CS 486/686 Project Report

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For your submission, please comment out any text in any section that is not relevant to the current deliverable.

Abstract

Complete the abstract for D4.

This is a short summary of your entire paper. You should include all the components of your project: the motivation, the problem, the methodology, and the main results and the takeaway messages. Do not attempt to include all your results. Instead, think of this as a highlight and an advertisement for your paper. If you only have 1 minute to describe your paper to someone, what would you say to grab their attention and make them remember your paper?

The abstract should be 1-2 paragraphs long. It should be at most 1/2 of the left column of the first page of the paper.

Introduction

The *Introduction* section ($\sim$1 page) consists of two parts. First, you will describe the problem you want to solve and the motivation for tackling the problem. Second, you will provide a summary of your project.

Complete the following part for D1.

The next part should be 2-3 paragraphs long.

Motivate your entire paper. Describe the problem that you are solving at a high level. Why is this an important problem to tackle? If there is a solution to this problem, what are some potential real-world impacts of this solution? Try to give a compelling motivating story. If possible, support your argument with evidence such as facts and statistics.

The next part should be 1-2 paragraphs long.

Describe the research question you are trying to answer. The research question describes the specific question you want to answer/address in this project. The question usually involves a comparison. You may want to compare two different algorithms. If you are evaluating one main algorithm, you will want to compare the algorithm to a baseline method. You can use the baseline method to establish a minimum performance that your main algorithm must achieve. The baseline method serves as a sanity check that your main algorithm is performing at a reasonable level.

Your description of the research question should answer the following questions.

1. What problem are you going to solve? (e.g., build a ML model to classify whether a book review is positive or negative.)

2. What main algorithm(s) will you implement or modify to solve the problem? (e.g. transformer-based models: BERT and RoBerta)

3. What other baseline methods will you use for comparison to evaluate the performance of the main algorithm(s)? (e.g. variants of RNNs: LSTM)

Here is an example of a research question: Will an AI agent based on [...] (the algorithm(s)) achieve higher/lower [...] (a quantifiable metric) compared to a model based on [...] (the selected baseline model)?

Here is an example of a research question: The research question our project will address is: Will an AI agent based on [...] (the algorithm(s)) achieve higher/lower [...] (a quantifiable metric) compared to a model based on [...] (the selected baseline model)?

Next, describe your methodologies. Briefly explain your main algorithms and baseline methods (1-2 sentences). Briefly explain how you adapt the algorithm to solve your problem.

Next, describe the performance measures you will use to evaluate the algorithms/models.

1. If the result is evaluated on a data-set:

    (a) What is the performance metric (e.g. accuracy/precision/recall/f1 score...)?

    (b) Are you going to use an existing data-set or collect data by yourself? For an existing data-set, please cite the source. If you are going to collect the data by yourself, briefly explain how you are going to collect the data.

2. If the result is evaluated in a simulated environment:

    (a) What are some features of the environment? Describe briefly and leave the details to D2.

    (b) Are you going to implement it or are you going to use an existing implementation?

3. If the result is evaluated on user study:

    (a) What is the format of the user study? online questionnaire/user interview...

    (b) Who will participate in the user study?

(c) What is the most important question in this user study?

Complete the following part for D4.
The next part should be 1-2 paragraphs long.
Describe your key findings.
The next part should be around 1 paragraph long.
Describe your contributions. How should we interpret the results? Why should people care about this work? Does this project introduce any novel techniques or reveal any unexpected findings? In bullet point forms, list 3-4 key contributions of your project.

Related Work

Complete the Related Work section for D1.
This section should be around 1 page long.

The *Related Work* section summarizes prior work for addressing the same problem or similar problems.

If you are an undergraduate student, you should aim to survey around 5-7 published papers. If you are a graduate student, you should aim to survey around 10-12 published papers.

Whenever possible, synthesize the literature by describing multiple papers in aggregate, i.e., mentioning a common technique that multiple prior work used.

Try to connect the prior work into a coherent story. Imagine that you are describing a story to someone about how researchers have used different techniques to solve the same or similar problems over time.

Please use BibTeX to do citations. Here are some examples (Shalev-Shwartz and Ben-David 2014; Block 1962; Novikoff 1962).

Methodology

Complete the Methodology section for D2.
This section should be 2 pages long.

The *Methodology* section describes the algorithms that you chose to implement. Describe in details how each algorithm works. Include their mathematical formulations, if necessary. Include pseudo-code, if necessary. If you had to extend an existing algorithm in order for it to work with the problem, describe in details what is different/new. Provide a rationale for why you selected these particular algorithms and how they are appropriate for the problem. You should provide enough details so that someone can reproduce the steps and replicate your results.

If you are tackling a machine learning problem, you may be using an existing data set or creating a new data set. In this case, you should describe the data-set that you are analyzing as well as any data filtering and merging procedures that you used to prepare/create your data-set. Your description should. include the size of the data-set(s) (i.e., number of examples), whether the class labels are balanced/imbalanced, the meaning of the features, and other unique characteristics of the data-sets. Explain why the data-sets are appropriate for your problem and what are their limitations. Include the URL of the websites from which you downloaded the data-set(s).

You should also describe any pre-processing steps you took to prepare or create the final data-set that you used to train and test the algorithms. Examples of pre-processing steps include procedures for joining multiple data-sets, filtering out certain examples, scaling features, etc. Provide the rationale for why you are using these data preparation procedures, with enough details so that someone can reproduce the steps and replicate your results. For example, if you chose to re-scale certain features, explain how the re-scaling was done and why.

Results

The *Results* section (∼2 pages) describes your experimental design and your results.

Complete the following part for D2.
Describe the measures that you used to evaluate the algorithms. Be as precise as possible by including their mathematical formulations. Provide a rationale for why these performance metrics are appropriate for your problem.

Describe other details about your experimental design. If you are tackling a machine learning problem, include details such as how you created the training, validation and test set, how you selected the model's hyper-parameters, etc.

Complete the following part for D3.
This part should present the experiment results to help answer your research question.

Please describe the following parts in this section.

(a) The design of your system (include UML diagrams if possible). Any technical challenges that you have encountered with your implementation and your data-sets and how you overcome those challenges. Your effort to optimize the performance of your implementation.

(b) The performance of your algorithms. Your effort to improve the performance of your algorithms. Detailed analyses of the hyper-parameters if possible. A qualitative analysis of how the performance changed for different values of the hyper-parameters. If possible, describe how your techniques compare to prior work.

(c) The lessons you have learned by working on the implementation. The lessons could be technical or otherwise.

If your project is implementation heavy (i.e., you implemented most of the algorithms by yourselves), your result section may focus more on (a) Talk about the design of your code, the technical challenges of the implementations and your efforts to optimize the performance of the code. You still need to present your model performance for (b). However, we are more lenient on your result.

If your project mostly uses codes from an existing library or repository, your part (b) should be more extensive. Describe your efforts to improve the model performance. More specifically, if you are doing a machine learning project, please include data exploration and detailed hyper-parameter analysis. Data exploration should include any interesting insights or challenges from the data set. Hyper-parameter analysis should include figures or tables to show how the model's performance changes with different values of each hyper-parameter.

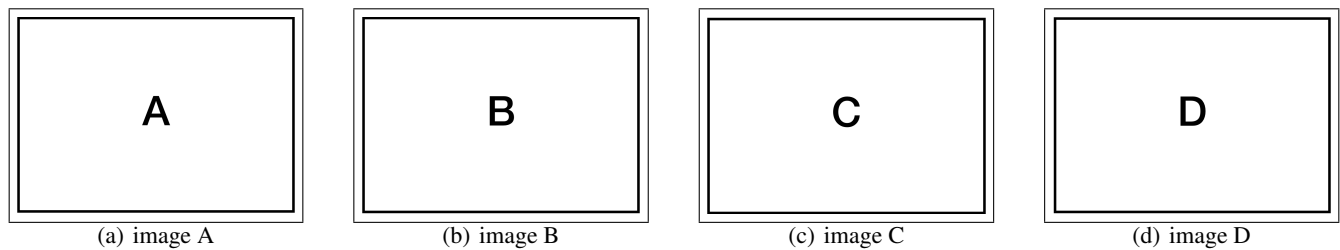(a) image A   (b) image B   (c) image C   (d) image D

Figure 1: Another example of figure layout

Prepare figures (e.g., Figure 2) and tables (e.g., Table 1) to describe your results clearly. Make sure to label your figures and tables and explain them in the text. If you are comparing the performance of algorithms, include statistical tests to assess whether the differences are statistically significant.

Techniques	F-1 Score
Baseline	0.80
Another Baseline	0.76
My Awesome Algorithm	**0.95**

Table 1: example of a table summarizing the results
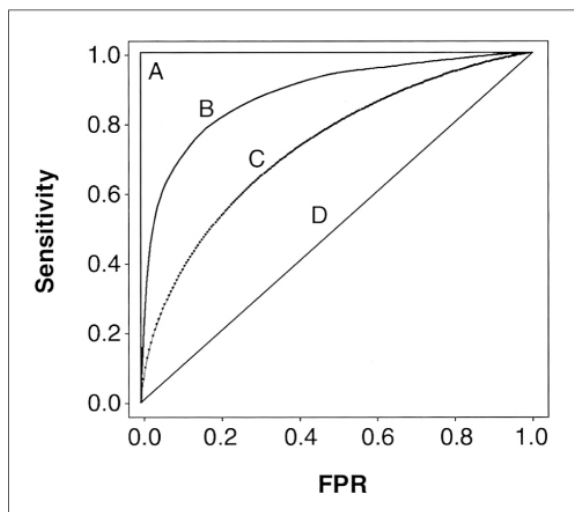

Figure 2: ROC curve of my awesome algorithms

Discussion

Complete the Discussion section for D4.

This section should be around 1 page long.

The *Discussion* section describes (a) the implications of your results, and (b) the impact and the limitations of your approach.

For the results, describe how a reader should interpret them. Try to form concise take-away messages for the reader. For your approach, describe the extent to which your approach helps to solve the problem. Describe any limita-

tions of your approach. If possible, compare your results and your approach to that of prior work.

Conclusion

Complete the Conclusion section for D4.

This section should be around half a page long.

The conclusion is another mini-summary/recap of your paper. Write about the problem, the motivation, and the methodology briefly. Then, summarize your results and the main takeaway messages. Finally, describe 2-4 future directions. See below for some examples of future directions.

- "We would like to try these other hyper-parameters for these reasons"
- "It would be interesting to try a different model .... because ..."
- "The related problem .... is interesting because"
- "A different data processing method may be useful because ..."

References

Block, H. D. 1962. The perceptron: A model for brain functioning. *Reviews of Modern Physics* 34(1):123–135.

Novikoff, A. 1962. On convergence proofs for perceptrons. In *Symposium on Mathematical Theory of Automata*, 615–622.

Shalev-Shwartz, S., and Ben-David, S. 2014. *Understanding Machine Learning: From Theory to Algorithms*. Cambridge University Press.