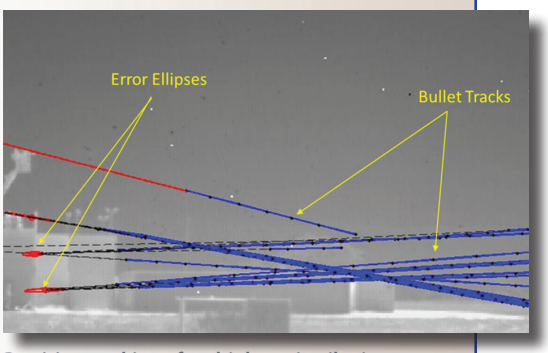
Lawrence Livermore National Laboratory

Engineers in the signal and image sciences work closely with Laboratory programs to develop technologies that support a wide variety of scientific inquiry. These technologies are often unique, and range from the analysis of signals from nuclear fusion reactions to adaptive optics for exoplanet discovery.



Gemini Planet Imager (GPI) 64 x 64 actuator MEMS deformable mirror, with 0.4 mm pitch.

With a rich history of innovation that extends over decades, work in this broad Laboratory competency area combines an understanding of underlying physical processes with statistical analysis and sophisticated mathematical techniques. Together, these tools are used to extract quantitative information and derive uncertainty estimates from corrupted observations and computational models. Applications include radiographic image analysis and object identification, biomedical image analysis, acoustic and seismic signal processing, and radionuclide detection and isotope identification.

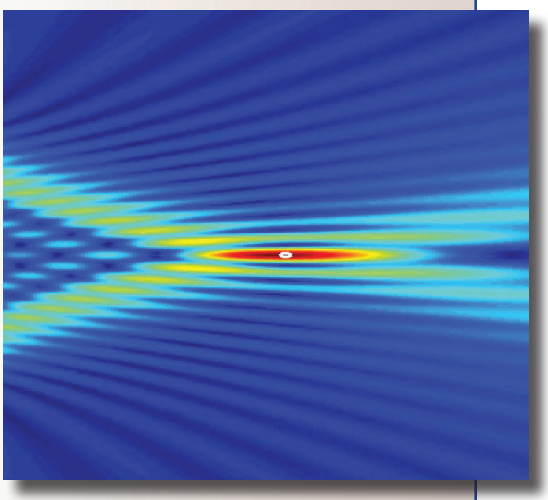


Precision tracking of multiple projectiles in complex, cluttered environments.

Given the significant impact that the signal and image sciences have on LLNL programs, the Laboratory organized the Center for Advanced Signal and Image Sciences (CASIS). The center hosts an annual workshop that features keynote presentations from distinguished researchers in the signal and image sciences.

Example Projects

- Developed computationally efficient and self-adapting algorithms for the Gemini Planet Imager's adaptive optics to correct for atmospheric turbulence
- Designed and tested a system to detect projectiles and trace their trajectories back to the source, allowing rapid identification of threats
- Real-time precision alignment of the beamlines in the National Ignition Facility (NIF)
- Analysis of nuclear reactions produced by high-energy-density physics experiments
- Research and development of image segmentation and object identification in radiographic imagery
- Real-time detection of buried objects using sophisticated radar arrays



Predicted acoustic intensity distribution produced by a time-reversal array that has locked onto a scattering object.

Expertise

- Adaptive optics
- Wide-area motion imagery analysis and video analytics
- Pattern analysis and machine learning
- Computer vision
- Tomographic imaging and reconstruction algorithms
- Radar signal processing
- Hyperspectral image processing and object identification

- Ultrawideband communications and RFID tagging
- Acoustic and seismic signal processing and analysis
- Adaptive control of large optical systems
- Analysis of signals from nuclear fusion reactions
- Radionuclide detection and isotope identification
- Optical engineering and imaging systems

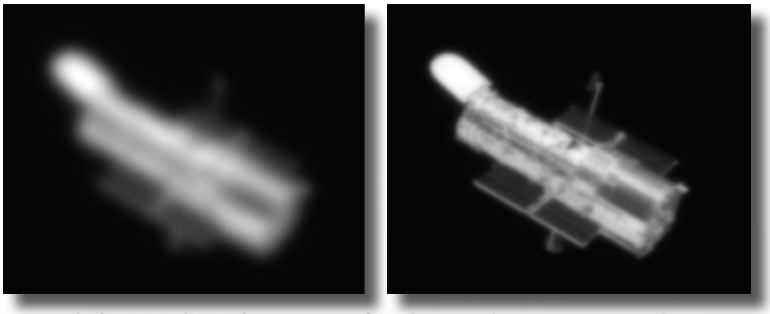
Sponsors

Department of Energy
Department of Defense
Advanced Research Projects Agency–Energy (ARPAe)
Defense Advanced Research Projects Agency (DARPA)

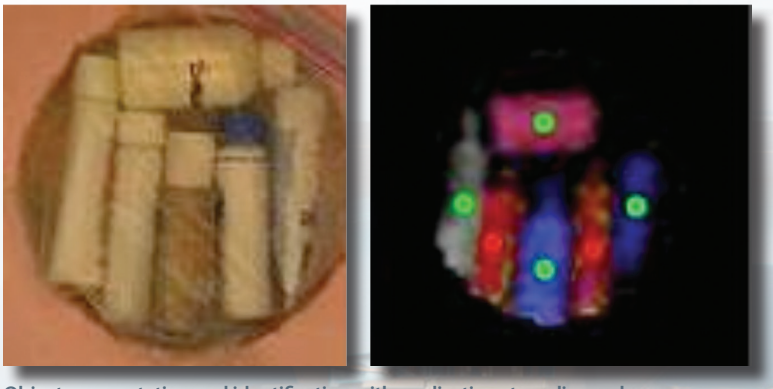
Academic/Industry Alliances

Northwestern University
University of California, Davis
Stanford University
Caltech
Rochester Institute of Technology
IEEE Signal Processing Society

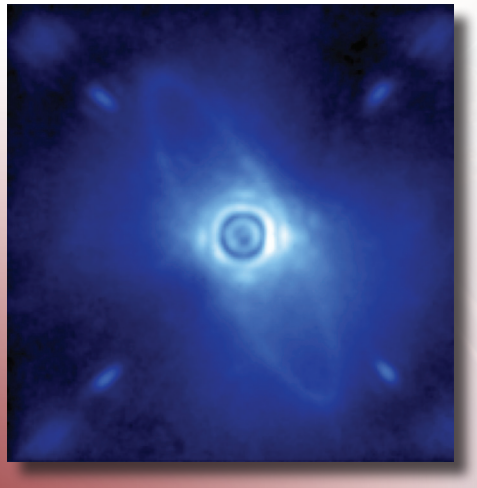
For more information please visit
casis.llnl.gov



Removal of temporal wavefront errors in fast-slewing telescopes using predictive adaptive optics.



Object segmentation and identification with applications to radiography.



Actual on-sky measurement from GPI of a dust disk orbiting a star after correction by LLNL adaptive optics system. *(photo courtesy of M. Perrin, Space Telescope Science Institute)*

Capability Leader

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Randy is the Signal and Image Sciences Section Leader within the Computational Engineering Division. He is also Co-Director of LLNL's Center for Advanced Signal and Image Sciences (CASIS). Randy's experience includes algorithm R&D for analysis of tomographic imagery, hyperspectral imagery, video projectile tracking, and acoustic signature classification. He is a Senior Member of the IEEE and R&D 100 Award winner. He received his B.S., M.S., and Ph.D. degrees in Electrical Engineering from UC Davis.

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