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ARCHES

2nd Health Care Engineering Systems Symposium

September 14, 2015
I Hotel, Champaign, IL

JumpLabs

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

OSF HEALTHCARE

2nd Health Care Engineering Systems Symposium

Monday, September 14, 2015
Chancellor Room, I Hotel

AGENDA

8:30 AM - 9:00 AM	Arrival of the Participants Breakfast and Registration
9:00 AM - 10:00 AM	**Andreas Cangellaris** Dean, College of Engineering-UIUC Opening of Symposium
	Peter Schiffer Vice Chancellor of Research-UIUC Opening Remarks
	Kevin Schoeplein CEO, OSF Healthcare System Remarks and Presentation of William DiSomma
	William DiSomma Managing Director, Jump Trading Remarks
	T 'Kesh' Kesavadas Director, Health Care Engineering Systems Center Remarks
	John Vozenilek Director, Jump Trading Simulation and Education Center Remarks
	Rashid Bashir Head, Department of Bioengineering Presenting New Medical School
	T 'Kesh' Kesavadas Opening of Presentations

10:00 -10:50 AM John Vozenilek, Moderator	*The Clinical Agenda* Stephen Hippler Senior Vice President of Clinical Excellence, Interim Chief Clinical Officer
	Current Issues Facing Providers of Care Lori Wiegand Chief Nursing Officer, OSF Healthcare System
	The Jump Simulation Research Agenda William Bond Director of Research, Jump Trading Simulation and Education Center, OSF Healthcare System and Professor of Clinical Emergency Medicine, UICOMP
	The Jump Simulation the Advanced Imaging and Modeling Matthew Bramlet Director of the Advanced Imaging and Modeling Program, Jump Trading Simulation and Education Center, OSF Healthcare System and Assistant Professor of Clinical Pediatrics, UICOMP
	Improving 3D Avatar Models for Applications to Healthcare Donald Halpin Director for Human Factors, Jump Trading Simulation and Education Center, OSF Healthcare System
	Innovation as a Strategic Imperative Healthcare Michelle Conger Senior Vice President, OSF Healthcare System, Chief Strategy Officer
	Transformation of Care Delivery to Population Health Jeff Tillery Senior Vice President and Chief Transformation Officer, OSF Healthcare System
	Break
11:00 AM -12:00 Noon Rakesh Nagi, Moderator	*Development of a Robotic Forearm to Simulate Abnormal Muscle Tone Due to Brain Lesions* Elizabeth Hsiao-Wecksler
	Diffuse Optical Imaging of Neural Activity in Humans Gabriele Gratton

Future Trends in Emission Tomography Instrumentations
Ling-Jian Meng

ASPIRE: Automation Supporting Prolonged Independent Residence for the Elderly
Venanzio Cichella

Low-Cost Optical Screening and Diagnostic Instruments for Primary Care
Stephen Boppart

Predictive Healthcare
Ravi Iyer

Towards Resiliency in Cyber-physical Systems for Robot-assisted Surgery
Homa Alemzadeh

Insertable Robot Arm for Minimally Invasive Surgery
Placid Ferreira

3-D Printing of Biological Systems for Tissue Engineering and Biological Soft Robotics
Rashid Bashir

12:00 -1:00 PM

Lunch
Quad room and Lobby

1:15 -2:15 PM
Liz Hsiao-Wecksler, Moderator

Towards a High Speed 3D Nonlinear Soft Tissue Deformation Simulation
Iwona Jasiuk

Simulating Fracture Reduction: The Importance of Passive Tissues for Restoring Joint Motion
Mariana Kersh

High Fidelity Methods for Blood Flow Simulation in Patient-specific Geometries: Blue Waters Platform and Massively Parallel Computing
Arif Masud

Intelligent Assistive Robots for Rehabilitation and Surgery
Pramod Chembrammel

Fracture Resistance of Biological Tissues: A Theoretical and Experimental Study
Ange Therese Akono

Point of Care Sensors for Early Sepsis Stratification
Bobby Reddy Jr.

CyPhy - 3D Teleimmersion for Home-Care Rehabilitation
Klara Nahrstedt

Patient Discharge Process and Communications Simulation Training
Deborah L. Thurston

Annual Rotation Schedules in Real-Time: Simplifying Life for an Internal Medicine Residency Program
Sheldon Jacobson

Break

2:25 -3:25PM
Klara Nahrstedt, Moderator

Conversational Agents and Comprehension of Self-Care Information in EHR Patient Portals
Dan Morrow

Fall Risk Assessment: The Potential for Home-based Technology
Jacob Sosnoff

Chemical Imaging and Printed Structures for Pathology
Rohit Bhargava

Reducing the Duration and Severity of Multiple Sclerosis Exacerbations in a Rat Model through Ultrasound-Based Lymphocyte Depletion
Michael Oelze

MRI-based Modelling of Traumatic Brain Injury
Martin Ostoja-Starzewski

Software Testing for Healthcare Software
Darko Marinov

3D Imaging and Augmented Reality for Health Care
Minh Do

Lifestyle Disease Surveillance via Social Media
Lav Varshney

Using Magnetic Resonance Imaging to Study the Speech Neuromuscular System
Brad Sutton

Application of 3D Avatar in Health
Thomas Huang

Break

3:30 - 4:30 PM **Poster Session-Lobby of Chancellor Room**

Role of Self Performed Ambulatory Electrocardiogram (ECG) by Patients in Assisting On Demand Consultation to Rule Out Life Threatening Conditions
Sandeep Banga

A mHealth Technology for Preventing Shoulder Injury in Manual Wheelchair Users
Adam Burns

Soft, Hydrated Matter Lubrication
Alison C. Dunn

Biomimicry for Healthcare Applications: Bone as an Example
Ahmed Elbanna

Toward Fast and Inexpensive DNA Sequencing: Intrinsic Stepwise Translocation of Stretched ssDNA through Graphene Nanopores
Qiu Hu

Perceived Pitch Shifts Elicit Vocal Corrections in Cochlear Implant Patients
Torrey Loucks

Predictive Modeling and Uncertainty Quantification for Engineered and Natural Complex Systems
Hadi Meidani

Spatial Light Interference Microscopy for Quantitative Biomedicine
Gabriel Popescu

Health Monitors for Chronic Disease by Gait Analysis with Mobile Phones
Bruce Schatz

Therapeutic Video Games
Rizwan Uddin

4:30 PM **Reception at Jump Labs**
2100 Oak Street, Research Park
(http://researchpark.illinois.edu/directory/jump-labs)

SYMPOSIUM INFORMATION

Internet Access

The Wi-Fi is free! You may connect to UI Public for access.

Organizing Committee

Pramod Chembrammel
T 'Kesh' Kesavadas
Jeff Ludwig
Tony Michalos
Paul Pribaz
John Vozenilek

The organizing committee would like to thank Michelle L. Osborne, and Daniel G. Hammerton for aiding the preparation of the symposium.

The organizing committee also wishes to thank Jump Labs for hosting the reception following the symposium.

For more information about the ARCHES program visit:

Health Care Engineering Systems Center: http://healtheng.illinois.edu/

Jump Simulation & Education Center: http://www.jumpsimulation.org/

The Clinical Agenda

Stephen Hippler
Senior Vice President of Clinical Excellence and Interim Chief Clinical Officer OSF HealthCare System

Dr. Hippler will present an overview of OSF's clinical agenda with respect to both research goals and patient outcome metrics.

Stephen Hippler, MD is the Interim Chief Clinical Officer and Senior Vice President for Clinical Excellence. He is responsible for several Ministry Services departments including: Clinical Quality Reporting, Clinical Quality and Effectiveness, Regulatory Readiness, Patient Safety and Clinical Research. Additionally, he continues with his current set of responsibilities as the Vice President of Quality and Clinical Programs for OSF Medical Group.

Dr. Hippler has been connected to The Sisters of the Third Order of St. Francis since 1988 when he joined the Medical Staff at OSF Saint Francis Medical Center upon completion of his residency training in Internal Medicine at the Mayo Graduate School of Medicine in Rochester, MN. He earned his Doctor of Medicine Degree from the University of Illinois College Of Medicine. Dr. Hippler is Board Certified by the American Board of Internal Medicine. He has authored articles about diabetes in professional medical journals and is a frequent presenter of continuing education topics throughout Central Illinois. He has participated in more than 50 clinical trials as a principal investigator and also serves on the board of directors for numerous non-profit community organizations.

Current Issues Facing Providers of Care

Lori Wiegand
Chief Nursing Officer, OSF HealthCare System

Dr. Wiegand will present an overview of the clinical challenges facing nursing practice and the complexities of a highly technology-driven clinical environment.

Lori Wiegand, MS, RN, DNP, is the Chief Nursing Officer for the OSF HealthCare System. As the Chief Nursing Officer, she is responsible for the practice of nursing, Ministry-wide, to ensure consistency in the standard of practice across the clinical settings, and to support and facilitate an interdisciplinary team approach to the delivery of care by creating a nursing environment in which collaboration is valued and excellence in clinical care and education is promoted and achieved. The CNO endorses and advocates for the continued advancement of the profession of nursing at OSF HealthCare.

Dr. Wiegand started her career at OSF Saint Francis Medical Center as an RN on the Medical Nursing Unit. Within two years, she was promoted to be a Charge RN on a Medical Nursing Unit, a position she held for five years until she shifted to a new role as a 6 Sigma Black Belt and, within one year, as a Master Black Belt. Wiegand was responsible for the effective deployment of 6 Sigma at OSF Saint Francis for patient care services as well as development of the Nursing Strategic Plan that included unit scorecards with cascaded outcome metrics. In 2007, she was promoted to become the Director of Nursing Operations and Care Management, and in 2009, she advanced to the position of Vice President Patient Care, Chief Nursing Officer. Lori was named Senior Vice President, Chief Nursing Officer for OSF Healthcare in September 2013.

Dr. Wiegand earned her Doctorate in Nursing Practice from the University of Miami, Miami, FL. She has a Master's Degree in Nursing Administration from Drexel University, Pittsburgh, PA and a Bachelor's of Science in Nursing from the University of St. Francis, Joliet, IL.

The Jump Simulation Research Agenda

William Bond
Director of Research, Jump Trading Simulation and Education Center
OSF Healthcare System and Professor of Clinical Emergency Medicine, UICOMP

Dr. Bond will present an overview of the research curriculum and future research agenda for the Jump Trading and Simulation Center, including the development and achievement of critical research milestones.

William Bond MD, MS is the Director of Simulation Research for Jump Trading Simulation and Education Center, a collaboration between OSF HealthCare and the University of Illinois College of Medicine at Peoria. He was previously Medical Director of Education Technology in the Division of Education in at Lehigh Valley Health Network (LVHN), a role that included direction of the LVHN Interdisciplinary Simulation Center (LVHNISC). He also served as Designated Institutional Official (DIO) and Chair of the Graduate Medical Education Committee (GMEC) for LVHN.

Dr. Bond was deeply involved in patient safety efforts at LVHN. He was a member of the LVHN Central Venous Catheter Process Improvement Committee and the LVHN Performance Improvement Committee. His past efforts include the successful network-wide deployment standardized airway carts and color coded pediatric code carts. He has mentored and initiated simulation efforts to improve patient safety throughout LVHN, including in situ, procedural, and inter-professional simulation.

Within the field of simulation Dr. Bond has developed areas of expertise including patient safety and cognitive error. This has led to peer-reviewed publications and invited speaking opportunities at the local, state, and national level. In regard to faculty development, Dr. Bond has created, produced, or facilitated various lectures, workshops, and courses. He serves as the Chair of the Society for Academic Emergency Medicine Simulation Academy.

The Jump Simulation the Advanced Imaging and Modeling

Matthew Bramlet
Director of the Advanced Imaging and Modeling Program,
Jump Trading Simulation and Education Center,
OSF Healthcare System
Assistant Professor of Clinical Pediatrics, UICOMP

Dr. Bramlet will present an overview of his involvement with advanced imaging and modeling technologies at the Jump Simulation Center and how these technologies are linked to improved patient outcomes in a variety of specialties.

Matthew Bramlet, MD is a pediatric cardiologist at Children's Hospital of Illinois, specializing in congenital cardiac MRI. He is also an Assistant Professor of Pediatrics at the University of Illinois College of Medicine at Peoria. His clinical training specialized in children with congenital heart disease which focuses on complex hemodynamic relationships of anatomy and physiology related to the human circulatory system. He became certified in Advanced Pediatric Cardiovascular Magnetic Resonance Training and took a position at the Children's Hospital of Illinois to develop the Congenital Cardiac MRI program as director.

Dr. Bramlet developed a state of the art congenital cardiac MRI program which ultimately led to research collaborative agreement with GE Healthcare. With a focus on 3D SSFP high quality imaging sequences, he combined resources with Jump Trading Simulation and Education Center to pioneer anatomically accurate 3D congenital cardiac models resulting in improved surgical planning through improved complex anatomic understanding. His expertise in this area propelled us into a curator role of the NIH's 3D print exchange's Heart Library, a nationwide collaborative effort to improve the education and understanding of congenital cardiac anatomy through an open science initiative to build a comprehensive library of congenital cardiac 3D digital models.

These successes transformed Dr. Bramlet's focus into a primarily research role as Lead Investigator of Advanced Imaging and Modeling through Jump Trading Simulation and Education Center.

Improving 3D Avatar Models for Applications to Healthcare

Donald Halpin
Healthcare Systems Engineering Consultant, Jump Trading Simulation and Education Center, OSF Healthcare System

Ann Willemsen-Dunlap, PhD, CRNA
Director, Interprofessional Education
Jump Simulation and Education Center

While many patients have a positive attitude toward Personal Health Record systems (patient portals), many more lack the medical knowledge to understand the messages and results delivered there. Thus, patient portals remain underutilized, despite being made a top development priority by the U.S. government. To improve the usability of patient portals, we propose to integrate 3D avatars with speech capability into traditional portal systems. We expect this to increase the usability of such portals by mitigating gaps in patients' health literacy, thereby increasing the effectiveness of Personal Health Record systems as a communication tool between patients and their clinical care providers.

In this project, we propose to further improve 3D avatar technology as a tool to deliver medical information such as test results and medical guidance in order to help patients better understand medical information. The main research goal is to make the avatar appear and sound more realistic by expanding on last year's work to improve the naturalness of lip movements associated with speech and emotion via expressive speech synthesis. Further, we will explore how accurately medical students assign emotions to these improved avatars, based on the medical information that the avatar will deliver. To explore the Uncanny Valley phenomenon, different appearances of the avatar will be presented to patients to learn which one is most acceptable to them.

Future directions for the research team include using their discoveries regarding the Uncanny Valley and the science of affective computing to develop relational avatars capable of providing guidance and support to young adolescents and their families who are navigating the challenges associated with moving from parent-directed care to self-care in Type I diabetes.

Don Halpin is a Healthcare Systems Engineering Consultant at the Jump Trading Simulation & Education Center in Peoria, IL. He earned his MS in Aeronautical Sciences from Embry-Riddle Aeronautical University in 1995 and his BS in Electrical Engineering from the US Air Force Academy in 1984. His work at Jump focuses on interprofessional education development and socio-technical innovation. Prior to joining Jump, he retired from the USAF after a 28 year aviation career which included two command tours, deployments, a Pentagon tour in strategic planning & assessments, political-military affairs at US Pacific Command, and a defense officer fellowship at the Hoover Institute, Stanford University, CA.

Ann Willemsen-Dunlap completed both her nurse anesthesia training and PhD in Science Education from the University of Iowa where she accepted a dual appointment in the College of Nursing and College of Medicine. She currently serves as the Director of Interprofessional Education at Jump Trading Simulation and Education Center, working in interprofessional education, the neurodynamics of healthcare team interaction, and healthcare safety management. She continues to practice as a nurse anesthetist as OSF Medical Center in Peoria, IL.

Innovation as a Strategic imperative Healthcare

Michelle Conger
Senior Vice President and Chief Strategy Officer OSF Healthcare System

Ms. Conger will present an overview of the OSF Healthcare system strategy; the strategic importance of innovation to the future healthcare delivery model and how ARCHES is connected to that work.

Michelle Conger is Senior Vice President and Chief Strategy Officer for OSF Healthcare System. She has over 20 years of healthcare leadership experience and has been in her current position since 2010. In this role, she has the responsibility for partnering with the CEO, board and leadership in the ongoing generation and refinement of the long term strategy which defines the competitive positioning of OSF Healthcare services. Along with these responsibilities, she also assists the organization and its leadership in ensuring the alignment of key strategic initiatives as well as marketing and business development plans.

In her current position, Michelle has led the creation of OSF Healthcare System's innovation agenda including health technology incubation, usability and simulation strategies, and venture capital investment strategies. She has led many transformation initiatives across the System including the implementation of Epic, organizational design transformation, population health strategy development, and the creation of a system wide program management office. Her past roles have included Senior Vice President, Performance Improvement Division (2008-2010), and Executive Director of Planning for the Information Technology division (2006-2008). Her professional accomplishments also include achieving a 6 Sigma Black Belt (2002) and 6 Sigma Master Black Belt (2003). Michelle has a Master's degree in psychology/social work from the University of Illinois.

Transformation of Care Delivery to Population Health

Jeff Tillery
Senior Vice President and Chief Transformation Officer, OSF Healthcare System

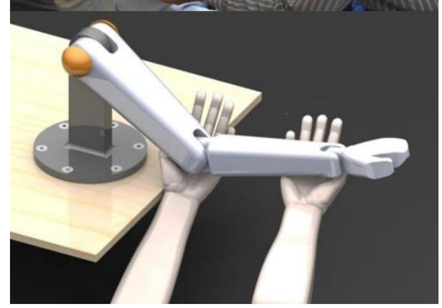
Dr. Tillery will present an overview of work underway within OSF Healthcare to transform healthcare delivery models to better meet the needs of our diverse community populations while integrating innovative technologies, expanding care teams and focusing on the holistic needs of the people we serve.

Jeff Tillery, MD currently serves as Chief Transformation Officer of OSF Healthcare System. In this role, he is responsible for shaping strategies and finding innovative care model solutions to advance the OSF Healthcare Mission and Vision. Dr. Tillery works in partnership with physicians and other clinical staff to grow and sustain an integrated healthcare delivery system.

Prior to this position, Dr. Tillery served as the Vice President and Chief Medical Officer for OSF Healthcare-Northern Region. In that role, he had oversight of a growing multi-specialty group as well as development and acquisition of multiple new practices. He delivered recruitment and retention of scores of clinicians, fully implemented and optimized Electronic Health Records, restructured the functional leadership of the region, and had driven outstanding quality and safety outcomes. He has led the development of a successful Physician Leadership Academy, acted as the OSF Medical Group Performance Improvement Champion and is the Ministry Champion for TeleHealth Services. More recently he has led a collaborative effort to advance the innovation competency for OSF Healthcare.

Development of a Robotic Forearm to Simulate Abnormal Muscle Tone Due to Brain Lesions

Elizabeth T. Hsiao-Wecksler
Professor
Department of Mechanical Science and Engineering
ethw@illinois.edu



This ARCHES-funded project is creating a novel robotic training simulator to afford healthcare students, residents, and young clinicians' opportunities to practice feeling and identifying abnormal muscle tone behaviors. These behaviors are observed during clinical examinations of patients with brain lesions, such as Parkinson's disease, multiple sclerosis, and stroke. Specifically, we are developing a forearm simulator for mimicking different levels of abnormal muscle behaviors (spasticity and rigidity) in the elbow. Since these hypertonic muscle behaviors display increased muscle resistance that are speed or position dependent, we are taking a new design approach. We seek to advance device design in a completely novel way by utilizing tunable fluids combined with creative flow geometry designs to mimic these behaviors. Our team also mentored two Mechanical Engineering senior design teams at Bradley University during AY 2014-2015. One team developed a preliminary prototype to quantitatively measure spasticity and rigidity in patients; the other prototyped a pneumatic training simulator. This project brings together a large team of clinicians, researchers and students from the University of Illinois' Colleges of Engineering at Urbana-Champaign and Medicine at Peoria, OSF HealthCare, Illinois Neurological Institute, and Bradley University.

Reference:

Heinrich, M, Mattson, C, Ramuta, M, Stock, J Liang, J, Morris, MJ, Tippett, SR, Hsiao-Wecksler, ET, and Henderson, J. "Pneumatic Elbow Simulator of Spasticity and Rigidity for Training of Healthcare Clinicians", 2nd Fluid Power Innovation and Research Conference (FPIRC), Chicago, IL, October 14-16, 2015.

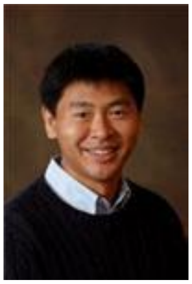
Liz Hsiao-Wecksler is the newly appointed Associate Head for Undergraduate Programs in the Department of Mechanical Science & Engineering. She is an affiliate of Bioengineering, Industrial & Enterprise Systems Engineering, Neuroscience Program, the Beckman Institute, Center on Health, Aging and Disability, and the multi-institutional NSF Engineering Research Center for Compact and Efficient Fluid Power. Her research addresses locomotion biomechanics and assistive device design & development with a focus on investigating and improving movement control and function in able- bodied and disabled populations. Her research program has been supported by agencies such as the NSF, NIH, and Dept. of Homeland Security. She has published over 60 peer-reviewed journal papers and extended conference proceedings, and over 110 conference abstracts/presentations. She is currently prosecuting 3 US patents, graduated 8 PhD, 21 MS and over 90 undergraduate students and created 1 small business

Diffuse Optical Imaging of Neural Activity in Humans

Gabriele Gratton
Professor
Department of Psychology and Beckman Institute
grattong@illinois.edu

The most commonly used methods for measuring neural activity of the human brain provide data with either high spatial resolution but limited temporal resolution (functional magnetic resonance imaging, fMRI) or high temporal resolution but limited spatial information (electroencephalography, EEG, and Event-Related Brain Potentials (ERPs). In our lab we have investigated a different approach based on detecting changes in light scattering that are associated with neural activity with diffuse optical methods. These methods are based on measuring changes in how near- infrared light propagates through the brain as a function of changes in the scattering and absorption properties of brain tissue. In a series of studies conducted in our lab we have demonstrated that this approach enables us to provide images of brain activity with a spatial resolution 5-10 mm and a temporal resolution of 8-20 ms. The technique is completely non-invasive and can be applied to very different populations, from premature infants (which can be imaged inside their incubator) to young infant, to normal and older adults. These data can be used to assess the dynamics of recruitment of different cortical regions during a large variety of psychological tasks.

Gabriele Gratton is a Professor in the Department of Psychology at the UIUC, with appointments in Neuroscience and Bioengineering. He earned his M.D. degree from the Universita' di Roma La Sapienza and a Ph.D. in Psychology from the University of Illinois. Before joining the University of Illinois, he has been an Assistant Professor at Columbia University in New York and an Assistant and then Associate Professor at the University of Missouri-Columbia. He has been President of the Society for Psychophysiological Research (2009-2010) and is a Fellow of the Association for Psychological Science. His list of awards includes an Early Career Award from the Society for Pscyhophysiological Research.

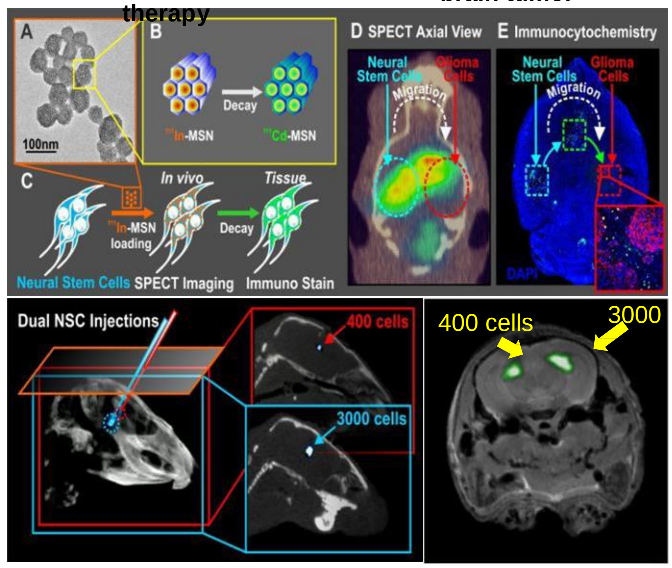


Future Trends in Emission Tomography Instrumentations

Ling-Jian Meng
Associate Professor
Department of Nuclear, Plasma and Radiological Engineering
ljmeng@illinois.edu

Nano-engineered neural stem cells for glioblastoma therapy

In vivo studies of the migration of NSCs towards brain tumor



CT-SPECT imaging of NSCs in mouse brain

MR-SPECT

Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) are among the most commonly used molecular imaging techniques for both clinical and pre-clinical studies. Interestingly, throughout their long history that dates back to more than half a century ago, emission tomography (especially SPECT) have been sentenced for numerous times as "dying" modalities, especially when compared to other *in vivo* imaging techniques, such as CT and MRI. So what would be the future directions for emission tomography instrumentations?

This presentation will be focused on several recent technological developments that were specifically designed to address the shortcomings of modern emission tomography instrumentations. These developments are based on state-of-art semiconductor gamma ray detectors and new system design concepts that could allow future SPECT and PET systems to offer a dramatically lowered detection limit, a significantly improved spatial resolution and the ability to work simultaneously with other imaging modalities (such as MRI and optical imaging). In addition, we are exploring a "smart" emission tomography technique that allows certain control of the signal-emission process and therefore a greatly simplified image formation. This technique could potentially be used for 3-D mapping of trace metals in biological samples, and for real-time monitoring the delivery of anti-cancer therapies (PDT).

Ling-Jian Meng obtained his PhD degree from the Department of Physics at the University of Southampton, UK in 2002. From 2002 to 2006, he has been working in the Department of Radiology and the Department of Nuclear Engineering at the University of Michigan, Ann Arbor, as an Assistant Research Professor. Dr. Meng joined the University of Illinois at Urbana- Champaign (UIUC) in 2006, and is currently an Associate Professor in the Department of Nuclear, Plasma and Radiological Engineering, and an affiliate faculty of the Department of Bioengineering, and the Beckman Institute of Advanced Science and Technology. He is also a Visiting Associate Professor of the Massachusetts General Hospital (MGH), and the Associate Editor of the IEEE Transaction of Medical Imaging (TMI). Dr. Meng's research interests are focused on the development of nuclear imaging instrumentations for biomedical, astrophysics and security applications.

ASPIRE: Automation Supporting Prolonged Independent Residence for the Elderly

Venanzio Cichella
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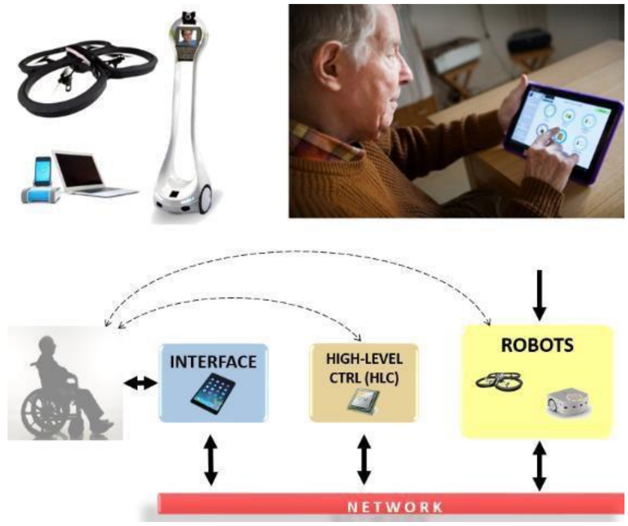
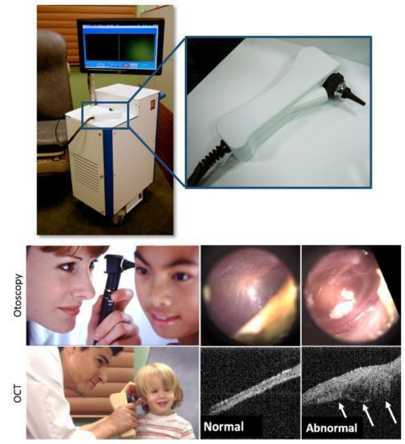


In the not too distant future, multiple cooperative robots will be helping the elderly population and people with disabilities with everyday activities, improving the quality of their lives by enabling them to live at home longer with increased independence. In order to assist humans, the robots have to be trusted by humans, implying that their behavior has to be predictable and consistent with principles of human spatial perception, and their appearance must foster a high level of comfort and not create high cognitive demands on the user. Inspired by these challenges, this talk discusses the design and control problems of cooperative ground and flying robots, which are required to adapt to unstructured and rapidly changing environments in a manner consistent with human perception and cognition, thus enhancing safety and robustness. The key focus areas include the design and acceptance of mobile ground and aerial robots that coexist in environments inhabited by humans, and the development of a multi-objective control framework to allow intuitive user control over an ensemble of cooperative robots that includes the design of both low-level controllers and a supervisory, high-level controller. The research aims to establish basic principles for safe interaction of humans, ground robots and miniature drones.

Venanzio Cichella received his M.S. in Automation Engineering in 2011 from the University of Bologna. Before that he spent 9 month at TU Delft as an Erasmus student, and 1 year at the Naval Postgraduate School as a visiting scholar and research assistant. In 2011 he started working on control of autonomous vehicles at the Naval Postgraduate School. In 2012 he moved to the University of Illinois at Urbana-Champaign, where he is currently a Ph.D. candidate in the Department of Mechanical Engineering. In 2015, he received the Ross J. Martin Memorial Award from the College of Engineering at UIUC for outstanding research achievement. His research interests include cooperative control of autonomous aerial and ground robots, collision avoidance, nonlinear systems, robust and adaptive control.

Low-Cost Optical Screening and Diagnostic Instruments for Primary Care

Stephen Boppart, M.D., Ph.D.
Director, *Imaging at Illinois*
Departments of Electrical and Computer Engineering, Bioengineering, and Medicine
Beckman Institute for Advanced Science and Technology
boppart@illinois.edu

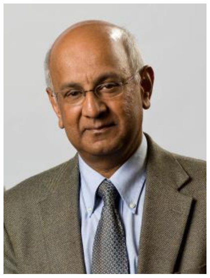


There is an important need for improving point-of-care screening technology, particularly in primary care medicine and for *our front-line health care providers.* Currently, such technologies are quite rudimentary, relying heavily on the senses of the health care provider and instruments such as the stethoscope, otoscope, and ophthalmoscope. As optical instruments, the otoscope for examining the ears and the ophthalmoscope for examining the eyes consist largely of magnifying optics and illumination to visualize the surface features of tissues. These observations, as well as the experience and subjective interpretation by the health care provider, are used for making an assessment and diagnosis. Advances in optical imaging technology have made it possible to visualize and quantify tissue microstructure in new ways. Optical coherence tomography (OCT) performs optical ranging in tissue by collecting depth-resolved reflections of light in an manner analogous to ultrasound imaging, except with spatial resolutions on the order of 5-10 microns. OCT can therefore perform label-free "optical biopsies" of tissue by generating cross-sectional sub-surface images of tissue microstructure with resolutions that approach those of histopathology (Figure).

With the development of low-cost optical screening instruments for the ear and eye, and the availability of new screening and diagnostic information, efforts must now be directed toward investigating the adoption and integration of these new technologies into the current standard-of-care, patient workflow, referral guidelines, disease management, and overall patient outcomes.

References: http://biophotonics.illinois.edu

Stephen Boppart is an Abel Bliss Professor of Engineering. His Biophotonics Imaging Laboratory is focused on developing novel optical biomedical diagnostic and imaging technologies and translating them into clinical applications. Prof. Boppart received his Ph.D. in Medical and Electrical Engineering from MIT, his M.D. from Harvard Medical School, and completed residency training at the University of Illinois in Internal Medicine. Since joining the faculty in 2000, he has published over 300 invited and contributed publications and over 40 patents related to optical biomedical imaging technology. He has mentored over 100 undergraduate, graduate, and post-graduate interdisciplinary researchers. He was recognized by MIT's Technology Review Magazine as one of the Top 100 Young Innovators in the World for his development of medical technology, and received the Paul F. Forman Engineering Excellence Award from the Optical Society of America for dedication and advancement in undergraduate research education. More recently, he received the international Hans Sigrist Prize in the field of Diagnostic Laser Medicine. He was Founding Director of the Mills Breast Cancer Institute at Carle Foundation Hospital, Urbana, Illinois, and has worked to establish and strengthen partnership ties between the University of Illinois and local medical institutions. Prof. Boppart has co-founded three start-up companies (LightLab Imaging, Diagnostic Photonics, and PhotoniCare) to commercialize and disseminate his optical technologies for biomedical imaging. He is a Fellow of AAAS, AIMBE, IEEE, OSA, and SPIE. Currently, he is Director of a campus-wide Imaging at Illinois initiative to integrate imaging science, technology, and applications across multiple modalities and fields, and has been a strong supporter for the integration of engineering and medicine in our newly established engineering-based College of Medicine at the University of Illinois at Urbana-Champaign to advance human health and our healthcare systems.



Predictive Heath: Data Driven Analytics and Systems

Ravishankar K. Iyer
George and Ann Fisher Distinguished Professor of Engineering Department of Electrical and Computer Engineering Department of Computer Science and Coordinated Science Laboratory
University of Illinois at Urbana-Champaign

With advances in computing systems, networking and storage, and sensing technologies, important trends are emerging in the area of health and medicine:

1) We are rapidly moving into an era where smart and connected devices are changing many aspects of health care and well-being. In medical and health care, there is a significant increase in the deployment of medical cyber-physical systems such as implantable pacemakers, defibrillators, wearable health-monitoring devices, complex patient monitors in the intensive care units combined with expensive systems for radiation therapy and robotically-assisted surgery.

2) We are experiencing an unprecedented increase in the availability and use of genomics and other -omics data. While accurate and accelerated analysis of such large amounts of genomic data presents many challenges, it generates significant additional data that must be analyzed. The impending bottleneck will be subsequent analyses: *extracting actionable intelligence that can be used to tailor medical diagnosis, surgery, and treatment.*

This talk will describe our research on data-driven predictive analytics addressing both rapid analysis of real time multi-dimensional data as well as longer-term predictive methods based on deeper analysis We will discuss example applications including, chronic diseases such as seizures as well as in patient-centric genomic analysis in specific cancer treatments.

Ravishankar Iyer is the George and Ann Fisher Distinguished Professor of Engineering at the University of Illinois at Urbana-Champaign. He holds joint appointments in the Department of Electrical and Computer Engineering, the Coordinated Science Laboratory (CSL), and the Department of Computer Science, and serves as Chief Scientist of the Information Trust Institute. Iyer has led several large successful projects funded by NASA, DARPA, NSF, and private industry. He currently co-leads the CompGen Center at Illinois. Funded by NSF and partnering with industry, hospitals, and research labs, CompGen is building a new computational platform to address both accuracy and performance issues for a range of genomics applications. Professor Iyer is a Fellow of the American Association for the Advancement of Science, the IEEE, and the ACM. He has received several awards including the American Institute for Aeronautics and Astronautics Information Systems Award, the IEEE Piore Award, and the Outstanding Contributions award of the ACM - Special Interest Group on Security. He is also the recipient of a degree of Doctor Honoris Causa from Toulouse Sabatier University in France.

Towards Resiliency in Cyber‐physical Systems for Robot‐assisted Surgery

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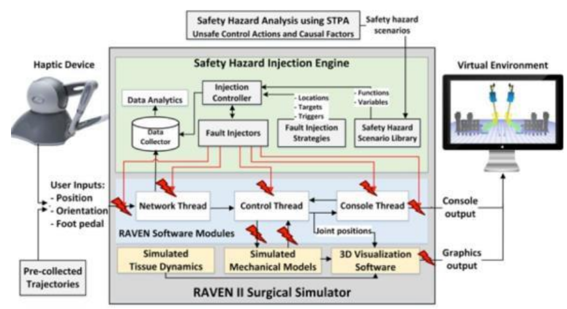
Robotic surgical systems are among the most complex medical cybe-physical systems on the market. During the past 14 years, they have been used in over 1.75 million minimall-invasive procedures in the U.S. across various surgical specialties, including gynecological, urological, general, cardiothoracic, and head and neck surgery. Increasing complexity and sophistication of surgical robots, especially their rapidly growing deployment in hospitals and widespread use in a variety of surgical procedures, makes their resiliency (i.e., the ability to maintain an acceptable level of safe operation despite accidental faults and malicious attacks) a challenging task. Even though stat—of-the-art robotic surgical s y stem s are designed with safety mechanisms that detect failures and put the system into a safe state, there have been ongoing occurrences of safety incidents during procedures that negatively impact patients.

We present our research on measurement-driven resiliency assessment of robotic surgical systems. We discuss i) the design challenges and opportunities in the context of our large-scale study of real failures and safety incidents reported to the U.S. Food and Drug Administration; and ii) the use of systems-theoretic hazard analysis and software fault-injection techniques for evaluating the resilience of the next-generation of tele-operated surgical robots to safety and security vulnerabilities.



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Homa Alemzadeh is a Ph.D. candidate in Electrical and Computer Engineering and a Graduate Research Assistant at the Coordinated Science Laboratory at the University of Illinois at Urbana‐Champaign. Her research interests are in measurement‐driven assessment and design of medical cyber‐physical systems and large‐scale data analytics for system resiliency. Alemzadeh is a student member of IEEE, the IEEE Computer Society, and the IEEE Engineering in Medicine and Biology Society.



Insertable Robot Arm for Minimally Invasive Surgery

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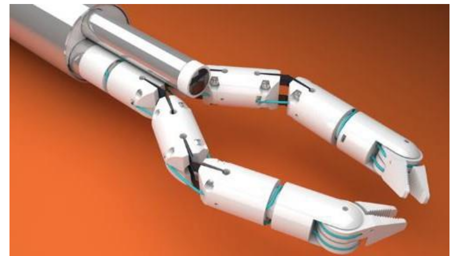
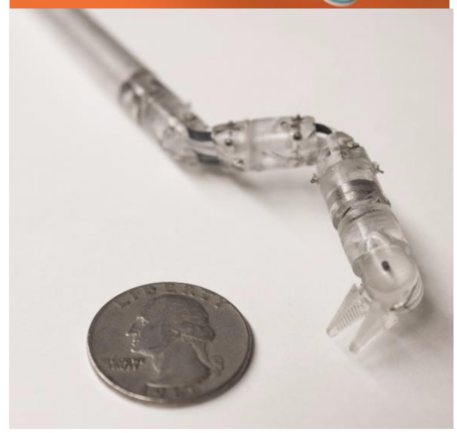

Medical robots are becoming increasingly common for laparoscopic or minimally invasive surgery (MIS) procedures as they offer more precision, flexibility and control than conventional techniques. Minimally invasive robotic platforms such as the Da Vinci surgical system, DLR MIRS, and RAVEN are currently available. A common characteristic of these systems is the implementation of one or many large robotic arm(s) in the operating room, to position and orient the trocar in the vicinity of the incision, and a 1 or 2 DOF manipulator in vivo. In addition to occupying a large space in the operating room, this approach leads to the fulcrum effect which adds to control complexity and restricts the mobility of the robot inside the patient. We envision a minimally invasive robotic system capable of reproducing the large workspace and dexterity of the human arm completely in vivo. This approach has the potential to enhance the set of motions available to the surgeon while eliminating the need for a large external robotic arm. The prototype presented in this work consists of a tendon-driven robot arm with a 9mm outer diameter allowing insertion through common laparoscopic trocars. The arm has 5+1 completely decoupled DOF enabling the control of the position and the pointing direction of the tool. The joints in the robot are designed as large-displacement, hybrid flexures. Early results of this work include a test of a preliminary control algorithm and kinematics. In this test a motion capture system (Optotrack) was used as controller input, and later mapped to the joint space through the inverse kinematic solution. Our future work includes an improved mechanical design to reduce tendon friction and slack, improved controller design to compensate for joint coupling, a teleoperation scheme for real-time input and embedded sensors for feedback.

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Placid Ferreira is the Tungchao Julia Lu Professor of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign. His research interests are in micro and nano-systems design and manufacturing.

Nicholas Toombs is a graduate student working towards an M.S. (Mech. Eng.) degree. He received his B.S. (Mech. Eng.) from University of Illinois in 2014.

Jorge Correa is a Ph.D. student in Mechanical Science and Engineering at Illinois. His research is in hybrid laminated structures for micro-systems.

3-D Bio-Printing of Biological Systems for Tissue Engineering, Biological Soft Robotics, and Organ Mimics for Surgery

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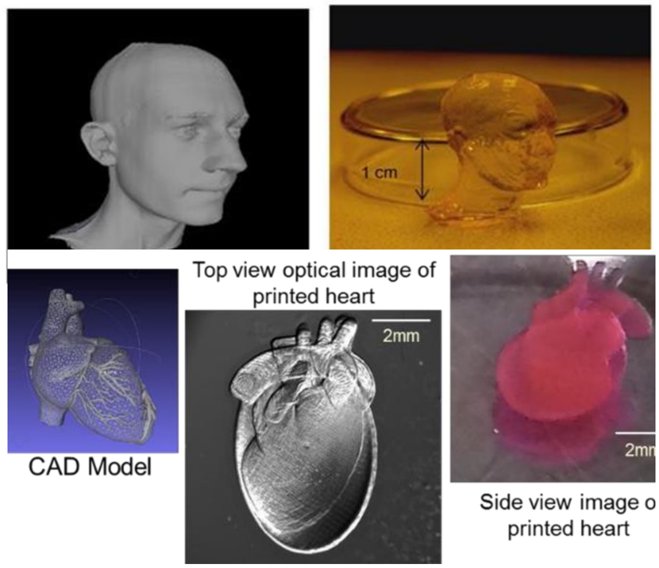

The integration of living cells with soft scaffolds can enable the fabrication of tissue constructs, soft robotics, and organ mimics for surgery. These cell-based biological machines can be defined as a set of sub-components consisting of living cells and cell-instructive micro-environments that could eventually mimic organ functions and perform a range of prescribed tasks. We have fabricated biological actuators made from hydrogels, cardiomyocytes, and skeletal muscles, using a 3D printer. The multi-material systems consisted of a 'biological bimorph' cantilever structure as the actuator to power the device, and a base structure to define the asymmetric shape for locomotion. The cantilever structure was seeded with a sheet of contractile cardiomyocytes. We will also describe the development of a 3D-printed electrically paced skeletal muscle based 'bio-bot' devices where skeletal myoblasts embedded in ECM proteins compacted around a hydrogel structure were used to create the power source of the biological walking machine. We have also developed 'optogenetic' bioactuators that can produce force and motion using optogenetically transfected skeletal muscle cells. These technologies and devices could have potential applications in drug delivery, power generation, and especially as organ mimics for training and simulations of surgical procedures.

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Rashid Bashir is the Abel Bliss Professor of Bioengineering and Department Head. He was the Director of the Micro and Nanotechnology Laboratory (a campus wide clean room facility) at the University of Illinois, Urbana-Champaign, and Co-Director of the campus wide Center for Nanoscale Science and Technology, a collaboratory aimed to facilitate center grants and large initiatives around campus in the area of nanotechnology. He has authored or co-authored over 200 journal papers, over 200 conference papers and conference abstracts, over 120 invited talks, and has been granted 34 patents. He is a fellow of IEEE, AIMBE, AAAS, and APS. His research interests include BioMEMS, Lab on a chip, nano- biotechnology, interfacing biology and engineering from molecular to tissue scale, and applications of semiconductor fabrication to biomedical engineering, all applied to solve biomedical problems. He has been involved in 2 startups that have licensed his technologies. He has been involved in the realization and the founding of the Health Care Systems Center and the ARCHES partnership from its inception.

Towards High Speed Soft Tissue Deformation Simulations

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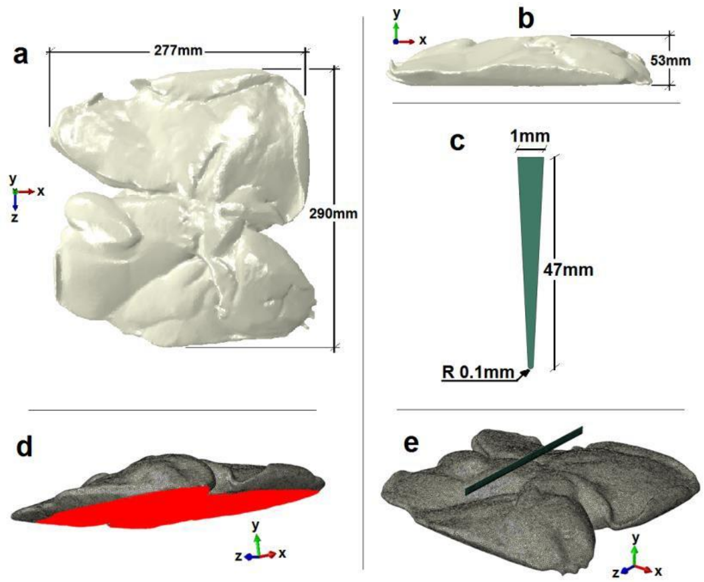
Modeling of soft tissue deformations under surgical tools can be used for surgery planning and training of surgical residents. We studied how to achieve fast and accurate 3D simulation of porcine liver deformation under a surgical tool using finite element software Abaqus. Nonlinear constitutive law was employed to capture large deformations. Effects of implicit versus explicit analysis schemes, element type and mesh density on computation time and accuracy of results were studied. Analysis involved applying a vertical displacement to the surgical knife (Figure 1). We found that Abaqus explicit and implicit solvers can simulate soft tissue deformations accurately using first order tetrahedral elements in a relatively short time by optimizing element size.



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A. Idkaidek and I. Jasiuk, “Towards High Speed 3D Nonlinear Soft Tissue Deformation Simulations using Abaqus Software,” *Journal of Robotic Surgery*, in revision.

Iwona Jasiuk is a professor of mechanical engineering and holds affiliate positions at the Department of Bioengineering and the Institute of Genomic Biology. Her expertise is in the multiscale characterization and modeling of biological and engineering materials. Her research projects in biomechanics include multiscale mechanics of bone (prediction of bone strength), bone adaptation and bone regeneration, and modeling of soft tissue deformations. She is also a site Director of the NSF I/UCRC on Novel High Voltage/Temperature Materials and Structures.

Simulating fracture reduction: The importance of passive tissues for restoring Joint motion

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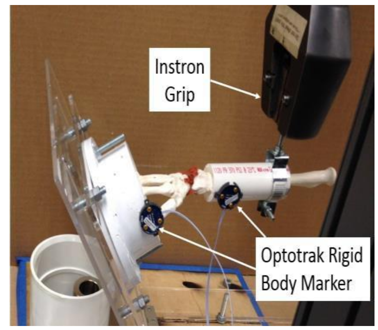

Human movement is the result of active muscles that drive the movement of our bones while ligaments, joint cartilage, and other passive soft tissues ensure stability during movement. This coordination can be disrupted with age, disease or injury. In the case of fracture, the mechanical and structural properties of the passive tissues are often compromised thereby limiting joint movement even after the bones have healed [1-3]. Improving the training of fracture reduction is an opportunity to reduce the personal and societal public health burden that occurs when fractures are not adequately treated. Our aim is to develop intelligent, biomechanics-based feedback tools that can be used by all medical learners without the need to wait for on-the-job training opportunities. Using an anatomical model of the wrist, we have developed a model to investigate the sensitivity of ligament strain to fracture reduction outcomes by intentionally misaligning the wrist joint and performing a series of joint movements. Increases in ligament strain are an indicator of compromised motion of the joint due to fracture misalignment. This tool will allow for a medical learner to practice reducing fractures using a hands-on model and provide instant feedback regarding the outcome of the new alignment in terms of ligament strain and range of motion. Future work for this study includes expanding the biomechanical database behind the tool to provide information regarding joint contact mechanics and cartilage pressure. The development of this tool serves as a platform for other simulation tools that can be applied to the shoulder and knee for other orthopedic-based training.

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Mariana Kersh is an Assistant Professor in the Department of Mechanical Science and Engineering at the University of Illinois at Urbana‐Champaign and is Director of the Tissue Biomechanics Laboratory. Dr. Kersh first received a BA in English from The University of Texas-Austin, then a BS and MS in Mechanical Engineering, and PhD in the Materials Science Program from the University of Wisconsin-Madison as a National Science Foundation Pre-Doctoral Fellow. She was a post-doctoral research fellow in the Department of Mechanical Engineering at the University of Melbourne as a McKenzie fellow and the awardee of the 2013 ANZORS Early Career Researcher Award. Her research uses experimental methods to evaluate mechanical and structural properties of bone, cartilage, and connective tissues, such as ligaments. This data is also used in finite element simulations to evaluate intervention techniques and develop novel hypotheses of tissue structure-function relationships. Current work in the Tissue Biomechanics Laboratory includes experimental measurements of bone strain under physiological loading conditions and identifying the compositional and structural determinants of bone strength. In collaboration with local orthopedic surgeons, Prof. Kersh is also investigating the sensitivity of shoulder function to rotator cuff tears using robotic‐actuated motion control to simulate functional tasks as well as using time-lapsed techniques to identify determinants of bone strength.

High Fidelity Methods for Blood Flow Simulation in Patient-specific Geometries: Blue Waters Platform and Massively Parallel Computing

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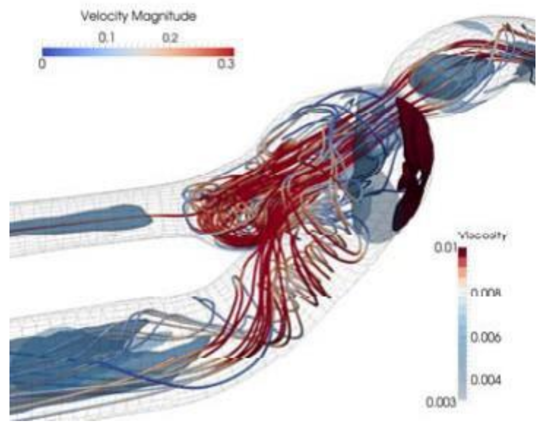

We have developed advanced numerical methods for modeling blood flow in patient specific geometries. These developments are aimed at predicting the potential post-surgical conditions in heart-transplant patients who have received Ventricular Assist Devices (VAD). We have developed shear-rate dependent constitutive models to accurately account for the non-Newtonian properties of blood. The resulting numerical methods possess higher accuracy and optimal stability for highly non-linear problems in Hemodynamics. These mathematical and computational attributes provide a strong platform for developing probabilistic simulation and modeling tools for patient specific applications. A number of representative simulations are presented to highlight the power of the virtual prototyping method as well as of the Blue Waters supercomputing platform that is used for simulations.

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Arif Masud received Ph.D. in Computational Mechanics from Stanford University in April 1993. He is Professor and Chair of Engineering Mechanics and Structures in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign. Dr. Masud has made fundamental contributions to the development of multiscale and stabilized finite element methods for nonlinear fluid and solid mechanics. He has authored or co-authored over 100 refereed journal articles, conference papers and book chapters on these topics, and is co-editor of the book Finite Element Method: 1970's and Beyond. Dr. Masud serves as an Associate Editor of the ASCE Journal of Engineering Mechanics, and ASME Journal of Applied Mechanics. He is Fellow of the U.S. Association of Computational Mechanics (USACM), Fellow of the International Association of Computational Mechanics (IACM), Fellow of the American Society of Mechanical Engineers (ASME), and Fellow of American Academy of Mechanics (AAM).

Intelligent Assistive Robots for Rehabilitation and Surgery

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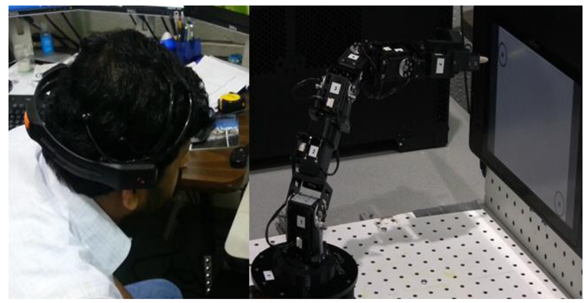

The advent of brain computer interface (BCI) technology is leading to methodologies to interface robots with human brain. Our work explores the possibility of using a low-cost non-invasive BCI using electroencephalogram (EEG) to control robots based on the intentions of a person. Conventional methods of using intentions identified from EEG of a user to discretely control robot's each simple action of the robot is a tedious process. The user's intentions are actions that are required to reach the goal state. Before the user does this, he/she needs to decide what sort of actions and intermediate states are to be used. Since the actions considered are at the level of primitive motions like "Move Up" or "Move Left", the user sometimes never reaches the goal because at that level of this detail there are too many steps in the solution and too much uncertainty in the control. This made the direct control an exhaustive process and sometimes failing to find goal state. The solution to these problems lies in mimicking the human hand which is capable of learning tasks, sensing the environment and navigating through the environment. The fundamental actions called "actemes" are combined by the robot itself to perform the complex task. The combination is based on a set of rules called "grammar". Grammar is a set of allowable and unallowable combinations of motions. The automatic construction of the task construction also requires that the robot is aware of its workspace to avoid collision with objects. This involves knowing its own internal states (proprioception) as well as the objects and other features of the working environment (spatial cognition). The ability to construct the task is called task awareness and knowing the workspace is called spatial awareness. The decision to perform an acteme based on the grammar is equivalent to finding a control policy at a state of the system (task) in Markov decision process (MDP). Thus the action grammar is modelled using stationary MDP. A self-map of the robot converts the sensory information about the objects in proximity to the reward function of a non-stationary MDP required for navigation. The task and spatially aware robot is easy to control using BCI. The effort of the user is reduced to the intentions of initiating a task and to proceed at any stage of the task. Our current research focuses on developing an observer that can learn from demonstrations of expert surgeons. This system will be able to identify the actemes by itself and develop its own grammar.

Pramod Chembrammel is a Research Scientist at Health Care Engineering Systems Center at the University of Illinois at Urbana-Champaign. He received his doctoral degree from State University of New York at Buffalo in 2015. His research interests are neuro-robotics, multibody dynamics, physics based medical simulations and imitation learning by robots.

Fracture Resistance of Biological Tissues: A Theoretical and Experimental Study

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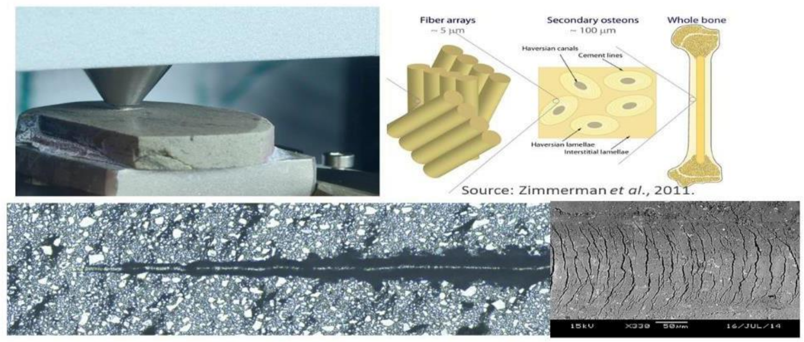

Bone fragility is major issue due to the prevalence of bone fracture and bone diseases such as osteoporosis in elderly people. Despite several theoretical and experimental studies, understanding the fracture resistance of the compact bone remains a challenging task. Compact or cortical bone tissue consists essentially of water, collagen and hydroxyapatite, with a highly hierarchical microstructure. This complex composition and architecture at multiple length-scales contributes to its high performance as the overall composite fracture resistance is much greater than that of the individual components. In our study, we investigate the fracture properties of bovine cortical bone using microscopic scratch tests. Previous investigation has established scratch testing as a powerful and robust method to characterize the fracture of homogeneous and composite materials. The goal is to tailor this innovative technique to the bone tissue, explore the failure mechanisms and assess the fracture toughness while taking into account the intrinsically heterogeneous and anisotropic nature of cortical bone. In turn, this work will pave the way towards a mechanistic understanding of the fracture resistance of bone at multiple scales, inspiring the design of biomimetic materials and opening new venues for innovative therapeutic treatments.

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Dr. Ange-Therese Akono is an Assistant Professor in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign. Prior to joining the University, she earned a Ph.D. (2013) and a M.Sc. (2011) in Civil and Environmental Engineering from the Massachusetts Institute of Technology (United States). In addition, she completed a M.Sc. in Innovative Technology, Engineering & Entrepreneurship (Ingénieur Polytechnicien, 2011) and M. Eng. (Ingénieur diplômé de l’École Polytechnique, 2009) in Mechanical Engineering at the École Polytechnique (France). Prof. Akono is the director of the Sustainability Under the Nanoscope laboratory, SUN Lab@CEE, a cutting-edge research laboratory dedicated to elucidating fracture processes in complex systems over a wide range of length-scales.

Point of Care Device for Accurate Early Screening of Sepsis in Hospitals

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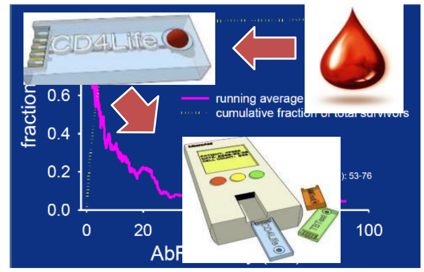

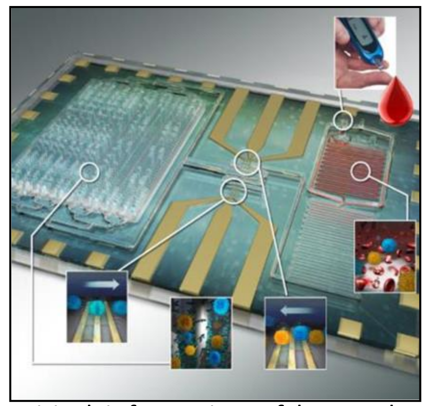

Sepsis costs the U.S. health care system over $24 billion every year, with as many as 3.1 million cases that claim over 300,000 lives annually. One out of every two to three hospitals deaths in the U.S. is due to sepsis. There are an estimated >19 million cases worldwide and some reports have estimated that 1 person dies from sepsis every 4 seconds. Mortality rates due to severe sepsis are between 20% and 50%. The most urgent problem is a lack of accurate early screening methods. Survival rates drop by 7.6% per hour treatment is delayed. Current screening for sepsis utilizes the SIRS criteria, which include temperature, heart rate, respiratory rate, and total WBC count. None of these parameters have any significant sensitivity or specificity to sepsis. We will replace these parameters with a panel of well-studied highly specific and sensitive biomarkers for sepsis. We are developing a hand-held point of care device capable of profiling 14 parameters of a patient's immune system from 10 µL of blood in less than 10 minutes with a credit-card sized, disposable cartridge. This device will enable a degree of biomarker multiplexing and frequency of sampling never before possible in any previous efforts at improving sepsis screening.

Our POC system has the potential to offer in a single device the critical information of hematology analyzers, flow cytometers, and protein assays. Our device enables the power of all of these tools to be harnessed from a single inherently simple, powerful, scalable, and unified platform. This tool could potentially measure the most important parameters of human host response (cell information and plasma biomarkers), and could be the first step towards a full pathophysiological mapping of sepsis and other diseases with sufficient temporal granularity. Such a device could dramatically increases both the frequency ("videos" of disease instead of "snapshots") and the multiplexing (measurement of many biomarkers simultaneously) of sampling of biomarkers from patient populations. Though we propose an initial starting panel for the two cell surface proteins and 6 plasma biomarkers for the device, these biomarkers can easily be swapped for different panels to further improve accuracy or to target other diseases.

Bobby Reddy, Jr. is a Research Scientist in the Department of Biomedical Engineering at UIUC. He received his Ph.D. in Electrical Engineering with a focus on electronic, label-free point-of-care devices in 2012. His research focuses on point of care devices for early disease screening in hospital environments. He is also the president and co-founder of ElectroCyt, a start-up focused on commercializing electronic POC devices.

CyPhy - 3D Teleimmersion for Home-Care Rehabilitation

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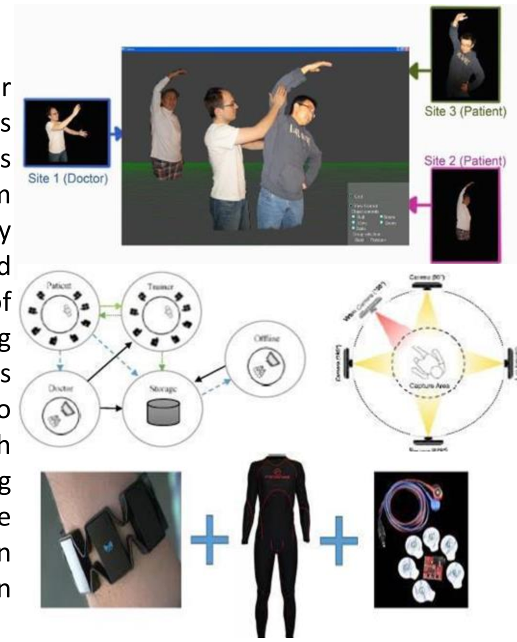

Each of us went through a physiotherapy treatment one or another time. One of the biggest challenges for physiotherapists is the follow-up of patient's exercises in home environments. In this presentation, we discuss CyPhy, a cyber-physiotherapy system that urges and records patient's home exercises, and brings daily rehabilitation to patient's home with supervision of trained therapist. CyPhy's characteristics enable recording of physiotherapy-related 3D multi-view multi-modal medical sensing data at home, efficient storage of rehabilitation sessions recordings, streaming delivery of rehabilitation sessions data to health care provider under different home networking bandwidth availability, and smooth view changing during 3D video streaming to therapist's devices. The ultimate CyPhy goal is an interactive tele-health-service for physiotherapists to see higher rate in exercises and for patients to experience improved rehabilitation in home environments.

Reference:

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Klara Nahrstedt is the Ralph and Catherine Fisher Professor in the Computer Science Department, and Director of the Coordinated Science Laboratory in the College of Engineering at the University of Illinois at Urbana-Champaign. Her research interests are directed toward 3D teleimmersive systems for health-care, mobile systems, Quality of Service (QoS) and resource management, Quality of Experience in multimedia systems, and real-time security in mission-critical systems such as power-grid. She is the co-author of widely used multimedia books `Multimedia: Computing, Communications and Applications' published by Prentice Hall, and ‘Multimedia Systems’ published by Springer Verlag. She is the recipient of the IEEE Communication Society Leonard Abraham Award for Research Achievements, University Scholar, Humboldt Award, IEEE Computer Society Technical Achievement Award, ACM Special Interest Group on Multimedia (SIGMM) Technical Achievement Award, and the former chair of the ACM Special Interest Group in Multimedia (2007-2013).

Klara Nahrstedt received her Diploma in Mathematics from Humboldt University, Berlin, Germany in numerical analysis in 1985. In 1995 she received her PhD from the University of Pennsylvania in the Department of Computer and Information Science. She is ACM Fellow, IEEE Fellow, and Member of the Leopoldina German National Academy of Sciences.

Patient Discharge Process and Communications Simulation Training

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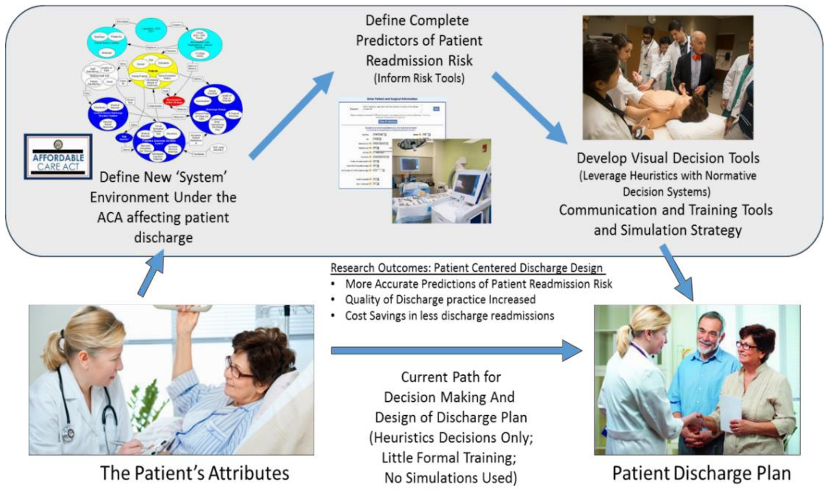


Approximately 20 to 25 percent of patients discharged from primary health care facilities are readmitted within 30 days at a cost of roughly $42 billion dollars per year to insurance providers. These costs are now the responsibility of Accountable Care Organizations (ACOs) under the Affordable Care Act (ACA) of 2010. In some cases, the patient was discharged too soon, or with inappropriate treatment. In others, the patient did not understand and/or comply with discharge instructions regarding prescribed medication, therapy or post-discharge activities. A system for training health care providers who make the discharge decision and execute the discharge process is needed. This project first analyzes the new environment under the ACA, and current procedures for the patient discharge process from a normative decision making viewpoint. A training tool focused on improving prediction and recognition of tradeoffs under uncertainty will be developed to decrease the number of unplanned readmissions. Decision analytic and risk assessment methods will be employed, along with recent findings from behavioral economics. The training simulation will provide the trainee with tools that will raise situational awareness and improve discharge decisions and processes. It will include strategies for information gathering, tradeoff decision making uncertainty, and patient communications. Input to the trainee will include text and quantitative information as well as graphical information within the model simulation. The result will be improved discharge process effectiveness, a reduction in the number of unplanned readmissions, and an improvement in overall health outcomes.

Deborah Thurston is a Gutsgell Professor of Industrial and Enterprise Systems Engineering at the University of Illinois. She also serves as Director of the Decision Systems Laboratory, and co-directs the Hoeft Technology and Management Program in collaboration with the College of Business. She earned the M.S. ('84) and Ph.D. ('87) from the Massachusetts Institute of Technology. Her pioneering research in normative decision based design brought mathematical rigor to design tradeoffs analysis under uncertainty. She has received numerous awards, including the NSF Presidential Young Investigator Award, two Xerox Awards for research excellence, and four best paper awards.

James Schreiner is a PhD Candidate in the Department of Industrial and Enterprise Systems Engineering. He is a Lieutenant Colonel in the U.S. Army Corps of Engineers and has served as an Assistant Professor in the Department of Systems Engineering at the U.S. Military Academy at West Point. His PhD research is in healthcare decision making and discharge with a follow on duties as the Engineering Management Program Director at West Point.

Annual Rotation Schedules in Real Time: Simplifying Life for an Internal Medicine Residency Program

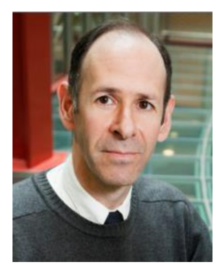
David R. Morrison, Researcher, Inverse Limit
Sheldon H. Jacobson, Department of Computer Science, University of Illinois at Urbana-Champaign
Janet A. Jokela, Department of Medicine, University of Illinois College of Medicine at Urbana

Scheduling medical residents is a challenging and time-intensive task that is manually performed at residency programs in the United States. Designing a schedule that equitably meets the needs of the individual residents, and satisfies all educational requirements and hospital coverage needs often require hundreds of man-hours of effort by faculty. This research describes an integer programming model that captures the key factors that go into the design of resident schedules, and how this model can be used to build schedules in real-time.

References:

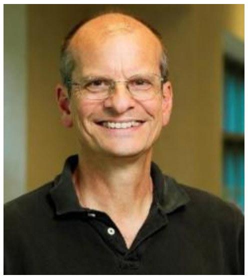
1. Complexity Results for the Basic Residency Scheduling Problem. J. Guo, D. Morrison, S.H. Jacobson, J.A. Jokela. Journal of Scheduling, 17 (3): 211-233. Jun 2014.
2. Annual Rotation Schedules in 45 Seconds: Simplifying Life for an Internal Medicine Residency Program. D. Morrison, T. Fairbank, S. Jacobson, J. Jokela. APDIM Spring Conference Poster Session. April 2014.

David R. Morrison, Ph.D., is a Researcher at Inverse Limit, where he applies novel mathematics and computer science methods to a diverse range of problems. He received his Ph.D. in Computer Science from the University of Illinois at Urbana-Champaign in August of 2014. His doctoral work was supported by a National Science Foundation Graduate Research Fellowship and a National Defense Science and Engineering Graduate Research Fellowship.



Sheldon H. Jacobson, Ph.D., is a Professor in the Department of Computer Science at the University of Illinois at Urbana-Champaign. He has applied operations research to health care systems problems since. The author of over 150 journal research, he has been recognized by several awards, including a Guggenheim Fellowship, and his research has been widely covered in the national media. He is a fellow of both IIE and INFORMS.

Janet A. Jokela, MD, MPH, FACP, FIDSA is a Professor of Clinical Medicine in the Department of Medicine at the University of Illinois College of Medicine at Urbana-Champaign. As the former Director of the Internal Medicine Residency Program, she currently serves as Head of the Department of Medicine, and as Infectious Disease Consultant for the VA Illiana Healthcare System in Danville, IL. She is a Fellow of the American College of Physicians and the Infectious Diseases Society of America.



Conversational Agents and Comprehension of Information in EHR Patient Portals

Dan Morrow[1], Mark Hasegawa-Johnson[1], Thomas Huang[1], William Schuh[1], Renato Azevedo[1], Kuangxiao Gu[1], and Rocio Garcia-Retamero[3]

1. University of Illinois Urbana-Champaign;
2. Carle Foundation, Urbana IL; 3. University of Granada, Spain

Our goal is to improve patients' ability to understand and act on information provided through patient portals to Electronic Health Record (EHR) systems. Portals are underutilized by patients with lower health literacy (Morrow & Chin, 2012). Barriers to portal use include limited portal usability and perceived value, and difficulty understanding portal information. Numeric information (e.g., test results) in portals is a particular challenge because this information is pervasive but misunderstood by patients with limited numeracy. Improving the use of portal-based numeric information by older adults who vary in numeracy and literacy will help portals support patient/provider collaboration and patient-centered care (IOM, 2012). Patients are more likely to act on numeric information when they can understand the gist of the numbers (e.g., whether risk is high or low), and are more likely to extract gist from contextualized numbers (e.g., Reyna, 2011). We compared typical portal numeric formats to several enhanced context formats. In this presentation, we focus on conversational agents (CA) that emulate face-to-face communication. Like providers during patient visits, CAs use nonverbal (intonation, facial expression) as well as verbal cues to convey affective and cognitive meaning. They should help patients create gist representations that engender trust, so that portals support patient understanding and provider/patient collaboration.

The CA is being developed from a human template (physician video-recorded while discussing test results). It consists of a text-driven 3D avatar and a speech synthesizer such that given a segment of text with affective markers, the CA outputs a "talking head" conveying semantic and affective information. In a preliminary study, older adults viewed recordings of the physician describing cholesterol and diabetes test results varying in risk level. After each message they identified risk level associated with the results and indicated reactions to the messages. They thought the delivery (facial expressions, tone of voice) was appropriate for the message content, and reported more positive affect after lower risk messages and more negative affect after higher risk messages. These findings suggest the physician's nonverbal cues help convey the affective gist of the messages. Participants also accurately identified the gist of overall risk from the messages. We will also report preliminary findings from the primary experiment, focusing on memory for standard versus video-enhanced messages.

Dan Morrow is professor and chair of the Department of Educational Psychology at the University of Illinois at Urbana-Champaign, with appointments in the Beckman Institute and the Departments of Psychology and Industrial and Enterprise Engineering. He received a PhD in cognitive psychology from the University of California Berkeley. His research on the impact of aging on cognition, communication and decision making in the health care and aviation domains has been funded by NIH and NASA-Ames. He is past president of American Psychological Association Division 21 (Applied Experimental and Engineering Psychology) and is a fellow of APA and the Human Factors and Ergonomics Society. He has served on advisory committees for the Food & Drug Administration and US Pharmacopeial Convention.

Fall Risk Assessment: The Potential for Home-based Technology

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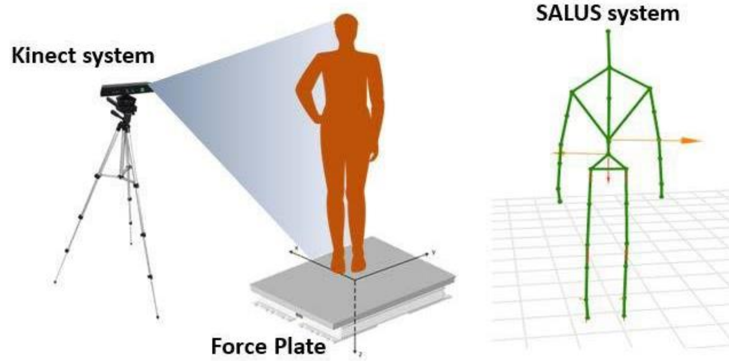

Falls are a serious health concern for older adults and associated with physical injury, reduced quality of life and even death. It has been consistently shown that postural instability is a significant risk factor for falls and can be modified with cost- effective interventions. However, the objective assessment of postural instability requires expensive equipment and is not viable in home settings. Home-based tele-rehabilitation systems such as the SALUS system may be a feasible approach to assess postural instability. The SALUS system is a Kinect™ camera based system that is specifically designed for remote, home-based rehabilitation. The purpose of this project was to validate the SALUS system as a measure of postural instability in young and old adults.

Method: 15 older adults (65+) and 15 young adults (18-30) comprised of 11 males and 19 females underwent postural sway assessment. Postural sway was assessed with force platform (i.e. posturography) while the body movement was recorded with the SALUS system simultaneously. To determine the concurrent validity of the SALUS system Spearman's rank-ordered correlations were completed.

Results: Overall, measures of postural sway were moderately to strongly correlated between the force platform and SALUS system (rho's ranging from 0.46 to 0.91; p's < 0.05).

Discussion: The results indicate the home-based tele-rehabilitation systems can measure postural sway. Next steps will examine the ability of the SALUS system to prescribe exercises based on postural sway assessment in an effort to reduce falls in older adults.

Reference:

1. Rubenstein, L. Z. (2006). Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing, 35 Suppl 2, ii37-ii41. doi: 10.1093/ageing/afl084

Jacob J. Sosnoff is an Associate Professor and the Director of the Motor Control Research Laboratory in the Department of Kinesiology and Community Health of the College of Applied Health Sciences at the University of Illinois at Urbana-Champaign. He earned his PhD in Kinesiology from the Pennsylvania State University where he was National Institute of Aging Pre-doctoral Scholar and Kligman Research Fellow. Professor Sosnoff's research has focused on the intersection between aging and chronic disease conditions specific to the control of movement including balance and gait. Dr. Sosnoff's current research focuses on the predictors, consequences and prevention of falls. He is a founding member of the International MS Falls Prevention Research Network and is principal investigator of 2 ongoing randomized control trials targeting falls in special populations.

Chemical Imaging and Printed Structures for Pathology

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Histopathology is essential to diagnosing most health conditions involving tissue changes. We develop technologies that can provide conventional histopathologic views without the need to stain or use dyes, while using new concepts to harness the microenvironment, we can now improve disease diagnosis well beyond human capability.[1] This is achieved by co-developing theory, simulations and equipment design to extract the best possible performance from imaging systems.[2] Recently, we have also developed nonlinear Raman imaging systems that permit 3D visualization of intact tissues and cell cultures. Here we show how the development of technology can lead to better pathology outcomes tomorrow by simulation and computer referencing. This technology,[3] in conjunction with computational methods,[4] can be used to translate the expertise of leading academic centers and consensus estimates to serve low-resource settings and community healthcare systems. Next, we show how cell culture systems can be developed in an increasingly sophisticated manner to mimic tissues and their biological processes.[5] In particular, the use of multiple cells in the same culture, with carefully developed relative cell positioning, can be used to understand molecular signaling that is relevant to simulation and prediction of breast cancer progression under different conditions. Finally, we have developed a 3D printer[6] to allow sophisticated investigations into cellular processes by precise control of chemical and physical cues.

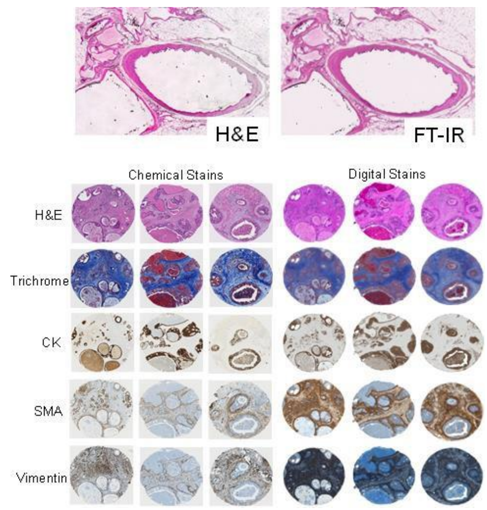

Figure 1.Physically stained (left) images may have artifacts but stainless images depend only on underlying composition, providing pristine images (*right*) for H&E (top). (Bottom) Various components of the TME can be seen using stainless staining approach. [from Mayerich et al *Technology 3, 27-31* (2015)]

References:
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2. M.J. Nasse et al *Nat. Methods*, 8, 413 (2011)
3. R. Bhargava *Appl. Spectrosc.* 66, 1091 (2012)
4. M.J. Baker et al *Nat. Protocols* 9, 1771 (2014)
5. S.E. Holton et al *PLoS One* 9, 5, e96878 (2014)
6. M. Gelber et al *Lab. Chip* 15, 1736 (2015)

Rohit Bhargava is a professor in the UIUC Department of Bioengineering and a full-time faculty member in the Beckman Institute Bioimaging Science and Technology group. His fields of professional interest are infrared spectroscopic imaging, cancer pathology, probes for molecular imaging, polymer structure and numerical methods for image processing. The reported research is sponsored by the National Science Foundation, National Cancer Institute, National Institute of General Medical Sciences and the National Institute of Biomedical Imaging and Bioengineering.

Reducing the Duration and Severity of Multiple Sclerosis Exacerbations in a Rat Model through Ultrasound-Based Lymphocyte Depletion

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Multiple sclerosis (MS) is a chronic and debilitating disease of the central nervous system and existing treatment options are only modestly effective for slowing eventual disease progression. This underscores the importance of developing new therapies. A novel therapeutic intervention for MS was applied to a rat model of MS, i.e., experimental autoimmune encephalomyelitis (EAE). Specifically, application of high intensity focused ultrasound (HIFU) was targeted to heat the superficial cervical lymph nodes in the rats showing symptoms of EAE and kill or degenerate lymphocytes residing in the lymph nodes. Lymphocytes are known to contribute to the inflammatory response resulting in EAE or MS. By killing lymphocytes residing in superficial cervical lymph nodes, we hypothesized that the severity of disability could be reduced. A total of 14 rats were used in the study. Each rat was injected with 50 µg $rMOG_{1\text{-}125}$. Seven rats were exposed to HIFU at days 9 and 12 after injection and six rats were sham exposed. The HIFU exposure was designed to elevate the temperature of the superficial cervical lymph nodes by 4 °C for 20 minutes. The EAE score was recorded up to day 21 post injection and the number of survival days post injection were recorded. Animals receiving treatment had a remittance in EAE symptoms and score following treatment (day 12). Two shams also had a small remittance over the period after day 12. Treated animals had a reduction in their EAE score on average of 1.14 whereas sham treated animals had a reduction in EAE score of 0.33. The reduction in EAE between treated and sham treated was statistically significant ($p < 0.05$). In addition, two sham treated animals were observed to have ataxia before being euthanized. HIFU treatment of the cervical lymph nodes in rats displaying EAE symptoms resulted in improved outcomes and remittance of EAE symptoms. This approach represents the first non-pharmaceutical therapy for reducing the symptoms of EAE.

Prof. Oelze is an associate professor in the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign. From 2002 to 2004, Dr. Oelze was a NIH fellow conducting research in quantitative ultrasound techniques. Dr. Oelze joined the faculty of ECE at the UIUC in 2005. His research interests include quantitative ultrasound imaging, ultrasound bioeffects, ultrasound tomography techniques, ultrasound-based therapy, and automated detection of tissue structures for image-guided surgical and orthopedic interventions. Currently, Dr. Oelze is a fellow of the AIUM, a senior member of the IEEE, and a member of ASA. He also serves as an associate editor of IEEE Transactions on Ultrasonic, Ferroelectrics, and Frequency Control, associate editor of Ultrasonic Imaging and associate editor for IEEE Transactions on Biomedical Engineering.

MRI-Based Modeling of Traumatic Brain Injury

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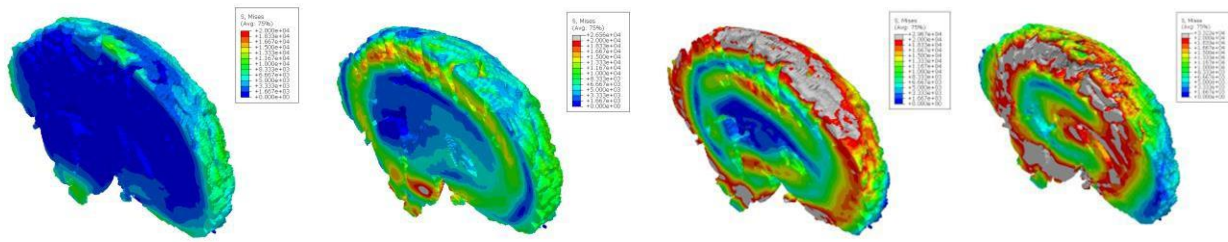

Detailed knowledge of in vivo human brain deformation within the skull is essential to understanding brain injury mechanisms. Studies in this direction are becoming possible thanks to 3D mechanics modeling based on magnetic resonance imaging (MRI) of the human head. Here we report on such a model, already validated by tagged MRI and HARP imaging analysis technique on *in vivo* human brain deformation [1,2]. The model is employed to study several transient wave dynamics scenarios during blunt head trauma. Side and top impact simulations indicate that the blunt impacts give rise not only to a fast pressure wave but also to a slow, and potentially much more damaging, shear wave that converges spherically towards the brain center. The wave amplification due to spherical geometry is balanced by damping due to tissues' viscoelasticity and the heterogeneous brain structure, suggesting a stochastic competition of these two opposite effects.

References:

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2. Y. Chen, B. Sutton, C. Conway, S.P. Broglio and M. Ostoja-Starzewski, "Brain deformation under mild impact: Magnetic resonance imaging-based assessment and finite element study," special issue "Brain Neuro-Mechanics" of *International Journal of Numerical Analysis and Modeling Series B* **3**(1), 20-35, 2012.

Martin Ostoja-Starzewski did his undergraduate studies (1977) in Poland, followed (after work in industry in Austria and Canada) by Master's (1980) and Ph.D. (1983) at McGill University, all in mechanical engineering. His research is in stochastic mechanics/physics, random and fractal media, and mulitfarious applications ranging to bio- and geo-sciences. He (co-)authored 170+ journal papers and two books: 1. *Microstructural Randomness and Scaling in Mechanics of Materials*, CRC Press (2008); 2. *Thermoelasticity with Finite Wave Speeds*, Oxford University Press (2010). He is/was on editorial boards of 10 journals, is Chair Managing Editor of *Mathematics and Mechanics of Complex Systems* journal, and co-Editor of *CRC Modern Mechanics and Mathematics Book Series*. He is Fellow of ASME, AAM, WIF, and Associate Fellow of AIAA. In winter 2012 he was Timoshenko Distinguished Visitor at Stanford University. Since 2014 he is Site co-Director of the NSF Industry/University Research Center for Novel High Voltage/Temperature Materials and Structures.

Software Testing for Healthcare Software

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Healthcare information technologies and many medical devices rely on software. Software problems, commonly called bugs, can lead to financial losses and even loss of life. Software testing is the most widely used method for finding and preventing software bugs. However, software testing for healthcare-related software is largely unexplored [1]. How can we improve software testing and thus the quality of the developed software?

Reference:
[1] John J. Majikes, Rahul Pandita, and Tao Xie. Literature Review of Testing Techniques for Medical Device Software. In Proceedings of the 4th Workshop on Medical Cyber-Physical Systems (MCPS 2013), Philadelphia, PA, April 2013. http://web.engr.illinois.edu/~taoxie/publications/mcps13-slr.pdf

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Darko Marinov is an Associate Professor in the Department of Computer Science at the University of Illinois at Urbana-Champaign. His main research interests are in Software Engineering: improving software reliability; software testing and model checking for sequential, parallel, and distributed code; and program transformations (refactorings). He has a lot of fun looking for software bugs. His group found hundreds of bugs in open-source software and released several testing tools (http://mir.cs.illinois.edu/marinov/software.html). He published over 60 conference papers, including four that won the ACM SIGSOFT Distinguished Paper awards, of which one also won the ACM SIGSOFT Impact Paper Award (2012). He received an NSF CAREER award (2008), an Illinois CAS Beckman Fellowship (2010-2011), an Illinois DCS C.W. Gear Outstanding Junior Faculty Award (2010), and an Illinois Engineering Council Award for Excellence in Advising (2014). His work has been supported by Google, IBM, Intel, Microsoft, NSF, and Samsung.

3D Imaging and Augmented Reality for Healthcare

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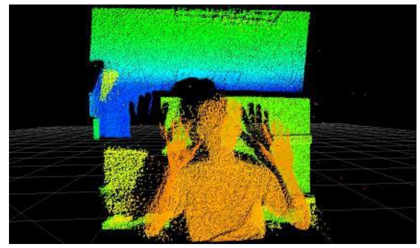

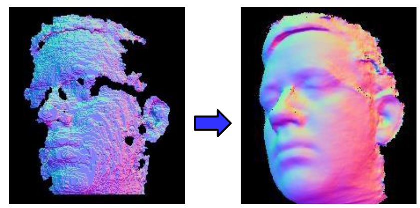

The ubiquity of digital cameras has made a great impact on visual communication as can be seen from the explosive growth of visual contents on the Internet and the default inclusion of a digital camera on cellphones and laptops. The recent emerging of low-cost and fast depth cameras (e.g. Kinect) provides a great opportunity to revolutionize visual sensing and communication further by enabling immersive and interactive capabilities. Depth measurements provide perfect complementary information to the traditional color imaging in capturing the three-dimensional (3D) scene. By effectively integrate color and depth information, we develop real-time systems that capture the live scene and render 3D free-viewpoint videos, and augment the captured scene with 3D virtual worlds. Such system can provide unprecedented immersive and interactive 3D viewing experiences for healthcare training and services.

Reference:

1. V. A. Nguyen, J. Lu, S. Zhao, D. L. Jones, and M. N. Do, Teleimmersive audio-visual communication using commodity hardware, IEEE Signal Processing Magazine, Nov. 2014.
2. M. N. Do, Q. H. Nguyen, H. T. Nguyen, D. Kubacki, and Sanjay J. Patel, Immersive visual communication with depth cameras and parallel computing, IEEE Signal Processing Magazine, Jan. 2011.

Minh N. Do is a Professor in the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign (UIUC). He received the B.Eng. degree in Computer Engineering from the University of Canberra, Australia in 1997, and the Dr.Sci. degree in Communication Systems from the Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland in 2001. Since 2002, he has been on the faculty of the Department of Electrical and Computer Engineering at UIUC, and holds joint appointments with the Coordinated Science Laboratory, the Beckman Institute for Advanced Science and Technology, the Advanced Digital Sciences Center, and the Department of Bioengineering. His work covers image and multi-dimensional signal processing, wavelets and multiscale geometric analysis, computational imaging, and visual information representation, and has led to more than 50 journal papers and more than 13000 Google Scholar citations. He received a Silver Medal from the 32nd International Mathematical Olympiad in 1991, a University Medal from the University of Canberra in 1997, a Doctorate Award from the EPFL in 2001, a CAREER Award from the National Science Foundation in 2003, and a Young Author Best Paper Award from IEEE in 2008. He received a Xerox Award for Faculty Research from the College of Engineering, UIUC, in 2007. He was an Associate Editor of the IEEE Transactions on Image Processing, and a member of the IEEE Technical Committees on Signal Processing Theory and Methods, and on Image, Video, and Multidimensional Signal Processing. He was elected as an IEEE Fellow for his contributions to image representation and computational imaging. He is a co-founder and Chief Scientist of Personify Inc., a spin-off from UIUC to commercialize depth-based visual communication

Lifestyle Disease Surveillance using Location-Based Social Networks

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There is emerging evidence showing that strong community structures, measurable via social capital metrics, are beneficial for health outcomes. Here we demonstrate an association between obesity prevalence in neighborhoods with check-in and venue data from a location-based social network. We first describe the possibility of using social media data to directly measure the presence of social capital, and then describe how to connect public health outcomes such as obesity to these new social capital measures. By using the Foursquare API, venue information including name, address, coordinates, number of check-ins, etc. are collected for New York City: information on 50,000 venues and over 15,000,000 check-ins were streamed within two months. The collected data is generalized and categorized into a two-by-two matrix according to location and category type; venue categories are created in a hierarchical fashion based on ones provided by Foursquare, e.g. "food,"' "event," "residence," "hotel," etc. We show the number of venues in neighborhoods of several categories is correlated with obesity prevalence, either positively or negatively. In particular, there are *social capital deserts* linked with greater obesity prevalence. Broadly, this work finds that location-based social networks can be used for surveillance of social capital, which is associated with prevalence of chronic diseases of energy imbalance. Results can be used to improve public health by targeting social capital interventions at the fine grain measurable through social media.

Reference:
H. Bai, R. Chunara, and L. R. Varshney, "Social Capital Deserts: Obesity Surveillance using a Location- Based Social Network," submitted.

Lav R. Varshney has been an assistant professor in the Department of Electrical and Computer Engineering, a research assistant professor in the Coordinated Science Laboratory, and a research affiliate in the Beckman Institute, all at the University of Illinois at Urbana-Champaign since 2014. He received the B. S. degree from Cornell University in 2004, and the S. M., E. E., and Ph. D. degrees from the Massachusetts Institute of Technology in 2006, 2008, and 2010, respectively. His theses earned the E. A. Guillemin Award and the J.-A. Kong Award honorable mention. From 2010–2013, he was a research staff member at the IBM Thomas J. Watson Research Center, where his work in data analytics, crowdsourcing, and computational creativity for culinary recipes (Chef Watson) received significant recognition and media attention. His papers have received several best paper awards. His current research interests include information and coding theory; collective intelligence in sociotechnical systems; food, nutrition, and flavor; data analytics; and disease surveillance using social media.

Using Magnetic Resonance Imaging to Study the Speech Neuromuscular System

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Co-authors: Maojing Fu[1], Joseph Holtrop[2], Giang-Chau Ngo[2], Alex Cerjanic[2], Curtis Johnson[3], Zhi-Pei Liang[1]
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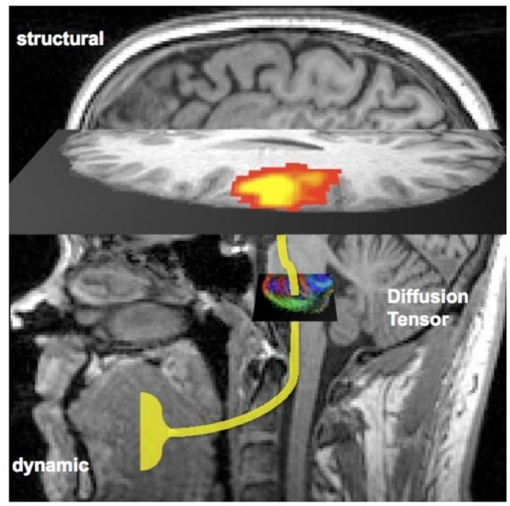
Speech and swallowing are critical functions across the lifespan, having a significant impact on development in children and in quality of life in older adults. However, proper functioning of these systems relies on central neural control, proper muscle geometry, and coordination across many neural and muscle groups. Different pathologies, and even healthy aging, can impact the proper functioning of this system by disruption of any of the components. Magnetic resonance imaging is a flexible imaging modality that enables researchers to visualize structure and function of various tissues and the changes associated with pathology, interventions, or aging. We have been examining the neuromuscular system for speech and swallowing, developing novel imaging technologies to provide unprecedented speeds for visualization of motions of over 150 frames per second, integrating functional MRI to see the brain signals associated with those motions, and achieving sub-mm resolution diffusion weighted imaging to delineate neural connections in the system. We will demonstrate these recent advances into imaging the speech and swallowing system.



Brad Sutton received his undergraduate education from the University of Illinois at Urbana--- Champaign in General Engineering (1998). Along with MS degrees in Biomedical Engineering and Electrical Engineering, he received his Ph.D. in Biomedical Engineering from the University of Michigan in 2003. He then returned to the University of Illinois to serve as a research scientist at the Biomedical Imaging Center of Beckman Institute. He joined the Department of Bioengineering at the University of Illinois at Urbana---Champaign in 2006. Since 2012, he has been an Associate Professor in the Bioengineering Department, Associate Head of Undergraduate Studies (2012---2015), and Technical Director of the Biomedical Imaging Center at Beckman Institute (2014---). Dr. Sutton's research is in development of magnetic resonance imaging acquisition and reconstruction methods to improve the accuracy, speed, and information content of neuroimaging methods.

Application of 3D Avatar in Health Care

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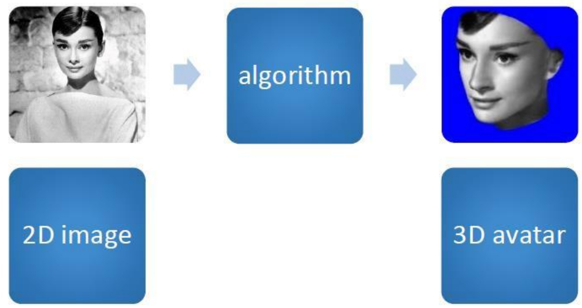
The Personal Health Record Systems (PHRs) has been listed as a top priority by the US government and many patients have a positive attitude toward such systems. However, most PHRs are underutilized, where the most important reason is that many patients lack the technical knowledge to understand the message and results delivered by the portal system. To improve the usability of PHRs, we propose to integrate 3D avatars into traditional portal systems as a way to assist patients toward a better understanding of portal messages, and to increase the effectiveness of PHRs as a communication tool between patients and their clinical care providers.



Currently an audio-visual emotive avatar (namely a "talking head"), which is capable of speaking a text script in different emotions, is going to be tested on human subjects. The goal is to find out the feasibility and effectiveness of using avatar to deliver medical messages such as test results or discharge instructions. The next step will be to further improve the visual and audio performance as well as exploring the Uncanny-Valley phenomenon in a medical, physician-patient communication scenario.

Thomas S. Huang received his Sc. D. in Electrical Engineering from MIT. He has been on the faculties of MIT, Purdue, and University of Illinois at Urbana-Champaign. He has been working in the broad areas of Multimedia, Human-Computer Interaction and Machine Learning. He is a member of the National Academy of Engineering, and has received the IEEE Jack S. Kilby for Signal Processing (together with Arun Netravali) and the International Association for Pattern Recognition's KS Fu Prize.

Role of Self Performed Ambulatory Electrocardiogram (ECG) by Patients in Assisting On Demand Consultation to Rule-out Life Threatening Conditions

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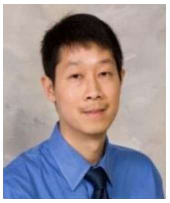
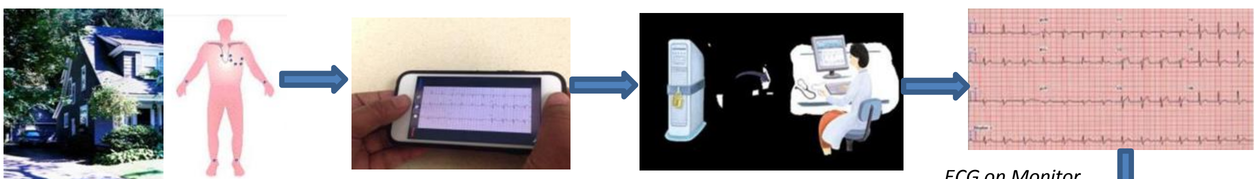
Visiting Research Scholar
University of Illinois College of Medicine at Peoria

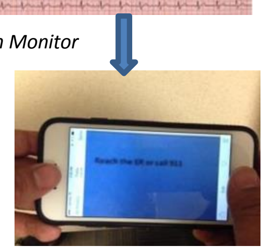


Keattiyoat Wattanakit MD, MPH
Clinical Assistant Professor
University of Illinois College of Medicine at Peoria,
OSF Saint Francis Medical Center

Telemedicine has been increasingly used by patients in many parts of the country. We at OSF provide a similar on-line consultation service through OSF On Call Virtual Urgent Care 24/7. With this online service, patients expect quick and accurate diagnosis.



ECG on Monitor



They seek advice whether they have a life threatening condition that requires emergency room evaluation or a benign condition that reassurance with follow up appointment with primary care provider is suffice. Some of the common complaints faced by online consultants are chest pain, shortness of breath, and palpitations. The most worrisome causes of these symptoms that must be ruled out are heart attack and abnormal heart rhythm. However, it is very challenging to rule out these life threatening conditions based on history alone.

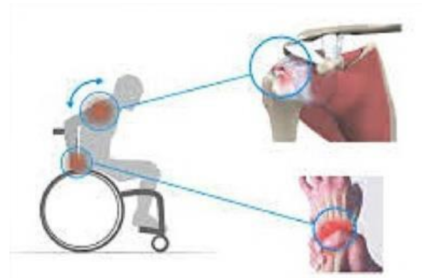
An additional diagnostic testing such as ambulatory electro-cardiogram (ECG) that can indicate whether patients have heart attack or abnormal heart rhythm would be useful to online consultants.
We have a plan in designing a complete kit that would allow patients to quickly perform an ECG using their cell phones. The system consists of an ECG Kit and a mobile application (app). The ECG kit will be universal or will be customized to the patient's needs. The patient would be able to place the leadless electrodes in appropriate positions and do the ECG using the mobile app on his own in few minutes. A button pushed by the patient will show 12-lead ECG on the screen which can be transmitted wirelessly to online consultants for further diagnostic purposes. As on demand consultation becomes rapidly adopted, this new innovative technology will help online consultants in ruling out life threatening conditions and further guide appropriate management for patients.

Dr. Sandeep Banga is a Research faculty with Cardiology fellowship program at University of Illinois College of Medicine at Peoria. He was an interventional cardiologist in India with 4 years of experience post cardiology fellowship. He moved to United States in 2013 and did one year post-doctoral EP research fellowship in Grand Rapids Michigan (2013-2014).

Dr. Keattiyoat Wattanakit is a clinical faculty and associate program Director with Cardiology fellowship program at University of Illinois College of Medicine at Peoria. He is a board certified Cardiologist with expertise in Vascular and Imaging. He obtained MPH in 2010.

mHealth Technology for Preventing Shoulder Injury in Manual Wheelchair Users.

C. Jayaraman, A. Burns, M. Khan, JJ. Sosnoff and C. L. Beck
University of Illinois at Urbana-Champaign.



It is estimated that over 2.8 million Americans use wheelchairs for mobility with a majority (~2 million) using manual wheelchairs. Although wheelchair use has numerous benefits, the repetitive strain to arm due to manual propulsion places a significant demand on the upper extremity, specifically the shoulder. This increased demand often results in shoulder pain. Indeed up to 70% of manual wheelchair users report shoulder pain. Upper limb pain in wheelchair users has been linked to difficulty performing activities of daily living, decreased physical activity and decreased quality of life. Research shows that training wheelchair users on proper propulsion technique minimizes injury. Recently our team has developed and prototype tested a custom developed wearable device/interface that can be used to implement affordable wheelchair propulsion training via mobile technology and provide continuous monitoring of propulsion activity to manual wheelchair users. Summary of pilot test results for the custom developed wearable device and the significant potential this technology offers to improve the quality of life and preventive care for manual wheelchair users will be discussed.

<u>Presenting team</u>

Mudassir Khan is finishing up his B.S. in Bioengineering at University of Illinois Urbana- Champaign (UIUC), his concentration is in imaging and sensing. He assists the team with signal processing and data acquisition. He also works on customer validation, particularly through focus groups and feedback from both clinicians and wheelchair users.

Chandrasekaran is currently a Doctoral student at the Department of Industrial Systems and Enterprise Engineering, UIUC. He holds a MS in Kinesiology from UIUC. His doctoral research focuses on understanding the relationship between manual wheelchair propulsion biomechanics and repetitive strain induced shoulder injury in manual wheelchair users.

Adam Burns is a graduate student in the Department of Civil and environmental engineering at UIUC. As an electronics engineer, Adam brings his expertise in circuit design, manufacturing and programming to the team. His interests lie in low-cost and low-power electronic solutions.

Soft, Hydrated Matter Lubrication

Alison C. Dunn
Assistant Professor of Mechanical Science & Engineering
Department of Mechanical Science & Engineering

The human body possesses exquisite systems of lubrication for sensing, metabolism, and mobility. The body's lubrication systems are water-based and often rely on high molecular weight lubricating molecules, like the mucins of the eye or lubricin of the large joints (Figure 1). If these solutions or the supporting tissue are injured or diseased, the lubrication is hampered, and those sensing, metabolism, and mobility functions break down as a result.

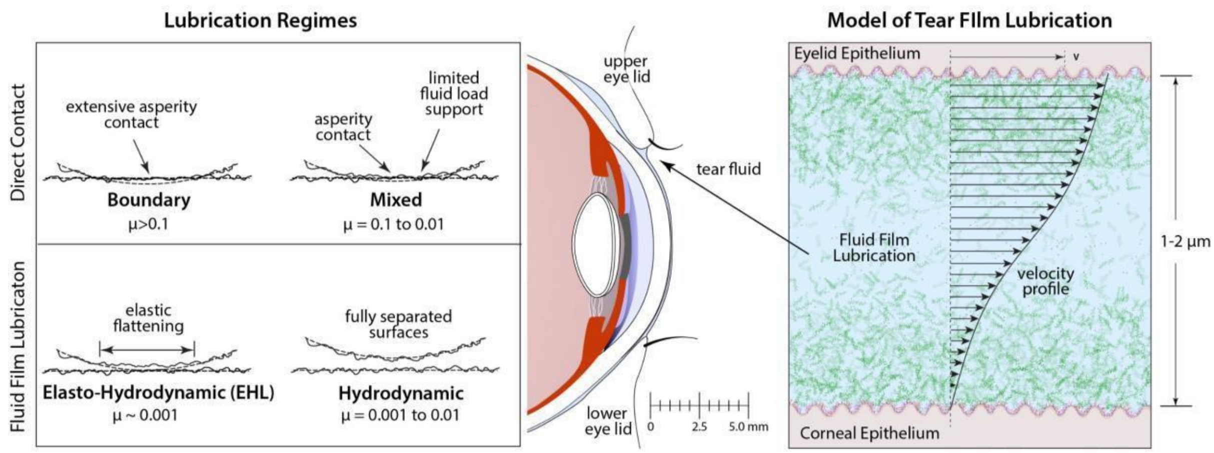


Figure 1. (Left) Schematic of lubrication regimes during sliding contact. (Right) A model of tear film lubrication during a blink.

My research seeks to understand the fundamental operation of these systems by measuring hydrogel lubrication as a function of composition and experimental conditions such as pressure, sliding speed, and environment. Their friction response against various other materials is measured using a custom low-pressure (~ 1 kPa) microtribometer. Low pressure prevents damage to the hydrogels and assesses them at physiologically-relevant pressures. From this we relate how the composition or surface properties of a hydrogel contribute to its lubricating ability.

Our long-term vision is to discover the mechanical origins of hydrated soft interface lubrication so that materials can be exploited for active biocompatibility in physiological sliding systems such as the eye and knee.

Reference:

1. A.C. Dunn, W.G. Sawyer, and T.E. Angelini (2014). Gemini Interfaces in Aqueous Lubrication with Hydrogels, Tribology Letters, 54

2. A.C Dunn, J.A. Tichy, J.M.Uruena, and W.G. Sawyer (2013). Lubrication regimes in contact lens wear during a blink, Tribology International, 63

Alison C. Dunn is an Assistant Professor in the Department of Mechanical Science and Engineering. She earned her PhD in Mechanical Engineering from the University of Florida in 2013 and remained as a postdoctoral associate and Teaching Scholar in 2014. Her PhD and postdoctoral work focused on fundamental lubrication mechanisms of hydrated materials, measuring micro-mechanical and surface properties, and designing and building in situ measurement systems.

Biomimicry for Healthcare Applications: Bone as an Example

Ahmed E. Elbanna
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Department of Civil and Environmental Engineering Fellow
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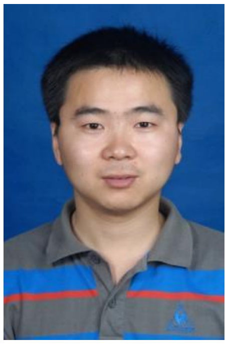
Nature is the master in creating materials and structures that exhibit remarkable combination of mechanical properties, such as strength, stiffness and toughness, under demanding constraints. With the recent progress in the manufacturing technologies, it is getting more feasible to reproduce the complex structure of biological tissues. This opens new opportunities for exploring biomimetic designs that are were not possible to fabricate a few years ago.

In this talk I will give an overview of our theoretical research aiming at understanding the relative role of different objectives controlling the growth of trabecular bone. Using tools from topology optimization, we show that trabecular structure may not be optimal from the structural perspective on its own but it provides a solution for simultaneous optimization of strength, buckling resistance, and fluid conductivity. We further show that the contribution of these different objectives varies from one place in the body to the other. For example stability constraints are crucial for evolution of trabecular structure in the vertebrae while it is less important to the evolution in the femur. We discuss implications of these findings for biomimicry. I will also outline our ongoing work in modeling bone microstructure and identifying fundamental sources of its fragility at the microscale. The long term objective of this work is to relate structure to function in bone and provide rigorous guidelines for designing optimal, robust and compatible bone implants.

Ahmed E. Elbanna holds a Ph.D. in civil engineering (2011) and an M.S. in applied mechanics (2006), both from the California Institute of Technology, and an M.S. in structural engineering (2005) and B.S. in civil engineering (2003) from Cairo University. He joined the faculty in December 2012. Dr. Elbanna's research focuses on constitutive modeling of complex biological and geological materials, computational fracture mechanics, and design optimization for biomimicry and smart composites engineering.



Toward Fast and Inexpensive DNA Sequencing: Intrinsic Stepwise Translocation of Stretched ssDNA through Graphene Nanopores

Hu Qiu
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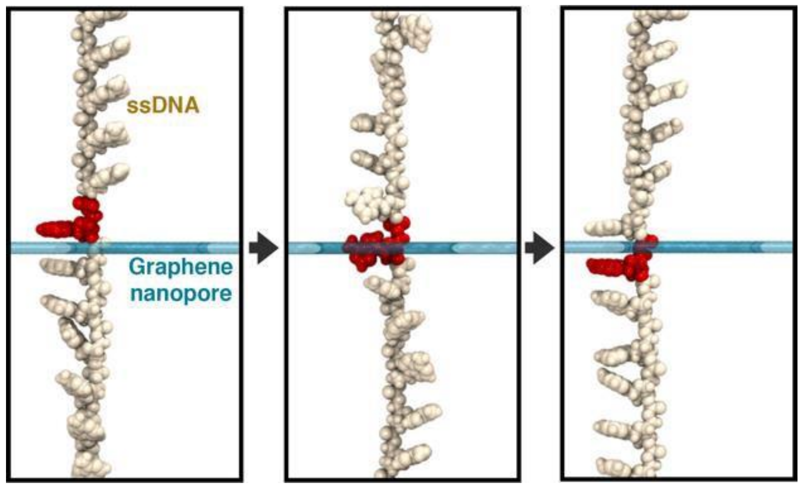

Among various biological and solid-state nanopores, graphene nanopores offer the possibility for revolutionizing the current sequencing technology because of its single-atom-thin layer that can provide enhanced resolution and sensitivity. However, sensing each nucleotide of a DNA strand by graphene nanopores is not yet realized at present mainly due to fast transport of DNA through the pores and stochastic conformational fluctuations of DNA in the pores. By using a stretched single-stranded DNA (ssDNA), our extensive molecular dynamics simulations have demonstrated that the nucleobases can spontaneously bind to graphene pore rim due to the hydrophobic interaction between them, making graphene sandwiched by two adjacent nucleobases. When applying a pulling force to DNA backbones or an electric field normal to graphene membrane, the ssDNA presents a step- by-step transport through alternate unbinding and binding to graphene pore rims. A graphene membrane shaped as a quantum point contact is capable of detecting, by means of transverse electronic conductance measurement, the stepwise translocation of the DNA as predicted through quantum mechanical Green's function-based transport calculations. The stepwise translocation holds the promise to enhance signal-to-noise ratio by not only slowing down DNA translocation that provides a sufficient time to ensure high fidelity sensing but also stabilizing DNA in the pores that reduces thermal and stochastic noise.

Hu Qiu is a postdoctoral research fellow in Theoretical and Computational Biophysics (TCB) Group in Beckman Institute, University of Illinois at Urbana-Champaign (advisor: Prof. Klaus Schulten). He received his PhD from Nanjing University of Aeronautics and Astronautics (China) in 2013. His PhD studies were mainly on the dynamical behaviors of molecules in bio- and nano-confined spaces. He joined the TCB group in 2014 as a postdoctoral research fellow, and his research focus on nanopore DNA sensing. He has published seven first-author papers in high-impact journals including Phys. Rev. Lett., ACS Nano, *etc*.

Perceived Pitch Shifts Elicit Vocal Corrections in Cochlear Implant Patients

Torrey Loucks, PhD Justin
Aronoff, PhD
Deepa Suneel, BSc
Contact: Tloucks@illinois.edu

Auditory deprivation experienced prior to receiving a cochlear implant could compromise neural connections that allow for modulation of vocalization using auditory feedback. In this report, pitch-shift stimuli were presented to adult cochlear implant users to test whether compensatory motor changes in vocal F0 could be elicited. In five of six participants, rapid adjustments in vocal F0 were detected following the stimuli, which resemble the cortically mediated pitch-shift responses observed in typical hearing individuals. These findings suggest that cochlear implants can convey vocal F0 shifts to the auditory pathway that might improve audio-vocal monitoring.

Torrey Loucks is an associate professor of Speech & Hearing Science at the University of Illinois at Urbana. He conducts research in the neural basis of speech production in typical development and stuttering. He graduated from the University of Toronto with a combined degree in Speech-Language Pathology and Neuroscience. He completed a post-doctoral fellowship at the National Institute of Neurological Disorders and Stroke that focused on neural mechanisms of voice and speech. Since 2007, he has been the Director of the Neuro-Speech Lab at the University of Illinois.

Predictive Modeling and Uncertainty Quantification for Engineered and Natural Complex Systems

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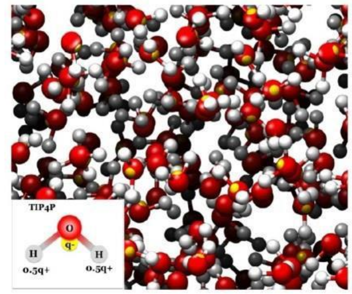

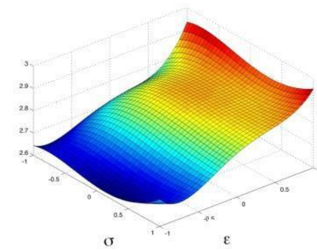

Predictive modeling for complex engineering or natural systems depends on the interplay of computational models with experimental observations, and how various uncertainties, relevant to the models and experiments are quantified. Uncertainties stem from model inaccuracy, numerical and approximation errors, and data incompleteness. Uncertainty Quantification (UQ), as an emerging field, concerns accurate representation of input uncertainties and also efficient propagation of these uncertainties through computer models. As a result, computer predictions can be qualified to support decisions and design procedures. We have developed computationally efficient UQ methods to solve challenging problems in a broad range of areas, including computational mechanics, infrastructure maintenance, disease progression, energy systems, and computational chemistry. Specifically, we focus on Polynomial Chaos (PC), a method proved to be computationally efficient in reliable stochastic analysis. Examples of our research work includes accelerated Bayesian calibration using PC surrogates for coarse---grained molecular models, ensemble prediction using multiple computer models with different fidelities. With the recent advancement in computational power, these UQ techniques could serve as a catalyzer in advancing the computational science for biological systems, clinical and surgical procedures, and effectively address the outstanding challenges induced by the uncertainties involved in their behavior.

Reference:

1. H. Meidani, J.B. Hooper, R.M. Kirby and D. Bedrov. Calibration and Ranking of Coarse---grained Water Models using the Bayesian Formalism, *in revision.*

2. H. Meidani and R. Ghanem (2013). Uncertainty Quantification for Markov Chain Models, *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 22(4)

Hadi Meidani is an Assistant Professor in the Department of Civil and Environmental Engineering at the UIUC he earned his Ph.D. in Civil Engineering and his M.S. in Electrical Engineering from the University of Southern California in 2012. His Ph.D. work focused on Uncertainty Quantification for complex physical systems with specific applications to model reduction, Markov chain models and Markov Decision Processes. He received the student paper award in probabilistic methods at the ASCE Engineering Mechanics Institute Conference in 2012. Prior to joining UIUC, he served as a postdoctoral research associate in the Department of Aerospace and Mechanical Engineering at USC (2012 2013) and in the Scientific Computing and Imaging Institute at the University of Utah (2013-2014).

Spatial Light Interference Microscopy for Quantitative Biomedicine

Gabriel Popescu
Associate Professor
Electrical and Computer Engineering

Most living cells do not absorb or scatter light significantly, i.e. they are essentially transparent, or phase objects. Phase contrast microscopy proposed by Zernike in the 1930?s represents a major advance in intrinsic contrast imaging, as it reveals inner details of transparent structures without staining or tagging. While phase contrast is sensitive to minute optical path-length changes in the cell, down to the nanoscale, the information retrieved is only qualitative. Quantifying cell-induced shifts in the optical path-lengths permits nanometer scale measurements of structures and motions in a non-contact, non-invasive manner. Thus, quantitative phase imaging (QPI) has recently enabled new basic biological studies such as cell growth, membrane fluctuations, intracellular transport, label-free tomography and clinical applications, including blood screening and cancer diagnosis.

Recently, we have developed Spatial Light Interference microscopy (SLIM) as a highly sensitive QPI method. Due to its sub-nanometer pathlength sensitivity, SLIM enables imaging interesting structure and dynamics studies over broad spatial (nanometers-centimeters) and temporal (milliseconds-weeks) scales. I will review our recent results on applying SLIM to basic cell studies, such as intracellular transport, cell growth, and single cell tomography. White-light diffraction tomography is a recent development that enables SLIM to solve inverse scattering problems and render 3D information with sub-micron resolution in all directions.

Gabriel Popescu is an Associate Professor in Electrical and Computer Engineering, University of Illinois at Urbana-Champaign. He received the B.S. and M.S. in Physics from University of Bucharest, in 1995 and 1996, respectively, obtained his M.S. in Optics in 1999 and the Ph.D. in Optics in 2002 from the School of Optics/ CREOL (now the College of Optics and Photonics), University of Central Florida. Dr. Popescu continued his training with the G. R. Harrison Spectroscopy Laboratory at M.I.T., working as a postdoctoral associate. He joined Illinois in August 2007 where he directs the Quantitative Light Imaging Laboratory (QLI Lab) at the Beckman Institute for Advanced Science and Technology. Prof. Popescu received the 2009 NSF CAREER Award, was the 2012 Innovation Discovery Finalist selected by the Office of Technology Management Office, UIUC, was elected as the 2012-2013 Fellow of the Center for Advanced Studies at UIUC, and a 2014 finalist in the New Venture Competition with Phi Optics, Inc., at UIUC Dr. Popescu is an Associate Editor of Optics Express and Biomedical Optics Express, and Editorial Board Member for Journal of Biomedical Optics. He is OSA Senior Member and SPIE Fellow. Over the past decade, Dr. Popescu has been working mainly on quantitative phase imaging of cells and tissues. He authored a book on this subject, edited another book on NanoBiophotonics, authored 100 journal publications, 120 conference presentations, 24 patents, gave 110 invited talks. Dr. Popescu founded Phi Optics, Inc., a start-up company that commercializes quantitative phase imaging technology.

Health Monitors for Cardiopulmonary Patients using Mobile Phones

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Professor, Department of Computer Science, College of Engineering
Resident Faculty, Institute for Genomic Biology
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Widespread availability of mobile devices is revolutionizing health monitoring. Smartphones are ubiquitous, but it is unknown what vital signs can be monitored with medical quality. Gait Speed and Oxygen Saturation measure health status, as standard composite vital signs. We have shown phone sensors can accurately measure walking patterns, and that such gait models can accurately predict six minute walk distance and GOLD level pulmonary function. These models were validated by cardiopulmonary patients carrying standard smartphones, in clinical experiments with 30 subjects at UI Health in Chicago. The accuracy is now 3% for walk tests and 11% for free walks. Our software models are far more accurate than commercial fitness devices worn on the wrist, or medical accelerometers worn on the waist. In subsequent clinical experiments with 20 subjects at Carle Hospital in Urbana, we showed that phone sensors can accurately measure oxygen saturation, including status transitions. The subjects performed six minute walk tests in pulmonary rehabilitation at this regional hospital. They wore pulse oximeters and carried smartphones running our MoveSense software, which continuously recorded saturation and motion. Continuous saturation defined categories corresponding to status levels including transitions. Continuous motion was used to compute spatio-temporal gait parameters from sensor data. Our existing gait model was then trained with this data and used to predict transitions in oxygen saturation. Oxygen saturation clustered into 3 categories, corresponding to pulmonary function GOLD 1 and GOLD 2, with a Transition category where saturation varied around the mean rather than remaining steady with low standard deviation. This category indicates patients who are not clinically stable. The gait model predicted status during each measured window of free walking, with 100% accuracy for the 20 subjects, based on majority voting. Continuous recording of oxygen saturation can predict cardiopulmonary status, including patients in transition between status levels. Gait models using phone sensors can accurately predict these saturation categories from walking motion.

References in *Telemedicine & E-Health 2014 & 2015,* the official journal of the American Telemedicine Association, with co-authors Qian Cheng and Joshua Juen.

Bruce Schatz has broad interests in mobile devices for health measurement, including population deployment using smart phones into health systems. He was program chair last year for the main computer science conference in health informatics. He was Principal Investigator of national flagship NSF projects in digital libraries, building the first distributed repository of structured documents across the Internet, and in bioinformatics, building the first semantic federation of biomedical literature for genomic analysis. He won best paper at AMIA for the first semantic indexing of Medline, on supercomputers. He is AAAS Fellow for developing the first network browser for multimedia documents, which led directly to creation of the Web. He is the author of the first technical book on using mobile technologies to revolutionize medicine and public health, *Healthcare Infrastructure: Health Systems for Individuals and Populations*, Springer series in Health Informatics, London 2011.

Therapeutic Video Games

Rizwan Uddin
Professor
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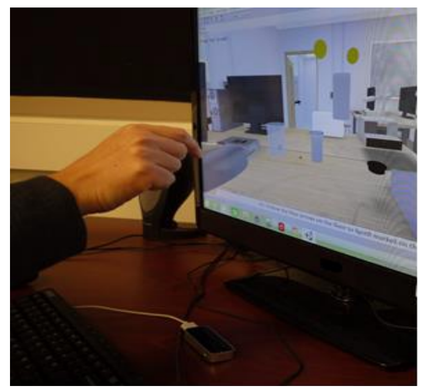
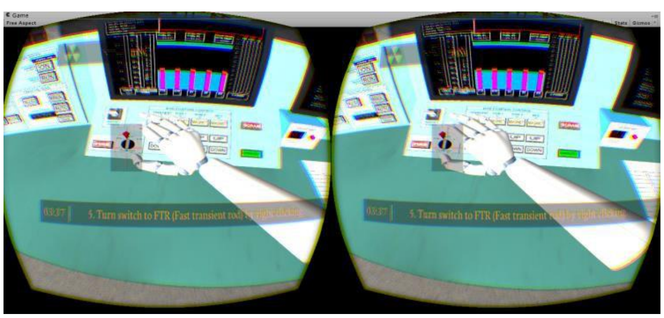
Video games and virtual reality (standard, augmented, mixed/blended) are increasingly being explored for use in education and training. Several features in these technologies make them very attractive for such applications. Augmented/blended reality and gesture-controlled interactions are likely to open doors for even more realistic applications. For example, we have incorporated *Kinect* and, more recently, *LEAP* in our virtual models of scientific laboratories to allow gesture (rather than mouse) based operations of laboratory equipment. Gesture-tracking video games may also allow development of more innovative applications.



Traditional occupational therapy can get assistance from appropriately designed video games that can help patients repeat certain actions on their own. Use of gesture tracking hardware— such as Wii, Kinect and LEAP—can allow incorporation of a set of specific therapist-recommended actions in the game. Therapists can then customize such general purpose games for patient needs. Based on patient's status, this customization may be varied over time. Developers at Clemson University recently reported a game to help in the recovery of stroke survivors.




The Post and Courier

Stroke survivors on road to recovery with help from 'Duck Duck Punch' video game

By Lauren Shirley
lshirley@postandcourier.com

Rizwan Uddin has been working in the area of Virtual Reality since around 2001. Primary interest has been in exploring the use of VR for education and training. His group's most significant contribution in this field has been the development of virtual 3D, immersive, interactive labs with real physics for multiplayers. These have been incorporated in head mounted devices with gesture tracking.