

# 4<sup>th</sup> Health Care Engineering Systems Symposium

**Monday, September 11, 2017**

**8:30 am – 4:30 pm**

**Chancellor Ballroom  
I Hotel, Champaign, IL**



**Hosted by:**

**Health Care Engineering Systems Center, UIUC**

**Jump Simulation and Education Center, OSF HealthCare**

**4th Health Care Engineering Systems Symposium  
Monday, September 11, 2017  
Chancellor Ballroom, I Hotel**

## **AGENDA**

- 8:30 – 9:00 AM**                      **Breakfast and Registration**  
Lobby
- 9:00 – 9:15 AM**                      **Welcome and Opening Remarks**  
Kesh Kesavadas  
John Vozenilek  
Andreas Cangellaris  
Michelle Conger
- 9:15 – 9:30 AM**                      **Rohit Bhargava**  
Introducing the New Cancer Center at the University of Illinois
- 9:30 – 10:15 AM**                      **Jump ARCHES Review**  
Kesh Kesavadas  
John Vozenilek
- Jump ARCHES Collaborations**
1. *Innovation*  
Michelle Conger
  2. *Clinical Excellence*  
Steve Hippler
  3. *Health Data Analytics*  
Joerg Heintz
- 10:15 – 11:15 AM**                      **Session I**  
**Medical Simulation Technologies: Devices & Software**  
Deborah Thurston, Moderator
1. *Aging-in-Place: Design of Technologies to Support Health and Autonomy*  
Wendy Rogers
  2. *Design, Fabrication, and Simulation of a Single-Port Minimally Invasive Surgical Robot*  
Nicholas Toombs

3. *Trials and Tribulations of Creating a Training Simulator for Spasticity*  
Elizabeth Hsiao-Wecksler
4. *Interactive Technology Support for Patient Medication Self-Management*  
Daniel Morrow
5. *Augmented Reality for Image Guided Surgery*  
Victor Gruev
6. *Multi-Model Medical Image Understanding*  
Honghui Shi
7. *ASPIRE: Automation Supporting Prolonged Independent Residence for the Elderly*  
Venanzio Cichella

**11:15 – 11:30 AM**

**Break**

**11:30 AM – 12:30 PM**

**Session II**

**Medical Simulation Technologies: Devices & Software**

Elizabeth Hsiao-Wecksler, Moderator

1. *3D Printed Hydrogel Heart Models for Pre-Operative Planning*  
Rashid Bashir
2. *Simulator for Training Extracorporeal Membrane Oxygenation*  
Pramod Chembrammell
3. *Movement Impairment Characterization and Rehabilitation for Dystonic Cerebral Palsy using Robotic Haptic Feedback in Virtual Reality*  
Citlali Lopez-Ortiz
4. *Readmission Risk Estimation Technology Acceptance and Practitioner Use*  
Deborah Thurston
5. *Automated Pipeline from the MRI Scanner to the 3D Printer for the Heart*  
Brad Sutton
6. *Simulation of Postural Dysfunction in Parkinson's Disease*  
Manuel Hernandez
7. *AI Driven Health Analytics and Systems*  
Ravishankar Iyer

**12:30 – 2:00 PM**

**Lunch**  
Quad Room and Lobby

**2:00 – 4:30 PM**

**Interactive Medical Simulation Expo - Supported by SIMnext**  
Technology Room and Alma Mater Room

**2:00 – 4:30 PM**

**Posters**

**3:00 – 3:15 PM**

**Introduction into ARCHES Funding Mechanism**  
Chancellor Room

**3:15 – 4:00 PM**

**Collaborator Matching Sessions**  
Chancellor Room

**3:30 PM**

**Reception Opens**  
Lobby

## Symposium Co-Chairs



**John Vozenilek**

Vice President & Chief Medical Officer for Simulation  
Jump Simulation and Education Center, OSF HealthCare  
Duane and Mary Cullinan Professor in Simulation Outcomes  
University of Illinois College of Medicine at Peoria  
College of Engineering, University of Illinois at Urbana-Champaign



**Thenkurussi (kesh) Kesavadas**

Director of Health Care Engineering Systems Center  
Professor  
Department of Industrial and Enterprise Systems Engineering  
College of Engineering  
University of Illinois at Urbana-Champaign

## Welcome and Opening Remarks



**Andreas C Cangellaris**

Dean, College of Engineering  
M. E. Van Valkenburg Professor in Electrical and Computer Engineering  
University of Illinois at Urbana-Champaign



**Michelle Conger**

Senior Vice President and Chief Strategy Officer  
OSF Healthcare System



## ***Introducing the New Cancer Center at the University of Illinois***

### **Rohit Bhargava**

Founder Professor of Engineering

Director, Cancer Center at Illinois

Director, Tissue Microenvironment Training Program

Departments of Bioengineering (primary), Electrical & Computer Engineering,  
Mechanical Science & Engineering, Chemical and Biomolecular Engineering and  
Chemistry and Beckman Institute for Advanced Science and Technology

**Rohit Bhargava** received a dual B.Tech. degree (Chemical Engineering with a minor in Polymer Science and Engineering) from the Indian Institute of Technology, New Delhi and doctoral degree from Case Western Reserve University. After a stint at the National Institutes of Health, Rohit has been at Illinois as Assistant Professor (2005-2011), Associate Professor (2011-2012) and Professor (2012-). Rohit has pioneered the development of infrared spectroscopic imaging, starting from his doctoral thesis that was the first in this field. Fundamental work in theory and numerical methods in his laboratory directly leads to new instrumentation and technologies. Instruments developed in his laboratory have been used to provide new means to characterize and define cancer using chemical imaging that are leading to the emergence of the field of digital molecular pathology. Using 3D printing and engineered tumor models, his most recent research seeks to create designer cancers in the laboratory.

Rohit founded the Cancer Community@Illinois, a University-wide effort dedicated to advancing cancer-related research and scholarship at Illinois. The effort has been a unique approach to oncology across the lifespan and the first such national center combining high quality engineering with the field of oncology. Earlier in his career, Rohit was among the first faculty in the new Bioengineering department at Illinois and played a key role in its development. This endeavor resulted in launching a new center of interdisciplinary collaboration—the Cancer Center at Illinois—to make a greater impact in the fight against the second leading cause of death in Illinois and the United States. Currently Rohit is the Director of the new Cancer Center in Illinois.



Jump Applied Research for Community Health through Engineering and Simulation (Jump ARCHES) is a partnership of clinicians and engineers working together for the advancement of health care.

An endowed fund supports these collaborative efforts between engineers at the College of Engineering at Illinois and health care providers at OSF HealthCare and University of Illinois College of Medicine at Peoria as they work to solve health care challenges through innovative solutions.

Jump ARCHES provides direct access and grants for engineers and clinicians of every discipline to work together, tackling problems in the real world of health care. Further, through international partnerships, Jump ARCHES is also developing simulation-based educational tools to meet global health care challenges

In collaboration with the Health Care Engineering Systems Center in the College of Engineering at Illinois, and the Jump Simulation and Education Center at OSF Healthcare in Peoria, Illinois, Jump ARCHES focuses on creating simulation and educational tools through imaging, health information technology, novel sensors and devices, and human factors engineering.

These teams work together and use the unique environment of Jump to hypothesize, test and redesign tools, techniques and processes being used by caregivers every day.

Through Jump ARCHES, our studies are intended to demonstrate improved clinical outcomes, reductions of cost and higher quality practices through simulation.



### ***Innovation***

#### **Michelle Conger**

Chief Strategy Officer  
OSF Healthcare System

**Michelle Conger** is the 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 lead 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 social work from the University of Illinois.



### ***Clinical Excellence***

#### **Stephen Hippler**

Senior Vice President of Clinical Excellence  
Chief Clinical Officer  
OSF HealthCare System

**Stephen Hippler, MD** is the Senior Vice President for Clinical Excellence and Chief Clinical Officer for OSF HealthCare. 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.





## ***Data Science Collaboration Report***

### **Joerg Heintz**

Dara Science Program Manager  
Health Care Engineering Systems Center  
College of Engineering  
University of Illinois at Urbana-Champaign.

Collaboration is a substantive idea repeatedly discussed in health care industry, and in universities. The benefits are obvious, and yet collaboration is seldom practiced. This report provides an overview on the expectations of each party, the administrative and technical challenges, and the learnings made in a typical data science project.

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**Joerg Heintz** is leading the Health Care Engineering Systems Center's Health Data Analytics Group. He manages the development and delivery of the health data analytics initiatives and serves as liaison between HCESC and healthcare providers, the healthcare industry, and other healthcare researchers.

Changing the healthcare delivery model and how the decisions are made relies heavily on the seamless combination of strategy, health data analytics, and implementation processes. The Health Data Analytics Group of HCESC powers those data-driven transformations and creates enormous opportunities to improve patient outcomes while managing costs.

Joerg has a proven track record in delivering IT transformation projects aimed to align the IT environment with the strategy. He has profound practical experience in designing enterprise and IT architectures, designing and implementing ITIL processes, operational risk- and compliance processes, and IT governance models. His past clients include Fortune 50 companies providing IT service, healthcare providers, reinsurers, and a world leading automotive manufacturer.

He gained his experience in academic environments at the National Center for Supercomputing Applications (NCSA), and at the University of Illinois' NIH BD2K Center for Large Genomic Data, where he served as Associate Director. In his industry career he served as executive manager and management consultant for IBM, Swisscom, and 1&1 Internet AG.



## ***Aging-in-Place: Design of Technologies to Support Health and Autonomy***

### **Wendy Rogers**

Shahid and Ann Carlson Khan Professor  
Department of Kinesiology and Community Health  
College of Applied Health Sciences  
University of Illinois at Urbana-Champaign

Older people live in a variety of settings and locations and their choices are now broader than ever before. In addition, living environments are evolving (e.g., cross-generational, communal). In this presentation, I will discuss the concept of aging-in-place and provide an overview of where older people live today, in terms of both the physical and the social environment. I will discuss the challenges of aging in place (e.g., caring for self, caring for others, caring for the home) and the potential for technology solutions, such as smart-home technologies.

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**Wendy Rogers** is Director of the Human Factors and Aging Laboratory, funded by the National Institutes of Health (*National Institute on Aging*) as part of the Center for Research and Education on Aging and Technology Enhancement and the Administration for Community Living [*National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR)*]. She is the Co-Director, Rehabilitation Engineering Research Center (RERC) on Technologies to Support Successful Aging with Disability. Dr. Rogers' research interests include design for aging, technology acceptance, human-automation interaction, aging-in-place, human-robot interaction, aging with disabilities, and cognitive aging.



***Design, Fabrication, and Simulation of a Single-Port Minimally Invasive Surgical Robot***

**Nicholas Toombs**

Doctoral Candidate

Department of Mechanical Science & Engineering

College of Engineering

University of Illinois at Urbana-Champaign

Minimally invasive robotic Single-Port Laparoscopic Surgery (SPLS) is of high importance, due to its ability to reduce operation times, recovery times, postoperative infection rates and improve cosmesis while providing surgeons with greater dexterity and precision than traditional SPLS techniques. Previous approaches to robotic SPLS rely on modifications to devices meant for multi-port procedures. These approaches suffer from larger port sizes and reduced dexterity. Here, we propose a scheme for SPLS involving 6-DOF robot manipulators and lumen designs that translate the dexterity triangulation capabilities of the surgeons arm completely in-vivo, using a novel insertion scheme where by three 8mm tools as well as a scope can be passed through a single 18mm trocar.

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**Nick Toombs** earned his Bachelors and his Masters degrees in Mechanical Engineering at the University of Illinois at Urbana-Champaign. His graduate work is focusing on micro manufacturing and working on a project to enable deterministic transfer printing of micro-electronics (on the order of 100 microns) onto various material substrates. His interests include: manufacturing, control and automation, and product design.



### ***Trials and Tribulations of Creating a Training Simulator for Spasticity***

#### **Liz Hsiao-Wecksler**

Professor and Willett Faculty Scholar  
Department of Mechanical Science & Engineering  
College of Engineering  
University of Illinois at Urbana-Champaign

Our multi-institute, interdisciplinary group has been developing a training simulator for replicating spasticity at the elbow. Spasticity, often observed in stroke, cerebral palsy, and multiple sclerosis patients, is speed-dependent such that muscle resistance increases with increased movement speed. To assess spasticity, clinicians use qualitative scales such as the Modified Ashworth Scale (MAS). For the MAS, the clinician assigns an integer score from 0 (normal) to 5 (most severe) while the joint is passively flexed or extended. To mimic muscle resistance in the simulator, we took a novel approach by placing a passive



hydraulic damper in the upper arm that is attached to the forearm through a linkage system. Different levels of resistance, joint range of motion, and catch angles will be selectable to match MAS levels 0 to 4. Muscle resistance is generated from the fluid being forced through different-sized



orifices on the damper's piston head. The design has no power source to generate any active resistance.

Due to limited published data to properly "tune" the simulator to match clinician expectations of MAS level with the device's performance specifications, we have also

developed a Position, Velocity, and Resistance Meter (PVRM). The PVRM is strapped around a patient's limb to measure joint muscle resistance, angular position and assessment speed. Validation testing has been completed. Testing on a large database of patients across MAS levels is forthcoming.

This project has been supported by the Jump ARCHES program of OFS Healthcare, UICOMP, and UIUC.

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Dr. Hsiao-Wecksler is the Associate Head for Undergraduate Programs. She is an affiliate in the Departments of Bioengineering, Industrial & Enterprise Systems Engineering, and Neuroscience; the Beckman Institute; the Center on Health, Aging and Disability; and the multi-institutional NSF Engineering Research Center for Compact and Efficient Fluid Power. Her research focus has changed to developing assistive devices and pneumatically powered exoskeletons for disabled and industrial workforce populations. Her research program has been supported by grants from agencies such as the NSF, NIH, and Dept. of Homeland Security; has published over 80 peer-reviewed journal papers and extended conference proceeding papers, and 125 conference abstracts/presentations; has been awarded 3 U.S. patents; graduated 11 Ph.D., 26 M.S., and over 100 undergraduate students; and created 1 small business. She is a Fellow of the American Society of Mechanical Engineers, Associate Editor for the ASME Journal of Medical Devices, and 2012 Program Chair for the American Society of Biomechanics.



### ***Interactive Technology Support for Patient Medication Self-Management***

**Dan Morrow**

Professor

Department of Educational Psychology

College of Education

University of Illinois at Urbana-Champaign

The goal of our project is to develop and evaluate technology that supports providers' ability to educate patients about medication management and patients' ability to accomplish this and other self-care goals. We are developing Natural Language Processing tools integrated with Electronic Health Record (EHR) systems that automatically translate technical medication information in the EHR into language that patients can easily understand and use, and integrate this language into a computer agent (CA)-based medication adviser system that supports distributed collaboration between providers and patients. We report progress on developing and evaluating the NLP translation tool, evaluating candidate CAs for the system, and initial evaluation of a prototype integrated system.

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**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.



## ***Augmented Reality for Image Guided Surgery***

### **Victor Gruev**

Associate Professor  
Department of Electrical and Computer Engineering  
College of Engineering  
University of Illinois at Urbana Champaign

Near infrared fluorescence (NIRF) based image guided surgery aims to provide vital information to the surgeon in the operating room, such as locations of cancerous tissue that should be resected and healthy tissue that should to be preserved. Targeted molecular markers, such as nerve targeted or tumor targeted, are used in conjunctions with NIRF imaging and display systems to provide key information to the operator in real-time. One of the major hurdles for the wide adaptation of these imaging systems is the high cost to operate the instruments, large footprint and complexity of operating the systems. The emergence of wearable NIRF systems has addressed these shortcomings by minimizing the imaging and display systems' footprint and reducing the operational cost. However, one of the major shortcomings for this technology is the replacement of the surgeon's natural vision with an augmented reality view of the operating room. In this talk, I will address our recent effort in bringing mix reality to surgery setting using Hololens. The adoption of this technology in the operating room during liver cancer surgery will be discussed.

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**Viktor Gruev** is an associate professor in the department of Electrical Engineering at University of Illinois at Urban Campaign. Prior to joining UIUC, he was an associate professor in the Department of Computer Science and Engineering at Washington University in St. Louis. Prof. Gruev received his B.S. in Electrical Engineering with distinction from Southern Illinois University in Carbondale in 1998. He completed his M.S. and PhD. in electrical engineering from Johns Hopkins University in 2000 and 2004 respectively. Dr. Gruev was a post doctoral researcher at the University of Pennsylvania before joining Washington University in St. Louis in 2008 as an Assistant Professor. He has received numerous awards for his research on imaging sensors and their application in the medical field, including the 2016 IEEE Donald G. Fink Award for an outstanding scientific contribution in the IEEE society. His current research focuses on bringing medical imaging technology to resources limited hospitals and to the developing world.



### ***Multi-Model Medical Image Understanding***

**Honghui (Humphrey) Shi**

Doctoral Candidate

Department of Electrical and Computer Engineering

College of Engineering

University of Illinois at Urbana-Champaign

The potential benefits of fusing information from multiple medical imaging modality to assistant medical image based diagnosis, analysis and intervention is fascinating, yet it's hard to be materialized without proper understanding of the medical images from each correspondent modality and their correlations. In this talk, we will present the challenges during our work in multi-modal CT to X-ray fluoroscopy registration project, and illustrate some success we achieved during our efforts with a focus on medical image understanding.

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**Honghui Shi** is a doctoral candidate in the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign (UIUC). He is a senior member of the Image Formation and Processing group (IFP) at Beckman Institute for Advance Science and Technology and also affiliated with Coordinated Science Laboratory (CSL). Shi is known for his research and engineering skills across multiple domains such as computer vision, pattern recognition, deep learning, and medical image analysis. As an IFP team leader, he has collaborated with graduate students and scholars and successfully funded a number of research projects both from national institutes and corporations. He has won many prestigious awards and competitions including winning the global object recognition challenge ImageNet Object Detection and Tracking from Videos, and IEEE Smart World Nvidia AI City Challenge.



***ASPIRE: Automation Supporting Prolonged Independent Residence for the Elderly***

**Venanzio Cichella**

Doctoral Candidate

Department of Mechanical Science and Engineering

College of Engineering

University of Illinois at Urbana Champaign

One day in the not so distant future, autonomous ground and flying robotic devices will be helping people with everyday activities, revolutionizing our conventional style of living, and improving the quality of our lives. In order to effectively and safely co-exist with humans, the robots have to be perceived as safe and trustworthy, implying that their behavior has to be consistent with principles of human spatial perception, and their motion must foster a high level of comfort of collocated others. Inspired by these ideas, this talk discusses the human-centered design and control problems for cooperative ground and flying robots, which are required to cooperate and interact with humans in shared spaces. The key focuses include: first, the understanding of how humans perceive and navigate complex and dynamic environments inhabited by autonomous vehicles, and second, the formulation and implementation of planning and control algorithms that allow the robots to improve the level of comfort and perceived safety of humans. Emphasis is placed on our group's research findings applied to ASPIRE, where teams of ground and flying robots are designed to assist the elderly population and people with disabilities, enabling them to live at home longer and independently.

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**Venanzio Cichella** received his B.S. and M.S. in Automation Engineering in 2007 and 2011, respectively, from the University of Bologna. Before that he spent 9 months at TU Delft as an Erasmus student, and 1 year at the Naval Postgraduate School, Monterey, CA, 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, and human-centered robotic design.





### ***3D Printed Hydrogel Heart Models for Pre-Operative Planning***

#### **Rashid Bashir**

Executive Associate Dean and Chief Diversity Officer of Carle-Illinois College of Medicine and Abel Bliss Professor and former Department Head of Bioengineering at the College of Engineering of the University of Illinois at Urbana-Champaign

Abstract: Congenital Heart Disease (CHD) affects 1% of infants born, with 25% of those affected requiring surgery within the first year of life. Due to the small size of the infant heart, as well as the wide variety of defects which may be present, these operations are not only high-risk, but difficult to prepare for. With recent advancements in 3D printing, however, medical imaging data can be used to fabricate highly accurate patient-specific 3D models of cardiac anatomy. These printed models allow surgeons to better visualize the unique 3D structure of patient anatomy prior to surgery. We are building upon current models by using stereolithography (SL) to 3D print patient-specific infant hearts using a cardiac tissue-mimicking PEGDA-based hydrogel material. These hydrogel hearts are similar in elastic modulus and wetness to live cardiac tissue, making them a more realistic model for pre-operative planning. Furthermore, through use of a tough hydrogel material, we aim to build models which are suturable and sufficiently withstand surgical repair techniques, thus enabling surgeons to practice on a patient-specific model prior to surgery. Using CT to image the printed hearts before and after surgical intervention, the surgeon's repair technique can be validated. We believe that these models will better prepare surgeons for unique CHD cases, while also serving as a valuable tool for general surgical training.

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**Rashid Bashir** is the Executive Associate Dean and Chief Diversity Officer of Carle-Illinois College of Medicine and Abel Bliss Professor and former Department Head of Bioengineering at the College of Engineering of the University of Illinois at Urbana-Champaign. He is the former 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.



### ***Simulator for Training Extracorporeal Membrane Oxygenation***

#### **Pramod Chembrammal**

Research Scientist

Health Care Engineering Systems Center

College of Engineering

University of Illinois at Urbana-Champaign.

Extracorporeal Membrane Oxygenation (ECMO) is used as salvage therapy to effect mechanical cardiorespiratory support regardless of the underlying cause. The widespread adoption of ECMO in adults is limited by the unfamiliarity with safe and rapid deployment of peripheral cannulation, limited working capabilities of the oxygenators, the cumbersome equipment and bulky tubes and cannulae. The unfamiliarity with the cannulation techniques is attributed to the lack of prior training, which, at present is done on patients who are critically ill. ECMO is usually initiated in these “crash and burn” situations and simulation technology has not been adapted yet to replicate these difficult scenarios. ECMO training simulator replicates the clinical situation with a rapidly decompensating patient who is failing all attempts at conventional resuscitation. The simulator has a customized mannequin with underlying vasculature that simulates a femoral artery building up to the iliac artery and then the aorta, a femoral vein going up to the iliac vein and then on to the inferior vena cava and the right atrium. The underlying flexible vasculature is manufactured by means of 3D printing using segmented data from MRI/CT scans of real patients. The biological tissue-like flexible vasculature is amenable to cannulation, stent placement and other endovascular procedures. The simulator can be scanned using ultrasound or X-ray permitting the trainees to acquire/improve the skills required to perform ECMO. Using a flexible vasculature enables one to monitor flashback of blood during cannulation/arterial access, unexpected puncturing of blood vessels etc. This also permits one to train on other endovascular procedures like angiogram/angioplasty using guidewires and catheters.

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**Pramod Chembrammal** 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.



***Movement Impairment Characterization and Rehabilitation for Dystonic Cerebral Palsy using Robotic Haptic Feedback in Virtual Reality***  
**Citlali López-Ortiz**

Assistant Professor, Department of Kinesiology and Community Health  
Neuroscience Program  
Illinois Informatics Institute, Department of Dance  
University of Illinois at Urbana-Champaign

Cerebral palsy (CP) is the most common developmental disorder in children. The prevalence of CP in children in the United States is estimated to be between 3.1 to 3.6 cases per 1000 live births. Approximately ten to seventeen percent of children with CP have dystonia and seek medical assistance at higher rates than other forms of CP. Dystonia is a movement disorder that presents involuntary muscle contractions causing twisting and repetitive movements, abnormal postures, or both. There is no cure for dystonia and rehabilitation exercises are unknown. We are conducting a clinical trial of a noninvasive, game-like movement puzzle, for in dystonic-CP using **virtual reality and haptic feedback** of low dimensions of canonical classical ballet postures. *This study will provide experimental evidence for the feasibility of training implicit motor learning of trajectory formation via postural tasks in children with dystonic CP to improve clinical motor scores.* By training movement as a series of static tasks of low force but high selective motor control, we hope to advance movement therapy protocols in dystonic CP. This intervention is fun and engaging which are both required in effective neuro-rehabilitation. This game-like intervention will also provide an **objective and quantitative characterization of dystonia and spasticity** presentations, even if combined, through the process of motor learning. As such, the proposed game-like protocol provides an invaluable tool for the **training of medical practitioners** in the identification of complex presentations of motor disorders, not limited to CP and doubles as a **therapeutic intervention** for the rehabilitation of dystonia in CP. Since May 2017 we have successfully developed and tested two haptic feedback protocols for a Kuka Youbot. One protocol is based on based on the principal component analysis of forces and torques of quasi-static upper limb force efforts against the robot as performed by typically developed young adults. This protocol is used to inform the virtual reality environment for the game with six levels of difficulty. The second protocol is a zero-force channel haptic environment used for assessment and classification of movement quality. This protocol guides the upper limb movements though trained via-points in the virtual reality game. We will address these recent developments and provide a live demonstration to the audience.

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Dr. López-Ortiz is the founder and director of the Neuroscience of Dance in Health and Disease Laboratory where she is developing the scientific basis for dance as therapy for rehabilitation of movement disorders and augmented motor learning. Her research focuses on how the human brain generates dexterity in motor coordination using the language of dance movement to inform the design of dance/movement training protocols in health, disease, and disability through the life span. Her research is intrinsically interdisciplinary. It includes the areas of dance, biomechanics, mathematical modeling, motor control, motor learning, physics, body-environment interfaces, mixed media, computational neuroscience, neurophysiology, and rehabilitation. Current research projects include the following:

1. Movement rehabilitation for dystonic cerebral palsy using classical ballet and robotic haptic feedback in virtual reality.
2. The effects of a targeted classical ballet class on spastic cerebral palsy.
3. Training voluntary saccades for improved mobility in Parkinson's disease (PD).
4. Targeted ballet program (TBP) for improved mobility in multiple sclerosis (MS).



## ***Readmission Risk Estimation Technology Acceptance and Practitioner Use***

**Deborah Thurston**

Gutsgell Professor

Department of Industrial and Enterprise Systems Engineering

College of Engineering

University of Illinois at Urbana-Champaign

Approximately 20 to 25 percent of patients discharged from primary healthcare facilities are readmitted within 30 days at a cost of roughly \$42 billion dollars per year. The Affordable Care Act (ACA) of 2010 directed Accountable Care Organizations (ACOs), a network of healthcare providers, to seek improvement of the quality of discharge care while integrating a new “pay for performance” business model which includes financial penalties for unplanned 30-day readmissions. This, along with incentives within the ACA for adoption of electronic health records (EHR) has motivated the rapid creation of new predictive risk estimation technologies, at least 26 of which have been created. These new technologies are often proposed without methods to guide their design or implementation. The impact of inserting them into the traditional human-centered expert decision process is not well understood. Previous research conducted on expert heuristics within the healthcare industry has not been specific to patient readmission risk estimation. The human-computer interactions are the subject of study here, specifically how technology might influence case manager readmission risk estimation through heuristics such as anchoring and adjustment. This paper presents the results of an experiment designed to simulate the reactions of healthcare providers to inputs from new readmission risk estimation technology developed by OSF. For example, results indicate that the healthcare workers’ estimates of risk were anchored on the output of the technology, but were then adjusted according to their own expertise. The healthcare workers further adjusted their estimates in response to new input from another human expert. Other results are also reported.

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Dr. Thurston serves as Director of the Decision Systems Laboratory, and co-directs the Hoefft 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.



### ***Automated Pipeline from the MRI Scanner to the 3D Printer for the Heart***

#### **Brad Sutton**

Associate Professor  
Department of Bioengineering,  
College of Engineering  
University of Illinois at Urbana-Champaign

The anatomy around the dynamic heart creates challenges for automated segmentation of cardiac muscle from a 3D or 4D magnetic resonance imaging (MRI) scan. It can be difficult to separate nearby intercostal muscles and the liver which may contact the cardiac muscle and often have identical imaging contrast. We have developed an approach, utilizing a convolution neural network coupled with bias-field correction to the input images that enables accurate segmentation without user intervention. The overall technique requires several steps, each using different software and data formats to complete. We will give an overview of the pipeline and its performance.

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**Brad Sutton** is Associate Head of Undergraduate Studies (2012---2015), and Technical Director of the Biomedical Imaging Center at Beckman Institute (2014---). He 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 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.



## ***Towards a Simulation of Postural Dysfunction in Parkinson's Disease***

**Manuel E. Hernandez**

Assistant Professor

Department of Kinesiology and Community Health

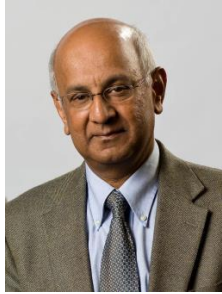
College of Applied Health Sciences

University of Illinois at Urbana-Champaign

Postural instability is a cardinal feature of Parkinson's disease (PD), which marks the onset of severe disability due to its unresponsiveness to dopaminergic therapy and increased risk of injury and falls. Abnormal neural oscillations and synchronization within numerous basal ganglia-cortical circuits due to the loss of dopamine-producing cells is a hallmark of PD. However, the cortical impairments underlying postural control deficits due to PD and the role of anxiety in mediating these alterations have not been well studied. This project proposes to investigate the role of anxiety in underlying postural dysfunction due to PD and further examine the effects of dopamine-replacement therapy. In addition to providing a greater understanding of the coordinated activity of the body and brain, the disruption of this coupling that results from PD, this work will provide a new computational method for the characterization and classification of neural and motor dysfunction relevant to a wide range of motor disorders, a new tool for use in long-term monitoring to disease progression and drug treatment efficacy, and a platform for simulation of the impact of altered sensorimotor function in postural control.

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**Manuel Hernandez** received the B.S. degree in Mechanical Engineering from Cornell University, Ithaca, NY, USA, in 2003, and M.S. and Ph.D. degrees in biomedical engineering from the University of Michigan, Ann Arbor, MI, USA, in 2005 and 2012, respectively. He completed his post-doctoral training in neuroscience at the Institute for Neural Computation at the University of California-San Diego, La Jolla, CA, USA, in 2014. He joined the faculty of the Department of Kinesiology and Community Health Champaign in 2014 and is currently the Director of the Mobility and Fall Prevention Research Laboratory. His research interests include biomechanics, motor control, and neuroscience in older adults. Dr. Hernandez's research has focused on the use of experimental and theoretical models of risk factors for injury or disability during the performance of goal-directed movements in older adults with and without neurological disorders, particularly Parkinson's disease. Dr. Hernandez is interested in the behavioral and neural mechanisms underlying postural dysfunction in older adults and particularly in the development of behavioral and neural biomarkers for early detection of neurological disorders.



## ***AI Driven Health Analytics and Systems***

### **Ravishankar K. Iyer-Chair**

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

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

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**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.

# Interactive Medical Simulation EXPO

4th Health Care Engineering Systems Symposium



Virtual Reality



Virtual Surgery



Virtual Patients



Augmented Reality

**Monday, September 11, 2017 | 8:30 a.m. – 4:30 p.m.**

Chancellor Ballroom, I Hotel, Champaign, IL

[healthengsymp.illinois.edu](http://healthengsymp.illinois.edu)





## Interactive Medical Simulation Expo - Supported by SIMnext

Technology Room and Alma Mater Room

1. *Movement Impairment Characterization and Rehabilitation in Cerebral Palsy using Robotic Haptic Feedback in Virtual Reality*  
**Citlali Lopez-Ortiz**, Sara McKeeman, Reika McNish, and Nathaniel Speidel
2. *AirwayVR: Learning Endotracheal Intubation in Virtual Reality*  
**Na-Teng Hung**, Pavithra Rajeswaran, Praveen Kumar, John Vozenilek, and T. Kesh Kesavadas
3. *Dr. Babel Fish: A Machine Translator to Simplify Providers' Language*  
**Tarek Sakakini**, Renato F.L. Azevedo, Victor Sadauskas, Kuangxiao Gu, Yang Zhang, Suma Bhat, Dan Morrow, Mark Hasegawa-Johnson, Thomas S. Huang, Ann Willemsen-Dunlap, Donald J. Halpin, and James Graumlich
4. *Multiplayer Platform-Independent Virtual Reality World for Education*  
**Lingzhi Chu**, Naveen Sankaran, Steve Lavalley, and Kesh Kesavadas
5. *A New Mixed Reality Platform for Best Practices in Sepsis Prevention*  
**Saleh Raghib**, Lisa Baker, Naveen Sankaran, John Vozenilek, and T. Kesh Kesavadas
6. *Medical Best Practice Guidance Systems: Sepsis*  
**Lui Sha**, Poliang Wu, and Maryam Rahmaniheris
7. *Mixed Reality Goggles for Image Guided Surgery*  
**Viktor Gruev**
8. *Bio-inspired Multi Near Infrared Fluorescence System for Image Guided Surgery*  
**Viktor Gruev**
9. *Novel Interactive Presentation Software Mentimeter Perceived as Accessible, Beneficial, and Helpful for Exam Preparation by Medical Students*  
**Ahmad Kashif**
10. *Safety and Reliability of Surgical Robots via Simulation*  
**Xiao Li**, Ravi Iyer, Kesh Kesavadas, and David Crawford
11. *Virtual Reality System Trainer for Robotic Assisted Surgery Operating Room*  
**Naveen Kumar Sankaran**, Tian Menglin, Kevin Pommier and David Crawford
12. *Simulator for Training Extracorporeal Membrane Oxygenation*  
**Pramod Chembrammal**, Jai Raman and Mathew Bramlet
13. *Augmented Reality as a Medical Diagnosis and Surgery Planning Tool*  
**Jackie Chen**, Shrey Pareek and Pramod Chembrammal

14. *Simulation of Postural Dysfunction in Parkinson's Disease*  
**Manuel Hernandez**
15. *Biogears - Virtual Physiology Engine*  
**Pavithra Rajeswaran** and Kesh Kesavadas
16. *Pneumatic Ergonomic Crutches with Soft-Robotic Actuator*  
**Chenzhang Xiao** and Girish Krishnan
17. *Design and Evaluation of a Passive Hydraulic Training Simulator for Elbow Spasticity*  
**Yinan Pei** and Elizabeth Hsiao-Wecksler
18. *Multi-Robot Minimally Invasive Single Port Laparoscopic Surgery*  
**Nick Toombs**, Fanxin Wang, and Placid Ferreira
19. *Position, Velocity, Resistance Meter (PVRM) for Quantifying Joint Behavior*  
**Leo Song** and Elizabeth Hsiao-Wecksler
20. *Carebots: Prolonged Elderly Independence using Small Mobile Robots*  
**Arun Lakshmanan, Ishaan Pakrasi**, and Naira Hovakimyan
21. *Haptic based Activities of Daily Living for In-Home Rehabilitation*  
**Shrey Pareek**, Ehsan Esfahani, and T. Kesh Kesavadas

## Posters

1. *Patient-specific Cardiovascular Simulation for Enhanced Health Monitoring and Treatment planning*  
**Hadi Meidani**
2. *Architected Atomically-Thin Materials for Advanced Biomedical Devices*  
**SungWoo Nam**
3. *Enabling Technologies for Blood Flow Simulation in Patient-Specific Models*  
**Soonpil Kang** and Arif Masud
4. *Visualizing Human Embryonic Development of the Heart's Outflow Tract*  
**Christina Sidorowych**
5. *Plasmonic "Ojogel" for Detecting Corneal Integrity Post Glaucoma Surgery*  
**Santosh Misra**
6. *Synthesizing the Medical Literature*  
**Jodi Schneider**
7. *Hierarchical, Dual Scale Structures of Atomically Thin MoS<sub>2</sub> for Tunable Wetting*  
**Jonghyun Choi**
8. *Home-based Automatic Fall Risk Assessment*  
**Jacob Sosnoff** and Rama Ratnam
9. *Medical Best Practice Guidance Systems: Sepsis*  
**Lui Sha**, Poliang Wu and Maryam Rahmaniheris



Applied Research for Community Health through Engineering and Simulation  
*A University of Illinois and OSF Health Care Collaboration*

## Request for Proposals

The Jump Applied Research for Community Health through Engineering and Simulation [Jump ARCHES] Endowment offers this Request for Proposals to members of faculty of the University of Illinois College of Engineering at Urbana-Champaign, members of faculty of the University of Illinois College of Medicine at Peoria, and/or OSF Healthcare System clinicians. The goal of this competitive grant is to improve healthcare quality and patient safety through the combined efforts of engineers and clinicians.

- **Deadlines**

**The request for Proposals Opens: September 18, 2017**

**Submission Deadline: October 25, 2017 at 5pm CST**

You are encouraged to attend the 4<sup>th</sup> Health Care Engineering Symposium on September 11<sup>th</sup>, 2017. A networking session is planned for those interested in submitting an application for the ARCHES grant. Please follow the link to register: <http://healthengsymp.illinois.edu/>

Proposals will be reviewed swiftly with an announcement of awards by first week of **January, 2018**.

**NOTE: A link to this online submission mechanism, which will closely follow the NIH R21 mechanism format, will be available after September 18, on:**

<http://healtheng.illinois.edu/funding/> and on

<https://jumpsimulation.org/research-innovation/research/jump-arches>

While a project may exceed \$50,000 in total funding for a single year, the strongest proposals will have a well-developed justification for expenses above this level.

- **How to prepare a responsive application**

The goal of this program is to use our combined expertise in the broad areas of Sensing Devices, Materials and Mechanics, Health Information Technologies, Simulation, Human Factors/Industrial Ergonomics and Design for executing collaborative projects which could be used for and directed to simulation in training of the healthcare practitioners of tomorrow.



Applied Research for Community Health through Engineering and Simulation  
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**During the current cycle we encourage proposals in the following areas:**

- ◆ **Serious Gaming for Medical Education and Training**
- ◆ **Virtual Reality and Augmented Reality in Simulation**
- ◆ **Advanced Software for Medical Education and Simulation**

The proposed research should address the needs of clinical simulations and training, and be amenable to translational activities, which lend themselves to full deployment and commercialization of the outcomes for use in medical training.

Proposals will be specifically evaluated for their respective alignment to program goals [Relevance], the potential impact on patient and learner outcomes [Impact], and the proposed plan and quality of the team proposed [Approach].

**Proposals are required to include two Co-Investigators: one from the University of Illinois College of Engineering at Urbana-Champaign and one from among the clinicians providing care within OSF Healthcare System. Including additional Co-Investigators from other disciplines are acceptable, as long as the two required investigators are included.**

- **About Jump ARCHES**

This endowed fund supports collaborative efforts between engineers and healthcare providers at OSF HealthCare and University of Illinois College of Medicine at Peoria as they work to solve healthcare challenges through innovative solutions that bend the cost curve of healthcare and optimize outcomes. Using the state-of-the-art resources available within the Jump Trading Simulation and Education Center (“Jump Sim Center”) at OSF Saint Francis Medical Center (the “Medical Center”), these collaborative efforts will impact the quality of healthcare on a global scale.

- **Use of Funds**

The Jump ARCHES grant program will fund:

- ◆ Salary support for engineers who will work primarily within Jump ARCHES in Peoria.
- ◆ Salary support for clinicians or investigators within OSF HealthCare, the University Of Illinois College, or others relevant to the research program.
- ◆ Salary support for other key personnel or consultants
- ◆ Administrative and staffing expenses within the Jump Simulation Center.
- ◆ Programmatic funding within project scope.

All proposals recommended for funding will be characterized by a statement of work and a budget. In addition the proposal must address how the research will meet the goals of the Jump ARCHES program. The application process and the steering panel’s recommendation for funding



Applied Research for Community Health through Engineering and Simulation  
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will be formalized by these two instruments and others which will define the background intellectual property of the contributing individuals and their institutions.

- **Review Process**

The steering panel for Jump ARCHES will prioritize:

- ◆ Applied research programs that evaluate the improvement of patient outcomes through clinical simulation.
- ◆ The creation of equipment and facilities to evaluate and improve health care through clinical simulation.
- ◆ Contributions to scholarship and support for advanced degrees to prepare new generations of experts in the field.
- ◆ Proposals which are competitive for additional external funding to advance the broader use of clinical simulation in healthcare.

Suitable space will be assigned to Jump ARCHES within the 3<sup>rd</sup> and 4<sup>th</sup> floor of the Jump Simulation Center building adjacent to the landmark Milestone building of OSF Saint Francis Medical Center, and at Health Care Engineering Systems Center if required. This location will provide access to a wide spectrum of clinical professionals and their existing healthcare technologies, and illuminate the challenges they face in the transformation of health care.

- **Phase 2 Continued Funding**

For the current ARCHES grantees, we invite you to submit a proposal for phase 2 funding to continue the project, if excellent progress has been made during the initial phase of the project. A final report will be required before continued funding request is reviewed. The proposal must show potential for translational research or external funding opportunity. Phase 2 proposal deadlines are the same as described earlier.

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Professor, Department of Industrial and Enterprise  
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