Yeshiva University

Course: **AIM 5007** Neural Networks and Deep Learning
Credits: 3 Credits / Graduate
Prereqs: AIM 5005 Machine Learning (and therefore AIM 5002 on Statistics and AIM 5003 on Numerical Methods) or permission of the program director.
Instructor: Mike Schulte
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269-567-0432 (cell) – no calls between 9pm and 7am please
Office Hours: Before and after live class sessions as well as online by appointment

COURSE OVERVIEW

Data scientists have been able to leverage better algorithms on faster hardware optimized with graphical processing units to deliver improved performance and accuracy in whole classes of applications that had been previously commercially unviable. The biggest beneficiaries are applications that require unstructured data, such as audio and or video processing. Deep neural networks have also provided gains for other complex applications, from recommender systems to natural language processing. This course builds on the concepts in machine learning to train multi-layered neural networks.

COURSE LEARNING PHILOSOPHY

My teaching philosophy essentially includes two different aspects. First, we should be teaching according to what science tells us is the best way to teach. In this case, three key concepts emerge: retrieval, spaced learning, and interleaving. Retrieval means that we will work to recall past content (without looking it up). You will have many opportunities, in quizzes, problem sets, and in-class discussion to practice retrieval.

Spaced learning means that we will try to spread things out. You cannot learn too much in a single session, no matter how good the material or instructor. Therefore, you will have a lot of small tasks throughout the term rather than a few big tasks. There will be roughly 50-60 small graded tasks (and some addition non-graded tasks) that you will be asked to complete. There will not be large exams (which promote poor learning as well as other undesirable behaviors) or high-stakes, grade-breaking assignments.

Finally, interleaving means we will frequently mix things up as we study. On eproblem might ask you for a mathematical calculation. The next might be a programming task. Then an ethics question. This is how science tells us we learn best. It also makes it easier to stay awake!

The second part of my teaching philosophy is that things should be practical! I have taught courses in economics, philosophy, statistics, mathematics, and even a few firefighter and EMT classes. People learn best by doing. This is an engineering program, and so you will be asked to build lots of things. I expect you to turn in working code for your projects.

With that in mind, I'm looking forward to an exciting semester together!

COURSE LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Build proficiency in the fundamentals of neural networks and in the use of industry-standard tools to build and deploy multi-layered neural networks.
2. Select and implement the appropriate neural network model, optimizer, and parameters for a variety of applications.

REQUIRED MATERIALS

Required Texts and Resources:

- There is no required textbook for the course. Any required readings will be made available through Canvas. In addition, there are several resources identified below for students who are interested in further explorations on their own.
- Students are expected to have sufficient internet and computing resources to complete the assignments and required activities for this course. Specific software and computing requirements are described below.

Additional Resources:

- Many resources will be identified throughout the course. These will be posted in Canvas.
- The most popular deep learning textbook these days is ***Deep Learning*** by Ian Goodfellow, Yoshua Bengio, and Aaron Courville. It is a pretty good and deep reference, but as a learning resource it is less useful. We will, however, occasionally read parts of it. The book is available in print (MIT Press, ISBN 978-0262035613) at usual bookstores and also online at https://www.deeplearningbook.org/.
- Practical implementation of deep learning concepts is a popular book topic these days. Two books stand out as reasonable learning resources: ***Deep Learning from Scratch*** by Seeth Weidman (O'Reilly, ISBN 978-1492041412) is an attempt to do just what the title says. Another is ***Programming Machine Learning*** by Paolo Perrotta (Pragmatic Bookshelf, ISBN 978-1680506600). Some of our assignments will draw inspiration from these books and their approaches to the subject. Both are highly recommended to those who know Python (or are willing to learn it or translate into other languages).
- When we get into using packages to do our work, there will be plenty of choices. Two interesting resources are ***Deep Learning with PyTorch*** by Eli Stevens, Luca Antiga, and Thomas Viehmann (Manning, ISBN 978-1617295263) and ***Deep Learning with R*** by Abhijit Ghatak (Springer, ISBN 978-9811358494).

ASSIGNMENTS & GRADING

There will be roughly 50-60 small graded tasks assigned during the course. The following table details the different types of assignments that will be given.

Assignment Type	Description	Submission
Problem Sets	Problem sets will contain a mix of calculation problems, programming exercises, and conceptual problems. The exact structure and content will vary from one set to the next. Specific instructions will be given in each assignment.	Jupyter notebooks, PDF Files
Problem Presentations	During live class sessions (typically in the classroom setting, though online if necessary), students will be asked to present some of the solutions they have submitted. This is a chance both to let students show off their work and to ensure students have a good understanding of what they have submitted. Each problem presentation will be followed by brief Q&A in which additional questions may be asked of the presenter.	Live

Assignment Type	Description	Submission
In-Class Quizzes	We will use occasional in-class quiz activities to assess learning and to identify areas where more attention may be needed. These will typically be relatively informal activities rather than formal quizzes like those that you may have had in other classes.	Live, Various
Online Quizzes	These will be formal quizzes and will be given in most weeks. Students will be given a timeframe to take each quiz.	Canvas Quiz
Mini-Projects	At the conclusion of each of our three main course parts, there will be a mini-project that will require programming. The size of these will be similar to problem sets, but they will be more focused on a single task or set of related tasks, and will always require that the student build some working piece(s) of code.	Jupyter Notebook
Mini-Project Presentations	Students will have a chance to present their work on mini-projects. This is a chance both to let students show off their work and to ensure students have a good understanding of what they have submitted. Due to time constraints, not every student will be able to present in class. However, students will also have a chance to record a brief online presentation to explain their work.	Live, Recorded
Ethics Tasks	Misuse of artificial intelligence is rampant and is a growing area of emphasis in artificial intelligence literature, practice, and education. Each ethics task will require students to think critically about an aspect of ethics in artificial intelligence. Students will write and submit responses for these tasks.	PDF Files
Course Feedback	As the course draws to a close, students will be asked to give specific feedback on the course structure and content. (This does not replace any evaluations Yeshiva University will ask students to complete.) The goal is for the students to look back on what they have learned and to offer constructive feedback on how the course could be improved. More details will be announced when the time comes. (Full credit will be given for completion of this task. The instructor will not see these until after final grades are published for the course.)	PDF Files
Peer Evaluations	At various points in the semester, students may be asked to perform a peer assessment of another student's work. Details will be provided at the time of the assignment.	PDF Files

GRADING SCALE

Quality of Performance	Letter Grade	Range %	GPA/ Quality Pts.
Excellent - work is of exceptional quality	A	93 - 100	4
	A-	90 - 92.9	3.7
Good - work is above average	B+	87 - 89.9	3.3
Satisfactory	B	83 - 86.9	3
Below Average	B-	80 - 82.9	2.7
Poor	C+	77 - 79.9	2.3
	C	70 - 76.9	2
Failure	F	< 70	0

Each assignment will be graded on a 10-point scale and will be counted equally toward your final grade. At the end of the semester, the average (arithmetic mean) of your scores across all assignments will determine your final grade according to the grading scale above.

We all occasionally stumble, and so an occasional assignment grade of less than 8 out of 10 is reasonable. However, if a student is regularly scoring less than 8 out of 10, a conversation with the instructor is recommended early in the course so that improvements can be sought.

Finally, many assignments will have due dates. Late work will typically not be accepted without either prior permission of the instructor (rarely given except in extraordinary circumstances) or a documented medical or family emergency. Time given to complete things will be generous.

In-class activities, however, will be less strictly enforced. If you are ill or otherwise unable to attend class, these activities can be made up with the instructor at a later time to be determined.

You should not come to class if you are sick.

If you are sick or have been recently exposed to a known Covid-19 patient, please participate online or stay home and make up missed activities. We will be very generous with this policy. Safety is our first priority for you and all of us.

It is expected that you will turn in work that is substantially your own. There are two important rules that come with this expectation. First, if you collaborate on figuring out assignments (which is encouraged!), please indicate on the assignment all those with whom you collaborated. It is good to work together on the concepts. It's even good to offer each other small help in debugging code or in figuring out a tough idea. It is not okay to copy another's work and submit it as your own. If you are unsure whether you are breaking this rule, please just ask. If you ask ahead of time, I'll tell you!

Second, the code, calculations, and responses you submit should be written by you. Do not copy from other sources. In the rare event that you are quoting a source or using a piece of code to illustrate something, use proper attribution. Again, if you are unsure, please ask ahead of time and we'll figure out the right approach.

UNIVERSITY POLICIES & RESOURCES

ACCESSIBILITY AND ACCOMODATIONS

The Office of Disability Services collaborates with students, faculty and staff to provide reasonable accommodations and services to students with disabilities. Students with disabilities who are enrolled in this course and who will be requesting documented disability-related accommodations should make an appointment with the Office of Disability Services, during the first week of class. Once you have been approved for accommodations, please submit your accommodation letter to ensure the successful implementation of those accommodations. For more information, please visit: http://yu.edu/Student-Life/Resources-and-Services/Disability-Services/

ACADEMIC INTEGRITY

The submission by a student of any examination, course assignment, or degree requirement is assumed to guarantee that the thoughts and expressions therein not expressly credited to another are literally the student's own. Evidence to the contrary will result in appropriate penalties. For more information, visit http://yu.edu/registrar/grad-catalog/

STUDENT SUPPORT SERVICES

If you need any additional help, please visit Student Support Services: http://yu.edu/academics/services/