A Short-Term Course
on

Network Sciences and Multi-Agent Systems

June 19 – June 30, 2023

Under the
Global Initiative for Academic Networks (GIAN)
Ministry of Human Resource Development
Government of India

Organized by

Department of Mathematical Sciences

Indian Institute of Technology (BHU) Varanasi

Overview of the Course

Network science is concerned with the structure and dynamics of graphs (and generalizations of graphs). Ever since the publication of the historic paper entitled "The Small World Problem" in the International Journal "Psychology Today" 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, the evolution of the internet, and inexpensive wireless connectivity, the degree of separation has shrunk even further to its lowest level.

The aim of this course is to provide a broad introduction to this exciting area where a collection of intelligent agents-be it a human, a robot, an animal, or a bird, interact only with his/her local neighbors but have the ability to make global decisions. This ability to arrive at a global consensus based on agents, distributed throughout the network, making decisions based only on local information, has been witnessed in many of the naturally occurring systems.

In this course, we will introduce a variety of mathematical tools based on algebraic graph theory, linear algebra, and dynamics that constitute a basis for the analysis of large-scale complex interconnected systems. The course will be divided into four modules that will be covered in a total of 40 hours spanning over ten working days in two weeks. On each working day, there will be a total of four lecture periods, each of 75 minutes of duration. 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.

Main Topics:

- Module I: Introduction and overview of graph theory- concepts, algebraic graph theory, various graph topologies and quantification of their properties.
- Module II: The dynamics on graphs – consensus formation in a distributed multi-agent system, agreement protocol, convergence analysis, and its dependence on the spectral properties of the graph Laplacian.
- Module III: Random walks on graphs - diffusion of information in networks, Cheeger's constant, spectra of the Laplacian, Expander graphs, Ramanujam graphs, and Markov chains-rate of the spread of infectious diseases/viruses, their relation to the spectral properties of the graph Laplacian, Google page rank algorithms and its variants for web search.
- Module IV: Research problems and application- Epidemics, tourism, the spread of fashion in social networks, electric power networks, water supply networks, and transportation networks of all kinds, Chip firing game and sand-piles, synchronization, chemical networks, and molecular descriptors.

Who should attend

- ✓ If you are an undergraduate, Master or Ph.D. level scholar and like to be introduced to the new and growing interdisciplinary area of Network Science and Multi-Agent systems.
- ✓ If you are a Faculty/ Researcher/ Scientist from academic/technical institutions/industries and R&D centres across the country.

Registration Process

Step 1: One-time Registration on GIAN portal (if already registered, go to step 2 for details regarding institute registration for this course)
Weblink: http://www.gian.iitkgp.ac.in/GREGN/index
Note that registration to the portal is one-time affair and will be valid for lifetime of GIAN. Once registered in the portal, an applicant will be able to apply for any number of GIAN courses as and when necessary.
Step 2: Institute Registration: All participants are required to pay the appropriate registration fee as given below.

M.Sc./B.Tech./M.Tech./Ph.D. students	**Rs. 2000**
Faculty/Scientists/Researchers from academic/technical institutions	**Rs. 3000**
Participants from industries	**Rs. 5000**
Participants from abroad	**USD 150**

Participants are requested to email the scanned copy of the duly filled registration form given at the end, along with the receipt of the prescribed fee submitted through State Bank Collect, to agtans2018@gmail.com on or before May 31, 2023. The procedure for making the fee payment is as follows.

Payment Instructions: Access **https://www.onlinesbi.com** Click on **SB Collect**. Click the Checkbox to accept 'Terms & conditions'. Then click on **'Proceed'.** Select the state as **'Uttar Pradesh'.** Select the type of category as **'Educational Institutions.'** Click on **'Go'.** Select the name of the institution as **'Indian Institute of Technology (B.H.U.), Varanasi'.** Select payment category as **'GIAN-short term course participation fee'.** Fill up the form and pay the fee according to your participation category. Save the receipt for record and get SB collect reference number; you need to fill it on the registration form.

About the City

The holy city of Varanasi, also called as Kashi or Banaras, is well known as the city of temples. Being one of the seven holiest cities, Varanasi is the oldest city aging more than 3000 years old, and is famous as the city of temples and the most popular pilgrimage point for the Hindus. This religious capital of India is situated on the bank of the holy river Ganges and is famous for temples of Lord Shiva, Buddha (at Sarnath) and Sankat Mochan etc. Sarnath is about 10 Km from Varanasi, famous for its museum, excavation sites, and Buddhist temples that bear the testimony of amalgamation of Indian culture with the neighboring countries. Varanasi is also the premiere place of oriental learning simultaneously keeping in pace with modern knowledge. It is reputed for silk fabrics, perfumes, artistic brass and copper wares, and a variety of handicrafts. This vibrant city with multiple dimensions of knowledge and liberation has a magnetic attraction for people around the world. It is a place of historical and cultural importance.

How to Reach?

The city of Varanasi is well connected by road, rail and air with all the important places of India. Regular flights are available from all major cities to Varanasi. IIT(BHU) is situated inside the Banaras Hindu University campus which is only 5 Kms from Banaras station, 10 Kms from Varanasi railway station, 20 Kms from Mughal Sarai railway station and 35 Kms from the airport.

About the Department

The Department of Mathematical Sciences, IIT (BHU) earlier known as Applied Mathematics has been functioning since 1968. Its importance lies in the fact that it caters to the needs of the undergraduate as well as post-graduate students of the Institute. In addition, the Department runs its own 5-year Dual Degree (B Tech & M Tech) programme in Mathematics & Computing. Computing is the glamour of the Department. It annexes several dimensions in terms of new and growing areas of research and further facilitates the simulation of mathematical models constructed for interdisciplinary areas.

Accommodation

The participants may be provided with accommodation at the Institute Guest House/Hostels on a nominal payment basis subject to availability. A request for accommodation has to be sent in advance. Otherwise, participants will have to make their own arrangements to stay.

About the Faculty

Prof. S. Lakshmivarahan, Retired George Lynn Cross Research Professor, School of Computer Science, University of Oklahoma, Norman, Oklahoma, USA.

He completed his Ph.D. in Electrical Engineering from the IISc Bangalore, India in 1973. After serving as an Assistant Professor at the Indian Institute of Technology, Madras, India, and as a Visiting Assistant Professor at Brown University and Yale University. He joined the University of Oklahoma in 1978. His major areas of teaching and research are learning algorithms, parallel and distributed processing, dynamic data assimilation, 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. 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, and the Regents Award for Superior Teaching in 1991. He has authored/coauthored 7 books, published over 80 journal papers, and has presented at over 120 international /national conferences. He has offered over 45 short courses at major centers of higher learning in Canada, China, Brazil, India, England, Germany, Japan, Mexico, Taiwan, and the USA. 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 book on Dynamic Data Assimilation published in 2006, has received the 2007 Outstanding Scientific Paper award from the National Office of Oceanic & Atmospheric Research, USA. Recognizing his overall contributions to teaching, research and service, the University of Oklahoma in 1995 bestowed on him its highest honor as George Lynn Cross Research Professor.

Dr. Lavanya Selvaganesh completed her M.Sc. and Ph.D. in Mathematics from IIT Madras (2008). She carried out her post-doctoral research at the University of Oklahoma, USA (2009), UMIT, Austria (2010-11), and IMSC, Chennai (2009-10, 2012-13). She then served as a Research Assistant Professor at SRM Research Institute, Chennai (2013-2016). Upon joining IIT(BHU) Varanasi in 2016, she established the "Graph Theory and Network Sciences" research group which focuses on inter-disciplinary research, utilizing techniques from maths, statistics, computer science, and Bio/chemo-informatics. Using network theory and computational techniques, the group studies the theoretical aspects of algebraic/spectral graph theory and applies these techniques to real-world systems in Chemistry, Biology, and Social Science.

Important Dates

Course duration:	***June 19 - 30, 2023***
Registration Starts:	***March 01, 2023***
Last date of registration:	***June 02, 2023***
Intimation to selected participants:	***June 05, 2023***

Address for all correspondence:

Course Coordinator

Dr. Lavanya Selvaganesh
Department of Mathematical Sciences,
Indian Institute of Technology (BHU)
Varanasi - 221005, Uttar Pradesh.
Mobile: +91 98413 39208
Email: agtans2018@gmail.com

Further Information:

- Number of participants for the course will be limited to forty.
- List of participants will be available on the webpage/intimated by email on June 05, 2023.
- Accommodation will be provided on a first come first serve basis (if available).
- Bring your fee receipt, registration form, and selection confirmation to attend the course.
- Participants will be provided a registration kit and course material covering the entire course. The registration fee includes all instructional materials, computer use for tutorials and assignments, and free internet facility.
- There will be continuous evaluation of each participant during the course on understanding the concepts and skills. Based on the performance, winners will be announced and some prizes may be given.
- After successful completion of the course, all participants will get a participation certificate.
- Last but not least, do not hesitate to contact the course coordinator if you have any questions or require any information about the course.

Indian Institute of Technology (BHU), Varanasi

Department of Mathematical Sciences

Registration Form

Network Sciences and Multi-Agent Systems

June 19 – June 30, 2023

Under

Global Initiative of Academic Networks (GIAN), MHRD

1. Name ……
2. a) Age …… b) Sex: M/F ……
3. Designation ……
4. Organization ……
5. Address for correspondence

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E-mail……Phone/Mobile……

6. Highest Academic Qualification……
7. Specialization ……
8. Category of Participant
   - Faculty/Research Scholar/Student of IIT (BHU) ☐
   - Faculty/Research Scholar/Student of other institutions ☐
   - Industry Participant ☐
   - Foreign Participant ☐
9. IIT (BHU) Accommodation Required Yes ☐ No ☐
10. Payment Details
    - Amount (Rs.) ……
    - SB Collect Reference Number ……

Payment mode: Through SB collect (see brochure for details regarding payment procedure)

Please register me for the course on ***Network Sciences and Multi-Agent Systems*** to be held at IIT (BHU) Varanasi during June 19-June 30, 2023.

Date……..

Place ……..

Signature of the Participant