Dual Linear Regression Classification for Face Cluster Recognition

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1 Introduction

This project deals with the following face cluster recognition problem: Given a galley set consists of a number of face image clusters, each containing the images of a known subject/identity; a probe cluster to be recognize contains a number of images of one subject; We are to match the probe cluster with the gallery set in order to determine the identity of the probe subject. The project is based on this paper. This should be taken to be a typical image set based face recognition problem and in this case it is LFW face database.

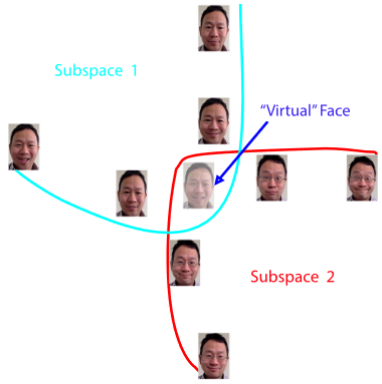

Figure 1: A "virtual" face in the intersection of two subspaces

The simple but efficient linear regression based classifi- cation (LRC) approach was developed by Maseem, Togneri and Bennamoun. It gave the algorithm for face recognition using linear regression.

Dual linear regression based classification (DLRC) algorithm generalizes the LRC ap- proach for the face cluster recognition problem. When com- paring two clusters of face images, we define the similarity between two clusters as the shortest distance between the subspaces each spanned from the face images of one cluster. In order to do so, DLRC attempts to find a virtual face image located in the intersection of the subspaces spanning from both clusters of downscaled face images (See Figure 1). The distance between the virtual face images recon- structed from both subspaces is then taken as the distance between these two subspaces. And the minimum distance found between the subspaces gives us the identity of the face.

2 State-of-the-art (Literature Survey)

Face recognition is a very important task in the fields of pattern recognition and computer vision because of its immense possible applications ranging from simple camera filters to needs in security. And their performance relies on the classifier used. A number of face recognition classifiers have been proposed. The most accurate ones are the following classifiers.

2.1 Face recognition classifiers

These classifiers use a single test sample for classification. Their classification performance, however, is generally dependent on the base or representation of individual test samples.

2.1.1 Linear Regression Classifier (LRC)

In this proposed classifier it is assumed that samples from a specific object class are known to lie on a linear subspace. This concept is used to develop class-specific models of the registered users simply using the downsampled gallery

images, thereby defining the task of face recognition as a problem of linear regression.

Least-squares estimation is used to estimate the vectors of parameters for a given probe against all class models. Finally, the decision rules in favor of the class with the most precise estimation. The proposed classifier can be categorized as a Nearest Subspace (NS) approach.

2.2 Face Cluster Recognition classifiers

Recently, researchers paid more attention to the image-set(Face images cluster) based classification which is much more accurate than any Face recognition classifiers. They use multiple test samples of the same class to form a cluster and used in classification.

2.2.1 Dual Linear Regression Classifier (DLRC)

For face cluster classification tasks, dual linear regression classification (DLRC) was proposed as a non-parametric approach. It borrows the idea of LRC and extends LRC from the single-query-sample based method to the image set/cluster based method. DLRC has a demonstrated better performance than a few well-known methods. However, DLRC considers only the related class-subspace for classification. That is to say, it pays attention only to minimizing the distance between the query set and the related train set.

2.2.2 Pairwise Linear Regression Classifier (PLRC)

PLRC and DLRC both follow the idea of restructuring the virtual sample of two image set for classification, and use the metric of the test set and the related train set.

However as an improved version of DLRC, PLRC introduces the new unrelated subspace to maximize the distance between the query set and the unrelated images set, and utilizes a new combined metric that integrates a related metric and a new unrelated metric for classification.

2.3 Tackling Curse of Dimensionality

Face recognition systems are known to be critically dependent on manifold learning methods. A gray-scale face image of an order a $\times$ b can be represented as an ab-dimensional vector in the original image space.

However, any attempt at recognition in such a high dimensional space is vulnerable to a variety of issues often referred to as the curse of dimensionality. Therefore, at the feature extraction stage, images are transformed to low-dimensional vectors in the face space using downsampling. The main objective is to find such a basis function for this transformation which could distinguishably represent faces in the face space.

3 Proposed Approach

3.1 Preprocessing Dataset

Firstly a subset of the dataset is extracted of persons having more than 20 face images. Also the images in lfw-a database are of the size 250×250. This includes the face and the background. Since background adds noise to the data we crop the images to the size of 90 ×78. These two things are done in the program filer.m .

Next, we partition the data. The first 10 images of each person are taken as training data and the last 10 images are used as train/probe set. This is done using the programs partition.m and partition_test.m .

3.2 Applying DLRC Algorithm

The DLRC classifier is using the algorithm given in the paper. This classifier is then used to predict the test/probe dataset. The accuracy is found out by -

$$Accuracy = (Correctpredictedclasses/Totalpredictedclasses) \times 100$$

This is all done in the program dlrc.m .

3.3 Changes done

Only two changes are done in this project.

Firstly, Instead of using downscaled images of sizes 10 ×10, the cropped images were used directly of sizes 90× 78. It was done because the accuracy obtained from the downscaled images was coming out very less (near to 25%).

Secondly there is a correction in the paper. The equation (9) -

$$r_1 = \hat{X}_c \left[\beta_1^c ... \beta_{N_c-1}^c\right]^T + x_{N_c}^c$$

$$r_2 = \hat{Z} \left[\beta_{N_c}^c ... \beta_{N_c+n-2}^c\right]^T + y_n$$

These equations are incorrect as there should not be transpose of β. It is wrong because the order of $\hat{X}_c$ is q×9 where q is size of each image and the order of $\left[\beta_1^c ... \beta_{N_c-1}^c\right]^T$ is 1×9. And we cannot multiply two matrices of the order q×9 and 1×9.

So the correct equation is -

$$r_1 = \hat{X}_c \left[\beta_1^c ... \beta_{N_c-1}^c\right] + x_{N_c}^c$$

$$r_2 = \hat{Z} \left[\beta_{N_c}^c ... \beta_{N_c+n-2}^c\right]^T + y_n$$

4 Result

4.1 Database

For DLRC, the database used for performance tests was LFW face database.

LFW face database were captured in unconstrained environments such that there will be large variations in face images including pose,age, race, facial expression, lighting, occlusions, and background, etc. We use the aligned version of

the LFW database, LFW-a database, to study the performance of the proposed classifiers.

All the images in LFW-a database are a size of 250 × 250. And for concentrating just on the faces and not the background, the images were cropped into a size of 90 ×78. A subset of LFW contains 62 persons, each people has more than 20 face images, is used for evaluating the algorithms. And in that, 10 images of each subject are selected to form the training set, while the last 10 image are used as the probe images.

4.2 Evironment used for Implementation

The operating system used is Windows 8.1 and programming is done on the software - MATLAB R2014a.

4.3 Evaluation Criteria

The testing is done by passing the 62 face clusters (each having 10 images of the same person) from the test/probe set one by one to the DLRC classifier. And the predicted class is compared with the actual class of that cluster.

4.4 Observations

- Correct predictions = 58
- Total predictions = 62
- Accuracy of the DLRC classifier = 93.55%

5 Conclusion

The Dual Linear Regression based Classifier (DLRC) for Facecluster Recognition MATLAB program was able to achieve the benchmark accuracy range given in the paper. The benchmark accuracy was in the range of 91.94% to 95.16% depending on the downscaled image size used. And the prediction accuracy of my program was 93.55