Report on: Mathematics for Biological Networks, Summer School Course, University of Victoria
May 10 - June 02, 2010

Organizers: Rod Edwards, Junling Ma, Pauline van den Driessche, Deapartment of Mathematics and Statistics, University of Victoria

1 Sponsors for the Summer School

This event was sponsored by:

- PIMS: via the International Graduate Training Centre (IGTC)

- MITACS (Event $09 - 01 - 040$): via the MITACS team "Transmission dynamics and spatial spread of infectious diseases: modeling, prediction and control" led by Jianhong Wu and by the MITACS Focus Period on "Network analysis and applications".

- The University of Victoria (UVic): via the Dean of Science, one course teaching credit for Rod Edwards and Junling Ma, provision of lecture room and lab facilities (software loaded by Kelly Choo), administrative support from Kristina McKinnon, the UVic PIMS Administrator

- Centre for Disease Modeling (CDM/CMM), York University

- BC Centre for Disease Control (BCCDC), Vancouver: via the Division of Mathematical Modeling (DMM)

The organizers, lecturers and students sincerely thank these sponsors for the opportunity to participate in this very successful event.

2 The Summer Course

This graduate summer school consisted of two parts:

- First Half: Infectious Disease Networks, May 10-20, 2010

  The first half covered ODE disease compartmental models briefly, followed by an introduction to probability and generating functions to set the stage for disease network models. Eight lectures were then given on contact network epidemiology, an area that has been developed over the past approximately ten years. It is believed that this summer school is the first one devoted to this newly emerging area of disease modeling. Case studies for West Nile virus and influenza were presented.

- Second Half: Dynamics of Neuronal Networks, May 23-June 02, 2010

  The second half introduced students to single neuron models from the Hodgkin-Huxley formalism to reduced models and models of synapses. It then proceeded to recent results on small networks including analyses of spiking, bursting, propagation and pattern formation. Case studies on cental pattern generation and Parkinson's disease were presented.

The full UVic course was listed as MATH 475/575 and was open to UVic students for 1.5 units credit. In addition IGTC students could register with the Western Deans' Agreement to take the full course for credit, or take it by Directed Studies arrangement. Non-credit students could take one or both halves of the course. The course attracted 25 students for the first half, and 18 students for the second half, with 6 IGTC students completing the full course for credit. Students came from Universities in BC, Alberta, Manitoba, Ontario and New Brunswick, with an international student from each of USA, Mexico and the Netherlands. Most students were doing graduate degrees, but two had just completed their undergraduate studies, and four were postdoctoral fellows. Full biographical details for each half of the course are attached as .pdf files of Demographic Survey Results.

3 Preparation for the Course

Planning started over a year ahead as detailed below.

- Financial Planning: PIMS (through IGTC) awarded a budget of $25K, MITACS awarded a budget of $30K + $10K to cover the travel and honoraria of the visiting lecturers and to help with local accommodation and some travel for students.

- Academic Room Bookings: One year in advance a lecture room in the Social Sciences and Mathematics Building (SSM) and a lab in the Human and Social Development (HSD) building at UVic were booked.

- Accommodation Booking: One year in advance on-campus accommodations in single residence rooms and cluster quads were secured. Craigdarroch House at UVic was already booked for some of the course duration, but a booking there was secured.

- Lecturers: One year in advance visiting lecturers were invited and agreed to participate. We were extremely fortunate in attracting as lecturers some of the leading researchers who are also excellent expositors.

- Student Applications: A website for the course was set up by PIMS, together with an application form for students that became live by the beginning of February 2010. For a graduate student, an application also required a supporting message from the student's supervisor. Acceptance of applicants was managed by the organizers, and PIMS set up a registration procedure for each half of the course.

- Website and Advertising: From the PIMS and MITACS web sites a link was established to the course web site on the UVic Math & Stats web page. This was maintained by Junling Ma and was updated in a dynamic way as the course proceeded. Information about the course was sent by e-mail to every Applied Mathematics Department in Canada, to the SMB and CAIMS Newsletters as well as to additional individuals.

4 Course Hours and Student Evaluation

The *first half* of the course had 18 lectures of 1 hr 20 mins each, together with a special seminar given by Mark Lewis, IGTC Director. In addition, students spent 17 periods of 1 hr 20 mins each in the labs, during which time they were instructed in the use of Matlab (by Bahman Davoudi) and Python/NetworkX (by Rafael Meza), and they worked on exercises and group projects with mentoring from all the lecturers.

On the second day of the course, students were given a list of projects (ably assembled by Julien Arino in consultation with the other lecturers), they expressed their preferences, and were assigned to groups of four or five to work on one of the projects. Projects 1, 3, 5, 7, 8 and 10 from the website list were chosen. In the afternoon of day five of the course, each group presented a maximum of ten minutes on their project,and received feedback and suggestions from other participants. On the last morning of the course, each group gave a 25

mins presentation during which every member of the group contributed. At the conclusion of each presentation, each student was awarded a personalized certificate of completion of the infectious disease networks half of the course. These presentations were possibly the highlight of the first half of the course, with both the enthusiasm and standard being very high.

Students taking the course for credit handed in solutions to 10 exercises on May 16th and 8 exercises on May 23rd as well as a written report of their project on May 19th.

The *second half* of the course had 23 lectures of 1 hr 20 mins each. In addition, students spent 12 periods of 1 hr 20 mins each in the lab, during which time they were instructed in the use of XPPAUT (by Cheng Ly assisted by Stefanos Folias), and they worked on exercises and group projects with mentoring from all the lecturers. One afternoon, Prof Delaney (Dept. Biology UVic) offered participants a tour of his lab, so they could see first hand some experimental neuroscience.

On the third day of this half of the course, students were given a list of projects (assembled by the 4 lecturers from Pittsburgh), they expressed their preferences, and were assigned to groups of three or four to work on one of the projects. Projects 1, 2, 3, 4 and 10 from the website list were chosen. On the last morning of the course, each group gave a 25 mins presentation during which every member of the group contributed. At the conclusion of each presentation, each student was awarded a personalized certificate of completion of the dynamics of neuronal networks half of the course. As in the first half of the course, this conclusion was possibly the highlight, with both the enthusiasm and standard of presentations being very high.

Students taking the course for credit handed in 8-11 solutions to exercises on May 31st as well as a write up of their project on June 02.

Details of all the lectures, projects and exercises for both halves of the course can be found on the course web page
http://www.math.uvic.courses/2010k/math575
and in the attachment. The marking scheme for IGTC students taking the course for credit is also included there.

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5 Prerequisites

Students were expected to have background in differential equations and linear algebra and preferably in modeling. The required biology was taught in parallel with the modeling and mathematical techniques. By asking about the prerequisites on the application form, requiring a message from a student's supervisor, and also conducting a survey of computational skills, the student body for the course was relatively homogeneous, although the students differed in their knowledge of the actual topics being taught.

6 Lecturers

The course was taught by the following instructors. The title of each talk is given on the course web page. Slides or notes of most lectures from the first half and some of the second half are also posted on the web. The remainder of lectures in the second half were delivered using the blackboard and a list of references is provided on the web.

First Half

- Julien Arino (University of Manitoba)

- Shweta Bansal (Penn State University)

- Fred Brauer (University of British Columbia)

- Bahman Davoudi (University of British Columbia, BCCDC)

- Junling Ma (University of Victoria)

- Rafael Meza (University of British Columbia, BCCDC)

- Babak Pourbohloul (University of British Columbia, BCCDC)

- Pauline van den Driessche (University of Victoria)

- Jianhong Wu (York University, CDM)

Second Half

- Kerry Delaney (University of Victoria)

- Rod Edwards (University of Victoria)

- Bard Ermentrout (University of Pittsburg)

- Jonathan Rubin (University of Pittsburg)

- Stefanos Folias (University of Pittsburg)

- Cheng Ly (University of Pittsburg)

7. **Social Activities**

On each morning and afternoon there was a 20 minute break during which simple refreshments were provided (coffee, tea, juice, water, and one item selected from a fruit plate, a vegetable platter, a cheese board, cookies, biscotti, squares, shortbread). An attempt was made to make this a "green event" in avoiding disposable dishes, cups and cutlery. The refreshments were provided by UVic catering, as required for events held on the UVic campus. The students really appreciated these breaks, and it gave them a chance to talk informally with the lecturers and other students. The participants were an enthusiastic and energetic group, and it was a pleasure to work with the students.

Each half of the course had a break day during which the students could work on their own or go on an afternoon hike organized by one of the students from UVic. On Saturday May 15th, sixteen students and lecturers went on a hike from the Aylard Farm entrance to East Sooke Park, and on Saturday May 29th, twenty students and lecturers went to the same park but at the Iron Mine Bay entrance. Both hikes were most enjoyable and gave visiting students an idea of the West coast environment and a time for discussion in an informal setting.

At the conclusion of the first half of the course, students and lecturers were treated to lunch at UVic University Club hosted by BCCDC DMM.

7 Recommendations

In random Order:

- We benefited greatly from advice from and the experience of Prof Leah Keshet who had run the first very successful IGTC summer school at UBC in May/June 2008. It is important to pass on ideas and suggestions.

- The mix of lectures, exercises, labs and student projects worked very well and is an excellent format for a graduate summer school.

- All non-local students and most lecturers stayed on campus, which helped create a friendly and social atmosphere for the course. It also helped minimize the budget for accommodation.

- An office on campus should be made available to long-term lecturers. We had not thought of this, but were able to accommodate a request.

- Lecturers in charge of computer labs should ensure that the labs work properly and that material is compatible with the software installed. The labs worked well in the second half but there were a few glitches in the first half.

- Students taking the course for credit were required to hand in exercise solutions, write up their projects and take part in their group presentations. There was some discussion about time available for each component, with various suggestions made for improvement (e.g. more time for projects, fewer exercises), but no consensus. We did modify the requirements a little as the course progressed, but feel that both exercises and projects are a vital part of the course. One student who took the course for credit volunteered that she had got much more out of the course by having to do the assigned work. It was suggested that a one day break before the student presentations would be good, but it is a balance between time and cost.

- Refreshment breaks were somewhat costly, but it was money well spent!

- The number of students taking the course for credit was somewhat disappointing, especially given the excellence of the lectures. This in no way detracted from the experience. However, IGTC students should be encouraged to take such a course for credit even if they have completed their minimum course requirements and/or the topics do not exactly match their own research interests.

- A lot of work is involved in organizing such a summer school, with the work including the scientific program and local arrangements. It is essential that main organizers be given course teaching credit.

- Accurate budgeting presents a problem as there are many unknowns (e.g. cost of flights, number of students), so it is essential to have some administrative help for this aspect of the course.

- The application/registration process was quite cumbersome, with interface between the organizers and PIMS staff.

- Maintaining a local website is essential, especially because the program needs to be somewhat dynamic as the student needs are met.

- This successful summer school and previous IGTC summer schools suggest a possible model for giving more summer graduate courses that are available to students across all PIMS Universities. Graduate credit is facilitated through the Western Deans' agreement. Advantages of such offerings are that the course has an increased number of students, and graduate students have a wider choice of courses.

8   Other Details

Details of the course timetable are posted at:
http://www.math.uvic.courses/2010k/math575
Links to project lists, references and group photos are also given there.

9   Measurable Outcomes

Students were exposed to lectures from top researchers in two highly active research areas of mathematical biology. They benefited greatly from the knowledge and skills they developed during the summer school. Thus these representatives of the next generation of mathematical biologists have been trained in both theoretical and computational aspects at the research frontier of the discipline. The students have also engaged in group research on real research topics. Six graduate students obtained course credit.

10   Budget

A copy of the financial statement will be forwarded to MITACS and PIMS when completed.