CSE 151B Deep Learning
UCSD, Spring 2022

Project Final Report

Due 11:59 p.m, June 5th, 2022

Please submit your report as a single PDF file using NeurIPS 2022 template :

- Comment out `\usepackage{neurips_2022}`(Line 10) and Abstract (Line 87-93)
- Uncomment `\usepackage[preprint]{neurips_2022}` (Line 15)
- Change title to **CSE 151B Project Final Report** (Line 37)
- Change author name and email to your team members' names and emails (Line 49)
- Follow the format instructions to write your report, especially Figures and Tables

You report will contain the following components with a minimum 4 pages (not including references). Some of the questions are the same as the milestone. You can reuse the materials from your milestone report. You are also welcome to update your answers given the new things you have learned since the milestone. Please copy the section titles, the problem numbers and write the details under each section title. Do **not** copy the questions themselves. Include a **github** repository link for your solution. You can make the repository public at this point.

Your report will be judged by (1) how well it is following the format requirements (2) how much detail it contains about your project (3) how creative/innovative/thoughtful your solution is for the project.

1 Task Description and Background (3 points)

Problem A [1 points]: Describe in your own words what the deep learning task is and why it is important. Provide some real-world examples where successfully solving this task can have great impact on our daily life and the society.

Problem B [1 points]: Use Google Scholar or other internet resources to research on this task. What type of methods have been proposed before in the literature? Include some references and discuss their ideas in a few sentences. How do these ideas relate to or differ from your own ideas. You can use Bibtex to manage your bibliography.

Problem C [1 points]: Define the input and output in mathematical language and formulate your prediction task as an optimization problem. From the mathematically abstraction, do you think your model can potentially solve other tasks beyond this project? If so, list some examples and explain your rationale.

2 Exploratory Data Analysis (4 points)

Perform exploratory data analysis and report your findings with texts/tables/figures. If you include more exploratory analysis beyond the listed questions that provides insights into the data, you will receive bonus points.

Problem A [1 points]: Run the provided Jupyter notebook for loading the data. Describe the details of this dataset. Your description should answer the following questions:

- what is the provided training and test data size?
- how many dimensions of inputs/outputs in the raw data?
- what are the meanings of these input/output dimensions?
- what does one data sample looks like? Visualize it.

Problem B [1 points]: Perform statistical analysis to understand the properties of the data. Your analysis should at least answer the following questions.

- what is the distribution of input positions for all agents (hint: use heatmap)
- what is the distribution of output positions for all agents (hint: use heatmap)
- what are the distributions of positions for different cities?

Problem C [2 points]: Process the data to prepare for the prediction task. Describe the steps that you have taken to process the data. Your description should at least answer the following questions.

- How did you split the training and validation data? What is the size of your train and validation dataset?
- Did you use any feature engineering? If yes, how did you design your features? Explain your rationale.
- How did you normalize your data? Why did you choose this normalization scheme?
- Did you use the city information provided in the dataset. If yes, how did you exploit this information.

3 Machine Learning Model (3 points)

Problem A [1 points]: Start with a machine learning model and answer the following questions. Pick any model that you are comfortable with, such as linear regression.

- What are the input output features that you end up using for prediction with simple machine learning models?
- Which model class did you pick? What is your loss function?

Problem B [1 points]: Describe the deep learning pipeline for your prediction task and answer the following questions.

- What are the input output features that you end up using for prediction with deep learning models?
- What is your model architecture and loss function? If you have multiple alternatives, discuss your ideas and observations.

Problem C [1 points]: Describe all the models you have tried to make predictions. You should always start with simple deep learning models (such as Multi-layer Perceptron) and gradually increase the complexity of your model.

- Use an itemized list to briefly summarize each of the models, their architecture, and parameters, and provide the correct reference if possible.
- If you end up designing your own model architecture, include a picture/sketch of your model architecture. Explain why you choose such a model.
- Describe different regularization techniques that you have used such as batch-norm, dropout, and max-pooling in your model.

You can also use mathematical equations to explain your prediction logic.

4 Experiment Design and Results (4 points)

Problem A [1 points]: Describe how you set up the training and testing design for deep learning. Answer the following questions:

- What computational platform/GPU did you use for training and testing?
- What is your optimizer? How did you tune your learning rate, learning rate decay, momentum and other parameters?
- How did you make multistep (30 step) prediction for each target agent?

- How did you utilize the city information?
- How many epoch did you use? What is your batch-size? How long does it take to train your model for one epoch (going through the entire training data set once)?

Explain why you made these design choices. Was it motivated by your past experience? Or was it due to the limitation from your computational platform? You are welcome to use screenshots or provide code snippets to explain your design.

Problem B [2 points]: Select a few representative models of yours and report the following results by comparing different models.

- Use a table to compare the prediction performances of different feature and model designs. What conclusions can you draw from this table.
- Provide an estimate of training time (in flops or minutes) for different models. What did you do to improve the training speed?
- Count and report the number of parameters in different models.

Problem C [1 points]: Play with different designs of your features and models. Report the following for your best-performing model design:

- Visualize the training/validation loss (MSE) value over training steps (You should expect to see an exponential decay).
- Randomly sample a few training samples after the training has finished. Visualize the ground truth and your predictions.
- Your current ranking on the leaderboard and your final test MSE.

5 Discussion and Future Work (1 point)

Problem A [1 points]: Analyze the results and identify the lessons/issues that you have learned so far. Briefly answering the following questions.

- What do you think is the most effective feature engineering strategy?
- What techniques (data visualization/model design/hyper-parameter tuning) did you find most helpful in improving your ranking?
- What was your biggest bottleneck in this project?
- How would you advise a deep learning beginner in terms of designing deep learning models for similar prediction tasks.
- If you had more resources, what other ideas would you like to explore?