Prosthetics and Motor Learning

Overview

Control of complex, compliant, multi degree of freedom (DOF) sensorimotor systems like humanoid robots, prosthetics and exoskeletons as well as autonomous vehicles have been pushing the limits of traditional planning and control methods. The next generation of robots are going to work much more closely with humans, other robots and interact significantly with the environment around it. As a result, the key paradigms are shifting from isolated decision-making systems to one that involves shared control -- with significant autonomy devolved to the robot platform; and end-users in the loop making only high-level decisions.

This course will introduce technologies ranging from robust multi-modal sensing, shared representations, compliant actuation and scalable machine learning techniques for real- time learning and adaptation that are enabling us to reap the benefits of increased autonomy while still feeling securely in control. This also raises some fundamental questions: while the robots are ready to share control, what is the optimal trade-off between autonomy and control that we are comfortable with? Domains where this debate (and for which this course) is relevant include self-driving cars, mining, shared manufacturing, exoskeletons for rehabilitation, active prosthetics, large scale scheduling (e.g. transport) systems as well as Oil and Gas exploration to list a few.

Specifically, the course will introduce the state of the art machine learning approaches to these challenges and will take the students through various aspects involved in motor planning, control, estimation, prediction and learning with an emphasis on the computational perspective. We will learn about statistical machine learning tools and methodologies particularly geared towards problems of real-time, online learning for robot and prosthetic control.

Issues and possible approaches for learning in high dimensions, planning under uncertainty and redundancy, sensorimotor transformations and stochastic optimal control will be discussed. This will be put in context through exposure to topics in human motor control, experimental paradigms and the use of computational methods in understanding biological sensorimotor mechanisms and motor control.

We will use live demonstrations of one of the most advanced fully articulated upper limb prosthetics, the **iLIMB** hand developed by Touch Bionics as well as a **19 Dof mini-humanoid robot**, as hands on experience of the concept of shared autonomy with EMG based inputs and force sensing based 'autonomous' control through hardware that will be transported to the site of the lecture. We will also organize a **'live link'** to demonstrate real time operation of the $2.5M **NASA Valkyrie Humanoid Robot** via skype link from the University of Edinburgh.

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informatics

Tentative Schedule

Modules

Dates: December 5th– December 9th, 2017 (5 days)

Day 1: December 5, 2017 (Tuesday)

Inauguration: Prof. K. VijayRaghavan FRS (PadmaShri)
Secretary, Dept. Biotechnology, Government of India

Lecture 1: Prof. Sethu Vijayakumar
Shared Autonomy for Interactive Robotics (Public Keynote)

Live Demonstration Showcase 1: Prof. Sethu Vijayakumar
Live Teleoperation of NASA Humanoid Valkyrie (India-UK Live Link)

Lecture 2: Dr. Deepak Joshi
Introduction to neuromuscular signals (EEG, EMG) and signal processing

Tutorial 1: Dr. Deepak Joshi
EMG signal during locomotion

Day 2: December 6, 2017 (Wednesday)

Lecture 3: Prof. Sethu Vijayakumar
Fundamentals of Coordinate Transformations, Kinematics, Dynamics for Robotic Systems

Tutorial 2: Prof. Sethu Vijayakumar
Demonstration of mini-humanoid (KHR-1HV) movement imitation

Lecture 4: Dr. Deepak Joshi
Introduction to lower limb prosthetics, sensors & instrumentation, locomotion and transition classification

Day 3: December 7, 2017 (Thursday)

Lecture 5: Prof. Sethu Vijayakumar
Machine Learning Tools for Robotics

Tutorial 3: Prof. Sethu Vijayakumar
Demonstration of iLIMB prosthetic hand

Lecture 6: Dr. Deepak Joshi
Role of artificial sensory feedback in intelligent prosthetics

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Modules	Day 4: December 8, 2017 (Friday)	**Lecture 7: Prof. Sethu Vijayakumar** Understanding Human Sensorimotor Control **Lecture 8: Dr. Deepak Joshi** A perspective on social acceptance of prosthetics **Tutorial 4: Dr. Deepak Joshi** EEG signal during motor imagery **Live Demonstration Showcase 6: Prof. Sethu Vijayakumar** Live Demo (India-UK Live Link) of APO Exoskeleton, Motion Capture and Motek Treadmill with Split-belt 6-axis Force measurement
	Day 5: December 9,2017 (Saturday)	**Hands-on Demo 7: Dr. Deepak Joshi** Force myography and center for pressure (COP) feedback **Tutorial 5: Dr. Deepak Joshi** Biomechanical variables (joint angle & acceleration measurement)
Who can attend?	• Executives, engineers and researchers from manufacturing, service and government organizations including R&D laboratories. • Students at all levels (BTech/MSc/MTech/PhD) or Faculty from reputed academic institutions and technical institutions.	
Fees	The participation fees for taking the course is as follows: Participants from abroad: **US $500** Industry/ Research Organizations: **15000 INR** Academic Institutions Faculty: **10000 INR** Students: **5000 INR** **Application Deadline: 27 October 2017. Register at: http://www.gian.iitkgp.ac.in/GREGN/index** **For any queries, please email to ----- gian.pml@gmail.com**	

Professor Sethu Vijayakumar FRSE is the Professor of Robotics in the School of Informatics at the University of Edinburgh and the Director of the Edinburgh Centre for Robotics. He holds the prestigious Senior Research Fellowship of the Royal Academy of Engineering, co-funded by Microsoft Research and is also an Adjunct Faculty of the University of Southern California (USC), Los Angeles. Professor Vijayakumar, who has a PhD from the Tokyo Institute of Technology, has pioneered the use of large scale machine learning techniques in the real time control of large degree of freedom anthropomorphic robotic systems including the SARCOS and the HONDA ASIMO humanoid robots, KUKA-DLR robot arm and iLIMB prosthetic hand. **His latest project (2016) involves a collaboration with NASA Johnson Space Centre on the Valkyrie humanoid robot being prepared for unmanned robotic pre-deployment missions to Mars.** He is the author of over 170 highly cited publications (as of 2017) in robotics and machine learning and the winner of the IEEE Vincent Bendix award, the Japanese Monbusho fellowship, 2013 IEEE Transaction on Robotics Best Paper Award and several other paper awards from leading conferences. He has led several UK, EU and international projects in the field of Robotics, attracted funding of over £24M in research grants over the last 8 years and has been appointed to grant review panels for the DFG-Germany, NSF-USA and the EU. He is a Fellow of the Royal Society of Edinburgh and a keen science communicator with a significant annual outreach agenda. He is the recipient of the **2015 Tam Dalyell Award for excellence in engaging the public with science** and serves as a judge on **BBC Robot Wars** and was involved with the UK wide launch of the **BBC micro:bit** initiative for STEM education.

Webpage: http://homepages.inf.ed.ac.uk/svijayak

Twitter: https://twitter.com/sethuvij

Dr. Deepak Joshi received his PhD in biomedical engineering from Indian Institute of Technology (IIT) Delhi. He has been working in the area of prosthetics design and development for last ten years. During his tenure at Department of electrical and computer Engineering in National University of Singapore (NUS), he worked on development of artificial hand with integrated sensors to create an illusion of touch from human hand. This work demonstrated a significant impact on the social acceptance of upper limb prosthesis and was reported to be the most popular article in IEEE Transaction on neural system and rehabilitation engineering. His research work at Institute of Neuroscience (ION), Newcastle University in United Kingdom (UK) discovered that artificial proprioception can significantly improve the myoelectric control in upper limb amputee. During his postdoctoral at University of Oregon in United States of America (USA), he worked on integration of various sensing modalities to provide seamless transitions in lower limb prosthesis. Dr. Joshi is currently exploring visual motor control for seamless transition in powered prosthesis and the role of artificial proprioception in lower limb prosthesis and gait rehabilitation. Besides that, he is actively engaged in projects related to development of biomedical instrumentation for applications specific to assistive devices for elderly and disabled. **Webpage**: http://cbme.iitd.ac.in/content/dr-deepak-joshi

Course-coordinator

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