CSE5ML: Machine Learning – Assignment 2

Semester 2, 2024

Overview

- This assignment contributes **30%** of your final mark in the subject. Please read this sheet carefully before doing your assignment.
- The assignment aims to consolidate your knowledge and practical skills to build **neural networks** (NNs) for **supervised learning**. The task is formulated as a **multi-class classification problem** for fashion images, and the goal is to model the relationship between the image's contents, network structure, and labels.

Policies

- You need to provide a working code and a written report of 750 words on the method and results.
- Plagiarism is the submission of somebody else's work in a manner that gives the impression that the work is your own. The Department of Computer Science and Information Technology at La Trobe University treats plagiarism very seriously. When it is detected, **penalties are strictly imposed**.

Submission

- The assignment is due at **11:59 pm, 23th Oct** 2024 (Wednesday).
- The submitted assignment consists of: 1) a report (in PDF format) with no less than 750 words; and 2) One or more code files for modeling, training, and testing the NN with TensorFlow in Python (you can choose to have one code file including all your codes, or you can have one code file for each task separately).
- The assignment is to be submitted on LMS, with all required files (Note: please submit all the files separately, with the original format, so that all the files will go through a plagiarism check. **Compressed files**, such as .rar or .zip files **will not be accepted**.
- A penalty of 5% per day will be imposed on all late assignments for up to 5 days. An assignment submitted more than five working days after the due date **will NOT be accepted and zero marks will be assigned**.
- As the assignment contributes over 15% of your final mark, you need to apply for **Special Consideration** to the University if requiring an extension. Please refer to the link below for more details.
  https://www.latrobe.edu.au/students/admin/forms/special-consideration

Problem Description

The **Fashion MNIST** database is a grayscale image dataset of 10 types of clothing, such as shoes, t-shirts, dresses, and more. The mapping of all 0-9 integers to class labels is listed below

- 0: T-shirt/top
- 1: Trouser
- 2: Pullover
- 3: Dress
- 4: Coat
- 5: Sandal
- 6: Shirt
- 7: Sneaker
- 8: Bag
- 9: Ankle boot

You can use the following code with TensorFlow in Python to download the data.

```
from keras.datasets import fashion_mnist
(x_train, y_train), (x_test, y_test) = fashion_mnist.load_data()
# reshape dataset to have a single channel
x_train = x_train.reshape((x_train.shape[0], 28, 28, 1))
x_test = x_test.reshape((x_test.shape[0], 28, 28, 1))
```

Note:

1. Since the Fashion MNIST dataset is a black and white image dataset, the shape of the dataset is (dataset_length, 28,28). But to fit data into a conv2d layer, we need to make the input shape comply with its required format: (batch_size, image_width, image_depth, image_channels). Although batch_size can be decided later when training it, we will still need to tell the number of image channels here. Therefore, we can reshape the dataset into (dataset_length, 28,28,1).
2. When loading the fashion_mnist data, some students may meet an issue with an error message *ModuleNotFoundError: No module named 'tensorflow_core.estimator'*. You can solve this issue by making sure that both tensorflow and tensorflow-estimator are in the same version in your anaconda environment. In this case, you just need to downgrade tensorflow-estimator to 1.15.1.

Every Fashion MNIST data point has two parts: an image of a piece of clothing and a corresponding label. We will call the images x and the labels y. Both the training set and test set contain x and y.

Each image is 28 pixels by 28 pixels.

As mentioned, the corresponding labels in the Fashion MNIST are numbers between 0 and 9. In this assignment, we regard the labels as **one-hot-vectors**, i.e., 0 in most dimensions, and 1 in a single dimension. In this case, the n-th digit will be represented as a vector which is 1 in the n dimensions. For example, 3 would be [0,0,0,1,0,0,0,0,0,0].

The assignment aims to build NNs for classifying images in the Fashion MNIST database, train the models on the training set and test them on the test set. Since the main object of this assignment is for you to understand the relationship between input, model, and output, you are not expected to achieve very high accuracy in model performance, instead, for each task, you should be able to identify how can you improve model performance with the change of different network structure.

There are three main tasks in this assignment:

1. Build a neural network without convolutional layers to do the classification task (hint: you will need the use of dense layers). Then, you can change the model structure (i.e., number of dense layers, number of neurons in dense layers, or activation functions), to be able to improve network performance.
2. Build a neural network with the use of convolutional layers (you can decide other layer types you want to include in your network). Then, you can change: the number of convolutional layers, the number of filters, or activation function functions in convolutional layers, to be able to improve network performance.
3. Change the type of optimizer or learning rate that you applied in the previous tasks, and see how these changes can influence model performance (You can keep the final network structure you applied in task 2, and try at least one different optimizer setting).

Please read the following comments and requirements very carefully before starting the assignment:

1. The assignment is based on the content of **Labs**.
2. In the assignment, you will need to train the NN on the training set and test the NN on the test set, without any given validation set. (If you want to monitor the training process, you can also try what we did in Lab 7B: you can consider the validation set is the same as the test set in this assignment.)
3. In the assignment, the performance of a NN is measured by its prediction accuracy in classifying images from the **test set**, i.e. number of the correctly predicted images/number of the images in the test set.
4. You are expected to show at least 2 models for tasks 1 and 2: one for the model you start with, and another model is the model that you identified to have better accuracy. For task 3, you need to show what optimizer and/or learning rate you applied.
5. Your report **MUST** at least contain the following content
    a. Your name and the student number;
    b. Architectures of the NNs, with figures for tasks 1 and 2;
    c. The description of the optimizer and learning rate you applied in the final model of task 2 and the optimizer or change of learning rate you used in task 3
    d. Experiments and performances, with parameter setting;
    e. Discussion on the improvement/deterioration of the NN's performance after changing the architecture and parameter setting for each task and findings of comparing the results from all three tasks;
    f. The ranking of all NN's performances from all three tasks.

Marking Criteria

Criterion	Contribution
The report includes your details	5
The report includes a detailed description of the model architectures for all the applied in task 1 and task 2 (at least 4 models), illustrated by figures.	20
The report includes a detailed description of the two optimizers or learning rates you applied in task 2 (final model) and task 3.	5
The report includes a detailed description of the experiments and the performances of all three tasks.	15
The report includes an in-depth discussion on the improvement / deteriorations of the NN's performance after changes for each task and findings of comparing the results from all three tasks.	30
The ranking of all NN's performances from all three tasks.	10
The codes are in good style and in accordance with the reported details.	15
Total	100