COMP6721 Applied Artificial Intelligence
Course Project Guideline—Winter 2024

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Email Inquiries

All inquiries about the course project (without any exception) should be communicated via *email* using addresses above. Your email subject line must follow a prefix topic
[COMP6721: *"YOUR SUBJECT"*].

All prefix characters are case-sensitive and opening/closing brackets must be included. Note that your subject i.e. *"YOUR SUBJECT"* can be anything. For example, if you are inquiring about the team formation, the subject line would be
[COMP6721: Course Project-Team Formation]
***Note: Other formats will NOT be replied.

Main Objective

The main goal of this project for students is to study a Computer Vision (CV) task in deep learning using Convolutional Neural Network (CNN) backbone models to address image classification problem from a real-world application of interest. Each team is at liberty to choose any image classification problem, under the following circumstances:

1. Availability of datasets online: you need to have at least Three (3) different datasets for the same classification problem. For instance, if you chose "Food Classification from Images" then you need to find three *different* datasets compiled on food classification problem (i.e. different sources).
2. The datasets should be different in terms of
    a. number of classes,
    b. number of images, and/or image structure (size/features).

    Note that the main aim here is to study the performance on datasets of varying complexity.
3. Only one of the datasets is allowed to have binary classification (i.e. 2 classes). The other two datasets must have at least 3 classes. You should keep in mind that the datasets need to have good variance in terms of number of classes. A good example of datasets is a set with 3, 10, and 30 classes (small, moderate, and large).
4. All the datasets should have <50K total images, with varying number of images across the datasets. You have the freedom of eliminating parts of the datasets if you need to, given that you still meet the requirement of different datasets. Noe that you cannot combine datasets from different sources together.
5. There is no right or wrong choice of problem. Choose a problem that interests you, given it satisfies the availability of varying datasets.

Once a problem is chosen, each team needs to train, optimize, and evaluate Three (3) CNN architectures to tackle the chosen classification problem. All CNN-related methods must be implemented using the PyTorch library. Specifically, the project has the following 3 main components:

1. Data Preprocessing: in this stage, the team needs to explore several data preprocessing methods that handle the data (images) before being fed to the CNN.
2. CNN Architectures and Training: each team must choose 3 CNN architectures to train on the chosen datasets. You **SHOULD NOT** design a CNN architecture from scratch, but choose from the available architectures (examples include, but not limited to: ResNet, Vgg, AlexNet, etc). We further suggest to consider choosing lighter models (such as MobileNet, ShuffleNet, etc) to overcome the complications of computational footprint as well as the availability of GPU resources for computation. The architectures should vary in terms of complexity (number of layers and learnable parameters). Given 3 datasets and 3 architectures, each team should train 9 different models. Additionally, each team should train 2 additional models using Transfer Learning (any 2 combinations of dataset+architecture). In total, each team should have at least 11 trained models, 9 from scratch and 2 with transfer learning. Keep in mind that, for fair comparison, all the models should be trained under the same conditions (i.e. same hyperparameters)

3. Optimization: each team should choose at least one of the 9 models trained from scratch and attempt to optimize it through hyperparameter tuning. You should choose at least one hyper parameter, only from the following options: learning rate, batch size, and loss function.

Please note the following

1. You should consider the computational complexity of the selected network models that needs to be trained on a commodity GPU hardware from available resources (e.g., lab GPU, cloud, personal PC, Google Colab, etc).
2. You should use several evaluation metrics, in addition to plots, to compare the performance of the different models. This includes, but not limited to, accuracy, recall, precision, F-score, etc. Each team should also use TSNE or Grad-CAM to visualize the performance of at least 4 different models in the final report.

Team Formation [Deadline: Thursday 11:59PM, February 1st, 2024]

Students are required to form a team of *Four(4) members* for the course project. Please engage in discussion with your classmates for brainstorming on potential problem you would like to solve according to the main objective above. Please submit your team's detail *by email* to the lecturer following the email inquiries guideline. A *Q&A discussion forum* is created for the course on Moodle and you can use the platform to open a discussion on team formation related topic. Students who cannot find a team will be randomly shuffled in incomplete teams. The team, once formed, will stay the same until the end of the semester.

Writing a One-Page Proposal

You should write a one-page proposal for the course project to cover the following topics

- *Problem Statement and Application:* Provide a background about the topic and specify why the problem is important? What are the associated challenges of your selected problem application? What are your expectations/goals throughout developing the application of interest?
- *Image Dataset Selection:* Explain your image dataset(s) and provide the statistical details of your data (e.g. number of images, image size, image format, etc). Specify where you have found the dataset(s) and means of access to the data (e.g. published paper, downlink, etc). You may consult Kaggle to find possible image datasets of interest, or you can use any data you have collected from your previous research activity or have access to.
- *Possible Methodology:* Highlight the "possible methods" you could use to solve the problem. Specify how you will be handling/processing the data to train your deep learning pipeline using a CNN model. Furthermore, discuss the metrics that will be used to assess and evaluate the pipeline, and your expectations regarding the kind of results/performance to be achieved. You need to discuss the possible method(s) and how the obtained results will be compared and analyzed to each other. Further, you need to discuss the potentials of your analysis and comparisons and how they can be useful for scientists and engineering in the field.
- *Gantt Chart:* use an additional page (supplemental material) to illustrate a Gantt chart of the project development to list (a) schedules and (b) items of milestones and deliverables. Note that you cannot use this page to extend your proposal description.
- *Bibliography:* You can add an additional page (if needed) to extend your reference list cited in your proposal. The citations may include, but not limited to, published papers and domain links. (include a link to your dataset). Please note that failure to properly cite your references constitutes to a plagiarism and will be deemed for reporting.

You will be given the opportunity to submit your proposal for revision by the professor/Lead-TA, before the final graded submission.

Proposal Submission [Deadline: Wednesday 11:59PM, February 7th, 2024] (Counts for 10% of the course project grade)

Only the admin (one person) of your team needs to upload the proposal in *PDF* file in Moodle. For the report format, please consult "Reports Formatting" Section in the third page. Our team (TAs and lecturer) will review your proposal and, if it is acceptable, you may proceed with developing the next phase of your project. Otherwise, we will instruct you to either revise or re-write the proposal according to the guidelines of the course project. All teams are highly encouraged to put great effort on preparing the first proposal draft to avoid further delays in project developments. Your proposal will be evaluated according to the guidelines and a feedback will be provided for one additional attempt revision due on Sunday 11:59PM, February 18th, 2024. Your grade will be evaluated based on this finalized proposal draft.

Progress Reporting [Deadline: Sunday 11:59PM, March 17th, 2024] (Counts for 20% of the course project grade)

Each team is required to submit a two(2)-page progress report highlighting the main steps taken after the proposal, and any initial results (if available). The progress report should contain the following sections

1. *Introduction and problem statement:* In addition to defining the problem and its applications, discuss the general strategy for tackling the issue at hand. Discuss the challenges faced in solving this problem and any possible solutions to address them. Discuss what results you expect and how you want to acquire/evaluate them.
2. *Proposed Methodologies:* Give updates regarding the methods used/to be used. Discuss the chosen dataset and CNN model in more detail than the proposal.
3. *Attempts at solving the problem:* elaborate on failed or successful attempts at tackling the problem. Furthermore, discuss any possible/preliminary results.
4. *Future Improvements:* Discuss briefly how and where you want to change to improve the accuracy of the model.
5. *References:* You can add an additional page (if needed) to extend your reference list cited in your progress report. The citations may include, but not limited to, published papers and domain links (include a link to your dataset). Please note that failure to properly cite your references constitutes to a plagiarism and will be deemed for reporting.
6. *Supplementary Material* [this section is appended to the main report draft]:
   You may include appendices to your report to support different sections of the main draft. **Note: this section will not be considered for marking. Furthermore, reviewing this section for all lecturer and TAs are not mandatory.

The progress report should be in PDF format and uploaded in Moodle. For the report format, please consult "Reports Formatting" Section in the third page. Please note only the admin (one person) of your team needs to upload the progress report in PDF file in Moodle.

Final Reporting [Deadline: Monday 11:59PM, April 15th, 2024] (Counts for 40% of the course project grade)

The final report should articulate the following sections

1. *Abstract.* Articulate on the abstract presentation of the project and what to expect by reading your report in full detail. Briefly discuss the problem, proposed methods and used data, and the achieved results. [maximum of 150 words]
2. *Introduction* [the abstract & introduction should be no longer than 1.5 pages].
   a) Write a section to cover the problem statement and its importance to the application field. What are the associated challenges with respect to the problem? How these challenges have been addressed in the literature? What are the pros/cons of the existing solutions? How is this report trying to solve the problem and a challenge in mind? Elaborate on the high-level abstract explanation of your methodology and what kind of implementations you have done. What kind of results you are obtaining?
   b) Related works. Write a subsection to cover literature review and related work descriptions.
3. *Methodology* [this section should be no longer than 2 pages].
   The methodology section should cover several subsections as follows
   a) *Datasets*. A comprehensive description of the datasets, including where and (how) there were collected, a complete statistical details, distribution and analysis of the datasets such as size of the data, number of images, number of classes, and any preprocessing and filtering steps you have taken to make it ready to be fed to your deep neural network pipeline. Provide image examples of the datasets and articulate on the complexity of their class representations. Explain your train/validation/test breakdown, cross-fold validations, resolution level for training, etc
   b) *CNN Models*. Describe the architecture of the selected CNN models for the chosen image classification task. Elaborate on why you think the selected models are suitable for your practice. Describe the computational complexities of the selected models for training and validation phases in terms of wall clock time for one-epoch training as well as number of FLOPS calculation. How does the selected model compare to other available models in terms of computational complexity, accuracy, suitability, etc.
   c) *Optimization Algorithm*. Discuss how you validated and optimized your model. What optimization algorithm(s) you are choosing to train the CNN model? What metric evaluations are considered for reporting the performance of the optimization algorithm. Describe the properties of the algorithm and its associated hyper-parameters for training.
4. *Results* [this section should be no longer than 2.5 pages].
   This section describes and analyzes the experimental design and obtained results in detail. More specifically
   a) *Experiment Setup*. you need to describe how you setup your experiments, optimized and validated your models, the performance of your models using appropriate metrics (precision, recall, F1-measure, …). Explain the ranges of hyper-parameters and rational behind selecting as such in relation to your data and models.
   b) *Main Results.* Demonstrate the main results in figure/table formatting and analyze the performance of your trained models, as well as comparison with other available results.

c) *Ablative Study*. Demonstrate the ablation results from tweaking different hyper-parameters such as number of classes for training, number of images per class training, different range of learning rates, different range of batch-size, etc, and explain your observations.

5. *References* [this section lists all references on the sixth page of your report]:
6. Cite any references you used in the projects, including any source code and dataset you have used in the project. Please note that failure to properly cite your references constitutes to a plagiarism and will be deemed for reporting.
7. *Supplementary Material* [this section is appended to the main report draft]:
   You may include appendices to your final report to support different sections of the main draft. **Note: this section will not be considered for marking. Furthermore, reviewing this section for all lecturer and TAs are not mandatory.

Reports Formatting

The proposal (1 page + 1 page Gantt Chart supplement + 1 page bibliography), the progress report (2 pages+1 page bibliography), as well as the final report (6 pages + 1 page bibliography + possible appendices) should **all** be written in LaTeX template from **here** for your final PDF submission. ***Note: other formats will NOT be accepted. Note to use the *reviewing style* for LaTeX compilation.

Final Presentation [Deadline: Monday 11:59PM, April 15th, 2024] (Counts for 15% of the course project grade)

Each team should prepare a six(6) minute recorded video from a slide presentation and submit the following

- A 10-Page deck of slides prepared in PDF format (you can use either PowerPoint or LaTeX beamer for your slide preparation). Slides should contain a high-level overview of the problem and goals, the type of data you were dealing with, your methodology, the obtained results, and the references used.
- A six(6)-minute recorded video from the team, each member taking a round of two minutes in a row to complete the record.

GitHub Submission [Deadline: Monday 11:59PM, April 15th, 2024] (Counts for 15% of the course project grade)

Whether you use Git to organize your coding throughout the project or not, each team should create a new GitHub page for the project from the beginning. The GitHub page should be created in "private" mode and each member should be given access to commit their updates on a regularly basis during the course of project. Furthermore, the assigned TA for the project team as well as the lecturer should be given access to the GitHub page for monitoring the progress of the team. Note that commits from each team member will be monitored for the engagement of individuals and considered as one of the means of marking to contribute to their final project. The final GitHub page should contain the following

- High level description/presentation of the project
- Requirements to run your Python code (libraries, etc)
- Instruction on how to train/validate your model
- Instructions on how to run the pre-trained model on the provided sample test dataset
- Your source code package in PyTorch
- Description on how to obtain the Dataset from an available download link

Please note that if the instructions to run your code are incomplete or not explicit enough, you might lose marks for that part of the project. You should add the professor and the Lead-TA as contributors to your project, using the following addresses:

- GitHub ID: mahdihosseini, email tied to GitHub: (mahdi.hosseini@mail.utoronto.ca)
- GitHub ID: ahmedalagha1418, email tied to GitHub: (ahmedn.alagha@hotmail.com)

How to Submit Your Project Materials? [Deadline: Monday 11:59PM, April 15th, 2024]

Submit all the files in one zip file including

- PDF file of the final report
- Deck of 10-Slide page presentation in PDF format
- README.txt containing the following two links
  - A link to your GitHub page.
  - A download link to your video presentation
- A sample test dataset (100 images)

- One page that includes a table listing the contribution of each team member to the project. The table format should be in Four(4) columns pertinent to individual members of the team. The pertinent information will be considered to grade individual contribution to the project.

The zip file should be uploaded by the admin of the team in Moodle by the final submission deadline.

Late Submissions

If you submit any part of the project later than the specified deadline on Moodle, your submission will be accepted until the cut-off date. However, you will lose 20% of the mark for each day you submit late. The cut-off date is maxed up to two (2) days and submission after the cut-off date will not be accepted. Further, please note that resubmitting your files will result in erasing all the previously submitted versions and their respective dates. The date of the last attempt at submission will be counted as the final submission date.