DS 8010 Interactive Learning in Decision Processes
Course Project Guidelines
Due April 27 (Wednesday), 2022 **11:59PM**

Project topics must be approved by me. I may be able to provide some suggestions on project topics, or you can choose a topic that is interesting to you. Students must submit a one-page project proposal by March 4, 11.59pm (EST). In this one-page proposal, you should summarize the project scope with proper citations/references to the relevant studies (e.g., in a similar way to the ones that you see in this document). For instance, if you are planning to replicate/extend a previously published paper, you can first summarize the main ideas in the paper, and then provide details on your overall ideas about how to do a project based on this paper. All students should submit a final project report (as a pdf file) by April 27, 11.59pm (EST). You are also required to submit an intermediate report by April 1, 11.59pm (EST). Intermediate report comprises Section 1-2-3 that you can find in "Report Format" section below. Your final report should be built on top of your intermediate report, e.g., by adding sections 4-5-6 on top of it.

Here are some potential paths you can pursue for the project:

- Incorporate reinforcement learning into your current line of research, or any other research area of your interest.
- Pick a (relatively recent) paper published in a "good journal", which includes some computational work. You may implement existing ideas in the paper, propose extensions, and provide computational tests and observations.
- Read papers in a particular area of application, experiment with different reinforcement learning models and algorithms.
- Conduct a comprehensive literature review on a selected topic. More specifically, read papers and become an "expert" in an area that we are unlikely to cover in detail in this class. In this case, you should provide a comprehensive overview of the subject, putting past and modern work into a context.

Many nice, recent papers on reinforcement learning can be found at arXiv.
Some research papers explored by previous students are provided below.

- S. Shah et al., Neural approximate dynamic programming for on-demand ride-pooling (2019) [link].
- J. Liu et al., Dynamic pricing on e-commerce platform with deep reinforcement learning (2019) [link].
- S. Luo, Dynamic scheduling for flexible job shop with new job insertions by deep reinforcement learning (2020) [link].

Final Deliverables

Project has two final deliverables (not following the submission guidelines will result in point deductions):

- PDF report prepared via LaTeX or Word/Google doc, named DS8010_project_report_lastName1_lastName2.pdf — lastName1 is for the first group member, lastName2 is for the second group member (if applicable).
  - You are required to convert your report to pdf if it is prepared in Word.
- Zip file of all your codes and documentation, named DS8010_project_codes_lastName1_lastName2.zip.
  - All the codes should be in python files (jupyter notebooks are not accepted).

  - As a part of documenting the implementation, you are required to include a file in your zip folder named README.md. This file should include information on the implementations, including how to run the codes (e.g., what is the main file, which arguments to pass etc), specific libraries that are needed to be implement as well as library requirements (e.g., tensorflow, keras versions etc). You can find information on how to prepare markdown files online, e.g., see
    * https://medium.com/@saumya.ranjan/how-to-write-a-readme-md-file-markdown-file-20cb7cbcd6f
    * https://github.com/awslabs/gluon-ts – a sample well prepared markdown included in a github repo!

- The clear and detailed commenting on the implementation/codes likely means higher grade!
- All the submissions (proposal, intermediate report, final report and the zip file) should be done via D2L. Project submission folders are under Assignments in the Assessment tab.

Report Format

Your written report should contain everything about the study (e.g., paper(s) selected for replication), your implementation and the experimentation process. There is no page minimum or maximum; just write enough to thoroughly describe your process, and *no more*. Remember the report is also graded on clarity and conciseness. At the very least, your report should contain the following information (the section outline is provided as an example, but highly recommended to be followed):

Section 1. **Introduction**: Explain the research problem in a detailed manner. Aim to answer questions such as

  - What is the motivation and background for the research problem?
  - Why are Markov Decision Processes (MDPs) and reinforcement learning (RL) a suitable modeling/solution techniques for the particular problem(s)?

Section 2. **Literature review**: A summary of the relevant studies.

Section 3. **Methods**: A detailed description of the underlying MDP/RL model and the solution methods (e.g., DQN, DDQN). If you proposed any modifications to the original study, what are those (be as specific as possible). Also, disclose data sources: if it is publicly available, provide references, if not, how did you generate synthetic data.

Section 4. **Experimental setup**: A detailed information on the experiments, hyperparameters used and if you performed hyperparameter tuning, which hyperparameters you experimented with.

Section 5. **Results**: A detailed comparison of your results with those of the original study (if applicable). Provide detailed explanation and interpretation of the results you obtain from your analyses. Use plots and tables whenever appropriate. Make sure the plots and tables you use are clear and easy to read (with proper captioning and referencing).

Section 6. **Conclusions**: Provide particular insights from your project. Aim to answer questions such as

  - What is the take away message from the study and the project?
  - What are the weaknesses of the study and your project (i.e., is there any strong modeling assumptions that might not be valid in practice)? What are the threats to validity?
  - What are the future research directions?

For the projects that aim to replicate a paper or paper(s), a sample report is provided in D2L (see DS8010_project_sample_replication_paper.pdf). For the literature review-focused projects, some of the above sections would not apply. Such projects can skip sections 3, 4 and 5 from the above list, and focus on Section 2 (Literature review) instead. In this case, Section 2 can be divided into multiple subsections:

Section 2.1. **Background on MDP/RL methodologies:** Provide a detailed description of the methods (e.g., DQN, DDQN, Prioritized Experience Replay) used in the studies that are included in your literature review.

Section 2.2. **Study group 1:** List of papers that can be grouped together should be described together. For each of the papers, explain in detail:

- *Research problem*
  - what is the problem being solved? what is the motivation/background?
- *Method*
  - e.g. is it just a particular deep RL model, is there any interesting baselines they are using for comparison purposes (be as specific as possible).
- *Data*
  - is it publicly available (if so provide a reference either as a footnote or in the references), size of the data etc
- *Results*
  - numerical performance values, interesting results.
- *Conclusions*
  - any particular insights from the paper
  - What is the take away message from the paper?

Section 2.3. **Study group 2:** Follow the same logic as in group 1.

It is important to note that, for the literature review-focused projects, the expectation is to cover a research area in a detailed manner. This task amounts to writing a survey paper (e.g., see Liu et al. (2020); Mason and Grijalva (2019); Mosavi et al. (2020)).

Grading Scheme

In grading literature review-focused projects, the grading scheme provided in Table 1 would not apply. Instead, the grading will be based on items such as "Report", "Depth of analysis", and "Insights from the studies" (extra points from "Novelty" is not applicable in this option, so choosing literature review option as the course project is less advantageous for collecting bonus points).

Table 1: Tentative point distribution over 100 pts

Item	Points
Report (proposal = 5 pts, intermediate report = 15 pts)	50 pts
Implementations/documentation	20 pts
Soundness of the results and comparisons	30 pts
Novelty	+10 pts
Individual project	+5 pts
Nicely written report in LaTeX	+5 pts

References

Siqi Liu, Kay Choong See, Kee Yuan Ngiam, Leo Anthony Celi, Xingzhi Sun, and Mengling Feng. Reinforcement learning for clinical decision support in critical care: comprehensive review. *Journal of medical Internet research*, 22(7):e18477, 2020.

Karl Mason and Santiago Grijalva. A review of reinforcement learning for autonomous building energy management. *Computers & Electrical Engineering*, 78:300–312, 2019.

Amirhosein Mosavi, Yaser Faghan, Pedram Ghamisi, Puhong Duan, Sina Faizollahzadeh Ardabili, Ely Salwana, and Shahab S Band. Comprehensive review of deep reinforcement learning methods and applications in economics. *Mathematics*, 8(10): 1640, 2020.