ELECTRICAL ENGINEERING KALEIDOSCOPE

EEK07

A PUBLICATION OF
THE ELECTRICAL ENGINEERING DEPARTMENT
UNIVERSITY OF WASHINGTON

ANNUAL RESEARCH REVIEW

Over the next five years the College of Engineering will grow significantly through three to five major initiatives helping define new technologies for the 21st century. For example, we have already started looking at molecular engineering (MolE) as a new approach to materials and systems fabrication. The intellectual focus of MolE is on building molecules that form the heart of innovative, game-changing, new products. Concepts such as the discrete nature of molecular interactions (not just the ensemble properties of large collections of molecules), self-assembly of molecular systems, autonomous control of molecular systems, and self-healing systems will become as important for our students as the differential equations describing mass transport and circuit dynamics. At a societal level, including many industrial sectors, MolE can radically change what it means to "manufacture."

I expect EE to be a major player in the MolE initiative. Self assembly of integrated systems is already a research topic in EE, and other MolE topics will become mainstream. I look forward to working with EE faculty and students to make UW a world leader in this exciting new area.

MATTHEW O'DONNELL, Ph.D.

FRANK AND JULIE JUNGERS DEAN OF ENGINEERING
COLLEGE OF ENGINEERING
UNIVERSITY OF WASHINGTON

On April 29, 2006 the EE Department celebrated its **Centennial.** Master of ceremonies for the entire event was (former) department Chair David Allstot. At lunch, Professor Rich Christie gave an interesting talk describing one hundred years of EE at UW. He has written a short book that documents the decade-by-decade development of the department. It can be downloaded from the Centennial Website www.ee.washington.edu/about/centennial. A second luncheon talk on "EE and the Future" was presented by Professor Howard Chizeck. During the afternoon, executives and engineers representing the breadth of our discipline shared their views on the future growth and evolution of electrical engineering during a panel discussion moderated by Mr. Ron Howell, President and CEO of the Washington Research Foundation. Following laboratory tours and demonstrations, centennial participants enjoyed a celebration dinner. After dinner, Dr. Bernie Meyerson, CTO of IBM's Technology Group, gave a keynote address. All of the talks plus reminiscences of visiting alumni can be seen on a DVD of the event, which can be obtained through the Centennial Website.

EEK07

ANNUAL RESEARCH REVIEW

Welcome to EEK 2007

The research goals of the University of Washington Department of Electrical Engineering are to be a leader in innovative and cutting-edge research, and to meet the societal needs in communication, transportation, energy, health and the environment. The Pacific Northwest has a strong technology industry, and UW has superior research records in physical and health sciences and in engineering.

Recently, the EE Department completed a strategic plan, taking into account the strengths and opportunities of UW and the Pacific Northwest. We identified three strategic research areas. They are 1) Nanoscience/technology, Physics-based Simulation, and Molecular Engineering; 2) Network/Information Science and Technology; and 3) Dynamical Systems and Systems Biology. We will work towards building centers of excellence in these areas and ask you to support our efforts.

LEUNG TSANG
ACTING CHAIR AND PROFESSOR
DEPARTMENT OF ELECTRICAL ENGINEERING

PUBLISHER

Electrical Engineering Department of the University of Washington

Leung Tsang, Acting Chair
Sumit Roy, Associate Chair for Research & Development
Jim Ritcey, Associate Chair for Education

DESIGN

Sarah Conradt

EDITORIAL STAFF

Howard Jay Chizeck, Faculty Editor
Laura J. Haas, Staff Editor

Print management by University of Washington Publications Services

WELCOME TO THE SEVENTH ANNUAL EDITION OF EEK

Each year we try to give a snapshot of research activities that UW EE students and faculty are engaged in. Our goal is to present our cutting edge research using the latest colors, innovative fonts, and edgy design hopefully in a way that is interesting to the reader. Last year, EEK focused on our students. Your feedback was overwhelmingly positive. So this year, once again, most of EEK describes student work.

EEK2007 reports the eclectical electrical engineering research by our students and faculty. Ionospheric science arrays, pelagic sonar, remote sensing of sea ice, robots in the desert for telesurgery, insect identification through feature analysis, motion analysis for improved golf swings, and software-defined radio are just some of the topics presented herein.

I hope that you find EEK2007 to be informative.

HOWARD JAY CHIZECK
EEK FACULTY EDITOR 2001-2007

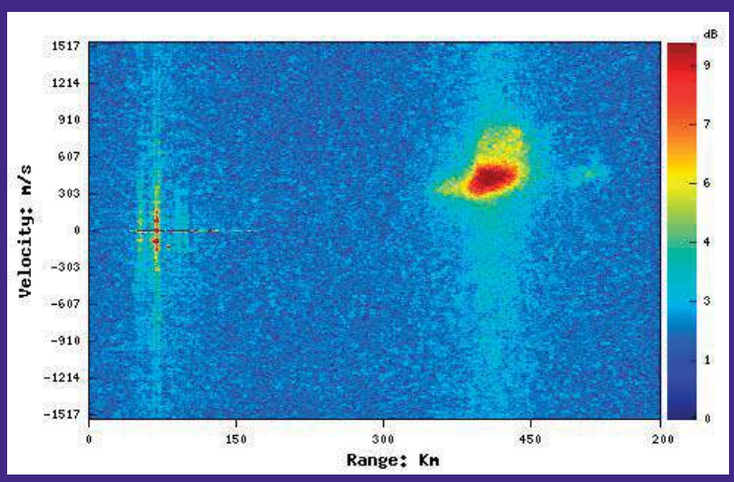
INTEGRATED SIGNALS for Ionospheric Science Arrays

ZAC BERKOWITZ — GRADUATE STUDENT (EE)

The Intercepted Signals for Ionospheric Science (ISIS) Array Project aims to create a multi-function distributed radio science instrument that can perform applications of active and passive multistatic radar imaging, satellite beacon observation of ionospheric TEC and scintillation, and radio intercept and time difference of arrival over operating frequencies ranging from 0.5 to 2000MHz. The system will comprise a series of high performance nodes, distributed primarily along the northern U.S. UW EE's Radar Remote Sensing Lab (RRSL) will deploy two of the initial seven nodes at its current sites (the Manastash Ridge Observatory (MRO), and UW), which form part of the Manastash Ridge Radar (MRR).

In its current implementation, the RRSL passive radar uses three receivers (UW, Seattle campus, MRO, and Eastern Washington University, Cheney, WA) to construct range-Doppler and interferometric radar data products from targets over southwestern Canada. The targets include auroral turbulence, plasma trails left by meteors in the atmosphere, and aircraft.

The immediate goal is to transfer the UW-MRO link responsibilities from the old receivers to the new, more capable ISIS nodes. These ISIS nodes can simultaneously sample six antennas, a significant advancement beyond the current limit of two antennas per location. More antennas permit greater detail in interferometric imaging, and allow for much better mitigation of ground clutter and local multipath. This expansion of the MRR with the new ISIS receivers will not only enable surveillance of a wider area, but will also produce much more data.



A RANGE-DOPPLER IMAGE FROM THE MANASTASH RIDGE RADAR SHOWING AURORAL TURBLULENCE MOVING TOWARDS THE RECEIVER AT A DISTANCE OF ROUGHLY 1KM.

This data will need to be moved and processed so the available network bandwidth will not be saturated. It is possible for the entire radar's data acquisition system to generate about 40 Mb/second, so judicious management of the data is critical to successfully operate the system.

In the long run, as more ISIS nodes come on-line across the northern U.S., the goal is to be able to track small spatial scale atmospheric events over large distances.EE

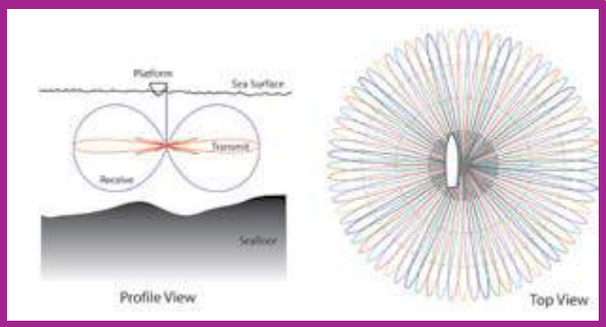
FACULTY ADVISOR: *Professor John Sahr* **COLLABORATORS:** *Melissa Meyer (MTU), Frank Lind (MIT), Andy Morabito (EE), Laura Vertatschitsch (EE)* **RESEARCH AREA:** *Radar, Ionospheric Physics, Statistical Signal Processing*
GRANT/FUNDING SOURCE: *National Science Foundation*

The Pelagic IMaging MIDFREQUENCY SONAR (PIMMS)

DAVID BURNETT — GRADUATE STUDENT (EE)

The behavior of fish schools near coastlines has been well-known for hundreds of years via the fishing industry, but pelagic (open ocean) schools are largely unstudied. This is primarily due to the extreme size of the open ocean versus the number of fish schools. To aid in the study of these schools, a long-range sonar instrument capable of quickly sampling large areas (~2-5km radius circles) of the ocean was created to find the fish.

The device, called PIMMS (Pelagic IMaging Midfrequency Sonar), consists of a receive array, transmit array and control electronics. The sonar pings and listens at 10kHz, which is a frequency well reflected by the gas-filled swim ballasts of fishes. The receive array is horizontal and circular with 64 omni-directional dipoles vertically-oriented and spaced one quarter wavelength apart to create nulls above and below (most importantly to cancel ship noise from above).



SIDE AND TOP VIEW DIAGRAM OF TRANSMIT AND RECEIVE BEAM PATTERNS. TOP VIEW OF TRANSMIT DIAGRAM NOT PICTURED, AS IT IS OMNIDIRECTIONAL IN THE X-Y PLANE.

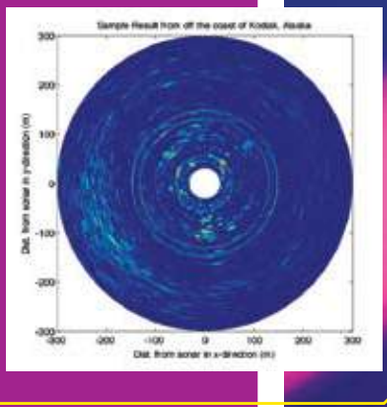
COMPLETED PIMMS READY TO DEPLOY OVERBOARD ON THE R/V SHARP.

The transmit array is formed from eight toroidal hydrophones stacked vertically, and protrudes down underneath the receive array. When driven together, these eight elements create a 10-degree thick horizontal transmission disk that can be steered up and down when driven with a phased waveform. The receive array is connected to the ADC after rigorous anti-alias filtering, and the transmit array is connected to the DAC via high-voltage pulse-width modulation amplifiers.

These converters reside in a PC/104 stack, which also includes typical computer components. The sonar itself runs a standard Linux distribution. When the sonar is deployed over the side of a ship (up to 100m deep, the maximum cable length of an Ethernet network), this Linux machine can be simply connected via Secure Shell (ssh) to issue ping and sample commands.

The sonar was successfully tested off the coasts of Alaska and Delaware, as well as in Chesapeake Bay, and found what is believed to be fish schools. Results are currently being verified from the data collected in parallel with conventional sonar equipment to confirm the PIMMS can be used as a standalone instrument.EE

A PLOT FROM A PING OFF THE COAST OF KODIAK, ALASKA SHOWING A LARGE POSSIBLE LOW-DENSITY SCHOOL 200M FROM THE SONAR, AND SEVERAL POSSIBLE HIGH-DENSITY SCHOOLS 50M-100M FROM THE SONAR. CONCENTRIC RINGS MOST LIKELY RESULT FROM SHIP-BASED NOISE DIRECTLY ABOVE THE SONAR, APPEARING TO BE OMNIDIRECTIONAL.



FACULTY ADVISOR: *Tim Chinowsky (EE – now working for* Verathon in *Bothell, WA) & Chris Jones (APL)*
COLLABORATORS: *Peter Kauffman (EE), Tim McGinnis (APL)* **RESEARCH AREA:** *Sensors*
GRANT/FUNDING SOURCE: *National Oceanographic Partnership Program*

REMOTE SENSING OF SEA-ICE THICKNESS

Using Angular and Frequency Correlation Function Radar

SERMSAK JARUWATANADILOK — RESEARCH ASSISTANT PROFESSOR (EE)

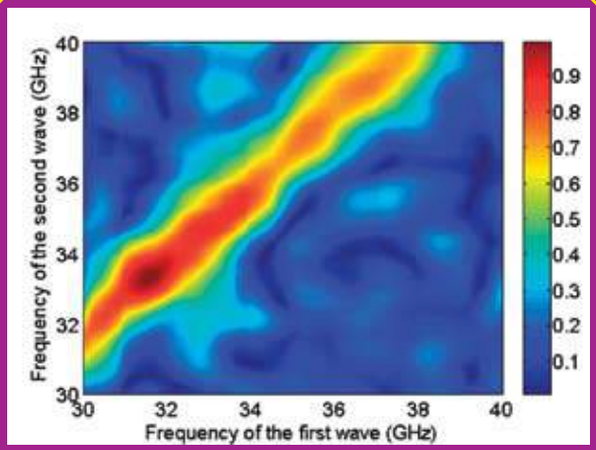
Global warming is one of the most important problems in the next decades. Sea ice exerts important influences in the coupled atmosphere-ocean system, and changes in its thickness modify the heat transfer from the ocean. The sea ice albedo effect is important as a decrease of sea ice extent will result in more heat absorption by the ocean. This is believed to cause an increase in ocean temperature, which triggers more tropical storms and hurricanes. The decrease of sea ice volume decreases the thermohaline circulation of the ocean, altering its surface currents and therefore the climate. This research focuses on developing electromagnetic wave remote sensing technology for sea-ice thickness measurement.

Satellite imagery is an excellent tool to estimate the extent of the snow and sea ice in the Arctic regions. However, the determination of their thicknesses over a wide area with sufficient accuracy is still an illusive goal. All current remote sensing methods, including passive microwave remote sensing of radiometry, active microwave remote sensing of scatterometry from satellites, upward-looking sonar from submarine, electromagnetic induction, and laser altimetry have disadvantages from either limited spatial coverage or low resolution.

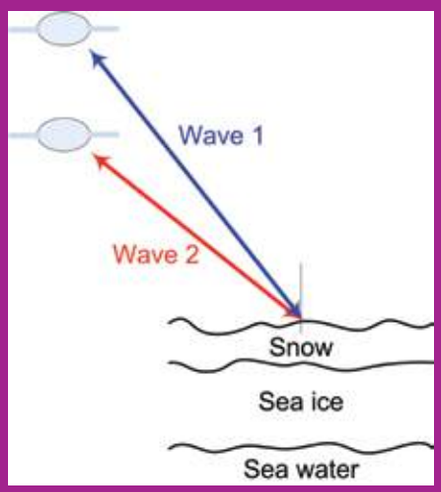
UW EE and several agencies including the Jet Propulsion Laboratory, the Cold Region Research Laboratory, and University of Kansas are developing a radar based on angular and frequency correlation function to measure the sea-ice thickness intended for the Arctic region. This radar uses electromagnetic waves at the frequency range of 135-170MHz which can penetrate through the sea-ice layer and obtain a response from the interface between the bottom of sea-ice and the sea water.

The radar sends waves with two different frequencies and incident angles. These are measured and correlated. The phase of the correlation function has a direct relationship with the sea-ice thickness. Therefore, the sea-ice thickness can be retrieved from the measurements. A model for wave propagation in multi-layer media of snow-sea ice-sea water has been developed, which simulates real-world scenarios.

UW EE is collaborating with JPL to obtain the radar measurement on the real sea ice from the aircraft to validate the retrieval algorithm. The ultimate goal is to develop the sensor for deployment on a satellite for wide and perennial coverage.EE



EXPERIMENT SHOWING THE CORRELATION FUNCTION IS STRONG.



SEA-ICE THICKNESS RETRIEVAL BASED ON THE ANGULAR AND FREQUENCY CORRELATION FUNCTION.

COLLABORATORS: *Professor Yasuo Kuga (EE) and Rasmus Solmer Eriksen (former EE Graduate student, M.S. 2005)*
RESEARCH AREA: *Electromagnetics and Remote Sensing* **GRANT/FUNDING SOURCE:** *Jet Propulsion Laboratory, Office of Naval Research*

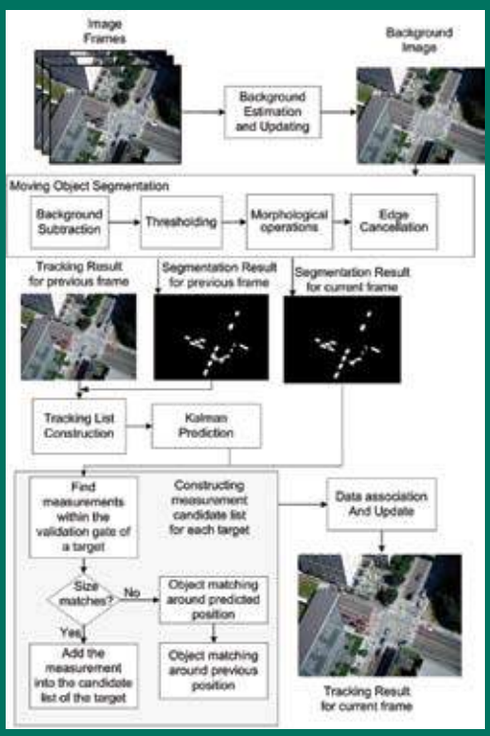
VEHICLE TRACKING SYSTEM

For Handling Multi-Directional Traffic and Occluded Vehicles

HSU YUNG CHENG — GRADUATE STUDENT (EE)

Vehicle tracking and event detection are important applications in Intelligent Transportation Systems (ITS). Principal events include traffic congestion, dropping items, accidents and regulation violations. Developing a desirable automatic monitoring system would track each vehicle, analyze its behavior, and recognize and report relevant events. Consequently, a robust tracking system must identify each individual moving vehicle in spite of occlusion caused by camera angle.

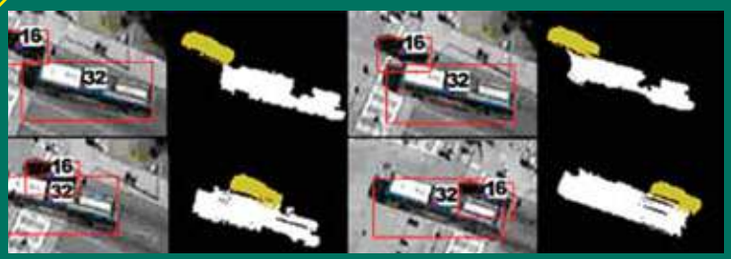
A multiple-target tracking system has been developed to analyze crossroad traffic systematically based on Kalman filtering and modified probabilistic data association (PDA). First, moving objects are segmented from the background scene based on background subtraction and the fourth order moment. Then, each object entering the region of interest is analyzed by its shape and orientation, and put into the tracking list. For each object in the tracking list, Kalman filtering is applied for the tracking purpose.



THE FRAMEWORK OF THE CROSS-ROAD TRACKING SYSTEM.

To make the tracking system more robust when handling multi-directional traffic and occluded vehicles, candidate measurement lists were constructed by first matching the measurement sizes and targets. When the sizes do not match, object matching within a limited area is performed. Because the correlation is computed only when occlusion or segmentation error occurs, and the searching is conducted within a very small range, this mechanism can solve the occlusion problems effectively without incurring too much computational complexity. The classical PDA method was also modified to enhance its performance and make it more suitable for vision-based systems.

This system can serve as a critical foundation for event detection systems at crossroads. Future work will develop an event detection system that can analyze the behaviors of the vehicles, as well as recognize and report abnormal or rule-violation events in real-time. EE



TRACKING RESULTS FOR TWO OCCLUDED VEHICLES AND THE CORRESPONDING SEGMENTATION RESULTS.

FACULTY ADVISOR: *Professor Jenq-Neng Hwang* **RESEARCH AREA:** *Video Analysis for Intelligent Transportation Systems* **GRANT/FUNDING SOURCE:** *National Science Council, Taiwan*

HIGH RESOLUTION PET SCANNER
Using FPGAs

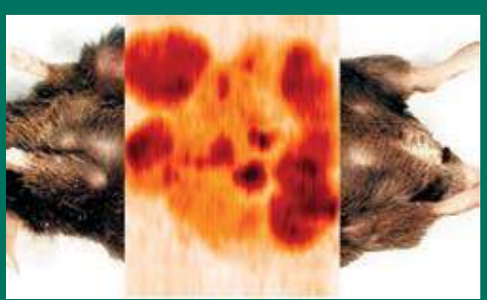
MICHAEL HASELMAN — GRADUATE STUDENT (EE)

Who would have thought that Field-Programmable Gate Arrays (FPGAs) would be the latest tool in the study of cancer? FPGAs are programmable chips used to implement complex digital logic, such as medical imaging and high-performance computing. Of course, FPGAs alone will not solve the mysteries of cancer, but when connected to a Positron Emission Tomography (PET) scanner, FPGAs can be a powerful tool. Current human PET scanners do not provide the resolution needed to study cancer in a small research animal such as a mouse. Researchers at UW's Electrical Engineering Department and Radiology Division of Nuclear Medicine are addressing this by developing a high resolution, small animal PET scanner, which may lead to revolutionizing PET scanners for humans as well.

A PET scanner is a medical imaging system that produces three-dimensional images of functional metabolic processes by detecting radiation. The radiation comes from short-lived isotopes that are attached to a metabolically active molecule (tracers) and injected into a subject. As certain portions of a body metabolize these tracers, they concentrate in certain tissues, and give off more radiation. While tracers have been developed to concentrate in tissues such as the heart and brain, PET is most widely used to study tumors. In small research animals, tumors can be only a few mm in diameter, so an effective study requires a high-resolution scanner. High-resolution requires large bandwidth data processing, complex statistical estimators to determine exactly where the radiation interacted with the scanner, and precise timing to determine when a radiation event occurred.

This is a task for FPGAs, and in this system, they constitute the core of the front-end electronics that receive the data from the detectors. They process this data before sending it to a host computer for image construction. FPGAs provide cheap, reconfigurable hardware that is well suited for this application. Because they are hardware, they provide data processing speeds that are not achievable in software. Since FPGAs are reconfigurable, it is easy to design and implement algorithms on them. Reconfiguration makes it possible to periodically load and run a maintenance or diagnostic routine.

This scanner will not only provide a tool for cancer research, but individual parts such as detector designs and timing algorithms will be useful for future human systems. The plan is to also investigate simultaneous PET and Magnetic Resonant Imaging (MRI) to combine the functional information of PET and the high anatomical resolution of MRI, so the electronics will have to work in a very strong magnetic field.EE



PET SCAN OF A MOUSE SHOWING TUMORS (IN DARK ORANGE) THAT OVERLAPS A PICTURE OF THE SAME MOUSE. THE TUMORS ARE DARKER BECAUSE THEY CONSUME MORE OF THE RADIOACTIVE TRACER.

DATA ACQUISITION PRINTED CIRCUIT BOARD WITH TWO FPGAS. THIS SCANNER CONTAINS 18 OF THESE BOARDS, ONE FOR EACH DETECTOR MODULE.

FACULTY ADVISOR: *Professor Scott Hauck* **COLLABORATORS:** *Thomas Lewellen, Robert Miyaoka, Paul Kinahan and Marie Janes (Radiology)* **RESEARCH AREA:** *FPGAs, PET medical imaging* **GRANT/FUNDING SOURCE:** *Zecotek Medical Systems, National Institutes of Health, National Science Foundation*

Extraction and Integration of Human Body Parts for 3D MOTION ANALYSIS OF GOLF SWING from Single Camera Video Sequences

IBRAHIM KARLIGA — GRADUATE STUDENT (EE)

Sports video analysis is an emerging topic as it has great commercial potential. A variety of sports including baseball, soccer, football and tennis have been used to demonstrate new ideas in many sports video content analysis projects. The methods employed include statistical methods, rule-based methods, Hidden Markov Models and Dynamic Bayesian Networks. These video content analyses are primarily categorized into two approaches: the frame-based approach, where features are extracted directly from frames, and the object-based analysis approach used to interpret the object behavior on a fine level.

An innovative video analysis system has been developed to analyze the human body 3D motion of a golf swing from single camera video sequences. It evaluates the 3D model for each major body part separately to derive a more accurate 3D representation. The algorithm combines watershed transformations, curve fittings, color region merging and 3D motion estimations. The human body parts used for the analysis are automatically extracted using a video object segmentation technique. The two-dimensional information estimated from the segmented body parts obtains three-dimensional body part models in a coordinated manner, consisting of head, upper arms, lower arms, body trunk, upper legs, lower legs and feet. This system aims to obtain the 3D motion information for performance evaluation in golf swinging, and compares this information to a different player. This system is capable of grasping the overall 3D human body structure in golf swinging, especially for the torso, and can be further improved by estimating the pose of the arms and legs. Ultimately, the objective of this system is to analyze and compare human body part parameters for different golf players.EE

SEGMENTATION PERFORMANCE FOR DIFFERENT FRAMES.

3D HUMAN BODY MODEL FITTED TO THE FRAMES ABOVE.

FACULTY ADVISOR: *Professor Jenq-Neng Hwang* **RESEARCH AREA:** *3D Object Modeling and Motion Trajectory Analysis of Golf Video* **GRANT/FUNDING SOURCE:** *Acucela Inc., U.S.A.*

AUTOMATED INSECT IDENTIFICATION
through Concatenated Histograms of Local Appearance

NATALIA LARIOS DELGADO — GRADUATE STUDENT (EE)

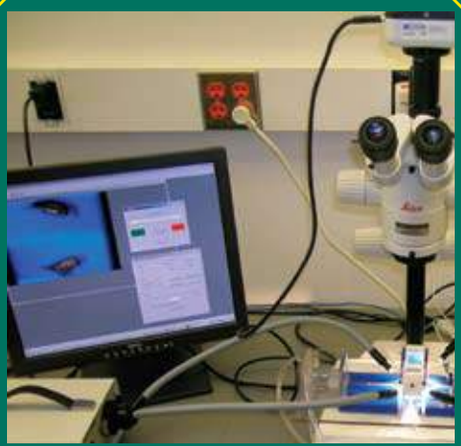
Population counts of stonefly larvae inhabiting streams are an indicator of stream health. However, specimen identification by human experts can be very costly. An automated stonefly-larvae classification system has been developed to address this problem. This method is based on a bag-of-features approach, which disregards the relative arrangement of regions. The features from image regions are summarized as a vector and classified via state-of-the-art machine learning methods. To provide a rapid-throughput system, a mechanical apparatus for manipulating and imaging is combined with a software system for classification.

The bag-of-features approach involves five stages: region detection, region description, region classification into features, combination of detected features into a feature vector formed by concatenated histograms, and final classification of the feature vector. For region detection, three different algorithms are employed: the Hessian-affine detector, the Kadir entropy detector, and a new detector, the principal curvature-based region detector (PCBR).

All detected regions are described using Lowe's SIFT descriptor. At training time, a Gaussian mixture model (GMM) is fit to the set of SIFT vectors, and each mixture component becomes a feature. At classification time, each SIFT vector extracted from the regions of a novel image is assigned to the most likely Gaussian component. A histogram with the number of SIFT vectors assigned to each feature is formed. Feature vectors from each of the separate detectors are concatenated to produce a larger vector when working with combinations of detectors.

The final labeling of the specimens is based on these feature vectors and performed by an ensemble of logistic model trees. As a result, any combination of region detectors can be used, which makes it possible to evaluate their contribution to discriminate between species.

Classification accuracy through this approach is slightly better than what humans can perform on the same set of images. By rejecting specimens with low confidence level, the accuracy reaches above 90%. The PCBR detector discriminates well between similar species (Calineuria and Doroneuria); combining all detectors gives the greatest accuracy.EE



ENTIRE STONEFLY TRANSPORTATION AND IMAGING SETUP WITH MICROSCOPE AND ATTACHED DIGITAL CAMERA, LIGHT BOXES AND COMPUTER CONTROLLED PUMPS FOR TRANSPORTING AND ROTATING THE SPECIMEN.

EXAMPLE IMAGES OF DIFFERENT STONEFLY LARVAE SPECIES. COLUMNS FROM LEFT TO RIGHT: CALINEURIA, DORONEURIA, HESPEROPERLA AND YORAPERLA.

FACULTY ADVISOR: *Professor Linda G. Shapiro (EE & CSE)* **COLLABORATORS:** *Hongli Deng, Wei Zhang, Matt Sarpola, Robert Paasch, Andrew Moldenke, David Lytle, Eric Mortensen and Tom Dietterich (Oregon State University), Salvador Ruiz Correa (Children's National Medical Center), Jenny Yuen (MIT)* **RESEARCH AREA:** *Classification, object recognition, interest operators, region detectors* **GRANT/FUNDING SOURCE:** *National Science Foundation*

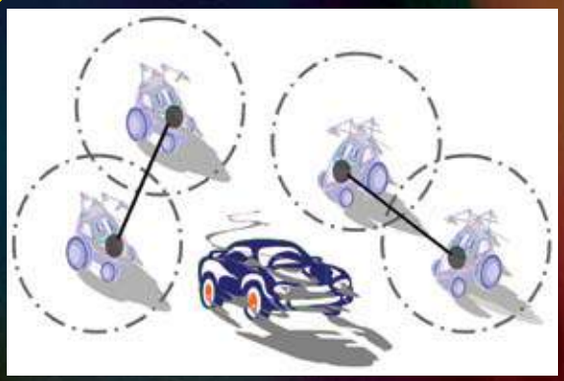
CONTROL OF COUPLED SYSTEMS
with Random Communication Delays

CHUN-I CHEN — GRADUATE STUDENT (EE)

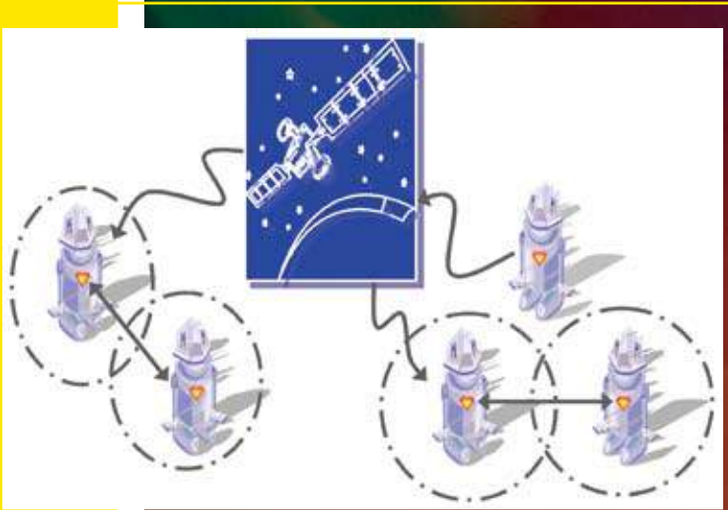
Consider the problem of optimally controlling many dynamic systems which are coupled, in that the control decisions of one system may be influenced by information obtained from others. Of particular interest is the effect of randomly time-varying communication delays in the transmission of information.

The coupled systems do not have access to the same information at any given time. Systems may obtain information about other systems, but only after a time delay that is not known in advance. Control decisions must be made locally, even though there may be overall goals that the collection of systems is trying to achieve.

This work is motivated by control problems arising in a wide variety of situations. For example, in a single-cell organism, there are a number of interacting subsystems that have local regulations and work collectively to achieve certain objectives. These subsystems, such as genetic circuits, dynamics of transcriptome, proteome, and metabolome, might communicate through diffusion of various molecules within the cell fluid that introduces randomly varying delays. A similar situation can be described for multi-cell organisms.



COLLABORATIVE TRACKING: ROBOTS ARE DESIGNED TO COOPERATIVELY PURSUE ONE OR MORE MOVING TARGETS. DESIGN ISSUES MIGHT INCLUDE TIME-VARYING FORMATIONS, COLLISION AVOIDANCE, COMMUNICATION LIMITED BY DIFFERENT SENSING CAPABILITIES, AND INDIVIDUAL AND COLLECTIVE TRACKING ERRORS.



FORMATION CONTROL: A TEAM OF ROBOTS ARE REQUESTED TO DEPLOY AND MAINTAIN A DESIRED FORMATION SHAPE (2D OR 3D) WHILE MOVING AROUND.

The time-varying random communication delays are modeled by the stochastic processes that are independent and identically distributed, or Markov. The optimal control law is then solved by the method of Dynamic Programming. For some cases it can be shown that the Separation Principle holds where the optimal solution involves the same control law as though the random quantities were known and combined with optimal estimates of these random quantities. Also, steady-state solutions to the control problem can exist with conditions that guarantee their existence can be obtained, as well as an algorithm to compute the optimal controller.

This work is developing new theoretical results for this type of problem. These mathematical results and algorithms will provide means to analyze and synthesize the control of systems (or collections of systems) that experience random communication delays.EE

FACULTY ADVISOR: *Professor Howard Jay Chizeck* **RESEARCH AREA:** *Control Theory*

Development of a Control Theory FOR NANOSYSTEMS

STEPHEN HAWLEY — GRADUATE STUDENT (EE)

Nanotechnologies have a broad range of potential applications in many fields from medicine to electronics. Nanotechnology is expected to be a one trillion dollar industry directly employing over two million people by 2015. First generation nanotechnologies are generally passive nanostructures; research has focused on synthesis and understanding, and commercial development has provided a few hundred products.

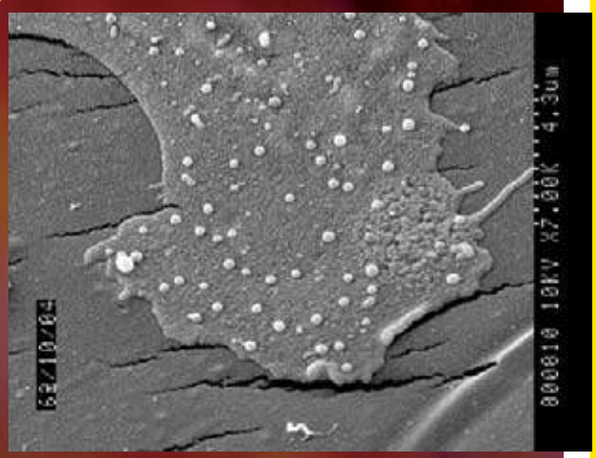
The next generation is in dynamic nanostructures and integrated systems. The unique nature of nanosystems raises some practical modeling and control problems. These are currently poorly understood and possibly computationally intractable. Development of nanotechnology provides compelling reason to investigate these issues.

The problems raised in control of nanosystems are related to the large number of interacting components leading to complex system dynamics across multiple time and length scales. In a practical sense, directly connecting the vast numbers of sensors and actuators to a single controller is impossible. Furthermore, the computational power required for such a controller would be prohibitive.

To address these problems new control theory must be developed. Issues of importance include decentralized control and hierarchical control structures, and situations where there are costs (or hard constraints) on communication channels and information flow.

The design of decentralized control laws for high order complex systems presents theoretical and computational challenges. To simplify the computational problem, methods of model order reduction and control design using these reduced order models are investigated. In addition to the "usual" questions of stability of the controlled system and transient tracking performance, issues of communication costs and computational costs are also explicitly considered.

As new actuators, sensors and hardware are developed for nanoscale systems, the ability to design and analyze control systems for them will become essential. This work is a first step to understanding the many issues presented by the control of nanoscale systems.EE



GOLD NANOPARTICLES ATTACH TO HUMAN FIBROBLAST. THIS RESEARCH ASKS WHAT WOULD BE REQUIRED TO CONTROL SUCH A SYSTEM. PHOTO CREDIT: DR. CATHERINE C. BERRY

FACULTY ADVISOR: *Professor Howard Jay Chizeck* **COLLABORATORS:** *Professors Les Atlas (EE), Jim Bassingthwaighte (BioEng), Hong Qian (Applied Mathematics)* **RESEARCH AREA:** *Control Systems and Nanotechnology* **GRANT/FUNDING SOURCE:** *Multiscale Grant National Science Foundation Award #0506477*

DEMO IN THE DESERT: High Altitude Platforms for Mobile Robotic Telesurgery (HAPs/MRT)

MITCHELL LUM — GRADUATE STUDENT (EE)

A large effort over the last four years in the UW EE BioRobotics Lab (BRL) focused on developing the RAVEN surgical robot system. The RAVEN will serve as a platform for development in the area of robot assisted surgery (See EEK2006, page 16). While, the challenge of teleoperated surgical intervention is not trivial, other groups have successfully demonstrated it on a number of occasions. The next step in telesurgery is to take the surgical robot to the patient, and the need for mobile healthcare is most urgently illustrated in combat casualties. Taking surgical robots to the wounded will reduce the time from injury to treatment, ultimately saving the lives of critically injured soldiers.

In June 2006, a team of students from BRL headed south in two UW vehicles. About 2000km away, the destination: the desert of Simi Valley, California. It was the first experimental deployment of the RAVEN into an isolated and extreme environment, and the culmination of months of preparation and coordination between the University of Cincinnati, AeroVironment (Simi Valley, CA), HaiVision (Montreal, Canada) and BRL.

Most research systems are developed in a lab for use in the lab environment. Surgical equipment is typically developed to operate in hospitals or other "clean" environments. Deployment into a desert environment adds new design requirements to the system. Environmental concerns include heat, wind, dust and noisy power from generators. Transportation concerns include shock absorption, packaging and packing.

Each day over a three day span, a different location was designated for deployment; each morning a plan was devised for setting up, which took into account the projected afternoon wind patterns. The surgical manipulators were set up in one tent, with the surgeons and master control console set up in a second tent about 100m away. The surgeon's commands were sent to the manipulators via a wireless digital datalink placed onboard an unmanned aerial vehicle (UAV) provided by AeroVironment. Video was compressed by a HaiVision hardware codec was relayed from the surgery site to the surgeon's console via the wireless datalink. The experimental protocol involved touching ten landmarks and tracing out a circle with the left hand, right hand and both hands. Two surgeons from the University of Cincinnati performed the five-task protocol.

Overall, a successful demonstration of remote surgery in an extreme environment through a wireless datalink onboard a UAV was accomplished.EE

THE FIELD TEAM WITH THE DEPLOYED SYSTEM. LEFT TO RIGHT: MITCH LUM, PROFESSOR BLAKE HANNAFORD, HAWKEYE KING, PROFESSOR JACOB ROSEN. FRONT: GINA DONLIN AND DIANA FRIEDMAN.

STUDENT TEAM MEMBERS: *Graduate Students Diana Friedman (ME), Hawkeye King (EE), Ganesh Sankarayanaran (EE); Undergrad Student Gina Donlin (EE)* **FACULTY ADVISORS:** *Professors Blake Hannaford and Jacob Rosen* **COLLABORATORS:** *Brett Harnett, Charles Doarn, Timothy Broderick (University of Cincinnati), AeroVironment, HaiVision* **RESEARCH AREA:** *Controls and Robotics* **GRANT/FUNDING SOURCE:** *The HAPs/MRT project has been supported by the US Army, Medical Research and Material Command grant number W81XWH-05-2-0080*

HYDROLOGICAL MANAGEMENT

of the Mekong Delta Via Sensors and Control Methodology

THO NGUYEN — GRADUATE STUDENT (EE)

The fertile Mekong Delta is an integral part of Vietnam's economy, and home to many rare species of birds, fish, mammals and unique ecosystems such as mangroves and wetlands. The recent aquaculture industry boom in this region has caused indiscriminant chemical use and irresponsible local hydrological management that have accelerated environmental degradation over the past decade. Vietnamese scientists at Can-Tho University (CTU) determined that soil acidification, salinization, nutrient degradation and pollution due to agricultural effluent are of the highest environmental priorities in the Mekong Delta. This research addresses these priorities by coupling education with technology-based solutions for monitoring and controlling the Delta's hydrology.

In the early 1990's, the Vietnamese government constructed a series of sluice gates on the coastal regions of the Mekong Delta to provide better hydrological control for farmland and minimize salinity invasion.

THE RIVER IS AN ESSENTIAL PART OF LIFE IN THE MEKONG DELTA. CLOSING THE GATES DISRUPT TRANSPORTATION, HYDROLOGY CIRCULATION, AND WILDLIFE MIGRATION. MINIMIZING THE CLOSING PERIOD IS THE MAIN GOAL OF THIS PROJECT.

GIS data compilation from the late 1990's to early 2000's shows obvious improvement in land-use and regional economy. Management conflicts between designated land-use areas and recent evidence of environmental degradation (such as acidification, nutrient loss and pollution due to inadequate circulation) call for a better monitoring and sluice gates management scheme. Robust, specially adapted, inexpensive sensors and new control engineering methodology are currently being developed to optimally manage the sluice gate operations. Researchers at UW EE and the Mechatronics Department at CTU are also developing university-level curricula, workshops and student exchanges to increase the education level and personal awareness of the delta inhabitants.

Potential broader impacts of this project are to: (1) establish a new method for modeling and control of hydrology in a large-scale, natural delta system, (2) provide better knowledge and control of the hydrology in the Mekong Delta for long-term socio-economic improvement, (3) establish more efficient land use and land distribution practices to improve the overall environmental health, (4) increase capacity of local inhabitants through research training, and (5) enhance long-term collaborations between UW and CTU.

UPDATES ON PROJECT

As a spin-off of the Mekong Delta project, UW EE and Professor Jennifer Ruesink in the Biology Department are building a data-logging, toroidal salinity sensor. The sensor's innovative design is low-cost and long-lasting in the environment. It will operate autonomously in the water of Willapa Bay for over two weeks. The data collected will be used to develop a real-time salinity map of the estuary.EE

FACULTY ADVISOR: *Professor Linda Bushnell* **COLLABORATORS:** *Can-Tho University, Professor Jennifer Ruesink (Biology)* **RESEARCH AREA:** *Controls and robotics* **GRANT/FUNDING SOURCE:** *Fulbright Fellowship, UW Royalty Research Fund, National Science Foundation IGERT Grant, National Science Foundation Research Grant No. ECS-0621605.*

ELECTRON TUNNELING
for Efficient Genome Sequencing

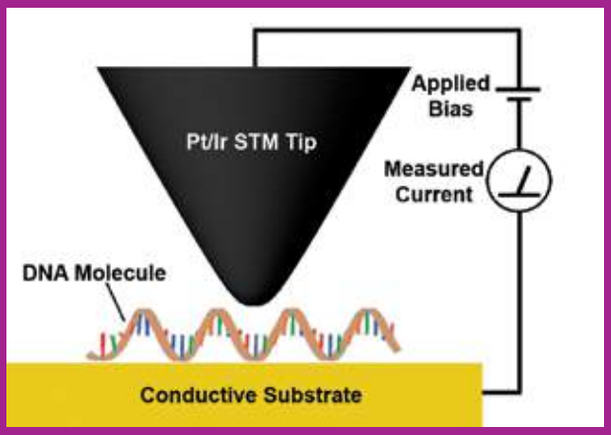
JOHN A. LUND — GRADUATE STUDENT (EE)

Existing methods for sequencing DNA are insufficient for rapid, low-cost sequencing of the entire human genome. While sequencing of the first human genome was a great milestone, the next milestone to personalized medicine is in the ability to create the genome sequencing in a matter of days with costs not exceeding $1000. Developing methods that depart from the existing sequencing technologies is essential to attaining this goal.

This research investigates a radically different approach to sequencing DNA, which identifies DNA bases using electron tunneling through the molecule. This electronic sequencing method relies on inelastic electron tunneling spectroscopy (IETS) to identify unique spectroscopic signatures of each individual DNA base. IETS identifies vibronic energy levels in molecules using electron tunneling. If a molecule is placed between two electrodes, and a voltage is applied between the electrodes, a tunneling current will result. As the voltage increases, the energy of electrons tunneling through the molecules will increase until it reaches the point where the electrons have enough energy to tunnel across the gap. It then excites a resonant mode in the molecule, allowing an increased concentration of electrons to tunnel between the electrodes.

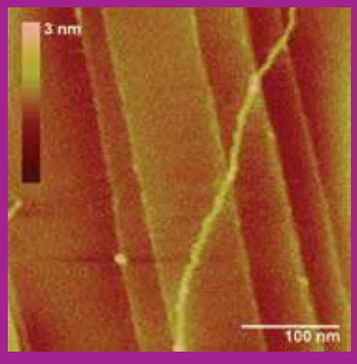
This results in an I-V curve that is kinked at points where new resonant modes are excited. These kinks appear as peaks in a second derivative representation of the I-V curve. Using this type of spectroscopy, differences can be identified between each of the four DNA bases.

The goal is to be able to conduct IETS spectroscopy along the entire length of a long DNA molecule and directly read the sequence of bases. To perform these measurements on DNA, methods have been developed to stretch both single-stranded and double-stranded DNA on highly ordered pyrolytic graphite. With this capability, researchers can use the conducting graphite substrate as one electrode, and the tip of a scanning tunneling microscope as the other electrode to perform IETS measurements. IETS measurements were successfully conducted on both atomically-flat gold and HOPG substrates.



AN EXPERIMENTAL SETUP SHOWING A SINGLE-STRANDED DNA MOLECULE ON A CONDUCTIVE SUBSTRATE, AND AN STM TIP CLOSE TO THE SURFACE TO PERFORM IETS MEASUREMENTS.

AFM IMAGE SHOWING A STRETCHED DNA MOLECULE ON AN HOPG SUBSTRATE. THE STRETCHED ORIENTATION OF THE MOLECULE MAKES IT WELL-SUITED FOR SEQUENCING.



This research aims to solve one of the most challenging problems of the next decade—the need for efficient genome sequencing. Initial results are very promising, and techniques will continue to be refined to achieve rapid individual base pair recognition in the future.EE

FACULTY ADVISOR: *Professor Babak A. Parviz* **RESEARCH AREA:** *Ultra-low cost nano-scale DNA sequencing using electron tunneling* **FUNDING SOURCE:** *Betty and Gordon Moore Foundation*

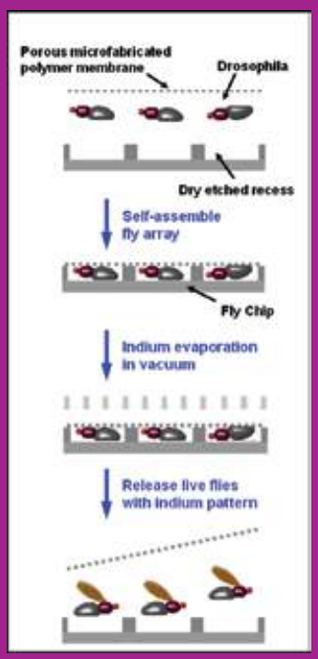
HYBRID MICRO-FLYING ROBOTS via Fruit Flies

ANGELA SHUM — GRADUATE STUDENT (EE)

The fruit fly, Drosophila, measuring only 3-4mm in length presents a sophisticated microsystem incorporating diverse functions such as energy storage, microactuation, sensing and decision-making. To obtain comparable mm-scale robots, insects have been harnessed via manual insertion of a microstructure or an electronic chip. However, this manual assembly is very slow. This project aims to adapt semiconductor processing techniques for parallel alteration of Drosophila in order to create mass quantities of hybrid micro-flying robots.

Many conventional microfabrication steps, such as physical vapor deposition or plasma processes, are performed under vacuum. To show that adult Drosophila can be exposed to moderate vacuum and live, a study has been conducted on the survival rate versus time. The vacuum environment acts as an asphyxiant rendering the flies unconscious temporarily. The data shows that adult flies can be subjected to 50mTorr vacuum for longer than one hour with a measurable chance of survival.

Thermal evaporation can be performed to deposit patterned thin film indium on many fruit flies at once.



THE PROCESS FLOW FOR THERMAL EVAPORATION ON TO FRUIT FLIES.

A constructed fixture with an adjustable height chamber contains the flies during processing. A mesh is microfabricated out of polymer (SU-8) with the desired pattern using conventional photolithography, and then attached as the ceiling of the fixture. A fly array template made of wells sized to fit individual flies is created by deep reactive ion etching through a silicon wafer, and attached as the floor of the fixture.

With the boundaries of the fixtures defined, the flies are loaded inside, and the floor is gradually raised towards the ceiling. This induces the fruit flies to self-assemble into the array template ensuring that they are in close proximity to the shadow mask. Indium is then deposited up to thicknesses of 100nm. Patterns with line widths of 20µm are deposited in this process, which lasts only 30 minutes.

The metal patterns can be modified for future use as interconnects or binding sites to which micron-scale objects such as flight control circuitry, sensors, or wireless telecommunication components can be attached.

Demonstrating fly survival in vacuum and patterned vacuum metal deposition directly onto a living organism are crucial steps towards developing a parallel manufacturing approach for modifying a large number of insects to construct hybrid inorganic-biological microsystems.EE

A MICROSCOPE IMAGE OF A FLY, ALIVE AFTER THE COMPLETION OF THE MICROFABRICATION STEPS, WITH AN ARRAY OF 50µM WIDE INDIUM CROSSES ON THE WINGS.

FACULTY ADVISOR: *Professor Babak Parviz* **COLLABORATORS:** *Professor Gerold Schubiger (Biology)*
RESEARCH AREA: *MEMS* **GRANT/FUNDING SOURCE:** *National Science Foundation*

SECURE ELECTRONIC STORAGE

and Distribution of Airplane Loadable Software Parts and Data

KRISHNA SAMPIGETHAYA — GRADUATE STUDENT (EE)

Recent advances in the aviation industry include "e-enabled" airplanes that possess networking capabilities for communication with off-board systems. The introduction of networks enables the electronic storage and distribution of airplane loadable software parts and data (e.g. airplane health data), leading to significant time and cost benefits for airplane operation and maintenance. However, as e-enabled airplanes connect with network environments off-board, vulnerabilities in open networks and use of commercial-off-the-shelf IT components open up opportunities for security attacks. This research identifies threats and security requirements when storing and distributing airplane software parts and data (herein referred as assets) over networks.

Certain airplane software, such as flight control software parts, are safety-critical. By corrupting them, attackers can lower safety margins of airplanes. For example, attackers can replace or delete portions of the software, or replace them with outdated/modified versions, or divert them to unsuitable destinations, presenting a potential threat to airplane safety.

Even by corrupting the non-critical software (ie: cabin light systems), attackers can induce unwarranted flight delays and expenses as well as lower passenger confidence and convenience, impeding the business of the airplane owner. Further, attackers can corrupt the airplane generated data to either hide component failure detections, or to trigger false alarm detections.

In order to mitigate the identified threats, this research proposes security primitives and mitigation mechanisms. For instance, to minimize threats the source and destination of asset distribution must perform mutual authentication and authorization. Upon receiving assets, the destination must verify their validity, correct software version, and intended destination of asset. Additionally, to mitigate attacks from on-board execution of software corrupted by insiders, robustness of software design is needed.

This research contributes a necessary security framework for protection of airplane software distributed over networks. Its applicability to other e-enabled functions that warrant security considerations, e.g. integration with air traffic management requiring communication with airplanes in-flight, will be explored next.EE

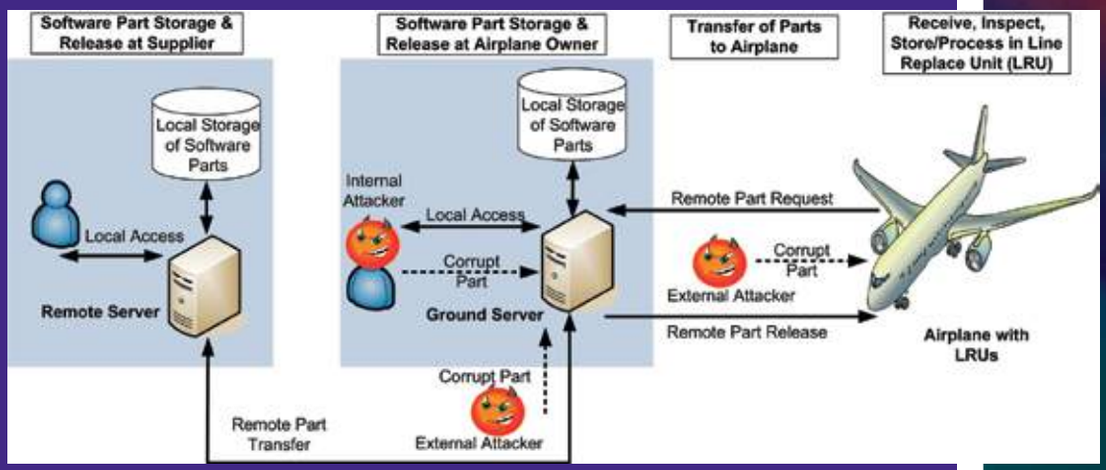


ILLUSTRATION OF STORAGE AND DISTRIBUTION OF AIRPLANE SOFTWARE PARTS FROM SUPPLIER TO AIRPLANE OWNER (MANUFACTURER OR AIRLINES) TO THE END DESTINATION (I.E. THE AIRPLANE LINE REPLACEABLE UNITS). THE INTEGRITY AND AUTHENTICITY OF SOFTWARE PARTS MUST BE PROTECTED FROM THE EXTERNAL AS WELL AS INTERNAL ATTACKERS (INSIDERS) AT ALL TIMES.

FACULTY ADVISOR: *Professor Radha Poovendran* **COLLABORATORS:** *Dr. Mingyan Li, Dr. Scott Lintelman and Mr. Richard Robinson (Boeing Phantom Works), Dr. David von Oheimb (Siemens Corporate Technology)* **RESEARCH AREA:** *Security of e-enabled airplanes* **GRANT/FUNDING SOURCE:** *The Boeing Company*

AMOEBA: How Group Navigation Helps Enhance Location Privacy of Users in VANET

KRISHNA SAMPIGETHAYA — GRADUATE STUDENT (EE)

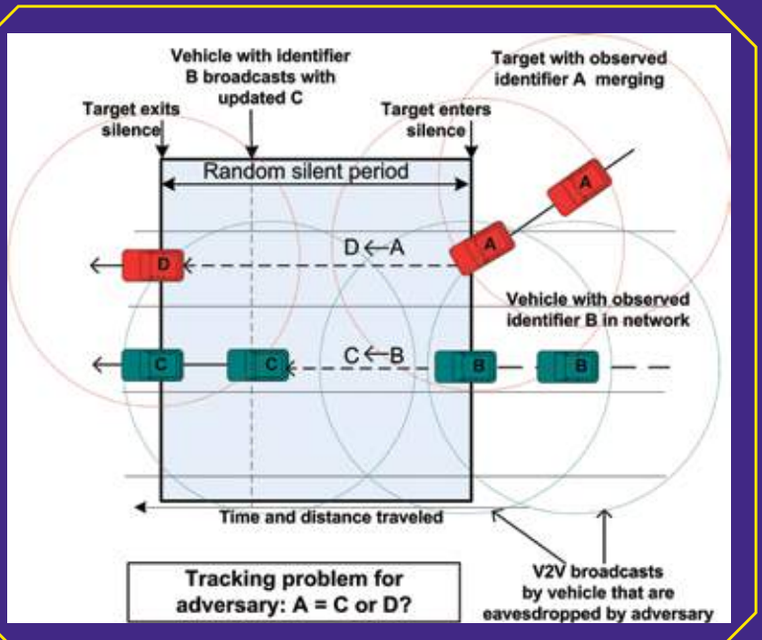
Vehicular ad hoc networks (VANET) leverage the sensing, computation, and wireless communication capabilities of intelligent vehicles to enable beneficial applications, from reducing traffic congestion and vehicle collisions to offering convenience for vehicle users. These applications are based on in-vehicle, vehicle-to-roadside infrastructure (V2I) as well as vehicle-to-vehicle (V2V) communications. However, advances in localization techniques allow adversaries to eavesdrop on vehicular communications and accurately locate and track target vehicles. The extracted location trajectories when correlated with geographic maps threaten the location privacy of users. This research investigates the implications of location tracking of vehicular communications on user privacy, and proposes defense mechanisms.

The movement of vehicles is predictable due to spatial restrictions and inter-dependency in mobility. Further, safety applications mandate that vehicles broadcast their locations every 100-500 milliseconds. Consequently, despite the traditional periodic change of network identifiers, a target vehicle remains traceable in VANET.

In order to mitigate location tracking of V2I, the group concept is proposed by observing that vehicles navigate as groups. A leader communicates for the group, and other members remain untraceable. For privacy and reliability the leader is periodically changed within the group, and for robustness against security attacks additional defense mechanisms are employed in the group operation.

To reduce the tracking of V2V, vehicles remain silent for a random period during identifier update. While a random period greater than 500 milliseconds helps tracking mitigation, the safety afforded by V2V broadcasts reduces. However, traffic studies report lower accident rates during lane merges/changes than when moving in lanes, suggesting that remaining silent when changing direction presents relatively low safety-risk opportunities to mitigate tracking. Further, a solution to the privacy-safety tradeoff is proposed by reducing vehicular transmission range, so that broadcasts do not reach roadside infrastructure. The proposed solutions perform well under Freeway and Manhattan mobility models.

Widespread surveillance is an increasing public concern, and a serious impediment to ongoing efforts towards realization of VANET such as the US DOT Vehicle- Infrastructure-Integration (VII) project. Therefore, this research addresses security and privacy of wireless communications in VANET, identifying threats due to location tracking, related tradeoffs, and potential solutions.EE



THE TARGET AND A ONE-HOP NEIGHBOR INDEPENDENTLY UPDATE THEIR IDENTIFIERS AND REMAIN SILENT FOR A RANDOM PERIOD BEFORE BROADCASTING WITH NEW IDENTIFIERS. SINCE THE TARGET IS MERGING LANES WHEN ENTERING UPDATE, THE ADVERSARY CANNOT BE CERTAIN OF THE TARGET'S NEW IDENTIFIER BASED ON MOVEMENT OF THE TARGET. NOTE THAT WE ASSUME THAT THE ADVERSARY CANNOT DISTINGUISH VEHICLES BASED ON ATTRIBUTES SUCH AS COLOR.

FACULTY ADVISOR: *Professor Radha Poovendran* **COLLABORATORS:** *Dr. Mingyan Li (Boeing Phantom Works), Dr. Leping Huang (Nokia Research Center Japan)* **RESEARCH AREA:** *Security and privacy of vehicular ad hoc networks*
GRANT/FUNDING SOURCE: *Army Research Office PECASE, National Science Foundation*

AES-CMAC:
A New Message Authentication Code Algorithm

JUNHYUK SONG — GRADUATE STUDENT (EE)

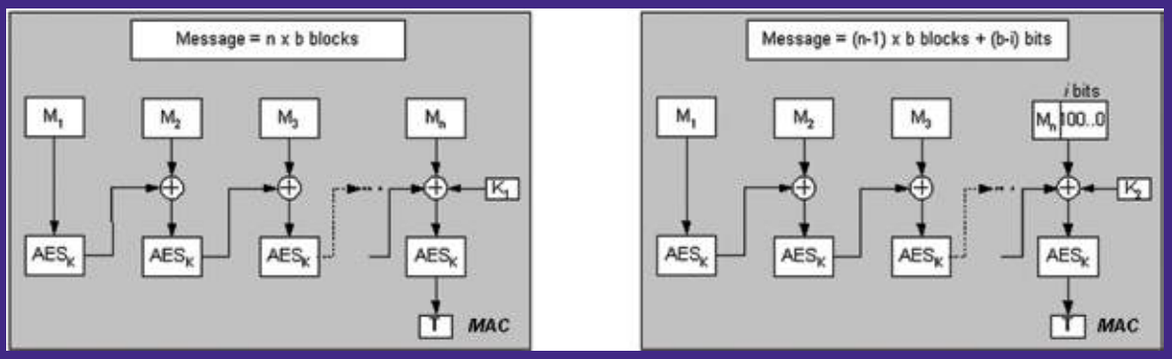
Message Authentication Codes (MAC) present computation-efficient cryptographic solutions to verify integrity and authenticity of data distributed over insecure networks, such as the Internet. Assuming the source and destination share a secret key, the source computes a MAC as a function of the message to be sent and the shared key. The destination computes the MAC using the received message and shared key, and checks if it matches with the received MAC. Compared to checksums and error-detection codes that detect unintended bit errors, a MAC additionally detects adversarial induced bit errors. This research contributes a new MAC algorithm, called the AES-CMAC.

A recent recommendation by the National Institute for Standards and Technologies for block cipher modes of operation, specifies the Cipher-based Message Authentication Code (CMAC) that is based on a symmetric key block cipher. The CMAC is a variant of Cipher Block Chaining MAC that overcomes the known security weaknesses under variable input message sizes. The Advanced Encryption Standard (AES) algorithm is an approved block cipher in the Federal Information Processing Standard Pub. 197. The proposed AES-CMAC is based on CMAC and with AES as the underlying block cipher. We employ AES-128 with block size of 128 bits, and propose the sub-key generation, MAC generation and verification algorithms.

Additionally, two extensions of this algorithm are proposed for IP Security implementations.

The AES-MAC-96 algorithm truncates the most-significant-bits from the AES-MAC based output of the Encapsulating Security Payload and Authentication Header protocols of IPsec to meet their default specifications. The AES-MAC-PRF-128 algorithm removes the 128-bit key restriction, and is applicable as a pseudo-random function supporting fixed key sizes for generating keying material as well as variable key sizes for authenticating with shared secrets in the IPsec/ Internet Key Exchange protocol.

As part of standardization efforts, the AES-CMAC algorithm is specified as an Internet standard in the form of request-for-comments (RFC 4493, RFC 4494). Additionally, the AES-MAC-PRF-128 is specified for pseudo-random-functions with fixed and variable key sizes (in RFC 4615).EE



THE AES-CMAC MAC GENERATION ALGORITHM USES THE INPUT MESSAGE, AND SUB-KEY K_1, K_2 DEPENDING ON WHETHER THE MESSAGE SIZE IS A POSITIVE MULTIPLE OR NOT, RESPECTIVELY, OF THE BLOCK SIZE B, TO GENERATE THE OUTPUT, T. THE SUB-KEYS K_1 AND K_2 ARE GENERATED USING THE SHARED SECRET KEY K. AES_K DENOTES THE AES-128 ALGORITHM USING THE KEY K.

FACULTY ADVISOR: *Professor Radha Poovendran* **COLLABORATORS:** *Jicheol Lee (Samsung Electronics), Tetsu Iwata (Nagoya University)* **RESEARCH AREA:** *Cryptographic algorithms for network security* **GRANT/FUNDING SOURCE:** *Army Research Office PECASE, National Science Foundation, Army Research Laboratory, Office of Naval Research*

VULNERABILITY OF SECURE WIRELESS NETWORKS: A Toolkit for Network Visualization

DAVID SLATER — UNDERGRADUATE (EE), **PATRICK TAGUE** — GRADUATE STUDENT (EE), AND **PHILLIP LEE** — GRADUATE STUDENT (UNIVERSITY OF CALIFORNIA, SAN DIEGO)

Wireless sensor networks (WSNs) are becoming a critical component for safety monitoring and surveillance systems. For these applications, properties such as integrity, confidentiality and availability of sensed data are crucial and require secure network protocols to establish trust between individual sensor nodes. However, WSNs present unique challenges including resource constraints and scalability requirements. This work analyzes and visualizes the structure and vulnerability of WSNs where symmetric cryptographic keys are assigned to sensor nodes prior to deployment, a solution known as key predistribution.

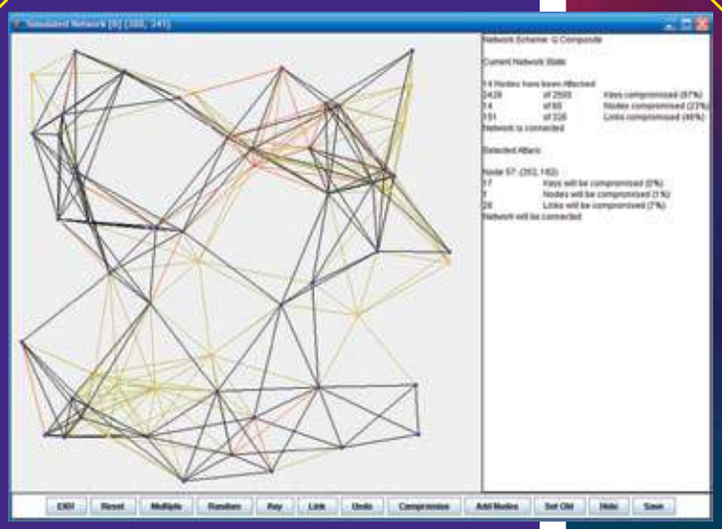
To establish trust and connectivity in a deployed sensor network, each pair of neighboring nodes must establish a secure communication link with high probability. Due to memory constraints and the randomness of node deployment, links are constructed using symmetric cryptographic keys, which are shared by a potentially large number of sensor nodes. The absence of tamper-proof hardware may allow a malicious adversary to acquire cryptographic keys by compromising sensor nodes. Hence, a secure link between two nodes may be compromised independently of either node.

In prior work, researchers analyzed the security of key predistribution schemes in homogeneous WSNs by computing the average fraction of links that remain secure after a given number of node compromises. This work models node compromise attacks which heuristically achieve a similar worst-case quantity with respect to various metrics. Furthermore, the model is generalized to include heterogeneous wireless networks.

A simulation toolkit has been developed to visualize the structure of WSNs using key predistribution. It implements a variety of key predistribution schemes, and allows for significant variation in network and security parameters. Many attack heuristics can be utilized, and the effects can be qualitatively visualized and quantitatively measured on that network.

The implications of this work are two-fold. The adversarial model provides a deeper understanding of the key predistribution security protocols in a realistic setting. The simulation toolkit also serves as a visual aid and educational tool for understanding the structure and vulnerability of wireless sensor networks.EE

THIS INTERFACE ALLOWS THE USER TO SELECT BETWEEN KEY PREDISTRIBUTION SCHEMES, AND GENERATE RANDOM NETWORKS BASED ON THE CORRESPONDING USER-SELECTED PARAMETERS.



THIS INTERFACE DISPLAYS THE RANDOMLY GENERATED NETWORK AND ALLOWS THE USER TO SELECT NODES TO COMPROMISE BASED ON VARIOUS ATTACK HEURISTICS. IT DISPLAYS NETWORK INFORMATION GRAPHICALLY AND TEXTUALLY, SHOWING THE POTENTIAL COMPROMISING EFFECTS OF THE SELECTED ATTACK IN RED AND GIVING THE NUMBER OF COMPROMISES IN THE TEXTBOX.

FACULTY ADVISOR: *Professor Radha Poovendran* **RESEARCH AREA:** *Wireless Sensor Network Security*
GRANT/FUNDING SOURCE: *National Science Foundation CAREER, Army Research Office PECASE*

LOW POWER IC DESIGN
with Subthreshold MOSFETs

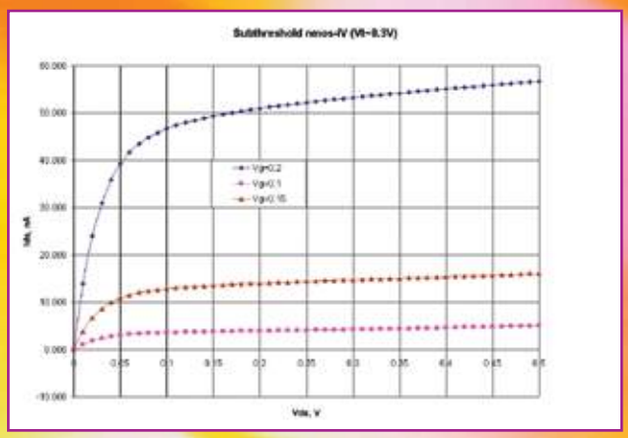
ISAAC P. ABRAHAM — GRADUATE STUDENT (EE)

Transistors in weak or moderate inversion are attractive for low power CMOS design. Traditionally, applications have been confined to frequencies of a few hundred kHz, to the low MHz. While the exponential relationship between the control gate and output node enables implementation of non-linear and logarithmic functions, challenges abound.

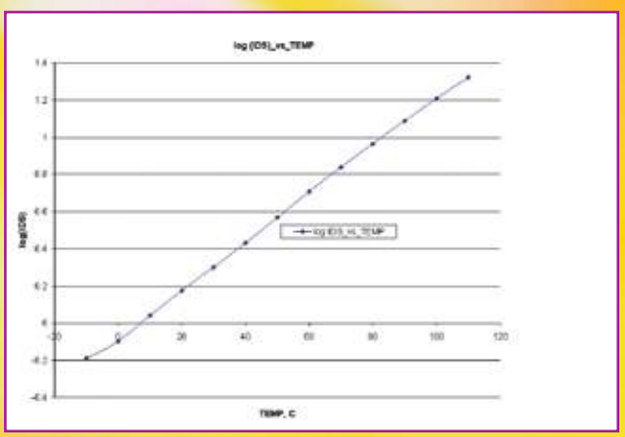
Such challenges include Drain Induced Barrier Lowering (DIBL), reduced limiting frequency f_T, minimization of the subthreshold slope factor η, and generation of a satisfactory analytical framework. This research aims to create viable digital/analog subsystems in subthreshold within a deep submicron technology node.

Subthreshold circuits already find application in low frequency portable electronics, pacemakers and watches where low f_T is not a concern. The limiting frequencies in contemporary technology nodes are at about 10-100MHz for subthreshold operation. Parallel computing offers a solution to this bottleneck. This research addresses the possibility of using weakly inverted transistors in parallel computing sub-systems as applicable to an IO interface construction. Circuit blocks being considered include impedance and current compensators, multi-tap de/pre-emphasis code generators and low frequency DFT blocks.

Mathematical models were tested using a 65nm technology node, and transition time predictions using these models are within 2% of simulated values. Drain current is a proportional indicator of circuit speeds for constant cap loads, gate and drain voltages. Simulations validate this prediction. This characteristic is contrary to a strongly inverted MOSFET. Subthreshold conduction relies on diffusion current. Particles such as electrons, holes and molecules diffuse proportional to temperature, hence the result. IV saturation at about 100mV independent of gate-source voltage can be an advantage for creating current sources, mirrors and amplifiers with high common-mode rejection. Power delay minimum occurs at about 30-50C, while f_T increases fast above 50C. Continued process scaling may increase f_T further.



TRANSISTOR SATURATION AT ABOUT 100MV OR (4KT/Q).



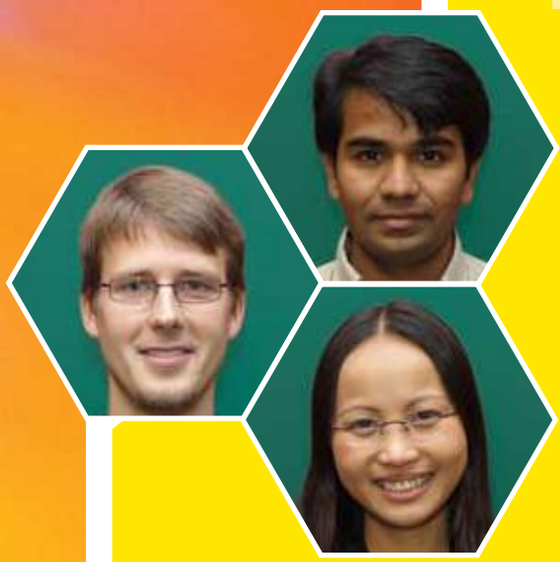
IDS PROPORTIONAL TO TEMP FOR FIXED VGS, VDS.

Mathematical modeling for f_T prediction based on a few key variables will be refined to handle complexity. Additional challenges include identifying the circuit "hooks" that interface with sub/trans-threshold circuits. Creating building blocks for a practical wired or unwired high-speed serial interface will follow. EE

FACULTY ADVISOR: *Professor Brian Otis* **COLLABORATORS:** *Wireless Sensing Lab (UWEE), Intel Corporation (Advanced Components Division)* **RESEARCH AREA:** *Low Power IC Design*

SOFTWARE DEFINED RADIO (SDR) PLATFORMS
For Wireless Research

J. AMMER, D. ALLSTOT, H. LIU AND S. ROY — EE FACULTY
P. ARABSHAHI — (APL-EE), **R. GUPTA, N. NEIHART, N. NGUYEN** — EE STUDENTS



BACKGROUND

Wireless testbeds are essential to the development and verification of technologies for future generation networks. Most current experimental research in academia suffers from the following limitations:

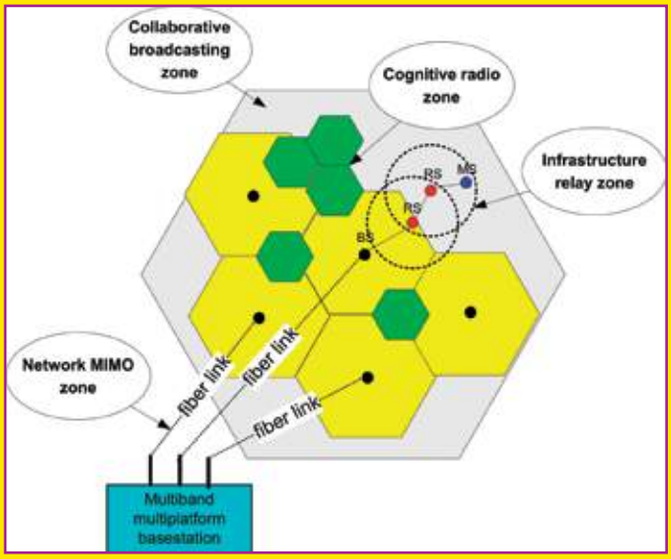
- addressing one type of network user (e.g., WiFi, cellular, UWB) at a time
- lack of programmability that impacts experimental efficiencies and repeatability

A group of EE investigators with intersecting interests/expertise in radio architectures and protocol stack implementation are looking to develop a new prototype for next generation adaptive wireless systems. The testbed under development attempts to break the platform bottleneck using the following features:

- state-of-the-art CompactPCI — embedded communication/computing platform
- modular and expandable PHY, MAC, networking, and control boards
- high speed links to multiband RF units
- maximum configurability and programmability

Once completed, the testbed will enable new research aimed at:

- developing and testing high-end PHY, MAC, and networking modules
- cross-layer optimization and end-to-end network performance analysis
- multi-standard, multi-band cognitive radio design
- local- and macro-collaborative transmission (networked MIMO)
- hybrid networks with broadcasting, relay, and multiple-access convergence

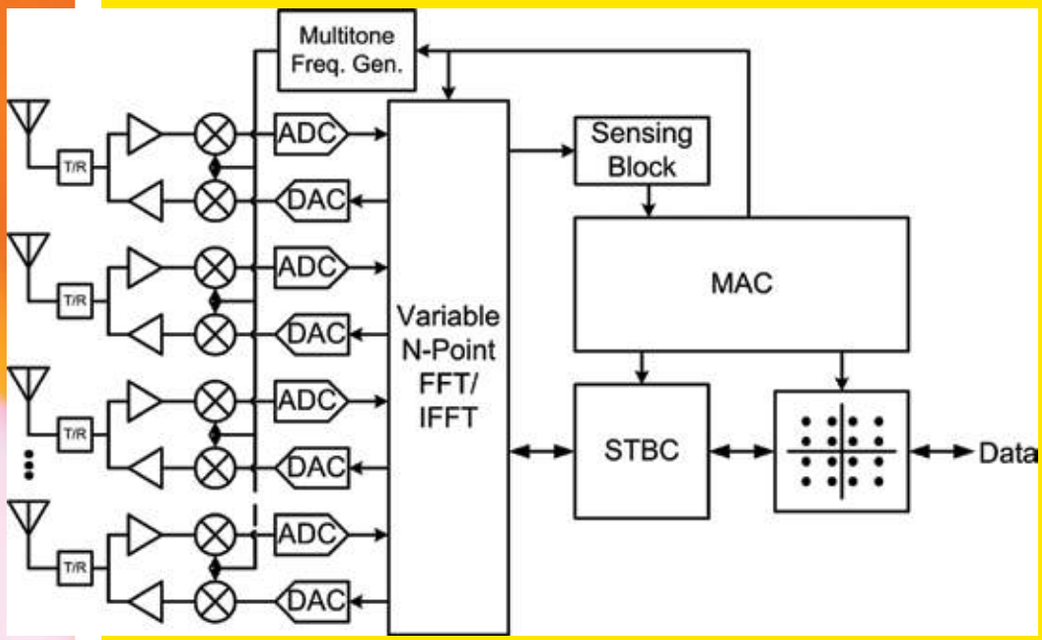


MULTIPLE RESEARCH THRUSTS ENABLED BY THE TESTBED.

DYNAMIC SPECTRUM REUSE

Traditionally, radio transceivers are constrained to operate within a band of frequencies set aside for their use by regulatory bodies (so-called licensed bands). With a multitude of legacy technologies and continuing emergence of new wireless standards, 1-10GHz spectrum is increasingly saturated. Measurements show, however, that actual spectrum usage varies between 15-85% based on location and time of day. This has led to the notion of 'cognitive' radios that are capable of recognizing unused frequencies, or 'white spaces' and opportunistically using them until a licensed primary user needs them, thereby enabling more efficient use of the available spectrum. A cognitive radio (CR) therefore must possess the additional capability (vis-à-vis traditional radio front-end architectures) to sense a broad spectrum and find white-spaces. An initial testing ground of these ideas is the proposed re-use of UHF spectrum for broadcast TV as a result of the transition to digital broadcasting that will free up some spectrum. The FCC proposes to allow secondary CR enabled users in these bands, which has prompted the creation of the IEEE 802.22 WG to draft a standard for a CR-based PHY/MAC air interface for license-exempt devices to access spectrum allocated in the TV bands.

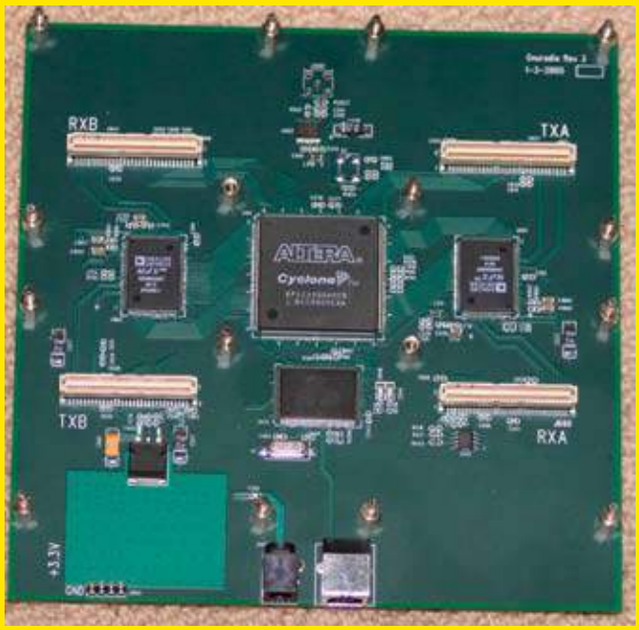
It is clear that keeping the sensing time to a minimum is important; the solution to this necessarily involves a mix of both architectural (RF front-end) and algorithmic innovations. Trade-offs between increased hardware and algorithmic complexity are an integral part of such designs. For example, with a single antenna front-end, the total sensing time to scan a large system bandwidth could be extremely long. One solution is to use multiple antennas (already present in multiple input, multiple output or MIMO systems) to perform the spectrum sensing in a parallel fashion. The total system bandwidth is sub-divided by the number of antennas performing the sensing. Furthermore, using a multi-resolution sensing approach where the total bandwidth is successively sensed with coarse to fine resolutions can result in much shorter sensing times. The figure below shows the block diagram of a possible implementation of such a radio; the multiple antennas and variable-point FFT implements the parallel, multi-resolution sensing scheme discussed above.



THE ARCHITECTURE OF A MIMO TRANSCEIVER

CURRENT SDR DEVELOPMENT @ UW EE

A specific goal of the research group is to design and implement a new SDR platform with MIMO RF front-end reconfigurability suitable for emerging high-rate wireless applications. Towards this end, researchers are experimenting with the increasingly popular and commercially available Universal Software Radio Peripheral (USRP) platform that can provide USB connectivity to a host computer[1].



A UNIVERSAL SOFTWARE RADIO PERIPHERAL PLATFORM (ETTUS RESEARCH, LLC).

The USRP consists of a small motherboard containing up to four 12-bit 64M sample/sec ADCs, four 14-bit, 128M sample/sec DACs, a million gate Alterra field programmable gate array (FPGA) and a programmable USB 2.0 controller. Each fully populated USRP motherboard supports four daughterboards — two each for receiving and transmitting. The RF front ends are implemented on the daughterboards that are chosen for the target frequency bands. The USRP is a SDR peripheral with open source software from GNURadio community that implements programmable PHY/MAC for a variety of applications. Current goals are to use the USRP to build an in-house 802.11 WLAN channel emulator to be used within an indoor, small-scale Enterprise High Density Wireless LAN test-bed already operational in Sieg Hall (4th floor). This will use .11 hardware donated by Intel and an acoustic modem transceiver (specifically the Woods Hole developed Micro-Modem, acomms.whoi.edu). However, current USRP boards do not possess sufficient real-time processing power nor the desired front-end adaptivity to support the sort of MIMO capabilities desired. Hence, these experiments are being treated as initial explorations to develop insights for future re-design of a true MIMO-SDR platform.EE

[1]COURTESY OF DAVID WETHERALL AND TOM ANDERSON, CSE WHO PROVIDED US WITH THE USRP BOARDS.

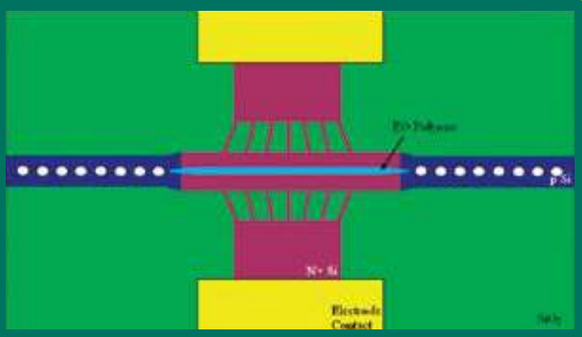
RESEARCH AREA: ***RF/Digital Circuits, Wireless Communications*** **GRANT/FUNDING SOURCE:** ***Intel, National Science Foundation/Center for Design of Analog-Digital Integrated Circuits, APL-Boeing Fellowship***

A HYBRID SILICON/EO POLYMER RESONANT CAVITY MODULATOR

KJERSTI A. KLEVEN — GRADUATE STUDENT (EE)

Silicon is a promising material for integrated optics because of its manufacturability. However, in order for integrated optics to be fully realized, the components must not only be CMOS compatible, but also have small dimensions and excellent operational characteristics. Optical modulators are one component where it is challenging to simultaneously achieve small size along with a strong, high-speed response in all-silicon devices. This research focuses on incorporating both silicon and an electro-optic (EO) polymer, which has a very strong, fast response in a single device that can be fabricated using current CMOS processing techniques.

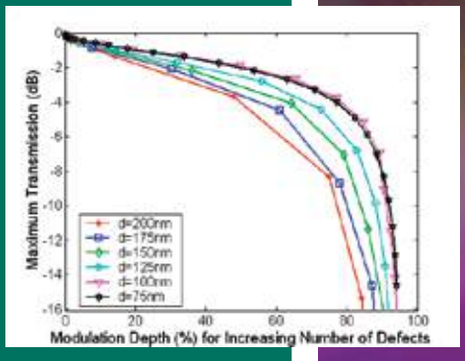
The design and simulation of a novel resonant cavity optical modulator incorporating a hybrid silicon/EO polymer slot waveguide structure is the focus of this project. The device utilizes the hybrid slot waveguide in the cavity region to provide an active material (EO polymer) for modulation, and includes distributed Bragg reflectors in single mode silicon waveguide regions at each end of the cavity. This creates a narrow response peak at the resonant wavelength, which can be shifted with an applied field to provide the modulation.



TOP VIEW OF THE HYBRID SILICON/ELECTRO-OPTIC POLYMER RESONANT CAVITY MODULATOR. THE TOTAL LENGTH OF THE DEVICE IS LESS THAN 30μM, AND THE BULK OF THE PROCESSING CAN BE COMPLETED USING STANDARD CMOS FABRICATION TECHNIQUES. THIS SHOULD EASE THE TRANSITION TO HYBRID SILICON/EO POLYMER DEVICES IN FUTURE INTEGRATED OPTICS APPLICATIONS.

The high operating frequency and complex nature of the structure requires full 3D simulations to obtain accurate propagation characteristics. However, 3D simulations are very computationally expensive, especially during the design optimization phase. Therefore, the device periodicity has been exploited to employ a cascade matrix approach, and to reduce the necessary computational resources and time required for accurate simulation of the propagation characteristics of the modulator. The design and fabrication process have also been developed so that the majority of the fabrication in the SOI wafer can be completed before the EO polymer is introduced into the process. This allows for the use of well-established CMOS fabrication methods.

Simulation results show that this modulator can simultaneously attain a large modulation depth, short device length and low drive voltage, all of which are expected to be necessary for future integrated optics devices. Current work focuses on fabricating the modulator to experimentally demonstrate and characterize this promising compact optical modulator.EE



THE SIMULATION RESULTS SHOW THAT THERE ARE LIMITS TO IMPROVED PERFORMANCE BY COMPARING THE TRADE-OFFS BETWEEN THROUGHPUT AND MODULATION DEPTH FOR VARIOUS HOLE DIAMETERS IN THE BRAGG REFLECTOR. THIS FIGURE ALSO DEMONSTRATES THE LARGE MODULATION DEPTHS THAT CAN BE ACHIEVED WITH THIS RESONANT CAVITY MODULATOR.

FACULTY ADVISOR: *Professor Scott Dunham* **COLLABORATORS:** *Mark Mendez, Jen Research Group (Materials), and Dalton/Chen Research Group (Characterization)* **RESEARCH AREA:** *Integrated Optics* **GRANT/FUNDING SOURCE:** *Intel Ph.D. Fellowship, National Science Foundation Center on Materials and Devices for Information Technology Research*

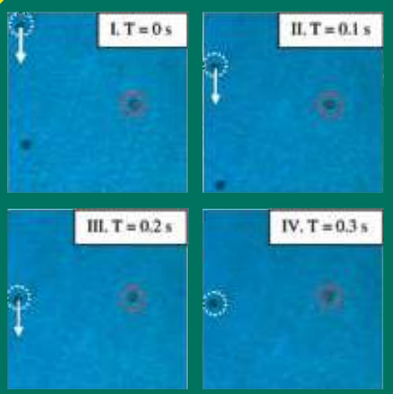
NEW OPTICAL MICRO-MANIPULATOR/ROTATOR

XIAOYU MIAO — GRADUATE STUDENT (EE)

In the fields of biophysics and cell biology, non-invasive manipulation of micro/nano objects is an important tool for basic biological research. It allows cells, cellular components, and synthetic marker objects treated with biochemical tags to be collected, separated, concentrated and transported without damage to the objects themselves. In the past, dielectrophoresis was the most widely employed method for such purposes. Recently, achieving such a goal using light has attracted much attention since the location of exerted force can not only be precisely defined, but also flexible and controlled by scanning the light.

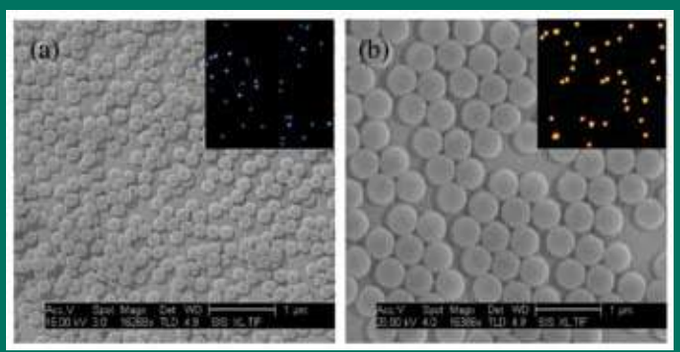
This research shows that trapping and rotation of single micro/nano objects can be realized through dielectrophoresis, which is induced by the radiation field from oscillating dipoles on the surface of gold (Au) nanoparticles. Polarized light excites localized surface plasmon resonance (LSPR) on the surface of an Au nanoparticle array. The surface plasmon consists of resonant dipole moments, which radiate and create a patterned radiation field with large gradient. Large dielectrophoresis force can be induced on the dielectric objects in the liquid solution without requiring high optical intensity. By tuning the polarization state of the incident light, the radiation pattern can be changed, thus achieving fine orientation control of the objects.

The cap-shaped Au nanoparticle array is formed by evaporating a thin layer of Au on a self-assembled polystyrene sphere monolayer. The scanning electron micrographs show the formed structures using a polystyrene sphere with different sizes. The insets are the fluorescence optical images under dark field illumination. Experiments have been performed to demonstrate the trapping capability of the device.



A DEMONSTRATION OF THE TRAPPING OF A SINGLE DIELECTRIC SPHERE (D=10 MICRON). THE SPHERE LOCATED AT THE LIGHT SPOT IS TRAPPED AND CIRCLED IN RED.

Opto-Plasmonic Tweezers have been developed in the UW EE Photonics Lab for optical manipulation and rotation of micro/nano objects with fine orientation control. The modeling results suggest that the device requires low optical intensity and can achieve fine orientation control. Trapping of a single dielectric sphere has already been experimentally realized. Further work to demonstrate the capability of orientation control is underway.EE



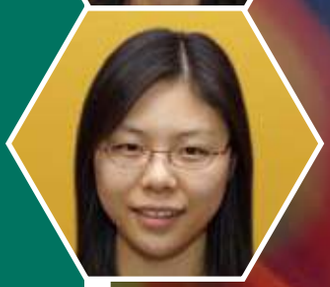
SCANNING ELECTRON MICROGRAPHS OF THE CAP-SHAPED Au NANOPARTICLE ARRAY.

FACULTY ADVISOR: *Professor Lih Y. Lin* **RESEARCH AREA:** *Biophotonics, Nanophotonics*
GRANT/FUNDING SOURCE: *National Institutes of Health, National Science Foundation*

NANOPHOTONIC WAVEGUIDES
for High-Density Photonic Integrated Circuits

CHIA-JEAN WANG — GRADUATE STUDENT (EE) AND
LUDAN HUANG — GRADUATE STUDENT (PHYSICS)

In EEK2006 (see page 24), a quantum dot (QD) waveguide was proposed to guide light at sub-diffraction dimensions. As a gain-enabled nanocrystal, a QD is an attractive structure for reducing the loss when developing ultrahigh-density photonic integrated circuits. Fabrication of the waveguide was achieved through e-beam lithography, and a rapid two-layer process to deposit colloidal QDs on a substrate. Since the EEK2006 publication, researchers have optimized the procedure, modeled the field distribution and examined device behavior through optical near-field testing.



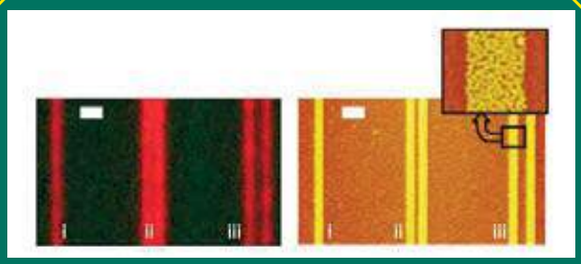
The QD waveguide utilizes a pump source, which create excitons within the QDs, as well as a signal light to generate stimulated recombination, or emission of photons that propagate downstream to the output edge. The fabrication process uses e-beam lithography, and a 3'APTES and carboxylated QD self-assembly procedure to create the waveguide structures.

For testing, a tapered fiber probe aligns to each waveguide edge. The input fiber is coupled to a signal laser, and the output taper connects to a photodetector. A pump light illuminates the device from above to excite e^{-}-h^{+} pairs and create gain. By polling both signal and pump powers on and off the waveguide, the device transmission behavior can be extracted.

It has been demonstrated that transmitted signal generally increases with pump power indicating a gain-enabled waveguiding effect in a sub-diffraction QD waveguide. Next steps will investigate loss as a function of waveguide length and crosstalk between adjacent devices, which will help determine device effectiveness as a gain-enabled waveguide for high-density photonic integrated circuits.EE

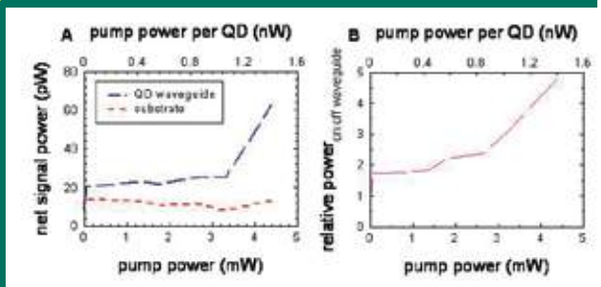
REFERENCE: C.-J. WANG, L. HUANG, B. A. PARVIZ, L. Y. LIN, "SUB-DIFFRACTION PHOTON GUIDANCE BY QUANTUM DOT CASCADES," NANO LETTERS, VOL. 6, NO. 11, PP. 2549-2553, NOV. 2006.

THIS WORK WAS ALSO HIGHLIGHTED IN NATURE PHOTONICS: http://www.nature.com/nphoton/reshigh/2006/1106/full/photon.2006.40.htm



FLUORESCENCE AND ATOMIC FORCE MICROGRAPHS OF 500nm WIDTH QUANTUM DOT WAVEGUIDE IN (I) SINGLE AND DUAL FORMATION SPACE (II) 200nm AND (III) 500nm APART.

ENERGY TRANSFER ALONG A 1D QD CHAIN.



TEST RESULTS FOR A 10μM LENGTH, 500nm WIDE QD WAVEGUIDE SHOW THAT THE NET SIGNAL ON THE WAVEGUIDE IS CONSISTENTLY HIGHER THAN ON THE SUBSTRATE. IT INCREASES WITH PUMP POWER, WHICH DEMONSTRATES WAVE-GUIDING WITH A GAIN MECHANISM.

FACULTY ADVISOR: *Professor Lih Y. Lin* **COLLABORATORS:** *Professor Babak A. Parviz (EE)*
RESEARCH AREA: *ECDT - Photonics* **GRANT/FUNDING SOURCE:** *National Science Foundation Graduate Research Fellowship, Intel Ph.D. Fellowship*

In Memorium

In Memory of Denice D. Denton

Denice D. Denton, who was dean of the UW College of Engineering from 1996 to 2005 and a member of the EE Department, died on June 24, 2006 in San Francisco. Denice was the first woman to become dean of a major research university. In 1987, she was at the University of Wisconsin-Madison, before coming to the UW in 1996. From February 14, 2005 until her death, she was Chancellor of the University of California, Santa Cruz.

> ***"Denice was an inspirational and transformational leader for the College of Engineering, with a strong focus on developing people to achieve their fullest potential."***
>
> PROFESSOR (AND FORMER INTERIM DEAN) MANI SOMA

Memorial web pages for Denice can be viewed at:
www.engr.washington.edu/denton and
www.ucsc.edu/administration//denice_denton/

In Memory of Endrik Noges

On June 6th, 2006, Professor Emeritus Endrik Noges passed away at the age of 79 years old. As an esteemed professor, he showed colleagues his dedication in the field, and as a World War II labor-camp survivor, he showed everyone the importance of overcoming life's struggles.

At age 17, Endrik escaped Estonia and Soviet rule, but was placed in a German labor camp for six months before World War II ended. After allied forces freed him, Endrik worked for the U.S. Army as a civilian in Germany. He finished high school in Germany with many other Estonians, and was offered a scholarship to attend Denison University in Ohio.

Endrik became an Assistant Professor at UW EE in 1958, and joined the late Professor Bob Clark as the 2nd faculty member of the new controls area. In 1965, he became the Assistant Dean of Engineering, where he worked on continuing education programs through 1972. He was promoted to full Professor in 1969.

In 1983, Endrik became the first Director of Televised Instruction in Engineering, and pioneered a system of remote course access that has continued, in one form or another, to the present. In 1986, he became Associate Chair to Robert Porter. After Porter stepped down as Chair, Endrik became Acting Chair and ran a very active faculty recruiting effort in 1988-89, hiring six new faculty.

Endrik also consulted at Boeing for more than 30 years and volunteered as a member of the National Ski Patrol at Crystal Mountain for 29 years. He is survived by his wife, Evelyn, his three children Paul, Rob and Linda, and seven grandchildren.

EE FACULTY

Afromowitz, Marty
Professor
Microtechnology/Sensors
Ph.D., 1969 Columbia University
NIH Career Development Award

Allstot, David
Professor
System-on-Chip VLSI
Ph.D., 1979 UC-Berkeley
IEEE Fellow

Ammer, Josie
Assistant Professor
Circuits and Algorithms for Wireless Communication
Ph.D., 2005 UC-Berkeley

Atlas, Les
Professor
Signal and Image Processing
Ph.D., 1984 Stanford University
NSF Presidential Young Investigator
IEEE Fellow

Bilmes, Jeff
Associate Professor
Signal and Image Processing
Ph.D., 1999 UC-Berkeley
NSF CAREER Award

Böhringer, Karl
Associate Professor
Microelectromechanical Systems (MEMS)
Ph.D., 1997 Cornell University
NSF CAREER Award

Bushnell, Linda
Research Assistant Professor
Controls and Robotics
Ph.D., 1994 UC-Berkeley
NSF ADVANCE Fellow

Chizeck, Howard
Professor
Controls and Robotics
Sc.D., 1982 MIT
IEEE Fellow

Christie, Rich
Associate Professor
Energy Systems
Ph.D., 1989 Carnegie Mellon University
NSF Presidential Young Investigator

Crum, Lawrence
Research Professor
Medical Ultrasound
Ph.D., 1967 Ohio University
ASA Fellow

Dailey, Daniel J.
Research Professor
Intelligent Transportation Systems
Ph.D., 1988 University of Washington

Damborg, Mark
Professor
Energy Systems
Ph.D., 1969 University of Michigan

Darling, R. Bruce
Professor
Devices, Circuits, and Sensors
Ph.D., 1985 Georgia Institute of Technology

Dunham, Scott
Professor
Materials and Devices
Ph.D., 1985 Stanford University

El-Sharkawi, Mohamed
Professor
Intelligent Systems and Energy
Ph.D., 1980 University of British Columbia
IEEE Fellow

Goldstein, Evan
Affiliate Professor
Lightwave Communications
Ph.D., 1989 Columbia University
IEEE Fellow, OSA Fellow

Gupta, Maya
Assistant Professor
Signal Processing
Ph.D., 2003 Stanford University

Hannaford, Blake
Professor
Biorobotics
Ph.D., 1985 UC-Berkeley
NSF Presidential Young Investigator, IEEE EMBS Early Career Achievement Award, IEEE Fellow

Hauck, Scott
Associate Professor
VLSI and Digital Systems
Ph.D., 1995 University of Washington
NSF CAREER Award, Sloan Research Fellowship

Hwang, Jenq-Neng
Professor
Signal and Image Processing
Ph.D., 1988 University of Southern California
IEEE Fellow

Jandhyala, Vikram
Associate Professor
Electromagnetics, Fast Algorithms, Devices
Ph.D., 1998 University of Illinois
NSF CAREER Award

Jaruwatanadilok, Sermsak
Research Assistant Professor
Electromagnetics
Ph.D., 2003 University of Washington

Kim, Yongmin
Professor
Digital Systems, Image Processing and Medical Imaging
Ph.D., 1982 University of Wisconsin - Madison
IEEE Fellow, IEEE/EMBS Early Career Achievement Award

Kirchhoff, Katrin
Research Assistant Professor
Multilingual Speech Processing, Machine Learning
Ph.D., 1999 University of Bielefeld

Klavins, Eric
Assistant Professor
Controls and Robotics
Ph.D., 2001 University of Michigan
NSF CAREER Award

Kuga, Yasuo
Professor
Electromagnetics
Ph.D., 1983 University of Washington
NSF Presidential Young Investigator Award
IEEE Fellow

Lin, Lih
Associate Professor
Photonics, MEMS
Ph.D., 1996 UC-Los Angeles

Liu, Hui
Associate Professor
Communications and Signal Processing
Ph.D., 1985 University of Texas, Austin
NSF CAREER Award, ONR Young Investigator

Mamishev, Alex
Associate Professor
Electric Power Systems, MEMS, Sensors
Ph.D., 1999 MIT
NSF CAREER Award

Nelson, Brian
Research Associate Professor
Plasma Physics
Ph.D., 1987 University of Wisconsin - Madison

Ostendorf, Mari
Professor
Signal and Image Processing
Ph.D., 1985 Stanford University
IEEE Fellow

Otis, Brian
Assistant Professor
RF/Analog IC Design
Ph.D., 2005 UC-Berkeley

Parviz, Babak
Assistant Professor
Microelectromechanical Systems (MEMS)
Ph.D., 2001 University of Michigan
NSF CAREER Award

Peckol, James S.
Lecturer
Digital Systems
Ph.D., 1985 University of Washington

Poovendran, Radha
Associate Professor
Communications Networks and Security
Ph.D., 1999 University of Maryland
NSA Rising Star Award, NSF CAREER Award, ARO YIP and ONR YIP Awards, PECASE Award

Riskin, Eve
Professor & Associate Dean
Signal and Image Processing
Ph.D., 1990 Stanford University
NSF Presidential Young Investigator, Sloan Research Fellowship

Ritcey, Jim
Professor & Associate Chair for Education
Communications and Signal Processing
Ph.D., 1985 UC - San Diego

Rosen, Jacob
Research Associate Professor
Biorobotics, Human-Machine Interfaces
Ph.D., 1997 Tel-Aviv University

Roy, Sumit
Professor & Associate Chair for Research & Development
Communications and Networking
Ph.D., 1988 UC - Santa Barbara
IEEE Fellow

Sahr, John
Professor & Associate Dean for UGrad Academic Affairs
Electromagnetics and Remote Sensing
Ph.D., 1990 Cornell University
NSF Presidential Young Investigator, URSI Booker Fellow, URSI Young Scientist Award

Shapiro, Linda
Professor
Signal and Image Processing
Ph.D., 1974 University of Iowa
IEEE Fellow, IAPR Fellow

Shi, C.J. Richard
Professor
VLSI and Digital Systems
Ph.D., 1994 University of Waterloo
NSF CAREER Award, IEEE Fellow

Soma, Mani
Professor & Associate Vice Provost for Research
Mixed Analog-Digital System Testing
Ph.D., 1980 Stanford University
IEEE Fellow

Strunz, Kai
Assistant Professor
Electric Power Systems and Power Electronics
Ph.D., 2001 Saarland University
NSF CAREER Award

Sun, Ming-Ting
Professor
Signal and Image Processing
Ph.D., 1985 UC-Los Angeles
IEEE Fellow

Tsang, Leung
Professor & Acting Chair
Electromagnetics, Remote Sensing
Ph.D., 1976 MIT
IEEE Fellow, OSA Fellow

Wilson, Denise
Associate Professor
Circuits and Sensors
Ph.D., 1995 Georgia Institute of Technology
NSF CAREER Award

EMERITI

Albrecht, Robert
Controls and Robotics
Ph.D., 1961 University of Michigan

Alexandro, Frank
Controls and Robotics
Ph.D., 1961 University of Michigan

Andersen, Jonny
Circuits and Sensors
Ph.D., 1965 MIT

Bjorkstam, John L.
Controls and Robotics
Ph.D., 1958 University of Washington

Dow, Daniel G.
Ph.D., 1958 Stanford University

Guilford, Edward C.
Ph.D., 1960 UC-Berkeley

Haralick, Robert
Signal and Image Processing
Ph.D., 1969 University of Kansas
IEEE Fellow

Helms, Ward
Circuits and Sensors
Ph.D., 1968 University of Washington

Hsu, Chih-Chi
Ph.D., 1957 Ohio State University

Ishimaru, Akira
Electromagnetics and Waves in Random Media
Ph.D., 1958 University of Washington
IEEE Fellow, OSA Fellow, IOP Fellow, IEEE Heinrich Hertz Medal, URSI John Dillinger Medal and Member, National Academy of Engineering

Jackson, Darrell
Ph.D., 1977 California Institute of Technology

Johnson, David L.
Ph.D., 1955 Purdue University

Lauritzen, Peter O.
Ph.D., 1961 Stanford University

Moritz, William E.
Ph.D., 1969 Stanford University

Peden, Irene
Ph.D., 1962 Stanford University
NSF "Engineer of the Year"
Member, National Academy of Engineering, IEEE Fellow, IEEE Harden Pratt Award, U.S. Army Outstanding Civilian Service Medal

Porter, Robert B.
Ph.D., 1970 Northeastern University
ASA Fellow, OSA Fellow

Potter, William
MSEE, 1959 US Naval Postgraduate School

Redeker, Charles C.
Ph.D., 1964 University of Washington

Sigelmann, Rubens A.
Ph.D., 1963 University of Washington

Spindel, Robert
Signal Processing/Ocean Acoustics
Ph.D., 1971 Yale University
IEEE Fellow, ASA Fellow, MTS Fellow, A.B. Wood Medal, IEEE Oceanic Engineering Society Technical Achievement Award

Yee, Sinclair
Photonics, Sensors
Ph.D., 1965 UC – Berkeley
IEEE Fellow

Zick, Greg
VLSI and Digital Systems
Ph.D., 1974 University of Michigan

Congratulations to Radha Poovendran who was promoted to Associate Professor, and to Jacob Rosen who was promoted to Research Associate Professor. Also, congratulations to Professor Sumit Roy for being named a 2007 IEEE Fellow.

WE APOLOGIZE FOR ANY ERRORS, OMISSIONS OR MISSPELLINGS IN 2007 EEK. WE WOULD LIKE TO EXTEND SPECIAL APPRECIATION TO THE FACULTY, STAFF AND STUDENTS WHO ASSISTED IN PRODUCING THIS PUBLICATION AND TO THE SPONSORS WHOSE GENEROSITY MADE IT POSSIBLE.

ENGINEERING A BETTER WORLD

Electrical Engineering students and faculty at the UW are actively involved in efforts to make the world a better place through volunteer activities and service learning. This year our local chapter of Engineers Without Borders has begun a multi-year project to provide engineering assistance to the town of Yanayo in the Andean region of central Bolivia. Their initial assessment visit is described here. Closer to home, the devastating impact of Hurricane Katrina and failures of human preparation and response have provided an opportunity for UW students and faculty to learn while they help the people of Bay St. Louis.

ENGINEERS WITHOUT BORDERS

Saving the World One Village at a Time

STEPHEN HAWLEY — GRADUATE STUDENT (EE)
DONEE ALEXANDER — GRADUATE STUDENT (CIVIL ENG)

As a founding member of the UW student chapter of Engineers Without Borders (EWB), EE graduate student Stephen Hawley recently led a site assessment trip to Bolivia. EWB is a non-profit organization dedicated to improving the quality of life of individuals in the developing world through sustainable engineering designs and training.

The project site, Yanayo, lies in the high Andean region of central Bolivia about 75km SSE of Cochabamba. For the past five hundred years, this small community has relied on traditional farming for its existence, but recent drought conditions threaten their way of life.

The trip was the culmination of a year long effort of fundraising and planning. As is often the case, travelers must quickly develop the ability to go with the flow or suffer extreme stress. Just before we left for Bolivia, we learned that our in-country contact would not be able to accompany us to Yanayo. Then our flight to La Paz experienced electrical problems and was rerouted to Santa Cruz where we slept on airport benches until a morning flight to Cochabamba. In Cochabamba, we made contact with our in-country contact Edward Gonzales and with the Peace Corps office. Edward arranged for two village leaders to make the 13-hour trip by foot and bus to guide us to the village. Tuesday, we drove 158km for six hours in a rented 4x4 on narrow, mostly dirt roads with the ever present fear of encountering a bus on a blind switchback.

THE LEADERS OF THE COMMUNITY, JESUSA (LEFT), HER HUSBAND GERMAN (RIGHT), AND FLORENTINO (CENTER) ALL CARE DEEPLY ABOUT THE FUTURE OF THEIR COMMUNITY.

AT TOP: OVERLOOKING THE VILLAGE OF YANAYO. NOTE: THE LARGE FIELD IN CENTER IS UNPLANTED DUE TO WATER SHORTAGE, YET THE TREES ARE GREEN AND HEALTHY INDICATING POTENTIAL GROUNDWATER SOURCES.

SCHOOL IN THE COMMUNITY GOES THROUGH GRADE THREE. THE SCHOOL CHILDREN EMBRACE CEE GRADUATE STUDENT DONEE ALEXANDER DURING THEIR LUNCH BREAK.

Upon arrival in the village, the children immediately greeted us and took great satisfaction in beating the dust from the car using tree branches (oh well, was a rental). The site assessment went extremely well. We had two well-attended and lively community meetings, and we visited their sites of concern, including roads and water sources. We came away with at least five years worth of work that will help the community improve their health, standard of living and income. Initial projects will work on improving stove efficiency and reducing household smoke, improving roofs to decrease habitat for disease vectors and rainwater catchments for household vegetable gardens to improve health and nutrition.

The opportunity for students to meet, interact with and help villages in foreign countries is a priceless learning experience. If you wish to encourage and facilitate these opportunities, we can use your skills and/or your donations.EE

For more information, email ewbuw@u.washington.edu, or visit www.nimret.org/ewbuw.

A ONE LANE DIRT AND ROCK ROAD IS NAVIGABLE IN A FOUR WHEEL DRIVE DURING THE DRY SEASON, BUT BECOMES DANGEROUS WHEN THE RAINS COME.

FACULTY ADVISOR: ***Susan Bolton (CFR)***

KATRINA: Service Learning to Repair the World

DENISE WILSON — PROFESSOR (EE)

Hurricane Katrina was a Natural disaster, made worse by human actions. Higher Gulf of Mexico temperatures possibly induced by global warming, widespread destruction of protective barrier wetlands, continued expansion of a city below sea level despite its continued sinking, and the brazen manipulation of water flow (the Mississippi Gulf Outlet) for economics rather than weather protection, all made a Category 3 storm (as Katrina was when she reached New Orleans) far more destructive.

During winter quarter 2007, the University of Washington conducted a full credit program on the Gulf Coast of Mississippi (Bay St. Louis/Waveland). It integrated a formal academic curriculum with service learning. This innovative program was designed and led by EE Professor Denise Wilson. It is committed to meeting the critical needs of those who are still suffering the aftermath of Hurricane Katrina. Three to four days a week, program participants are rebuilding homes for local residents, and two days a week, they are engaged in an academic curriculum titled "The Impact of Katrina on Technology and Infrastructure." Students have a unique opportunity to engage in meaningful Service Learning, providing desperately needed semi-skilled labor (Wiring, Plumbing, Drywall, Flooring, etc) in the Katrina Rebuilding. They are also studying the impacts of technology development as they relate to what went wrong and right with the preparation and response to the storm.EE

THE STUDENTS IN THE PROGRAM. FROM LEFT TO RIGHT (STANDING): CHARLENE REYES, JIMMY ZHU, JESSICA NGUYEN, KATRINA DUELL, ROB O'BRIEN, DOROTHY YEUNG, JENNA ROVEGNO. FROM LEFT TO RIGHT (KNEELING): MAYRA GARCIA, HALEY BRANDT, JOHN FRANKLIN, ASHLEY JENKINSON. NOT PRESENT: GEN BELCHER.

GRANT/FUNDING SOURCE: ***First Presbyterian Church in Bay St. Louis, the University of Washington, and the Ford Foundation.***

JIMI LOTT / THE SEATTLE TIMES

www.ee.washington.edu

UNIVERSITY OF WASHINGTON
DEPARTMENT OF ELECTRICAL ENGINEERING
PAUL ALLEN CENTER — ROOM AE100R
CAMPUS BOX 352500
SEATTLE, WASHINGTON 98195-2500