

# Project II Guidelines (CS 553 - Neural Networks)

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## 1 Guidelines

- Projects should be done in groups of a maximum size of 3-5 people. Solo project is NOT allowed and group submission is highly recommended. Each group should be registered on canvas.
- Your project should investigate some aspect of neural network not covered in the lectures or on the homework. Please see our syllabus and just ask using canvas, or during office hours if you are unsure whether a topic will be covered in class.
- For your project you should identify a deep neural network setup/architecture, understand and implement at least one method and apply it to one or more datasets so as to clearly demonstrate its efficacy or lack thereof. Students can also select a paper in which a method is introduced or developed by the authors and apply it to one or more datasets.
- If the paper was published before 2015, it should be a seminal paper.
- Your project report should explain the method(s) at a reasonable level of detail, and place the method(s) in context with an appropriate literature review. You should also discuss strengths and weaknesses of the method(s) you study. You should compare against baseline methods, including those covered in class, if feasible.
- If you choose to develop extensions to the method you study, that's great, but not at all required.
- The experiments should use at least one real (as opposed to simulated) data set. There is a large repository of machine learning data sets called the "UCI Machine Learning Repository". Or you can use Hugging Face repository.
- There are other more domain-specific sources as well that you might find by searching, such as physionet (<https://physionet.org/>).
- Some other resources for datasets:  
<https://github.com/caesar0301/awesome-public-datasets>  
[https://en.wikipedia.org/wiki/List\\_of\\_datasets\\_for\\_machine\\_learning\\_research](https://en.wikipedia.org/wiki/List_of_datasets_for_machine_learning_research)  
<https://www.kaggle.com/datasets>
- When you submit your final report, every group member will be asked to individually (and anonymously) assess the contribution of all group members. This can be done remotely or via email.
- If it does not take that much effort to implement and apply the method(s) you have chosen, then you will need to find a way to add more work. For example, you could study two methods, or implement a competing algorithm for comparison, or develop some extension.
- If you need more computing power, consider using free tier colab, Google Cloud or Amazon AWS clusters (if possible).
- You can use popular deep learning frameworks tensorflow, pytorch, caffe, theano etc. However your project should involve substantial work on top of the NNs capabilities readily available in these frameworks.

## 2 Deliverables and grading

- Project proposal (10% of your Project II grade): An assignment will be created on Canvas.
- Final report (90% of your Project II grade): Report length: 6 pages + references. This is described in detail in another section.
- Project Presentations (5% of your total course grade). Last three-four lectures are dedicated to group project presentations. The details will be announced once the groups are created (after proposal submission)!

## 3 Project ideas

To get ideas for a project, you might look at recent publications such as Journal of Machine Learning Research, and conferences like ICML, NIPS, ICLR, AAAI, CVPR, and AISTATS.

Here are some topics in deep learning that may be of interest, in addition to those covered so far in lecture:

- Semi-supervised learning (how to use unlabeled data to help design a deep neural network classifier)
- Novelty/anomaly detection (classification when one class has no training data)
- Multi-label learning (when patterns have multiple valid labels)
- Multi-modal learning (learning with two disparate sources of information, e.g. audio and video, or speech and text)
- Nonparametric Bayesian neural network methods (e.g. latent Dirichlet allocation for topic modeling)
- How to handle missing data in deep neural networks (when some features are not observed)
- Robust methods (for neural networks)
- Advanced methods for nonlinear dimensionality reduction via neural networks
- Random projections and randomized algorithms for learning
- Multi-task learning (learning several related classification tasks at the same time)
- Continual Learning and sequential knowledge transfer
- Transfer learning (when training and testing distributions differ)
- Online learning (data arrive sequentially in real-time)
- Sparsity and high dimensional inference for deep neural network (overcoming the curse of dimensionality)
- Privacy-preserving deep learning
- Online/parallel/distributed implementation of established deep learning algorithms
- Adversarial learning with deep neural networks
- Visual transformers
- Language Models
- Foundation Models and Generative AI

## 4 Final Project Report Guidelines

The report shall be **6 pages** in length, plus an additional page of references only.

In addition to the project report, every group should submit a single zip file containing all source files of computer programs written by group members. These should be commented so as to indicate authorship. While these files will not be graded, and I won't try to run your code, I ask you to submit this work in case some question arises during grading that the code would help to clarify. A separate Canvas assignment will be created for the code archive submission.

Your report should be written to your classmates and instructors. Therefore you need not provide lengthy explanations of background material on methods we covered in class.

Every report should address the following (but don't feel obligated to make these the section headings or to cover the topics in this order)

- **Problem statement**, both conceptual and mathematical. Motivation: What is the problem that existing methods are unable to adequately address?
- **Related work**.
- **Methodologies** explored, and the rationale behind them. Include supporting implementation details or theory as you deem fit and as space allows. You should try to teach the reader as if you want them to be able to understand and implement the method for themselves.
- **Evaluation**: You should conduct experiments on real (and possibly synthetic) data. Discuss performance measures used, results, parameter tuning, design choices, etc. We hope to see quantitative, objective evaluations, and comparisons with natural competitors. Ideally, someone should be able to reproduce your work based on what you describe.
- **Conclusions**: What did you learn? What were the methods' strengths and weaknesses? What were the project's success and failures?
- **Description of individual effort**: At the end of the report, in a paragraph (included in the 6 page limit), please include a brief description of each project member's contribution to the project. If some aspect of the work took much more time, or less time, than expected, please indicate this to help with evaluation of effort.
- **References**: Is the report supported by appropriate references?

**Please keep the following points in mind:**

- Define all terms and variables. Keep in mind that even if a term is a very simple concept in a certain field or application domain, do not assume others are familiar with it.
- Your report should detail at least one successful application, on real data, of the method(s) you are investigating.
- However, it is not necessary to show that your chosen method is superior to others. Your conclusion may indeed be that a method has some weaknesses that were not highlighted in the original publication.
- Every group member should contribute equally, and every group member should contribute in a way that involves learning about new deep learning techniques. If you think another member of your group has not put forth a reasonable effort, you may let us know by email and we will take that into consideration.

- Even if different group members work more or less independently on different parts of the project, the final report should read as a unified whole. How do the different parts relate to and inform the others? All group members should participate in writing the final report.
- We encourage the use of figures to make concepts visual and concrete. Figure captions should be pretty much self contained.

Please see below for the criteria by which the final project report will be evaluated (Total point 55).

	Ratings		Pts
Motivation: Did the authors clearly motivate the importance of this research?	Full Marks 10.0 pts	No Marks 0.0 pts	10.0 pts
Previous work: Did the authors identify, cite, and describe previous related work sufficiently? Did the authors put current work in context of previous work?	Full Marks 10.0 pts	No Marks 0.0 pts	10.0 pts
Problem statement: Is the problem clearly stated and easy to understand, in clear conceptual or mathematical language?	Full Marks 10.0 pts	No Marks 0.0 pts	10.0 pts
Approach: Is the technical approach clearly explained? Is the math/algorithm (or both) clearly explained?	Full Marks 10.0 pts	No Marks 0.0 pts	10.0 pts
Significance: Does the evaluations reasonably measure the usefulness (e.g. evaluating on real problems might be more motivating than on small toy problems, identifying strengths and weaknesses, spaces of problems where their approach will excel and spaces of problem where their approach may not excel. Does the evaluation sufficiently prove the authors claims?	Full Marks 10.0 pts	No Marks 0.0 pts	10.0 pts
Presentation: Is the report written in fluent/easy-to-understand language? Should the report be organized differently? Could any of the data be presented better (figures, graphs, tables, etc.)?	Full Marks 5.0 pts	No Marks 0.0 pts	5.0 pts

## 5 Project Proposal

The project proposal should include a tentative project title, a list of group members, and a description of the project (1 page limit not including references). In your project description, describe the problem statement, motivation, the paper(s) you will be focusing on, methods to be compared or developed, data sets to be examined, relevant references, and group member roles. The proposal is not set in stone, so you can change your goals after you start working on the project. This proposal will be graded and will count as 10% of your project grade. Please submit the proposal as a pdf file.

Please see below for the criteria by which the project proposal will be evaluated (Total point 30).

	Ratings		Pts
The proposal clearly identifies a problem statement and motivates the importance of the problem.	Full Marks 5.0 pts	No Marks 0.0 pts	5.0 pts
The proposal identifies a machine learning research paper addressing the chosen problem, and provides relevant references.	Full Marks 5.0 pts	No Marks 0.0 pts	5.0 pts
The proposal includes a title, the names of the team members, and does not exceed the 1 page limit (not including references).	Full Marks 5.0 pts	No Marks 0.0 pts	5.0 pts
The proposal explains what machine learning method(s) will be examined.	Full Marks 5.0 pts	No Marks 0.0 pts	5.0 pts
The proposal explains what data set or sets (including resources) will be used to evaluate the method(s).	Full Marks 5.0 pts	No Marks 0.0 pts	5.0 pts
The group member assignments seem reasonable, and the amount of work involved is appropriate.	Full Marks 5.0 pts	No Marks 0.0 pts	5.0 pts