UCRL-ABS-408826

Abstract Proceedings

Signal and Imaging Sciences Conference

CASIS 2008

Thursday, November 20, 2008
Friday, November 21, 2008

Sponsored by
Lawrence Livermore National Laboratory
Engineering Directorate

Center for Advanced Signal and Image Sciences (CASIS)
Steve Azevedo, Randy Roberts, Co-Directors
http://casis.llnl.gov

Center for Advanced Signal and Image Sciences

ENGINEERING

WELCOME

Welcome to the 15th annual Workshop on the Signal and Image Sciences sponsored by the Center for Advanced Signal and Image Sciences (CASIS) and the Engineering Directorate.

What a milestone! For 15 years, we have gathered the week before Thanksgiving to present ideas and innovations in dealing with what some might consider the most important products a laboratory can produce -- data, leading to insight. The "big science" we are all engaged in depends on faithfully recording and analyzing experimental data, and being able to make sense of the results.

We like to think that the CASIS Workshop is an important part of scientific discovery. Over the years, there have been presentations from all major program areas at LLNL, as well as many from other laboratories and universities. Unique and innovative technologies, including some that become new programs or R&D 100 award winners, are often presented first at CASIS. This year appears to be no different, with a wide variety of interesting topical presentations in areas such as NIF, radiation detection, surveillance technologies, imaging and controls, and a special session on Pattern Recognition for Cyber Security.

Our keynote speaker this year is Dr. Jose Principe from the University of Florida. He will speak on "Information Theoretic Signal Processing", which has broad application across domains in data analysis. Please welcome him to the CASIS Workshop, where he joins an impressive list of luminaries in the field who have been prior keynote speakers.

We would especially like to thank the Engineering Directorate, the S&T Council in Engineering, and Acting Associate Director Monya Lane, for so generously supporting this workshop for all 15 of those years. And, of course, it would be impossible to organize CASIS each year without our outstanding administrative and art team of Carol Richardson, Karla Knox-Stauffer, Debbie Leal, and Kathy McCullough. Thank you, thank you!

So on behalf of the entire CASIS staff and the LLNL Engineering Directorate, we welcome you to this 15th CASIS Workshop. Take advantage of this opportunity to learn about the depth and breadth of your colleagues' work. Also, please fill out and return the feedback/survey form so we can make the Workshop even better next year!

Stephen Azevedo and Randy Roberts
C.A.S.I.S. Co-Directors
http://casis.llnl.gov

Signal and Imaging Sciences Conference

Keynote Speakers Over the Years

Year	Speaker	Title
1997	Dr. Donald Kania	Overview of the Advanced Microtechnology Program
1998	Dr. Anthony Devaney, Northeastern University	Diffraction Tomography
	Dr. Ronald Bracewell, Stanford University	Detection of Nonsolar Planets by Spinning Infrared Interferometer
1999	Dr. Bernard Widrow, Stanford University	A Microphone Array for Hearing Aids
	Dr. Avi Kak, Purdue University	A Retrospective on Computer Vision Research
2000	Prof. Simon Haykin, McMaster University	Adaptive Systems for Signal Processing
	Dr. Christian Pichot, University of Nice	Subsurface Tomography Using Ultra-Wide Band Systems
2001	Dr. James Greenleaf, Mayo Foundation	Vibro-Acoustography: Ultrasonic Imaging Without Speckle
	Prof. A. Paulraj, Stanford University	Multiple Input - Multiple Output (MIMO) Wireless: The New Frontier
2002	Dr. Alan Witten, University of Oklahoma	Expedition Adventure: Using Geophysics to Find Dinosaurs, Pirate Ships and Cavemen
	Dr. Leon Cohen, University of New York	Time-Frequency Description of Signals
2003	Dr. Thomas Budinger, UC Berkeley	Recent Advancements in Medical Imaging
2004	Prof. Alan Oppenheim, MIT	Things My Mother Never Told Me (About Signal Processing)
	Prof. James McClellan, Georgia Tech	Array Signal Processing for Locating Buried Objects and Tracking Moving Targets
2005	Prof. James Flanagan, Rutgers University	Natural Interfaces for Information Systems
2006	Prof. Sanjit Mitra, University of Southern California	Recent Research Results in Image and Video Processing
	Dr. James Candy, LLNL, UC Santa Barbara	A Bayesian Approach to Nonlinear Statistical Signal Processing
2007	Prof. Jitendra Malik, University of California, Berkeley	Recognizing Objects and Actions in Images and Video

CASIS

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Agenda

Signal and Imaging Sciences Conference

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

November 20 – 21, 2008

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

Center for Advanced Signal and Image Sciences

ENGINEERING

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

THURSDAY, NOVEMBER 20, 2008 BUILDING 482 AUDITORIUM

8:00 AM Registration, Distribution of Proceedings and Continental Breakfast
8:45 AM Opening Remarks, Introductions ..... Stephen Azevedo, CASIS Director
8:55 AM Welcome from Engineering ..... Monya Lane, Acting Engineering AD
9:00 AM Keynote Address: Information Theoretic Signal Processing ..... Professor Jose Principe, University of Florida

10:00 AM BREAK

10:15 AM NIC Shot Data Information - Optical through Nuclear..... Dr. Otto Landen, Associate Program Leader for Target Physics, ICF and HED Science Program, NIF and Photon Science Directorate

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NIF 1: Diagnostics Analysis
Session Chair: Tim Frazier

10:45 AM Measuring Drive Symmetry at NIF with Gated X-Ray Camera Images ..... Steve Glenn
11:00 AM NIF Dante Target Diagnostic Analysis ..... Judy Liebman
11:15 AM Near-backscatter Imaging (NBI) Analysis for the National Ignition Facility ..... Essex Bond
11:30 AM Electrromagnetic Pulses at Short-Pulse Laser Facilities: Measurement System, Signal Processing Methods, and Simulation Results ..... Charlie Brown
11:45 AM Cable Damage Detection Algorithms for Time Domain Reflectometry Signal ..... Grace Clark

12:00 PM LUNCH

NIF 2: Controls and Optics Inspections
Session Chair: Karl Wilhelmsen

1:00 PM Alternative to Hough Transform-based Alignment ..... Richard Leach
1:15 PM Avoiding the Highest Peaks (in correlation discrimination) ..... Abdul Awwal
1:30 PM NIF Laser-Induced Optics Damage Data-Based Predictions and Visualizations ..... Wade Williams
1:45 PM Applying Avatar Machine Learning to NIF ..... Laura Kegelmeyer

2:00 PM BREAK

Radiation Detection for Homeland Security
Session Chair: Harry Martz

2:15 PM Hardware Architecture for Image Development Database (IDD) Project ..... Faranak Nekoogar
2:30 PM Bayesian Sequential Processing for Radionuclide Parameter Estimation ..... Eric Breitfeller
2:45 PM Signal Processing Model for Radiation Transport ..... Dave Chambers
3:00 PM Adaptive Noise Cancellation for Mechanical HPGe Detectors ..... Karl Nelson
3:15 PM Use of X-rays to Detect HomeMade Explosives (HME) and Next Generation X-ray Systems ..... Harry Martz
3:30 PM 3-1-1 Baggies ..... Cary Pincus

3:45 PM ADJOURN

AGENDA
Signal and Image Sciences Conference

Center for Advanced Signal and Image Sciences
Lawrence Livermore National Laboratory

FRIDAY, NOVEMBER 21, 2008 BUILDING 482 AUDITORIUM

8:00 AM Registration, Distribution of Proceedings and Continental Breakfast

8:45 AM Opening Remarks, Introductions ..... Randy Roberts, CASIS Co-Director

9:00 AM Innovative Technology for Global Security ..... Dr. Craig Wuest, Deputy Program Manager Z Program, Global Security Principle Directorate

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Special Session
Pattern Recognition for Cyber Security:
Session Chair: Tina Eliassi-Rad

9:30 AM Situational Awareness at Internet Scale—Detection of Extremely Rare Crisis Periods ..... Philip Kegelmeyer

9:50 AM Analysing Network Traffic Data Using Latent Dirichlet Allocation for Graphs ..... Keith Henderson

10:10 AM Classification of HTTP Attacks: A Study on the ECML/PKDD 2007 Discovery Challenge ..... Brian Gallagher

10:30 AM BREAK

Advanced Imaging and Controls
Session Chair: Sean Lehman

10:45 AM VisiBuilding: Remote Non-Invasive Building Floor Plan Identification ..... Sean Lehman

11:00 AM Predictive Control for Astronomical Adaptive Optics: Experimental Verification of the Frozen Flow Hypothessis ..... Lisa Poyneer

11:15 AM Visualizing Single Cell Biology: Nanosims Studies of Carbon and Nitrogen Metabolism in Bacteria ..... Jennifer Pett-Ridge

11:30 AM Using Supercomputers to Advance Robotics ..... Freddy Hansen

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Wide-Area Surveillance Technologies
Session Chair: Randy Roberts

11:45 AM Scalable Data Architectures for Object Identification and Synaptic Cueing in Wide-Area Video Imagery ..... Holger Jones

12:00 PM Gigapan, Photosynth, and Stereo Data Maker ..... John Toeppen

12:15 PM Novel Architectures and Progressive Algorithms for Real-Time Analysis of Streaming Data ..... Ming Jiang

12:30 PM Vehicle Tracking and Super-Resolution in Overhead Video ..... Siddharth Manay

12:45 PM Lunch and Adjourn

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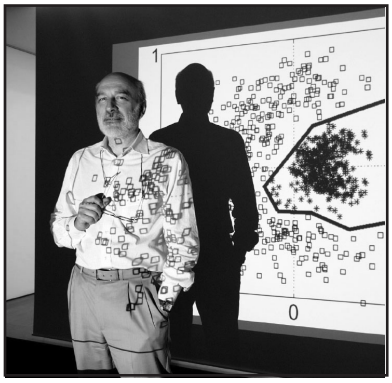
Keynote Speaker

Dr. Jose Principe
University of Florida

Center for Advanced Signal and Image Sciences

Information Theoretic Signal Processing

Jose C. Principe
Distinguished Professor of Electrical Engineering
University of Florida



This talk describes our efforts to go beyond the second order moment assumption still prevalent in optimal signal processing. We show how the second norm of the PDF can be estimated directly from data avoiding an explicit PDF estimation step. The link between PDF moments, information theory and Reproducing Kernel Hilbert spaces will be established. Applications to adaptive systems with entropic cost functions will be demonstrated. A generalized correlation function called correntopy will be defined and its applications in signal processing will be outlined. Correntopy leads to new measures of similarity, to a new definition of dependence subspaces and to new tests for causality.

Jose C. Principe Jose C. Principe (M'83-SM'90-F'00) is a Distinguished Professor of Electrical and Computer Engineering and Biomedical Engineering at the University of Florida where he teaches advanced signal processing, machine learning and artificial neural networks (ANNs) modeling. He is BellSouth Professor and the Founder and Director of the University of Florida Computational NeroEngineering Laboratory (CNEL) www.cnel.ufl.edu. His primary area of interest is processing of time varying signals with adaptive neural models. The CNEL Lab has been studying signal and pattern recognition principles based on information theoretic criteria (entropy and mutual information). Dr. Principe has more than 400 publications. He directed 62 Ph.D. dissertations and 65 Master theses. He wrote an interactive electronic book entitled "Neural and Adaptive Systems: Fundamentals Through Simulation" published by John Wiley and Sons and more recently co-authored a book on Brain Machine Interfaces.

NIF 1: Diagnostics Analysis

Tim Frazier, Session Chair

Center for Advanced Signal and Image Sciences

Measuring Drive Symmetry at NIF with Gated X-Ray Camera Images

S. Glenn, Glenn (LLNL), G. Kyrala (LANL), N. Izumi (LLNL), National Ignition Facility

LLNL-ABS-407716

The Gated X-Ray Detector (GXD) is a target diagnostic that will be used to characterize the symmetry of X-ray emission from NIF targets. This presentation describes the GXD instrument, the experimental setup, and analysis techniques used to measure symmetry, including contour identification in the presence of noise and Legendre decomposition. These techniques are illustrated by applying them to simulated GXD images.

NIF Dante Target Diagnostic Analysis

Judy Liebman, Klaus Widmann, John Kline, Abbie Warrick, Aseneth Lopez, Steve Azevedo, National Ignition Facility

LLNL-ABS-407622

The National Ignition Facility is developing a variety of automated target diagnostics to capture target implosion metrics. These diagnostics instruments and analyses will be used to determine NIF experimental results. In this talk we will discuss the Dante diagnostic instrument and signal analysis. Dante estimates radiation temperature during target implosion by using 18 x-ray diodes to measure emitted soft x-rays. Soft x-rays are a result of black body radiation, so their spectrum relates to temperature. Dante is mounted on the NIF target chamber wall, where each of its filtered x-ray diodes measures flux at a different energy range. For some low-energy channels, x-ray mirrors are used in addition to the filters. The signal from each channel travels through a 50m cable, attenuators, and other electrical components to an oscilloscope which records its time history. The Dante software must compensate for each of the electrical components, cables, mirrors, filters, diode responses, as well as adjust the signal timing alignment, before finding a best fit blackbody radiation curve to estimate temperature. We will be presenting a hardware introduction and an overview of the signal processing software.

Near-Backscatter Imaging (NBI) analysis for the National Ignition Facility

E. Bond, P. Neumayer, J. Moody, National Ignition Facility
Laser and Systems Engineering, Lawrence Livermore National Laboratory

LLNL-ABS-407996

The near-backscatter imaging (NBI) system is one of two diagnostics used to assess the coupling efficiency of the National Ignition Facility (NIF) 3ω (351 nm) laser energy to an ignition target. Ideally, all laser energy incident on the target would remain in the target. However, laser-plasma instabilities cause some of the laser energy to be backscattered resulting in a reduction of energy available for achieving ignition. The backscattered energy is expected in two primary spectral bands. Stimulated Brillouin scattering is observed in the 350-353 nm range and Stimulated Raman scattering is observed in the 450-750 nm range. It is important to ensure that the total backscattered energy remains below required levels (~ 10% of the total incident energy). The NBI diagnostic uses a gated intensified charge couple device (ICCD) camera to quantitatively measure the energy backscattered outside the focusing cone angle of the incident laser beam. The ICCD provides 2 mm resolution over a 2 m field of view at the NIF target chamber wall. This talk will briefly describe the NBI imaging system and the algorithms used to determine backscattered energy from acquired images. The challenges with NBI analysis will also be discussed, including transforming the perspective of an image and interpolating the distribution of backscatter over each laser port entrance.

Electromagnetic Pulses at Short-Pulse Laser Facilities: Measurement System, Signal Processing Methods, and Simulation Results

Charles G. Brown Jr., David C. Eder, Alan L. Throop, Joseph R. Kimbrough,
Mark L. Stowell, William J. DeHope, Daniel A. White
Lawrence Livermore National Laboratory

LLNL-ABS-407708

New Electromagnetic pulse (EMP) is a known issue for short-pulse laser facilities such as Vulcan, Titan and Omega EP[1]; therefore, understanding and mitigating EMP is an important part of the effective use of ARC on NIF. (The Advanced Radiographic Capability (ARC) uses up to 4 of NIF's 192 beams in a short picosecond pulse mode to provide short-pulse, high-energy, x-ray backlighting). Short-pulse lasers produce very energetic (MeV) electrons, and because of their high energy more can escape from the target. Even in the case of short-pulse lasers, the number of electrons that escape (~1012) is a small fraction of the total number produced in the target, and the associated charge is a small fraction of a Coulomb. However, the small fraction of electrons that do escape produce very large transient currents and EMP. In addition, since the impulse of escaping electrons is short, it has a correspondingly broad spectrum with the potential of highfrequency EMP. For effective shielding it is critical that the spectrum of the EMP, as well as the time-domain behavior, is known.

Both electromagnetic measurements and simulations are critical to understanding EMP in short-pulse lasers. We have fielded many different diagnostics in the Titan short-pulse laser [2], which is a part of the Jupiter Laser Facility at LLNL, in order to characterize the EMP inside and outside of the Titan laser chamber. Also, in order to establish predictive capabilities so that the EMP can be characterized beforehand and mitigation techniques developed, we have simulated EMP generation by having a specified number of electrons leave the target and strike the chamber wall using EMSolve [3]. EMSolve is a numerical electromagnetics code developed at LLNL. Reference [4] describes some of our early measurement, analysis, and simulation work. This presentation outlines the measurement system; details the signal processing techniques; and presents some electromagnetic simulation results from our most recent campaign.

References

[1] Mead M J et al. 2004 Electromagnetic pulse generation within a petawatt laser target chamber Rev. Sci. Instr. 75 4225-7
[2] Titan and target chamber descriptions http://jlf.llnl.gov
[3] "EMSolve Unstructured Grid Computational Electromagnetics using Mixed Finite Element Methods," http://www.llnl.gov/CASC/emsolve.
[4] Brown Jr. C G et al. 2008 Electromagnetic pulses at short-pulse laser facilities J. Phys.: Conf. Ser. 112 032025

Cable Damage Detection Algorithms for Time Domain Reflectometry Signals

Grace A. Clark, Katherine A. Wade, Christopher L. Robbins
Lawrence Livermore National Laboratory

LLNL-ABS-407974

Critical cables can undergo various types of damage (e.g. short circuits, open circuits, punctures, compression) that manifest as changes in the dielectric properties of the cables. Only one end of the cable is accessible, and no exemplars of actual damage are available.

This work addresses the detection of dielectric anomalies in transient time domain reflectometry (TDR) measurements on the cables. Machine learning classification algorithms are effectively eliminated from consideration, because only a small number of cables are available for testing; so a sufficient sample size is not attainable. Nonetheless, a key requirement is to achieve very high probability of detection and very low probability of false alarm.

The approach is to compare TDR signals from possibly damaged cables to signals or an empirical model derived from reference cables that are known to be undamaged. This requires that the TDR signals are reasonably repeatable from test to test on the same cable, and from cable to cable. Empirical studies show that the repeatability issue is the "long pole in the tent" for damage detection, because is has been difficult to achieve reasonable repeatability. The two-step model-based approach is summarized as follows:

Step 1, Cable Modeling:
Given input-output TDR signals $s(t)$ and $x_u(t)$ for a cable known to be free of damage, system identification algorithms are used to compute a dynamic prediction-error cable model that has output $\hat{x}_u(t)$. The model is declared valid when the innovations $e_u(t) = x_u(t) - \hat{x}_u(t)$ satisfy a statistical zero-mean whiteness test. This validated model output is then used as a known reference to which other cables can be compared.

Step 2, Cable Testing:
The TDR output signal $x_D(t)$ from a cable under test is compared with the model output $\hat{x}_u(t)$ by computing the innovations $e_D(t) = x_D(t) - \hat{x}_u(t)$. The innovations are tested using a short-term whiteness test statistic, which employs a statistical confidence interval. If the cable passes the test, this implies that the model is valid and the cable is declared undamaged. If the cable fails the test, this indicates a model mismatch, which means that the cable's dielectric properties have changed; and this implies that the cable is damaged. The test threshold is adjusted to maximize probability of detection and minimize probability of false alarm according to an empirically determined receiver operating characteristic (ROC) curve. An associated confidence interval on the probability of correct classification is also provided.

The effectiveness of the algorithm is demonstrated using measured TDR signals for undamaged and damaged cables. Experimental and algorithmic methods for coping with repeatability issues are presented.

NIF 2: Controls and Optics Inspections

Karl Wilhelmsen, Session Chair

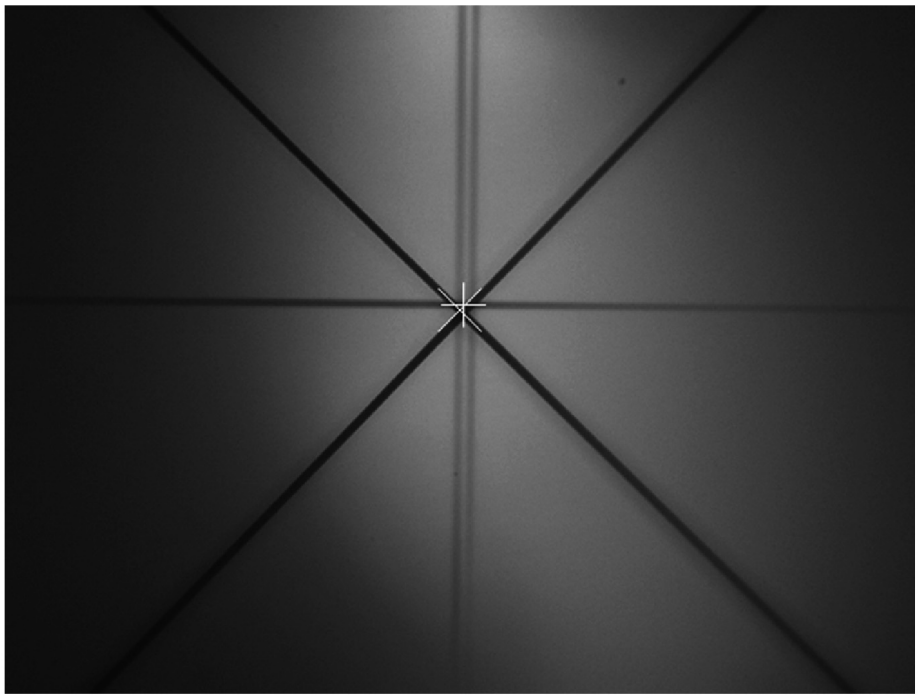
Center for Advanced Signal and Image Sciences

Alternative to Hough Transform-based Alignment

Richard R. Leach Jr.
Integrated Computer Control System, National Ignition Facility

LLNL-ABS-407712

The Hough transform is a feature extraction technique used in image analysis, computer vision, and digital image processing. One classical application of the Hough transform is the identification of lines in images. This approach has been successfully used in critical camera-based beam alignments in the target chamber of the National Ignition Facility. The accurate location of line objects in images that is required can suffer from optical distortions due to low-light conditions. In these instances, the Hough transform is not able to identify objects with the required precision. In addition, the computation load of this approach can be prohibitive. An alternative method has been developed that simplifies the task by avoiding time intensive approaches like the Hough transform. This method employs a contrast detection strategy to identify localized line segments that are merged together to form the target line objects. This approach significantly reduces the processing load. We show this with examples from automatic alignment laser beam images used in the National Ignition Facility. We introduce terms like vector fit and detection bands to identify lines of interest in target images. With the new algorithm, alignment objects are accurately detected and the computational time is reduced from up to 90 seconds to 5 seconds
per image.



Example alignment image from NIF target chamber shows the alignment gridlines (dark 'x' and grey '#' lines) with position identification superimposed with a white 'x' and '+' symbol.

Avoiding the Highest Peaks (in correlation discrimination)

Abdul Awwal
Integrated Computer Control System, National Ignition Facility

LLNL-ABS-407565

The common approach for correlation detection is to choose the highest peak when finding an object of interest in a scene. This generally works when the object of interest has a higher (than one) signal to noise ratio. However, when the signal to be detected is very weak, this approach is not effective. The highest peaks act as traps for false detection. Example of such images shown in Fig. 1, are the active target images used for automatic alignment in the National Ignition Facility. In these images the fiducials of interest are of extremely low intensity and contrast. These images also have very bright noise in the background. The highest correlation peaks are generated by these bright noise sources. In this work, we show how the shape of the correlation is exploited to filter out a valid match from hundreds of invalid matches. Using the information from self-correlation, we are able to avoid false matches and find the best match under very challenging lighting conditions.

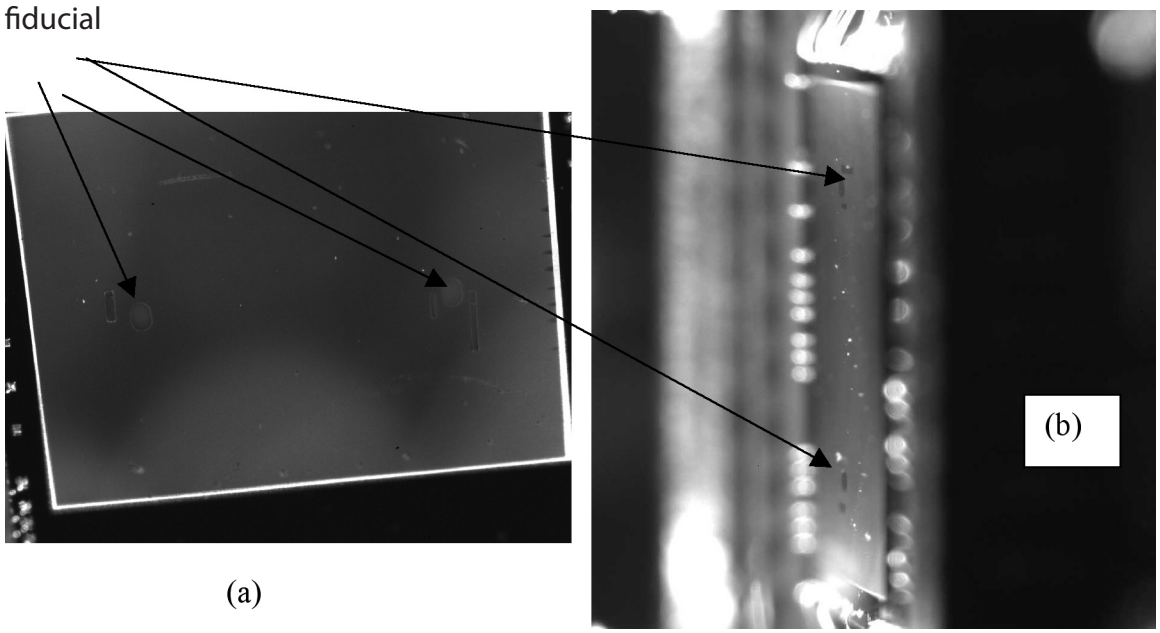


Fig. 1 Two active target images showing the fiducials to-be-detected, which are barely visible with extremely low contrast. The image on the right, known as side camera image (b), shows the presence of extremely bright noise source.

NIF Laser-Induced Optics Damage Data-Based Predictions and Visualizations

Wade Williams, Dan Potter, Judy Liebman, Laura Kegelmeyer, Amber Marsh, Alan Conder, Jim Chang, National Ignition Facility Laser and Systems Engineering, Lawrence Livermore National Laboratory

LLNL-ABS-408256

One of the significant operational challenges on NIF will be monitoring and managing the damage done by high laser fluences to the final optics. This damage will be manifest as a total of 10's to 100's of thousands of pinpoint-size damage sites over the surfaces of the ~1000 final optics.

There are several contributing layers in our response to this need. 1) The Final Optics Damage Inspection (FODI) system takes high-resolution images of the various optics after a shot in a way which allows detection of damage sites ~50 micron diameter and larger. Repeated measurements between shots allows us to watch the sites grow. 2) Sophisticated image analysis by Optics Inspection software then identifies the damage sites in each of the ~1000 images and estimates their size (based on previous calibrations). 3) The next layer takes the image analysis results for each beamline, and combines it with expected laser beam fluences at the defect locations in upcoming shots to estimate how large the defects may grow. Defects below a certain size can be mitigated in off-line labs at LLNL, using one of various techniques, after which the optic can be returned to use. If defects are allowed to grow larger then this then they must be completely re-polished, which is significantly more expensive. To minimize cost and impact on operations, we must pull the optic as close to, but before, this threshold, as possible. 4) The final layer combines information for all beamlines in a "red/green" light visualization with "drill-down" capability, allowing ready decision-making after a laser shot.

It is the purpose of this talk to discuss the final two layers: Determination of the estimated defect sizes in upcoming shots (by the code RecycleNow), and collation of this large amount of information into useable tools for shot operations (through the codes NIF Loop Viewer and RecylceNowInteractive).

Applying Avatar Machine Learning to NIF

Laura M. Kegelmeyer
Lawrence Livermore National Laboratory

UCRL-ABS-407660

Machine learning is emerging as the way to handle huge quantities of data that are too cumbersome to handle with traditional mathematical or human analysis methods. The NIF Optics Inspection Analysis group is using a self-configuring pattern recognition tool called Avatar (WP Kegelmeyer, Sandia National Laboratories) to apply machine learning techniques to various aspects of the optics inspection project. We train Avatar to categorize flaws on optics and then use the resulting ensemble of decision trees during shot operations to quickly report on the status of a beamline. We've also applied Avatar to predict growth of flaws on optics.

The advantages of Avatar over other available machine learning tools is that it has innovative advances built-in to automatically determine necessary parameters so that the user can operate in a "hands-off" fashion. One of these innovations is an automatic, data-driven stopping condition for out-of-bag validation which determines how many trees are needed in the ensemble, or forest, to maximize accuracy of the output. Another innovation, available only in Avatar, improves accuracy when you have skewed data (where one class, usually the most interesting, is far less represented than the other classes).

As stated by Drawbaugh (U Pittsburgh Medical Center) in Wired Magazine (July 30, 2008), "It will be through the use of technologies such as machine learning, ... that will help to address this information overload. By using such technologies, a computer will soon be able to sift through the data and present ... the most important areas of concern."

Radiation Detection for Homeland Security

Harry E. Martz, Jr., Session Chair

Center for Advanced Signal and Image Sciences

Hardware Architecture for Image Development Database (IDD) Project

Don Mendonsa, Faranak Nekoogar, Harry Martz
Lawrence Livermore National Laboratory

LLNL-ABS-408508

One of the tasks in IDD project is to become a national repository for DHS to store large volumes of data and images from US airports and other sources and allow the users to retrieve the archived data efficiently. The users include LLNL NDE staff and outside collaborators. The requirements for this archival system are to be able to efficiently archive large volumes (~100 TBytes) of image data per daily data transfer and data acquisitions. This environment will receive data from many remote sites by way of various delivery methods, quickly be scanned for viruses and malware, then be saved for both long-term storage and further processing.

In this presentation, we discuss the details of the available hardware as well as its workflow with recommendations for future improvements. We also will discuss how collaborators could download their algorithms onto the database and access the data without it having to be sent to them.

Bayesian Sequential Processing for Radionuclide Parameter Estimation

Eric F. Breitfeller, James V. Candy
Lawrence Livermore National Laboratory

LLNL-ABS-408462

The timely and accurate detection of nuclear contraband whether it is located in a vehicle at a border crossing, a cargo container entering a port or simply in luggage at an airport scanner is an extremely important problem of national security especially in this era of constant terrorist activities. Radionuclide emissions from threat materials challenge both detection and measurement technologies to capture and record each event. The development of a Bayesian sequential processor that incorporates both the underlying phenomenology as well as the measurement of photon energies offers a physics-based approach to attack this challenging problem. This approach enables the development of an effective detection technique and can be implemented using advanced signal processing methodologies such as sequential Monte Carlo processors or equivalently particle filters to enhance and extract the required parametric information. Here we discuss a statistical approach based on Bayesian inference and physics-based signal processing to extract unique radionuclide parameters required for the implementation of an on-line sequential detection paradigm.

Signal Processing Model for Radiation Transport

D. H. Chambers
Lawrence Livermore National Laboratory

UCRL-ABS-407616

This talk describes the design of a simplified gamma ray transport model for use in designing a sequential Bayesian signal processor for low-count detection and classification. Event mode sequences and other time-dependent photon flux sequences are assumed to be marked Poisson processes that are entirely described by their rate distributions. A simple one-dimensional geometric model is used to transport the rate distributions from the emitting source through a shield and into the detector. The model is a generalization of a single photon event model sequence simulator created by Alan Meyer. Individual realizations of fluxes or event mode sequences can be constructed from the rate distributions using a random Poisson point sequence generator.

Adaptive Noise Cancellation for Mechanical HPGe Detectors

Karl Einar Nelson
Lawrence Livermore National Laboratory

LLNL-ABS-408441

HPGe detectors are used to measure gamma ray spectroscopy to detect and identify radiological sources in the field. These detectors must operate at cryogenic temperatures and thus field operation requires mechanical cooling solutions. Semiconductor detectors employ sensitive preamplifiers to convert tens of thousands of electrons produced by the gamma ray into an electronic signal. Mechanically vibrations from the cooler induce changes in capacitance which are translated by the preamplifier into "micro-phonic noise." By using classical adaptive filtering techniques, we can greatly attenuate these noise sources and thus improve the quality of field instruments.

Use of X-rays to Detect HomeMade Explosives (HME) and Next Generation X-ray Systems

H. E. Martz, Jr
Lawrence Livermore National Laboratory

LLNL-ABS-408697

Over the past 3 years, LLNL has been funded to support the Department of Homeland Security, Science and Technology, Explosive Division in better understanding of the use of X-rays to detect HomeMade Explosives (HME) and the development of the next generation X-ray systems to detect conventional (military, commercial and sheet) explosives. The latter is referred to as Manhattan II. This effort includes the development of an archival and query database, analysis of digital radiography, limited view computed tomography and standard (many view) computed tomography systems. We have developed several test plans, acquired over 30 TeraBytes of X-ray data. The presentation will summarize this work and present a summary of our results.

3-1-1 Baggies

Cary Pincus
Lawrence Livermore National Laboratory

Abstract not available at time of publication

Special Session

Pattern Recognition for Cyber Security: Special Session

Tina Eliassi-Rad, Session Chair

Center for Advanced Signal and Image Sciences

Situational Awareness at Internet Scale — Detection of Extremely Rare Crisis Periods

Philip Kegelmeyer, Sandia National Laboratories, CA

Sandia Release Number -235651

It would valuable to have early warning of the onset of disruptions to the Internet. Border Gateway Protocol (BGP) data captures one aspect of communications between autonomous routers, and so, if monitored properly, might provide that warning. There is a fundamental difficulty in doing so, however. Disruptions, though of critical importance, are very, very rare. This problem, of imbalanced data, afflicts many applications, and is becoming even more prevalent as data volumes grow.

In response, we are investigating a novel coupling of supervised machine learning methods. Hellinger trees are a new decision method that is robust in the face of imbalanced data. Ensemble methods, properly deployed, can extract every possible bit of accuracy from noisy, awkward data. We are therefore applying ensembles of Hellinger trees to the problem of internet crisis detection.

In this talk we will set up the problem, briefly explain the principles of both Hellinger trees and ensembles, and illustrate progress to date against real BGP data.

Analyzing Network Traffic Data using Latent Dirichlet Allocation for Graphs

Keith Henderson and Tina Eliassi-Rad
Lawrence Livermore National Laboratory

LLNL-ABS-408155

Cyber-security analysts often have access to IP traffic over a network (a.k.a. trace data). Detecting cyber threats (e.g., compromised IPs) in this traffic is a challenge. The skew in volumes between legitimate and malicious traffic makes classification difficult. Moreover, a single IP address can dynamically map to several different physical machines during a given period of time, and the behavior of a physical machine can change (e.g. after a virus infection). While there are some promising methods for classifying network traffic, most of them require analysis of the packet payloads (which are computationally costly) and/or prior knowledge of malicious behavior (which makes them vulnerable to unseen attack types).

Given network trace data that evolves over time, we propose an analysis based solely on the topology of the dynamic IP-to-IP communication graph. In particular, we apply our *dynamic Latent Dirichlet Allocation for Graphs* algorithm (a.k.a. dynamic LDA-G) to network trace data. Dynamic LDA-G is a nonparametric Bayesian model that discovers latent group structure in time-evolving graphs. It produces two matrices: (1) the IP x *Group Membership Matrix,* where each entry is the probability of an IP belonging to a specific group; and (2) the *Group x Group Likelihood Matrix,* where each entry is the probability of a connection between two given groups. The statistical models inferred by LDA-G can perform link prediction between a pair of IPs and discover "unstable" IPs with volatile communication patterns. Our experimental study on trace data collected over 5-days at an access link demonstrates that dynamic LDA-G is highly predictive of communications (i.e., links) between IPs, even with very little observed data. Moreover, our study shows that dynamic LDA-G can accurately flag various IP addresses in the graph based on "volatility," a measure of how much their role in the graph changes over time.

Classification of HTTP Attacks: A Study on the ECML / PKDD 2007 Discovery Challenge

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LLNL-ABS-408035

As the world becomes more reliant on Web applications for commercial, financial, and medical transactions, cyber attacks on the World Wide Web are increasing in frequency and severity. Web applications provide an attractive alternative to traditional desktop applications due to their accessibility and ease of deployment. However, the accessibility of Web applications also makes them extremely vulnerable to attack. This inherent vulnerability is intensified by the distributed nature of Web applications and the complexity of configuring application servers. These factors have led to a proliferation of Web-based attacks, in which attackers surreptitiously inject code into HTTP requests, allowing them to execute arbitrary commands on remote systems and perform malicious activities such as reading, altering, or destroying sensitive data.

One approach to deal with HTTP-based attacks is to identify malicious code in incoming HTTP requests and eliminate bad requests before they are processed. Using machine learning techniques, we can build a classifier to automatically label requests as "Valid" or "Attack." For this study, we develop a simple, but effective HTTP attack classifier, based on the vector space model used commonly for Information Retrieval. Our classifier not only separates attacks from valid requests, but can also identify the specific type of an attack (e.g., "SQL Injection" or "Path Traversal").

We demonstrate the effectiveness of our approach through experiments on the ECML/PKDD 2007 Discovery Challenge data set. Specifically, we show that our approach achieves higher precision and recall than previous methods. In addition, our approach has a number of desirable characteristics, including robustness to missing contextual information, interpretability of models, and scalability.

Advanced Imaging and Controls

Sean Lehman, Session Chair

Center for Advanced Signal and Image Sciences

VisiBuilding: Remote Non-Invasive Building Floor Plan Identification

Sean K. Lehman & David H. Chambers
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LLNL-JRNL-403542

A model-based approach to estimating wall positions for a building is developed and tested using simulated data. It borrows two techniques from geophysical inversion problems, layer stripping and stacking, and combines them with a model-based estimation algorithm that minimizes the mean-square error between the predicted signal and the data. The technique is designed to process multiple looks from an ultrawideband radar array. The processed signal is time-gated and each section processed to detect the presence of a wall and estimate its position, thickness, and material parameters. The floor plan of a building is determined by moving the array around the outside of the building. In this presentation we describe how the stacking and layer stripping algorithms are combined and show the results from a simple numerical example of three parallel walls.

Predictive Control for Astronomical Adaptive Optics: Experimental Verification of the Frozen Flow Hypothesis

Lisa A. Poyneer
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LLNL-ABS-407677

Predictive Fourier Control (PFC) is a real-time control algorithm for astronomical Adaptive Optics (AO). Using closed-loop AO telemetry, it characterizes the atmosphere in terms of layers of frozen flow turbulence. Using the layer velocities and powers, it then determines and implements the steady-state Kalman filters that independently predict each Fourier mode of the wavefront.

It is essential to verify that the underlying statistical model of PFC, namely frozen flow, is valid. To do so, we have analyzed AO telemetry from the Altair and Keck AO systems on Mauna Kea. We present the results of out initial year-long campaign: frozen flow is strongly identified > 94% of the time, and wind variability is low enough to allow PFC to measure and adapt on 10-second time scales.

Visualing Single Cell Biology: Nanosims Studies of Carbon and Nitrogen Metabolism in Bacteria

Jennifer Pett-Ridge and Peter K. Weber, Chemical and Isotopic Signatures Group, Lawrence Livermore National Laboratoy

UCRL-ABS-215387

The technical challenges of tracing isotopes within individual bacteria can be overcome with high resolution Secondary Ion Mass Spectrometry (NanoSIMS). In NanoSIMS analysis, samples are sputtered with an energetic primary beam (Cs^+, O^-) liberating secondary ions that are separated by the mass spectrometer and detected in a suite of electron multipliers. Five isotopic species may be analyzed concurrently with spatial resolution as fine as 50nm. A high sensitivity isotope ratio 'map' can then be generated for the analyzed area and presented as a false color image. We used this technique to quantitatively describe ^{13}C and ^{15}N uptake and transport in bacteria grown on $NaH^{13}CO_3$ and $^{15}N_2$. We combine this technique with elemental labeled in situ hybridization that can identifiy specific microbial taxa. With a combination of TEM, SEM and NanoSIMS analyses, we also mapped the distribution of C, N and Mo (a critical nitrogenase co-factor) isotopes in intact cells. This combination of Nano-Secondary Ion Mass Spectrometry (NanoSIMS) analysis and high resolution microscopy allows isotopic analysis to be linked to taxonomic identity and morphological features and holds great promise for fine-scale studies of bacteria metabolism.

Using Supercomputers to AdvanceRobotics

J. F. Hansen,
Lawrence Livermore National Laboratory

Scientists as well as politicians often speak of the grand challenges facing us the coming century; these are what we must overcome to maintain our economic competitiveness, avoid ecological disaster, or simply to survive. Undeniably, these are important undertakings. However, society cannot thrive by merely surviving – it is equally important to grasp the grand opportunities of the century. Among these, the multi-functional humanoid robot is possibly the grandest opportunity of them all, and could lead to a societal shift on par with the industrial revolution.

Unfortunately, progress in robotics is slowed by limited computing power. I will speak on how supercomputers can open a new frontier in robotics. There are significant advantages of using the immense computing power of modern supercomputers in pre-computing robot gaits, grips, machine vision models, and swarm behavior. Besides these obvious benefits, the use of a supercomputer can also give a tremendous boost to a real-time robot, by enabling the integration of a very large number of algorithms related to machine vision, gait, grasping, and so on. In this scenario, the supercomputer is used to control a robot remotely, but in real time, by running many state-of-the-art, CPU-intensive algorithms concurrently. Typically, hundreds of such algorithms must run in real time, but even a single algorithm often runs slower than real time on the computer systems typically available to robotics scientists today. I envision a project where robotics researchers around the world can work together and to submit their best algorithms to run on a supercomputer to control a multi-functional humanoid robot. Such a project can spur collaboration on a scale more typically found in other sciences, such as physics or biotechnology.

Wide-area Surveillance Technologies

Randy Roberts, Session Chair

Scalable Data Architectures for Object Identification and Synaptic Cueing in Wide-Area Video Imagery

Holger Jones, Mark Duchaineau, Jonathan Cohen, Yang Liu, Ming Jiang, Siddharth Manay, David Bremer, Peter Lindstrom, Daniel Laney, Sheila Vaidya, and Randy Roberts
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LLNL-ABS-408360

Wide-area persistent surveillance is an important technology with applications to many national security problems. Due to the large volume of imagery produced by these systems, and the need for real-time exploitation, data processing architectures are key to the success of this technology. We are currently building a data pipeline that will provide scalable, high fidelity and near real-time object identification in urban environments. Based on dense-correspondence video stabilization, the pipeline will additionally provide 100x to 10,000x data reduction over raw imagery, super-resolution imagery and be optimized for power/weight /form-factor on many sensor platforms. This talk will provide an overview of the algorithms and hardware that will implement the pipeline.

Gigapan, Photosynth, and Stereo Data Maker

John Toeppen
Lawrence Livermore National Laboratory

LLNL-ABS-366475

Commercially available hardware and software tools allow photos to be used to build large data sets suitable for many applications. These shareware tools have been provided by Microsoft, Google Earth, NASA, and camera hackers. Each one of these technologies provides simple user interfaces that provide new opportunities in imaging. A review of each of these developments will be given and suggestions will be made regarding their professional use. Gigapan allows the assembly of hundreds of images into single large gigapixel panoramas that are inserted into Google Earth maps. Photosynth is an image based relational database that extracts common features connecting images to determine the position from which the photos were taken and is used for input into Microsoft's Live Maps. Stereo Data Maker software interfaces with Canon firmware to provide the simultaneous triggering of multiple cameras used to acquire images suitable for photogrammetric uses.

Novel Architectures and Progressive Algorithms for Real-Time Analysis of Streaming Data

Ming Jiang
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LLNL-ABS-407825

Many scientific and government communities are facing a crisis in their inability to analyze massive volumes of imagery. Nearly every aspect of national security and intelligence is tied to the acquisition and interpretation of images. As the images increase in size and complexity, the algorithms needed for processing them to find patterns and relationships must be enhanced as well in order to meet the real-time demands. In this talk, I will discuss my research in the NAPA-ViSUS project on developing scalable and progressive methods for accessing and processing large-scale imagery. First, I will describe the theoretical framework for our cache-oblivious data layout scheme using the hierarchical Z-order (Lebesgue) space-filling curve. The streaming infrastructure that we have developed is scalable not only in terms of data size, but also across a wide range of running conditions. Next, I will present three image analysis algorithms that have been adapted into our progressive processing pipeline: image differencing for change detection, content-based image retrieval for feature segmentation, and Poisson image editing for seamless cloning. I will demonstrate the application of these progressive algorithms on a terabyte of imagery in real-time on a laptop. Lastly, I will highlight the current applications of my research in both geospatial and astronomical domains, and discuss the future directions of my research for different types of data and potential applications in other domains.

Vehicle Tracking and Super-Resolution in Overhead Video

Mark Duchaineau and Siddharth Manay
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LLNL-ABS-407724

One component of semantic compression for large-format overhead video is to separate the static scene (background) from the dynamic scene (in this case, moving vehicles). Vehicle tracking separates the dynamic content. We present preliminary work on tracking via appearance modeling. In this method, the appearance model is propagated through successive frames of video using dense and affine registration. A thumbnail of the vehicle serves as an appearance model, while registration parameters form a motion model. For increased accuracy, motion detection is used to segment the vehicle from the background. Additionally, super-resolution images of the vehicle can also be computed.

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Signal and Imaging Sciences Conference Survey
November 20 – 21, 2008

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

1. Length of the presentation at the CASIS Conference:

   _____ Too long
   _____ Too short
   _____ Just right

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

3. Suggestions for next year's keynote speakers:

4. General comments/suggestions?

5. Please rank the overall Conference as follows:

   _____ Excellent
   _____ Very good
   _____ Good
   _____ Fair
   _____ Poor

Please return this form at the end of the Conference or send to Carol Richardson at L-153 or email at: richardson3@llnl.gov.

Thank you,
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