GIAN @ SCIS

SYNTHETIC ANALOG CIRCUIT DESIGN IN LIVING CELLS

2018

SEMINAR SERIES

SUMMER SCHOOL

JULY 28 - AUGUST 05, 2018

Professor **Rahul Sarpeshkar**

Professor Rahul Sarpeshkar is currently the Thomas E. Kurtz Professor at Dartmouth College and a Professor of Engineering, Microbiology and Immunology, Physics, and Physiology and Neurobiology. His longstanding and frequent work in analog and biological computation, his book, Ultra Low Power Bioelectronics: Fundamentals, Biomedical Applications, and Bio-inspired Systems, and his most recent publications have pioneered the pioneered the field of Analog Synthetic Biology. This content will form the basis of the course.

His unique interdisciplinary research creates both wet DNA-protein and dry electronic analog circuits, many of which have achieved world records. He holds over 36 awarded patents and has authored more than 127 publications, including one that was featured on the cover of Nature.

He has won several awards for his interdisciplinary work including the NSF Career award, the ONR Young Investigator award, and the Packard Fellow award given to outstanding faculty. His work on a glucose fuel cell for medical implants was featured by BBC Radio, the Economist, and listed among Scientific American's top ten breakthroughs of 2012. Professor Sarpeshkar obtained Bachelor's degrees in Electrical Engineering and Physics at MIT. After completing his PhD at CalTech, he joined Bell Labs as a physics member of technical staff in their department of biological computation. Before joining Dartmouth, he was a tenured professor at MIT for several years.

Overview

Living cells use DNA-RNA-protein circuits to perform sensing, actuating, computing, and control functions with amazing energy and part-count efficiency. They use noisy and unreliable parts to perform reliable computation with probabilistic digital and collective analog strategies. The complexity of computation within the ~30,000-node nonlinear, stochastic, feedback dynamical system in a single cell is so staggering that our attempts to engineer cells (synthetic biology) or to understand their function and malfunction (systems biology and medicine) are still in their infancy after decades of research. The treatment of several diseases from cholera to cancer would be revolutionized if we had a principled way to design and analyze circuits in living cells.

Based on the astounding similarities between the mathematical equations that govern biochemical reaction flux and electron transport in subthreshold transistors, both of which obey the Boltzmann laws of thermodynamics, it is possible to map analog electronic circuits to analog bio-molecular circuits and vice versa in a principled fashion. Digital circuits comprise a special case and are automatically included as well. Founded on these similarities, this course will introduce the basics of a cytomorphic approach for designing circuits in cells based on analog transistor circuit design.

The course is offered by Prof. Rahul Sarpeshkar, who has pioneered the fields of analog synthetic biology and cytomorphic electronics. His work on analog circuits and analog computaiton has had and continues to have several applications in biotechnology, implantable medical devices, microbiology and immunology, and bio-inspired and ultra-energy-efficient systems.

Objectives

I. This course will introduce :

[1] Fundamentals of Feedback Systems.
[2] Subthreshold transistor physics including the fundamentals of noise, linear, and nonlinear operation.
[3] The Representation of Biological Pathways and Networks with Electronic Circuit Schematics.
[4] Synthetic Biological Circuit Design Using Analog Circuit Design.

II. To build an India-centric community which uses integrated skills drawn from electrical engineering, bioengineering, biotechnology, and computational biology.

Teaching and Learning Methods

Course details

1. Introduction:
Circuit Pathways and Networks in Cells. The key ideas behind the cytomorphic mapping. A big-picture view of the course including an outline.

2. Feedback Systems
The linear feedback loop. Feedback loops and circuits. Root-locus techniques in controls system analysis and design. Feedback loops in biology and electronics.

3. Transistors
Metal-oxide-semiconductor (MOS) transistor operation. Weak-inversion, Strong-inversion, Small-signal models.

4. Analog Circuit Representations of Cellular Computation
Analog v/s Digital computing. Analog Synthetic Biology. Schematics for DNA-protein computation in cells including analog, logic, and analogic functions.

5. Thermodynamic Circuits in Electronics and Living Cells
Electronic analogies of chemical reactions. Log-domain current-mode models of chemical reactions and molecular networks. Analog circuit models of gene-protein networks.

6. Logarithmic Analog Computation in Living Cells
Design and implementation of synthetic analog circuits in cells. The creation of a bio-molecular slide rule that computes.

7. Synthetic Biology: A unifying view and review using analog circuits
A Review of 17 circuits in Synthetic Biology using the language of analog circuits.

Additional topics to be covered by host faculty will include lectures on Signals and Systems, and on Synthetic and Systems Biology.

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.

Registration Fees

JNU M. A. / M. Sc. Students : Free
JNU M.Phil/Ph.D students : ₹ 1000.00
JNU Faculty : ₹ 2000.00
Students of other recognised institutions : ₹ 2000.00
Faculty of other recognised institutions : ₹ 4000.00
Industry, private institutes : ₹ 10000.00
Participants from outside India : ₹ 10000.00

How to apply ?

Visit for registration & fees Visit : **http://www.gian.iitkgp.ac.in**

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