

Evolution and Computation

Overview

Computer Science has largely evolved in an attempt to understand what computational models and resources can and cannot do. As the discipline matured, fascinating new models and problems arose which required novel and deep techniques to resolve. Many more questions are arising now as computational thinking is reaching beyond the traditional boundaries of computer science. Several fundamental problems in biology, physics, economics and the social sciences have turned out to be inherently computational and can be, and are being studied under the powerful “computational lens”, making use of the rich toolkit that computer science has developed over time.

This course is one the first attempts to elaborate on the emerging connection between computer science and one of the key tenets in biology: evolution. Traditionally, the language of mathematical biology has been dynamical systems and Markov chains and these have been able model evolutionary processes locally. However, full understanding and rigorous analysis of these processes often require a global view. Algorithms provide such a view by making available a broader language and a richer set of tools. This course will illustrate how the algorithmic paradigm helps us explain and analyze certain evolution related biological phenomena.

The objective of this course is to expose computer scientists to the richness of biology as an application area of the computational paradigm as well as to introduce the algorithmic methodology to mathematical biologists by providing examples of how certain evolution related problems have benefitted by applying the “computational lens” to them. The course should be of interest to CS students with an interest in biology, in particular, in evolution and to mathematical biologists interested in enriching their toolkit.

The course is for 2 credits with 15 one-hour lectures and 5 one-hour tutorial/discussion sessions. Following topics will be covered under this course:

Modules

- Course Start Date: 25/06/2016; Course End Date:02/07/2016
- Number of Participants (maximum): 50 (Preference will be given to the participants registering against 2 Credits)
- Mathematical and algorithmic background (5 Lectures)
 - Linear algebra,
 - Dynamical systems,

Who can attend...

- Probability and Markov chains, Convex optimization.
- Applications (10 Lectures, about 2 Lectures per topic below)
 - Linear models of evolution: Eigen’s quasispecies model and the Error threshold,
 - Quadratic models of evolution: Sex and language dynamics,
 - Stochastic finite population models of evolution: Wright-Fisher, Moran,
 - Algorithms as a product of evolution: the computational abilities of slime mold,
 - Instance as a product of evolution: computational aspects of protein folding.
- Faculties, Engineers, Scientists, and Researchers from academic, industrial and government organizations including R&D laboratories from India or abroad.
- Students at all levels (BE/BTech/MSc/ME/MTech/PhD/Other) from academic and technical institutions/universities from India or abroad.

Number of participants for the course will be limited to fifty. Preference will be given to the participants opting against credits.

Fees

The participation fees for taking the course is as follows:

Participants from abroad : US \$500
Industry/Research Organizations: INR 10,000
Academic Institutions: INR 2,000 (half for SC/ST students)

The above fee include all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hours free internet facility. The participants will be provided with accommodation on payment basis.

The Faculty



Dr. Nisheeth Vishnoi is a B. Tech. from IIT Bombay and a PhD from Georgia Institute of Technology, and is currently an Associate Professor at the EPFL Lausanne, Switzerland. After his PhD in 2004, Nisheeth was in IBM Research till 2008, in CNRS, France during 2008-09, and in Microsoft Research during 2009-14. He was awarded the INSA Young Scientist Medal in 2011, IBM Research Pat Goldberg Memorial Award for 2005, and the Best Paper Award at IEEE FOCS in 2005. Nisheeth is the Co-Organizer of Dagstuhl Seminar on Evolution and Computing, 2016, Breakthroughs in Theoretical Computer Science 2011, 2013, Co-Chair of FSTTCS 2013, and PC Member of ITCS 2016, 2015, SODA 2014, STOC 2011, and FSTTCS 2009, 2011. His research focuses both on foundational problems in algorithms, complexity, and optimization, and on how theoretical computer science can be used to gain insight into fundamental processes that occur in nature and society which are inherently computational.



Prof. Somenath Biswas obtained his B.Tech (Electronics and Electrical Communication Engg.) from IIT Kharagpur in 1973, M.Tech and Ph.D in Computer Science, from IIT Kanpur, in 1976 and in 1980, respectively. Joined the faculty of the Computer Science and Engineering Department of IIT Kanpur in 1980, where currently he is the Sanjay and Rachna Pradhan Chaired Professor. He is a Fellow of the National Academy of Sciences, India. Has been a Visiting Associate Professor at the Aarhus University (1989) and a Visiting Professor at University of Nebraska, Lincoln (1999). Has been the Department Head (1986-87, 1995-97), and the Dean, Faculty Affairs (2005-07), IIT Kanpur. Has been the President of the Indian Association for Research in Computing Science (2000-2002). His Research interest includes computational complexity theory, randomized algorithms, computational biology, logic in computer science.

Course Coordinator

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