# STATS/DATASCI 315: Statistics and Artificial Intelligence

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## Overview

**Description.** Statistical concepts are increasingly integrated into artificial intelligence applications, which often draw on a large amount of data received, transmitted, and generated by computers or networks of computers. This course introduces students to statistics and machine learning techniques such as deep neural networks, with applications to text and image data.

At the end of this course, students will be familiar with the deep learning paradigm, and will be able to analyze data using different classes of deep learning models. The course gives an introduction to the basics of deep neural networks, and their applications to various AI tasks.

**Prerequisites.** The prerequisites are: (STATS 250 or STATS 206 or STATS 280 or STATS 412 or IOE 265) and (STATS 306 or EECS 183 or ENG 101) and (MATH 116 or MATH 121 or MATH 156 or MATH 176 or MATH 186)

**Textbooks.** Class readings will mainly come from the following books.

- *Dive Into Deep Learning* by Zhang, Lipton, Li, and Smola. Link.
- *Deep Learning with Python (2nd edition)* by Chollet.
- *Deep Learning Step by Step with Python: A Very Gentle Introduction to Deep Neural Networks for Practical Data Science* by N. D. Lewis.
- *Neural Networks and Deep Learning* by Michael Nielsen. Link.
- *Deep Learning* by Goodfellow, Bengio, and Courville. Link.
- *Introduction to Deep Learning* by Charniak.

**Piazza and participation bonus.** All communications with the teaching team should be conducted on piazza; please do not email. If you wish to ask a question privately to the teaching team, please post a private note on Piazza; see instructions here; you can expect an answer within 24 hours during weekdays (except holidays). The GSIs and the instructor will be monitoring piazza, endorsing correct student answers, and answering questions that remain after a discussion.

As a bonus, **up to 3 percentage points will be added to your final course grade based on piazza participation.** You will get $x \cdot 3\%$ bonus points if the number of your total Piazza contributions lies in the top $(x \cdot 100)$-th quantile among all students. The number of Piazza contributions will be determined by Piazza class statistics.

## Requirements and Grades

The requirements are just-in-time teaching (JiTT) questions (5%), weekly quizzes (24%), weekly homework assignments (50%), and one final project (21%).

1. **Just-in-time teaching (JiTT) questions (5%)** : Before each class, you will answer short just-in-time teaching (JiTT) questions that prepare you for the class. The JiTTs test background knowledge, check that you've done the required reading, and give you a chance for feedback. They are required. To get a perfect grade on the JiTTs you do not need to get the right answers but you need to take them seriously.

   The JiTT questions are due two hours before each class. Late submissions are not accepted.

2. **Weekly quizzes (24%)** : Every week, we will hold a 10-minute quiz on Gradescope.

   Only your top eight quiz scores will be counted; this policy is expected to accommodate circumstances where students could not complete the quizzes due to the add/drop period, registration matters, and/or personal reasons.

   The quizzes are released on Monday evening and are due at 11:59 pm EST each Wednesday.

3. **Weekly homework assignments (50%)** : There will be weekly homework assignments involving problems, programming, and data analysis. We encourage you to prepare all written work using the LaTeX templates we provide.

   Only your top ten homework scores will be counted; this policy is expected to accommodate circumstances where students could not complete the homework assignments due to the add/drop period, registration matters, and/or personal reasons.

   The homework assignments are due at 11:59 pm EST each Monday.

   **Submission requirements:** Homework will be submitted electronically through Gradescope, along with any notebook used to generate results. You must run all cells in your notebook to receive credit; we will not rerun your notebook. Note that the homework assignments may involve coding up the model and algorithm and applying it to a given dataset. You can code in Julia, Python (PyTorch, Tensorflow, JAX), or R (i.e. as long as it runs in a Jupyter notebook).

   Homeworks should be written up clearly and succinctly; you may lose points if your answers are unclear or unnecessarily complicated.

   **Late days:** Homework due dates are strict, and you may turn in work late only with the use of "late days." *You have seven late days to use over the course of the semester.* For each late day you spend, you extend the deadline for homework by 24 hours. You may spend multiple late days per homework. Once you have turned in your homework you may not spend more late days to turn in your homework again.

   Once you run out of late days, you will incur a 25% penalty for each extra late day you use. Each late homework should be clearly marked as "Late" on the first page.

The purpose of this late-day policy is to enable you to deal with unexpected circumstances (e.g., illness, family emergencies, job interviews) without having to come to me. If dire circumstances arise (e.g., long-term illness that causes you to miss multiple weeks of lectures), please contact me as soon as possible.

Due to the university grading schedule, you may not use late days to extend the deadline of the last homework assignment.

**Regrade Policy:** You may submit a regrade request if you believe that the course staff made an error in grading. Any regrade requests should be submitted through Gradescope within ten days of receiving your grade. Please try to be as specific as possible with your regrade request.

4. **Final project (21%)** : The final project is an opportunity to use and develop deep learning models to analyze real-world data.

   **Proposal (1%):** The project proposal is an abstract that imagines the completed project. Start thinking about what datasets you'd like to study and what questions you'd like to answer early! These will inform your choices about modeling tools. As a forcing function, part of your grade will be based on your proposal.

   The project proposal is due at 11:59 PM EST on Oct 3.

   **Milestone (4%):** The project milestone describes the problem you are addressing and discusses some preliminary results. Include what you have completed and what you plan to finish by the end of the semester. By this point, you should have a pretty clear idea about the dataset and question, and some initial thoughts about the types of models you will explore and experiments you will run.

   The project milestone is due at 11:59 PM EST on Nov 7.

   **Report (16%):** The final report will present your theoretical work and experimental results.

   The project report is due at 11:59 PM EST on Dec 12. No late days are allowed for deadlines related to the course project.

   We grade your project proposal and report on both content and writing quality. Please prepare all written work using the LaTeX templates we provide.

5. **Final letter grade** : The final grade will be set so that the distribution of final grades approximately matches that of previous offerings of the course. That said, your final grade is guaranteed to be the same as or better than the following assignment mechanism of letter grades:

   [95, 100]: A+;

   [90, 95): A;

   [85, 90): A-;

[80, 85): B+;

[70, 80): B;

[60, 70): B-;

## Schedule

The schedule is subject to change.

*Introduction*

1. Introduction
2. Neural Nets as Universal Approximators
3. Logistic Regression as a Neural Network
4. TensorFlow, Keras, Google Colab
5. First steps with TensorFlow
6. First steps with TensorFlow
7. Vectorization and Linear Algebra Bootcamp I
8. Vectorization and Linear Algebra Bootcamp II
9. Vectorization and Linear Algebra Bootcamp III
10. Shallow Neural Networks
11. Backpropagation and Multivariable Calculus Bootcamp I
12. Backpropagation and Multivariable Calculus Bootcamp II
13. Deep Neural Networks
14. Getting started with NNs: Classification
15. Getting started with NNs: Regression
16. Generalization and Regularization for Neural Networks
17. Optimization Algorithms for Neural Networks
18. Hyperparameter Tuning and Batch Normalization
19. Evaluation Metrics and Error Analysis
20. Convolutional Neural Networks Basics
21. Deep Convolutional Neural Networks
22. Convolutional Neural Networks for Object Detection
23. Applications of Convolutional Neural Networks
24. Recurrent Neural Networks
25. Word Embeddings
26. Sequence Models and Attention Mechanisms
27. Attention and Transformers
28. Summary (and wiggle room)

## Support Resources

**Course recordings.** Course lectures may be audio/video recorded and made available to other students in this course. As part of your participation in this course, you may be recorded. If you do not wish to be recorded, please contact the instructor during the first week of class (or as soon as you enroll in the course, whichever is latest) to discuss alternative arrangements.

**Academic integrity.** The University of Michigan community functions best when its members treat one another with honesty, fairness, respect, and trust. The college promotes the assumption of personal responsibility and integrity and prohibits all forms of academic dishonesty and misconduct. All cases of academic misconduct will be referred to the LSA Office of the Assistant Dean for Undergraduate Education. Being found responsible for academic misconduct will usually result in a grade sanction, in addition to any sanction from the college. For more information, including examples of behaviors that are considered academic misconduct and potential sanctions, please see https://lsa.umich.edu/lsa/academics/academic-integrity.html for more information.

You are welcome to discuss homework with your classmates, but the work that you turn in must be yours and yours alone, and you must disclose the names of those you spoke with in your homework, including both classmates and others outside the class. This disclosure applies whether a student has helped someone else or has received help. However, it is not necessary to disclose any discussion you have with the course instructor or the course GSIs.

**Accommodations for students with disabilities.** The University of Michigan recognizes disability as an integral part of diversity and is committed to creating an inclusive and equitable educational environment for students with disabilities. Students who are experiencing a disability-related barrier should contact Services for Students with Disabilities https://ssd.umich.edu/; 734-763-3000 or ssdoffice@umich.edu). For students who are connected with SSD, accommodation requests can be made in Accommodate. If you have any questions or concerns please contact your SSD Coordinator or visit SSD's Current Student webpage. SSD considers aspects of the course design, course learning objects and the individual academic and course barriers experienced by the student. Further conversation with SSD, instructors, and the student may be warranted to ensure an accessible course experience.

**Mental Health and Well-Being.** University Students may experience stressors that can impact both their academic experience and their personal well-being. These may include academic pressures and challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc. If you are experiencing concerns, seeking help is a courageous thing to do for yourself and those who care about you. If the source of your stressors is academic, please contact me so that we can find solutions together. For personal concerns, U-M offers a variety of resources, many of which are listed on the Resources for Student Well-being webpage. You can also search for additional well-being resources here.

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