Computer Vision Assignment 05: Object Recognition

1. File Structure

```
root_directory
├──Computer_Vision_Assignment5.pdf
├──runs
├──codes
      ├── bow_main.py
      └── models
          └── vgg_simplified.py
```

2. Bag-of-words Classifiers

2.1 Local Feature Extraction

2.1.1 Feature detection - feature points on a grid

- Use `np.linspace` and `np.meshgrid` to generate samples
  - Notice the start point and end point should consider the border
  - The number of samples equals to `nPointsX` and `nPointsY`
- Use `np.vstack` to stack the generated grid.

2.1.2 Feature description - histogram of oriented gradients

- Compute the angle by using `np.arctan2`
- For each 4×4 Cell, compute the gradient histogram by using `np.histogram`
  - Notice the `num` parameter should be set to `nBins + 1`

2.2 Codebook construction

- For each image call
  - `grid_points` to generate grids
  - `descriptors_hog` to collect local features
- Concatenate all the features

2.3 Bag-of-words Vector Encoding

2.3.1 Bag-of-Words histogram

- Call `findnn` function to get the indices of nearest neibors for each query vector
- Calculate the histogram using `np.histogram`

2.3.2 Processing a directory with training samples

- For each image call `grid_points` and `descriptors_hog` to transform it into feature
- Call `bow_histogram` to get the word frequency histogram

2.4 Nearest Neighbor Classification

- Use `findnn` function to calculate the minimum distances in two classes

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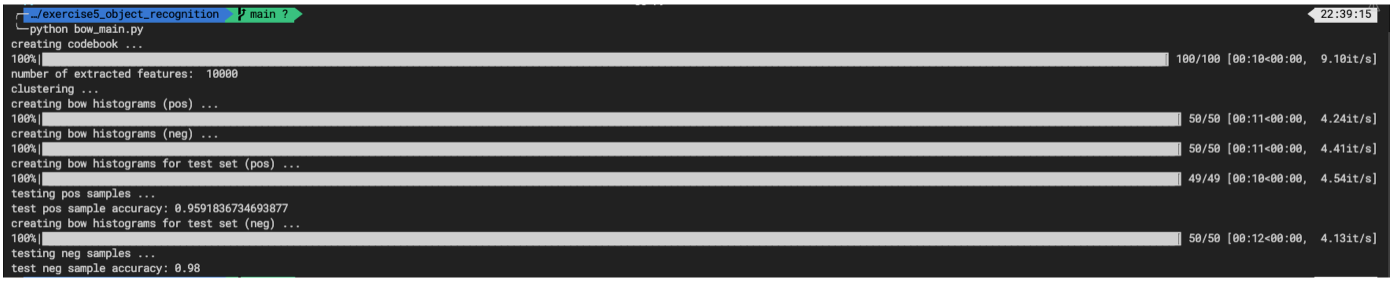
2.5 Result

- For training, I found that the hyperparameter `k=200`, `num_iter=10` results in the best accuracy `0.96` for positive class, `0.98` for negative class:



```
┌─…/exercise5_object_recognition  main ?                                                                  22:39:15
└─python bow_main.py
creating codebook ...
100%|████████████████████████████████████████████████████████| 100/100 [00:10<00:00,  9.10it/s]
number of extracted features:  10000
clustering ...
creating bow histograms (pos) ...
100%|██████████████████████████████████████████████████████████| 50/50 [00:11<00:00,  4.24it/s]
creating bow histograms (neg) ...
100%|██████████████████████████████████████████████████████████| 50/50 [00:11<00:00,  4.41it/s]
creating bow histograms for test set (pos) ...
100%|██████████████████████████████████████████████████████████| 49/49 [00:10<00:00,  4.54it/s]
testing pos samples ...
test pos sample accuracy: 0.9591836734693877
creating bow histograms for test set (neg) ...
100%|██████████████████████████████████████████████████████████| 50/50 [00:12<00:00,  4.13it/s]
testing neg samples ...
test neg sample accuracy: 0.98
```

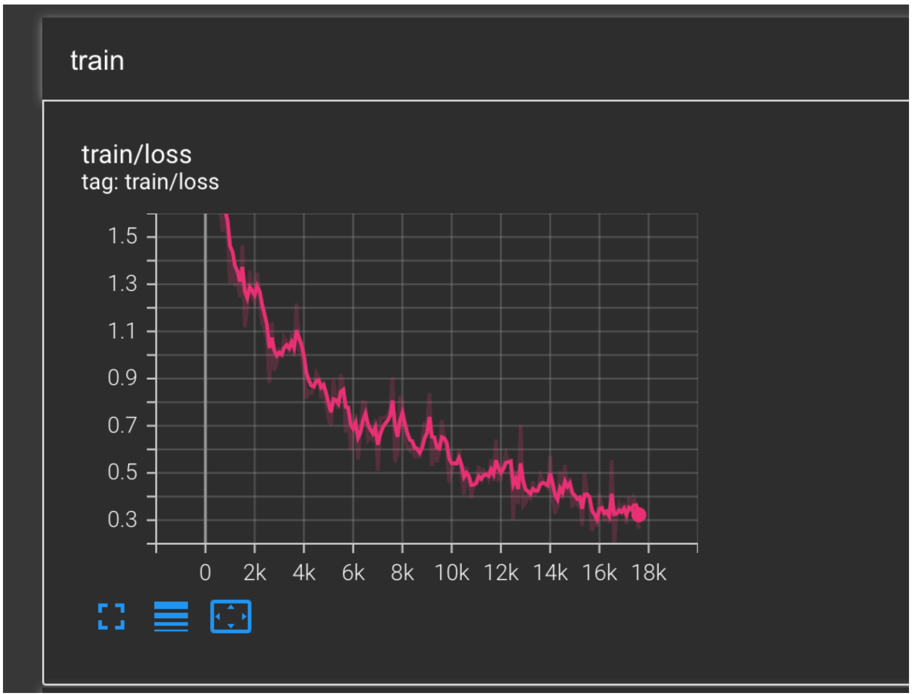
3. CNN-based Classifier

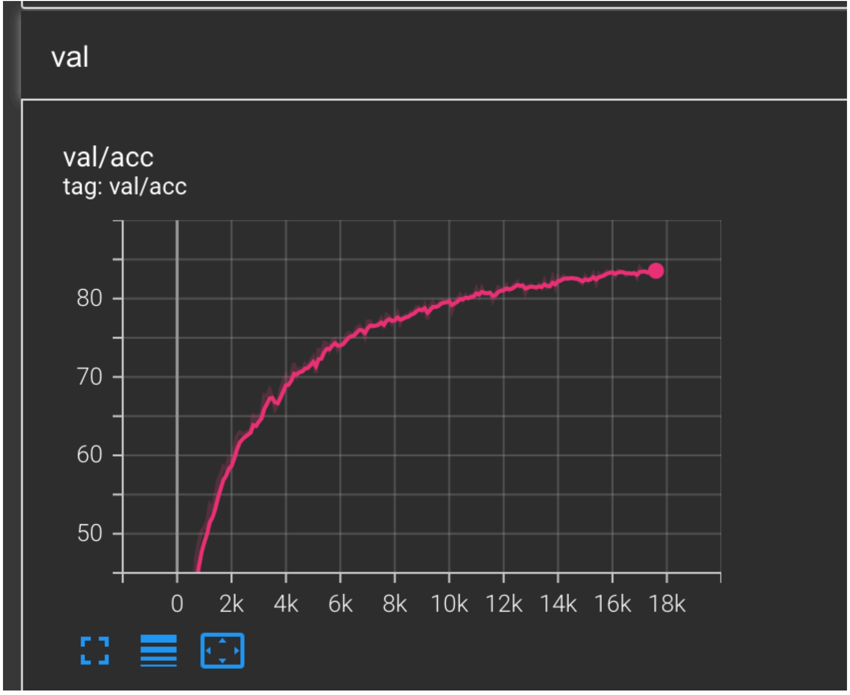
3.1. A Simplified version of VGG Network

- Convolution padding and stride size: by observation, the height and weight of the tensor divide by two for each convolution block. Therefore we choose `padding=1` for convolution and `stride=2` for max pooling.
- Use `nn.Sequential` to stack a convolutional layer (Cone + ReLU + MaxPooling)
- Choose dropout probability to be `0.5`
- Remember to flatten the tensor in the last step in `forward` method.

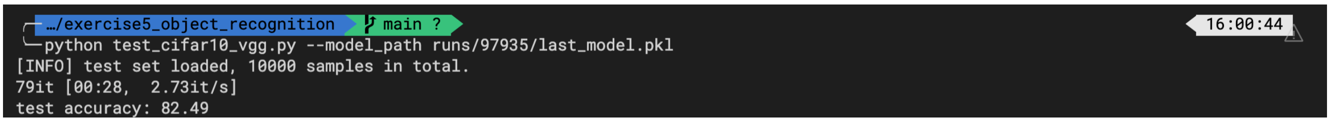
3.2. Training and Testing

- Training: the model is trained on GPU supported by `Google Colab`.
    - loss of last epoch: `0.2620`
    - accuracy of last epoch: `83.84%`
    - The loss function and validation accuracy curve is shown as below:





- Testing:



```
╭─ …/exercise5_object_recognition  main ?                                                          16:00:44
╰─python test_cifar10_vgg.py --model_path runs/97935/last_model.pkl
[INFO] test set loaded, 10000 samples in total.
79it [00:28,  2.73it/s]
test accuracy: 82.49
```

  - The directory of the best model is `runs/97935/last_model.pkl`
  - The testing accuracy is `82.49%`