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ECE DEPARTMENT

2009/10 RESEARCH, DEVELOPMENT, AND ACTIVITIES

Design of iPhone Game Applications for the Eyes on the Earth Initiative

Dean R. Johnson, Summer Faculty Fellow, 2009

Western Michigan University

Visualization Technology Applications and Development

Introduction

Two games that demonstrate principles inherent with NASA's Eyes on the Earth (EOE) initiative have been designed as applications for the Apple iPhone and iPod Touch. The purpose of these apps is to help explore various roles that earth-borne satellites have in monitoring atmospheric, sea and land features of the Earth, as well as to gain some insight concerning the processes of climatic change. iPhone apps such as these would be very useful for educational outreach purposes, both internally to NASA as well as for public consumption, especially to the student population.

Design

Approximately 30 pieces of art were designed to storyboard the navigation paths for the Metropolis and Satellite Hunter apps. The art was produced using special iPhone Photoshop

templates provided by the design firm TEEHAN LAX, including templates for the navbar, toolbar and tabbar artwork required by the project. While the Metropolis design eventually forgoed usage of the 2D art, and was instead built by JPL engineers as a 3D game, Satellite Hunter was designed as a traditional 2D iPhone app, which could display a splash page (see left) and a 4-button tab bar (see above right), superimposed upon a rotating globe that could also turn into a pushbutton. The premise of Satellite Hunter is to search for the closest satellite by orienting the iPhone to the proper elevation and azimuth angle, and pressing the capture button. Audio feedback is provided to the user in the form of a tricorder-like sound whose pitch and spacing varies with the search angles, as provided under the Search tab. The Direction tab helps locate north, while the Found tab lists all of the closest satellites that have been found so far, and the Video tab provides some help. Finally, a piece of cake is awarded to all those who can find all of the satellites in proper closest order.

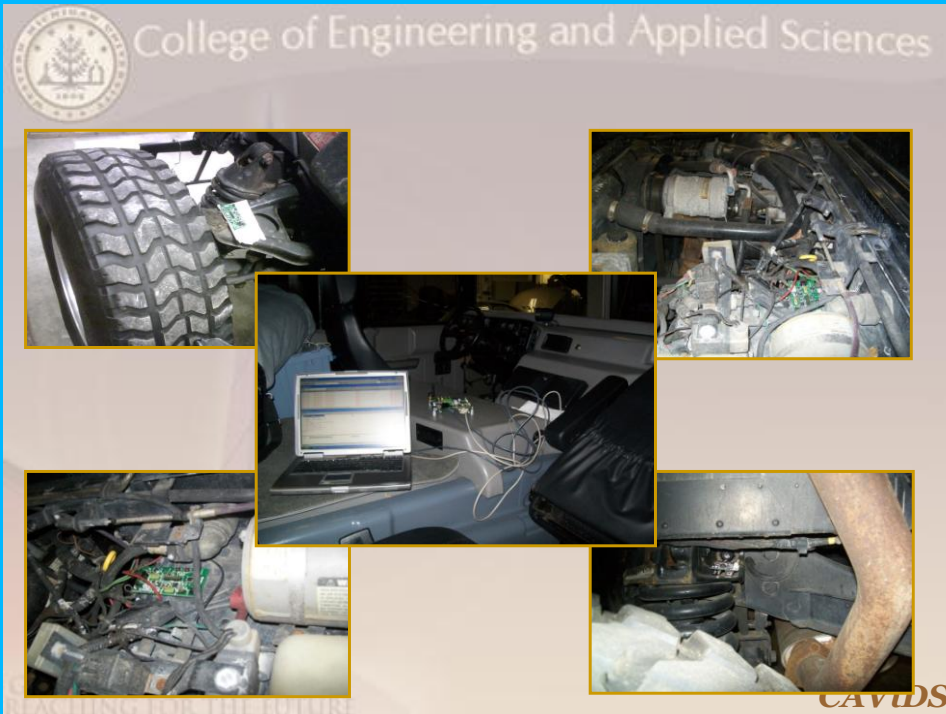
Results

Satellite Hunter was built and successfully run in skeleton form by deploying the designed artwork for the Search, Direction, Video and Found tab functions using Interface Builder, and loading the resulting app into an iPhone using the Xcode development environment. Beyond this useful initial start, substantial programming work for the pushbutton, search angles display, satellite tracking and capture, and video playback remains.



Printed Electronics Research and Sensor Development – As a continuation of research activities into printed Radio Frequency Identification (RFID), Drs. Massood Atashbar and Bradley Bazuin have become founding members of the Center for the Advancement of Printed Electronics (CAPE) collaborating with Dr. Margaret Joyce (director) and a large team of faculty and students from the Paper Engineering, Chemical Engineering, and Imaging (PCI) department as well as other department in CEAS. Drs. Atashbar and Bazuin continue to be involved in a range of funded research activities and proposals with the goal of making electronic devices, semiconductor and electronic sensors and small electronic systems using roll-to-roll printing techniques and electrically functional inks; including inks based on organic and polymer semiconductors, various nanomaterials, and carbon nanotubes. Drs. Atashbar and Bazuin will also be supporting upcoming CAPE training classes on "Mastering Printed Electronic Principles" that are being offered on 8-9 June and 27-28 October. (Brad Bazuin)

Dual-Use Ground Vehicle Condition-Based Maintenance – The U.S. Army is poised to introduce Condition



Based Maintenance (CBM) across its land-based vehicle fleet. CBM is expected to increase the vehicles' readiness and operational availability and reduce the soldiers' maintenance burden. Within this research our team is to develop an intelligent vehicle health management system for light tactical vehicles. Our focus is on vehicle systems as follows: engine, axles and wheels. We will also develop a secure vehicle identification method through RFID technology. The front-end of our vehicle health management system will have the following elements: data acquisition, data manipulation, condition monitoring, health assessment (diagnostics) and prognostics. The \$345,000 project is funded by the U.S. Army Tank-Automotive Research, Development, and Engineering Center (TARDEC)

through CAVIDS. In 2009 an additional \$70,000 supplement was added to this project. (ECE faculty involved in this project are **Janos Grantner**, CoPI; **Bradley Bazuin**, **Liang Dong** and Richard Hathaway and Claudia Fajardo of the MAE Dept.).

TS-Type Fuzzy Automaton for Software Agents – In this project our objective is to develop a new, Takagi-Sugeno type fuzzy automaton. Tracking the status of an event driven, large control system is a difficult problem. Those systems often encounter unexpected events in an uncertain environment. The use of fuzzy automata offers an effective approximation method to model continuous and discrete signals in a single theoretical framework. A Max-Min automaton can successfully model a cluster of relevant states when a decision is to be made on the next state of a goal path at the supervisory level. However, to provide analytical proof for stability and other key properties for inference performed by a fuzzy controller the Takagi-Sugeno model is preferred. This project is a continuation of a previous one referred to as Generic Encapsulated Fuzzy Automaton Software Agent. This project is overseen by **Janos Grantner**, ECE Professor and George Fodor, of ABB Automation Technologies, Sweden.

NEW DEAN – College of Engineering & Applied Sciences

Dr. Anthony J. Vizzini received his Ph.D. in Aeronautics and Astronautics in 1986 from M.I.T. and joined the faculty at the University of Maryland. In January of 1987 he was appointed as the founding director of the Composites Research Laboratory and was responsible for the composites program within the A. James Clark School of Engineering. He has led sponsored research projects such as delamination prevention through structural tailoring techniques; short duration, high temperature effects of composites; crushing mechanisms of composites; and damage tolerance of composite sandwich panels. He was involved in the Center of Rotorcraft Education and Research funded by the Army Research Office and the Office of Naval Research University Research Initiatives program on thick-section composites. In August 2003, he became Professor and Department Head of the Aerospace Engineering Department at Mississippi State University and in 2005 became the inaugural holder of the Bill and Carolyn Cobb Chair within the Bagley College of Engineering. Recently he has been involved in the design and manufacture of composite structures for space applications and uninhabited air vehicles. He is the author of over 100 articles on such topics as delamination prevention, crashworthiness, tapered structures, structural integrity of fire-exposed composites, expanding monomers, and advanced manufacturing techniques. He is a member of the Executive Cabinet of the Society for the Advancement of Material and Processing Engineering (SAMPE), is the Vice President (president elect) of the American Society for Composites, serves on the editorial board of the *Journal of Advanced Materials*, and is a Fellow of the American Society for Composites and an Associate Fellow in the AIAA.



Nonlinear Circuits and Systems Laboratory

Room A-209

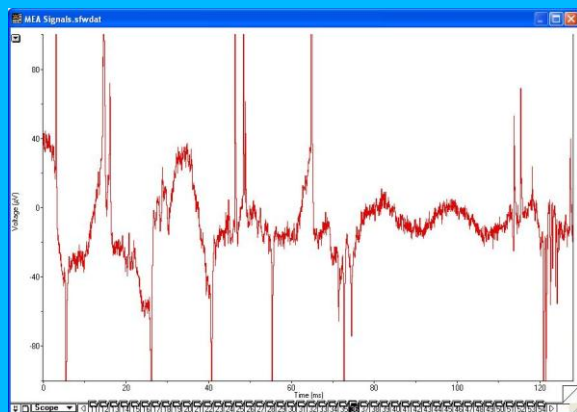
Under the direction of Dr. Miller, this laboratory continues to explore circuit implementations of chaotic systems. Undergraduate students **James Truskowski** and **David Kirklewski** are finalizing the design of discrete time chaotic circuits, building on work by previous WMU students, including **Donovan Squires**. Research in this laboratory is conducted in collaboration with Dr. Giuseppe Grassi of the University of Salento and WMU faculty Drs. Bazuin and Severance. A journal article by Drs. Grassi, Severance, and Miller entitled "Multi-wing hyperchaotic attractors from coupled Lorenz systems" was published in *Chaos, Solitons, and Fractals* in July 2009.



to

(Pictured

Donovan Squires and David Kirklewski in the Nonlinear Circuits and Systems Lab)



Waveform captured by Michael Ellinger from a Multi Channel Systems MEA electrode using ADInstruments hardware and software. It is likely that these spikes correspond to cortical neuron action potentials, representing a major milestone in the development of the Neurobiology Engineering Laboratory

Neurobiology Engineering Laboratory

Room A-211

Under the direction of Drs. Miller and Severance, the Neurobiology Engineering Laboratory investigates the principles and mechanisms of information processing and knowledge representation in biological neurons and neuronal networks. The laboratory utilizes the theory and practice of electrical engineering, computer engineering, and computer science coupled with mathematics in its work.

This laboratory has made great strides over the past year, particularly after several laboratory personnel attended the Neuroscience 2009 conference in Chicago. This progress has been made possible by close collaboration with Drs. Bazuin and Gesink, Biological Sciences Department faculty Drs. Jellies and Spitsbergen, and Mathematics faculty Dr. Koelling. Supporting organizations include the NASA Michigan Space Grant Consortium, the WMU Faculty and Creative Activities Support Fund, the WMU Graduate Student Research Fund, and Sunstone® Circuits. The laboratory will be in a position to culture neural cells and to investigate signal processing in those cultures by fall.

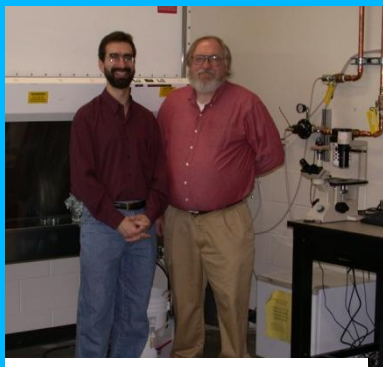
Michael Ellinger and **John Stahl** successfully defended Master of Science in Electrical Engineering theses in the summer of 2009 entitled "Acquisition and Analysis of Biological Neural Network Action Potential Sequences" and "Dual Channel Low Noise Amplifier for Experiments in Neurophysiology" respectively. Both Mike and John have continued their research in the laboratory as ECE Ph.D. students. Mike visited Dr. Brewer of Southern Illinois University Medical School in fall 2009, returning with a microelectrode array (MEA) populated with rat cortical neurons.

Michael Ellinger and John Stahl are advising a senior design group consisting of **Kyle Batzer**, **Richard Corsi**, and **Edward Crampton** in the development of a multichannel "Electrophysiology Measurement and Stimulation System." This system is the culmination of previous work by WMU faculty and students and is a critical component in the long term research goals of the laboratory. Once completed, the lab will have instrumentation for measurement and stimulation of neural electrical activity via multiple electrodes. Kyle will

continue as a graduate student in the lab after a summer internship in FPGA working at the NASA Glenn Research Center. Undergraduate students

Stephen Goveia and **Shannon Kloha** were each awarded a WMU Seibert Undergraduate Research and Creative Activities Award to research methods of improving the effectiveness of cell culture techniques.

A research group within the laboratory led by Dr. Severance consisting of Michael Ellinger, Dr. Melinda Koelling, Dr. Miller, and John Stahl are investigating application of optimal control theory to modeling of neuron dynamics.



WMU Neurobiology Engineering Laboratory Directors Drs. Miller and Severance.



WMU Neurobiology Engineering Laboratory faculty and students (left to right): John Stahl, Dr. Bazuin, Dr. Koelling, Rick Corsi, Kyle Batzer, Shannon Kloha, Ed Crampton, Stephen Goveia, and Mike Ellinger. Not pictured: Dr. Gesink, Dr. Jellies, Dr. Spitsbergen, Dan Kueh, and Sr. John-Mary Vianney.

ECE supporting Sunseeker Solar Rayce Team - The 2009-2010 activities include the development of a third generation Telemetry System for installation as part of the Controller Area Network (CAN) in the 2010 Sunseeker that is expected to be "raycing" this June in the 2010 North America Solar Challenge. The Solar Car Telemetry Module work is being performed by David Landreth, Heather Scherer and Jerry Taylor as their senior project with Dr. Bradley Bazuin's support as the faculty advisor. Dr. Bazuin is also expected to travel with the team this summer. In addition to the 2010 car work, two other senior project teams, one group with Meng Chun Cheah, Siok Yee Lim, and Kong Siew Yu and the second group with Dan Heilman, Mohammed Islam, and James Truszkowski II, are developing new battery protection systems (BPS) for the Sunseeker 2012 vehicle. Advanced BPS systems are required when using high density lithium polymer batteries in order to avoid potentially dangerous conditions. The new BPS systems under development should significantly reduce size, weight, and power while using some of the latest electronic devices designed for advanced commercial battery and hybrid vehicles. (Bradley Bazuin)

DOE Strategic Training and Education in Power Systems (STEPS) Funding



Our proposal submitted to US Department of Energy - DOE ("Workforce Training for the Electric Power Sector," - **Strategic Training and Education in Power Systems (STEPS)** DOE Opportunity Number: DE-FOA-0000152) is funded. The total project value is **\$4,175,423.00 (\$2,500,000.00** from DOE and **\$1,675,423.00** cost sharing mainly from companies and from the individual collaborating universities).

DOE has recognized Power Systems, Power Electronics, and Electric Drives as enabling technologies to support renewable energies. The utility and electric power-related companies are making every effort to recruit power systems engineers and other related personnel to work in the power and energy industries. The proposal, therefore, sought funding from DOE to enable the rebuilding of educational programs in Power Systems, Power Electronics, and Electric Drives to meet the manpower demands of the utility and electric power-related companies. The objectives include faculty development, develop new curriculum, and set up laboratories with the state-of-the-art equipment. Dr. Asumadu has been participating in an on-going programs sponsored at various times by some of the following institutions: NSF, NASA, Electric Power Research Institute (EPRI), American Electric Power (AEP), US Navy of Office of Naval Research (ONR), and other institutions with the University of Minnesota as the lead university. Dr. Asumadu is one of the faculty resources for this consortium of collaborators. The University of Minnesota is taking the lead role with the collaboration of about 30 universities in the US. Dr. Asumadu is the the collaborator from Western Michigan University (WMU) - the only university from Michigan in the present funding.

The consortium worked on the grant proposal. Each collaborator will be funded with at least \$25,000.00 and provided new teaching classroom materials and state-of-the-art laboratory equipment to facilitate the implementation of laboratories. The cost sharing from WMU is \$12,500.00 for the equipment. The duration of the project is three years. Picture above is the consortium and guests at a conference held in Napa last year including Drs. Johnson and Gesink. (Johnson Asumadu)

Increasing Opportunities and Improving Outcomes for Engineering Students in Engineering and Applied Sciences Awarded

Andrew Kline, Principal Investigator, Drs. Edmund Tsang, **Ikhlas Abdel-Qader** and Betsy Aller are Co-Principal Investigator

This project is awarding up to 86 one-semester scholarships to academically talented but financially needy students who are working towards baccalaureate degrees in engineering and applied science. The program is targeting first-time, first-year students, and the scholarships are supporting students through their undergraduate programs. The success and eventual graduation of the scholars is being supported not only through scholarships, but also with monthly scholar meetings. These meetings include discussions of available university resources, field trips to local industries, seminars with speakers from industry, and workshops on career planning and development. Each scholarship recipient is participating in one of three professional development programs: Student Organizations of Professional Societies, Undergraduate Research, or Co-Op. Scholars may choose different professional development programs in different years. The goals of the project are to enhance the retention and graduation rates of students in engineering and applied sciences and to prepare these students to successfully enter professions or continue in graduate studies.



Active WMU IEEE Student Branch - Students and faculty advisor, Johnson Asumadu have been active throughout 2009-2010 academic year. Students shared knowledge from their research or study experience by giving seminar presentations. **Nicole Maggio** gave a presentation titled "Graduation-course auditing, advising, & interviewing", while **Peter Larr** "Graduating-interviewing" seminar. **Michael Ellinger** shared his graduate research study in his talk "EE Opportunities in Neurobiology" and **Umair Ahmad's** presentation was "Power the world". Some other seminar presentations were the IEEE recruitment material "Who are Engineers? You?" and "Project Management" which was offered by **Tarek Lahdhiri** in Grand Rapids. Apart from sharing WMU IEEE students attended information sessions events such as AFE tour of Air Zoo Kalamazoo, US Air Force, and Professor for a day where students

continue to build their careers. IEEE sales including rummage sale are charity activities students are encouraged to be involved in. Indeed WMU IEEE students have become a community that involves not only academic events but also fun events so that to keep in touch.

(Pictures taken at the IEEE Student Bowling Event held in April 2010)



Drs. Brad Bazuin, John Gesink, Sridevi Krishnamurthy and Massood Atashbar.

Electrical and Computer Engineering Doctoral Degree

The ECE Department started its PhD program in 2001, Our 1st graduate was Dr. Sridevi Krishnamurthy who received her degree in the Summer of 2007. Her dissertation topic was "**Wireless Pass Surface Acoustic Wave (SAW) Sensing System**". Dr. Massood Atashbar served as her faculty advisory and dissertation chair. Also serving on her committee from the ECE Department was Dr. Bradley Bazuin and Dr. John Gesink and from the IME Department Dr. Abdolazim Houshyar. Dr. Krishnamurthy is a research scientist at Bruker Biospin.

Networks". Dr. Liang Dong served as his faculty advisor and dissertation chair. Also serving on his committee from the ECE Department were Drs. Frank Severance and Bradley Bazuin. Dr. Wuwei Shen from the Computer Science department also served on his committee.

Dr. Yao Zhao graduated in the summer of 2009. His dissertation topic was "**Communications and Positioning in Wireless**



Drs Liang Dong and Yao Zhao



Dr. Tomislav Bujanovic received his Doctorate in Electrical and Computer Engineering this past Fall. His dissertation topic "**Spatial Frequency Localization in Mammograms Using Wavelets**" and his faculty advisor and dissertation chair was Dr. Ikhlas Abdel-Qader. His committee was comprised of Dr. Liang Dong, ECE Department and Dr. Dionysios Kountanis of the Computer Science Department.

Drs. Krishnamurthy, Zhao and Bujaniv's dissertation are published and can be accessed via the internet at: <http://www.wmich.edu/grad/dissertation/index.html>

Dr. Ikhlas Abdel-Qader, Tomislav Bujanovic, Imad Zyout and Qais Alsafasfeh fellow PhD Candidates in the ECE program



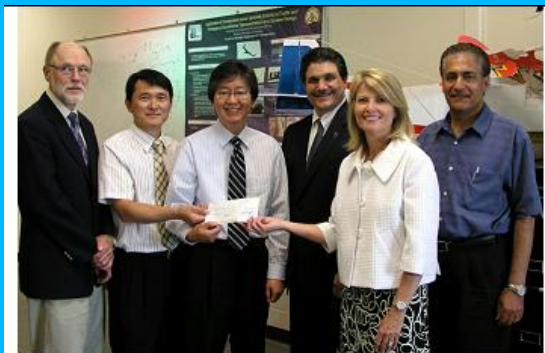
DyKnow (Dynamic Knowledge)- This semester, three CEAS classes are using a system that enhances communication between students and their professors. DyKnow is being used to promote student engagement in the classroom. **Dr. Dean Johnson** said that with DyKnow, he can write on his PowerPoint lecture slides or perform handwritten calculations using an electronic pen. These notes are displayed on the students' laptops or to PC desktops outfitted with pen-on-screen devices. Students get copies of the professor's notes in real time. "These notes are stored along with any notes that the student may make on a special DyKnow server set up in the CAE center, and that information can be retrieved by students at home," Johnson said. Dr. Karlis Kaugars, CEAS director of IT and facilities, was credited for initially introducing the DyKnow system to WMU. It was discovered at Virginia Tech and described to the CEAS College Information Technology Policies Committee (ITPC), which Johnson chairs. Johnson used DyKnow last summer to teach a section of ECE 2100, which he described as a basic circuits class offered at a time popular with mechanical engineering students. "The ME students were the guinea pigs and it was a lot of fun," Johnson said. This semester Johnson is using DyKnow to teach ECE 3610 Applied Electromagnetics, and **Dr. Ralph Tanner** is also using it for ECE 3710 Linear Systems.



Students complete an ARIS assignment using DyKnow system components Photo provided by Dean Johnson

DENSO supports student projects in smart-car technology

In a ceremony held in July at the Parkview Campus, DENSO North America Foundation (NAF) provided a \$20,000 grant to promote student projects that advance smart vehicle technology. Karen Cooper-Boyer-DENSO General Manager for HR/Corporate Services at DENSO Manufacturing Michigan, Inc. in Battle Creek, a trustee on the DENSO North America Foundation Board, and a WMU alum (BBA '86, Mgmt; MA '88, Educational Leadership)- presented the check. **Drs. Jun-Seok Oh** (Civil and Construction faculty member), **Liang Dong** (Electrical and Computer Engineering faculty member), and **Kapseong Ro** (Mechanical and Aeronautical Engineering faculty member) will be using the funds for the Smart Vehicle Laboratory (SVL) and to support multi-disciplinary student engineering projects related to smart-car technology. The SVL is a multi-disciplinary laboratory that is being developed to expose undergraduates enrolled in CCE, ECE, and MAE majors to smart vehicle systems research and development. "The research plan calls for the development of traffic simulations and test platforms of a Global Positioning System/Inertial Navigation System (GPS/INS) integrated with a vehicular ad-hoc network (VANET) environment," Dong said.



At a CEAS Parkview Campus ceremony, **Karen Cooper-Boyer** (front), - DENSO General Manager for HR/Corporate Services at DENSO Manufacturing Michigan, Inc. in Battle Creek, a trustee on the DENSO North America Foundation Board, and WMU alum presents check to (back, from left): **Dr. John Gesink** (ECE chair), **Dr. Jun-Seok Oh** (CCE), **Dr. Kapseong Ro** (MAE), **Dr. Tony Vizzini** (CEAS Dean), and **Dr. Parviz Merati** (MAE chair)

3 ECE PhD Candidate Defend their Dissertations this Spring 2010

The following ECE PhD candidates defended their dissertation and have applied to graduate on May 1, 2010.

- **Ahmad Aljaafreh** - topic "Collaborative Classification of Multiple Ground Vehicles in Wireless Sensor Networks Based on Acoustic Signals" Committee members consist of Dr. Liang Dong, chair and Drs. Janos Grantner, ECE Department and Dr. Ala Al-Fuqaha, CS Department.
- **Abdel Ilah Alshbatat** - topic - "Cross Layer Design of Mobile Ad-Hoc Unmanned Aerial Vehicle Communication Networks" Committee members consist of Dr. Liang Dong, chair and Drs. Ikhlas Abdel-Qader, ECE Department and Abdolazim Houshyar, IME Department.
- **Hanyi Dai** - topic "Design of Adaptive Collective Foraging in Swarm Robotic Systems" Committee members consist of Dr. Frank Severance, chair and Drs. Liang Dong, ECE Department and Gerald Sievers, Statistical Department..



Abdel Ilah Alshbatat



Dr. Frank Severance, Candidate Hanyi Dai, Dr. Liang Dong and Dr. Gerald Sievers, Statistical Department



Dr. Janos Grantner, Ahmad Aljaafreh, Dr. Liang Dong and Dr. Ala Al-Fuqaha, Computer Science Dept.

Rehabilitation Engineering - The major thrust of activity in these studies relates to veering of visually impaired individuals. Veering is the drift from one's intended path of travel and it happens to most persons when position feedback is absent. One of the major efforts in these studies has been the development of a device to train blind individuals to better walk a straight path without veering in short missions such as crossing a street or walking across a parking lot. Such a device, an Anti Veering Training Device (see Photo), has been developed and is waiting field-testing. Other activity in this area focuses on the development of a Veer Analyzer, a device which, when coupled to a veering individual, will measure and record, in two dimensions, the trajectory of the individual's movement. The recorded trajectory is then analyzed in an effort to decompose the trajectory into a rotational and a translational component. If successful, the analysis will be useful in developing programs to reduce veering. Thus far, hardware has been developed to record the trajectory and progress is being made on analytical techniques to extract the rotational and translational components. **John Gesink** heads this effort and the National Institute of Disability Rehabilitation and Research funds it.



Energy-Efficient Wireless Information Network

Network information theory involves efficient and reliable communication in multi-terminal settings. This field has recently attracted renewed attention due to fast-growing applications such as the Internet, wireless cellular and local-area-network data services, ad hoc networks and sensor networks. This research focuses on the balance of energy consumption and communication performance of wireless information networks. In distributed ad hoc networks, untethered nodes depend on small batteries for continuous sensing, processing, and communication. Traditionally, most power is consumed by radio transmission. However, for short-range and low-data-rate multihop ad hoc and sensor networks, the energy consumed by circuit signal processing is comparable to that consumed by radio transmission. There is an interesting question that needs to be addressed: How to distribute the individually constrained node energy between radio transmission and transceiver signal processing, so that the maximum network throughput can be achieved? The circuit energy consumption needs to be incorporated in network design to minimize the total energy consumption. The research considers a tradeoff between energy used in a network and the performance of a network taking into account a plethora of factors that affect performance from the physical layer up to the network layer. (Liang Dong)

Cooperative Localization and Tracking in Ad Hoc Networks

As wireless networks evolve over time, there is an increasing interest in combining location awareness with communications. The future of wireless networks will not follow the traditional base-station to mobile model, but will be peer-to-peer. Without fixed infrastructure or centralized administration, the knowledge of node positions plays an important role in network implementation. Location awareness can aid network routing and provide information to improve network performance and efficiency. Location awareness can be exploited for design of cognitive wireless systems and ad hoc networks, and it is an enabling technology for the seamless integration of cyber and physical systems. The node location information alongside data collection and distribution can enable many location-aware applications in networked sensing and control for manufacturing, person and asset tracking, healthcare, smart homes, transportation and security, search and rescue, and in future pervasive sensing, computation, communication, and actuation. This research develops cooperative localization and tracking in wireless ad hoc networks. Cooperation among network nodes can be exploited to improve positioning and tracking reliability. (Liang Dong)

Green Electronics: Energy Harvesting for Sustainable Wireless Sensor Networks

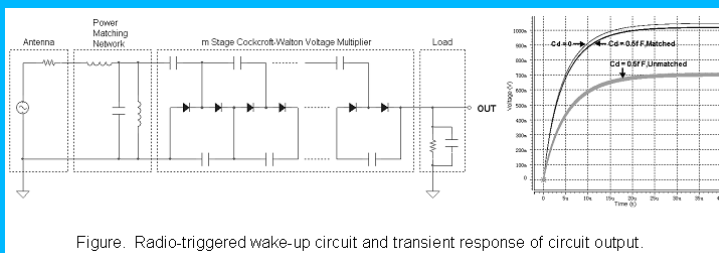


Figure. Radio-triggered wake-up circuit and transient response of circuit output.

Going green means different things to different people, but it generally means reducing pollution; conserving resources and ecosystems; being energy efficient; and reducing climate change. As wireless sensor networks are to be widely deployed in the future, we look into sustainable engineering solutions that incorporate environmental and social constraints as well as economic considerations into engineering decisions. Micro-scale energy harvesting, along with

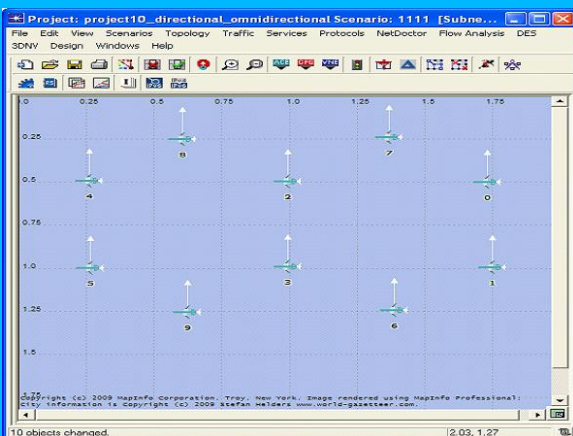
ultra-low-power technology, offers virtually perpetual wireless sensor networks and little or no adverse environmental effects. Micro-energy harvesting systems can scavenge milliwatts from solar, radio, vibrational, thermal and biological sources. The current research starts with wireless networks with energy harvested from radio emission. We have developed analytical models of UHF voltage multipliers under ultra-low-power operating conditions. The models are verified through HSPICE simulations, and are used for design and analysis of radio-triggered wake up circuits (Above figure). With an incident 2.4-GHz signal of less than -30 dBm power, the circuits can produce a voltage above 1 V within tens of microsecond. This dc output switches an inverter of 200 MΩ load and wakes up the rest of the circuits on a wireless node. (Liang Dong)

Vehicular Ad Hoc Network Augmenting GPS Systems

Smart vehicle involves a variety of technologies ranging from basic automotive engineering to vehicle navigation. Global Positioning Systems (GPS) have been widely applied for identifying vehicle positions. However, large positioning errors may occur when the system is used in urban canyon environments, where tall buildings occlude satellite signals as well as reflecting them. There have been some efforts to improve the positioning accuracy: (1) using inertial navigation system (INS) to fill the gaps when GPS signals are temporarily interrupted; (2) using terrestrial television broad-casting or cellular signals for positioning in downtown areas; and (3) reducing the required minimum number of “visible” satellites by modeling the vehicle path in downtown areas and adding this information as a constraint. These possible solutions have their limitations due to cost and other implementation issues. Future smart vehicle systems rely on vehicle-to-vehicle and vehicle-to-roadside-infrastructure communications. The vehicular ad hoc network (VANET) consists of the vehicles as mobile nodes and the roadside elements as anchor/reference nodes. This applied research aims at the development of a VANET that can be incorporated with the GPS to provide reliable navigation services for vehicles in urban canyons. Using pair-wise measurements among neighboring vehicles, the VANET system will generate relative position information of multiple vehicles present in the urban area. This relative map will be incorporated with accurate GPS information provided by, for example, GPS receivers on vehicles at the edge of the downtown area who have good GPS reception, or a few GPS repeaters that are installed on buildings at major intersections of the downtown area (Figure). The hardware modules are to be tested with specifications of dedicated short-range communications for intelligent transportation systems.



There are other cases where GPS is intentionally or unintentionally denied. Conventionally, the INS of vehicles can be calibrated by the GPS to correct integration drift. In GPS-denied environment, alternative means is required for the INS to maintain accurate tracking. When a fleet of unmanned aerial vehicles (UAVs) fly in proximity within GPS-denied environment, the INS drifts could cause serious navigation problems even collisions. As multiple UAVs form an airborne wireless ad hoc network, vehicle relative positions and velocities can be estimated for collective INS calibration. This technique can also be employed in cases when GPS receivers are not available onboard every single UAV due to cost or damage during mission. Fast algorithm is instrumental to adapt to the real-time process for high dynamic vehicles. The theoretical work will be verified through OPNET simulator (Figure). In addition, for a highly dynamic VANET such as that consists of UAVs, mobility-aware opportunistic routing can be adopted for reliable and effective network operation. A fleet of autonomous underwater vehicles (AUVs) can be another example, where positioning and tracking of each vehicle can be achieved with an underwater wireless network using acoustic signals. (Liang Dong)



Wireless Sensor Networks for Disaster Response

Disasters such as earthquakes, storms, floods, fires and terrorist attacks can be of large scale. Situational awareness in a disaster is critical to effective response. As normal organized community support is possibly damaged or destroyed, a wireless ad hoc sensor network can be solution to quick deployment and easy installation. For examples, wireless sensor nodes can be dropped by airplanes to form a networked coverage over an area devastated by a major earthquake (Figure). Various types of life sensors collaborate inter- and intra-node to detect people trapped beneath the rubble. Such a network should be able to support disaster response with distributed collaborative sensing, accurate localization, and topology-aware routing using a multichannel protocol. The information needs to be delivered timely to the disaster responders and rescue teams. Sensing suites use collaborative and distributed mechanisms to optimize data collection and minimize total energy use. For disaster response, multi-target classification, effective data fusion, and prompt and accurate decision making are challenges. This applied research implements decentralized classification in cluster-based wireless sensor networks with non-identically distributed observations. Limited network energy and computational/communication constraints will be considered as design variables. Moreover, the measurement signal strength and the communication signal-to-noise ratio determine the weight for each local decision in the decision fusion. (Liang Dong)

