Fundamentals of Bio-inspired Robotics

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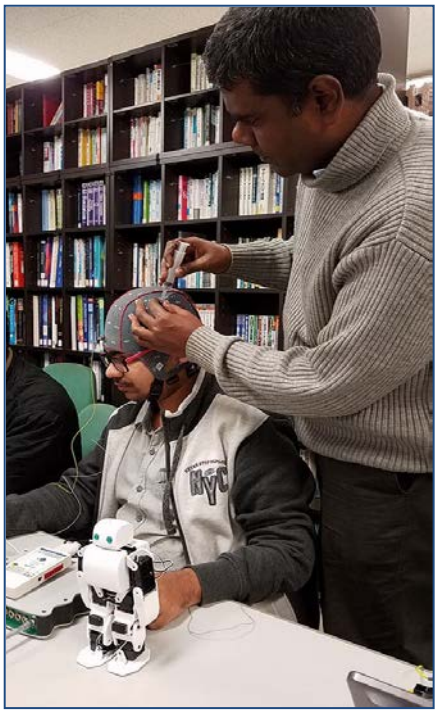
Overview

Intelligent systems have found their way from being pure engineering systems to becoming ubiquitous beings in daily life of humans. Be it the numerous sensor based appliances that make up the modern household, or the wearable devices that are being devised, they are designed to be extensions of the sensory network of the user.

IOT technologies are envisaging the ubiquitous network to be either as an augmentation or a supplement to the user's cognition. The former tries to take cues from the human and other natural sensory networks and the later tries to mimic the cognitive science theories of individual and social cognitive process. This evolution has brought to the fore, an expression to the much attempted endeavour amongst scientists to realise animal/human like robots. A robotic snake, a squid, devices like AIBO and ASIMO are some of the endeavours that stand as a testimony to these efforts. Active researches in focused areas like assistive technologies are witnessing adaptations in the day to day life activities of humans. This has brought forth a new stream of robots called Social Robots. With the development of Social Robots, Human-Robot interaction has reached a new paradigm, where the designs of robot actions are coupled with the study of cognitive reactions from the human brain. This new group of robots are not designed for simple industrial environment; rather, it is based on more deep understanding of human emotions, morphological similarity to social environment and higher cognitive capability. Some of the major challenges in this direction are the development of brain-body systems which includes bio-inspired information processing system, artificial muscle development, design of locomotion system, hierarchic control system design, intelligent sensing and information fusion. In this short-course, we intend to introduce some of the basic foundations towards this direction and provide a flavor of the cutting edge research.



A subject interacting with a humanoid robot, during which his brain signals and Eye tracking information is aquired.

The underlying theory to be discussed in this course is driven by an understanding of the intelligence prevalent in nature, from a fruit fly, or a small fish (copella Arnoldi), to the intelligent being of the highest order – the humans. Understanding of the brain's constituents and its functioning is a rapidly evolving multidisciplinary research endeavor that is revealing newer insights everyday. Even though modern intelligent devices are keeping up with the rapid progress in brain science, there exists a marked gap between brain theory and engineering systems being developed.

This course aims to bridge this gap. It gives insights into brain theory and the challenges that are faced in building intelligent systems that either try to replicate the brain or interface with it. A typical example would be, the quantum of intervention that an intelligent assistive device for old age people are required to get up from a chair is based on the acquisition of brain signals that define the motor plan and transfer of this signal to actuate an intelligent effector with bare minimum force to help the person on their feet. This system involves understanding of brain function, psychology, control theory, Brain computer/machine Interface, Dynamic Analysis and Product design. The aim of this course is to introduce the students to these disciplines and the challenges of making them interwork to build effective intelligent systems.

Modules

Dates: October 5, 2017 - October 10, 2017

Day 1 : October 5, 2017 (Thursday)

Lecture 1: 1 Hr. - Dr. Bishakh Bhattacharya
Introduction to Bio-inspired Design, Design Philosophy
Introduction to Dynamic System Modelling
Modelling of Robotic System

Lecture 2: 1 Hr. - Dr. Hiroaki Wagatsuma
Fundamentals of Brain theory
Central nervous system – brief overview

Lecture 3: 1 Hr. - Dr. Hiroaki Wagatsuma
Problems of enquiry in brain research

Day 2 : October 6, 2017 (Friday)

Lecture 4: 1 Hr. - Dr. Hiroaki Wagatsuma
Fundamentals of Brain theory

Lecture 5: 1 Hr. - Dr. Hiroaki Wagatsuma
Brain Dynamics
(Central Pattern Generator and Local Pattern Generator)
(limit cycle oscillator)

Lecture 6: 1 Hr. - Dr. Hiroaki Wagatsuma
Brain rhythms

Day 3 : October 7, 2017 (Saturday)

Lecture 7: 1 Hr. - Dr. Hiroaki Wagatsuma
Problems of enquiry in brain research

Lecture 8: 1 Hr. - Dr. Hiroaki Wagatsuma
Gap between Brain Theory and Engineering systems

Lecture 9: 1 Hr. - Dr. Hiroaki Wagatsuma
Brain Computer Interfaces and Brain Machine Interfaces

	Day 4 : **October 9, 2017** **(Monday)**	**Lecture 10: 1 Hr. - Dr. Hiroaki Wagatsuma** **Introduction to multibody dynamics. Modelling of a simple arm movement** **Lecture 11: 1 Hr. - Dr. Hiroaki Wagatsuma** **Methods of Measurements and tapping of the Brain Signals** **Lecture 12: 1 Hr. - Dr. Hiroaki Wagatsuma** **State of the art applications. Fundamentals.** **Laboratory 1 - 1 Hr : Dr. Bishakh Bhattacharya** **EEG Signal acquisition**
	Day 5 : **October 10, 2017** **(Tuesday)**	**Lecture 13: 1 Hr. - Dr. Hiroaki Wagatsuma** **Brain based assistive devices** **Lecture 14: 1 Hr. - Dr. Hiroaki Wagatsuma** **Brian based rehabilitation devices** **Laboratory 2 - 1 Hr : Dr. Bishakh Bhattacharya** **Eyetracker based experiment design and PID controller**
You Should Attend If…	▪ **You are an Engineer or Research Scientist interested in Cognitive Science & Technology and Robotics.** ▪ **You are a Student or Faculty from academic institution interested in learning how to do research on Bio-inspired Robotics.**	
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $250** **Industry/ Research Organizations: 15000 INR** **Academic Institutions Faculty: 5000 INR** **Students: 2000 INR** The above fee includes all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hr free internet facility. The participants will be provided with accommodation on payment basis.	

The Faculty

Dr. Hiroaki Wagatsuma is an Associate Professor in the Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology. He is also a visiting scientist at RIKEN Brain Science Institute. He is also a Cross-Appointment Fellow, Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology.
His areas of specialization are Nonlinear Dynamics, Emergent Intelligence, Episodic Memory and Emotion, Societal Robot, Computational Neuroscience, Neuroinformatics, Sport Biomechanics, Rehabilitation Support. His current research areas are Bio-medical Signal Processing and Sparse Coding, Sport Dynamics and Synergy analysis, Computational Neuroscience and Brain-Inspired Robotics, Neuroinformatics. In addition to being actively involved in interdisciplinary research to develop assistive devices to physically challenged people, he has authored books on Neuromorphic and Brain-Based Robots, and a chapter of the Information Extraction from the Internet.

Dr. Bishakh Bhattacharya is currently Dr. and Mrs. G. D. Mehta Chair Professor in the department of Mechanical Engineering at IIT Kanpur. He has been involved in modeling and development of hybrid composite laminate activated by smart materials like Terfenol-D alloy and found its application in controlling vibration of flexible rotating members like helicopter rotor. He has subsequently expanded the composite system to include nano-particle reinforced composite layer for better broad band damping. In the field of micro and mini-actuators, he has modeled and developed Ionic Polymer Matrix Composite system for vibration control of flexible open and closed link systems. The technique is further expanded for modeling and development of Shape Memory Alloy based smart muscle and applied for trajectory control of multi-link actuators. Based on this work, a new technology is developed for shape control of continuous structure which has ushered in the development of space-born reconfigurable parabolic antenna system for Indian Space Research Organization (ISRO). His current research interest is Brain Inspired Robotics, Vibration Control by Active & Passive Smart materials, Active Shape Control of Flexible Systems, Structural Health Monitoring, Intelligent System Design.

Course Co-ordinator

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