Under the aegis of MHRD—Global Initiative of Academic Networks (URL: http://iiti.ac.in/GIAN/)

Biomathematics: from Gene Expression to Bone Mechanics

Overview

Modern biology is using increasingly sophisticated mathematical techniques because of rapid advance in the development of experimental techniques and data mining. Revolutionary genome sequencing, new experimental possibilities to construct synthetic genetic networks, detailed investigation of neural activity require systematic development of the corresponding mathematical modelling. Modelling is of utmost importance for modern biology because it provides cheaper analysis than experiments and because it can explain emergence of unexpected dynamics, which appear due to nonlinearity, communication or noise.

For the successful research in mathematical modelling it is important to study systematically the number of tools provided by modern mathematics. In the present course we will consider four modelling directions: mathematical description of gene expression to model genetic networks, modelling neural dynamics, blood dynamics and bone mechanics. In all these modules we will start with the consideration of experimental observations and proceed with mathematical modelling to explain the experimental results. Doing so, we will answer the questions like: i) How genetic networks regulate cell differentiation or function of genetic clock? ii) How to model neural activity, neural excitatory and oscillatory dynamics? iii) Which equations describe pulse waves in blood? iv) Why long human bones are hollow? For all these questions the corresponding mathematical formalism will be developed and analysed.

In summary, in this course we will introduce a variety of tools for mathematical modelling required for modern biology, following multi-scale approach and considering different problem set-ups from gene expression to blood and bone mechanics.

The Objectives of this course include:

1) Teach students how to model real world problems appearing in modern biology and how to use modelling approaches to explain experimental results.

2) Discuss formalism and approaches required by experimental situations in biology, from experimental observations through development of mathematical formalism to the analysis of the model.

3) Demonstrate power of mathematical analysis by developing models for gene expression, neural activity, blood and bone mechanics.

The course will be divided in to four modules that will be covered in a total of 16 periods spanning over five working days in one weeks. The topics in Module A will expose the participants to the introduction and overview of modelling gene transcriptional regulation. It will cover mathematical models of self-regulated motifs, bistable switch and simple genetic clock. In Module B, we will consider simple models of neural excitations and oscillations, and models to describe propagation of neural impulses. Module C will cover introduction to modelling bone elastic and viscoelastic behavior. Module D will focus on basics of blood fluid dynamics, Bernoulli's and Poiseuille's laws, and methodology to measure blood viscosity and erythrocyte sedimentation rate. Finally, we will derive wave equation to describe pulse wave and consider principles of transient ischemic attack and Korotkoff's sounds.

Modules	**A: Mathematical modelling of gene expression** **B: Modelling neural activity** **C: Bone Mechanics** **D: Blood Dynamics**
Schedule	**August 15 - 20, 2016,** 1 Credit course covering 16 lecture hours. **Number of participants for the course will be limited to fifty.**
You Should Attend If…	▪ Undergraduate, Master or PhD level scholar who would like to be introduced to the new and growing interdisciplinary area of Biomathematics and Systems Biology. ▪ Young and budding members of the faculty at various Engineering and Computer Science departments wanting to learn develop research programs in the respective departments. ▪ Scholars in governmental, industrial or consulting agencies interested in understanding the state of the art in this area.
Fees*	The participation fees for taking the course is as follows: **Participants from abroad : US $500** **Industry/ Research Organizations: Rs. 6000** **Academic Institutions: Rs. 1500 (For Students) and Rs. 3000 (For Post Docs and Faculties)** The above fee includes course materials, computer use for tutorials. The participants will be provided single-bed accommodation on payment basis *Please note that the following fees waiver will be provided if you register for our both the GIAN courses *i.e.* Biomathematics: from Gene Expression to Bone Mechanics (August 15-20, 2016) and Statistics in Systems Biology and Programming in R (August 22-27, 2016). **Participants from abroad : US $800** **Industry/ Research Organizations: Rs. 10,000** **Academic Institutions: Rs. 2500 (For Students) and Rs. 4500 (For Post Docs and Faculties)**

The Teaching Faculty

Professor Alexey Zaikin (AZ) holds a Chair in Systems Medicine joint between Institute for Women's Health and Applied Mathematics at the University College London. AZ studied physics at the Moscow State University, and received a MS in Physics with distinction and the Khoklov Award for Excellence in Research. AZ got his PhD in 1998 in Moscow and Habilitation in 2003 in Potsdam, Germany. AZ has published 107 papers (92 in peer-reviewed journals) in areas including Stochastic Processes, Nonlinear Dynamics, Systems Biology (e.g., dynamics of genetic networks and complex molecular machines) and Systems Medicine (e.g., Women's Cancer, Proteomics, and Epigenetics).

Many of his research findings resulted from close collaboration with experimental biologists or clinicians, e.g., modelling brain control schemes (DAAD prize for outstanding research 1996), quantification of bone dynamics (ESA project), or modelling the proteasome and immune system (PI in VW project 2005-2008). AZ has extensive experience in statistics and data analysis, especially with biological or medical applications, e.g., in finding new oncomarkers, investigation of cancer in women, or development of new statistical measures for human DNA methylation patterns and networks.

AZ has worked on modelling information processing and dynamics in networks and found several new phenomena, e.g., speed-dependent cellular decision making, multistability and clustering, or timing cellular decision making. Recently his group investigated the effect of stochasticity on information processing in intracellular genetic perceptrons.

Course Coordinator:

Dr. Sarika Jalan completed her PhD in Physics with specialization in nonlinear dynamics and Complex Systems from Physical Research Laboratory, India in 2005. She has six years post-doctoral experience at MPI-MiS, Leipzig, MPI-PKS and NUS, Singapore. During this period she worked on spectral properties of complex systems as well as applications to biological systems. Upon joining IIT Indore In December 2010, she established Complex Systems Lab, which focuses on fundamental research in the inter-disciplinary field of complex systems, utilizing techniques from Physics, Mathematics, Bio-informatics and Computer Science. Using network theory, nonlinear dynamics and computational techniques, the lab on one hand works on developing techniques for complex systems research and on other hand applies these techniques to real world systems coming from Biology and Social science.

Short Course Location

Indian Institute of Technology Indore

Duration

One week:
August 15 - 20, 2016

Course Coordinator

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