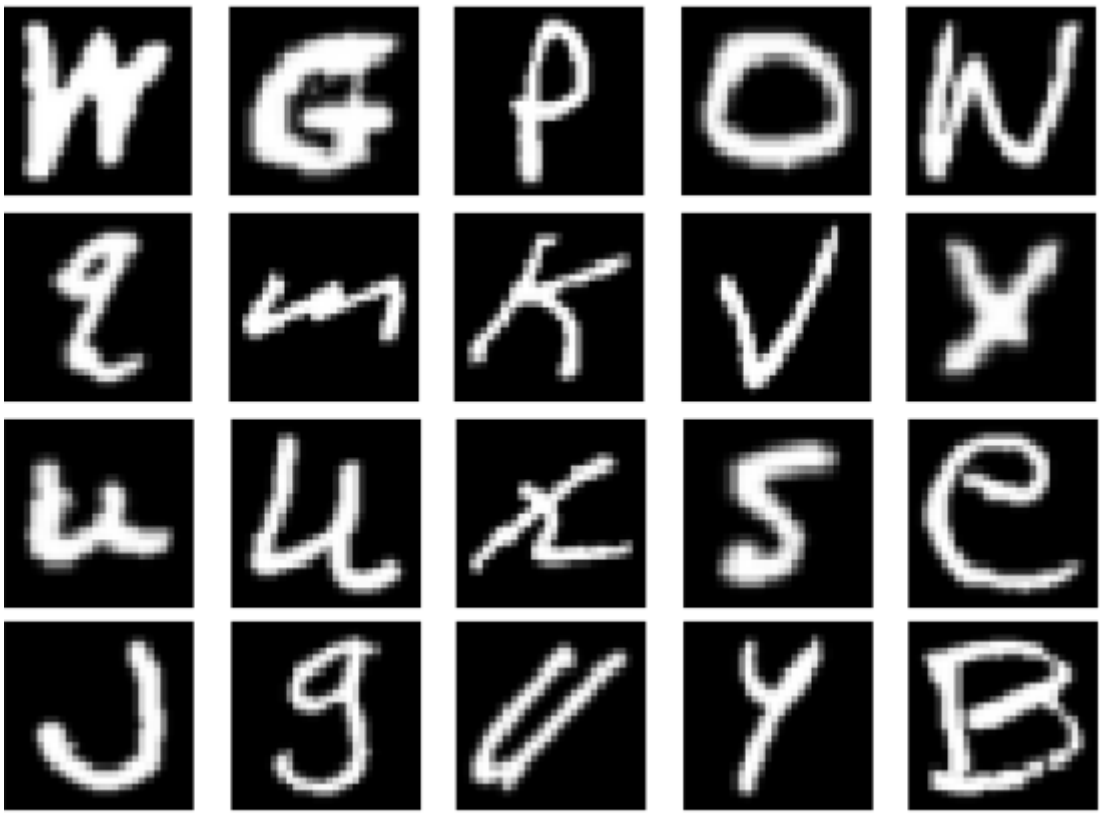
ST1504 DEEP LEARNING ASSIGNMENT 2



From https://arxiv.org/abs/1702.05373

School Name	School of Computing
Semester	AY2024/25 Semester 1
Course Name	DAAA
Module Code	ST1504
Module Name	Deep Learning

Assignment 2 (CA2: 40%)

The objective of the assignment is to help you gain a better understanding of applying Generative Adversarial Networks (GAN) and Reinforcement Learning (RL).

There are three parts in this assignment, Parts A, B, C.

Guidelines

1. You are to work in groups of two for Parts A and B. For Part C, this is an individual task.

2. In this assignment, you will:

   A. Create GAN for image generation and evaluate the performance of the network.
   B. Create RL to solve the task at hand.
   C. Carry out some literature research and prepare a technical paper on CNN, RNN, GAN/VAE or RL. (Just ONE topic.)

3. For Parts A and B, you should prepare the following:

   a) Jupyter notebook including your code, comments and visualisations (.ipynb).
   b) In addition, please save a copy of the Jupyter notebook as a .html file.
   c) Include your best neural network weights (.h5 file).
   d) A deck of presentation slides (.pptx file) for your project.
   e) A statement indicating the contributions by each member of the group, including percentage of workload for specific contributions.

   *NOTE: Each student must be well-versed with **both** Parts A and B. Whilst you can consider splitting the workload, you will still be evaluated on everything in this CA. You cannot expect to only do one part but know little or nothing about the other part.*

4. For Part C, you should submit your file as a Word (.docx) or .pdf document. If you write your own codes, you must include them.

5. Submit all materials in a zipped file. Each student must submit his/her own complete set of files, even if you are sharing for Parts A and B.

   Any missing files (like missing .h5 file for best weights, missing .html file for your code, etc.) would incur marks deduction.

6. The normal SP's academic policies on Copyright and Plagiarism applies. Please note that you are to cite all sources. You may refer to the citation guide available at: https://sp-sg.libguides.com/citation

7. You need to submit your declaration of academic integrity. You may access this document on Brightspace. Without this, your submission is deemed incomplete.

Submission Details

Deadline: 5 Aug 2024, 08:00 AM
Submit through: Brightspace

Late Submission

50% of the marks will be deducted for assignments that are received within ONE (1) calendar day after the submission deadline. No marks will be given thereafter. Exceptions to this policy will be given to students with valid LOA on medical or compassionate grounds. Students in such cases will need to inform the lecturer as soon as reasonably possible. Students are not to assume on their own that their deadline has been extended.

Neural network models

You must build your own neural network models, with explanations and justifications.

Your neural networks models can be improved upon with tweaks to your architectures.

If you wish to implement transfer learning, it is only acceptable after you have done the above (building your own models with justifications).

Otherwise, transfer learning is rejected.

Save the best weights of your neural networks. This is important for reproducibility without having to re-train over some extended duration.

Reminder: Please check that all files are valid, especially after zipping. If files cannot be opened, it would be considered as no submission. It is your responsibility as students to ensure this is properly carried out.

PART A: GAN (45 marks)

Task

Apply some suitable GAN architectures to the problem of image generation. Use the given dataset to create **260** small black-and-white images. There should be 26 classes of images for you to generate. You **must submit** your generated images.

You should implement some ways to evaluate the quality of your images:

A simple "by-eye" or "eye-power" method is to just generate say 50 images (or 49 = 7 by 7 grid), and count manually how many are acceptable images (not perfect, but display some plausible features of the images --- perhaps as "clear", "marginal", "nonsense"). Alternatively, you can consider other metrics/indicators.

If you are asked to generate images of a specific class, propose a way of doing it.

If you are asked to generate coloured images instead of black-and-white ones, do you think it would be easier or harder to produce better quality results?

What class(es) is/are relatively easier/harder to generate? Why?

Note: Do not worry too much about generating "perfect-looking images". Whilst quality of images would represent the quality of your model, the more important aspects are the process, your workflow and planning, your EDA, evaluation analysis, etc., as a whole.

As this is a pair-work, you should discuss and optimise the GAN training between yourselves, making use of available computing resources for both of you.

Dataset

You must use the dataset that is provided.

You **cannot use any external data** to train your model.

Nevertheless, you are allowed to apply augmentation on the provided data, if you wish. If you choose to do so, you must concretely explain why you make such a choice, as well as investigate whether it is actually beneficial.

Submission requirements for Part A

1. Submit a zip file containing all the project files (source code, Jupyter notebook .ipynb file, .html file, and best neural network weights .h5, slides, 260 generated images).
2. Submit a .docx file containing the list of specific contributions by each team member in the deliverables for Part A.
3. Submit online via the Assignment link.

Evaluation criteria:

Background research, feature engineering	9 marks
Application of GAN, explanation of architecture(s)	9 marks
Evaluation and improvements of GAN performance	9 marks
Presentation/Demo	9 marks
Quality of report (Jupyter)	9 marks

PART B: REINFORCEMENT LEARNING (45 marks)

Task

Apply a suitable modification of deep Q-network (DQN) architecture to the problem. Your model should exert some appropriate torque on the pendulum to balance it.

You must use DQN and satisfactorily demonstrate its viability.

You may consider other reinforcement learning architectures, if you wish, but only after successfully implementing DQN. Otherwise, any other non-DQN architecture will be rejected.

In your work, you should plan clearly what you are doing, your approaches, and how you systematically optimise your solutions.

For example, what hyperparameters can you tune? Is one trial enough or should you repeat the trials? Why?

How do you conclusively demonstrate your so-called "best setup" to be the best? Are you considering fastest learning, most stable learning, or some other criteria that you choose to define?

Dataset

Please use the following environment from OpenAI Gym.
https://www.gymlibrary.dev/environments/classic_control/pendulum/

NOTE: Stay within the older version of gym 0.17.3, as implemented in the lab for cartpole.

Submission requirements for Part B

1. Submit a zip file containing all the project files (source code, Jupyter notebook .ipynb file, .html file, and best neural network weights .h5, slides).
2. Submit a .docx file containing the list of specific contributions by each team member in the deliverables for Part B.
3. Submit online via the Assignment link.

Evaluation criteria:

Background research, explanations of approach(es) taken	9 marks
Application of RL with appropriate rationale and explanations	9 marks
Evaluation and improvements of RL	9 marks
Presentation/Demo	9 marks
Quality of report (Jupyter)	9 marks

PART C: Technical Paper (10 marks)

This part of the assignment is to be completed individually. This is a challenge task for students who wish to attempt it for higher marks.

Write a technical paper in single column format on any **ONE** of the following topics:

- CNN (computer vision, in general)
- RNN (natural language processing, in general)
- GAN, VAE (generative AI, in general)
- RL (reinforcement learning, in general)

In our lessons, we covered some fundamental and basic architectures for these topics. However, there are certainly more advanced models available beyond what we covered. Take this opportunity to dive deeper into such extensions.

Here are some examples (but you are free to do other topics not listed here):

There is a raft of advanced CNN models: ResNet, Inception, VGG. Consider focusing on one such interesting models to you, and explore deeper.

For RNN, you may delve into how ChatGPT works, the underlying architecture, large language models, for example.

For GAN, there are various other improvements apart from the basic DCGAN. Even VAE has extensions to areas like physics.

For RL, we only covered DQN. How can we improve DQN? Double DQN, duelling, priority sampling, etc. How about other RL architectures beyond DQN?

The paper should have the following components:

1. Abstract
2. Introduction
3. Related Works
4. Dataset/Methodology/Experiment
5. Discussion
6. Conclusions
7. References

Submit the paper in Word or PDF format (page limit of 10 pages). If you write your own codes, you must submit them to support your work.

NOTE: Do not just copy some advanced research paper without some proper understanding. It does not need to be too technical/mathematical.

It is more meaningful to relate the advance topics you are exploring to something we dealt with in class and in CA1/CA2. Demonstrate how it improves upon those basic architectures that we covered.

Rubrics for technical paper:

Marks	Requirements
1 to 2	(a) Review of one research article. Any citation must be properly documented and accurately attributed. The review must be meaningful and complete to be considered. Otherwise, it is rejected. (b) And/or attempt to build an original/advance model, but only sketchily. The model must be original/advance, i.e. not something done in class so far. Otherwise, it is rejected.
3 to 4	(a) Review of several research articles. (b) And/or attempt to build an original/advance model, with some interesting results.
5 to 6	(a) Attempt to build an original/advance model, with some substantial results. This must be properly demonstrated, otherwise it is rejected. (b) Review of relevant research articles must be included.
7 to 8	(a) Extensive original/advance work on building an advance machine learning architecture, with training and evaluation to demonstrate good but not state-of-the-art results. This must be properly demonstrated, otherwise it is rejected. (b) Review of relevant research articles must be included.
9 to 10	(a) Extensive original/advance work on building an advance machine learning architecture, with training and evaluation to demonstrate near state-of-the-art results. This must be properly demonstrated, otherwise it is rejected. (b) Review of relevant research articles must be included.

— End of Assignment —