Network Science and Multi-Agent Systems

Overview

Ever since the publication of the historic paper entitled "The Small World Problem" in the international journal "Psychology Today" (Vol. 2, pages 60-67) by S. Milgram in 1967 promoting the concept of six degrees of separation, there has been ever growing interest in the analysis of interconnected systems. Thanks to the advances in computer and communication technologies - with the evolution of internet, World Wide Web and inexpensive wireless connectivity, the degree of separation has shrunk even further to its lowest level. This increased connectivity provides great opportunities for easy interaction. The aim of this course is to provide a broad based introduction to this new and exciting area where a collection of intelligent agents - be it human, a robot, an animal, bird, interacting only with his/her local neighbors but have the ability to make global decisions. This ability to arrive at global consensus based on agents distributed throughout the network making decisions based only on the local information has been witnessed in many of the naturally occurring systems - ant colonies, migrating birds, synchronized firing of the fire-flies in tropical jungles, synchronization of clocks, to name a few.

Consequently, there is an ever growing interest in the analysis of these multi-agent systems - be it understanding the migration of birds which has great implications in the spread of contagious diseases such a bird flu , accessing an important record from the world wide web, aircraft flying in formation, cooperating set of robots to clean a dangerous spill, driverless cars/trucks transporting large good to different parts of a country, to name a few, - all these have applications that cuts across national boundaries have enormous implications for the well being of the mankind. Network Science and Distributed control of multi-agent systems lies at the core of these multitudes of application domain and are increasingly important for the survival of the future of humanity.

In this course we will introduce a variety of mathematical tools based on algebraic graph theory, linear algebra and dynamics that constitutes a basis for the analysis of large scale complex interconnected systems.

The Objectives of this course include:

1) Provide a solid background in graph theory, dynamics, distributed decision making, and the evolution of global strategies based on simple local interactions;

2) To analyze the diffusion of information in a network, quantify the measures that guarantee faster dissemination of information and explore various network topologies - naturally occurring and man-made types from the point of view of information flow in them;

3) Demonstrate the power of this theory by applying to the design of web search engines, model and analyze the spread of infectious diseases and develop strategies for controlling their spread, synchronization of clocks, spread of fashion in sociological human networks.

The course will be divided in to four modules that will be covered in a total of 40 periods spanning over ten working days in two weeks. The topics in Module A will expose the participants to the introduction and overview of graph theory concepts, algebraic graph theory, various graph topologies and quantification of their properties. In model B, the dynamics on graphs will be emphasized. The topics in the module include the consensus formation in a distributed multi-agent system, agreement protocol, convergence analysis and its dependence of the spectral properties of the graph Laplacian. Module C will cover the random walks on graphs. The topics include diffusion of information in networks - Cheeger's constant and its relation to the spectra of the Laplacian, Expander graphs, Ramanujam graphs, random walks on a graphs and Markov chains - rate of spread of infectious diseases among humans, spread of computer virus and their relation to the spectral properties of the graph Laplacian and Google page rank algorithms and its variants for web search- core of the search engines. In Module D, some research problems and applications will be discussed, for example, Epidemics, tourism, spread of fashion in social networks, electric power network, water supply network, transportation networks of all kinds - road, water, air, etc., Chip firing game and sand-piles, synchronization.

On each working day, there will be a total of four lecture periods each of seventy five minutes duration with two in the morning and two in the afternoon. We will have formal lectures in the first three periods and the last period will be devoted to problem solving sessions to gain hands on training. The time frame for each day will be the following:

First period: 9.00-10.15 am, Coffee break: 10.15-10.45 am, Second period: 10.45-12.00 noon

Third period: 1.30-2.45 pm, Coffee break:2.45-3.15pm, Fourth period: 3.15-4.30pm

Modules	**A: Graph Theoretic Concepts** **B: Dynamics on Graphs** **C: Random Walks on Graphs** **D: Applications** **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 Network Science and Multi-Agent systems. ▪ 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 10,000** **Academic Institutions: Rs 4,000** The above fee include 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

Prof. S. Lakshmivarahan completed his Ph.D. in Electrical Engineering from the Indian Institute of Science, Bangalore, India in 1973. After serving as an assistant professor at the Indian Institute Technology, Madras, India and as a visiting assistant Professor at Brown University and Yale University, he joined the University of Oklahoma in 1978, where he is currently the George Lynn Cross Research Professor at the School of Computer Science. His four major areas of teaching and research are learning algorithms, parallel and distributed processing, dynamic data assimilation, and computational sciences and finance. He has directed over 42 Master's theses and over 30 Ph.D. dissertations, and has been ranked an outstanding teacher each year for the past thirty five years in a row. The University of Oklahoma has acknowledged his superiority in teaching by awarding him the Regents Award for Superior Teaching in 1991. Within a short span of four years after he joined OU, he received the Regents award for Superior Accomplishments in Research and Creative Activity in 1982. He has authored/coauthored 6 books, published 80 archival journal papers and has presented research papers at 115 international/national conferences. He has offered over thirty short courses at major centers of higher learning in Canada, China, Brazil, India, England, Germany, Japan, Mexico, Taiwan and USA. For these accomplishments he was elected a Fellow of the Institute of Electrical and Electronic Engineers (IEEE) in 1993 and a Fellow of the Association for Computing Machinery (ACM) in 1995. His recent 2006 book has received the 2007 Outstanding Scientific Paper award by the NOAA Office of Oceanic and Atmospheric Research. Recognizing his overall contributions to teaching, research and service, the University of Oklahoma bestowed on him its highest honor by naming S. Lakshmivarahan a George Lynn Cross Research Professor in 1995.

Dr. Sarika Jalan is 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 inter-disciplinary research, 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 tools pertaining to 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

Two weeks:
May 30 - June 10th, 2016

Course Coordinator

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