Homework 2
Principles of Artificial Intelligence
2nd November, 2023

Question 1.

CIFAR-10 is a well-known dataset consists of 60,000 color images in 10 classes of dimension $32 \times 32 \times 3$, with 6,000 images per class. The classes include airplane, automobile, bird, cat, deer, dog, frog, horse, ship and truck. There are 50,000 training images and 10,000 testing images. It has been one of the most widely-used datasets for the evaluation in computer vision. In this homework, you will implement neural networks with CIFAR-10 based on the knowledge you have learned in class. High level frameworks such as Keras and PyTorch are encouraged to be used.

Part 1: A Simple Neural Network Implementation (20pt)

Use the following steps to develop a simple neural network. You are expected to achieve an accuracy about *50%*.

- Import the framework (Keras only).

- Import the CIFAR-10 dataset.

- Assign the dataset to training and testing dataset (variables), respectively.

- Convert the labels to the *one-hot encoding* scheme.

- Build a three-layer model, use *relu* as the activation functions for the three hidden layers, then use *softmax* as the activation function for the output layer.

- Choose *categorical crossentropy* as the loss function, *adam* as the optimizer.

- Train the model by epochs of *50* and batch size of *1024*.

- Note that you may add extra tricks like *dropout* in your model to support the training.

Part 2: Convolutional Neural Network (CNN) Implementation (20pt)

Follow the steps in **Part 1** but construct the model as the way you like, as long as it is a CNN. You are expected to achieve an accuracy about *75%*.

Part 3: Hyperparameter selection (40pt)

Now, play around with various settings and discuss your results.

- You may increase the *number of layers*, change the *number of neurons* in each layer, change the *loss function*, *optimizer*, *epochs*, *batch size*, etc. to analyze the corresponding results.

- Report the hyperparameters you use and the resulting accuracies.

Part 4: Further Studies for CNN (20pt)

For the previous parts, you may observe a trend that increasing the number of layers in the neural networks may enhance the accuracy. However, when the number of layers becomes too large, you may suffer a serious deterioration. Some special network architectures are thus introduced to overcome the problem. In this part, you will implement the following techniques to overcome this.

- First, identify some reasons of the accuracy deterioration while increasing the layers.

- Then, find at least one network architecture that solves the problem. Write a paragraph for the architecture to explain how exactly it has been done to overcome the problem.

Hints:

- For constructing a neural network, a rule of thumb is to start with a large number of neurons and gradually reduce the number of neurons in each layer.

- You may refer to the structures in `https://weikaiwei.com/tf/tensorflow-mnist/` and `https://clay-atlas.com/blog/2019/10/03/python-chinese-tutorial-keras-cnn-cifar10/`.

- TAs are your friends. Please **DO NOT** hesitate to contact the TAs if you have questions.

Grading: Please submit your program and a short report (less than **5 pages**). In your report, please provide the required results as mentioned by screenshots, followed by some discussions about these results. Your grades will be decided based on both the demo and report.