Detailed Syllabus for CSS 485

Introduction to Artificial Neural Networks

As computing systems have grown in power, so has our ability to use them to mimic some of the capabilities of biological computers: nervous systems and brains. This course is an introduction to artificial neural networks (ANNs) and the application of simple biological computing principles to artificial intelligence (AI). In particular, this course focuses on the mathematical fundamentals behind ANNs (i.e., understanding how they work — and when they don't work) and their implementation and on implementing ANN algorithms "from scratch" (rather than using high-level tools to merely apply ANNs to problem solving). Prerequisites include CSS 342 and prior exposure to linear algebra, probability, and calculus.

Course Objectives

The goals of this course are for you to be able to do the following:

- Be able to explain the relationship between artificial neural networks and biological neural networks.
- Be able to apply mathematical concepts, including linear algebra and optimization, to machine learning problems.
- Be able to select from among a number of different artificial neural network approaches, including supervised, unsupervised, and reinforcement learning, to solve machine learning problems.
- Be able to apply fundamental knowledge of artificial neural network principles to understand and use modern machine learning tools.

ABET Student Outcomes

For engineering accreditation purposes, this course supports the following ABET student outcomes:

- Outcome (a): An ability to apply knowledge of mathematics, science, and engineering. (Strongly Supported)
- Outcome (b): An ability to design and conduct experiments, as well as to analyze and interpret data. (Supported)
- Outcome (c): An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. (Minimally Supported)
- Outcome (k): An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (Strongly Supported)

engineering practices (strongly supported)

Instructor

Michael Stiber <**stiber@uw.edu** (mailto:stiber@uw.edu) >, room UW1-340. Office hours Wednesdays at 11AM-noon in the Linux lab or by appointment (for example, if you'd like to meet privately).

Textbook

Martin T. Hagan, Howard B. Demuth, Mark Hudson Beale, and Orlando De Jesús, *Neural Network Design*, 2nd Edition, available at **hagan.okstate.edu/nnd.html** (http://hagan.okstate.edu/nnd.html) .

Group Homeworks

Some of your homework assignments will be completed in groups (I will insist that all groups be pairs, unless there is an odd number of students in the class, in which case I will allow one group of three; I will work with that group on small, additional components in the homework). I will *not* use the group feature of Canvas, as I've found its user interface to be more trouble than it's worth. You will write up a group homework report and submit it on Canvas on the due date. A **rubric** (https://canvas.uw.edu/courses/1232683/pages/group-homework-report-rubric) is available on Canvas that describes the elements of a good report. Only one student in a group should submit the report; *make sure your report lists all group members' names*! All members of a group will receive the same grade, so I'm assuming that you can work within your group to coordinate work, and take responsibility for that work. Like any course, pay attention to due dates and times in Canvas.

The final group homework is a substantive project and will be used in lieu of a final exam; it will be due Monday of finals week (when the final exam would otherwise be).

Individual Homeworks

There will be some homeworks that carry lesser weight and should be done individually.

Software

Our work this quarter will make heavy use of **Matlab** (https://www.mathworks.com) ; a tool for mathematical and scientific programming, data analysis, and visualization. Matlab should be installed on all CSS Windows and Linux computers. You can also **purchase a license** (https://itconnect.uw.edu/wares/uware/matlab/#students) for Matlab to install on your own computer for $30 (expires June 30). **GNU Octave** (https://www.gnu.org/software/octave/) is open source, implements much of what Matlab does, and is compatible with Matlab programs. However, I cannot guarantee that it will work with everything we need to do this quarter, so use at your own risk. **SciPy** (https://scipy.org)

will work with everything we need to do this quarter, so use at your own risk. SciPy (https://scipy.org) implements a much more limited subset of Matlab; I mention it here only for the sake of Python fans and to warn you that I'm highly skeptical that it would be useful this quarter.

Additional Readings

L.F. Abbott, "Lapicque's introduction of the integrate-and-fire model neuron (1907)", *Brain Research Bulletin* **50**(5/6): 303–304 (https://canvas.uw.edu/courses/1232683/files/50352383/download?wrap=1) , 1999.

Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, and A. J. Hudspeth, eds., *Principles of Neural Science*, 5th Edition, McGraw-Hill, New York , 2013 (chapter 2 (https://canvas.uw.edu/courses/1232683/files/50352388/download?wrap=1)). (PONS)

Grading

Your course average is computed as: 50% group homeworks +20% individual homeworks + 30% midterm

I don't grade on a curve. I compute everyone's quarter average based on the formula above. I then use my judgment to determine what averages correspond to an 'A', 'B', etc. for the quarter. Some quarters' assignments, etc. turn out harder, and so the averages are lower. Other quarters, averages are higher. I adjust for that at the end. Decimal grades are then computed using the equivalences in the Time Schedule, linearly interpolating between letter-grade boundaries. Furthermore, I am well aware of the significance of assigning a grade below 2.0, in terms of impact on your career here at UWB. I can assure you that I examine in detail the performance in this course of each student before assigning a grade below 2.0.

What is the difference between this and grading on a curve? With the latter, the goal is to have *X*% "A"s, *Y*% "B"s, etc. My way, I would be happy to give out all "A"s (if they were earned).

Access and Accommodations

Your experience in this class is important to me, and it is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law. If you experience barriers based on disability, please seek a meeting with Disability Resources for Students (DRS) to discuss and address them. If you have already established accommodations with DRS, please communicate your approved accommodations to your instructor at your earliest convenience so we can discuss your needs in this course.

DRS offers resources and coordinates reasonable accommodations for students with disabilities.

Reasonable accommodations are established through an interactive process between you, your instructor(s) and DRS. If you have not yet established services through DRS, but have a temporary or permanent disability that requires accommodations (this can include but not limited to; mental health, attention-related, learning, vision, hearing, physical or health impacts), you are welcome to contact DRS at (425) 352-5307 or **rosal@uw.edu (mailto:rosal@uw.edu)** .

For Our Veterans

Welcome! We at UW Bothell understand that the transition into civilian life can be challenging for our veteran students and we MANY resources for any who may want to reach out for guidance or assistance in these matters including our Vet Corp Navigator through the WDVA and our Student Veterans Association (SVA) and tutors/mentors for veterans. Please contact Veteran Services at (425) 352-5307 or **rosal@uw.edu (mailto:rosal@uw.edu)** . For those of you needing more URGENT support, please call The Suicide Prevention Hotline (800) 273-8258 or connect with the **UWB CARE Team (https://www.uwb.edu/studentaffairs/care-team)** .

Problems

If you have problems with anything in the course, please come and see me during office hours, make an appointment to see me at some other time, or send email. I want to make you a success in this course. If you have trouble with the assignments, see me before they are due. If you fall behind, it will be difficult to catch up. I will not give out grades of “incomplete” except in extreme circumstances.

Etiquette, Etc.

- Please read the readings for each class meeting before that meeting. Come to class prepared to ask questions to clarify anything you are unsure about.
- As far as the exams are concerned, I hope I don't need to remind anyone that it's not acceptable to take a break in the middle – i.e., leave the room for any reason – and expect to be able the resume taking the exam afterwards. It's not a matter of me doubting your honesty – it's a matter of you, as a professional, avoiding doing anything that might even hint at being less than honest and focused on the task at hand. Please ensure that you've either taken care of any personal matters before the exam or provide me with documentation of a medical condition that precludes spending two hours at uninterrupted work.
- You are responsible for making back-up copies of your work. Disk crashes, etc. are *not* acceptable reasons for extensions of assignment due dates. Note that your Linux and UW IT home directories are professionally backed up, as are Google Drive, Microsoft OneDrive, etc.
- Assignments are due when specified. Barring illness or similar extenuating circumstances, please do not attempt to submit amendments, bug fixes, or forgotten material after the fact.

- I expect you to treat fellow students, and other UWB community members, with the utmost respect and consideration.
- Please do not post your work to publicly accessible repositories (i.e., github). Use a private repo, like in Bitbucket or Gitlab, if you want to create a portfolio that you can grant access to.
- Do not seek out programming assignment solution code on the web. You need to submit your own work.
- Please be considerate of other students regarding your activities in class. Do not arrive late, leave early, get up at random times, walk about, leave the classroom and return, etc. I will make sure we take a break halfway through each class; you make sure that you take care of whatever personal business you need to so that you can make it to the break. Finally, please do not use a computer during class for anything other than note taking or testing code.
- Please use your UW email (*netid*@uw.edu) for communications with me. This is the only way that I can authenticate that you are who you say you are. I will endeavor to only email you at that address. I do this because that address is the only one guaranteed to be connected to you, based on information in the student database.
- You are expected to provide original work based on your own effort for this course. You will receive a zero for any coursework for which you are discovered cheating or plagiarizing. You will be referred to the University for further action. It is your responsibility to know and uphold the Student Conduct Code for the University of Washington, available at **http://www.uwb.edu/students/policies/ (http://www.uwb.edu/students/policies/)** .

CSS 485 A Au 18: Introduction To Artificial Neural Networks

Jump to Today | Edit

Course Description:

As computing systems have grown in power, so has our ability to use them to mimic some of the capabilities of biological computers: nervous systems and brains. This course is an introduction to artificial neural networks (ANNs) and the application of simple biological computing principles to artificial intelligence (AI). In particular, this course focuses on the mathematical fundamentals behind ANNs (i.e., understanding how they work — and when they don't work) and their implementation and on implementing ANN algorithms "from scratch" (rather than using high-level tools to merely apply ANNs to problem solving). Prerequisites include CSS 342 and prior exposure to linear algebra, probability, and calculus.

This is a summary and schedule for CSS 485; the full syllabus is located here.

Course Summary:

Date	Details	
Wed Sep 26, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172207&include_contexts=course_1232683)	11am to 12pm
	Course overview; What are Neural Networks? (https://canvas.uw.edu/calendar?event_id=1163739&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Oct 1, 2018	Neural Modeling (https://canvas.uw.edu/calendar?event_id=1163738&include_contexts=course_1232683)	3:30pm to 5:30pm
Wed Oct 3, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172208&include_contexts=course_1232683)	11am to 12pm
	Perceptrons (https://canvas.uw.edu/calendar?event_id=1163737&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Oct 8, 2018	Machine Learning: Signal and Weight Vector Spaces (https://canvas.uw.edu/calendar?event_id=1163736&include_contexts=course_1232683)	3:30pm to 5:30pm
	ANN Fundamentals and Matlab (Individual)	due by 3:30pm

	(https://canvas.uw.edu/courses/1232683/assignments/4338321)	
Wed Oct 10, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172209&include_contexts=course_1232683)	11am to 12pm
	Machine Learning: Linear Transformations (https://canvas.uw.edu/calendar?event_id=1163735&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Oct 15, 2018	Hebbian Learning (https://canvas.uw.edu/calendar?event_id=1163734&include_contexts=course_1232683)	3:30pm to 5:30pm
	Perceptron Learning Rule (Group) (https://canvas.uw.edu/courses/1232683/assignments/4338326)	due by 3:30pm
Wed Oct 17, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172210&include_contexts=course_1232683)	11am to 12pm
	Machine Learning: Performance Surfaces (https://canvas.uw.edu/calendar?event_id=1163733&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Oct 22, 2018	Machine Learning: Optimization (https://canvas.uw.edu/calendar?event_id=1163732&include_contexts=course_1232683)	3:30pm to 5:30pm
	Hebbian Learning (Individual) (https://canvas.uw.edu/courses/1232683/assignments/4338324)	due by 3:30pm
Wed Oct 24, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172211&include_contexts=course_1232683)	11am to 12pm
	Backpropagation (https://canvas.uw.edu/calendar?event_id=1163731&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Oct 29, 2018	Midterm Review (https://canvas.uw.edu/calendar?event_id=1163730&include_contexts=course_1232683)	3:30pm to 5:30pm
Wed Oct 31, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172212&include_contexts=course_1232683)	11am to 12pm
	Midterm (https://canvas.uw.edu/calendar?event_id=1163729&include_contexts=course_1232683)	3:30pm to 5:30pm
	Midterm Exam (https://canvas.uw.edu/courses/1232683/assignments/4338325)	due by 5:30pm

Mon Nov 5, 2018	Backpropagation, cont'd (https://canvas.uw.edu/calendar?event_id=1163728&include_contexts=course_1232683)	3:30pm to 5:30pm
Wed Nov 7, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172213&include_contexts=course_1232683)	11am to 12pm
	Backprop, cont'd; Generalization (https://canvas.uw.edu/calendar?event_id=1163727&include_contexts=course_1232683)	3:30pm to 5:30pm
Wed Nov 14, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172214&include_contexts=course_1232683)	11am to 12pm
	Dynamic Networks, cont'd (https://canvas.uw.edu/calendar?event_id=1163721&include_contexts=course_1232683)	3:30pm to 5:30pm
	Generalization, cont'd (https://canvas.uw.edu/calendar?event_id=1163726&include_contexts=course_1232683)	3:30pm to 5:30pm
	Backpropagation (Group) (https://canvas.uw.edu/courses/1232683/assignments/4338322)	due by 11:59pm
Mon Nov 19, 2018	Associative Learning; Competitive Learning Intro (https://canvas.uw.edu/calendar?event_id=1163725&include_contexts=course_1232683)	3:30pm to 5:30pm
Wed Nov 21, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172215&include_contexts=course_1232683)	11am to 12pm
	Competitive Learning, cont'd (https://canvas.uw.edu/calendar?event_id=1163718&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Nov 26, 2018	Radial Basis Functions (https://canvas.uw.edu/calendar?event_id=1163719&include_contexts=course_1232683)	3:30pm to 5:30pm
Wed Nov 28, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172216&include_contexts=course_1232683)	11am to 12pm
	Practical Matters (https://canvas.uw.edu/calendar?event_id=1163720&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Dec 3, 2018	Deep Neural Networks (https://canvas.uw.edu/calendar?event_id=1163724&include_contexts=course_1232683)	3:30pm to 5:30pm
Wed Dec 5, 2018	Office hours (https://canvas.uw.edu/calendar?event_id=1172217&include_contexts=course_1232683)	11am to 12pm

	Deep NN, cont'd (https://canvas.uw.edu/calendar?event_id=1163723&include_contexts=course_1232683)	3:30pm to 5:30pm
Mon Dec 10, 2018	Mini-Project: Fashion MNIST (Group) (https://canvas.uw.edu/courses/1232683/assignments/4338320)	due by 5:30pm