Lab Assignment - Image Categorization

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1 Pipeline of Image Categorization

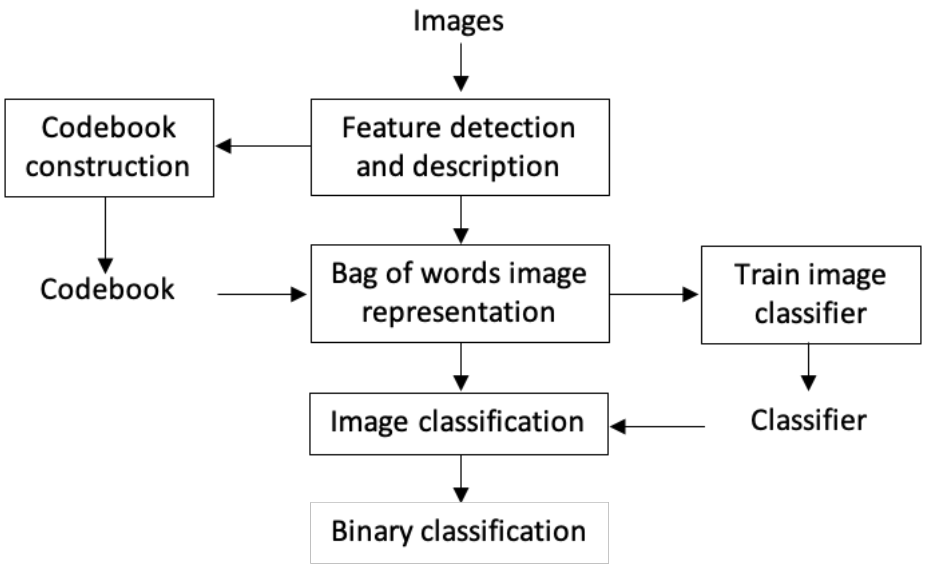

Figure 1: Pipeline of Image Categorization

The whole pipeline of image categorization is shown in figure 1. It consists of following steps:

1. **Feature detection and description.** We simply use the points on a regular grid as the local feature points. Then, for each point, we extract the 4*4 cells in its neighboring area, with each cell a 4*4 pixels patch. For each cell, we extracted the histogram of oriented gradients (HOG) descriptor, which are further concatenated together to be the final descriptor.

2. **Codebook construction.** We construct a visual vocabulary by mapping high-dimensional descriptors to words via k-means.

3. **Bag of words image representation.** Now with codebook, we can build the histogram of visual words for each training and testing image. We simply count the number of descriptors belong to each cluster.

4. **Image classification.** We implement two classification methods: Nearest Neighbor Classification and Bayesian Classification. For the first one, we simply find the nearest neighbor of each histogram in the positive and negative training sets, and assign it with the label of the nearest-neighbour. For the second one, we classify based on the posterior. We use Bayes' theorem and assume the likelihood to follow a normal distribution. The parameters of normal distribution can be computed using the training sets.

2 Experiment results

I display the visualization of codebook for different codebook size k in figure 2, and the accuracy curves for two classification methods in figure 3. The accuracy is computed as the mean accuracy after running 10 times for each k.

(a) Codebook size=25 (b) Codebook size=75 (c) Codebook size=200

Figure 2: Codebook visualization for different codebook sizes k

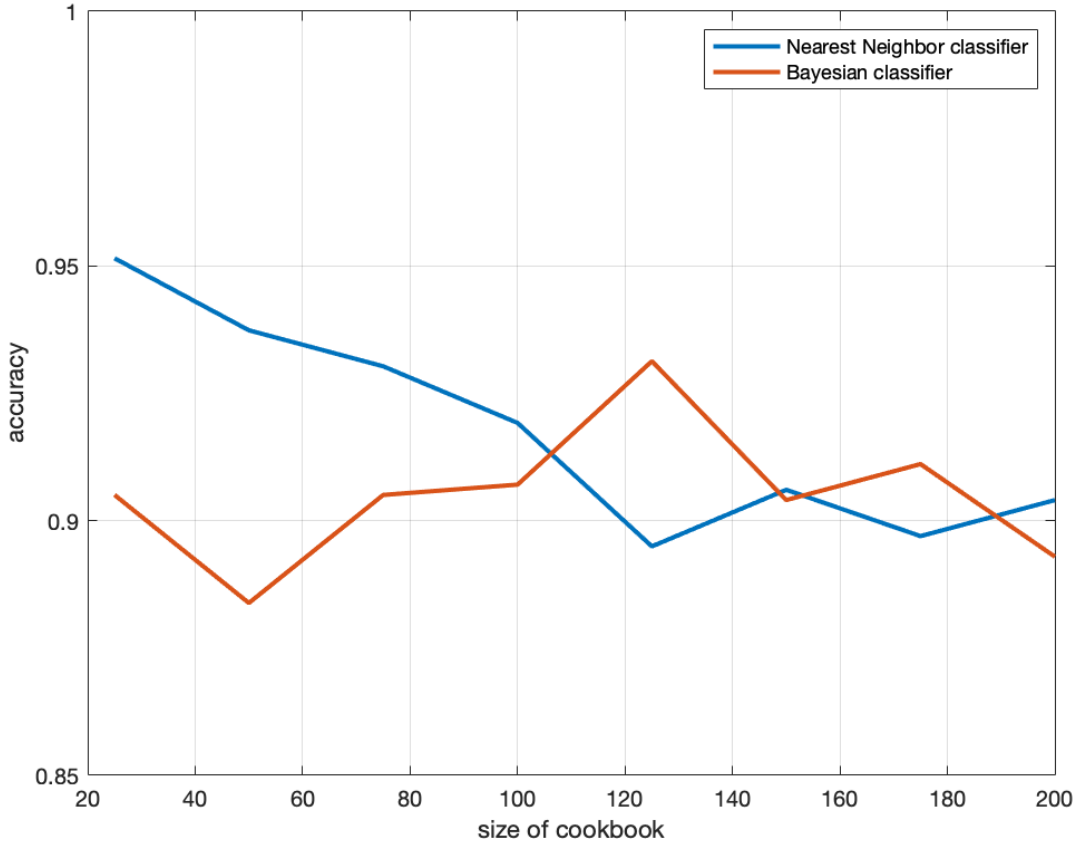

Figure 3: Classification Accuracy with different number of cluster centers k using two methods (10 tests)

From figure 3, we can compare the performance of two classifiers:

- When the number of cluster centers k is not very large (smaller than 120), the classification accuracy using Nearest Neighbor Classifier (NN) will decrease as k increases, while the classification accuracy using Bayesian Classifier (Bayes) will increase. I think the reason is for NN, the classification criterion is simple, just taking the label of nearest-neighbor in the training sets. Larger k means more cluster centers, and more likely to overfit. But for Bayes, it need to compute the parameters of likelihoods, an important part of the model, using the training sets. Larger k, higher feature (histogram) dimensions, more precise the model is.
- When the number of cluster centers k is large (larger than 120), the classification accuracy using both methods does not change a lot. I think the reason is at this time, the bag of visual words is already large enough to represent the image. Adding more features will not add more new information that can help the classification process.
- In a nutshell, when the number of cluster centers k is small, Nearest Neighbor Classifier performs better than Bayesian Classifier. When the k is large, two methods performs similarly.

3 My own dataset

I use dog (positive) & cat (negative) dataset. The dog training/testing set each contains 50 images, the cat training/testing set each contains 50 images. I display some images in figure 4. I also try dog (positive) & car (negative) sets. The accuracy curves are separately shown in figure 5, 6.

From figure 5, we can see the average accuracy is not as high as that in figure 3 for both classification methods. I think the reason is that shape difference between cat and dog category is not as large as car and road category. So the extracted histogram differs less in the feature space, which makes it difficult to tell two categories apart. Figure 6 can further verify our idea. The shape difference between dog and car is quite large, so the classification task is easy and the accuracy is high, almost 0.99 for Bayes classifier. We can also see that the Bayes classifier performs better than Nearest Neighbor Classifier in all cases. The accuracy of NN classifier decreases as the k increases, which may due to overfitting.

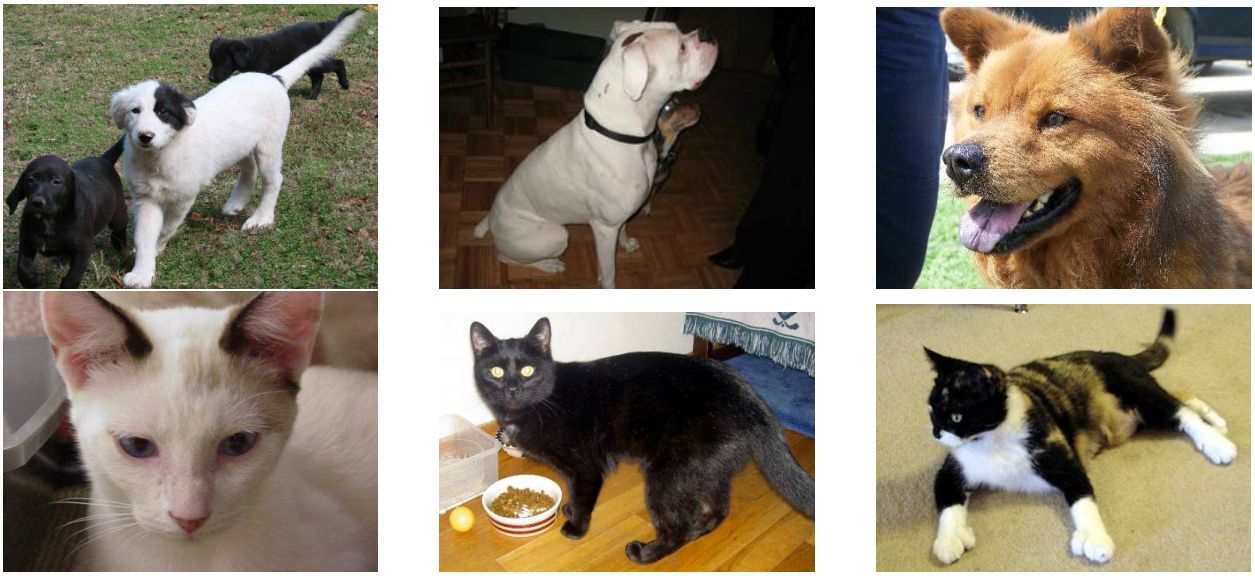

Figure 4: samples of Dog & Cat dataset

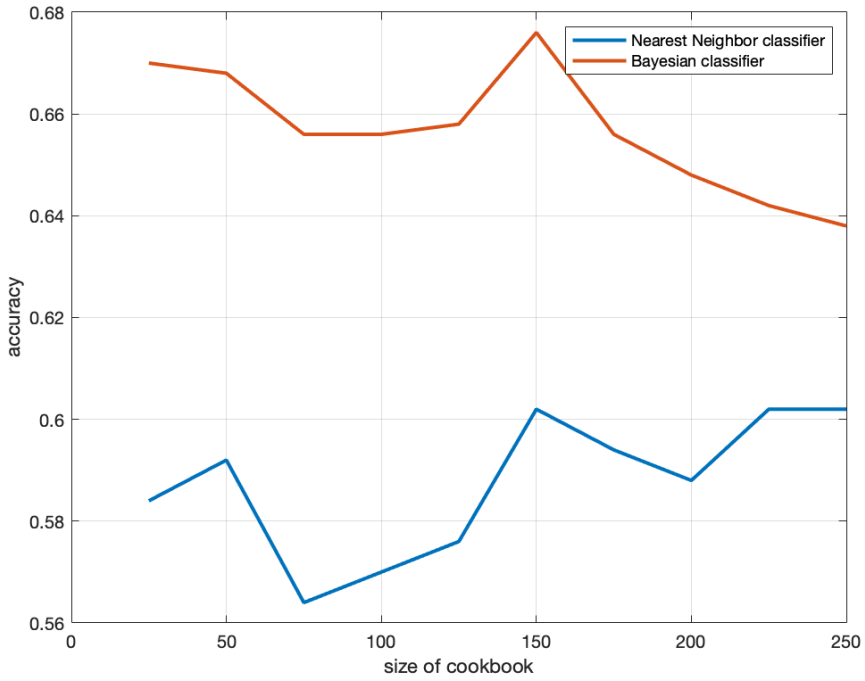

Figure 5: Classification Accuracy on dog (positive) & cat (negative) dataset (5 tests)

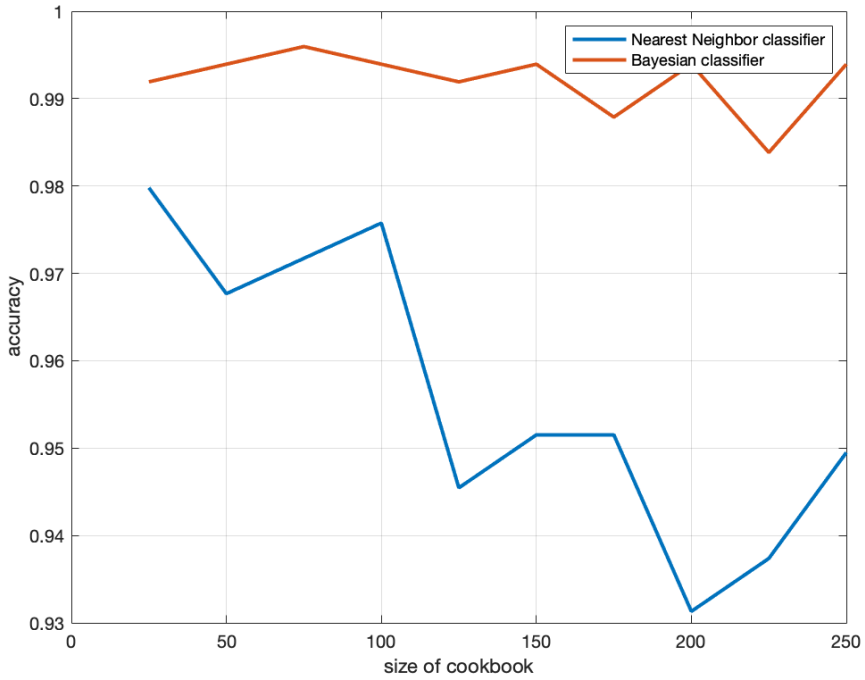

Figure 6: Classification Accuracy on dog (positive) & car (negative) dataset (5 tests)