Engineering Institute

UCSD Jacobs School of Engineering | Los Alamos NATIONAL LABORATORY

this issue

LA-UR-08-06620

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.

farrar@lanl.gov

505-663-5330

505-663-5206

Energy Harvesting and Wireless Energy Transmission Systems for Embedded Sensor Nodes

The proper management of energy resources is essential for the development of any successful wireless sensing system. In many applications a sensor network must operate in locations that are difficult or impossible to access, and these systems often have a desired operational lifespan that exceeds the shelf life of conventional batteries. Research at the Engineering Institute has focused on developing innovative methods for powering wireless sensor nodes. Traditional energy harvesting methods have been used to scavenge ambient energy from solar, thermal and kinetic sources. While some of these sources had been considered impractical in the past, advances in low power electronics have made them a viable solution for new sensing systems. Several of the research projects at the Engineering Institute have been inspired by this goal, with researchers and students investigating the use, and optimization, of electromechanical transducers to extract electrical energy from mechanical vibrations the excitation sources for these studies were taken from real-world systems such as bridges, compressors and vehicle engines. Lab results have demonstrated the traditional piezoceramic materials can power a wireless impedance device developed here at the Engineering Institute.

Another avenue of research that has been studied at the Engineering Institute is a hybrid power solution in which energy is wirelessly transmitted to a receiving antenna that is part of the sensing network. This approach uses energy transmitted in the 2.4 – 5.8 GHz range to 'beam' energy to the embedded sensor node. This method is capable of powering the sensor node directly, or it can be used to supplement a traditional energy harvesting device. This hybrid approach would allow for unscheduled interrogations of a structure that may have been exposed to an event such as an earthquake or an industrial accident. The hardware can be mounted on a small unmanned vehicle and placed within environments that would otherwise be inaccessible for humans. In this manner a robotic vehicle could be used to monitor the structural health of containers storing hazardous materials, or it could be deployed in structures to determine if it is safe for first responders to enter.

Staff members from the Engineering Institute along with faculty and students from UCSD conducted a second field demonstration of this technology on the Alamosa Canyon Bridge near Truth or Consequences, NM in early September. The unmanned ground vehicle shown below was used to power a wireless impedance device which was used to monitor bolt preload along the bridge. The unmanned ground vehicle (UGV) was able to charge the sensor node in less than 30 seconds, at which point measurements were made and the data were transmitted to a computer mounted on the UGV. This successful demonstration brings us one step closer to having a cost-effective ubiquitous sensing system that monitors every bolts in a structure and could one day help emergency response personnel around the world assess the risks associated with structures damaged in natural or man-made disasters.

Los Alamos NATIONAL LABORATORY

UCSD Jacobs School of Engineering

UCSD Course Sequences

Signal Processing
Digital 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

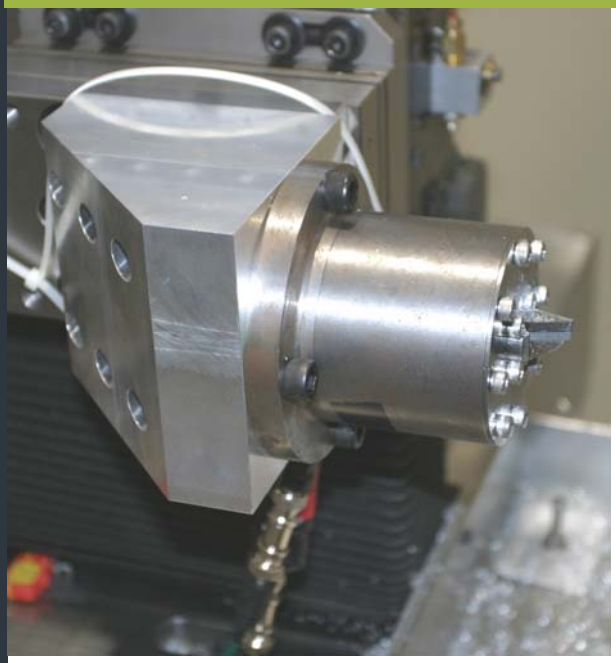
NDE/SHM
Experimental Mechanics and NDE
Structural Health Monitoring

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 SE 272
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
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)



Improving a turning process using Collocated Piezoelectric Actuators

Active vibration suppression using a high-bandwidth actuator for high-precision turning applications

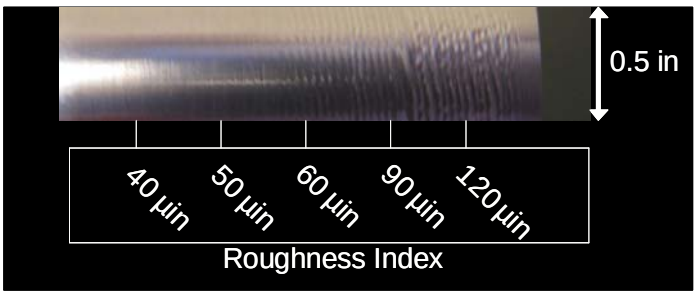
The turning process is very important in many manufacturing applications. In high precision machining, surface finish is strongly correlated with the vibrations and dynamic interactions between the part and the cutting tool. Process characteristics such as spindle speed, cut depth, feed rate, and the part's material properties can vary in real-time with unexpected or undesirable effects on the surface finish of the resulting product.

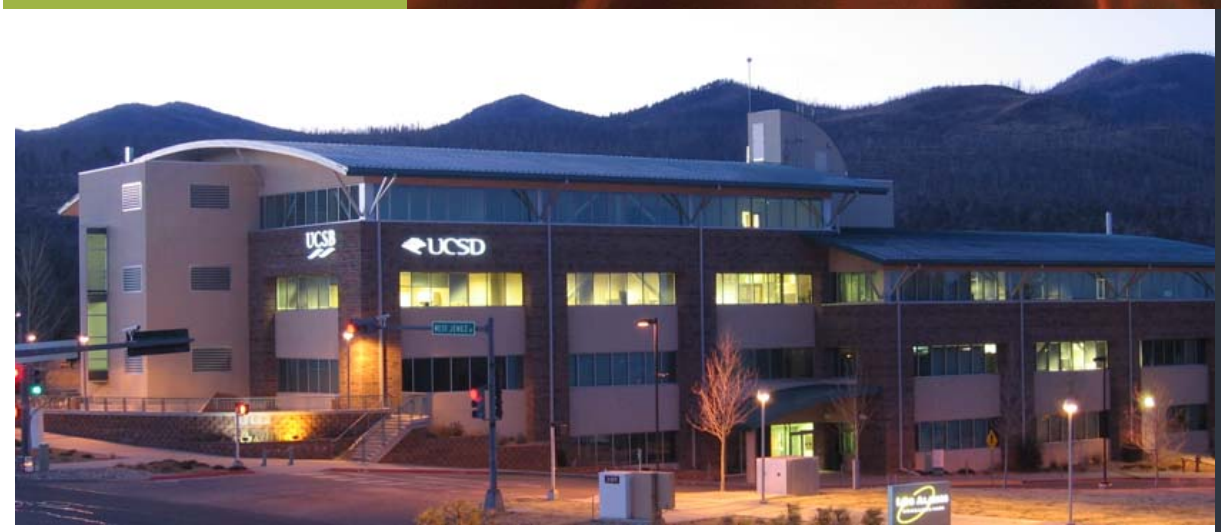
Specifically at LANL, machining components with high-quality surface finish is required for weapons manufacturing. Outside of the weapons community, high-precision turning processes could be applied to many applications such as those in the automobile and aerospace industries.

Consequently, EI researchers and students working with **WCM-2, MST-X and CCS-3 engineers** have focused on the design and applications of a high-band width, high-force actively controlled tool holder for use on a conventional lathe to improve surface quality.

Unlike traditional approaches, this newly developed fast tool servo (shown in the above figure) utilizes the concept of self-sensing actuation, accommodating various control strategies to achieve precision turning. This is accomplished without the need for any external sensors, reducing the bulk and expense of the system while also eliminating sensors whose performance could easily degrade in the harsh operating environment found in many industries. This device is compact, self-contained and can be used to compensate for the static and dynamic deformations caused by high cutting forces developed during the turning operation.

High-quality surface finishing depends on a robust control strategy to compensate for unknown disturbances and process variations. An adaptive positive position feedback algorithm has been used for control by the EI researchers. The performance of this method has been evaluated by comparing the surface finish obtained during baseline (uncontrolled) cuts and those obtained using the active vibration control algorithm (results shown in the figure below). The results show significant improvement in surface quality, resulting in roughness averages of 40 micro-inches, while the baseline roughness was as high as 100 micro-inches. In addition to improving the surface finish of test samples, a significant reduction in chatter was also observed.





Student's Highlight—Chad Foerster

Chad Foerster is a second year graduate student in structural engineering studying under Dr. John Kosmatka at UCSD. Prior to studying at UCSD, Chad received his BS in Engineering at Harvey Mudd College with coursework concentrations in systems engineering and mechanics. For two years following the completion of his undergraduate education, Chad worked at Honeywell International in the Turbo Technologies and Aerospace divisions.

At UCSD, Chad is continuing his interest in aerospace engineering as a member of the multidisciplinary LANL-UCSD Plume Project. The goal of this project is to field a multi-vehicle UAV system to monitor and forecast contaminant plume dispersion. Chad is responsible for the UAV platform used for the mission. He was involved in extensive flight testing of a pair of test-bed aircrafts this past summer at the newly established LANL UAV flying site, Kelly Field under the direction of **IAT-2 engineers.** Chad's research interests include autopilot control schemes, specifically those relating to coordin-ated path following and swarming, as well as characterization of limit cycle oscillations in high aspect ratio composite aircraft wings.

Engineering Grand Challenge

The Engineering Institute solicited white papers from the technical staff regarding potential technical thrusts for engineering research at LANL. These white papers are being used to define an Engineering Grand Challenge that will guide future LDRD investment as well as help to develop LANL's strategic plan for an engineering research agenda. Here "engineering research" is defined as the adaptation of basic and applied science as well as the integration of current engineering capabilities to develop the next generation of hardware and software tools to better solve future engineering problems.

In contrast to scientific research, the outcome of engineering research is necessarily the next generation of hardware or software products to solve current and future engineering problems. The Principal Associated Director for Science, Technology and Engineering along with the Engineering Institute is leading this effort and is currently evaluating white papers that were submitted and subsequently presented at the Engineering Grand Challenge town hall meeting, held on October 8-9th at the Rosen Auditorium. White papers and presentations are available for review at the EI website (http://www.lanl.gov/projects/ei).

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 (CCS-3)
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)

EI Annual Workshops

EI hosts an annual workshop with focus on the broad areas of predictive modeling, advanced sensing, and information technology. The reports which are the outcome of these workshops are available in 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.

- **Engineering Grand Challenge Town Hall Meeting, Oct. 8-9th at the Rosen Auditorium (TA-53, Bldg.1, Rm B105).**
- **Fall 2008 UCSD courses**

  Detection Theory, Tu/Th 9:00-10:20 am

  Fundamentals of Signal Processing, Tu/Th 10:30am—12:00 pm

  Mechanical Behaviors of Polymers /Composites, Tu/Th 12-1:20 pm

  Software for Embedded Systems, Tu/Th 1:30—2:50 pm

  Statistical Learning I, M/W 12:30—1:50 pm

Los Alamos NATIONAL LABORATORY

UCSD Jacobs School of Engineering

MS T001
Los Alamos, NM 87545
505.663.5206 ph
505.563.5225 fax
http://www.lanl.gov/projects/ei