

Research in Deep Learning: Final Project

The final project for this course is open-ended and flexible. It is your opportunity to explore some topic(s) of this course more deeply. I provide some ideas below – you can pick some combination to form a cohesive project. At a minimum, your project must include a paper you write (see below), coding, and experiments.

Some possibilities:

- Work with some new datasets.
 - If you plan on working with image datasets, I recommend picking datasets with small image sizes, or your experiments may take far too long to run practically in the time we have. In general, datasets that are not too large would be best for our context.
- Some types of datasets may require different techniques for best results. There are tutorials for these online.
 - “Structured data” refers to tables like what we’ve discussed with housing prices.
 - “Natural language processing” deals with text datasets.
 - Dealing with sequential data (audio or text) typically requires recurrent neural networks, so this is something else you could look into.
- Study more about TensorFlow and apply what you learn in a tangible way.
 - Make sure you document what resources you’re using to learn, and what code is yours versus what is just coming from a tutorial you followed. You must include code that is your own (e.g. applied to a new problem, a combination of various concepts you’ve learned...) as opposed to just doing precisely what the tutorial says and nothing more.
 - I’ve included some additional notes I took on TensorFlow in case you’d like to peruse them. They’re based on tutorials primarily on tensorflow.org. At one point I had thought about using them more explicitly in this course, but ended up going in a different direction. Nevertheless, you may find them useful depending on what you want to do.
 - You could also consider an introductory exploration of reinforcement learning or unsupervised learning in TensorFlow, instead of continuing our focus in supervised learning.
- Explore the use of cloud resources.
 - Amazon Web Services, Google Collab, and Microsoft Azure are options, to enable exploration of larger model architectures and datasets. I’ve done very little with this myself, so I don’t have resources to provide you, but I believe at least some cloud resource providers offer free limited resources for educational use.
- Explore a paper we’ve read more deeply.
 - Read the entire paper. Take special note of the work the authors did, the claims they make, and the next steps they suggest. Can you replicate some of the work they did? Can you verify with your own experiments some of the results they find? Can you try one of the next steps they suggest?
- Explore a new paper.
 - I’d recommend taking some concept and finding the first paper that discusses it. Often this can be done by searching on scholar.google.com. Pick a paper that talks about what you’re interested in and skim it. Look for a place where they say something like “this paper extends the work of *some paper*”, and go look up that paper. Repeat as needed to get to the “original” paper on some topic of interest.

If you have something else in mind, let’s talk about it!

The Paper

Your project must include a LaTeX paper. In life, if you don't communicate it, it's as if it didn't happen. So make sure your paper documents your work. Don't think of it as a "diary" of each step you took, but rather a report of the important accomplishments you've achieved, decisions you made and why, tools and algorithms you used, experiments you ran, results you got, etc. **Write it clearly in detail so that I understand the scope of your excellent work. This is very important for your grade.** Don't assume I'll just recognize the value of your work by looking at your code. Write about what makes it great. This approach isn't just for me; it will be very beneficial for any future readers (employers, admission and scholarship committees) of your paper as well. Write it up so that this is something you could post proudly on your LinkedIn account, include in an application, etc. Think of the target audience as computer science people that know the same content we discussed in class, but would need an explanation for anything further. Your paper should include:

- Abstract – a paragraph or two providing a preview of what the paper is about. This is to get the reader's attention and get them interested. If the reader only reads one section of your paper, this will be it! Impress them with this preview of what you've done.
- Introduction – describe the context of your work. This could include things like what dataset(s) you used, the algorithms you applied, the tools you used... But just an overview here. Details will come later. In the last paragraph, give a quick outline of the paper.
- *Details* (title these sections as you see fit) - provide a more detailed discussion of the algorithms you applied, the tools you worked with (including more specifics about TensorFlow), decisions you made and why.
- One or more cycles of the following three sections (whatever you think best explains your work):
 - Experiments – describe the experiments you ran. Give details so that others could plausibly run the same experiments.
 - Results – describe the results you obtained
 - Analysis – discuss what the results mean. Why do you think system A did better than system B? Why is the graph shaped that way? What do the results tell you? What general conclusions might you draw based on the results?
- Future work – whether you intend to do this work or not, describe what the next steps would be if someone were to continue the work you've done.
- Conclusion – a summary of what you did and what you found. If the reader only reads two sections, this will be the second one! (The abstract will be the first.)
- Bibliography – use BibTeX, and include citations in the sections above as appropriate. Cite websites you used as well as formal academic papers. Taking the time to situate your work in the context of published academic papers (not just websites) will increase the credibility of your work. This takes time!

Include a few related formulas (using the MathJax syntax surrounded by $...$), and make sure you include some graphs and tables of results, and perhaps an image helping to explain your algorithm. (If you use an image I made, please cite me.) This is useful to help your explanation. And honestly, when people are skimming your paper to decide if they're impressed or not, these things draw the eye and can make a subconscious difference.

General Notes

The single most significant part of your final grade in this course will come from what you turn in for your final project, and the most important submission item in your final project is the paper. Once we're done with the regular homework assignments, please expect to work on the project about 8 hours every weekday through the end of the course. (Just like summer research and full-time jobs!) I will look for evidence of this level of deep engagement of each group.

Plan a project that can work in stages. Start with something fairly small and gradually build on it. You want to have tangible results to show in your project – both for your grade in this course, but more importantly, for job and/or grad school applications. So don't just propose something big and then say "yeah, we didn't have time to get this done".

If your work involves experiments that take a long time, you'll need to plan how to nevertheless use all your time effectively. Waiting for experiments to run will not be justification for a less substantial final project. Find a way to make progress in your work in other ways while you wait! Also make sure the experiments are planned well and carefully debugged first so you don't have any wasted effort.

Initial and Ongoing Dialogue

Think about what you'd like to do. Soon, I will talk with each group about your plans. If you think you'd like to change your plans significantly after that discussion, let's talk again. For this project, please plan on spending about 8 hours per day each weekday. Your final grade on this project will be based on how deeply you pursue the tasks you've chosen. And of course, keep in close communication with me! I'm ready to help!