ECE 7868 Project 1 Report

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Abstract

In this project, I applied the Principle Component Analysis (PCA) algorithm into the image classification problems. I used the PCA subspace and correlations&KNN methods to classify the images. ETH-10, AR face database and CIFAR-10 are used in testing. I computed the accuracy by using the leave-one-out method and compared classification accuracy under these 2 methods..

1 Problem 1: PCA Subspace

I calculated the Euclidean distance between the sample and its projection into each PCA subspace created by its category, i.e., $\|t-t^T V_i V_i^T\|_2$, where t is the vector of the sample and $V_i = (v_{i1}, \cdots, v_{ik})$ is a matrix which has k PCs, and v_{ij} is the jth PC in the ith subspace. I assigned the sample to a category if the distance between it and its projection in this category's PCA subspace is the smallest one.

1.1 Experiment and Result

In these experiments, I changed the percentage of variance of kept in all PCA subspace, and compared the results of them. In AR face dataset, I used the leave-one-out method to train the data and did the testing. I also changed the colorful images to gray images in order to shorten the running time.

In ETH-80, I used the black& white images to train and test my algorithm. I did not use the leave-one-out method since there are 410 images in each category, delete one image would change the PCA subspace only a tiny bit. Besides, since the there are 3280 samples totally, recalculating the PCA subspace each time will cost a lot of time.

In CIFAR-10, I used 50000 images to train and 10000 images to test. All results are showing in Table 1.

Percent of Var. / Dataset	baseline	20%	40%	60%	80%
ETH-80	0.1250	0.5875	0.5506	0.4982	0.4159
CIFAR-10	0.1000	0.2933	0.3023	0.2515	0.2047
AR face	0.0100	0.4212	0.4081	0.5119	0.8200

Table 1: Classification accuracy (and standard deviation) under different percentage of variance kept for PCA subspace method.The estimated standard deviations are extremely small, smaller than 10^{-4}.

Comparing with the baseline (random choice), we can see that the PCA Subspace method can improved the result much better.

1.2 Discussion

We can see that the algorithm has different performance in different datasets. It performs pretty well in ETH-80 and AR face, I think the reason is different categories of images have very different shapes (e.g., apple, cow, cup, etc.) or the images are well collected (only face in the images). Thus the PCA subspace of them are very different. However, this algorithm did not work well in CIFAR-10. In CIFAR-10, the pictures are too small to distinguish them, and they contains many other factors in the images.

Also, when we kept different percentage of variance in our Principle Components (PCs), the classification accuracy are different. Choosing too many or too few PCs cannot allow the algorithm to get the best result. Instead, for different datasets, we should choose different amount of PCs to get the best result.

2 Problem 2 Correlation Coefficients

In this part I used the correlation coefficients and KNN method to classify the data. I tried to use the Pearson, inner-product, Intra-class and rank correlation between the sample and its projection in each PCA subspace, but I finally decided to use the Person-correlation since it can measuer the directions between these 2 vectors. If two images are similar, then the directions of them in the pixel space must be close to each other. Then I used KNN method to classify the samples into the categories based on their correlation coefficients with other training images.

2.1 Experiment and Result

In these experiments, I tested app samples one-by-one in AR face and ETH-80. In CIFAR-10, I used 50000 images to train and used other 10000 images to test. The results are showing below.

K in KNN / Dataset	baseline%	1	3	5	10	15
ETH-80	0.1250	0.9122	0.8902	0.8817	0.8488	0.8256
CIFAR-10	0.1000	0.3672	0.3557	0.3609	0.3607	0.3556
AR face	0.0100	0.6723	0.4708	0.4285	0.3773	0.3677

Table 2: Classification accuracy under different K for correlation coefficients and KNN method. The estimated standard deviations are extremely small, smaller than 10^{-4}.

2.2 Discussion

Comparing with the PCA subspace method, we can see that the correlation coefficients & KNN works better in ETH-80 and CIFAR-10 dataset, but worse in AR face. I think it is because AR face is a small dataset, so PCA subspace works better in this case. Further investigation is needed.

Besides, we can see that when I chose $K = 1$, the algorithm works the best. I think when the dataset becomes larger, the best choice of K will be larger than 1.

References

[1] Turk, Matthew, and Alex Pentland. "Eigenfaces for recognition." Journal of cognitive neuroscience 3.1 (1991): 71-86.