Course Project

1 Logistics

For the course project, you will implement a research idea related to the course material. The purpose of the final project is to give you some experience working on a piece of original research and writing up your results in a paper style format. You are expected to describe your research idea/application clearly in the project proposal, relate to existing work. You will document the project progress in the final report.

You **should aim to form a group of two or three** to complete the project. Your report must clearly **list the contributions of each team member**. Solo projects are permitted but discouraged, as the amount of time we will be able to help out with projects will be reduced if there are too many separate ones. It is possible to form teams of four, but remember that expectations for larger projects will be greater.

There are two important dates: the initial project proposal is **due 2:00 pm November 12th**, and the final report is **due 2:00 pm December 14th**.

2 Writing format

All submissions must be in PDF format. You may include algorithm blocks, tables, and figures. The write-ups should be prepared in the NeurIPS paper format:
`http://www.cs.columbia.edu/~zemel/Class/nndl-2025/Projects/neurips2023.sty`

You may find online editors such as Overleaf helpful for writing the reports:
`https://www.overleaf.com/project/67d1de3db0228ff46351c625`

Proposal: The project proposal is limited to max two pages. It should roughly have the following sections:

- 1/4 page introduction
- 1/2 page related work
- 1/2 page method / algorithm to be investigated
- 1/4 page references

The point of the proposal is mainly for us to give you feedback and formulate a plan for the final report. The proposal will not be graded. We will set up project consultation appointments after we have collected all the project proposals. You will submit your proposal report through Gradescope.

Final report: You will expand out your project proposal to include experiments and comprehensive method sections. You are expected to discuss the experimental results in details and highlight any interesting findings. We recommend the final report to be 4-6 pages plus the references.

You will submit your final report through Gradescope. You must also submit the code necessary to reproduce your experiments.

3 How to choose a project

The course project should build on top of the course materials. You are encouraged to use neural networks as the function approximators for your method or application. There are three categories of projects to choose from.

(1). **Understanding and analysis**: For the students who would like to have a more in-depth understanding of the course material, it is often a good idea to re-implement an existing method and re-evaluate the implementation against some standard benchmarks.

- Reproduce the experimental results from some existing papers. Perform sensitivity analysis on hyperparameters.
- Apply / extend existing algorithms to a new application / task / dataset.

If you choose to work on a project in this category, you will need to implement and analyze the performance of **at least two** different deep learning algorithms / methods in a task domain, e.g., image recognition or natural language processing. You are asked to discuss the strength and weakness of each of the approaches backed by your experimental findings.

Doing a proper analysis for the existing methods is non-trivial. Here are two great examples of this type of study: Visualizing and Understanding Convolutional Networks https://arxiv.org/pdf/1311.2901.pdf, and https://arxiv.org/pdf/1506.02078.pdf

(2). **Exploratory research**: You may also choose to work on a novel research idea that may lead to a potential publication. The examples of such projects are:

- Improve / fix an existing algorithm. Evaluate the improvement on benchmark environments.
- Develop novel model architectures / algorithms to a new application / area / environment.

If you decide to work on a research idea, you will need to implement and compare the performance of your method against **at least one** existing approach in your problem.

Here is some advice on picking a good research problem from Bill Freeman:
http://6.869.csail.mit.edu/sp21/lectures/L22/freeman.pdf and from David Patterson's slides part III and IV: https://people.eecs.berkeley.edu/ pattrsn/talks/BadCareer.pdf.

You are welcome to do a project related to your research, or to another project you are working on. In this case, your project proposal and final report must **each** clearly explain the relationship to your research or other project, what work was already done prior to the course, and what work (if any) was done by people not on the project team. Our expectations will be higher in this case.

(3). **Pre-defined project, on transfer learning.**

We have prepared a dataset with images from 3 classes of entities, including bird, dog, and reptile. Each of these classes also includes sub-classes (e.g., hawk in bird, golden retriever in dog, etc.). The objective is to predict the correct super-class label and sub-class label for each image. An important difficulty is that the distribution of classes may differ between training and test, and new sub-classes may be introduced.

There will be a leaderboard for this task. Projects will be judged not based on their performance but instead according to which approaches you explored, and description and analyses of the results of the various methods you tried. You are not required to come up with your own method for this type of project, but are welcome to if you'd like.

4 Grading scheme

You may receive full marks for the course project by choosing any of the three categories. There will be no advantage for choosing an exploratory project over an analysis one or the pre-defined one, regarding achieving a higher grade. The goal of the project is for you and your group to conduct original research. The proposal and the final report will be graded according to the criteria of top machine learning conference submissions. We will use the NeurIPS review criteria for this purpose:

- **Quality [40%]** Is the report technically sound? Are claims well-supported by theoretical analysis or experimental results? Is this a complete piece of work, or merely a position report? Are the authors careful (and honest) about evaluating both the strengths and weaknesses of the work? To get full marks in this category, you will need to include at least one of:
  - An algorithm box.
  - Equations describing your model.
  - A theorem or formally stated conjecture.
- **Clarity [30%]** Is the report clearly written? Is it well-organized? (If not, feel free to make suggestions to improve the manuscript.) Does it adequately inform the reader? Are the figures/tables properly labeled? (A superbly written report provides enough information for the expert reader to reproduce its results.)
- **Originality [25%]** Are the problems or approaches new? Is this a novel combination of familiar techniques? Is it clear how this work differs from previous contributions? Is related work adequately referenced? We recommend that you check the proceedings of recent NeurIPS conferences to make sure that each report is significantly different from papers in previous proceedings. Abstracts and links to many of the previous NeurIPS papers are available from http://books.nips.cc.
- **Significance [5%]** Are the results important? Are other people (practitioners or researchers) likely to use these ideas or build on them? Does the report address a difficult problem in a better way than previous research? Does it advance the state of the art in a demonstrable way? Does it provide unique data, unique conclusions on existing data, or a unique theoretical or pragmatic approach?