EFFECT OF COMPRESSION ON FACE RECOGNITION

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ABSTRACT

Multimedia systems have a need to deal with compressed information - images, audio, and video. Face recognition research has focused mainly on recognition using uncompressed images. Research in multimedia has addressed face recognition in compressed domain mainly for computational efficiency. However, in many practical systems, there can be a mismatch between training and test scenarios: systems can be trained on uncompressed images and tested with compressed images. In this paper we systematically study the effect of testing on *JPEG compressed* images. Though the images are compressed, recognition is performed in the pixel domain. We conclude that illumination effects are the major obstacles when recognition is performed on compressed images. Local Histogram Enhancement (LHE) is marginally better that Global Equalization (GE) in this task.

1. INTRODUCTION

Face recognition is currently one of the most sought after applications of computer vision – especially for surveillance. Face recognition is usually performed under the supervised learning paradigm in which the system is trained using a set of training examples. During recognition, another face is supplied. Training can be performed under controlled conditions. In an application scenario – in an office, for example – the images for training can be obtained at desired resolution, illumination, etc. The test scenario is less constrained. Surveillance cameras usually have low resolutions (for reasons of cost), store the images in compressed format, illumination cannot be precisely controlled etc.

In this paper, we explore the effect of using compressed images at recognition time on a system which is trained on uncompressed images. Note that we used "compressed images" but perform recognition in the "pixel domain" and not "compressed domain". While compressed domain face recognition has been studied in multimedia – see [1] [2], for example – the use of compressed images only in recognition has received less attention. In this paper, we study the effect of compression on face recognition. In FERET terminology, we use uncompressed gallery images and compressed probe images for various recognition tasks. The performance is studied as a function of JPEG quality factor.

This paper is organized as follows. Section 2 provides a brief discussion of face recognition techniques. In section 3 different FERET recognition tasks are discussed. Section 4 contains the simulation methodology and results. The paper closes with a conclusion.

2. FACE RECOGNITION

A variety of techniques have been developed for face recognition – from vector space approaches to probabilistic techniques. These techniques can be broadly categorized into two classes: template matching based systems and geometrical feature based systems. Template matching systems mostly captures the global features of the images. Support Vector Machines (SVM) [3], Linear Discriminant Analysis (LDA) [4] [5], Principal Component Analysis (PCA) [6], Probabilistic Bayesian Matching [7] [8], etc. are some of the methods in this approach.

The geometrical feature based approaches [9] [10], on the other hand, try to find certain attributes in the image like shape, colors or facial features. Some of the recent approaches use 3D information to model variations in pose and illumination [11] [12].

The face recognition task is affected by various factors like, face pose, illumination, expression, occlusion, and ageing. Apart from this the quality of image like compression and resolution also affects the face recognition task. Compression of images can be viewed as low pass filter, where the compression is achieved by eliminating high frequency information at the same time preserving low frequency information. The compression experiments conducted in Facial Recognition Vendors Test-2000 (FRVT) [13] evaluation shows that the compression of facial images does not necessarily adversely affect performance. This suggests that the low frequency information plays an important role in face recognition. We study the effect of compression on all FERET tasks and conclude that the above conclusion does

Evaluation Task	*Probe Name*	*No of images*
Aging of subjects	DUP1 (Duplicate I)	722
Aging of subjects	DUP2 (Duplicate II)	234
Facial expression	FAFB	1195
Illumination	FAFC	194

Table 1. FERET test tasks.

not hold for illumination task.

3. FERET RECOGNITION TASKS

The testing probe sets are divided into four sets according to FERET test protocol 1996 [14]. Table 1 gives the division and terminology. DUP-I probes were obtained anywhere between one minute and 1031 days after their gallery matches. DUP-II images were taken at least 18 months after their gallery entries. FAFB probe set captures the effect of facial expression and FAFC probe set represents changes in illumination.

The FRVT-2000 evaluation carries out compression experiments to estimate the effect of lossy image compression on the face recognition algorithms. The study represents the situation where gallery images are uncompressed images but the probe sets contain compressed images. The compression was achieved by setting appropriate quality value on the JPEG compressor.

The gallery used for these experiments was 1196-image FERET gallery. But the probe set consist of only FERET DUP1 set. The effect of compression on other sets like DUP2, expression changes (FAFB) and illumination changes (FAFC) was not evaluated. In fact, the FRVT 2000 Evaluation recommends that additional studies on the effect of compression on face recognition systems be conducted.

4. SIMULATION AND RESULTS

We evaluate the effect of compression by considering the following case: gallery images are uncompressed images and probe images are compressed images with various compression quality.

Three recognition algorithms and two preprocessing schemes were used. The algorithms used for evaluation are:

Linear Discriminant Analysis This uses Fisher's Linear Discriminant to produce a linear transformations that emphasize differences between classes while reducing differences within classes [5]. The distance measure used is LDASoft [15].

PCA with Mahalanobis Cosine distance measure This is an angle measure between images in Mahalanobis space. The two images are first scaled by the sample standard deviation along each dimension and then the cosine of the angle between two images is computed [16].

The preprocessing algorithms tested are:

1. global histogram equalization (GE)

2. local histogram enhancement(LHE)

The following paragraph briefly discuss LHE.

4.1. Local Histogram Enhancement

As the effect of illumination is a local phenomenon in the facial images, the global equalization may not compensate properly for illumination changes. On the other hand, application of global histogram equalization locally, modifies the level sets of the image. This results in creation of spurious objects in the image. The level sets contain the basic information of an image and hence should be preserved [17]. Authors in [18] propose a new approach to local histogram equalization which enhances the contrast while preserving the level sets in the image. This is achieved by equalizing the histogram in all connected components within the pixel subranges of the image. But this approach shows an accumulation effect at the end points of intensity ranges. This accumulation effect is more pronounced for smaller connected components. To avoid this, we equalize the histogram in the range set instead of equalizing component wise which is represented by LHE.

We use CSU Face Identification Evaluation System 5.0 [16] to perform the experiments. All the images were preprocessed to normalize geometry and to remove background and hair. Both GE and LHE are performed outside the software. Figures 1 and 2 show the performance of LDA and PCA with Mahalanobis distance respectively. The JPEG quality factors used were: 40%, 60%, and 80%. The figures show the accuracy when top 50 ranks are considered. It can be seen that

1. For LDA (figure 1), the accuracy slightly increases with reduction in quality for three tasks: DUP1, DUP2, and FAFB. For FAFC (illumination task), GE results in a decrease in accuracy. With LHE, the performance is almost constant.

2. With PCA and Mahalanobis distance (figure 2), there is a slight increase in accuracy for DUP1 and DUP2 tasks. For FAFB and FAFC, the accuracy of GE is almost constant. In contrast, LHE performs better than GE for FAFC.

5. CONCLUSION

In this paper we have systematically explored the results of uncompressed gallery-compressed probe case. The experiments were performed on all four FERET tasks with two classifiers. We have shown that the behavior is different for illumination task (FAFC) and that LHE provides small advantage in this task.

We have also explored the case in which both gallery and probe are compressed images. The systematic increase in accuracy with decrease in quality is not observed in this case for all the tasks. The accuracies remain either flat or show small increase-decrease behavior. It is likely that local methods like Elastic Bunch Graph Matching, are more immune to compression. This needs to be investigated.

6. REFERENCES

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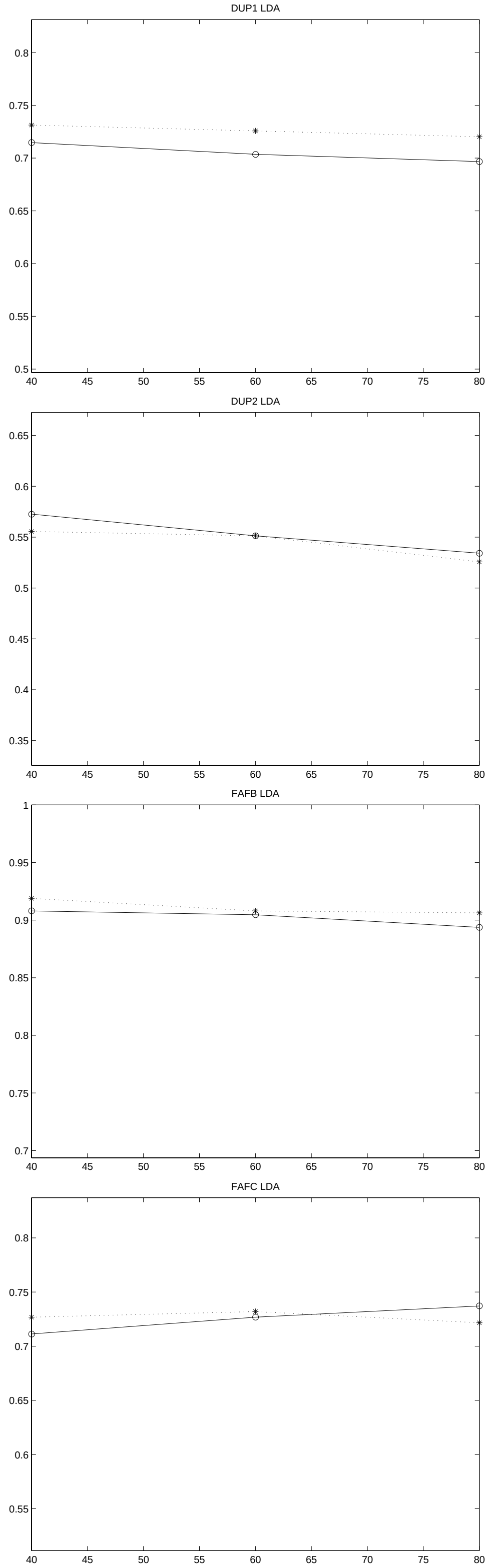

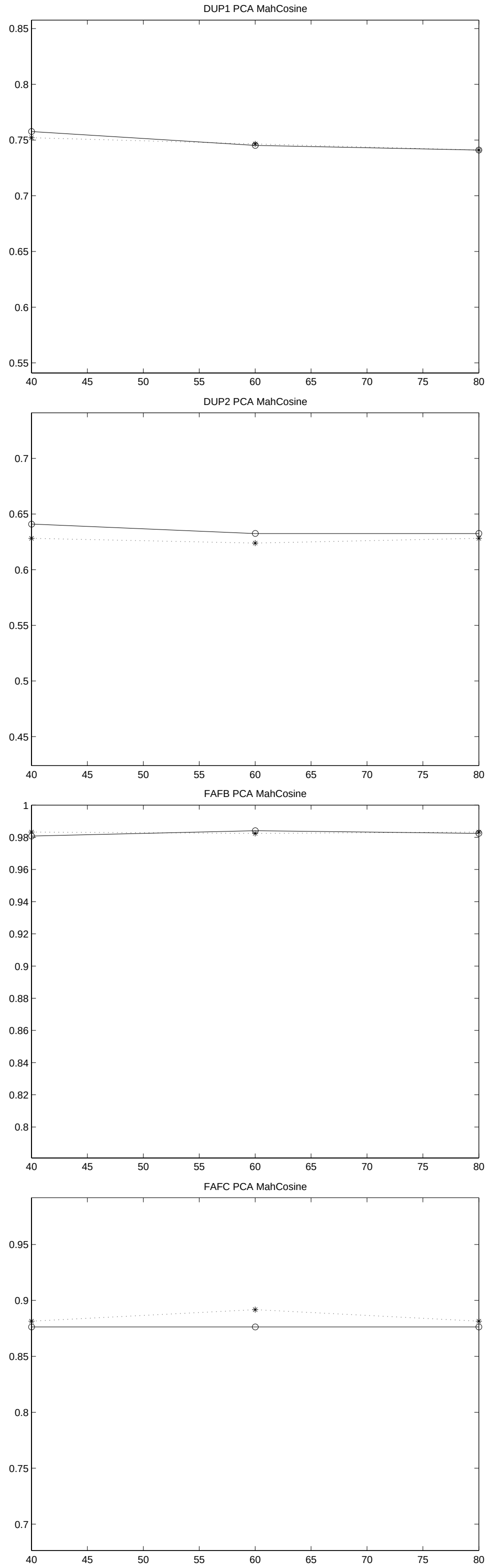

Fig. 1. Performance of LDA. The graphs show the accuracy of correct recognition at rank 50. The continuous line represents GE and the broken line LHE.

Fig. 2. Performance of PCA with Mahalanobis distance. The graphs show the accuracy of correct recognition at rank 50. The continuous line represents GE and the broken line LHE.