A Fast Method for Face Detection based on PCA and SVM

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Abstract

In this paper, we propose a fast face detection approach using PCA and SVM. In our detection system, first we filter the face potential area using statistical feature which is generated by analyzing local histogram distribution. And then, we use SVM classifier to detect whether there are faces present in the test image. Support Vector Machine (SVM) has great performance in classification task. PCA is used for dimension reduction of sample data. After PCA transform, the feature vectors, which are used for training SVM classifier, are generated. Our tests in this paper are based on CMU face database.

Keyword

SVM, PCA, histogram distribution, face potential area

I. Introduction

Face detection is a very useful subject and it plays an important role in the real applications. Face detection has been researched for more the 15 years. Nowadays, face detection is still concerned by amount of researchers in computer vision fields.

People used lots of methods or algorithms to solve the detection problem [1]. In this paper, we proposed a fast method for face detection. We analyzed the histogram of face and non-face samples; according the character of their histogram distribution, we make out a method to eliminate most of non-face area. Based on PCA and SVM algorithms we combined our method, and then made a face detection system.

The detail of PCA transform is given in section II. In section III, how the Support Vector Machine works is showed. Our method, face potential area selection is proposed in section IV. In section V, we will show the detection result of our method. Conclusion and future works are presented in section VI.

II. Principal Component Analysis

PCA is a useful statistical tool that has found application in fields such as face detection and image compression, and is a common technique for finding patterns in data of high dimension. Applying PCA transform, we obtain the largest features of samples.

The central idea of PCA is to find a low dimensional subspace (the feature space) which represents most of the variation within the sample data. Sample data can be approximately reconstructed with only part of their projection onto the PCA subspace. Figure 1 shows the PCA feature vectors and subspace. After projection onto the principal component axis, we choose several largest vectors as feature vectors in our experiments. In Our test, sample images are 19 by 19 pixels. We obtain 19 vectors by PCA transform; we select 5 largest vectors that can represent most of information of the sample image as the feature vectors.

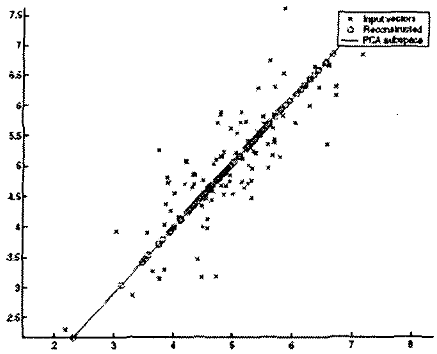

Fig 1. Principal Component Analysis subspace

III. Support Vector Machines

In SVM algorithm, there is a hyperplane used for separate different classes. The goal of SVM is to find out an optimal separable hyperplane to solve the classification task. Here is a brief introduction about SVM works in linear case and nonlinear case. In our experiment, the SVM is a two-class classifier. It is trained by face and non-face samples which are represented by PCA.

In linear separable case, all the data of the same class are on the same side of the hyperplane. We illustrate an example to explain this problem, see Figure 2.

We can see from Figure 2, the left side of hyperplane is pattern one, and another side is pattern two. In linear case, the hyperplane is straight line.

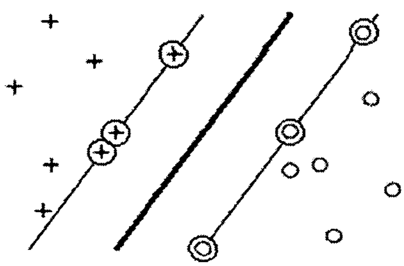

Fig 2. Hyperplane and support vectors in linear separable case

But unfortunately, not all the cases there is a hyperplane that can solve the classification problem. In nonlinear case, we have to map the original feature space into a high-dimensional space that we can figure out an optimal hyperplane, this is the solution for nonlinear classification.

A kernel function is used here, it response to the mapping from input space to feature space.

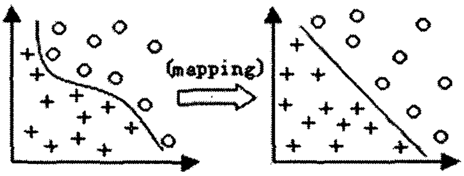

Fig 3. The mapping from input space to a high dimension feature space

Three kernel functions are usually used, polynomial function, RBF function and sigmoid function.

Polynomial: $K(\mathbf{x}_i,\mathbf{x}_j)=(\gamma \mathbf{x}_i^T xj+\tau)^d, \gamma>0$

RBF: $K(\mathbf{x}_i,\mathbf{x}_j)=\exp(-\gamma\left\|\mathbf{x}_i-\mathbf{x}_j\right\|^2), \gamma>0$

Sigmoid: $K(\mathbf{x}_i,\mathbf{x}_j)=\tanh(\gamma \mathbf{x}_i^T \mathbf{x}_j+\tau)$

Here, γ , τ and d are kernel parameters.

The kernel function nonlinearly maps samples into a higher dimensional space. The RBF kernel has less numerical difficulties; its computation is not as complex as the other kernel's. So we choose the RBF kernel in the test.

IV. Face Potential Area Selection

In the detection procedure, we scan each position on the test image using a sliding window, and identify whether there is a face present or not. Usually, non-face area is far more than face area. It always wastes us much more time to detect face on large number of non-face area. It also might make many misclassification regions in the non-face area.

In this paper, we propose a method for eliminating most of the non-face area in gray images, so that we can save more the detection time and improve the detection accuracy. Face area has different pixel character with most of the non-face area. By analyzing histogram distributions, it shows face and non-face area have different histogram distribution. The histogram of face areas has Gaussian-like distribution but non-face area histogram has irregular distribution.

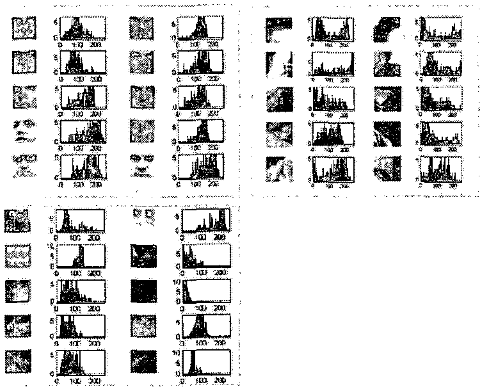

Fig 4. histogram distribution of face and non-face samples

According to the histogram distribution feature, we select the face potential area. The histogram which is distributed in a small range, its mean value is a high value. If the histogram distribution is in a wide range, it has a small mean value. The histogram of face image is a Gaussian-like distribution; the mean value is an intermediate value. By a number of tests, we make out the histogram mean value of face potential area is in a fixed range. The fixed range is the mean value range of face potential area. So if the mean value of a sample area is falling in that range, this sample area is selected as a face potential area. Otherwise, it is filtered as non-face area.

V. Experiments and Results

The MIT face databases are used in our test as face and non-face training samples. Using these samples we trained a SVM classifier. In our detection procedure, all the test images are from the CMU face databases.

A sliding window is used for scanning the test images. The face potential areas are selected first, and then we identify the sliding window on all the position in the face potential area. Finally, we mark all of the detected face regions on the test images.

Fig 5. Selected face potential area and detection results

VI. Conclusion

This paper presented a fast face detection method based on PCA and SVM. Combining PCA and SVM has high performance in face detection task. In addition, our method selected the face potential areas to save the detection time and reduced the detection areas. We can see from the result, most of the non-face areas have been eliminated. The detection time is saved by eliminating the non-face areas. Our results indicated a high detection rate and low misclassified rate. In the future works, we need to improve the performance of classifier and the face potential area selection method.

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