ADTA 5550: Deep Learning

Final Project

1. Overview

The final project covers all the topics that have been discussed during the course. The materials in any format that have been posted for the class activities should be considered and used for the project. Additionally, the student can use any other source of information that he/she can gather.

The student is required to create an MS Word document named "**ADTA5550_final_project.docx**" that will contain all his/her work, except for the Python coding.

IMPORTANT NOTES:
--) The student should present his/her work for each section using both text and images.
--) The sources can be from class lectures, assignments, etc., or other sources
--) One picture is worth 1000 words. It would be much more convincing to add one or more images along with the text. However, an image without text explaining what it is and what it is for is considered incomplete.
--) Images can include the screenshots that the student has taken while working on the classwork.

IMPORTANT NOTES:
--) When discussing a topic or answering a question, it is expected that the student has to provide adequate explanation and supporting details to his/her presentation.

IMPORTANT NOTES:
*--) If MS Docx is the document format required for submission, the student is required to submit the contents as MS Docx files, **not** submit PDF documents.*
--) However, before submitting, the student should make a backup copy of the documents by converting them into PDF files that could be used for re-submission if the submitted file was corrupted.

IMPORTANT NOTES:
*--) If Jupyter Notebook documents are required in a Submission Requirement, the student is required to submit the Jupyter Notebook documents, i.e., ***.ipynb documents**, **not** python programs, i.e., **not** *.py programs.*

IMPORTANT NOTES:
*--) For the Python code, the student is required to write the **code of each step** in **one cell** of the Jupyter Notebook document, as shown in the lectures. Then the student is required to **run the code of each cell** to **show the results of each step** in each submitted Jupyter Notebook document.*

IMPORTANT NOTES:
As discussed in the syllabus, the course curriculum covers two AI frameworks: TensorFlow and Keras.
*--) The **first half** of the course (until midterm) focuses on **Keras**.*
*--) The **second half** of the course (including the final project) focuses on **TensorFlow**.*

*--) While working on the **final project**, it is **required** that the student should use the **TensorFlow (Version 1.xx) directly** as the AI framework to build the neural network (as shown in the lecture videos of WEEK 5 and WEEK 6).*

*--) In other words, the student should **not** use Keras APIs, e.g., Keras sequential API, to build the neural network.*

IMPORTANT NOTES:
*--) In the **final project**, the student is required to use "**STEP**" (in the code shown in the videos of WEEK 5 and WEEK 6), **not** "EPOCH," in training the neural network.*

- ***STEP**: Each time an input batch is fed into the model during the training*
- ***EPOCH**: Each time all the input batches (split from the training data set) have been fed into the model during the training*

2. PART I: Use TensorFlow Directly in Coding (5 Points)

TO-DO
Answer the following questions:

- **Question 1.1**: Is the student required to use TensorFlow directly in coding (build, train, and test CNN) in this homework assignment?

- **Question 1.2**: Should the student use Keras in coding (build, train, and test CNN) in this homework assignment?

SUBMISSION REQUIREMENTS #1:

The student is required to answer the above questions.

3. PART II: A Dataset of Images or Audio Files (10 Points)

TO-DO
--) Search on the Internet, using Google search or any other approach, to find a dataset in the public domain, i.e., available for use without restrictions.
--) This dataset may contain either images or audio files.
--) This data of the dataset has already been appropriately labeled and ready for use in deep learning research.
--) The dataset should **not** be one of the datasets that are used in classwork: MNIST, CIFAR-10 (or CIFAR-100).

SUBMISSION REQUIREMENT #2:

--) Write a report on the dataset that includes (but not limited to) all the critical information of the dataset, e.g., name, official website, links to download, the data (how many items), the data structure of the data contained in the dataset, and so on.

IMPORTANT NOTES:

--) Some suggestions for websites to start:

- *Dataset Search (Google): https://toolbox.google.com/datasetsearch*
- *Kaggle: https://www.kaggle.com/datasets*
- *Awesome public datasets:* https://github.com/awesomedata/awesome-public-datasets

*--) The student should **avoid** well-known public datasets like the **Image-net** (image-net.org) or **Fashion-MNIST** because they are already so popular.*

4. PART III: Obtain CIFAR-10 Dataset (5 Points)

The CIFAR-10 dataset consists of 60000 32x32 color images in 10 classes, with 6000 images per class. There are 50000 training images and 10000 test images.

The dataset is divided into five training sub-datasets and one test sub-dataset, each with 10000 images. The test sub-dataset contains exactly 1000 randomly-selected images from each class. The training sub-datasets contain the remaining images in random order, but some training sub-datasets may contain more images from one class than another. Between them, the training datasets contain exactly 5000 images from each class.

The classes are entirely mutually exclusive. There is no overlap between automobiles and trucks. "Automobile" includes sedans, SUVs, things of that sort. "Truck" includes only big trucks. Neither includes pickup trucks.

TO-DO

--) Access the Canvas module: …/DATA_SETS

--) Download all the dataset files available there (7 files)

- NOTES: These data files belong to the CIFAR-10 dataset

--) Transfer all the data files of the dataset to the remote virtual machine

- Access the remote virtual machine in GCP using SSH:
- Open the sub-folder **JP_NTBK** in the remote VM
- Create a new sub-folder under **~/JP_NTBK** and name it as "**CIFAR_10_DATA**"
- Upload all the data files of the aforementioned dataset, CIFAR-10, from the student's local computer to the newly-created sub-folder in the remote instance.

SUBMISSION REQUIREMENTS #3:

--) The report about downloading the data set from Canvas and uploading them to the remote server.

IMPORTANT NOTES:
--) The student needs to download the data set from the Canvas module: .../DATA_SETS, and then upload it to the remote deep learning server

--) The steps of how to upload the data file to the remote server are discussed in the document: ***HOWTO_upload_files_to_remote_server_using_GCP_SSH****.pdf (Canvas module: .../SW_DOCS)*

5. PART IV: Build, Train, and Test CNN on CIFAR-10 Dataset (30 Points)

To provide help to students while working on the final project, **the instructor has created a Jupyter Notebook document and provided code to re-arrange the dataset**, **making it similar (**but **not** exactly the same**)** to the MNIST dataset and ready for use in the project**.**

IMPORTANT NOTES:
--) The Jupyter Notebook document, ***DL_TF_cnn_cifar_10_final_project.ipynb****, that the student downloads from Canvas has already contained TensorFlow and Python code.*
--) The existing code is used to load the data into the project, reshape, and re-arrange it so that the data is ready for use.
--) It is recommended that the student should use the provided Jupyter Notebook to start working on the project. However, he/she is ***welcome to rewrite the existing code*** *as he/she wants.*

IMPORTANT NOTES:
--) The Jupyter Notebook document, ***DL_TF_cnn_cifar_10_final_project.ipynb****, should be* ***uploaded*** *into the folder ~/****JP_NTBK*** *in the remote server.*

IMPORTANT NOTES:
--) The code that is used to build, train, and test the CNN model using the CIFAR-10 dataset should be very similar to that for the MNIST dataset ***except for*** *only one step: Original input data can be fed directly into the 1st convolution layer, i.e.,* ***no need to reshape*** *it. All other steps should be the same.*

TO-DO
--) **Design the convolution neural network** used for the project
--) **Build, train,** and **test** the **convolutional neural network** on the **CIFAR-10 dataset using the TensorFlow AI framework** and Python:

- **Train** the network with 5000 (five thousand) steps
- **Test** the network after every 100 steps of training
    - **NOTES:** *each time of testing, one data point of the accuracy level can be collected.*

--) After building, training, and testing the model, copy the results of the tests into a section of the project report (**ADTA5550_final_project.docx**).

--) Write a report on the results of testing the model (in the same project report file)

IMPORTANT NOTES:
--) In the final project, the student is required to use TensorFlow ***1.xx****,* ***not*** *Keras in building the model.*

SUBMISSION REQUIREMENTS #4:

The student is required to submit the following work items:
--) The design of the model, including the diagram of the network architecture and the list of the critical information of each layer (in the above project report file)
--) The results of testing the model (in the above project report file).
--) The report on the results of the test (in the above project report file)
--) The Jupyter Notebook document that contains all the code of building, training, and testing the model.

6. PART V: Compare Convolutional Neural Network Performance (10 Points)

TO-DO

In HW 4, when the student runs the code (in a Jupyter Notebook document) to train and test the CNN on the data set MNIST, the accuracy level is printed 50 times (one test for every 100 steps of training).

--) Collect the data (50 data points) of accuracy levels produced by the CNN with the MNIST dataset that the student worked on in HW 4. Let's name the collected dataset as "ACC_cnn_mnist."
--) Collect the data (50 data points) of accuracy levels produced by the CNN with the CIFAR-10 dataset. Let's name the collected dataset as "ACC_cnn_cifar_10."

--) Compare the performance of the two CNN's that have been used on the datasets – MNIST and CIFAR-10

--) Using critical thinking, write a report on the results of comparing their performance, i.e., the accuracy levels, in which the student is expected to **provide possible reasons** to **explain** the **gap** in the **performance** of the two CNN's used on these two datasets if such a gap exists.

SUBMISSION REQUIREMENTS #5:

The student is required to submit a report that includes the following work items:
--) The dataset (50 data points) of accuracy levels produced by the CNN with the MNIST dataset that the student worked on in HW 4.
--) The dataset (50 data points) of accuracy levels produced by the CNN with the CIFAR-10 dataset.
--) The results of comparing these two datasets
--) The explanation of the gap in the performance of the two CNN's used on these two datasets, if such a gap exists.

7. PART VI: Improve Convolutional Neural Network Performance (20 Points)

TO-DO

--) It is assumed that there is a gap in the performance of the two CNN's.
--) Based on the student's observations while working on PART IV, he/she is asked to think of some ways to improve the performance of the CNN that has worse performance.
--) Using critical thinking and the experiences of working with the MNIST dataset, the student proposes some changes to the network or the network training process with which the network performance may be improved.

--) Write a proposal to make changes to improve the CNN performance (in the above project report file)
--) **Make the changes to** the network or the network training process as proposed in coding
--) **Build, train, and test** the **updated convolutional neural network** on the **CIFAR-10** dataset using the TensorFlow AI framework and Python with the proposed changes implemented in **another** Jupyter Notebook document.

--) Write a report on the results of testing the model (in the above project report file)

IMPORTANT NOTES:
*--) The student's proposal to make changes to the network or the network training process **may** or **may not** result in real improvements in the network performance.*
*--) It is **OK** if the changes do **not** improve the performance because this is an experiment – part of the project.*
--) The most important achievement should be that the student has used what he/she has learned and critical thinking to come up with some reasonable proposals to make changes.

SUBMISSION REQUIREMENTS #6:

The student is required to submit the following work items:
--) The proposal to make the changes to improve the CNN performance (in the above project report file)
--) The results of testing the model (in the above project report file)
--) The report on the results of the test (in the above project report file)
--) The updated Jupyter Notebook document that contains all the code of building, training, and testing the updated model, if necessary.

8. PART VII: Project Report (20 Points)

TO-DO
--) Complete the project report (**ADTA5550_final_project.docx**)

SUBMISSION REQUIREMENTS #7:

The student is required to submit the following additional sections to the report:

- (1) Write an introduction section to introduce the project
- (2) Describe what the student has done in the project (in all three parts: IV, V, and VI)

- (3) List all the conclusions that he/she has learned from the results of testing the CNN models in three parts of the projects (PART IV, V, and VI of the Final Project)
- (4) Write a conclusion section to conclude the project report.

IMPORTANT NOTES:
--) For Item (3) of Submission Requirements #6, the student should clearly state how many (1, or 2, or ...) conclusions he/she can learn from the results of the tests.
--) For each conclusion, it is expected that the student should clearly present what it is and provide adequate details, facts, and other relevant information to support the conclusion.

9. HOWTO Submit

9.1 Final Project Report and All Related Documents

The student is required to submit all the required documents – Microsoft Word and Jupyter Notebook documents – to Canvas

Due date & time: 11:59 AM – Friday 7/26/2024

IMPORTANT NOTES:
*--) Due to the limited time for grading and posting the grades as required by the Registrar Office, **no late submission** is accepted.*