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

Please contact Chuck Farrar (farrar@lanl.gov, 663-5335) for more information.

- Winter 2010 UCSD courses (Instructor)
  - Structural Health Monitoring (SE265, Charles Farrar), Tu/Th 9:00-10:20 am
- EI staff will attend the following conferences
  - IMAC-XXVIII Conference & Exposition on Structural Dynamics, February 1-4 2010, Jacksonville, FL
  - SPIE Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring, March 7-11 2010, San Diego, CA

Engineering Institute News

Los Alamos NATIONAL LABORATORY

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Engineering Institute

UCSD Jacobs | School of Engineering

Los Alamos NATIONAL LABORATORY

this issue

LA-UR-10-00441

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
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Plume Forecasting using Unmanned Aerial Vehicles

Plume forecasting is needed for civilian and military purposes including natural disaster assessment and malicious attack monitoring. With sufficient data from the plume perimeter and interior, predictions can be surmised about the plumes movement. A safe way to collect the necessary data is to use an Unmanned Aerial Vehicle (UAV). The Engineering Institute is conducting research on the design of a multi-UAV plume monitoring system. The project involves collaborative efforts between various engineering departments at UCSD to develop the necessary components of the system including the UAV platform, plume forecasting algorithms, novel sensor suites, data sharing, and path coordination amongst UAVs.

Research is underway on the plume forecasting algorithm using Model Predictive Estimation. While these modeling efforts mature, flights tests are being conducted at LANL's Kelly Field, a UAV flying site located on TA-49. The test flights provide an arena for validating sensor configurations, communications protocols, and source tracking with the UAV test bed platform. The UAV utilizes COTS airframes and autopilots to provide high level functionality for the various payloads. The test bed platform will eventually be replaced by an internally developed UAV design tailored to the potential plume mission profiles. Further, a multi-aircraft approach will probably be necessary for accurate monitoring of any contaminates with the unique plume UAV acting as the backbone of the system.

In the summer 2009 at Kelly Field, test flights were conducted with two objectives. The first objective was to conduct autonomous flights with both the Kestrel and Piccolo autopilot while collecting accurate wind speed measurements from sensors located near the ground. One of the main pieces of data the plume simulation needs is wind information. Both wind magnitude and direction are important variables that need to be estimated by either the autopilot or the ground station computer. A specialized algorithm can produce these real time estimates using the navigation telemetry from the UAVs. A localized wind map can then be constructed with the estimates to be fed into the forecasting system. The tests were used to characterize the current algorithms during various flight scenarios in order to provide the simulation team with a range of wind estimation accuracies for various flight conditions. The comparison was done with data from dedicated wind sensors mounted a few meters above the ground. The flight tests consisted of rectangular and hexagon ground tracks in addition to loiter circles at various altitudes from 25 m to 75 m. In addition, data were gathered for both RC and autopilot flights providing a comparison between benign and dynamic flying conditions. Looking forward into the fall and winter quarters more test flights will commence for the wind estimation comparisons. These will involve wind sensors that are mounted to helium balloons at the altitudes which UAVs are flying, providing more accurate wind sensor readings with which to compare to the autopilot's estimation.

Wind correlation flights lead up to the primary goal of the summer flight tests, detecting a plume release with a sensor board mounted on a UAV. The sensor board contained a variety of sensors for detecting environmental changes that a hot particulate plume could generate, which include variations in temperature, light transmission, humidity and particulate count. Short and long duration smoke grenades were sourced by the team for use at Kelly Field. A slow progression from ground based RC tests, to in air RC flights, to eventual autonomous flights through the plume was identified as the safest method for eventually achieving the primary objectives. Plume release flights commenced and resulted in some incremental improvements in sensor placement and data sharing between the sensor board and autopilot. Data gathered from these flights demonstrated that the multi-UAV platform were able to identify a particulate plume leading the way towards further tests with source seeking and path planning algorithms running on-board the vehicles. Successful plume releases at Kelly Field with the smoke grenades clears the UAV field for future more involved plume release tests with these autonomous platforms as the LANL-UCSD plume project continues forward.

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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)

Fiber optic sensing for distributed kinematic measurements

The capability of taking highly accurate, distributed kinematic measurements is critical in many engineering applications, including ensuring the security of sensitive materials in transit. Optical sensors are an attractive alternative to traditional electronic sensors for applications in hazardous environments, because they are immune to electromagnetic interference, are non-corrosive, and are not spark emitting. Furthermore, it is relatively easy to integrate several optical sensors, making them well suited for taking distributed measurements.

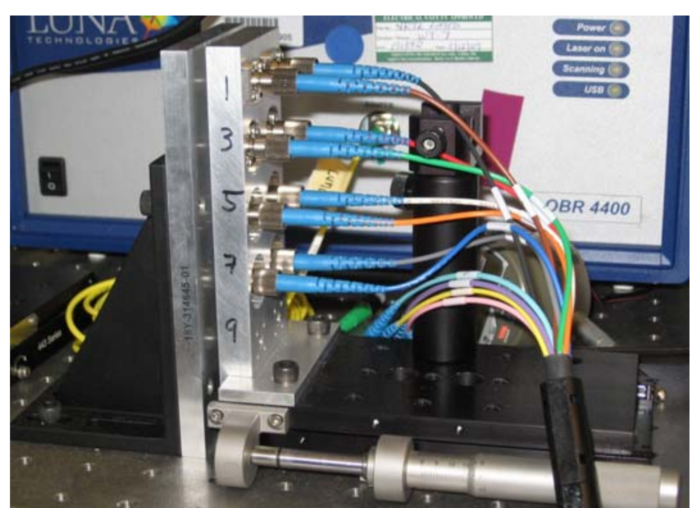
EI Ph.D. Student Erik Moro, advised by Prof. Michael Todd (UCSD) and Dr. Anthony Puckett (W-13), is utilizing a new optical sensing methodology where discretely distributed position measurements are obtained through the use of several integrated optical sensors. They are preparing to run quasi-static creep tests with the hope of obtaining high-accuracy, high-resolution, distributed displacement data, and plan to use an optical switch in order to multiplex several sensors to a single sensing module.

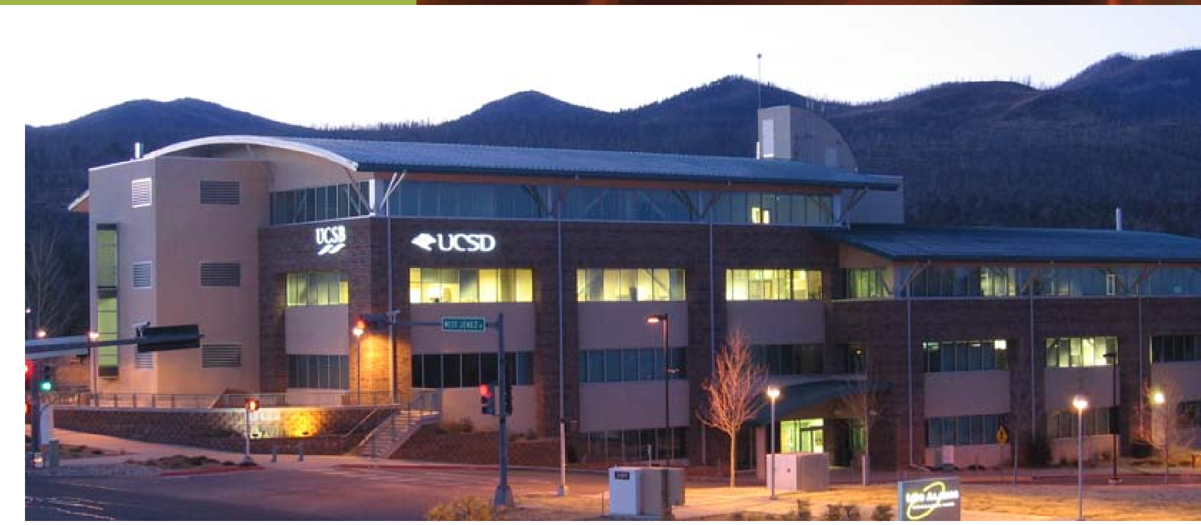
To conduct creep tests, a four-channel optical sensing module, which generates a broadband optical signal spanning the 1510-1590 nm range, is used in conjunction with four 36-channel fiber optic switches. An optical filter in the sensing module sweeps across the 80 nm range once per second, allowing transmission of a narrowband portion of the generated signal at a given instant. This signal travels along a given optical cable to a corresponding sensor, ultimately reflecting back to the sensing module which samples optical intensity as a function of wavelength. This setup is capable of interrogating up to four sensors simultaneously once per second and as many as 144 multiplexed sensors in 36 seconds. This sampling capability will provide excellent sampling density considering the quasi-static nature of the creep tests.

The goal of these tests is to measure the relative displacement of an object's surface. The gap between a sensor and the nearby surface is referred to as an optical resonant cavity. To calculate displacement, the spatial frequencies of standing electromagnetic waves formed in the resonant cavity are measured, which are directly relatable to the length of the cavity by the speed of light. A critical property

of the resonant spatial frequencies is that they are equally spaced in the frequency domain. After passing through the optical resonant cavity, the signal returns to the sensing module where it was generated, carrying with it information regarding the resonant cavity length.

Various signal processing techniques, including power spectral estimation, averaging of spectral data, and autoregressive modeling, are being implemented for the purpose of extracting the resonant cavity length from the power spectral density estimate of the optical signal with sufficient accuracy, resolution, and signal to noise ratio. These researchers are currently comparing the tradeoffs associated with these signal processing approaches, emphasizing implications on real-time testing capabilities.





Student Highlight—Dustin Harvey

Dustin Harvey is a post-baccalaureate student with the Engineering Institute (EI) . After graduating from the Rose-Hulman Institute of Technology in Mechanical Engineering, Dustin attended the 2009 Los Alamos Dynamics Summer School where he investigated a method to reconstruct dynamic inputs to a system from measured structural response data. Chuck Farrar (INST-OFF) and Matthew Bement (X-3) served as mentors for the project, which Dustin will present at the 28th International Modal Analysis Conference, Jacksonville FL, February 2010. Dustin is currently developing a graphical user interface for use with the structural health monitoring (SHM) software package soon to be released by EI. Dustin plans to continue research in SHM as he begins his graduate studies next fall under the advisement of Prof. Michael Todd in UCSD's Structural Engineering Department. In his free time, Dustin enjoys roller coasters, playing guitar, road trips, sports, and the great outdoors.

11th Los Alamos Dynamic Summer School (June-August 2010)

The solicitation for the 11th edition of the Los Alamos Dynamics Summer School (LADSS) has recently sent out, and the EI is currently accepting student applications. In short, the goal of the LADSS is to get US citizens to attend graduate schools. 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 in 9 weeks. Students will present their research work in an international conference. Please visit http://institute.lanl.gov/ei/dynamics-summer-school, for more information.

We are 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, please contact Chuck Farrar <farrar@lanl.gov> or Gyuhae Park <gpark@lanl.gov> for further discussion. The research projects in the previous years are listed in the following link (http://institute.lanl.gov/ei/dynamics-summer-school/projects/). The EI staffs will assist the projects by co-mentoring the student teams for the duration of the school. The quality of the LADSS students are excellent and the outcome of their research work usually exceeds the expectation.

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)