# MIT Introduction to Deep Learning (6.S191)

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# Course Information

## Summary

MIT's introductory course on deep learning methods with applications to computer vision, natural language processing, biology, and more! Students will gain foundational knowledge of deep learning algorithms and get practical experience in building neural networks in TensorFlow. Course concludes with a project proposal competition with feedback from staff and a panel of industry sponsors.

## Prerequisites

We expect basic knowledge of calculus (e.g., taking derivatives), linear algebra (e.g., matrix multiplication), and probability (e.g., Bayes theorem) -- we'll try to explain everything else along the way! Experience in Python is helpful but not necessary. Listeners are welcome!

# Schedule

**Monday Jan 18, 2021**

- Lecture: Introduction to Deep Learning and NNs
- Lab: Lab 1A Tensorflow and building NNs from scratch

**Tuesday Jan 19, 2021**

- Lecture: Deep Sequence Modelling
- Lab: Lab 1B Music Generation using RNNs

**Wednesday Jan 20, 2021**

- Lecture: Deep Computer Vision
- Lab: Lab 2A Image classification and detection

**Thursday Jan 21, 2021**

- Lecture: Deep Generative Modelling
- Lab: Lab 2B Debiasing facial recognition systems

**Friday Jan 22, 2021**

- Lecture: Deep Reinforcement Learning
- Lab: Lab 3 pixel-to-control planning

**Monday Jan 25, 2021**

- Lecture: Limitations and New Frontiers
- Lab: Lab 3 continued

**Tuesday Jan 26, 2021**

- Lecture (part 1): Evidential Deep Learning
- Lecture (part 2): Bias and Fairness
- Lab: Work on final assignments
- *Lab competition entries due at 11:59pm ET on Canvas! Lab 1, Lab 2, and Lab 3*

**Wednesday Jan 27, 2021**

- Lecture (part 1): Nigel Duffy, Ernst & Young
- Lecture (part 2): Kate Saenko, Boston University and MIT-IBM Watson AI Lab
- Lab: Work on final assignments
- Assignments due: Sign up for Final Project Competition

**Thursday Jan 28, 2021**

- Lecture (part 1): Sanja Fidler, U. Toronto, Vector Institute, and NVIDIA
- Lecture (part 2): Katherine Chou, Google
- Lab: Work on final assignments
- Assignments due: 1 page paper review (if applicable)

**Friday Jan 29, 2021**

- Lecture: Student project pitch competition
- Lab: Awards ceremony and prize giveaway
- Assignments due: Project proposals (if applicable)

# Lectures

Lectures will be held starting at 1:00pm ET from Jan 18 - Jan 29 2021, Monday through Friday, virtually through Zoom. **Current** MIT students, faculty, postdocs, researchers, staff, etc. will be able to access the lectures during this two week period, synchronously or asynchronously, via the MIT Canvas course webpage **(MIT internal only)**. Lecture recordings will be uploaded to the Canvas as soon as possible; students are not required to attend any lectures synchronously. Please see the Canvas for details on Zoom links.

The public edition of the course will only be made available after completion of the MIT course.

# Labs, Final Projects, Grading, and Prizes

Course will be graded during MIT IAP for 6 units under P/D/F grading. Receiving a passing grade requires completion of each software lab project (through honor code, with submission required to enter lab competitions), a final project proposal/presentation or written review of a deep learning paper (submission required), and attendance/lecture viewing (through honor code). *Submission* of a written report or *presentation* of a project proposal will ensure a passing grade.

MIT students will be eligible for prizes and awards as part of the class competitions. There will be two parts to the competitions: (1) software labs and (2) final projects. More information is provided below. **Winners will be announced on the last day of class, with thousands of dollars of prizes being given away!**

## Software labs

There are three TensorFlow software lab exercises for the course, designed as iPython notebooks hosted in Google Colab. Software labs can be found on GitHub: https://github.com/aamini/introtodeeplearning. These are self-paced exercises and are designed to help you gain practical experience implementing neural networks in TensorFlow.

**For registered MIT students, submission of lab materials is not necessary to get credit for the course or to pass the course.**

At the end of each software lab there will be task-associated materials to submit (along with instructions) for **entry into the competitions, open to MIT students and affiliates during the IAP offering**. This includes MIT students/affiliates who are taking the class as listeners -- you are eligible!

These instructions are provided at the end of each of the labs. Completing these tasks and submitting your materials to **Canvas** will enter you into a per-lab competition. **MIT students and affiliates will be eligible for prizes during the IAP offering**; at the end of the course, prize-winners will be awarded with their prizes.

**All competition submissions are due on January 26 at 11:59pm ET to Canvas.**

For the software lab competitions, submissions will be judged on the basis of the following criteria:

1. Strength and quality of final results (lab dependent)
2. Soundness of implementation and approach
3. Thoroughness and quality of provided descriptions and figures

## Gather.Town lab + Office Hour sessions

After each day's lecture, there will be open Office Hours in the class GatherTown, up until 3pm ET. **An MIT email is required to log in and join the GatherTown.** During these sessions, there will not be a walk through or dictation of the labs; the labs are designed to be self-paced and to be worked on on your own time.

The GatherTown sessions will be hosted by course staff and are held so you can:

- Ask questions on course lectures, labs, logistics, project, or anything else;
- Work on the labs in the presence of classmates/TAs/instructors;
- Meet classmates to find groups for the final project;
- Group work time for the final project;
- Bring the class community together.

## Final project

To satisfy the final project requirement for this course, students will have two options: (1) write a 1 page paper review (single-spaced) on a recent deep learning paper of your choice or (2) participate and present in the project proposal pitch competition. The 1 page paper review option is straightforward, we propose some papers within this document to help you get started, and you can satisfy a passing grade with this option -- you will not be eligible for the grand prizes. On the other hand, participation in the project proposal pitch competition will equivalently satisfy your course requirements but additionally make you eligible for the grand prizes. See the section below for more details and requirements for each of these options.

## Paper Review

Students may satisfy the final project requirement by reading and reviewing a recent deep learning paper of their choosing. In the written review, students should provide both: 1) a description of the problem, technical approach, and results of the paper; 2) critical analysis and

exposition of the limitations of the work and opportunities for future work. Reviews should be submitted **on Canvas** by **Thursday Jan 28, 2021, 11:59:59pm Eastern Time (ET).**

Just a few paper options to consider...

- https://papers.nips.cc/paper/2017/file/3f5ee243547dee91fbd053c1c4a845aa-Paper.pdf
- https://papers.nips.cc/paper/2018/file/69386f6bb1dfed68692a24c8686939b9-Paper.pdf
- https://papers.nips.cc/paper/2020/file/1457c0d6bfcb4967418bfb8ac142f64a-Paper.pdf
- https://science.sciencemag.org/content/362/6419/1140
- https://papers.nips.cc/paper/2018/file/0e64a7b00c83e3d22ce6b3acf2c582b6-Paper.pdf
- https://arxiv.org/pdf/1906.11829.pdf
- https://www.nature.com/articles/s42256-020-00237-3
- https://pubmed.ncbi.nlm.nih.gov/32084340/

# Project Proposal Presentation

## Keyword: proposal

This is a 2 week course so we do not require results or working implementations! However, to win the top prizes, nice, clear results and implementations will demonstrate feasibility of your proposal which is something we look for!

## Logistics -- please read!

- **You must sign up to present before 11:59:59pm Eastern Time (ET) on Wednesday Jan 27, 2021**
- **Slides must be in a Google Slide before 11:59:59pm Eastern Time (ET) on Thursday Jan 28, 2021**
- **Project groups can be between 1 and 5 people**
- **Listeners welcome**
- **To be eligible for a prize you must have at least 1 registered MIT student in your group**
- **Each participant will only be allowed to be in one group and present one project pitch**
- **Synchronous attendance on 1/29/21 is required to make the project pitch!**
- 3 min presentation on your idea (we will be very strict with the time limits)
- Prizes! (see below)

**Sign up to Present here: by 11:59pm ET on Wednesday Jan 27**

**Once you sign up, make your slide in the following Google Slides; submit by midnight on Thursday Jan 28. Please specify the project group # on your slides!!!**

**Things to Consider**

1) This **doesn't** have to be a new deep learning method. It can just be an interesting application that you apply some existing deep learning method to.
2) What problem are you solving? Are there use cases/applications?
3) Why do you think deep learning methods might be suited to this task?
4) How have people done it before? Is it a new task? If so, what are similar tasks that people have worked on? In what aspects have they succeeded or failed?
5) What is your method of solving this problem? What type of model + architecture would you use? Why?
6) What is the data for this task? Do you need to make a dataset or is there one publicly available? What are the characteristics of the data? Is it sparse, messy, imbalanced? How would you deal with that?

## Project Proposal Grading Rubric

Project proposals will be evaluated by a panel of judges on the basis of the following three criteria: 1) novelty and impact; 2) technical soundness, feasibility, and organization, including quality of any presented results; 3) clarity and presentation. Each judge will award a score from 1 (lowest) to 5 (highest) for each of the criteria; the average score from each judge across these criteria will then be averaged with that of the other judges to provide the final score. The proposals with the highest final scores will be selected for prizes.

**Here are the guidelines for the criteria:**

1. **Novelty and impact**: encompasses the potential impact of the project idea, its novelty with respect to existing approaches. Why does the proposed work matter? What problem(s) does it solve? Why are these problems important?
2. **Technical soundness, feasibility, and organization**: encompasses all technical aspects of the proposal. Do the proposed methodology and architecture make sense? Is the architecture the best suited for the proposed problem? Is deep learning the best approach for the problem? How realistic is it to implement the idea? Was there any implementation of the method? If results and data are presented, we will evaluate the strength of the results/data.
3. **Clarity and presentation:** encompasses the delivery and quality of the presentation itself. Is the talk well organized? Are the slides aesthetically compelling? Is there a clear, well-delivered narrative? Are the problem and proposed method clearly presented?

## Past Project Proposal Ideas

Recipe Generation with RNNs
Can we compress videos with CNN + RNN?
Music Generation with RNNs
Style Transfer Applied to X
GAN's on a new modality
Summarizing text/news articles

Combining news articles about similar events
Code or spec generation
Multimodal speech → handwriting
Generate handwriting based on keywords (i.e. cursive, slanted, neat)
Predicting stock market trends
Show language learners articles or videos at their level
Transfer of writing style
Chemical Synthesis with Recurrent Neural networks
Transfer learning to learn something in a domain for which it's hard or risky to gather data or do training
RNNs to model some type of time series data
Computer vision to coach sports players
Computer vision system for safety brakes or warnings
Use IBM Watson API to get the sentiment of your Facebook newsfeed
Deep learning webcam to give wifi-access to friends or improve video chat in some way
Domain-specific chatbot to help you perform a specific task
Detect whether a signature is fraudulent

## Awards + Categories

**Final Project Awards:**

- 1x NVIDIA RTX 3080
- 4x Google Home Max
- 3x Display Monitors

**Software Lab Awards:**

- Bose headphones (Lab 1)
- Display monitor (Lab 2)
- Bebop drone (Lab 3)

# Important Links and Emails

**Course website**: http://introtodeeplearning.com
**Course staff**: introtodeeplearning-staff@mit.edu
**Mailing list**: http://eepurl.com/gQJo2D
**Piazza forum (MIT only)**: https://piazza.com/mit/spring2021/6s191
**Canvas (MIT only):** https://canvas.mit.edu/courses/8291
**Software lab repository**: https://github.com/aamini/introtodeeplearning
**Lab/office hour sessions (MIT only):**
https://gather.town/app/56toTnlBrsKCyFgj/MITDeepLearning