Syllabus
Introduction to the Methods of Computational Neuroscience and Psychology
Fall 2010

Britt Anderson

1 Instructor Information

Name: Britt Anderson

Office: PAS 4039

Extension: 33056

Office Hours: Tuesday 10am - 12pm

2 Course Description

This course is intended for students, undergraduate and graduate, who wish to learn more about computational methods and their application to neuroscience and psychological topics. In particular, I envision two groups of students: those students who come from backgrounds like computer science and who feel comfortable with computational techniques, but have little sense of how to apply those tools to psychological and neuroscience topics, and the psychologist whose last math course was in grade 11 and while knowing exactly what problems interest him, has little confidence in his ability to learn to apply computational techniques. While I look forward to working with students from both traditions, it is the latter that I am particularly eager to recruit. For these students I would like the course to not only provide information, but to improve confidence; to get students to believe what I believe, which is that you don't have to be particularly gifted to be able to use computational approaches and that by virtue of being a successful student at a University you have demonstrated that you have all the smarts you need to do this stuff.

However, saying you are smart enough is not the same as saying it is easy. The course will probably require you to push yourself a little and may take a fair amount of time. The trade is that I will not be an unmerciful grader. If you work hard, and persevere, you will get a decent grade. If you are interested in this stuff, this is your chance to learn it. I want to make the classroom a "safe place" for intellectual exploration. For students from a computational background, I will ask the same effort and make the same offer: make an effort to stretch and expand your skill set, e.g. use a new programming language that you have never used before, and I won't penalize you if it crashes.

The course has three basic pedagogical goals. First, we explore how computational techniques are used in cognitive neuroscience research so that we can be critical readers of research papers. No more should the words: model, computation, or equation, lead you to skip from introduction to discussion. Second, you should develop a computational vocabulary and start to know what some of those squiggly symbols mean. This will help with the first goal of being a critical consumer of computational research, and it will also help you to be an effective collaborator in computational research. Even if you don't go on to do any programming on your own, you should have a better understanding of what a programmer does, how she does it, and to propose suggestions that are sensible. Third, I want to dispel the notion that computational approaches require some special cognitive ability or months spent learning some arcane language. Anyone who has ever used a spreadsheet to sum a column of numbers is a computer programmer in a functional language and nothing beyond that knowledge is necessary to start using computational techniques. For this reason, you can do everything this course requires in Excel. I hope you will try to move beyond Excel, and when you see the advantages that come with other approaches, I suspect you will give it a try, but you don't have too. Spreadsheet programming is enough. And by using it you will see one of the great advantages of programming: the requirement to be clear, concrete, and explicit, forces you to understand what you are doing.

In summary, the goals for the course are to become informed readers of research articles using computational techniques, learn enough mathematical and computational terminology to be active scientific collaborators, and to actually program computational simulations at a rudimentary level.

2.1 Specific Topics

I try to outline the course around a few principal topics that I allow me to showcase different domains and types of maths that are used in computational modeling for psychology and neuroscience. How far we get depends a bit on how smooth things go. Here is the initial plan.

Build your own Hodgkin - Huxley model	differential equations
Construct a Hopfield Network	linear algebra and neural networks
Race Models and Reaction Time Modeling	probability
Other topics: information theory	attention
Class Presentations	

Table 1: The list of mathematical topics and their companion psychological or neuroscience application.

The basic format is that for each row of that table, I will introduce the topic with some review of the relevant neuroscience or psychology background. Then I will give a little primer on the maths involved. Then I will guide you through a series of exercises, some done in class and some down as homework, that increase in complexity and work towards a concrete implementation of some computational method.

3 Textbook

I tried my best to find us a textbook for this course, and I failed. Please feel free to make suggestions. My problem was that there is essentially only one textbook on computational approaches to *cognitive* neuroscience. This is the book: *Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simulating the Brain*. I really like this book, but it is too detailed for our purposes, and it limits us to a specific software implementation. Chapter 1 was scanned and is available for reading. It provides another good overview of relevant issues for computational modeling.

There are several good textbooks on *computational* neuroscience, but they, too, either bind themselves to one particular computer language, or are too high level for us. Two good books are *Theoretical Neuroscience* by Dayan and Abbott (this one is fairly high level) and *Fundamentals of Computational Neuroscience* by Trappenberg (a bit more basic, but reliant on MATLAB).

Therefore, we will be relying on handouts and pdfs. I will try and post as many of these as I can on our course site on UW-ACE.

I am thinking of trying to collect the presentation material and wrap some text around it as a course note book. I would be very interested in recieving any detailed feedback on the lectures. If you take good notes and are proud of them, send me a copy, and maybe I can incorporate some of your material in a future course.

4 Course Requirements, Expectations, and Grading

4.1 Requirements

There really are no pre-requisites beyond an interest in the material and a willingness to work. Any prior calculus, linear algebra, or programming experience will be convenient, but it is not necessary, the course is intended to be self-contained. If you want to get anything out of this course you will probably have to work pretty hard, but the pressure to do so, will have to be self-applied. Just because the course is classed as a "seminar" does not mean that it is all about reading and talking. You will have to work to learn anything.

4.2 Expectations

I expect you to attend every class or send me advance notice indicating why you cannot. There will be periodic assignments during the course. You must complete all assignments. If you complete a reasonable effort at every assignment then you will pass. I hope to use much of our class time for group discussion and small projects. My grading scheme is subjective. Because there are a relatively small number of students I will learn each of your names and I will become a pretty good judge of your capabilities. I will judge whether you are making an effort and I will adjust my evaluation for what I understand to be your level of computational expertise. A computer science major and a psychology major might not get the same grade for the same assignment.

4.3 Grading

There are three graded components:

- Classroom assignments and homework 50% aggregated
- Peer Evaluations 20%
- Presentation/Project 30%

The class room assignments and homework are assignments that you do alone, or in collaboration (just make sure that I know in advance who is collaborating with whom and that if I question you later you are able to

demonstrate an understanding of the work submitted). They are announced in class, distributed on ACE and returned in electronic drop boxes on ACE.

To meet the major goal of making you informed consumers of computational approaches the course builds towards an in-class final presentation. These are often done individually, but I am open to pairs of students working together if the collaboration improves the offering, and not just as a way of lessening the work. For example, a psychologist collaborating with a neuroscientist might provide a synergy that neither working alone could do. The presentations can take different forms. For example, you could present based on an article you have read, describing the method or elaborating on the technique. You could give a lecture; pick a topic of interest and present a mini - version of what I do. Or you could actually try to do something. Make it a mini-research presentation based on some method you learned or idea you had during the course. The overarching principle is that you should be able to effectively present scientific matter to an audience of your peers. More information on the details of the presentation and the rubric used for scorring will be distributed during the course.

Graduate students have to meet all the obligations of the undergraduates and in addition will have to deliver a more extensive presentation (both in duration and in content).

No midterms or finals are projected at this time.

5 UW-ACE

I will be trying to use UW-ACE for everything. We have a course web page where all readings and assignments will be posted. Drop boxes in the course web page will be used for you to submit your assignments. A discussion forum on our course web page will be there for the discussion of topics that you think other students might be able to answer for you, or that you think other students will be interested in my comments.

Some of the assignments will have templates of spreadsheets that you can work from as a starting point. These will be located in a folder in the Contents tab of the UW-ACE page.

I will use the grade book option of UW-ACE to keep you informed of your performance on the assignments.

6 Communications

6.1 Email

Please email me through the UW-ACE page. It is good for both of us if our academic correspondence goes through ACE. This gives us both a record of what was sent and when. Because of this I will only answer email inquiries about the course through the UW-ACE site. You should verify that UW-ACE forwards your email, or that you check the course site regularly.

6.2 Other

In general, email is not a very good communication media for anything but simple inquiries. If you have a deep question, or personal issue, please come by and see me. My office hours are listed above. If you come by and my door is open, please feel free to knock and see if I am busy. I am also happy to schedule a time for an appointment and my office extension is available if you want to check on my availability before walking over to PAS.

7 The Official Course Outline

If there is a discrepancy between the hard copy outline and the outline posted on UW-ACE, the outline on UW-ACE will be deemed the official version. Outlines on UW-ACE may change as instructors develop a course, but they become final as of the first class meeting for the term.

8 Students with Disabilities

The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.

9 Concerns About the Course or Instructor

9.1 Informal Stage

We in the Psychology Department take great pride in the high quality of our program and our instructors. Though infrequent, we know that students occasionally find themselves in situations of conflict with their instructors over course policies or grade assessments. If such a conflict arises, the Associate Chair for Undergraduate Affairs (Dr. Colin Ellard) is available for consultation and to mediate a resolution between the student and instructor. Dr. Ellards contact information is as follows:

Email: cellard@uwaterloo.ca
Ph 519-888- 4567 ext 36852

9.2 Formal Stage

A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. See Policy 70 and 71 below for further details.

10 Academic Integrity, Academic Offenses, Grievance, and Appeals

Academic Integrity: in order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.

Discipline: A student is expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about 'rules' for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 - Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline, http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4, http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm

Appeals: A student may appeal the finding and/or penalty in a decision made under Policy 70 - Student Petitions and Grievances (other than regarding a petition) or Policy 71 - Student Discipline if a ground for an appeal can be established. Read Policy 72 - Student Appeals, http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm

Academic Integrity website (Arts):
http://arts.uwaterloo.ca/arts/ugrad/academic_responsibility.html

Academic Integrity Office (UW):
http://uwaterloo.ca/academicintegrity/