

Effect of Edge Based Contours on Face Recognition

N.Suguna¹, T Anil Kumar Reddy², G.Suresh³Assistant Professor, Department of ECE, S V College of Engineering, Tirupati, A.P, India^{1,2,3}

ABSTRACT: This paper provides an insight into the effectiveness of edge detection algorithms as a method to enhance the performance of a correlation filter in face recognition application. Correlation filters are a class of pattern classifiers that makes the classification based on the Fourier magnitude spectrum of the images. CMU-PIE expression set is used for the experiments. We found that edge detection algorithms enhance the performance of correlation filters considerably. This was also established by the mean entropy scores of edge detected images. The reason for the improvement in the performance would be the narrowing of the magnitude spectrum spread in edge detected face images.

KEYWORDS: Face recognition, correlation filters, edge detection algorithms.

I. INTRODUCTION

Face recognition is an important non-invasive method for authentication of an individual and gains much significance in biometric applications. The fundamental concept of face recognition as stated by Zhao [1] can be generalised as follows: Given a video or still image of the scene, identify or verify one or more persons in the scene by utilising a stored database of faces. An attempt is made in this paper to study the relevance of edge information in face images for a system designed using Correlation Filter [2]. The performance of a specific kind of Correlation Filter called the Minimum Average Correlation Energy (MACE) Filter [3], evaluated using database collected at the Advanced Multimedia Processing Lab at Carnegie Mellon University (CMU) [4].

Over the last decade, Face Recognition and Computer Vision in particular, have been two key areas which have been researched extensively. Apart from being the fundamental areas which have driven the developments in the field of Robotics and Machine Intelligence, it is also of the general perception that understanding computer vision would help us to decipher the way human brain works.

II. LITERATURE REVIEW

Fundamentally, face recognition can be classified into two main approaches – Holistic Approach and Feature Based Approach. Section 2.1 discusses holistic approaches in brief and Section 2.2 provides an insight into various feature based approaches that are reported in the literature.

A. HOLISTIC APPROACH

The Principal Component Analysis (PCA) procedure was presented by Turk and Pentland [5]. Given a high dimensional vector representation of each face image in a training set of images, PCA tends to find a lower dimensional subspace whose basis vectors correspond to the maximum variance direction in the original image space. New basis vectors define a subspace of face images called face-space. All images of known faces are projected onto the face space to find sets of weights that describe the contribution of each vector. To identify an unknown image, that image is projected onto the face space as well to obtain its set of weights. By comparing a set of weights for the unknown face to sets of weights of known faces, the face can be identified.

Linear Discriminant Analysis (LDA) as reported [6] finds the vectors in the underlying space that best discriminate among classes. A between class matrix and within class matrix are computed. The ratio of determinants of these matrices is taken and the objective is to maximize this ratio. Holistic approaches primarily analyse the image as a

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

whole instead of separating the background and foreground, the performance of the same is found in the literature [7][8]. Although this approach is primitive, simple to implement and the least computationally intensive method of face recognition, it is also least tolerant to noise.

B. FEATURE BASED APPROACH

In order to account for the decreased performance of holistic approaches in cluttered scenes as reported by [7], several feature based approaches were developed. In this section we mainly discuss Gabor Based approach and Sparse Encoding technique. Face recognition using Gabor feature [9][10] is performed by modulating a Gaussian kernel function in spatial domain by a sinusoidal plane wave. A more robust Sparse Encoding technique [7] for face recognition is performed by converting a full matrix of face image into sparse form by eliminating any non-zero entity and directing the resultant to zero. Motivated by the performance of feature based approaches [11] coupled with the effectiveness Sparse Encoding [7], we intuitively perceived that an image with only edge information would be more sparse, thereby increasing the PSR value [2] of the correlation filter output and enhancing the face recognition characteristics of the system.

III. CORRELATION FILTER

A. INTRODUCTION

Object recognition using correlation filters is performed by cross-correlating an input image with a synthesised template or filter developed from a set of training images or database and processing the resultant correlation output. Figure 1 represents the schematic process of the efficiently implementing cross-correlation using Fast Fourier Transforms (FFTs) [2].

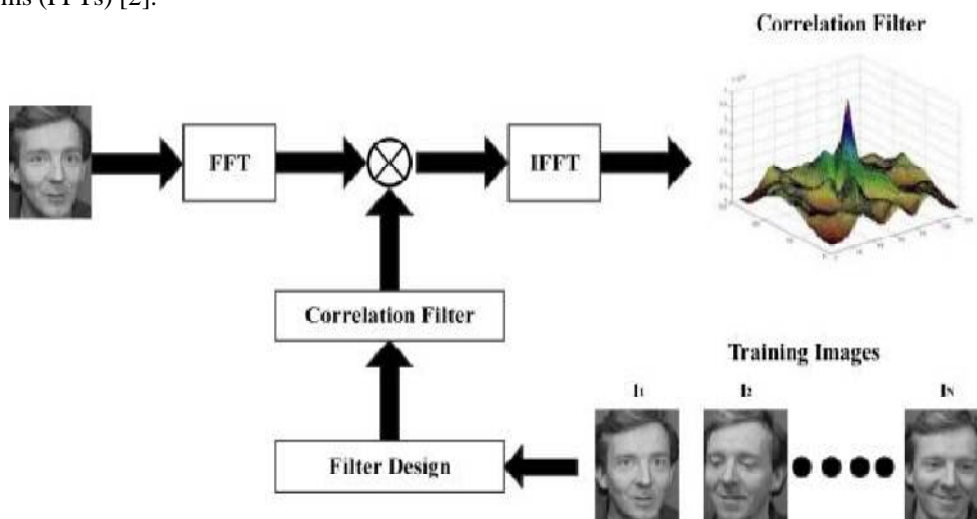


Figure 1. Block diagram of MACE Correlation Filter

The most extensively used basic correlation filter is Matched Spatial Filter (MSF), whose spread spectrum impulse response in 2-D is an inverted version of the of the reference image. Although the MSF is reported to outperform [12] holistic based recognition approaches by detecting a reference image corrupted by white noise, it fails to perform when the reference image is subject to distortions (rotations, scaling etc.). Hence to comprehensively detect an object, one MSF will have to be developed for each appearance of the object, which is not computationally viable. Synthetic discriminant function (SDF) filter [13] was developed to address the challenge of MSF. To eliminate the unmerited presence of large sidelobes which are developed in ECP SDF filter, Mahalanobis [3] developed the Minimum Average Correlation Energy (MACE) filter. MACE filter minimizes the average correlation energy (ACE) of

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

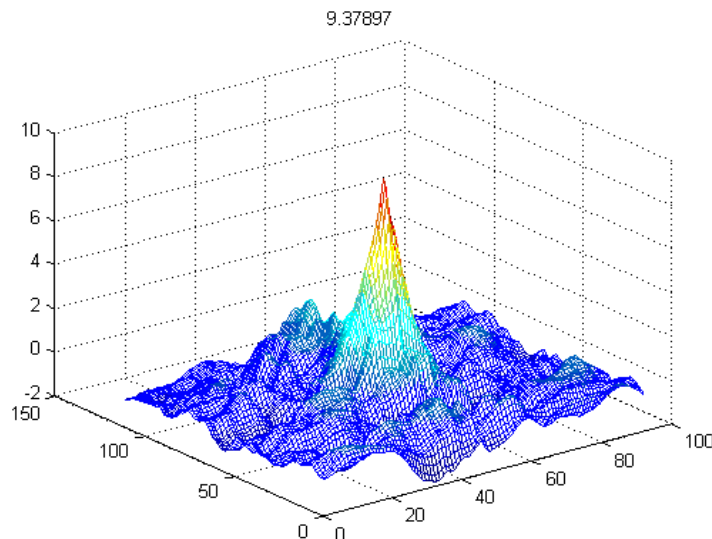
the correlation outputs due to the training images while simultaneously satisfying the correlation peak constraints at the origin. The effect of minimizing the ACE is that the resulting correlation planes would yield values close to zero everywhere except at the location of a trained face, where it would produce a strong peak. The resulting MACE filter is as follows in a vector form:

$$hmace = D - 1X(X + D - 1X)c \quad (1)$$

Assuming we have N training images from the true class, with each image having d pixels in it. 2-D FFTs are performed on these images which are further converted into 1-D column vectors by lexicographic ordering. These vectors are the column vectors of the $d \times N$ matrix \mathbf{X} in Eq.(1). Column vector \mathbf{c} with N elements contains the prespecified correlation peak values of the training images and the $d \times d$ diagonal matrix \mathbf{D} contains along its diagonal the average power spectrum of the training images (i.e., average of the magnitude squares of the columns of \mathbf{X}). Note that the synthesized \mathbf{hMACE} is a column vector with d elements and the 2-D correlation filter is obtained by reordering the column vector back to a 2-D array. MACE filter is quantitatively evaluated using the Peak to Side lobe Ratio (PSR). The peak sharpness of the curve is measured using the Peak to Side lobe Ratio (PSR) as defined below.

$$PSR = \frac{\text{peak} - \text{mean}}{\sigma} \quad (2)$$

The PSR is the ratio of (peak-mean) to standard deviation as shown in Eq. (6). Figure 3 (Top) depicts a typical correlation output for an authentic face image with a positive PSR value, while Figure 3 (Bottom) depicts a typical correlation output for an impostor face image with negative PSR value .



International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

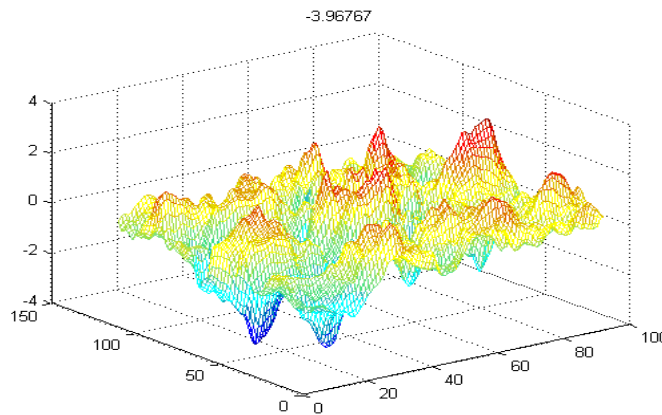


Figure 3. Correlation Filter Output using MACE filter designed for Subject X. (Top): Correlation output for an authentic face of Subject X with positive PSR value. (Bottom): Correlation Output for an imposter face not belonging to Subject X with negative PSR value.

B. SUMMARY

The MACE filter by itself is inherently robust, tolerant to a high degree of noise and presents a fairly reasonable accuracy for face recognition. The fact that can better be comprehended by Figure 4, in which a texture-based image and edge-based image are analysed using Fourier Transform respectively. Figure 4 (Right) represents the magnitude of the Fourier Spectrum for a texture-based image, which is characterised by a broad spectrum coupled with a low PSR value. This feature increases the probability of misclassification. Figure 4 (Left) represents the magnitude of the Fourier Spectrum for an edge-based image, which is characterised by a limited spectrum and high PSR value. Thus, by limiting the spectrum of the image under analysis coupled with a high PSR value, the performance of the system is enhanced. Hence, this paper presents a novel method of incorporating an Edge-Based filter to the MACE filter for optimal face recognition.

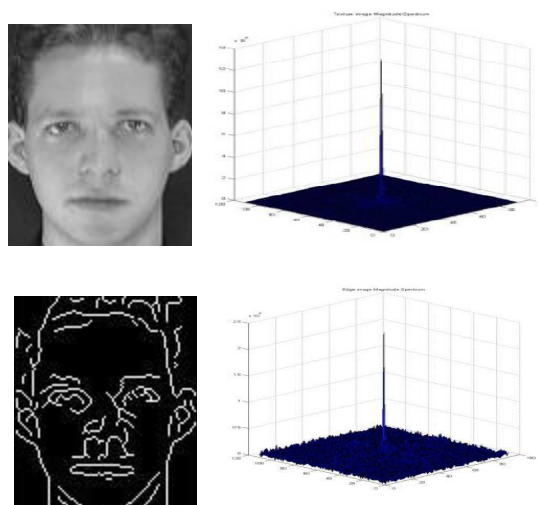


Figure 4. (Top): Fourier Spectrum Magnitude of Texture-Based Image. (Bottom): Fourier Spectrum Magnitude of Edge-Based Image.

IV. EXPERIMENT

A. DATABASE

The computer simulations described in this paper was implemented using the facial expression database collected at the Advanced Multimedia Processing (AMP) Lab at the Electrical and Computer Engineering Department of Carnegie Mellon University [4]. The database consisting of 40 subjects with 10 images each, whose facial images were captured with varying expressions. The faces were captured in a video sequence, where a tracker [14] tracked the movement of the user’s head based on an eye localisation algorithm and extracted registered face images of size 12x92.

B. EDGE DETECTION ALGORITHMS

For the experiments, we utilised and evaluated 3main edge detection algorithms: Roberts, Sobel and Canny. Roberts Edge Detection algorithm is based on the Roberts Cross [15]. It is one of the earliest know edge detection algorithms which uses a differential operator to calculate the gradient of the image by computing the sum of the squares of the difference between diagonally adjacent pixels. Sobel Edge Detection algorithm [16] is a discrete differential operator which computes edges by convolving the images into smaller entities and further approximation of the gradient of the image intensity function. Canny edge detection algorithm [17] is the most extensively used method. The performance of Canny algorithm can be attributed to the use of calculus of variation technique – technique which finds a function which optimises a given functional. The mean entropy value of 400 images in the database was calculated, by subjecting each image to Roberts, Sobel and Canny edge detection algorithms. The results are as shown in Table 1. It was observed that the mean entropy value for Canny Edge Detection Algorithm was the highest, indicating the maximum probability of gray scale components. Hence, the use of Canny Edge Detector could enhance the performance of the MACE filter.

Algorithm	Mean Entropy
Canny Edge Detection	0.4699
Sobel Edge Detection	0.2419
Roberts Edge Detection	0.1893

Table 1: Mean Entropy values of various edge based face recognition systems

C. MODIFIED BLOCK DIAGRAM

The proposed system was implemented on MATLAB Simulink and evaluated using the CMUPIE database. A total of 40 subjects with 10 images, each measuring 92 pixels x 112 pixels were used as a database for the experiment, from which 30 subjects were classified as authentic users (also known as *true class*) and were assigned a peak constraint value of +1. The consecutive 10 subjects were classified as imposters (also known as false class) and were assigned a peak constraint value of -1. The same database was implemented on the proposed system, using holistic approach (texture based) and several edge-based feature approaches (Roberts, Sobel and Canny edge detection filters).

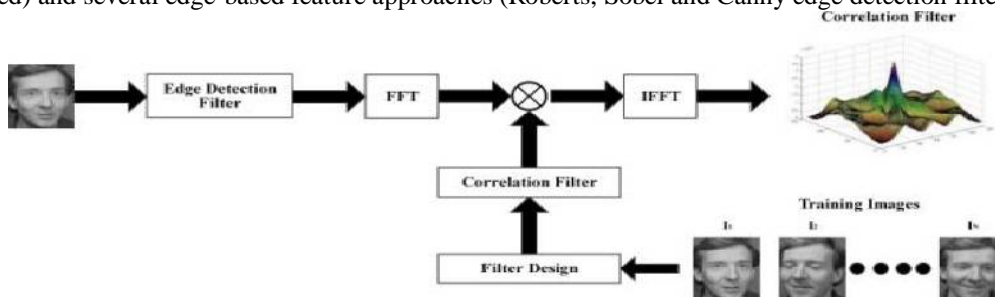


Figure 5. Block diagram of modified MACE Correlation Filter

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

D. RESULTS

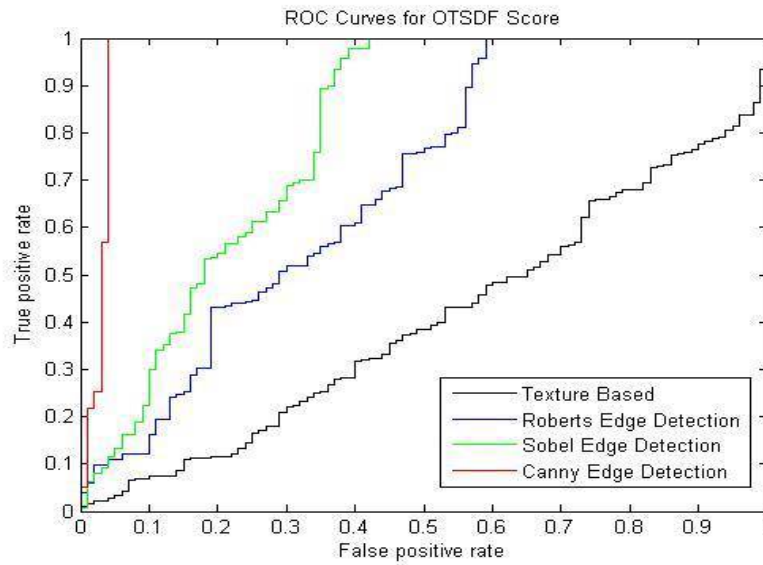


Figure 6. Plot of ROC curves for OTSDF score

Type	AUC
Texture Based	0.4005
Roberts Edge Based	0.6911
Sobel Edge Based	0.7958
Canny Edge Based	0.9709

Table 2: Area Under Curve values for various facerecognition systems implemented using MACE filters.

The Optimal Trade-off Synthetic Discriminant Function (OTSDF) score was recorded for each experiment and a comprehensive Receiver Operating Characteristics (ROC) curve was plotted as shown in Figure (6). The ROC curves which characterise the relation between the true positives (authentic users) and false positives (imposter users) have been used as the standard for comparison of efficiency of various systems. The area under the curve (AUC) value is directly proportional to the efficiency of the system. From the ROC curves as shown in Figure (6), the AUC values were tabulated as in Table 2.

V. CONCLUSION

The study of the paper was to test the effectiveness of edge detection algorithms on face recognition using correlation filter. There were some interesting results that were obtained. We further explored the effect of edge detection algorithms and found that the Shannon entropy of edge detection algorithms. The results are tabulated in Table 1. The probable reason for the increase in the performance of the correlation filter would be that the magnitude spectrum of the face image appears to be sparse and to train the filter on a set of equally sparse matrices would add to the randomness of the classifier. On the other hand, the edge detected face image spectrum exhibits non-sparse nature and hence would increase the performance. The second major conclusion that can be drawn from the experiment is the texture information spreads the spectrum across as the data has many gray levels. Edge contour based algorithms contain only binary images and hence localize the magnitude spectrum there by increasing the chances of obtaining higher PSR in correlation filter classification.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

To test the robustness of the algorithm, the system may be subject to noisy edges or low resolution images. Further it may also be subject to pose or illumination variation, non-specificity of face in large low resolution cluttered environment for better evaluation of the face recognition system. Future scope of this work would include implementation and analysis of non-linear transforms for face recognition systems.

REFERENCES

- [1] W. Zhao, R. Chellappa, J. Phillips, and A. Rosenfeld, "Face recognition in still and video images: A literature survey", *ACM Computer Survey* 35 (2003), 399–458.
- [2] Savvides, Marios, BVK Vijaya Kumar, and Pradeep Khosla. "Face verification using correlation filters." *3rd IEEE Automatic Identification Advanced Technologies* (2002):56-61.
- [3] A. Mahalanobis, B.V.K. Vijaya Kumar, and D.Casasent, "Minimum average correlation energy filters," *Appl. Opt.* 26, pp. 3633-3630 (1987).
- [4] Sim, Terence, Simon Baker, and Maan Bsat. "The CMU pose, illumination, and expression (PIE) database." *Automatic Face and Gesture Recognition*, 2002. Proceedings. Fifth IEEE International Conference on. IEEE, 2002.
- [5] Turk, Matthew, and Alex Pentland. "Eigenfaces for recognition." *Journal of cognitiveneuroscience* 3.1 (1991): 71-86.
- [6] Belhumeur, Peter N., João P. Hespanha, and David J. Kriegman. "Eigenfaces vs. fisherfaces: Recognition using class specific linear projection." *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 19.7 (1997): 711-720.
- [7] Wong, Yongkang, et al. "On robust biometric identity verification via sparse encoding of faces: Holistic vs local approaches." *Neural Networks (IJCNN), The 2012 International Joint Conference on.* IEEE, 2012.
- [8] Kresimir Delac, Mislav Grgic, Sonja Grgic, "Independent Comparative Study of PCA, ICA, and LDA on the FERET Data Set".
- [9] Liu, Chengjun, and Harry Wechsler. "A Gabor feature classifier for face recognition." *Computer Vision, 2001. ICCV 2001.Proceedings. Eighth IEEE International Conference on.* Vol. 2. IEEE, 2001.
- [10] Liu, Chengjun, and Harry Wechsler. "Gabor feature based classification using the enhanced fisher linear discriminant model for face recognition." *Image processing, IEEE Transactions on* 11.4 (2002): 467-476.
- [11] Hjeltnäs, Erik, and Boon Kee Low. "Face detection: A survey." *Computer vision and image understanding* 83.3 (2001): 236-274.
- [12] Kumar, B. V. K. V., et al. "Spatial frequency domain image processing for biometric recognition." *Image Processing. 2002. Proceedings. 2002 International Conference on.* Vol. 1. IEEE, 2002.
- [13] C. F. Hester and D. Casasent, "Multivariate technique for multiclass pattern recognition," *Appl. Opt.* 19, pp.1758-1761 (1980)
- [14] F. J. Huang and T. Chen, "Tracking of Multiple Faces for Human-Computer Interfaces and Virtual Environments", *IEEE Intl. Conf. on Multimedia and Expo.,* New York (2000).
- [15] R.Gonzalez, R.Woods – "Digital Image Processing"-3rd Edition
- [16] Sobel, Irwin, and Gary Feldman. "A 3x3 isotropic gradient operator for image processing." (1968).
- [17] Canny, John. "A computational approach to edge detection." *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 6 (1986): 679-698.