Algorithm for Face Matching Using Normalized Cross-Correlation

C. Saravanan, M. Surender

Abstract— ***Face matching is the most important and crucial procedure in face recognition. It is difficult to achieve robust face matching under a wide variety of different image capturing conditions, such as lighting changes, head-pose or view-angle variations, expression variations, etc. Robust face matching is essential to the development of an illumination insensitive face recognition system. This paper proposes a face matching algorithm that allows a template called extracted face of person which is the Region of Interest from one image and start search for matching with the different image of same person taken at different times, from different viewpoints, or by different sensors using Normalized Cross-Correlation (NCC). The algorithm is implemented in MATLAB. The experimental results show that developed algorithm is robust for similarity measure.***

Index Terms— Face Matching, Normalized Cross-Correlation (NCC), Region of Interest (ROI).

I. INTRODUCTION

Face matching is the most important and crucial procedure in face recognition. It is difficult to achieve robust face matching under a wide variety of different image capturing conditions, such as lighting changes, head-pose or view-angle variations, expression variations, etc. Robust face matching is essential to the development of an illumination insensitive face recognition system.

There have been a number of methods proposed to achieve robust face recognition under different illumination conditions. They can be roughly classified into three approaches; namely, the feature-based approach [14], [17], [11], [13], the appearance-based approach [15], [16], [4], [5], and a mixed approach [18], [10]. In the feature-based approach, it requires the extraction of the face feature points robust against illumination variations. Extracted face edge maps are then compared based on holistic similarity measures, such as the Hausdorff distance [12]. Many methods have been presented for robust feature point extraction from face images. For example, attention points are selected as the feature points through the analysis of the outputs of the Gabor filtered images. Points of maximum curvature or inflection points of the shape of the image function were used as the face feature points in [4]. For the comparison of edge maps, an affine coordinate based reprojection framework was proposed to match dense point sets between two input face images of the same individual in [11]. In the appearance-based face recognition, the eigenface-based approach has been popular. To alleviate the illumination variation problem in the eigenface approach, it is common to ignore some of the most dominant eigenfaces in the eigenface representation [17], due to their strong relationship with illumination conditions. Recently, Georghiades et al. [13] proposed a new approach to comparing face images under different illumination conditions by introducing an illumination cone constructed from several images of the same person captured at the same pose under different illumination directions. Furthermore, Zhao and Chellappa [14] developed a shape- based face recognition system through an illumination- independent ratio image derived from applying symmetric shape-from-shading to face images. In the mixed approach, face recognition is achieved by using a face model consists of face shape as well as image intensity information.

In compared to above, this paper proposes a new face matching algorithm based on Normalized Cross Correlation for matching the faces.

II. LITERATURE SURVEY

Cross Correlation is the basic statistical approach to image registration. It is used for template matching or pattern recognition. Template can be considered a sub-image from the reference image, and the image can be considered as a sensed image. In [3] the authors has proposed a method of medical image registration by template matching based on Normalized Cross-Correlation (NCC) using Cauchy-Schwartz inequality. They have implemented the algorithm for template matching using NCC in MATLAB. The developed algorithm was robust for similarity measure. They have showed experimental results with medical images registration with noise and without Noise.

In [2] the authors has proposed a fast pattern matching algorithm based on the normalized cross correlation (NCC) criterion by combining adaptive multilevel partition with the winner update scheme to achieve very efficient search. This winner update scheme is applied in conjunction with an upper bound for the cross correlation derived from Cauchy–Schwarz inequality. To apply the winner update scheme in an efficient way, they have partitioned the summation of cross correlation into different levels with the partition order determined by the gradient energies of the partitioned regions in the template. Thus this winner update scheme in conjunction with the upper bound for NCC could

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be employed to skip unnecessary calculation. Experimental results showed the proposed algorithm has very efficient for image matching under different lighting conditions.

In [1], the author has proposed a combined approach to enhance the performance of template matching system using image pyramid in conjunction with Sum of Absolute Difference (SAD) similarity measure. Based on results it was found that the capabilities provided by the proposed method significantly improved the accuracy and execution time of template matching system. The experimental investigations were based on the use of color and gray scale images with different sizes and illumination.

The paper [5] has presented a robust and efficient matching method for face sequences obtained from videos. Face information is quite important especially for news programs, dramas, and movies. Face sequence matching for such videos enables many multimedia applications including content based face retrieval, automated face annotation, automated video authoring, etc. However, face sequences in videos are subject to variation in lighting condition, pose, face expression, etc., which cause difficulty in face matching. These problems were tackled to achieve robust face sequence matching applicable to real video domains, and its efficient implementation is presented. The paper proved the proposed method achieves good performance in actual video domains. In addition, by the combination with the high dimensional index structure, the algorithm achieved practical computational time, as well as scalability against increase of the number of faces.

In [6], the authors have presented a review of recent as well as classic image registration methods in paper "Image registrations method: A survey". The reviewed approaches were classified according to their nature (area based and feature-based) and according to four basic steps of image registration procedure: feature detection, feature matching, mapping function design, and image transformation and resampling. Main contributions, advantages, and drawbacks of the methods were mentioned in the paper. Problematic issues of image registration and outlook for the future research were discussed too. The major goal of the paper was to provide a comprehensive reference source for the researchers involved in image registration, regardless of particular application areas.

From the review of literature it is observed that the template matching algorithm based on Normalized Cross-Correlation is the best approach for matching the template with same image accurately. In this paper we proposed a face matching algorithm based on Normalized Cross-Correlation and used to matching the extracted face of the person from one image, with the different images of same person. The rest of this paper is organized as follows. We describe the proposed face matching algorithm in the next section. We show some experimental results in section 5, finally, we conclude in the last section.

III. CROSS-CORRELATION

Correlation is an important tool in image processing, pattern recognition, and other fields. The use of cross-correlation for template matching is motivated by the distance measure (squared Euclidean distance) [8], [9]

$$d_{f,t}^2(u,v) = \sum_{x,y}[f(x,y) - t(x-u,y-v)]^2 \qquad (1)$$

Where f is the target image and t is the feature, the sum is over x,y under the window containing the feature t positioned at(u, v). In the expansion of d^2

$$d_{f,t}^2(u,v) = \sum_{x,y}[f^2(x,y) - 2f(x,y)t(x-u,y-u) + t^2(x-u,y-v)] \qquad (2)$$

The term $\sum t^2(x-u,y-v)$ is constant. If the term $\sum f^2(x,y)$ is approximately constant, then the remaining cross-correlation term

$$c(u,v) = \sum_{x,y}[f(x,y)t(x-u,y-u) \qquad (3)$$

is a measure of the similarity between the image and the feature.

Normalized Cross-Correlation

There are several disadvantages to using (3) for template matching:

- If the image energy $\sum f^2(x,y)$ varies with position, matching using (3) can fail. For example, the correlation between the feature and an exactly matching region in the image may be less than the correlation between the feature and a bright spot.
- The range of c(u, v) is dependent on the size of the feature.
- Eq. (1) is not invariant to changes in image amplitude such as those caused by changing lighting conditions across the image sequence.

The correlation coefficient overcomes these difficulties by normalizing the image and feature vectors to unit length, yielding a cosine-like correlation coefficient

$$\gamma(u,v) = \frac{\sum_{x,y}[f(x,y) - f_{u,v}][t(x-u,y-u) - t]}{\{\sum_{x,y}[f(x,y) - \bar{f}_{u,v}]^2 \sum_{x,y}[t(x-u,y-v) - \bar{t}]^2\}^{0.5}} \qquad (4)$$

Where $\bar{t}$ is the mean of the feature and $\bar{f}_{u,v}$ is the mean of f(x, y) in the region under the feature. We refer to (4) as *N*ormalized Cross-Correlation.

IV. PROPOSED FACE MATCHING TECHNIQUE

Face matching system involved 2 stages of operation (1): First stage is the model registration which is concerned with the storage of an image with computer memory. (2): Second stage is the process of searching for an extracted face in an image. This study is mainly focused on the latter process of template matching system [6], [7].

The following is the face matching algorithm for matching the extracted face with the different images of same person, which are taken at different times, from different viewpoints, or by different sensors.

Algorithm

1. Read the source image, and Extract the ROI from the source face image. ROI will be the sub image, and must be smaller than the Target image.
2. Do Normalized Cross-Correlation and find Coordinates of Peak with the ROI and Target images. Calculate the normalized cross-correlation and display it as a surface plot. The peak of the cross-correlation matrix occurs where the sub images are best correlated.
3. Find the total offset between the images. The total offset or translation between images depends on the location of the peak in the cross correlation matrix, and on the size and position of the sub images.
4. Check if the face is extracted from the target Image. Figure out where face exactly matches inside of target image.
5. Pad the face image to the size of the target image using the offset determined in step 3.
6. Use Alpha blending to show images together. Display one plane of the face image with the target image using alpha blending.

The above detailed algorithm is also shown pictorially as shown in the fig 1.

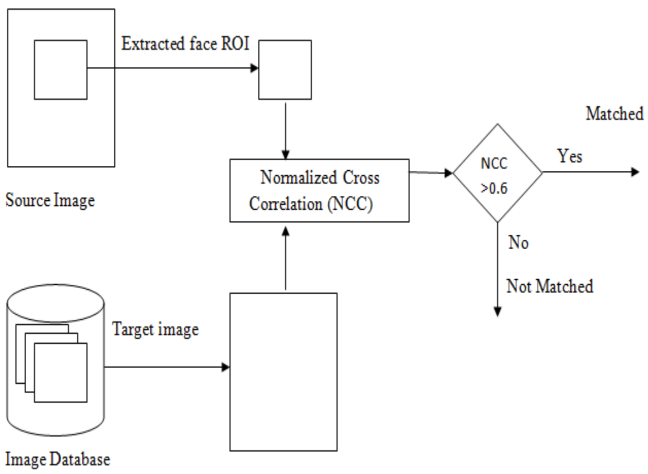


Fig 1: different stages of face matching algorithm for matching extracted face of the person from one image with different images of same person

V. RESULTS

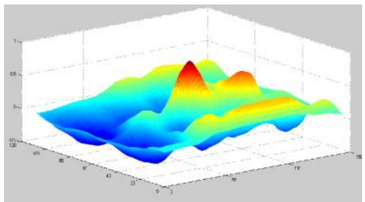
We present the results for the proposed algorithm. The experiments are conducted on color images of various sizes. Different sizes of faces are extracted from the source images by using Region of Interest, and search for matching with the different images.

First we have taken a source image of size 512X512 as shown in the figure 2(a), and an extracted face of size 80x80 from the source image by using Region of Interest as shown in the figure 2.(b). Target image of size 512x512 as shown in figure 2.(c) is chosen from the image database which consists of different images of same person taken at different times, from different viewpoints. Now select the sub region of both extracted face and target images. Finally Normalized Cross Correlation is performed on these images. Figure 2.(e) shows the perfect matching of extracted face with the target image with the maximum NCC value. The plot of NCC is also shown in a figure 2. (d).

Fig 2
(a)Source image

(b) extracted face(Region of Interest) from source image

(c)Target image



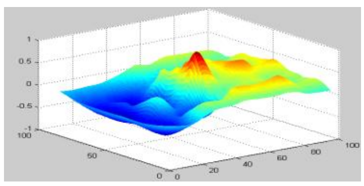
(d)NCC plot

(e)perfect matching of extracted face with target image

Fig 3
(a)Source image

(b)extracted face(Region of Interest) from source image

(c)Target image



(d)NCC plot

(e)perfect matching of extracted face with target image

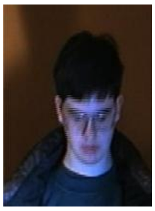
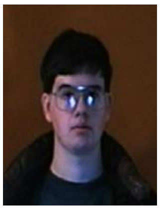
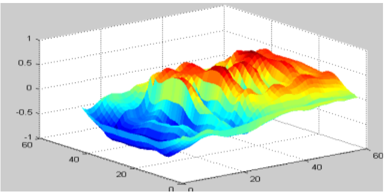


Fig 4
(a)Source image

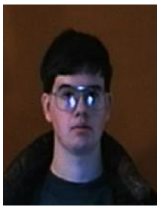
(b)extracted face(Region of Interest) from source image



(c)Target image



(d)NCC plot



(e)Not matched with the target image

Table 1: NCC value for different extracted faces (ROI) with different Target images

Sl. No.	Extracted face (ROI) size	Target Image	NCC value
1	60x80	Image 1 (512x512)	0.9996
		Image 2 (512x512)	0.9983
		Image 3 (512x512)	0.9995
		Image 4(512x512)	0.7357
2	75x85	Image 1 (512x512)	0.9997
		Image 2 (512x512)	0.9991
		Image 3 (512x512)	0.9995
		Image 4(512x512)	0.7125
3	85x100	Image 1 (512x512)	0.9997
		Image 2 (512x512)	0.9991
		Image 3 (512x512)	0.9895
		Image 4(512x512)	0.7287
4	95x115	Image 1 (512x512)	0.9997
		Image 2 (512x512)	0.9991
		Image 3 (512x512)	0.9895
		Image 4(512x512)	0.6983

Table 1 show that different sizes of extracted faces (ROI) are taken for matching with different target images and their NCC value is also given in the table. The first three images whose NCC value is greater than 0.9, and are perfectly matched with the extracted face images, but the last image in all four experiments, whose NCC value is less than 0.75, and is not perfectly matched with the target image due to low brightness or contrast, but we can consider for the match. From the above results, it is observed that the extracted face not matches with the target image, if its NCC value is less than 0.6.

VI. CONCLUSION

We have proposed a face matching algorithm, based on Normalized Cross Correlation for matching extracted face of person from source image with the different target images of same person. By observing the results, it is clear that Normalized Cross-Correlation (NCC) is the best approach for face matching. It gives perfect face matching in the given target image. The Maximum Cross-correlation coefficient values indicate the perfect matching of extracted face with the target image. This approach gives registered face image, if the sensed images do not have any rotation or scaling.

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