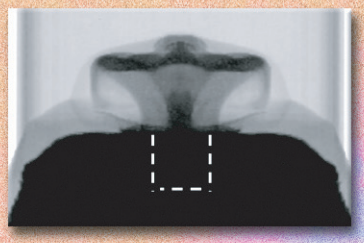
UCRL-PROC-216994

ABSTRACT PROCEEDINGS

Signal and Image Sciences Workshop



CASIS workshop 2005

Thursday, November 17, 2005
Friday, November 18, 2005

Sponsored by
Lawrence Livermore National Laboratory
Engineering Directorate

Center for Advanced Signal and Image Sciences (CASIS)
Steve Azevedo, Director
http://casis.llnl.gov/

Center for Advanced Signal and Image Sciences

ENGINEERING

ENGINEERING

Front cover far left images:
Back-lit fast X-ray image (top) and HYDRA computer simulation (bottom) of a supersonic (70,000 mph) aluminum plasma jet through aerogel 22 ns after a two-beam laser ablation pulse. The experiment was performed by LLNL, LANL, and AWE in the National Ignition Facility (NIF). *Images courtesy of Harry Robey, ICF Program, LLNL.*

Front cover far right images:
Unprocessed (top) and speckle-processed (bottom) images of Lick Observatory from Mt. Diablo, 60 km away through distributed turbulence. Bispectral speckle processing recovers a high-resolution image of Lick from 100 short-exposure frames taken through an 11-inch telescope. *Images courtesy of Carmen Carrano, EE/PAT, LLNL.*

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November 2005
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This work was performed under the auspices of the U.S. Department of Energy, National Nuclear Security Administration by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

Welcome

Welcome to the Twelfth Annual 2005 CASIS Workshop! Over the years, this workshop has provided a forum for laboratory employees and guests to share their work with colleagues in the signal and image sciences. Often, we find that the answers to our tough technical problems lie within a mile of us, and the CASIS Workshop brings those resources to light. We hope this year's Workshop will be as productive for you as it has been in the past.

The CASIS Workshop is a yearly event at the Lawrence Livermore National Laboratory, presented by the Center for Advanced Signal & Image Sciences and sponsored by the LLNL Engineering Directorate. This year, as in the last 11 years, we have convened a diverse set of engineering and scientific talent to share their work in signal processing, imaging, communications, controls, along with associated fields of mathematics, statistics, and computing sciences. The sessions for this year are in "As Built" Modeling, Adaptive Optics, Scientific Data Mining, Tracking & Signal Processing, Image Processing & Analysis, and NIF Optics Inspection.

We are especially pleased to present our keynote speaker for the workshop, Dr. James L. Flanagan, Professor Emeritus at Rutgers University. Dr. Flanagan has had a very distinguished career at AT&T Bell Labs and at Rutgers, best known for his pioneering work in speech processing. He has received many scientific awards, including the 1996 National Medal of Science and the 2005 IEEE Medal of Honor. Dr. Flanagan will characterize the current research challenges in the new field of multimodal communication. We are honored to have Dr. Flanagan address this year's workshop.

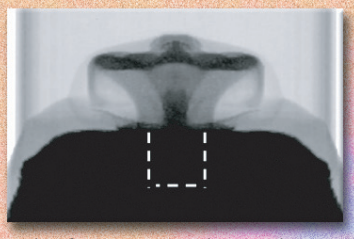
We want to thank our sponsors in the LLNL Engineering Directorate (Steve Patterson, AD) for providing support for this Workshop. My personal thanks go to our excellent staff who actually organize and run the workshop, especially Dora Da Rosa and Deana Eshpeter. They have been a tremendous help. We also thank the Engineering Art & Edit Team, including Lucy Dobson, Irene Chan, and Kathy McCullough. Thank you for your very hard work this year.

We hope that you enjoy the next two days of presentations, and that you find time to exchange ideas openly with the participating scientists and engineers. Thank you for attending this year's CASIS Workshop.

Stephen Azevedo
CASIS Director
http://casis.llnl.gov/

AGENDA

Signal and Image Sciences workshop



Back-lit fast x-ray image (above) and HYDRA computer simulation (below) of a supersonic (70,000 mph) aluminum plasma jet through aerogel 22 ns after a two-beam laser ablation pulse. The experiment was performed by LLNL, LANL, and AWE in the National Ignition Facility (NIF).

Images courtesy of Harry Robey, ICF Program, LLNL

CASIS is a workshop for LLNL, UC community personnel, and others to share accomplishments, ideas, and areas of need in the Signal, Imaging and Communications Sciences

November 17–18, 2005

Unprocessed (above) and speckle-processed (below) images of Lick observatory from Mt. Diablo, 60 km away through distributed turbulence. Bispectral speckle processing recovers a high-resolution image of Lick from 100 short-exposure frames taken through an 11-inch telescope.

Images courtesy of Carmen Carrano, EE/PAT, LLNL

Sponsored by LLNL Engineering Directorate and the Center for Advanced Signal and Image Sciences (CASIS)

Center for Advanced Signal and Image Sciences

AGENDA
Signal and Image Sciences Workshop
Center for Advanced Signal and Image Sciences
Lawrence Livermore National Laboratory

THURSDAY, NOVEMBER 17, 2005 ***BUILDING 123 AUDITORIUM***

8:15 AM ***Registration and Continental Breakfast***
8:45 AM *Opening Remarks, Introductions* . . . . . *Stephen Azevedo, CASIS Director*
8:55 AM *Welcome from Engineering* . . . . . *Dr. Steven Patterson, AD Engineering*
9:00 AM *Natural Interfaces for Information Systems* . . . . . *Prof. James L. Flanagan, Keynote Speaker, Rutgers University*
10:00 AM ***MORNING BREAK—Complimentary***

"AS BUILT" MODELING
Harry E. Martz, Session Chair

10:15 AM *As-Built Modeling Overview* . . . . . *Harry E. Martz*
10:30 AM *As-Built Modeling for Performance Assessment: Nondestructive Characterization* . . . . . *Diane J. Chinn*
10:45 AM *Registration and Fusion of X-Ray and Ultrasound Images for As-Built Modeling* . . . . . *Grace A. Clark*
11:00 AM *As-Built Modeling with VisIt* . . . . . *Edwin J. Kokko*
11:15 AM *Extraction of Object Geometry from X-Ray CT Data* . . . . . *David H. Chambers*

ADAPTIVE OPTICS
David W. Palmer, Session Chair

11:30 AM *Ophthalmic Imaging with Adaptive Optics* . . . . . *Diana C. Chen*
11:45 AM *Angular Differential Imaging: Removing Quasi-Static Speckles for High Contrast Exoplanet Detections* . . . . . *Christian Marois*
12:00 PM ***LUNCH BREAK—Complimentary***
1:30 PM *"Extreme" Adaptive Optics for Direct Imaging of Extrasolar Planets* . . . . . *Bruce A. Macintosh*
1:45 PM *Characterization and Performance of a MEMS Deformable Mirror for High Contrast Imaging* . . . . . *Julia W. Evans*
2:00 PM *Image Restoration in Remote Imaging with Use of Scene-Based Wavefront Sensor Data* . . . . . *Lisa A. Poyneer*
2:15 PM *Enhanced Infra-red Surveillance Imaging* . . . . . *Carmen Carrano*
2:30 PM ***AFTERNOON BREAK—Complimentary***

SCIENTIFIC DATA MINING
Chandrika Kamath, Session Chair

3:00 PM *Classification of Orbit Data* . . . . . *Chandrika Kamath*
3:15 PM *Segmentation in Multi-Variate Data* . . . . . *Abel G. Gezahegne*
3:30 PM *Phase Contrast Radiography for Dynamic Plasma Experiments* . . . . . *Brian K. Spears*
3:45 PM *Three-Dimensional Hydrodynamic Experiments on the National Ignition Facility* . . . . . *Brent E. Blue*
4:00 PM *Image Processing and Data Reduction for Dynamic X-Ray Diffraction with Multiple Film Planes* . . . . . *James S. Stölken*
4:15 PM *Characterization of High-Gain NIF Fusion Target Fuel Layers* . . . . . *Bernard J. Kozioziemski*
4:30 PM ***ADJOURN***

FRIDAY, NOVEMBER 18, 2005 **BUILDING 123 AUDITORIUM**

8:15 AM **Registration and Continental Breakfast**
8:40 AM *Opening Remarks, Introductions* . . . . . *Stephen Azevedo, CASIS Director*

TRACKING & SIGNAL PROCESSING
Randy S. Roberts, Session Chair

8:45 AM *Image Processing for the Fight Sight Bullet Tracking Experiment* . . . . . *Randy S. Roberts*
9:00 AM *Data Association and Bullet Tracking Algorithms for the Fight Sight Experiment* . . . . . *Eric F. Breitfeller*
9:15 AM *Sapphire Video Tracking Pipeline* . . . . . *Cyrus D. Harrison*
9:30 AM *Comparison of Block Matching Techniques for Tracking* . . . . . *Nicole S. Love*
9:45 AM *Ultra-Wideband Urban Tracking Positioning System* . . . . . *Claudia Kent Hertzog*
10:00 AM **MORNING BREAK—Complimentary**
10:15 AM *Model-Based Algorithms for Detecting Cable Damage from Time-Domain Reflectometry Measurements* . . . . . *Grace A. Clark*
10:30 AM *Towards Transportation Surveillance Video Analysis for Detection of Chemical Threats* . . . . . *Lenny Tsap*

IMAGE PROCESSING & ANALYSIS
David W. Paglieroni, Session Chair

10:45 AM *Using the Image Content Engine (ICE) for Large-Scale Model-Based Image Query and Search* . . . . *David W. Paglieroni*
11:00 AM *Diverse Problems–Similar Solutions: Applying Geophysical Imaging Algorithms to NDE Problems* . . . . . *Sean K. Lehman*
11:15 AM *Super-Resolution Algorithms for Ultrasonic Nondestructive Evaluation Imagery* . . . . . *Grace A. Clark*
11:30 AM *Pulsed and CW Laser De-speckling Techniques Used in High-Magnification High-Speed Photography* . . *James T. Wade*
11:45 AM *Using Image Analysis to Determine Permeability in Otherwise Unmeasurable Systems* . . . . . *John H. Kinney*
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1:45 PM *NIF Target Alignment Sensor Algorithm* . . . . . *Walter Ferguson*
2:00 PM *An Alternate Method for Detecting a Correlation Mismatch* . . . . . *Abdul A. S. Awwal*

NIF OPTICS INSPECTION
Laura M. Kegelmeyer, Session Chair

2:15 PM *NIF Optics Inspection Analysis: Overview and Update* . . . . . *Laura M. Kegelmeyer*
2:30 PM *Detection Limits and Registration Issues for Optics Inspection Analysis Software* . . . . . *Judith A. Liebman*
2:45 PM **AFTERNOON BREAK—Complimentary**
3:15 PM *Detection of Laser Optic Damage Using Gradient Direction Sensitive Matching* . . . . . *Barry Y. Chen*
3:30 PM *Lessons Learned Using MATLAB™ for Image Processing in a Production Application Environment* . . . . *Steven M. Glenn*
3:45 PM *Optics Inspection Data Visualization* . . . . . *John W. Carlson*
4:00 PM *Ultrasonic Shear Wave Imaging of Optics Features* . . . . . *Sean K. Lehman*
4:15 PM **ADJOURN**

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Keynote Speaker

Dr. James L. Flanagan

Natural Interfaces for Information Systems

Dr. James L. Flanagan, Professor Emeritus
Rutgers University

How can computers faithfully reproduce a sense of face-to-face communication? High-speed networking is globally pervasive, enabling collaboration and communication that is largely independent of geography and time. Invariably, machines mediate the process and augment human actions. Toward this end, ease of use is a legitimate research target for harnessing technology that serves a greater population. Ideally, one desires user environments that capture features of face-to-face information exchange in which signaling occurs in simultaneous sensory dimensions—primarily sight, sound, and touch.

While current implementation cannot offer spatial realism in these dimensions, primitive component technologies can be brought together to initially address multimodal applications. Speech usually bears a primary burden, so advances in automatic speech recognition, text-to-speech synthesis, and acoustic transduction can be used. Visual imaging of gestures complements speech and provides emphasis, disambiguation, emotional indicators, and identification. Tactile interaction and manual gesture with force-feedback further complement the exchange and are especially valuable when manipulating graphics. To integrate and interpret simultaneous sensory input requires a strategy for fusing technology while preserving the context of communications. A prime research objective is to reliably estimate the intent of users and come up with an intelligent response. In this presentation, I will characterize the current research challenges and summarize fledgling progress in multimodal communication.

Biography

Dr. James Flanagan has enjoyed two careers – in industry, and in academia. After 33 years with AT&T Bell Laboratories, Flanagan joined Rutgers University in 1990. At AT&T, he was Director of Information Principles Research, and had responsibilities for departments conducting research in digital communications and networked information systems. Dr. Flanagan holds SM and ScD degrees in Electrical Engineering from M.I.T. He has published approximately 200 technical papers in scientific journals and is the author of a research text Speech Analysis, Synthesis and Perception (Springer Verlag). He has received many scientific awards, which include the National Medal of Science 1996 and most recently the IEEE Medal of Honor 2005.

"As Built" Modeling

Harry E. Martz, Session Chair

As-Built Modeling Overview

Harry E. Martz, AD Engineering Staff
Edwin J. Kokko, ME/New Technologies Engineering Division, LLNL
UCRL-ABS-213529

Currently most finite element analysis models are based on an object's "as-designed" configuration with information obtained from technical drawings and computer aided-design models. The basic idea and goal of "as-built" computational modeling is to incorporate the most representative geometry and material information for an object into engineering and physics simulations using non-destructive characterization techniques to provide the "as-built" feature information. As-built features might include geometry deviations (asymmetries, dents, etc.) or material anisotropies and flaws (inclusions, voids, cracks, etc.) originating from the manufacturing process or from the object being exposed to a certain physical environment during service conditions. By incorporating more representative geometry and material features as initial conditions, the uncertainty in the (finite element) simulation results could potentially be reduced providing a new understanding of the event and object being modeled.

In order to do this, multiple discipline areas that have been disconnected in the past must be coupled together through a common understanding of the process, requirements, tools, and caveats at each step. The key steps and technology areas in the "as-built" modeling framework include: (1) characterization using non-destructive evaluation (NDE) and metrology techniques; (2) signal and image processing (including artifact removal, data sensor fusion, and geometric feature extraction); and (3) engineering and physics analysis using finite element codes.

An overview of the key concepts will be presented with application to a real engineering object data set. Following the overview, subsequent session presentations will provide additional detail, discussion points, and applications within each of the technology areas of the "as-built" modeling framework.

As-Built Modeling for Performance Assessment: Nondestructive Characterization

Diane J. Chinn, ME/Manufacturing & Materials Engineering Division, LLNL
Jessie A. Jackson, EE/Defense Sciences Engineering Division, LLNL
Harry E. Martz, AD Engineering Staff, LLNL
Dan Schneberk, CAR-NIFE, LLNL
Edwin J. Kokko, ME/New Technologies Engineering Division, LLNL
UCRL-ABS-216680

The goal of "as-built" modeling is to reduce uncertainty and improve understanding of components and systems. By making full use of enhanced characterization information, the gap between predictive simulation and experimental results can be minimized. Computational approaches have traditionally used "as-designed" models to perform simulations. Incorporation of "as-built" geometry and material information obtained by nondestructive characterization into simulations can produce more accurate simulations thereby reducing error margins.

This tech-base project explored the process of as-built modeling using characterization, analysis and visualization tools at LLNL. Three samples were designed to highlight different aspects of the process. Each sample was characterized using ultrasonic imaging and X-ray computed tomography, and each technique showed different features from each sample. Processing of characterization data was performed to allow direct comparison and future work on fusion of the data sets.

Registration and Fusion of X-Ray and Ultrasound Images for As-Built Modeling

Grace A. Clark, EE/Electronics Engineering Technologies Division, LLNL
Jessie A. Jackson, EE/Defense Sciences Engineering Division, LLNL
UCRL-ABS-215991

Our goal in the as-built modeling effort is to provide high-quality nondestructive evaluation (NDE) imagery of mechanical parts to our colleagues doing finite element analysis (FEA). We need to depict the locations and physical characteristics of boundaries, as well as cracks, inclusions, voids, delaminations, ablations and other flaws. The X-ray computed tomography (CT) images and Ultrasound test (UT) images we use have performance strengths and weaknesses. For example, ultrasound images are useful for detecting closed cracks, but they have very low spatial resolution. On the other hand, X-ray images have very high spatial resolution, but are not generally useful for detecting closed cracks. The goal of our work is to improve the probability of correct classification of flaws and the probability of a successful inspection by exploiting the strengths of *both* X-ray CT and Ultrasound imagery. Fusion is greatly simplified if the images are co-registered. Currently, relatively little sensor fusion work has been reported in the NDE literature, largely because attempts to register images have led to great difficulty and limited success. The primary challenge lies in the fact that, unlike CT images, UT images are difficult to scale to dimensional units. Scaling requires estimating the sound velocities in the various materials, and locating acoustic events. Most other ultrasonic work is qualitative enough that such analysis is not necessary.

We present an algorithmic approach and preliminary registration and fusion results using real CT and UT images from a known "phantom" part in controlled experiments. We show that the image formation process (reconstruction) and the registration process are coupled.

As-Built Modeling with VisIt

Edwin J. Kokko, ME/New Technologies Engineering Division, LLNL
Hank Childs, CAR-DNT Computing Applications Division, LLNL
UCRL-ABS-213656

VisIt is a data handling infrastructure designed to visualize and analyze some of the largest simulations ever run. VisIt has many capabilities that go beyond standard post-processing. These include numerous data readers, a parallelized, scalable architecture for data handling, and many routines to subset and analyze data. Moreover, VisIt is highly flexible and extensible, allowing these capabilities to be applied to new types of problems, such as *as-built modeling*.

VisIt's basic strategy for as-built modeling involves processing the data in three stages. First, experimentally obtained data is read in and transformed to a state that is conducive for further processing. Second, material classification is performed. Third, a mesh is created that incorporates the material positions.

The details of these three stages vary on a case-by-case basis. We will focus on a concrete example where the experimental data consists of computed tomography (CT) data and the object being modeled is closely related to its idealized form.

Processing CT data is difficult, because it contains billions of density values. When doing parallel processing, VisIt partitions this data among its processors. Data is then extracted along rays, creating a series of line segments and their density profiles.

Material classification occurs by analyzing each of the line segments. Standard wall-thickness schemes are used; rises and drops in the derivative of the density profile indicate change in materials. A *priori* knowledge of the object is also used to guide the detection of the material boundaries.

Finally, the mesh is generated. This is done by starting with a mesh of an idealized form of the object and displacing its vertices to match the extracted material boundaries. Of course, mesh generation of this type is most appropriate when the object closely resembles its idealized form.

In addition, issues with this process and the resulting mesh will be discussed.

Extraction of Object Geometry from X-Ray CT Data

David H. Chambers and Dennis M. Goodman, EE/Defense Sciences Engineering Division, LLNL
Richard R. Leach, EE/Electronics Engineering Technologies Division, LLNL

UCRL-ABS-213562

Computed tomography (CT) is commonly used for nondestructive evaluation of systems and assemblies. This gives information about the as-built configuration of the object, which can be different from the as-designed configuration. A long-time goal for performance analysts is a systematic method for using as-built information to obtain better predictions from the performance codes. In this talk, we compare two methods for extracting as-built geometric information from X-ray CT data. One method uses image processing techniques to extract geometric information from the CT reconstruction. The other uses a model-based technique to extract geometric information directly from the measured radiographs. These two approaches were applied to radiographic data of a cylindrical test object. Though the results from both methods are in general agreement, the model-based method gave added information about the magnitude of the error in the geometric parameters. We conclude that model-based methods have an advantage over conventional CT reconstruction methods when extracting large-scale geometric information from CT data.

Adaptive Optics

David W. Palmer, Session Chair

Ophthalmic Imaging with Adaptive Optics

Diana C. Chen, EE/Electronics Engineering Division, LLNL
Steven M. Jones, EE/Defense Sciences Engineering Division, LLNL
Dennis A. Silva, EE/Laser Engineering Division, LLNL
Scot S. Olivier, PAT/I-Division, LLNL
UCRL-ABS-216569

Conventional ophthalmic instruments provide basic imaging of human retina, but with limited resolution. The adaptive optics group in LLNL is working on developing new ophthalmic imaging instruments, such as a scanning laser microscope with adaptive optics (AOSLO). AOSLO provides capabilities to visualize photoreceptors, nerve fibers, flow of white blood cells, etc. for disease studies and clinical treatments. In the presentation, we will discuss the system design of the compact AOSLO and show the clinical results of high-resolution human-retina images.

Angular Differential Imaging: Removing Quasi-Static Speckles for High Contrast Exoplanet Detections

Christian Marois
PAT/Institute for Geophysics & Planetary Physics, LLNL
UCRL-ABS-216601

One of the biggest challenges involved in detecting planets orbiting other stars is the removal of residual speckles in the image. Such planets will be 10^6 to 10^9 times fainter than stars and located only at a few lambda/D separation, so they are deeply buried under the speckled halo of scattered light from the atmosphere turbulence and telescope and instrument optics. With the use of adaptive optics systems, it has been possible to remove most of the atmospheric speckles, but long exposures are still dominated by uncorrected telescope and instrument quasi-static speckles. I will describe the angular differential imaging technique, an observing method that uses the rotation of the earth relative to the telescope, and show that it can, after careful postprocessing, efficiently remove the quasi-static speckle noise while retaining the exoplanet flux. Gemini and Keck data will be shown to demonstrate the impressive results that this technique has currently achieved. The use of this technique for future instruments (like the LLNL Gemini ExAOC project) will also be discussed.

"Extreme" Adaptive Optics for Direct Imaging of Extrasolar Planets

Bruce A. Macintosh
PAT/I-Division, LLNL
UCRL-ABS-216525

As adaptive optics (AO) matures, it becomes possible to envision AO systems oriented towards specific important scientific goals rather than general-purpose systems. One of the most important goals for the next decade is the direct imaging detection of extrasolar planets. An "Extreme" AO system optimized for extrasolar planet detection will have very high actuator counts and rapid update rates, an order of magnitude more powerful than current AO. An LLNL team has been selected by the international Gemini Observatory to build such a system, the Extreme Adaptive Optics Coronagraph (ExAOC).

This will combine advanced adaptive optics, precision wavefront sensing, pupil apodization to suppress diffraction, and an imaging infrared spectrograph to produce hyperspectral data cubes of target planetary systems. We present an overview of the ExAOC design and capabilities, including the key issues in distinguishing planets from PSF artifacts.

Characterization and Performance of a MEMS Deformable Mirror for High Contrast Imaging

Julia W. Evans
PAT/Student, LLNL
UCRL-ABS-216038

"Extreme" adaptive optics systems are optimized for ultra-high-contrast applications, such as ground-based extrasolar planet detection. The Extreme Adaptive Optics Testbed at UC Santa Cruz is being used to investigate and develop technologies for high-contrast imaging, especially wavefront control. We use a simple optical design to minimize wavefront error and maximize the experimentally achievable contrast. A phase shifting diffraction interferometer (PSDI) measures wavefront errors with sub-nm precision and accuracy for metrology and wavefront control. Previously, we have demonstrated RMS wavefront errors of <1.5 nm and a contrast of $>10^7$ over a substantial region using a shaped pupil without a deformable mirror. Current work includes the installation and characterization of a 1024-actuator Micro-Electro-Mechanical Systems (MEMS) deformable mirror, manufactured by Boston Micro-Machines for active wavefront control. Using the PSDI as the wavefront sensor we have flattened the deformable mirror to <1 nm within the controllable spatial frequencies and measured a contrast in the far field of $>10^6$. Consistent flattening required testing and characterization of the individual actuator response, including the effects of dead and low-response actuators. Stability and repeatability of the MEMS devices was also tested. An error budget for MEMS performance will summarize MEMS characterization. Ultimately this testbed will be used to test all aspects of the system architecture for an extrasolar planet-finding AO system.

Image Restoration in Remote Imaging with Use of Scene-Based Wavefront Sensor Data

Lisa A. Poyneer
EE/Defense Sciences Engineering Division, LLNL
UCRL-ABS-216215

In our remote imaging scenario of observation of a target with a 20-cm telescope over short horizontal paths, images are degraded by the atmosphere. We study how scene-based wavefront sensor data obtained from the target can be used to improve image quality, either through real-time correction or through post-processing techniques.

Enhanced Infra-red Surveillance Imaging

Carmen Carrano
EE/Electronics Engineering Technologies Division, LLNL
UCRL-ABS-216216

This talk will describe work on enhanced infra-red (IR) surveillance using speckle imaging. Speckle imaging in this context is an image post-processing algorithm that aims to solve the atmospheric blurring problem of imaging through horizontal or slant path turbulence. Descriptions of the IR imaging systems used in our data collections will be given and imagery before and after speckle processing will be shown. Comparisons of IR imagery to visible wavelength imagery of the same target in the same conditions will be shown to demonstrate the benefits of going to longer wavelengths.

Scientific Data Mining

Chandrika Kamath, Session Chair

Classification of Orbit Data

Chandrika Kamath and Abraham H. Bagherjeiran
Center for Applied Scientific Computing, LLNL
UCRL-ABS-215896

One of the tasks in the analysis of experimental data from prototype fusion reactors is the classification of orbits in Poincaré plots. These plots are generated by the particles in a fusion reactor as they move within the toroidal device. In this talk, we describe the use of graph-based methods to extract features from orbits. These features are then used to classify the orbits into several categories. Our results show that machine learning algorithms are successful in classifying orbits with few points, a situation which can arise in data from experiments.

Segmentation in Multi-Variate Data

Abel G. Gezahegne, Center for Applications Development & Software Engineering, LLNL
Chandrika Kamath, Center for Applied Scientific Computing, LLNL
UCRL-ABS-215867

Given a multi-variate dataset from fluid mix simulation, our goal is to identify bubbles in an image of the top view of the fluid. We use various segmentation methods to identify the different bubble regions and discuss the pros and cons of these methods. We also show how we can take advantage of the properties of multiple variables to improve the quality of segmentation.

Phase Contrast Radiography for Dynamic Plasma Experiments

Brian K. Spears, David H. Munro, K. Twelker, M. Marty Marinak, M. J. Edwards
AX Division, LLNL
UCRL-ABS-213716

Common X-ray imaging relies on differential attenuation of X-rays by the object to produce intensity contrast in the image. Such contrast is known as absorption contrast. However, intensity contrast may be enhanced due to interference resulting from phase shifts introduced by wave propagation through the object. This is known as phase contrast. We examine the utility and feasibility of phase contrast imaging for diagnosing dynamic laser plasma experiments in support of the National Ignition Campaign. We do this using numerical simulations of phase contrast radiographs produced with PHAT, a modification of the ray trace code DRAT. PHAT takes as input data from the radiation hydrodynamics code HYDRA, and accounts for both absorption and phase effects. As specific examples, we consider plasma jets produced by indirectly driving planar beryllium foils. We also look at imploding National Ignition Facility ignition capsules. We finally discuss the influence of constraints, such as source size, target chamber geometry, and noise, on expected experimental phase contrast results.

Three-Dimensional Hydrodynamic Experiments on the National Ignition Facility

Brent E. Blue
Inertial Confinement Fusion Program, LLNL
UCRL-ABS-210802

The production of supersonic jets of material via the interaction of a strong shock wave with a spatially localized density perturbation is a common feature of inertial confinement fusion and astrophysics. In this paper, the commissioning activities on the National Ignition Facility (NIF) to enable hydrodynamic experiments will be presented as well as the results from the first series of hydrodynamic experiments. In these experiments, two of the first four beams of NIF are used to drive a 40 Mbar shock wave into millimeter scale aluminum targets backed by 100 mg/cc carbon aerogel foam. The remaining beams are delayed in time and are used to provide a point-projection X-ray backlighter source for diagnosing the three-dimensional structure of the jet evolution resulting from a variety of 2D and 3D features. Comparisons between data and simulations using several codes will be presented.

Image Processing and Data Reduction for Dynamic X-Ray Diffraction with Multiple Film Planes

James S. Stölken, ME/New Technologies Engineering Division, LLNL
Daniel H. Kalantar, National Ignition Facility, LLNL
UCRL-ABS-216617

The study of complex phenomena, such as phase transitions under dynamic loading conditions, requires the acquisition of increasingly larger amounts of information in order to provide sufficient data to develop and validate physically based models. The use of multiple film planes (MFP) in X-ray diffraction (XRD) experiments is one strategy to increase the amount of data gathered from dynamic experiments; however, the analysis and interpretation of the data can become quite complex if the technique is to be fully exploited. We have developed image processing and data reduction procedures needed to extract quantitative three-dimensional crystal lattice structure and deformation information from MFP data gathered during dynamic XRD experiments. We shall give a brief overview of the MFP XRD imaging system followed by a detailed description of the image recording and processing procedures. The methods of quantitative data reduction used include computational diffraction ray tracing, path inversion, and multi-dimensional orthogonal distance regression. These techniques are used to establish the actual imaging parameters of the experiment, estimate the three-dimensional deformation of the material during shock loading, and for material phase identification. We shall conclude with an outlook on future work and extensions.

Characterization of High-Gain NIF Fusion Target Fuel Layers

Bernard J. Kozioziemski, John D. Moody, James D. Sater, Inertial Confinement Fusion Program, LLNL
David S. Montgomery, C. Gautier, Los Alamos National Laboratory
UCRL-ABS-216146

NIF ignition targets consist of a 2 mm diameter outer diameter ablator, 150 micrometers thick of either beryllium or plastic surrounding a 100 micrometer thick solid deuterium-tritium (D-T) fuel layer. The D-T fuel layer must be smooth and uniformly thick, with a maximum root-mean-square roughness less than 1 micrometer. Additionally, defects in the bulk must be less than 0.3 m^3. Both requirements present characterization challenges.

Phase-contrast enhanced X-ray imaging of D-T inside of a beryllium capsule has recently been demonstrated in our laboratory. We have demonstrated that this method can characterize D-T surface roughness down to the NIF specification under ideal conditions. However, we do not have a method to characterize the small bulk defects. Furthermore, the X-ray imaging for NIF ignition experiments may be limited by mechanical stability.

We will present images and current analysis methods for determining the D-T surface roughness. We will also discuss how sources of noise, such as mechanical vibration, reduce the analysis accuracy.

Tracking & Signal Processing

Randy S. Roberts, Session Chair

Image Processing for the Fight Sight Bullet Tracking Experiment

Randy S. Roberts, Eric F. Breitfeller
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UCRL-ABS-216282

Previous LLNL investigators developed a bullet and projectile tracking system over a decade ago. Renewed interest in the technology has spawned research that culminated in a live-fire experiment, called Fight Sight, in September 2005. The experiment was more complex than previous LLNL bullet tracking experiments in that it included multiple shooters with simultaneous fire, new sensor-shooter geometries, large amounts of optical clutter, and greatly increased sensor-shooter distances.

This presentation describes the image processing for the Fight Sight experiment. The image processing includes temporal and spatial filtering to reveal the bullets and suppress clutter, and feature extraction operations to isolate and quantify signals produced by the bullets. These features are passed to a tracking algorithm which locates the source of the gunfire. In addition to describing the image processing steps, several examples from the Fight Sight experiment are also presented.

Data Association and Bullet Tracking Algorithms for the Fight Sight Experiment

Eric F. Breitfeller, Randy S. Roberts
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UCRL-PROC-216285

Previous LLNL investigators developed a bullet and projectile tracking system over a decade ago. Renewed interest in the technology has spawned research that culminated in a live-fire experiment, called Fight Sight, in September 2005. The experiment was more complex than previous LLNL bullet tracking experiments in that it included multiple shooters with simultaneous fire, new sensor-shooter geometries, large amounts of optical clutter, and greatly increased sensor-shooter distances.

This presentation describes the data association and tracking algorithms for the Fight Sight experiment. Image processing applied to the imagery yields a sequence of bullet features which are input to a data association routine. The data association routine matches features with existing tracks, or initializes new tracks as needed. A Kalman filter is used to smooth and extrapolate existing tracks. The Kalman filter is also used to back-track bullets to their point of origin, thereby revealing the location of the shooter. It also provides an error ellipse for each shooter, quantifying the uncertainty of shooter location. In addition to describing the data association and tracking algorithms, several examples from the Fight Sight experiment are also presented.

Sapphire Video Tracking Pipeline

Cyrus D. Harrison, Chandrika Kamath
Center for Applied Scientific Computing, LLNL
UCRL-ABS-215893

We are interested in robust methods for tracking moving objects in video. Processing video data requires several steps, each with algorithm choices that vary in effectiveness when combined. To streamline experimentation, we created a five stage tracking pipeline that isolates the major processing tasks. We will detail the design of our pipeline and show examples of its use on real world data.

Comparison of Block Matching Techniques for Tracking

Nicole S. Love, Cyrus D. Harrison, and Chandrika Kamath
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UCRL-ABS-215895

We present a comparison of block matching techniques for the purpose of object tracking. There are three main components in block matching: (1) determining the block size, (2) determining where to search, and (3) the matching criterion. We use several techniques for each component and discuss the tracking performance using various image sequences.

Ultra-Wideband Urban Tracking Positioning System

Claudia Kent Hertzog
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UCRL-ABS-216518

We designed and built a set of high-accuracy indoor ranging devices using ultra-wideband (UWB) RF signals. UWB radios are particularly suited to ranging because of their large bandwidth, narrow pulses. Furthermore, our ranging and positioning techniques directly address some known challenges in UWB localization. We recover noisy, corrupted signals by repeating range measurements across a channel, and we combine distance measurements from many locations surrounding the target in a way that minimizes the range biases associated to indirect flight paths and through-wall propagation delays.

Ranging accuracy depends heavily on being able to resolve the exact arrival time of the incoming signals. In harsh ranging environments, in buildings, caves, or urban canyons, the signals are forced to travel though walls or around corners along a non-line-of-sight (NLOS) transmission channel. UWB signals provide enough frequency diversity to allow portions of the signal to penetrate walls and buildings, but traveling through structures stretches and distorts the original pulse, the signal-to-noise ratio deteriorates, and the incoming signal is closely trailed by reflected versions of itself. Finding the once sharp pulses now buried within the noise floor becomes significantly more challenging.

Positioning accuracy depends on the quality of the range measurements, and with remote units deployed in harsh environments, range measurements undergo transit delays when traveling through walls and around corners. These delays create biases in the range measurements and have been described as the most fundamental and limiting source of error in UWB localization. Range measurement biases are caused by NLOS signal propagation, signal propagation delays through materials other than air, and time-of-flight (TOF) range measurements consisting of travel time plus unknown remote unit processing time. In these cases, every measurement is longer than the actual distance.

We set up several scenarios to test the performance of the TOF ranging, and we are specifically interested in the performance in two areas, namely: signal-to-noise ratio (SNR) gain by repeating measurements across a channel and absolute accuracy of a measurement obstructed by several types of walls. The results suggest we would be able to recover a UWB signal from within difficult operating environments such as in caves or buildings. From the recovered signal, we expect we can determine range to within several inches or feet. We expect with range information accurate to several feet we would be able to determine position to within an equivalent amount.

Model-Based Algorithms for Detecting Cable Damage from Time-Domain Reflectometry Measurements

Grace A. Clark, EE/Electronics Engineering Technologies Division, LLNL
Eric F. Breitfeller, EE/Defense Sciences Engineering Division, LLNL
UCRL-ABS-215990

Critical cables can undergo damage that manifests as changes in the dielectric properties of the cable. Such damage can include short circuits, open circuits, punctures, compressed regions, etc. We are testing cables nondestructively using transient time domain reflectometry (TDR) measurements, which are sensitive to changes in dielectric properties.

We have found empirically that the TDR measurements are quite repeatable from test to test on the same cable, and from cable to cable. This enables us to use a model-based approach to cable damage detection. We use an equation-error based linear predictor model in a system identification scheme to compute a dynamic model for cables that are known to be free of damage. This model is then used as a reference to which other cables can be compared. When the TDR signals from the known reference cable model are compared with the TDR signals from a cable under test, we can use the innovations (or "errors," or "residuals") to develop a detection algorithm. If the output signal from the reference model matches the output signal from the cable under test, then the innovations must be statistically white. A digital signal is white if its autocorrelation is a Kronecker delta function at the origin and its spectrum equals one for all frequencies. We can then use statistical whiteness tests as detection criteria. If the whiteness criterion exceeds its theoretical threshold, then the innovations are declared non-white, implying a model mismatch. We then infer that the model mismatch implies that the cable has experienced damage of some kind. The detection algorithms have the desirable property that they are useful for *locating* damage.

We demonstrate preliminary cable damage detection results using example measurements from controlled experiments with real cables in a relatively simple workbench environment. Future work includes experiments in complex physical environments that can affect the TDR signals, moving from the damage detection problem to the damage *classification/identification* problem, and cable reliability assessment.

Towards Transportation Surveillance Video Analysis for Detection of Chemical Threats

Lenny Tsap and Thomas A. Edmunds, EE/Electronics Engineering Technologies Division, LLNL
Min Shin, University of North Carolina, Charlotte
UCRL-ABS-216726

This talk addresses video-based detection and analysis of chemical threats as applicable to the transportation infrastructure and people protection. It establishes the importance of the task and provides a framework for development of a comprehensive system. Initial results are provided using both downloaded data and surveillance video provided by a subway system operator. Further steps described are necessary to achieve complete robust system coverage.

Image Processing & Analysis

David W. Paglieroni, Session Chair

Using the Image Content Engine (ICE) for Large-Scale Model-Based Image Query and Search

David W. Paglieroni
EE/Electronics Engineering Technologies Division, LLNL
UCRL-ABS-216715

A system known as the Image Content Engine (ICE) developed at the Lawrence Livermore National Laboratory for large-scale image query and search is described. The ICE software architecture ports to various platforms (Windows, Linux, Mac) and scales to compute clusters. It embodies a number of tools for matching patterns to images and provides an interface that allows the user to specify the images to be searched and patterns to match. The ICE query interface then allows a human analyst to search the matching results for specified types and combinations of patterns.

We describe in some detail the most mature ICE tool, which matches physical models of objects to images using an efficient novel algorithm sensitive to gradient direction. It handles images acquired with various sensors under various conditions, and converts images to sets of points that can be ranked in descending order of similarity to a model. The impact of image spatial magnification and the number of model orientations on matching performance is investigated.

Diverse Problems–Similar Solutions: Applying Geophysical Imaging Algorithms to NDE Problems

Sean K. Lehman, EE/Defense Sciences Engineering Division, LLNL
Karl A. Fisher, ME/Manufacturing & Materials Engineering Division, LLNL
Robert A. Clapp and Brad Artman, Stanford University
UCRL-ABS-216281

The Center for Subsurface Sensing & Imaging Systems (CenSSIS, www.censsis.neu.edu) has been advancing the concept of "Diverse Problems–Similar Solutions" whereby imaging, inversion, and tomography (IIT) algorithms developed for one field or physical regime are applied to another. Following this philosophy, we have applied algorithms developed for geophysical imaging to a non-destructive evaluation (NDE) problem in a planar multilayer. The depths and acoustic frequencies of geophysical problems are on the orders of kilometers and sub-Hertz while those of NDE are millimeters and megaHertz. Just the same, the propagation phenomenon is entirely wave-based in both cases and thus, algorithms developed for one can be applied to the other. We provide a successful demonstration of this concept.

Super-Resolution Algorithms for Ultrasonic Nondestructive Evaluation Imagery

Grace A. Clark, EE/Electronics Engineering Technologies Division, LLNL
Jessie A. Jackson, EE/Defense Sciences Engineering Division, LLNL
Steven E. Benson, ME/Manufacturing & Materials Engineering Division, LLNL
UCRL-ABS-215975

Generally, one of the major desired results from a nondestructive evaluation (NDE) test of a mechanical part is a segmented image or a 3D image cube showing the locations and physical characteristics of cracks, inclusions, voids, delaminations, ablations and other flaws. A key NDE goal is to obtain images having the best possible spatio-temporal resolution. Unfortunately, the resolution of all ultrasonic measurements is severely limited by the inherent fundamental band-limited spectral transfer function of ultrasonic transducers, the uncertainty principle and the diffraction limit. In the time domain, the transducer causes severe ringing, which greatly limits resolution.

We present super-resolution algorithms and a MATLAB-based software system for improving spatial resolution in 1-D ultrasonic NDE pulse-echo signals (A-Scans). Future work includes extending these algorithms to two and three dimensions. Given a measured noisy reflection signal u(t) and an associated reference signal x(t), the algorithms first produce an optimal least-squares estimate $\hat{h}(t)$ of the impulse response of the material under test. Next, we use a super-resolution algorithm to produce a spectrum-extrapolated version $\hat{h}_e(t)$ of the impulse response estimate. The algorithm uses the method of Alternating Orthogonal Projections to extrapolate the frequency spectrum, resulting in higher spatio-temporal resolution

The spectrum-extrapolated impulse response $\hat{h}_e(t)$, when used in place of the raw reflection signal x(t), enhances the spatial resolution of the ultrasonic measurements by removing distortion caused by the transducers and the materials under test. We demonstrate the resolution enhancement results using (1) simulated signals, (2) example measurements from controlled experiments using real material samples, and (3) Lab programmatic material samples.

Pulsed and CW Laser De-speckling Techniques Used in High-Magnification High-Speed Photography

James T. Wade, ME/Defense Technologies Engineering Division, LLNL
Anthony T. Rivera, EE/Defense Sciences Engineering Division, LLNL
UCRL-ABS-215807

Laser speckle has long been a problem when using a laser source for illumination in high-speed photography. The de-speckling of continuous wave (CW) and pulsed laser illumination becomes necessary when speckle size exceeds camera resolution thus adversely effecting image quality. We will explore three de-speckling techniques used in high-magnification high-speed photography. The first will present a technique used for CW illumination applications necessary for camera focusing. The second will present two pulsed laser techniques one of which is currently being used to carry out experiments at the High Explosives Application Facility (HEAF). These techniques have enabled effectively de-speckled high-resolution CCD image capture of high-speed objects using exposures as short as 7 nanoseconds at distances of up to 40 feet.

Using Image Analysis to Determine Permeability in Otherwise Unmeasurable Systems

John H. Kinney and J. J. Roberts
ME/Manufacturing & Materials Engineering Division, LLNL
UCRL-ABS-216570

Permeability of Fe-S melts in crystalline olivine at high temperatures and pressures provides an important constraint on models of planetary core formation. However, the permeability at high temperatures and pressures has proved to be unmeasurable. Instead, permeability has been inferred from empirical relationships based on microstructure. These empirical relations are based upon power-law relations for which the scaling exponents are unknown; in addition, they also require adjustable parameters that must be inferred from independent measures of the microstructural parameters. Accordingly, estimates of the permeability vary widely, from 10^{-12} m^2 to 10^{-17} m^2 at low concentrations of the Fe-S melt (~3% by volume), to 10^{-13} m^2 to 10^{-14} m^2 at higher concentrations (~13% by volume). Here, we use high-resolution, synchrotron X-ray computed tomography to image the three-dimensional network of melt-containing pores in an olivine matrix, and calculate the permeability directly by solving the equations of Stokes flow through the pore network using a lattice-Boltzmann solver. Of importance, we find evidence that the scaling exponent that relates the permeability to the pore volume is greater than 3, and is closer to the value of 3.8 predicted by a pore closure model developed for crustal rocks. These estimates of permeability provide an important constraint on models of planetary core formation, and support the broader application of three-dimensional image analysis to resolve a variety of transport problems in systems that otherwise can't be measured.

Tomographic Reconstruction by Reciprocal Space Optimization

Eugene A. Ingerman, University of California, Davis
Hanna Szoke and Abraham Szoke, PAT/V-Division, LLNL
UCRL-ABS-216818

The program SPEDEN was developed originally for the reconstruction of diffraction images. The Fourier transform of tomograms produces a sample of the diffraction amplitudes, with well-defined phases. Therefore, SPEDEN could be used directly for tomographic reconstruction. A well-known problem of tomographic reconstruction is that the samples of the diffraction amplitudes are not uniformly distributed in diffraction space. The newly developed fast Fourier transform algorithms for non-equispaced data (NDFT) were implemented in SPEDEN. With this improvement, we obtained very promising results both for X-ray tomographic test objects and for electron microscope tomograms of auditory receptor (hair) cells.

NIF Target Alignment Sensor Algorithm

S. Walter Ferguson, Abdul A. S. Awwal, and Mina R. Bionta, EE/Laser Engineering Division, LLNL
Stephen G. Azevedo, EE/Electronics Engineering Technologies Division, LLNL
Sean K. Lehman, EE/Defense Sciences Engineering Division, LLNL
Holger E. Jones, Center for Applications Development & Software Engineering, LLNL
UCRL-ABS-216363

The NIF Target Alignment Sensor (TAS) algorithm is a challenging line detection problem. Horizontal, vertical, and angled lines must be identified and their intersections calculated to sub pixel accuracy. The detection algorithm is complicated by spatially varying illumination, noise, diffraction patterns, and a large contingent of interfering lines caused by multiple reflections. This presentation outlines an ongoing effort to create algorithms to align the NIF Target Alignment Sensor to stringent NIF requirements.

An Alternate Method for Detecting a Correlation Mismatch

Abdul A. S. Awwal
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UCRL-ABS-216364

Matched filtering is a robust technique to identify objects in the presence of noise. Traditionally, the amplitude of the correlation peak is used for detection of a known object present in an image. However, when the change in the object shape from the original is small, the reduction in the magnitude of the correlation peak may not provide an adequate indication of this difference. This poses a problem in the identification of objects that may be slightly different. One way to enhance the discrimination is to normalize the correlation output with respect to the total output in the correlation plane. This normalized correlation peak captures the percentage of the total power in the correlation plane that is concentrated in the correlation peak. One more direct measurement of the dissimilarity is therefore the broadness of the peak. For an autocorrelation the peak is usually narrow. Thus the area under the peak is smaller. On the other hand, when there is a mismatch there is a broadening of the peak or many false peaks. In this work, we present with simple examples how this novel measurement may be exploited to detect when the object at hand is different from the template. We show that this particular feature of the correlation peak increases the discrimination efficiency of the mismatch for both classical matched filtering and amplitude modulated phase only filter. The above technique was used in KDP image processing for discriminating between different beam lines or indicating a change in the beam template. To our knowledge, this is the first time such a feature has been used for correlation discrimination.

NIF Optics Inspection

Laura M. Kegelmeyer, Session Chair

NIF Optics Inspection Analysis: Overview and Update

Laura M. Kegelmeyer, EE/Defense Sciences Engineering Division, LLNL
Stephen G. Azevedo and Barry Y. Chen, EE/Electronics Engineering Technologies Division, LLNL
Erlan s. Bliss, IAP Worldwide, LLNL
Scott C. Burkhart, Alan D. Conder, Judith A. Liebman, and Vicki Miller Kamm
EE/Laser Engineering Division, LLNL
John W. Carlson and Steven M. Glenn, CAR-NIFE, LLNL
Jim J. Chang and J. Thad Salmon, National Ignition Facility Project, LLNL
Rahul Prasad, Laser Science & Technology, LLNL
UCRL-ABS-216036

The NIF at LLNL is a research facility for ignition and high energy density physics. It will be the world's largest and most energetic laser. Thousands of optics guide amplify and tightly focus the light from 192 beamlines onto a tiny target. The performance of these optics is key to the economic, efficient, and safe performance of the NIF.

Camera systems throughout the laser focus on the optics to image any flaws and then send the images for Optics Inspection Analysis. The Optics Inspection Analysis team has been developing an automated method to track the condition of each optic throughout its lifetime by analyzing all optics before, during, and after they are installed on the NIF beamline. We have a large central database at our core, integrating image analysis, statistics, pattern recognition, optical physics theory, decision-making and data visualization for a unified inspection system.

Here, we present an overview of the different image acquisition systems and introduce the topics to be discussed in the following talks, including detection limits, image registration issues, finding diffraction rings, data visualization, and the lessons learned from using MATLAB™ for a very large project.

Detection Limits and Registration Issues for Optics Inspection Analysis Software

Judith A. Liebman, EE/Laser Engineering Division, LLNL
Laura M. Kegelmeyer, EE/Defense Sciences Engineering Division, LLNL
Steven M. Glenn, CAR-NIFE, LLNL
Stephen G. Azevedo, EE/Electronics Engineering Technologies Division, LLNL
UCRL-ABS-216022

The large optics of NIF's main laser (the amplification stage) must be examined after every shot to characterize laser damage sites and track their growth. Our custom-built automated inspection software currently conducts these inspections as part of the NIF shot cycle. Our software must report whether defects are candidates for off-line spot mitigation or whether the optic must be refinished. This analysis is crucial to the economical and safe operation of the NIF laser since it is inefficient to replace optics that are still viable, while defects that are approaching 25% of critical flaw size must be identified.

Here, we present the updated detection finding algorithm that is at the core of our analysis. We will show examples from each system of some of the smallest detections that have been made. Finally, we will briefly introduce the final optics (final focusing stage) and new results in image registration that allow us to track detections through time to determine historical growth.

Detection of Laser Optic Damage Using Gradient Direction Sensitive Matching

Barry Y. Chen, Judith A. Liebman, Stephen G. Azevedo, David W. Paglieroni
EE/Electronics Engineering Technologies Division, LLNL
Jack Tzeng, EE/Laser Engineering Division, LLNL
Laura M. Kegelmeyer, EE/Defense Sciences Engineering Division, LLNL
UCRL-ABS-215938

For some defect sites on NIF optics, diffraction ring evidence from alternate focal-plane images can improve detection reliability. This paper presents the application of a robust pattern matching algorithm based on the gradient direction information of individual pixels for finding diffraction ring patterns in out-of-focus images of features. This algorithm, Gradient Direction Sensitive Matching, finds candidate ring centers by computing the similarity of the gradient direction of a ring pattern to that of a luminance disk. These initial candidates are further refined to reduce false alarms. Finally, for damage sites that can be modeled as simple absorbers, we fit the theoretical ring pattern equation to the candidate ring patterns for size and distance estimates. Detection results on images from simulated and real features demonstrate the potential effectiveness of our approach, showing improved true positive detections with fewer false alarms.

Lessons Learned Using MATLAB™ for Image Processing in a Production Application Environment

Steven M. Glenn, CAR-NIFE, LLNL
UCRL-ABS-215941

MATLAB™ is a popular development environment with a rich feature set that allows rapid development and deployment of sophisticated, computationally-intensive applications such as image processing. This presentation describes how MATLAB™ is used for NIF optic inspection analysis as well as accomplishments, setbacks, and lessons learned in converting an image processing application from compiled "C" to MATLAB™, with emphasis given to potential pitfalls.

Optics Inspection Data Visualization

John W. Carlson, CAR-NIFE, LLNL
UCRL-ABS-216175

Interactive data visualization is an important part of the optics inspection (OI) tasks on the National Ignition Facility (NIF). We have developed a tool that accesses the OI database and provides a powerful user interface allowing image manipulation. Our application displays NIF optics inspection data in a web accessible format. This feature allows a wide variety of users the capability to quickly see and measure features found in images. Our tool provides line outs, zoom capability, graphs, and tables. The display tool is written in the Java Swing toolkit, and uses a web server to access the data and images found in an Oracle database.

Ultrasonic Shear Wave Imaging of Optic Features

Sean K. Lehman, EE/Defense Sciences Engineering Division, LLNL
Michael J. Quarry, ME/Manufacturing and Materials Engineering Division, LLNL
UCRL-ABS-215974

The National Ignition Facility (NIF) at Lawrence Livermore National Laboratory is under construction. When complete NIF will be the world's largest and most energetic laser and will be capable of achieving for the first time fusion ignition in the laboratory. Detecting optics features within the laser beamlines and sizing them at diameters of 100 µm to 10 mm allows timely decisions concerning refurbishment and will help with the routine operation of the system. NIF optics under consideration are large, 430 mm x 430 mm x 43 mm, and made of fused silica. Features are generally on the surface and must be detected with sensors placed outside the aperture of the optic, on the edge.

Previous studies investigated 5 MHz longitudinal waves and showed detection abilities from 1 mm to 10 mm, but sizing was not conclusive. Also, mode converted multiple echoes from the top and bottom surfaces made data analysis difficult. This work examined using 10 MHz horizontally polarized shear waves. Experimental results on machine damaged and laser damaged optics show damage that is detected, located, and sized from 500 µm to 8 mm. The higher frequency and shorter wavelength of shear waves improved the resolution. Horizontal polarization of shear eliminated difficulties from mode conversions and multiple echoes from the top and bottom surfaces of the optic.

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November 17–18, 2005

Thank you for attending the Signal and Imaging Sciences Workshop. We would appreciate your input for future workshops.

1. Length of the presentation at the CASIS Workshop:

   ___ Too long
   ___ Too short
   ___ Just right

2. Topics/issues you would like to see in future workshops:

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5. Please rank the overall Workshop as follows:

   ___ Excellent
   ___ Very good
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Please return this form at the end of the Workshop or send to Dora Da Rosa at L-130 or e-mail at: darosa2@llnl.gov.

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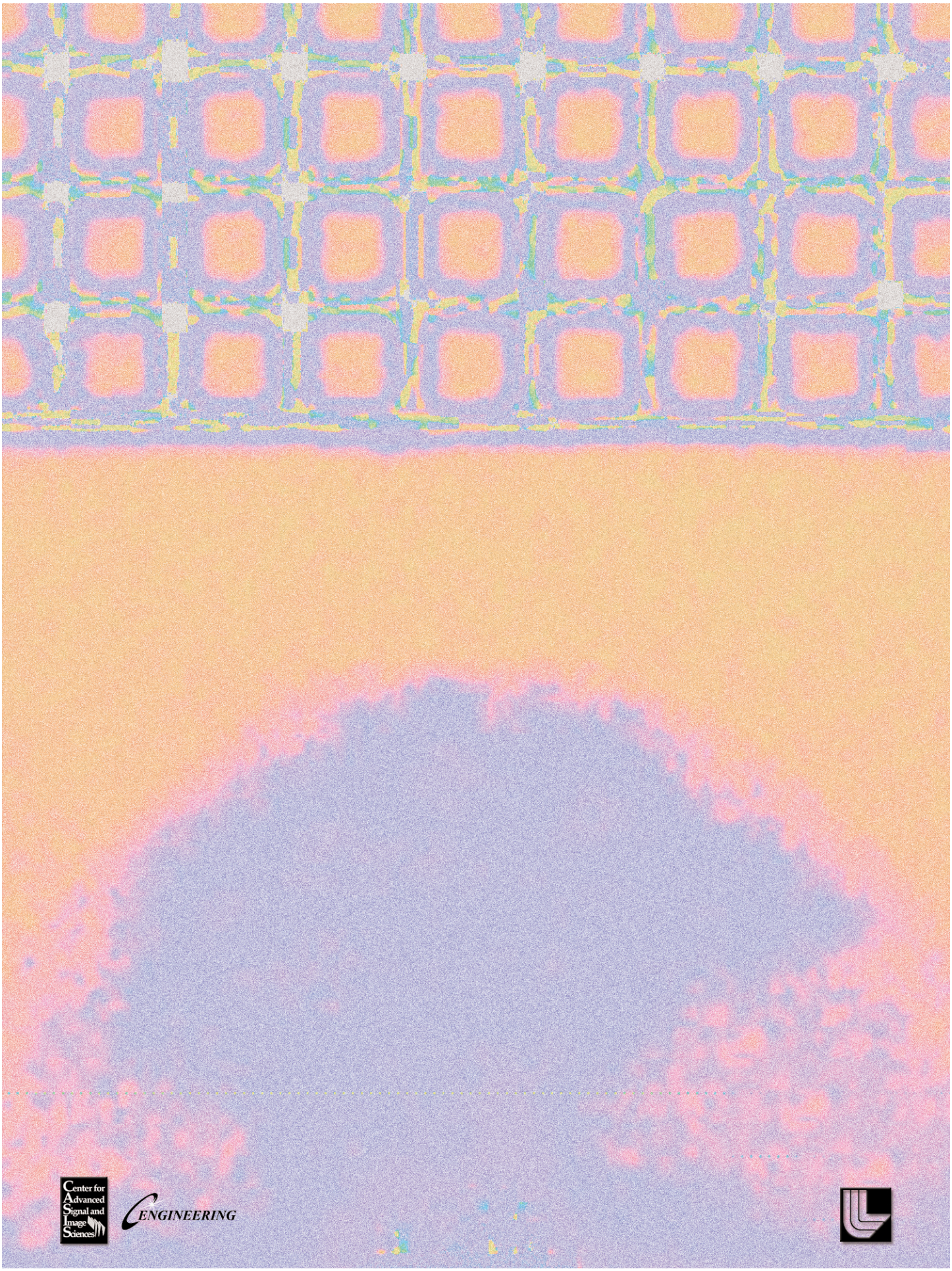

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