IEEE ICMA 2016 Conference

Plenary Talk I

Quantitative Imaging Informatics in Cost effective PET Imaging and Classification of lung disease

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Abstract:

This talk presents a novel method for emphysema quantification, based on parametric modeling of intensity distributions in the lung and a hidden Markov measure field model to segment emphysematous regions. The framework adapts to the characteristics of an image to ensure a robust quantification of emphysema under varying CT imaging protocols and differences in parenchymal intensity distributions due to factors such as inspiration level. Compared to standard approaches, the present model involves a larger number of parameters, most of which can be estimated from data, to handle the variability encountered in lung CT scans. The method was used to quantify emphysema on a cohort of 87 subjects, with repeated CT scans acquired over a time period of 8 years using different imaging protocols. The scans were acquired approximately annually, and the data set included a total of 365 scans. The results show that the emphysema estimates produced by the proposed method have very high intra-subject correlation values. By reducing sensitivity to changes in imaging protocol, the method provides a more robust estimate than standard approaches. In addition, the generated emphysema delineations promise great advantages for regional analysis of emphysema extent and progression, possibly advancing disease subtyping, including COPD.

An important tool for studying brain disorders is positron emission tomography (PET), a nuclear imaging technology that allows for the in vivo functional characterization and quantification of blood flow, metabolism, protein distribution, and drug occupancy using radioactively tagged probes (tracers). Full quantification of PET images requires invasive arterial input function (AIF) measurement through online arterial blood sampling for the duration of the scan (1-2 hours). The AIF is used to correct images by accounting for the tracer bioavailability, which depends on an individual's physiological capacity for clearance, distribution and metabolism of the tracer. However, AIF measurement is invasive, risky, time consuming, uncomfortable for patients, and costly. Perhaps most importantly, it is impractical at the point-of-care and therefore limits clinical utility of PET. We believe an integrative multi-modal approach is possible via the amount of personalized information about the physiological and biochemical makeup of individuals available in their electronic health record (EHR). This talk will outline a novel approach to combine EHR and dynamic PET imaging data in an optimization framework based on simulated annealing to non-invasively estimate the AIF. Techniques that will be outlined are applicable across imaging modalities, organs and diseases, such as functional imaging of prostate cancer images where increasingly more complex tracers are utilized for assessment and require AIF measurement.

Dr. Andrew F. Laine received his D.Sc. degree from Washington University (St. Louis) School of Engineering and Applied Science in Computer Science, in 1989. He was a Professor in the Department of Computer and Information Sciences and Engineering at the University of Florida (Gainesville, FL) from 1990-1997. He joined the Department of

Biomedical Engineering in 1997 and served as Vice Chair of the Department of Biomedical Engineering at Columbia University since 2003-2011. He is currently Chair of the Department of Biomedical Engineering and Director of the Heffner Biomedical Imaging at Columbia University and the Percy K. and Vida L. W. Hudson Professor of Biomedical Engineering and Professor of Radiology (Physics).

He has served on the program committee for the IEEE-EMBS Workshop on Wavelet Applications in Medicine in 1994, 1998, 1999, and 2004. He was the founding chair of the SPIE conference on “Mathematical Imaging: Wavelet Application in Signal and Image Processing”, and served as co-chair during the years 1993-2003. Dr. Laine has served as Chair of Technical Committee (TC-BIIP) on Biomedical Imaging and Image Processing for EMBS 2004-2009, and has been a member of the TC of IEEE Signal Processing Society, TC-BISP (Biomedical Imaging and Signal Processing) 2003-present. Professor Laine served on the IEEE ISBI (International Symposium on Biomedical Imaging) steering committee, 2006-2009 and 2009 – 2012. He was the Program Chair for the IEEE EMBS annual conference in 2006 held in New York City and served as Program Co-Chair for IEEE ISBI in 2008 (Paris, France). He served as Area Editor for IEEE Reviews in BME in Biomedical Imaging since 2007-2013. He was Program Chair for the EMBS annual conference for 2011 (Boston, MA). Professor Laine Chaired the Steering committee for IEEE ISBI, 2011-2013, and Chairs the Council of Societies for AIMBE (American Institute for Medical and Biological Engineers). Finally, he served as the IEEE EMBS Vice President of Publications 2008 – 2012, and currently the President of IEEE EMBS (Engineering in Biology and Medicine Society), 2015 - 2016. He is a member of the IEEE Big Data Initiative. He is a Fellow of IEEE and AIMBE.

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Plenary Talk 2

From Modular Robotics to Modular Playware

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Abstract:

Decades of research into intelligent, playful technology and user-friendly man-machine interfaces has provided important insight into the creation of robotic systems and intelligent interactive systems which are much more user-friendly, safer and cheaper than what appeared possible merely a decade or two ago. This is significantly disrupting the industry in several market sectors. This talk describes the components of the playware and embodied artificial intelligence research that has led to disruption in the industrial robotics sector, and which points to the next disruption of the health care sector and other application areas. This includes playful robotics, LEGO robots for kids, minimal robot systems, user-friendly, behavior-based, biomimetic, modular robotics and intelligent systems. The insight into these components and the use in synthesis for designing robots and intelligent systems allows anybody, anywhere, anytime to use these systems, providing an unforeseen flexibility into the sectors, which become disrupted with these systems.
Indeed, with recent technology development, we become able to exploit robotics and modern artificial intelligence (AI) to create playware in the form of intelligent hardware and software that creates play and playful experiences for users of all ages. Such playware technology acts as a play force which inspires and motivates you to enter into a play dynamics, in which you forget about time and place, and simultaneously become highly creative and increase your skills - cognitive, physical, and social skills. The *Playware ABC* concept will allow you to develop life-changing solutions for *anybody, anywhere, anytime* through *building bodies and brains* to allow people to *construct, combine and create*.

Professor Henrik Hautop Lund, Center for Playware, Technical University of Denmark, is World Champion in RoboCup Humanoids Freestyle 2002, and has more than 175 scientific publications. He has developed shape-shifting modular robots, presented to the emperor of Japan, and has collaborated closely on robotics and AI with companies like LEGO, Kompan, BandaiNamco, Mizuno for the past two decades. He has developed technical skill enhancing football games and global connectivity based on modular playware for townships in South Africa for the FIFA World Cup 2010 (together with footballers Laudrup and Hoegh). Two decades of scientific studies of such playware in the form of playful robotics, LEGO robots for kids, minimal robot systems, user-friendly, behavior-based, biomimetic, modular robotics lead Prof. Lund's students to form the Universal Robots company, which disrupted the industrial robotics sector, and recently was sold for 285 million USD. Together with international pop star and World music promoter Peter Gabriel, he has develop the MusicTiles app and MagicCubes as a music 2.0 experience to enhance music creativity amongst everybody, even people with no initial musical skills whatsoever, and used for stage performance during Peter Gabriel's tour. He has invented the patented modular interactive tiles (www.mototiles.com) for playful prevention and rehabilitation, which are implemented in large numbers amongst elderly. He is currently board member of the 20m euro Patient@Home project in Denmark – and partner in the EU projects Human Brain Project and REACH. In all cases, the modular playware technology approach is used in a playful way to enhance learning, creativity and activity amongst anybody, anywhere, anytime.

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Plenary Talk 3

Motion Planning and Control for Robot and Human Manipulation

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Abstract:

In this talk I will describe our progress on motion planning and control for two very different manipulation problems: (1) nonprehensile manipulation by robots and (2) control of neuroprosthetics for humans with spinal cord injuries.

The first part of the talk will focus on graspless manipulation modes commonly used by humans and animals but mostly avoided by robots, such as rolling, sliding, pushing, pivoting, tapping, and throwing and catching. These manipulation modes exploit dynamics to control object motions that would otherwise be impossible.

In the second part of the talk I will describe a recent project on control of a functional electrical stimulation neuroprosthetic for the human arm. The goal of the project is to allow people with high spinal cord injury to recover the use of their arms for activities of daily living. Beginning with traditional methods for system identification and control of robot arms, I will describe how we have extended the approach to identification and control of an electrically stimulated human arm.

Kevin Lynch is Professor and Chair of the Mechanical Engineering Department at Northwestern University. He is a member of the Neuroscience and Robotics Lab (nxr.northwestern.edu) and the Northwestern Institute on Complex Systems (nico.northwestern.edu). His research focuses on dynamics, motion planning, and control for robot manipulation and locomotion; self-organizing multi-agent systems; and functional electrical stimulation for restoration of human function.

Dr. Lynch is a Senior Editor of the IEEE Robotics and Automation Letters, co-author of *The Principles of Robot Motion* (MIT Press, 2005) and *Embedded Computing and Mechatronics* (Elsevier, 2015), an IEEE fellow, and the recipient of the IEEE Early Career Award in Robotics and Automation, Northwestern's Professorship of Teaching Excellence, and the Northwestern Teacher of the Year award in engineering. He earned a BSE in Electrical Engineering from Princeton University and a PhD in Robotics from Carnegie Mellon University.