Faculty Research Profiles
2008-09

Electrical Engineering
Industrial & Systems Engineering
Mechanical Engineering

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Mission Statement
USD Engineering is distinguished by student-centered education that emphasizes modern engineering skills and development of the whole person. We are dedicated to innovative teaching, meaningful scholarship, and compassionate service.

Message from the Director

I am proud to present this report that introduces our well qualified faculty and their meaningful scholarship by providing an overview of the research topics currently being pursued in Engineering at USD. Engineering research lays the groundwork for the innovations of tomorrow that can improve the lives and the livelihood of many.

Faculty areas of research include advances technology and processes in wide array of topics in Electrical, Industrial & Systems, and Mechanical Engineering with applications to healthcare & medicine, telecommunications, manufacturing, aerospace, and more. Scholarship in engineering education helps to address the engineering workforce crisis by providing innovations in teaching and learning that help students succeed in the demanding preparation needed to become the engineers of tomorrow.

-Kathleen A. Kramer

Faculty and Their Research Interests

Electrical Engineering

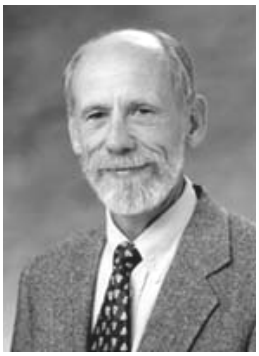
Ernest M. Kim, P.E.
Ph.D. New Mexico State University
Radio Frequency Design, Optical Transmission Systems, Embedded Systems, Analog Circuits, RF circuits, Optoelectronic circuits, Fiber Optics, Cable Television

Kathleen A. Kramer
Ph.D. California Institute of Technology
Sensor Data Fusion, Kalman Filters, Neural Network, Adaptive Classification, Target Intercept, Multi-Sensor, Uncertainty, Level 2 Fusion, Evidence Accrual, Fuzzy Logic, Markov Chain Approaches

Susan M. Lord
Ph.D. Stanford University
Engineering Education, Persistence of Women in Engineering, Lifelong Learning, Feminist and Liberative Pedagogies, Cooperative Learning, Service learning, Optoelectronic Materials and Devices, RF Photonics

Mikaya L.D. Lumori
Ph.D. University of Arizona
Nonlinear System Identification Techniques, Electromagnetic Hyperthermia

Michael Steven Morse
Ph.D. Clemson University
Biological Effects of Electricity, Diffuse Electrical Injury, Modeling of Current Pathways, Carpal Tunnel Syndrome, Electrical Injury and Safety, Electromechanical Product Failure



Thomas F. Schubert
Ph.D. University of California, Irvine
Fourier Optics, Wave Propagation, Analog Electronics, Communication Systems, Engineering Education.

Industrial & Systems Engineering

Bradley Chase
Ph.D. University of Louisville
Human Factors Engineering, Ergonomics, Measurable Movement Behaviors, Eye Movement, EEG And Cognitive Performance, Neuro-Dynamic Behaviors, Stress And Performance, Health Administration, Occupational Safety, Work Design.

Rick T. Olson
Ph.D. University of Illinois at Urbana-Champaign
Operations Research, Heuristic Optimization, Scheduling, Health Systems, Decision Support Systems

Leonard A. Perry
Ph.D. Arizona State University
Design of Experiments (DOE), Six Sigma, Quality, Process Improvement, Statistical Process Control (SPC)

Claribel Bonilla
Ph. D. Texas A&M University
Research Areas: Manufacturing and Production Systems, Manufacturing Processes, Process Improvement, Supply Chain and Six Sigma

Mechanical Engineering

Ming Z. Huang
Ph. D. Ohio State University
Mechanical Design, CAD/CAE,
Robotics, Kinematics, Control Coordination,
Manufacturing Automation, Engineering Pedagogies

Frank G. Jacobitz
Ph.D. University of California, San Diego
Fluid Mechanics and Turbulence, Geophysical Flow, Bio-Fluid Mechanics, Microcirculation, Hemo-Dialysis, Virus Removal, Student Learning

James G. Kohl
Ph.D. Rensselaer Polytechnic Institute, NY
Coating Characterization, Foul Release Coatings,
Silicone, Foul Release,
Elastomer, Coating, Adhesion

David Malicky
Ph. D. University of Michigan
Biomechanics, Orthopedics, Ligament Mechanics, Finite Element Modeling, Strain Analysis, Experimental Methods, Education Psychology, Pedagogy, Retention, Women In Engineering.

Matthew McGarry
Ph. D. University of Vermont
Design of PEM fuel cells,
Fluid distribution for PEM fuel cells,
Performance enhancement for PEM fuels cells,
Bio-Fluid Mechanics, Fluid Mechanics of the systemic circulatory system,

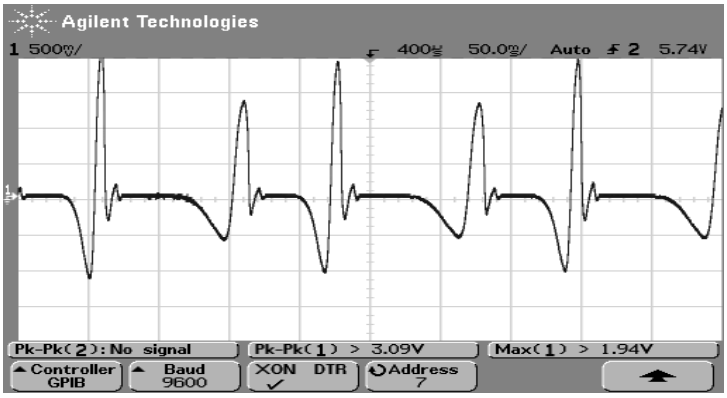
Electrical Engineering

Adaptive Neural Network Target Tracking (K. A. Kramer)
The concept of target tracking, a part of Level 1 data fusion, is to combine measures from various sensors to form a coherent picture of the scene. It has become an important field of research as its applications in robotics, space systems, and missile defense have grown. Target tracking systems are usually based on estimation techniques such as the extended Kalman filter (EKF) that use sensor measurements over time and a model of the kinematics of the target. Such tracking systems, although widely used, have difficulty when the target being tracked undergoes a maneuver. The neural extended Kalman filter (NEKF) is an adaptive EKF that uses functions approximation to learn the error between the true target dynamics and the mathematical model used in the prediction states of the EKF. The NEKF is the focus of several research efforts to improve and analyze tracking performance, perform system identification, and assist in improving control performance. The NEKF uses an artificial neural network that does not use a priori training sets common to most neural network techniques as a function approximation technique. Instead, it adapts and trains as the target is moving using the same residuals as the Kalman filter of the track estimation.

Diffuse Electrical Injury (DEI) (M. S. Morse)
Tissue damage from electrical contact has historically been thought to arise from resistive heating of tissues along the current pathway. A more modern view has accepted that tissue damage can result from cellular rupture (electroporation) induced by the presence of an electric field. In rare electrical contacts, diffuse symptomatology arises that does not fit well within either model. Such disproportionate, remote electrical injury is most notable when the contact voltage is low (120 and 240 V). Symptoms occur, absent diagnostic evidence, which defy explanation as organic injury. Research has been undertaken that statistically suggests that there is a common symptomatology, called Diffuse Electrical Injury (DEI) that is neither linked to voltage nor loss of consciousness at the time of contact.

Semiconductor Laser Beam Shaping using Magnetic Fields (E. M. Kim)Preliminary tests on shaping the radiation pattern of laser diodes using magnetic fields have been completed. Radiation patterns at both below and above threshold are being studied. Dependence on laser structure is being considered. Potential applications include beam shaping and beam steering of the exit radiation from semiconductor diodes.

Eco-Responsible Product Design (E. M. Kim)
Over 2 billion batteries end up in landfills yearly. Unlike glass, paper, and plastic, which fill up landfills, but are relatively benign, batteries are filled with reactive chemicals. Eco-responsible electrical designs are being developed specifically for the toy industry.



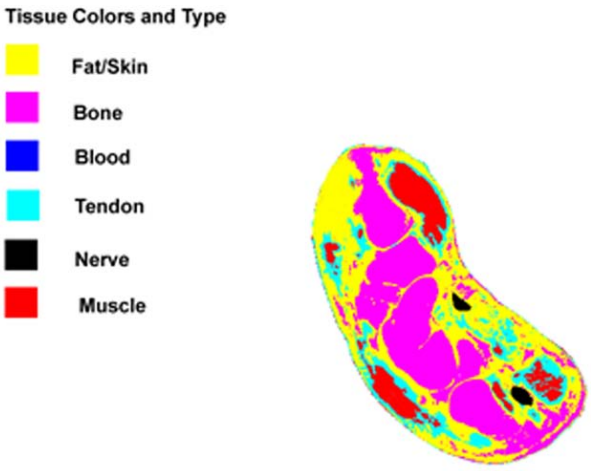
Faraday Effect Charging Cycle

Electromagnetic Hyperthermia (M. L. D. Lumori)
Research Focus: Gaussian Beam Modeling of Field Sources. There are several types of electromagnetic radiating antennas used for localized or regional hyperthermic treatment of tumors. These are based on waveguiding structures that may be used individually or as phased arrays. However, their performance must be ascertained by application of 3-D numerical models to the *electric field integral-equation* (EFIE), the *magnetic field integral-equation* (MFIE), etc., to simulate *specific absorption rates* (SAR) in a tumor. Gaussian Beam modeling of the field sources improves SAR simulations considerably. The Gaussian Beam Model (GBM) is the exact solution to the Schrödinger-type equation which is an approximation to the scalar wave equation.

Embedded Control of Optoelectronic Devices (E. M. Kim)
An EDFA can be used to directly amplify optical signals, avoiding signal conversion to-from electrical, and a microprocessor can be programmed to control and monitor this amplification. The microprocessor makes digital data available to an external computer via standard serial link, and it may also receive external digital commands via the same path. A principal control function of the microprocessor is to determine the current of either laser, independently, by setting or varying a reference voltage to which the backface control photodiode output of the laser is compared. The systems involved to control vary with either one or two pump lasers and supporting analog circuitry present, and in the various numbers of monitor detectors and associated analog circuitry. Such differing configurations require different designs for the embedded control system.

Finite Element Analysis of the Internal Current Pathway (M. S. Morse)
An active area of research focuses on trying to distinguish the *real* current path from the theoretical path during an electrical contact. A variety of mathematical techniques, including the Finite Element Method (FEM), have been applied to this problem to determine current distribution within the human

body. Specific efforts to date have included evaluating current distribution in the carpal tunnel region with the specific intent of explaining post-electrical-contact carpal tunnel syndrome (CTS). CTS has been diagnosed in as many as 10% of the hand-involved electrical contacts; such a diagnosis typically indicates median nerve compression, which would not be consistent with the known apparatus of electrical injury. Using FEM, current density has been evaluated in the carpal tunnel region during an electrical contact. Results of research have indicated that while the majority of current does not transverse the nerve tissue, the current density is significantly elevated in the nerves as they traverse the carpal tunnel region. Such a localized current elevation could cause nerve damage which would masquerade as CTS when diagnostically tested.

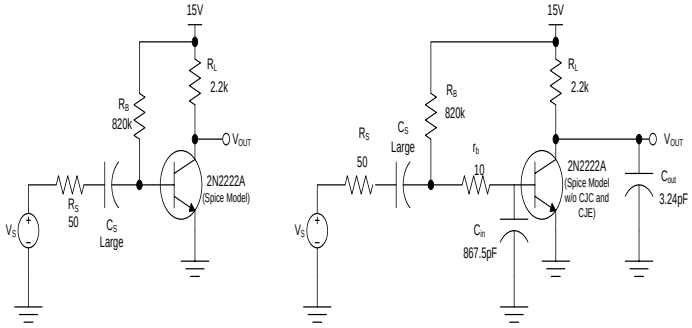


Finite Element Model of Human Tissue

Persistence of Women in Engineering (S. M. Lord)
"The Effect of Climate and Pedagogy on Persistence: A Longitudinal Study of Women in Undergraduate Engineering Programs," capitalizes on a unique opportunity to conduct a longitudinal, multi-institutional, and multivariate study determining how climate and pedagogy affect the persistence of women in undergraduate engineering programs to an extent never before possible. We focus on the nine partner institutions that comprised the NSF-funded Southeastern University and College Coalition for Engineering Education (SUCCEED) Coalition and account for 1/12 of the engineering bachelor's degrees awarded from 1987 to 2004. A key benefit of the choice of this population is three key overlapping sources of data: 1) the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), 2) climate surveys and 3) teaching practices surveys. We are conducting new analyses on this existing data as well as new studies focusing on our research questions. Such a triangulated approach provides a powerful historical context to explain changes and successes in persistence. *This project is funded by the National Science Foundation (NSF) Research on Gender in Science and Engineering (GSE) program and is in collaboration with Dr. M. Camacho in Sociology at USD and Drs. M. Ohland and M. Wasburn at Purdue University.*

Nonlinear System Identification Techniques
(M. L. D. Lumori)
Research Focus: Measurement, Modeling and Identification of Dynamic Systems. A typical nonlinear complex system is often decomposed into subsystems that are then characterized using dedicated tools. Experimental data, sometimes obtained from poor measurement/simulation sources, are used by the designer to extract a wide variety of models that must meet specific requirements. Since most systems are nonlinear in nature, the best linear approximation (BLA) is often sought to give an insight into the dynamics of a nonlinear system. System Identification is via use of the appropriate estimators (e.g. least squares, weighted least squares, Maximum likelihood, or Bayes estimators) for each system and associated environment (e.g. errors on the input and output data)

Analog Circuit Design (E. M. Kim)
Detailed investigation of Miller's Theorem as it applies to transistor amplifier design has yielded results that are counter to the Miller effect pole that is used in many electronics circuit textbooks as the only pole of significance. In fact, careful application of Miller's theorem provides pole locations that accurately represent true circuit behavior.

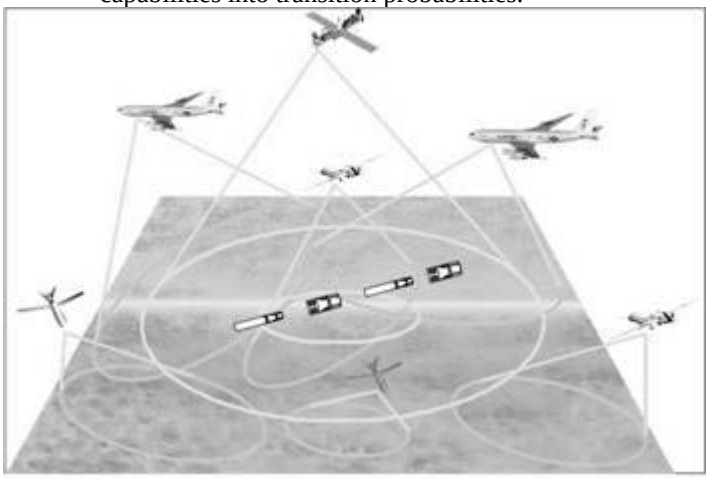


Miller Effect Model of a BJT Amplifier using SPICE Circuiit Parameters

Sensor Data Fusion (K. A. Kramer)
Multi-sensor data fusion is the process of combining, comparing and interpreting information across a number of disparate sensors. Often, in a sensor fusion environment, the sensors are of a wide variety providing a diverse set of measurement types. Level 1 fusion identifies and tracks entities, while Level 2 fusion, also known has Situational Assessment, develops and interprets relationships among the entities, including such concepts as group kinematics, group formation, and group composition. Research is being

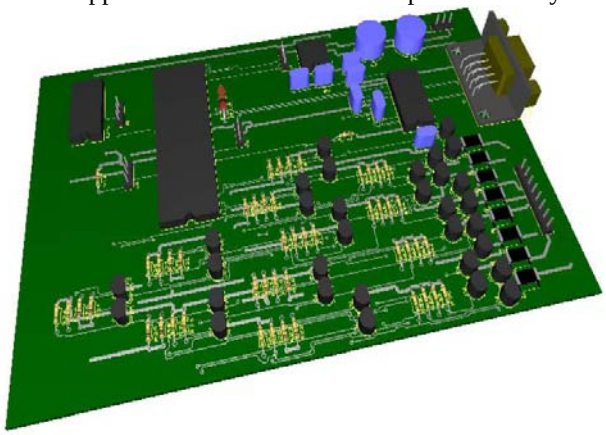
undertaken to apply a variety of techniques to these complex problems including:

- For classification, methods to better interpret measurements of from various sensors that have different degrees and types of uncertainty, accrue disparate evidence over time, and apply fuzzy logic.
- For L1 association, application of a fuzzy-logic based method that emulates the chi-squared metric for both Gaussian and non-Gaussian measurements for data association.
- For group composition, Markov chain methods that make use of multiple composition hypotheses and incorporate terrain, group dispersion, and sensor capabilities into transition probabilities.



Multi-Sensor Data Fusion – information from different sensors fused together to provide assessment of situation.

Embedded Control of Magnetics Circuits (E.M.Kim) Magnetics circuits can be energized in sequence using embedded controllers. User interfaces are employed that allows for sequence modifications in pattern and time. Current applications include the development of a toy.



Embedded Controller for Magnetics Circuits

Engineering Education

Enhancing Student Learning (S. M. Lord)
Current research areas in engineering education include investigating a range of strategies for enhancing student learning including cooperative learning, hands-on laboratories, and using Tablet PCs. The researcher is a leader in the field actively involved with the Educational Research Methods division of ASEE and the Education Society (EdSoc) of IEEE. Leadership positions include General co-Chair of the 2006 Frontiers in Education Conference, IEEE EdSoc Vice President for 2007 and 2008, and Guest Co-Editor of Special issue of *International Journal of Engineering Educatio*n. Another area of interest is an investigation of the potential benefits of feminist pedagogy for engineering education, a joint effort which received the Helen Plants Award in 2004.

Retention of Women Engineers (D. Malicky)
Rigorous research is applying topics in educational psychology and advanced work in engineering – to various topics in engineering education. Educational psychology interests in under-represented populations and constructivist inquiry learning are being applied to the development of an empirically-supported model of retention for women in engineering to guide the discipline. Other investigations include the risks and benefits of different pedagogies as they relate to the students, instructor, course, and institution.

Tablet PCs Use in the Classroom (L. A. Perry, S. M. Lord)
Tablet PCs are the latest technology in notebooks and laptops, but is it worth it for engineering faculty to make the investment of their time to change their course content development and delivery method to include a Tablet PC? This research addresses a range of options that faculty have for course development and utilization of the Tablet PC. Various lecture methods of using the Tablet PC are compared including writing on it directly, using PowerPoint, and using Classroom Presenter. Faculty might have a range of motivations for moving to incorporating a Tablet PC in their classrooms from capturing content for faculty review, providing handouts for students, increasing active learning, and even distributed learning.

Lifelong Learning (S. M. Lord)
"Role of faculty in supporting lifelong learning: An investigation of self-directed learning environments in engineering undergraduate classrooms" examines how faculty choices in the classroom influence students' lifelong learning skills. Lifelong learning is a critical skill for engineering graduates. While the literature on self-directed learning offers insight into how to develop lifelong learning skills,

engineering educators have focused more on assessing lifelong learning than on understanding how instructors can foster such skills. With a project team from engineering and education at four different institutions, we are well positioned to investigate a variety of learning environments making results useful to the wider engineering education community. *This project is funded by the National Science Foundation (NSF) ECC Innovations in Engineering Education, Curriculum, and Infrastructure (IEECI) program and is in collaboration with Drs. M. Prince, C. Stefanou, K. Nottis of Bucknell University, Dr. J. Stolk of Olin University, and Dr. J. Chen of Rowan University.*

Faculty Beliefs about Effective Teaching (S. M. Lord)
We are investigating the beliefs about effective teaching espoused by three groups of faculty: faculty who embrace alternative pedagogies, engineering faculty who regularly attend engineering education conferences, and more typical engineering faculty. We use cultural consensus analysis to determine if each of these groups can be considered a cultural group and to examine the similarities and differences among them. *This project has been funded by the NSF Rigorous Research in Engineering Education (RREE) program and a USD University Professorship and is in collaboration with Dr. M. Camacho in Sociology at USD.*

Industrial & Systems Engineering

Cognitive Performance under Stress (B. Chase)
The environment in which we work can place many constraints upon our ability to perform both physical and cognitive tasks. For nearly five decades researchers have investigated thermal stress effects on human cognitive performance. Although much data have been collected, relatively little consensus was reached with regard to either the true nature of thermal stress effects, or an existing mechanism for predicting human performance under thermal stress. Several factors have likely contributed to the substantial variation in the findings of previous thermal stress investigations. Research in this area attempts to quantify cognitive deficits due to thermal stress, develop interventions and inform both task redesign and policy decisions.

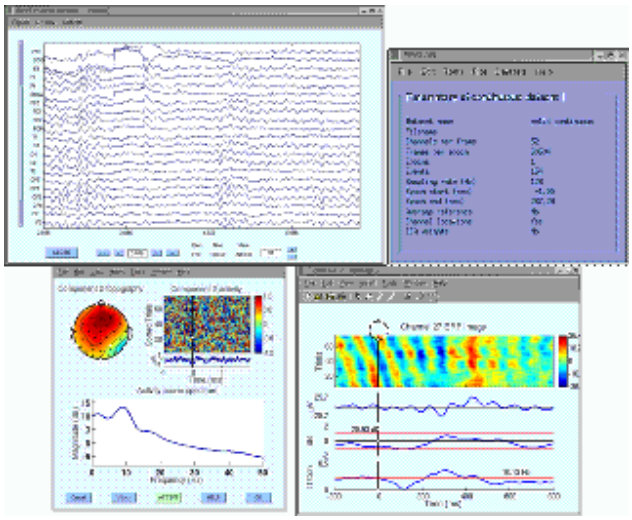
Design of Experiments (L. A. Perry)
Experimental design is a systematic approach to planning and analyzing experiments so that meaningful results can be obtained in an efficient and timely manner. Design of Experiments (DOE) can be used to reduce product development time or improve a manufacturing or service process. In design of experiments, the experimenter is concerned with processes of planning and conducting an experiment; once the experiment is conducted, the resulting data can be analyzed so that legitimate, objective conclusions can be made. The application of DOEs in the engineering discipline has become a critical tool for developing and improving manufacturing processes and systems as well as the product development cycle. If a process exists, DOEs can be used to improve it. Currently, experimental design methods are being used to improve yields and reduce variability in products in local biotech, pharmaceutical, and telecom companies.

Electrophysiological Measures of Cognitive Performance (B. Chase)
Research in this area is based on the understanding that numerous cognitive processes are ongoing in parallel. There are externally measurable reflections of these processes available to us including: measurable movement behaviors (button presses), recordable brain activity measures (such as the electroencephalogram (EEG)) and eye movement behavior. While eye movement behavior is perhaps the most information impoverished of these measures, it is the most unobtrusive measure that can provide *millisecond-to-millisecond* reflections of underlying cognitive processes. While there are tasks that are obviously reflected in eye movement activity (e.g. visual searching paradigms), nearly all cognitive processes have at least some indirect influence on eye movement behavior. The eye movement behaviors can be analyzed in terms of the *neuro-dynamics*, the system-wide behavior of the brain in action. This capability is largely based on advanced EEG recording and analysis techniques. The goal is to elucidate the neuro-dynamic behaviors in eye movement activity as it relates to cognitive processes. With input concerning operator state available to an adaptive system, the task itself could be modified to account for operator fatigue, attentional state, and other performance characteristics of interest.

Genetic Algorithms in Optimization (R. T. Olson)
Heuristic optimization methods are used to quickly find high quality solutions to optimization problems that are easy to describe are very difficult to solve such as scheduling problems. One approach uses genetic algorithms (GAs) based on principles from biological evolution to search for a solution by combining desirable characteristics of good solutions to form better ones. Although GAs have proven to be able to solve efficiently many types of problem, it is generally necessary to tune the GA by carefully selecting several search parameters for each type of problem being solved. This makes it difficult for analysts to use GA without significant training.

This research strives to develop simple rules for setting the parameters of a GA so that high quality searches can be achieved. Taguchi methods for robust design are used to guide the processes of tuning a GA for several types of problem of a particular class; for example, makespan scheduling, flowshop scheduling and jobshop scheduling. The result will be sets of robust parameter settings for each class of problem. This will allow analysts to devote less time

developing GA strategies and more time solving difficult problems.



Measuring Different Cognitive Processes in Parallel

Public Health Vaccination Programs (R. T. Olson)
In many communities, public health facilities are the primary administrators of influenza and other vaccination programs. While most people agree the programs benefit the community, it is not clear how these programs can be administered the most effectively to high-risk adults. One alternative is to administer vaccinations during routine in-office wellness visits between a patient and physician. A second strategy used large scale mass immunization walk-in clinics to treat many people in a short time.

The purpose of this research is to better understand the nature of the two types of clinic experience. Work methods analysis is being preformed to determine the staffing needed to support each strategy and to assess the clinical efficacy of each method. The resulting decision support system will allow clinic administrators to decide how each strategy should be used in their setting.

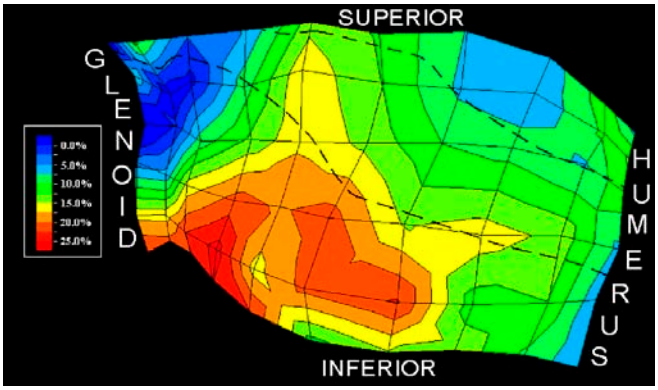
Public Health Management (B. Chase, L. A. Perry)
Several projects have been undertaken in the area of management engineering where Industrial Engineering concepts and techniques are applied within the health care arena. Projects include hospital staffing, discrete event simulation, lean and six sigma, supply chain management, reduction of wait times, operational performance improvement, electronic medical record implementation, occupational safety, and work and workstation design.

Six-Sigma (L. A. Perry)
Six-Sigma is a systematic, data-driven quality improvement methodology that has proven quite effective in recent years. Specifically, it is an approach by which a cohesive collection of quality improvement tools is utilized to reduce process variation. More broadly, it is a managerial and cultural directive toward achieving near-perfect quality, only 3.4 defects per million opportunities (DPMO). Six-Sigma is becoming commonplace in the manufacturing sector due to the benefits that are undeniable, but still there exists an element of skepticism that prevents its widespread use in the service sector. Continuous improvement initiatives still have plenty of growth potential in health care, financial, and defense industries as Six-Sigma becomes more visible and cost savings are identified.

Mechanical Engineering

Applications of Time Compression Technologies (M. Z. Huang)
Time compression technologies refer to the modern industry practices that integrate rapid prototyping with modeling, analysis, and simulation techniques, such as computer-aided design (CAD) and finite element analysis (FEA), for product design and development. This study aims to explore novel ways of incorporating these practices into existing undergraduate engineering curriculum. Application studies will be conducted using Pro/E ad Z-Corp 3D Printer available at USD.

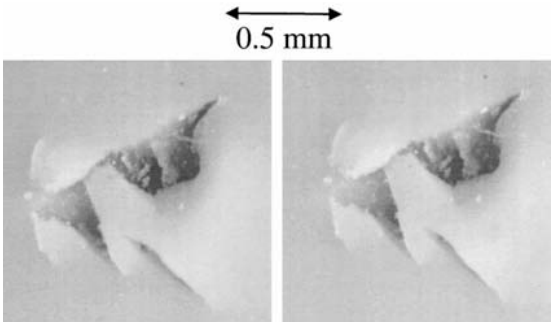
Bi-directional Man-Machine Interface System (M. Z. Huang)
This project is concerned with the design and development of a cable-drive, active bi-directional controller which serves as the man-machine interface in such applications as rehabilitation or training where operators are to follow or guide through a certain prescribed motions. A bi-directional controller is one that allows the operator to 'feel' the task load while executing through the task trajectory. This investigation explores the interactions between the various configurations of the cables and the actuation schemes and seeks an optimal implementation based on range of motions and sensitivity of responses.



Maximum principal strain fields of the antero-inferior glenohumeral capsule of a human shoulder

Biomechanics (D. Malicky)
Research in this area is being undertaken as a continuation of award-winning dissertation work to measure the *in vitro* two-dimensional strain fields of the ligamentous capsule of the unstable human shoulder which raised new questions about the relationship between strain fields, joint kinematics, and ligament/bone contours. Current work addresses these questions with a finite element model and correlate findings to the prior experimental data. A greater understanding of these factors would improve clinical shoulder joint reconstructions. Other bioengineering research topics of interest include foot/ankle mechanics and sinusitis etiology and treatment mechanics.

Durability of Elastomer Coatings (J. G. Kohl)
Silicone is currently being investigated for use as foul-release coatings. Silicone when used as a coating has been known to suffer from both poor adhesion and poor durability. Efforts are being directed at improving the toughness and adhesion of these coatings without reducing their foul release behavior. One method of evaluating the toughness and adhesion of these coatings is by means of a scratch tester. It was found in earlier work that the failure mode and durability of the coating depended on coating thickness. Current work is being performed in the identification and modeling of material parameters that contribute to the toughness and adhesion of these coatings. Nanoindentation techniques are used to determine the parameters under investigation.



Electron Microscope Image of Coating Failure

Dynamic Analysis of Hybrid Series-Parallel Mechanisms (M. Z. Huang)
Robotic mechanisms traditionally are either of 'serial' or 'parallel' configurations. While a serial robot has larger workspace, it lacks stiffness inherently and thus has poor load carrying capability. A parallel robot, on the other hand, exhibits just the opposite to its serial counterparts. Robotic mechanisms with unconventional, hybrid series-parallel configurations could provide a natural compromise. My research in this area focuses on the study of coordination, which is the level of control where inputs to the actuators are determined given the geometric structure of a mechanism. This investigation aims to develop a generic theory whereby the kinematics and dynamics characteristics of hybrid mechanisms of different geometric structures may be evaluated for their design implementation.

Engineering Practice (D. Malicky)
Numerous past industry-based projects have encompassed topics in mechanical engineering design, product development, vehicle design, manufacturing, manufacturability, materials, metrology, experimentation, instrumentation, ergonomics, safety, and conformity engineering (CE). Projects have been applied to a wide variety of industries including: automotive, manufacturing, consumer products, and pneumatic conveyance.

Foul Release Coatings (J. G. Kohl)
It has been shown that the foul release properties of silicone elastomer coatings are related to not only the work of adhesion but also to bulk modulus and thickness. Thick and thin coatings have different release behavior. There is a thickness dependence for thin coatings whereas beyond a certain thickness the release properties are independent of thickness. This transition in behavior is currently being investigated.

Microcirculation (F. G. Jacobitz)
The microcirculation in rat skeletal muscle and skeletal muscle fascia is investigated. Tissue samples are prepared such that the micro-vessel network pattern can be reconstructed and studied. Those networks consist of arterial vessels supplying blood, capillaries for the exchange of nutrients and metabolites with the surrounding tissue, and venule vessels collecting blood. The vessel topology is used in computer simulations of the flow in the network that provide comprehensive information about pressure and velocity distributions in the network that is not available from experiments. The simulations take passive and active vessel properties into account. The non-Newtonian properties of blood are modeled as an apparent viscosity based on previous experimental data.


Micro-Vessel Network

Turbulence in Stratified Shear Flows (F. G. Jacobitz)

The evolution of turbulence and turbulent mixing is investigated in stably stratified rotating shear flows using direct numerical simulations. Such flows are important in many engineering applications as well as in flows in the atmosphere and oceans. An understanding of the competing effects of shear, rotation, and stratification is required in order to quantify the transport of momentum, heat, pollutant, and nutrients in such flows. Most recently, the effect of rotation has been investigated using wavelet-based coherent vortex extraction methods. The direct numerical simulations resolve all dynamically important scales of the motion and therefore require considerable computational resources. The simulations are carried out on a parallel computer with 12 64-bit CPUs and a total of 48GBytes of memory housed at USD and on the facilities of the San Diego Supercomputer Center.

Virus Removal from Blood (F. G. Jacobitz)

Research is currently underway to develop a mathematical model for the flow in hemo-dialysis cartridges. These cartridges are used to remove viruses and toxins from blood, such as HIV or hepatitis, and viruses which might be used in bioterrorism, such as smallpox. The mathematical model is developed in close collaboration with experiments performed at Aethlon Medical, Inc.. The model, once validated, will be used to optimize the filter design in order to minimize treatment time for patients.