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PCA-HOG Descriptors for Face Recognition in very Small Images

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Abstract— Face recognition has become an important issue in many applications such as security systems, credit card verification and criminals identification. In tiny images people appear very small, but we may still be interested in detecting faces for recognition or analysis. In this paper we take advantage of both HOG and PCA for object recognition in very small images, where firstly we use HOG to extract features from the images at different scales and then apply PCA to reduce the dimensionality of these feature vectors.

Keywords— Feature Extraction; Histograms of Oriented Gradients (HOG); Dimensionality Reduction; PCA; Face Recognition.

I. INTRODUCTION

Histogram of Oriented Gradients (HOG) features were introduced by Navneed Dalal and Bill Triggs [2] who developed and tested several variants of HOG descriptors with differing spatial organization, gradient computation and normalization methods.

The essential thought behind the Histogram of Oriented Gradient descriptors is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. The implementation of these descriptors can be achieved by dividing the image into small connected regions, called cells, and compiling a histogram of gradient directions or edge orientations for the pixels within the cell. The combination of these histograms then represents the descriptor. For improved performance, the local histograms can be contrast-normalized by calculating a measure of the intensity across a larger region of the image, called a block, and then using this value to normalize all cells within the block. This normalization results in better invariance to changes in illumination or shadowing [2].

Principal components analysis (PCA) is a very popular technique for dimensionality reduction. Given a set of data on n dimensions, PCA aims to find a linear subspace of dimension d lower than n such that the data points lie mainly on this linear subspace. Such a reduced subspace attempts to maintain most of the variability of the data [3].

In this paper, we used HOG descriptors and PCA for object recognition in very small images where firstly we use HOG to extract features from the images at different scales and then apply PCA to reduce the dimensionality of these feature vectors.

II. OVERVIEW OF THE METHOD

Histogram of Oriented Gradients measures the occurrences of different gradient orientations within a local neighborhood of an image. Each pixel within a cell (local neighborhood) contributes with a weighted vote for an orientation histogram channel based on the values found in the gradient computation. A group of spatially connected cells are called a block where the gradient strengths are locally normalized within each block to account for changes in illumination and contrast [4].

In this work, a dense HOG feature extraction was used, this means that HOG features extraction covered the whole image. Moreover, different scales, i.e. different block and cell sizes, of HOG features were extracted simultaneously over different sizes of the image and therefore represent different face sizes, see Fig.1.

Using a different cell size is the key point to extract an adequate amount of information to construct a good descriptors of different image sizes. Five cell sizes (8, 5, 3, 2 and 1 pixels) were used to extract HOG features from six different image sizes (112*92, 68*56, 41*34, 25*21, 15*13 and 9*8 pixels) to investigate the influence of changing the cell size on recognizing faces in tiny images.

Fig.2 shows a visualization of HOG features extracted from images of size 15*13 using different cell sizes.

In order to reduce the descriptor size and avoid over-fitting resulting from feature redundancy, a feature selection technique had to be used.

The set of values resulting from feature extraction from all face images is then processed by the PCA algorithm and the results are fed into Nearest Neighbor classifier that uses Euclidean distance to measure the distance (matching degree) between different feature vectors (subjects/classes).

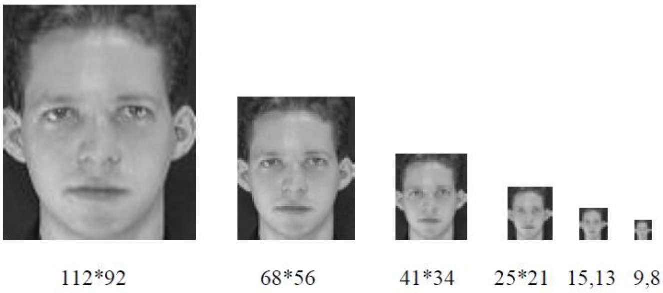

Fig.1. Sample of image sizes used for training and testing

Nearest Neighbor algorithm assigns a class to a given sample based on the dominant class of the nearest neighbor of the given sample in the feature space. The recognition results were presented as the average correct recognition rate.

III. EXPERIMENTAL DATA AND RESULTS

A. Database

ORL Database of Faces were used in the experiments of this paper. There are ten different images of each of 40 distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses). All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement). Five images per person were used for training (200 images for training) and five images for testing (200 images for testing). Both training and testing sets were resized for five times with a percentage of 0.6 starting with the original image size (112*92 pixels) ending with the smallest scale (9*8 pixels), which means that the system was trained on 1200 images and tested on the same number of images.

Also, the cell size was rescaled four time with same percentage to get five different cell sizes (8,5,3,2 and 1 pixels).

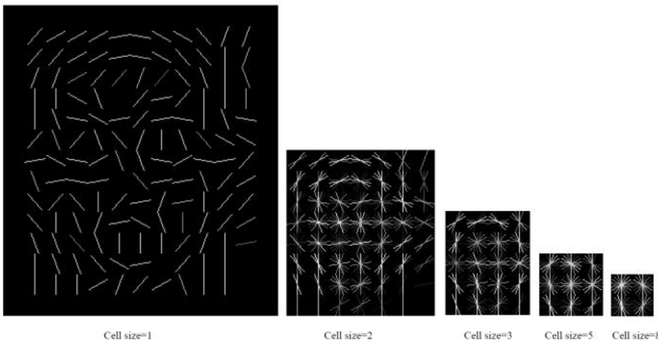

Fig.2. HOG features of 15*13 image using different cell size

Table.1. Experimental results

Cell size / Image size	1	2	3	5	8
112*92	58%	78%	80.5%	81%	83.5%
68*56	72.5%	81.5%	83%	85%	86%
41*34	78%	85.5%	85%	89.5%	50%
25*21	80.5%	88.5%	91%	65%	26%
15*13	79%	86.5%	64%	32%	15.5%
9*8	67.5%	42%	26%	10.5%	8.5%

B. Experimental results

The main goal of this work is to recognize faces in very small images where the face details are not so distinguishable, see Fig.1. The other goal is to investigate the influence of using small cell size to extract HOG features in order to achieve that. Fig.2 shows that by using small cell size, HOG descriptor gives a fairly good description of tiny images.

In this paper we use VLFeat function vl_hog to extract HOG features from images[5], then we concatenate these features into 1D vectors to construct the training data matrix. The training data matrix processed by the PCA algorithm to reduce the high dimensionality of that matrix then the results are fed into Nearest Neighbor classifier that uses Euclidean distance to measure the distance between different feature vectors.

Table.1 shows the recognition rate of using HOG descriptors with different cell sizes to recognize face at different image scales. The results show that the system gives a comparable recognition rate of faces at very small size with a low resolution where the face details are quite difficult to be distinguished even by human's eyes, see Fig.3.

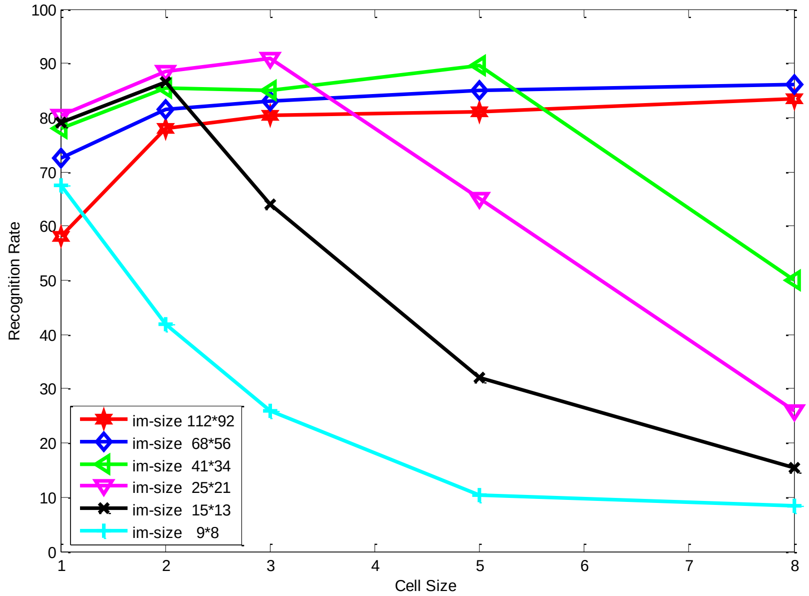

Fig.3.Recogntion rate of all different images scales using different cell size

IV. CONCLUSIONS AND DISCUSSION

From the results we can conclude the following:

1- The proposed method gives a very good recognition rate especially in small images (smaller than 41*34), and quite good result in medium and large image size.

2- Using small cell size to extract HOG features from tiny images improves the robustness of the system, but that doesn't work with large images which means an adequate cell size must be used to construct a good image descriptor depending on the image size.

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