EI Annual Workshops

EI hosts an annual workshop with focus on the broad areas of predictive modeling, advanced sensing and information technology. The reports from these workshops are available on our website. We also work with other LANL organizations to co-host workshops. For more information, please contact Chuck Farrar at farrar@lanl.gov, 663-5330.

Events

- **Winter 2011 UCSD courses (Instructor)**
  - **Digital Signal Processing I (SIO207B/ECE251/MAE251B, William Hodgkiss), Tu/Th 9:00-10:20 am**
  - **Structural Dynamics (SE203, Michael Todd), Tu/Th 10:30-11:50 am**
  - **Finite Element Methods in solid Mechanics II (SE276B/MAE232B, David Benson), Tu/Th 1:30-2:50 pm**
  - **Structural Health Monitoring (SE265, Charles Farrar), W/F 9:00-10:20 am**

- **12th Los Alamos Dynamic Summer School (June-August 2011)**

The solicitation for the 12th edition of the Los Alamos Dynamics Summer School (LADSS) has recently sent out, and the EI is currently accepting student applications. During the 9-weeks summer school, students will participate in weekly tutorials and guest lectures from distinguished personnel on various aspects of engineering dynamics, and be placed into 3 person teams to do a research activity. Students will present their research work in an international conference. Please visit http://institute.lanl.gov/ei/dynamics-summer-school, for more information. EI is also currently seeking research projects for LADSS. If you feel you have an interesting research topic that can be completed in a 9 week time frame, and need students' support, please contact Chuck Farrar <farrar@lanl.gov>.

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Engineering Institute

UCSD Jacobs School of Engineering

Los Alamos NATIONAL LABORATORY

this issue

LA-UR-11-00150

The Engineering Institute

The Engineering Institute (EI) is a collaboration between LANL and the University of California at San Diego (UCSD) Jacobs School of Engineering whose mission is to develop a comprehensive approach for 1) conducting mission-driven, multidisciplinary engineering research and 2) recruiting, revitalization and retention of the current and future staff necessary to support LANL's national security missions.

The components of the Engineering Institute are 1) the Los Alamos Dynamic Summer School 2) a joint LANL/UCSD degree program, 3) joint LANL/UCSD research projects, 4) annual workshops, and 5) industry short courses.

Contact:
Engineering Institute Leader
Charles R. Farrar, Ph.D. P.E.
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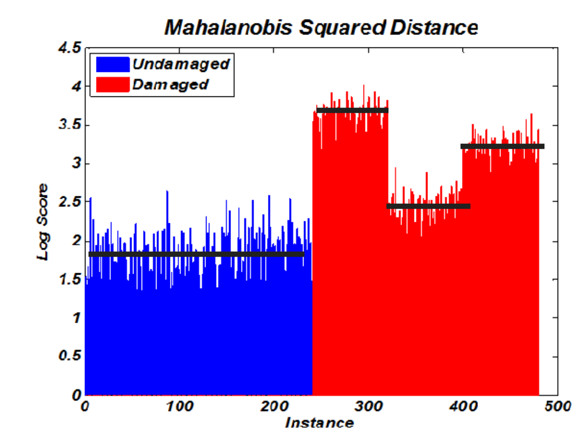
Real-Time Structural Health Assessment of RAPTOR Telescope Systems

The RAPid Telescopes for Optical Response (RAPTOR) observatory network consists of several robotic astronomical telescopes primarily designed to search for astrophysical transients called gamma-ray bursts (GRBs). Although intrinsically bright, GRBs are difficult to detect because of their short duration. Typically, GRBs are first observed by satellites that then relay the coordinates of the GRB to a ground station which, in turn, distributes the coordinates over the internet so that ground-based observers can perform follow-up observations. Given the short durations of GRBs, ground-based observations usually begin after the GRB has ended when only residual emission (the "afterglow") is left. However, if the satellite relays the GRB coordinates quickly enough, a "fast" robotic telescope on the ground may be able to catch the GRB in progress.

The RAPTOR telescope system of LANL is one of only a few in the world to have accomplished this feat. In order to achieve these results, the RAPTOR telescopes must operate autonomously at a high duty-cycle and in peak operating condition. However, given the nature of this work, telescopes are often stationed in remote locations, making maintenance difficult and time-consuming, leading to a more ad-hoc maintenance schedule in which the telescopes operate in a run-to-failure mode and are repaired as schedules allow.

To address this concern, a team consisting of EI and ISR researchers (Christopher Stull, Stuart Taylor, James Wren, and Chuck Farrar) is exploring the application of SHM methodologies to these RAPTOR telescopes. Early efforts were focused on pinpointing the primary failure mechanisms associated with these telescopes and devising strategies to efficiently measure changes in their response due to these failures. More recently, efforts have extended toward the construction and validation of a damage classifier, using the EI software packages, "SHMTools" and "mFUSE." The current form of the damage classifier adopts the Mahalanobis distance to measure the difference between two sets of response features, where a deviation from the so-called "baseline" response indicates some level of damage in the telescope system.



It is envisioned that this or a similar damage classifier will eventually be integrated into one or more remote sensor nodes which will autonomously monitor the applicable subcomponents of each telescope in the RAPTOR observatory network. Ultimately, this effort aims at a near real-time assessment of the remaining service life of these subcomponents, such that improvements may be made in maintenance schedules, resulting in an overall decreased level of "downtime" for each telescope.

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UCSD Jacobs School of Engineering

UCSD Course Sequences

Signal Processing
Digital Signal Processing
Array Processing
Detection Theory
Parameter Estimation
Stochastic Processes
Sensor Networks
Random Processes

Embedded Systems
Introduction to Embedded Systems
Software for Embedded Systems
Validation and Testing of Embedded Systems
Design Automation and Prototyping for Embedded Systems

Parallel Computing
Large Scale Computing
Parallel Computation

Controls
Linear Systems Theory
Nonlinear Control Systems
Approx Identification and Control
Applied Structural Control

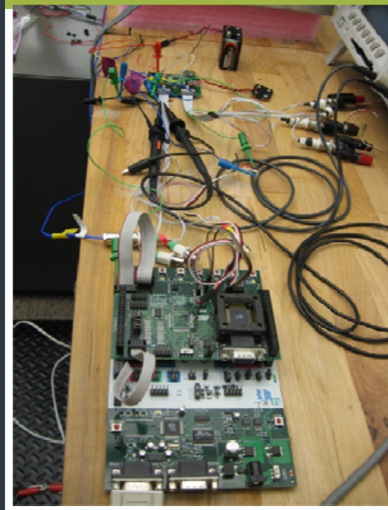
NDE/SHM
Experimental Mechanics and NDE
Structural Health Monitoring

Structural Dynamics
Structural Dynamics
Advanced Structural Dynamics
Nonlinear Mechanical Vibration
Random Vibrations
Wave Propagation in Elastic Media
Wave Propagation in Continuous Structural Elements

Applied Mechanics
Theory of Elasticity
Theory of Plasticity/ Viscoelasticity
Structural Stability
Solid Mechanics for Structural and Aerospace Engineering
Mechanics of Laminated Composite Structures

Computational Mechanics
Numerical Methods
Finite Element Analysis I & II
Computational Fluid Dynamics
Model Verification and Validation

If you are interested in having any of these classes or a class sequences offered at LANL, please contact Kathie Womack (Womack@lanl.gov, 663-5206)



Embedded Compressive Sensing

Embedded computing and sensing are entrenched in many facets of daily life. Embedded devices must be able to collect large amounts of data from multiple sources, and then present the user with an "executive summary" of the observations. A user can then use this distilled information to quickly plan a course of action. It is therefore imperative that new methods are explored for distilling data to a form that is suitable for a user. Furthermore, the prevalence of wireless communications demands that relevant information be pre-extracted from high-dimension data in order to reduce bandwidth, memory, and energy requirements.

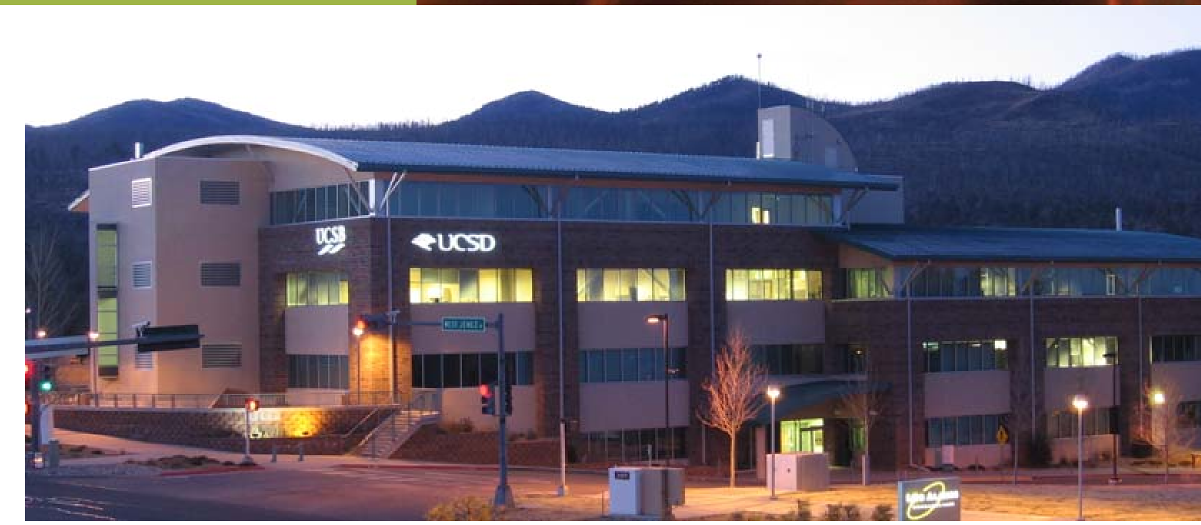
Applications of interest to the EI such as structural health monitoring (SHM) and treaty verification typically require the collection of data from large arrays of wireless sensor nodes at high data rates. Data from different sensors must be combined in order to draw inferences about the state of the system under observation. The sensor nodes used to collect these data typically have severe data storage and energy constraints. Wireless transmission of data must be executed in a thoughtful manner and only the most relevant data should be committed to memory.

Recently, compressed sensing has presented itself as a candidate solution for directly collecting relevant information from sparse, high-dimensional measurements. The main idea behind compressed sensing is that, by directly collecting a relatively small number of coefficients, it is possible to reconstruct the original measurement. The coefficients are derived from linear combinations of measurements. Conveniently, most signals found in nature are indeed sparse with the notable exception of noise. The findings of the compressed sensing community hold great potential for changing the way data are collected.

EI and ISR researchers (David Mascarenas, Chuck Farrar, Don Hush, James Thieler) has begun exploring the possibility of incorporating compressed sensing principles into SHM and treaty verification wireless sensor nodes. Advantages offered by compressed sensing include lower energy use for data collection and transmission, as well as reduced memory requirements. Compressed coefficients also have the interesting property that they are democratic, in the sense that no individual coefficient has any more information than any other. In this way they exhibit some robustness against data corruption. It is also worth noting that compressed sensing versions of conventional statistical signal processing techniques have been adopted by EI based on the use of smashed filters. The extension of statistical signal processing to the compressed domain helps facilitate the transition of the SHM strategies to take advantage of compressed sensing techniques.

Currently, a digital version of the compressed sensor onboard a microcontroller is developed. (shown in Figure). This compressed sensor node is being tested for a SHM application requiring acceleration measurements, as well as a CO_2 climate treaty verification application. The prototype compressed sensor is capable of collecting compressed coefficients from measurements and sending them to an off-board processor for reconstruction. In addition, the smashed filter has also been implemented onboard the embedded compressed sensor node. Preliminary results have shown that the smashed filter successfully distinguishes between the damaged and undamaged states using only 1/32 the number of measurements used in the conventional matched filter.

EI plans to extend the compressive sensing to the mobile-host wireless sensing network architectures that has been studied in the past, as compressed sensing holds great promise for distilling data collected from wireless sensor networks.



Student's Highlight— David Zhang

David Zhang is a PhD student in the Department of Mechanical and Aerospace Engineering of UCSD, under the supervision of Prof. Tom Bewley (UCSD) and Dr. Charles R. Farrar (INST-OFF). David is part of the team in the joint UCSD/Engineering Institute (EI) project in environmental contaminant sensing and forecasting. He received his B.S. In mechanical engineering from UCSD and stayed to pursue his PhD in control theory. His research topic focuses on vehicle sensing strategies in environmental systems such as oceanic and atmospheric system. He is part of the Flow Control and Coordinated Robotics (FCCR) lab directed under Tom Bewley. Not only is he proficient in the aspect of flow control, because of his knowledge in electrical engineering and computer science he also plays an integral part in vehicle/sensor platform development in the coordinated robotic portion of the lab. In collaboration with others, David co-developed Switchblade, a versatile multi-sensor platform vehicle. Switchblade was used in the first real-life plume-release experiment as a first stage proof-of-concept for the joint project. More information about the experiment and the FCCR lab are available in fccr.ucsd.edu. Besides his work, David is an amateur Photographer and an avid tennis player.

Workshop: Modeling of Wind Turbine Interactions

EI and the LANL Intelligent Wind Turbine (IWT) team jointly host a 2-day workshop on ***Modeling of Turbine-Turbine Interaction with Experimental Validation*** on March 2-3, 2011. The workshop focus is modeling realistic turbine-turbine interactions as well as techniques for providing accurate aerodynamic and structural validation data sets. One theme of interest is investigating modeling techniques that enable simulation of aeroelastic rotors exposed to realistic operating phenomena. Interaction between turbines and surrounding atmosphere can generate highly variable and often cyclic loads on wind turbine blades and life-reducing asymmetric loads on the rotor and gearbox. These interactions also impact the kinetic energy that is available for harvesting by downstream turbines. Another theme of interest is experimental approaches to obtaining both aerodynamic and structural data needed for system level model validation. Aerodynamic approaches include novel wind tunnel and field measurements of velocity and turbulence around rotating turbines, including PIV, LIDAR, and flow visualization. Structural approaches include the use of low- and high-frequency, fiber optic, and acoustic sensing techniques. If you have any inquiries about this workshop, please contact Curtt Ammerman (ammerman@lanl.gov) or Chuck Farrar (farrar@lanl.gov).

Advisory Board for EI

The EI has formed an internal advisory board to help guide its educational and research activities. The purpose of this Board is to maximize the positive impact the EI's recruiting, training and retention activities have on LANL engineers and maximize the number of line organizations impacted by these activities.

The roles and responsibilities of the EI Advisory Board include

- Represent their respective line organization's needs in terms of recruiting, training and retention to the EI staff.
- Guide the collaborative research projects and educational activities of the EI
- Help to define other EI activities such as workshops and development of proposal writing teams
- Bridge a gap between line organization and EI for summer internships, for post-doctoral research appointments, or for staff hiring.

The following members will serve on this advisory board for a two-year period,

Frank Addessio (T-3)
Don Hush (ISR-2)
Doug Kautz (WCM-2)
Thomas Mason (W-6)
Evelyn Mullen (IAT-DO)
R. Alan Patterson (MST-DO)
Ray Guffee (AET-1)
Daniel Rees (AOT-RFE)
Angela Mielke (ISR-3)