NUS-PKU

Joint Summer Programme on Mathematical Modeling

26 June – 7 July 2006

National University of Singapore

NUS-PKU Joint Summer Programme on Mathematical Modeling
Course Outline

Monday, 26 June

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Lin Ping, Department of Mathematics

Title: Multi-scale modeling (or atomistic-to-continuum modeling), analysis and simulation of material fracture

Outline:

In many applications materials are modeled by a large number of particles (or atoms) where any one of the particles interacts with all others through a pair of potential energy. The equilibrium configuration of the material is the minimizer of the total energy of the system. Material fracture or crack occurs when one or a number of atomic bonds are broken.

The course will present
- background of material fracture
- classical models
- multi-scale modeling (or atomistic-to-continuum coupling)
- steady state case: quasicontinuum approximation and its analysis
- fracture dynamics: virtual internal bond model or other heuristic thoughts
- numerical methods and some simulation results

Monday, 26 June

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Lin Ping, Department of Mathematics

Title: Multi-scale modeling (or atomistic-to-continuum modeling), analysis and simulation of material fracture

Outline:

Continue from morning session.

Tuesday, 27 June

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Stephenson, Alec Grant, Department of Statistics and Applied Probability

Title: Extreme Value Statistics in the Environment

Outline:

1. Environmental Maxima (2 hours)
   - 1.1 Role of Extreme Value Theory
   - 1.2 Environmental Applications
   - 1.3 Theory for Maxima
   - 1.4 Domains of Attraction
   - 1.5 Modeling Environmental Maxima in R

...more details on next page

2. Modeling Threshold Exceedances (2 hours)
   - 2.1 Extending Theory for Maxima
   - 2.2 Environmental Applications
   - 2.3 Threshold Exceedances for IID Random Variables
   - 2.4 Threshold Exceedances for Stationary Processes
   - 2.5 Modeling Threshold Exceedances in R

Description of course:
Most conventional methods in statistics are concerned with what goes on in the centre of the distribution. In environmental applications the primary interest is often in the tails of a distribution i.e. in the extreme values at the upper or lower end. Specific examples include; pollution monitoring, where concern is raised if pollution levels exceed a certain specified level; oceanography, where occurrences of extreme sea-levels lead to flooding and damage to property or loss of life; meteorology, where modeling of high temperatures can be used to assess the possibility of an increasing trend.

In this course you will learn about an area of statistics known as Extreme Value Theory, and you will use this theory to model environmental data. Extreme Value Theory focuses on modeling the tails of a distribution, and it is often applied to environmental problems. The course is separated into two sections; in the first section we will discuss the analysis of maxima and minima; in the second section we will discuss exceedances of a pre-specified threshold. You will use the R statistical computing system to model extreme wind speeds, flood discharges, sea-levels and temperatures.

Tuesday, 27 June

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Stephenson, Alec Grant, Department of Statistics and Applied Probability

Title: Extreme Value Statistics in the Environment

Outline:

Continue from morning session.

Wednesday, 28 June

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Xia Yingcun, Department of Statistics and Applied Probability

Title: Cumulative Effects of Air Pollution on Public Health

Outline:

Cumulative effect is an important way through which the pollutants affect public health. In this lecture, I will discuss some dynamical models to detect or quantify the cumulative effects and to answer pertinent questions posed by the World Health Organization (WHO): “Is there a threshold below which no effects of the pollutants on health are expected to occur in all people?” and “What averaging period (time pattern) is the most relevant from the point of view of health?”. We show that the cumulative effects on health due to continual exposure to environmental pollutants can be very serious even at levels below the national ambient air quality standards of America (NAAQS). The situation is especially worrying for chronic sufferers. Possible revision of the ambient air quality standards is suggested.

NUS-PKU Joint Summer Programme on Mathematical Modeling
Course Outline

Wednesday, 28 June

Time: 2.00pm-4.00pm

Venue: S14 #03-10

Speaker: Karthik Balkrishnan Natarajan, Department of Mathematics

Title: Modeling with Linear and Integer Programming (I)

Outline:

The purpose of this lecture is to introduce students to modeling ideas with tools of linear and integer programming. Key concepts of identifying the appropriate decision variables, constraints and costs in an optimization framework will be introduced. The focus will be on modeling puzzles using optimization formulations.

Proceed to S14 #03-11 for tea break from 4.00pm-5.00pm

Thursday, 29 June

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Dai Min, Department of Mathematics

Title: Finance

Outline:

Option pricing modeling: including (a) concepts of options and futures (b) no-arbitrage argument (c) binomial model (d) Black-Scholes model

Thursday, 29 June

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Dai Min, Department of Mathematics

Title: Finance

Outline:

Optimal investment: including (a) single period mean-variance analysis (b) the continuous time model

Friday, 30 June

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Lee Seng Luan, Department of Mathematics

Title: Geometric Modeling

Outline:

In interactive computer aided design of free-form curves and surfaces, the designer inputs a set of points to form a polygonal or polyhedral shape of the desired object: curve, surface or solid. The points input by the designer are called ***control points***, and the polygonal (polyhedral) shape is called the ***control polygon (polyhedron).*** From the control points the computer automatically generates a smooth object that approximates the shape of the control polygon (polyhedron). An important feature of a good design algorithm allows the designer to interactively manipulate the shape of the smooth object locally by shifting the position of one or more control points around the region. This is the principle used in computer-aided design and computer graphics.

In the talk I will explain the mathematical models and the algorithms used in standard computer system for interactive design of free-form curves and surfaces. In particular, I will introduce Bernstein polynomials and uniform spline functions, which are the mathematical functions that define the models.

Friday, 30 June

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Lee Seng Luan, Department of Mathematics

Title: Geometric Modeling

Outline:

Continue from morning session.

Monday, 3 July

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Teo Chung Piaw, Department of Decision Sciences

Title: Gambling

Outline:

Basic probability, mean, variance, and overview of the case, particularly on the role of hot number management

A set of data will be provided for students to do their analysis and to try out the performance of their proposal. (The problem is simple enough for the students to work on using only excel.) The students will then be formed into groups and work on the case at night.

Students do their presentation and discussion.

NUS-PKU Joint Summer Programme on Mathematical Modeling
Course Outline

Monday, 3 July

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Bao Weizhu, Department of Mathematics

Title: Mathematical Models in Biology

Outline:

1. Population models for single species
   - 1.1 Continuous models: exponential growth models, logistic model, etc.
   - 1.2 Discrete models
   - 1.3 Population model with age distribution
   - 1.4 Equilibrium and bifurcation
   - 1.5 Numerical methods for ODEs

2. Models for interacting populations
   - 2.1 Lotka-Volterra systems
   - 2.2 Realistic Predator-Prey models
   - 2.3 Complexity and stability

3. Reaction kinetics
   - 3.1 Enzyme kinetics
   - 3.2 Cooperative phenomena
   - 3.3 Multiple steady states

4. Biological oscillators and switches

Tuesday, 4 July

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Bao Weizhu, Department of Mathematics

Title: Mathematical Models in Biology

Outline:

Continue from 3 July afternoon session.

Tuesday, 4 July

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Teo Chung Piaw, Department of Decision Sciences

Title: Gambling

Outline:

Continue from 3 July morning session.

Wednesday, 5 July

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Zhang Louxing & Kong Yong, Department of Mathematics

Title: Graph modeling in genomics

Outline:

The topics include how to apply Euler cycles, TSP problem, trees and other concepts to developing efficient algorithms for multiple genomic sequence alignment, sequence assembly, genome rearrangement and tandem duplication detection.

Wednesday, 5 July

Time: 2.00pm-4.00pm

Venue: S14 #03-10

Speaker: Zhang Louxing & Kong Yong, Department of Mathematics

Title: Graph modeling in genomics

Outline:

Continue from morning session.

Proceed to S14 #03-11 for tea break from 4.00pm-5.00pm

Thursday, 6 July

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Mabel Chou, Department of Decision Sciences

Title: Supply chains

Outline:

We will introduce mathematical modeling tools to handle supply chain management problems in a stochastic environment. In particular, we will focus on coordination in supply chains, one of the most important topics in supply chain management. Our objective is to provide the students a basic understanding of this topic and how to use mathematical modeling tools to analyze related issues. We will start with a basic newsboy model, followed by discussions on interactions between stages in a supply chain, double marginalization and contracts for supply chain coordination.

Thursday, 6 July

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Mabel Chou, Department of Decision Sciences

Title: Supply chains

Outline:

Continue from morning session.

Friday, 7 July

Time: 9.00am-11.00am

Venue: S14 #03-10

Speaker: Chen, Ben M., Department of Electrical and Computer Engineering

Title: Modeling and Control System Design for a UAV Helicopter

Outline:

In the last decade, some great achievements have been made in the development small scale UAV helicopters. Compact and light-weight onboard computer systems are commonly adopted to form a crucial component in the UAV helicopters. Some identification techniques have been successfully used in modeling the dynamics of full scale helicopters and some linearized models, which yields fairly accurate responses, have been derived. For control system design, the classic control method such as PID together with some gain-scheduling schemes has been commonly used and implemented in small scale UAV helicopters. Recently, more advanced nonlinear control methods have also been investigated in a wider flight envelope.

In the last two years, we developed a UAV helicopter at the National University of Singapore, which is now called NUSIX. Our motivation to construct such a UAV helicopter is to develop a test bed for testing and implementing advanced linear and nonlinear control techniques. It is a fairly challenging process. The aerodynamics of small scale helicopter is similar to its full scale counterpart but owns some unique characteristics such as the utilization of stabilizer bar and higher main/tail rotor's rotation speed. Besides these, the strict limitation on payload also increases the difficulty on upgrading a small scale helicopter to a UAV with full capacities. Based on its various characteristics and limitations, a light-weight but effective onboard computer system with corresponding onboard/ground software should be carefully designed to realize the system identification and automatic flight requirements. In this talk, we will report: i) a complete system identification of the hovering flight of the UAV helicopter, and ii) an automatic flight control system design and implementation for hovering and circling test flights using a newly developed composite nonlinear feedback control, which has the capacity of yielding a fast transient response with minimal overshoot.

Friday, 7 July

Time: 3.00pm-5.00pm

Venue: S14 #03-10

Speaker: Chen, Ben M., Department of Electrical and Computer Engineering

Title: Modeling and Control System Design for a UAV Helicopter

Outline:

Continue from morning session and visit the test field in Bukit Batok to see how to model a UAV helicopter.

End of Summer Programme