Mini Courses
Mini-cours

ANTHONY BONATO, Ryerson University

Vertex Pursuit Games on Graphs

In vertex pursuit games such as Cops and Robbers, we consider simplified, combinatorial models for the detection or neutralization of an adversary's activity on a network. The mini-course will give a brief overview of this emerging area of graph theory, highlighting recent results and emphasizing open problems.

LELAND MCINNES, Tutte Institute for Mathematics and Computing

Topological Data Analysis

Topological data analysis seeks to bring powerful tools from topology to bear on problems in data science, helping to elucidate the geometry and structure of diverse data sets. This mini-course will offer an introduction to relevant topological ideas and approaches, as well as demonstrating how they can be used in data science. Particular focus will be given to problems in unsupervised learning and exploratory data analysis where such tools are most effective.

KIRSTEN MORRIS, University of Waterloo

Control of Partial Differential Equations

In many systems the physical quantity of interest depends on several independent variables. For instance, the temperature of an object depends on both position and time, as do structural vibrations and the temperature and velocity of water in a lake.

The state of a system modeled by an ordinary differential equation evolves on a finite-dimensional vector space. In contrast, the solution to a partial differential equation evolves on an infinite-dimensional space. For this reason, these systems are often called infinite-dimensional systems. This creates challenging issues in stability analysis and more so in controller design. Another issue is the construction of estimation of the entire solution to the partial differential equations using only measurements taken at a finite number of points. Although there are many similarities, the systems theory for infinite-dimensional systems differs in some important aspects from that of finite-dimensional systems. Also, for systems modeled by PDEs, control system and estimator performance depends not only on the controller/estimator design but also on the location of the control and the measurements. Physical intuition does not always lead to the best choice of locations. Since it is often difficult to move hardware, and trial-and-error may not be effective when there are multiple sensors and actuators, mathematical analysis is crucial.

This short course will provide an introduction to control and systems theory for infinite-dimensional systems. It is expected that a previous course in PDEs and also in functional analysis has been obtained. No previous exposure to control systems theory is assumed.

POURIA RAMAZI,

Machine-learning methods for modeling biological processes

Although traditional models used to predict biological processes from underlying covariates have a record of success, they also suffer from limitations: typically, (1) they cannot handle highly correlated covariates, (2) they cannot make predictions when one or more covariates are missing, and (3) they do not provide a "primary" set of covariates, which are sufficient to make accurate predictions, and specify which other "secondary" covariates can help to make an educated prediction when the values of some primary covariates are missing. I will show how Bayesian Belief Networks (BBN) provide a very useful structure for analyzing factors governing biological processes, and this approach overcomes the typical limitations posed by traditional models. Things you will learn in the minicourse are: * How to preprocess a dataset for the use of BBN's, including discretization of continuous variables, * How to properly partition the dataset into train and test, * How to choose the score function, e.g., BIC, AIC, AUC, for evaluation, * How to learn, fully from data and without any human expert interference, a BBN that scores highest on the training dataset (using the bnstruct package in R), * How to construct other types of BBN's, such as Naive Bayes (using the bnlearn package in R), * How to decide on the 'best BBN', * How to properly interpret a BBN by its conditional probability tables (using the bnlearn package in R),

---

SUJATHA RAMDORAI AND DEBANJANA KUNDU,
Iwasawa Theory of Fine Selmer Groups

In this mini-course we will understand the Iwasawa theory of Elliptic Curves with a focus on the module theoretic structure of (fine) Selmer groups of elliptic curves. There is growing evidence that conjectures in classical Iwasawa theory are equivalent to the conjectures on the side of elliptic curves. We will explore some new partial results on either side of the story.

THOMAS S. SALISBURY, York University and the Fields Institute
Mathematical Finance

This three-hour minicourse will provide an introduction to the mathematics used in modern finance, and to the type of applications it finds in the world of quantitative analysts (also known as quants). We will touch on such mathematical techniques as the Ito calculus, stochastic control, and BSDE's. These open up applications in finance, to topics such as derivative securities, hedging, risk neutrality, complete and incomplete markets, credit risk, volatility modelling, portfolio optimization, and optimal execution.

CHRISTOPHER SCHAFHAUSER,
On the classification of simple nuclear C-algebras*

A conjecture of George Elliott dating back to the early 1990's asks if separable, simple, nuclear C*-algebras are determined up to isomorphism by their K-theoretic and tracial data. Restricting to purely infinite algebras, this is the famous Kirchberg-Phillips Theorem. The stably finite setting proved to be much more subtle and has been a driving force in research in C*-algebras over the last 30 years. A series of breakthroughs were made in 2015 through the classification results of Elliott, Gong, Lin, and Niu and the quasidiagonality theorem of Tikuisis, White, and Winter. Today, the classification conjecture is now a theorem under two additional regularity assumptions: Z stability and the UCT. In my recent joint work with José Carrión, Jamie Gabe, Aaron Tikuisis, and Stuart White a much shorter and more conceptual proof of the classification theorem in the stably finite setting was provided. I hope to give an overview of the classification problem for C*-algebras and discuss some of the new techniques that led to the new proof.

DANIEL SKOOG, Maplesoft
Programming and Mathematics in Maple

Since its inception in the early 80's at the University of Waterloo, the Maple programming language has been evolving to solve problems in many different mathematical and scientific domains.

In this three-hour hands-on workshop, you learn the basics of this uniquely Canadian programming language as well as learn more about recent trends in symbolic analysis, visualization, code translation, data analysis and user interface construction.

Newcomers to Maple, as well as experienced users who are interested in trying out the latest we have to offer, are welcome.

Requirements: Bring your laptops! Registrants will receive a 1-year copy of Maple that they can use in the course and then after!

ALEJANDRO URIBE, University of Michigan
Geometric Quantization: Old and New

Geometric Quantization, introduced in the late 1960s by Kostant and Souriau, unifies ideas from quantum mechanics with the "orbit method" from representation theory. While many parts of the theory are well-developed, some of the deep, old mysteries of the subject (such as "independence of polarization" phenomena) are still unresolved, and there are exciting new connections to other areas of mathematics (of which mirror symmetry is one example). The purpose of this minicourse is to introduce participants to classical geometric quantization, and provide preparation for the session "Geometric quantization: old and new."

HUAIPING ZHU, York

Modeling and Dynamics of Mosquito Population and Transmission of Mosquito-borne Diseases

Vector mosquitoes and mosquito-borne diseases (MBDs) have become a severe burden of the public health. For prevention and control, it is essential to understand the triggers and mechanisms of an outbreak and repeated infestations. In this short course, I will first introduce some models for the population dynamics of vector mosquitoes. Compartmental models are used to study the transmission dynamics of MBDs. Dynamical system and bifurcation theory, and geometrical singular perturbation approach will be used to study the dynamics of the models to answer the two questions mathematically. I will present the local stability and lower codimension bifurcations to explain the triggering conditions for an outbreak and mechanisms for repeated outbreaks. I will also explain the global stability, existence, and non-existence of periodic solutions, multi-scale dynamics of the models, and the challenge of the study by connecting to Hilbert's 16th problem. In the end, I will show our predictive modeling studies based on the surveillance data for weekly real-time forecasting of mosquito abundance and risk of West Nile virus in five regions of the Greater Toronto Area.