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Moment Invariants-Based Face Recognition

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Abstract— Face detection and recognition is a hot research area for more than a decade ago as they play an important role in many applications like identity resolve, security, personalization and so many others. Usually the detection process is isolated from the recognition stage. In this paper, the role of moment invariants is investigated regarding both face detection and face recognition and the focus will be on face recognition. The image or a window of an image is first converted to grey scale image. Then, a seven moment invariants are calculated for each window. This is followed by feature vector calculation for each window of interest. The classifier is then employed to recognize the under-check face/window. These moment invariants are invariant to scale change, rotation transformation, mirroring/pose reverse, and also invariant to translation. These characteristics proof that the proposed features of moment invariants are strong in object detection and recognition in general and in face detection and recognition, this proof is validated through the explained results in this work. The Yale face dataset is used to show the results of the proposed method.

Index Terms— Moment Invariants, Face Detection, Face Recognition, Scale Invariant, Rotation Invariant, Mirror Invariant, Translation Invariant, and Two Dimension Moments.

1 INTRODUCTION

THE rapid advances in the technological devices and the proliferation of these devices brings the demand of identity resolve, security, and personalization…etc. The identity resolve discusses who is/has doing/done what, who possesses what, who access what, so the main problem here is the recognition of the person, and by default one of the main distinguishing biometric is the human face. Also, the security is another domain of application which discuss who has the authority of doing something and it is also seeks for identity resolve. With the availability of huge number of products and applications, the personalization is needed to offer what is most likely to be asked by a person. The face provides a mean to recognize the person and so feed him/here with most liked products or applications.

The person identity can be resolved using a lot of biometric means. Fingerprint is usually used as they almost not repeated, and so can differentiate person from another. Also, palm print is used to distinguish people. There are a lot of biometric measures, but face has the advantages of no touch property, as it needs to a camera not sensors.

Face detection and recognition faces many difficulties. First problem is regarding the image acquisition and the related irregularities such as different illumination changes, different resolution of the camera, the zoom of the taken image and so on. Second is the angle of acquisition, which may be called pose, which adds another level of difficulty as many significant details may be disappeared. Third is the wearing of glasses, which may lead to big difficulties of person identification as it obscure the human eyes. All of these difficulties make the task of face detection and recognition is a challenging process.

The moment invariants are statistical features that have many advantages of interest to overcome the aforementioned difficulties, see Gonzales and Woods [1]. First, these features are translated invariant, which means whenever the face is in the image its values remains almost the same. Second, the moment invariants are invariant to rotation, which means whatever the angle of the photograph; the values of these measures are not changed. Third, they are invariant to scale, which means that whatever the zoom of the camera, or whatever the size of the face in the image, their values are almost not changed. Forth, the moment invariants are robust to mirroring of the object/face in the image as their values may suffer only a sign change without values change.

In this work, a proposed method of exploiting the moment invariants and its advantages in face recognition process is presented. Where the image or the window of interest is converted into gray level image as the color is not used in these measures. Then, seven moment invariants are calculated for each image or window of interest are calculated. The feature vector is then constructed by post-processing the pre-calculated moment and fed to the classifier to decide upon it. We use the Yale Face Database that contains 165 grayscale

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images of 15 individuals. There are 11 images per subject, one per different facial expression or configuration: center-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, sleepy, surprised, and wink, [2], see fig.1.

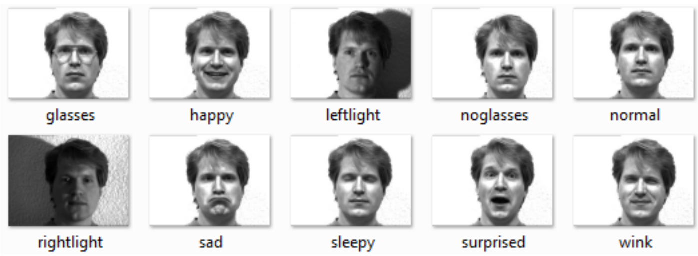

Fig. 1: different facial images for the same person.

Some of the state of the art of face recognition research work is presented in section 2. Then the proposed method is explained in section 3. The results are presented in section 4 followed by the conclusions and discussion in section 5. Finally the list of references is trailing the paper.

2 Related Work

Face recognition is a hot research area for more than a decade ago, [2]-[21]. For example, the work presented in [3], discusses a framework to improve the results of face recognition process through rotating the image for many angles and propose a cropping method to enhance the accuracy of the extracted features to be more representative. The Euclidean distance measure and Angle Cosine methods are used to measure feature vectors similarities.

And in [4], a method for face recognition is described after removing what is called obstacles through a Support Vector Machine classifier after dividing the underlying image into smaller regions, each region is checked separately for the occlusions. These obstacles are something like sunglasses. After detecting the occluded area(s), they are discarded and according to what are remained in the image the face recognition is done using what is called near set approach. While in [5], a method called “Non-Negative Sparse Low-Rank Representation Classification” is presented for getting better results for face recognition, which tries to make the features more discriminative. A similar idea to produce sparse features is also presented in [6] but using asymmetric kernel.

The authors of [7] present a hardware fueled system for face recognition based on images acquired using near infrared emissions to overcome the illumination changes in the ordinary images. Then after motion detection and interpolation the identity is resolved by hierarchical linear discriminant analysis based on face. A comparative review of different approaches for feature extraction in face recognition is presented in [8].

The work described in [9] discuses a face recognition algorithm that starts noise removal by with blurring the image by Gaussian of Laplacian with Median and Weiner filters, as the noise is usually a high frequencies. Then the Discrete Wavelet Transform and modified Discrete Cosine Transform are used for feature extraction. The Binary Particle Swarm Optimization is then utilized for feature selection. Finally, Euclidean classifier is used for face recognition from face gallery and the testing face feature vector. While in [10], a trial of combining sparse reconstructive information and local preserving information together to project the input high-dimensional image into a low-dimensional feature vector for face recognition. The research explained in [11] describes a system for face recognition using low resolution scanners. An algorithm for face recognition in low resolution images captured by long range surveillance cameras is presented in [12]. Where a mixer classifier is utilized to measure the distance between different resolutions images, as the high resolution reference image is converted back to a lower resolution like the test image for the comparison process.

A different method for face recognition is introduced in [13], where the authors are trying to help/support the criminal departments through suggestion of face features through linguistic description provided by witnesses or victims in order to catch the offender. The experts use the linguistic description and assign a degree of membership to a corresponding fuzzy term depending on corresponding measurable facial parts. For example the nose length and size, eyebrows position, mouth width …etc. Then, these individual descriptors are concatenated to construct a feature vector for the classification process. The fuzzy logic is utilized also in [14] but for edge detection in order to enhance the face recognition process. Face recognition from a surveillance video is addressed in [15] using convolutional neural network as the quality of the acquired images may be very low. Where the number of network layers are limited as images are low resolution. The network training is using a loss function to maximize the distance between positive/similar images and minimize it between different images.

3 Proposed Method

If you have an image *f(x,y)* of dimensions M and N, where x and y are the coordinate variables, then the 2-d moment of order (p + q) defined as [1]:

$$m_{pq} = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} x^p y^q f(x,y) \quad (1)$$

Where p = 0, 1, 2 … and q = 0, 1, 2 …

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Then the corresponding central moment is defined as:

$$\mu_{pq} = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(x-\bar{x})^p (y-\bar{y})^q f(x,y) \quad (2)$$

Where: $\bar{x} = \frac{m_{10}}{m_{00}}$ and $\bar{y} = \frac{m_{01}}{m_{00}}$

Then the normalized central moment is defined as:

$$\eta_{pq} = \frac{\mu_{pq}}{(\mu_{00})^\gamma} \quad (3)$$

Where: $\gamma = \frac{p+q}{2}$

for $p+q = 2,3,4,\ldots$

Then the moment invariants defined as:

$$\phi_1 = \eta_{20} + \eta_{02} \quad (4)$$

$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}{}^2 \quad (5)$$

$$\phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \quad (6)$$

$$\phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \quad (7)$$

$$\begin{aligned}\phi_5 = {} & (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})\ldots \\ & [(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2]\ldots \\ & + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})\ldots \\ & [3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]\end{aligned} \quad (8)$$

$$\begin{aligned}\phi_6 = {} & (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 \ldots \\ & - (\eta_{21} + \eta_{03})^2]\ldots \\ & + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})\end{aligned} \quad (9)$$

$$\begin{aligned}\phi_7 = {} & (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})\ldots \\ & [(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2]\ldots \\ & + (3\eta_{12} - \eta_{30})(\eta_{21} + \eta_{03})\ldots \\ & [3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]\end{aligned} \quad (10)$$

These seven moment invariants are proved to be robust against many deformations. First, they are rotation invariant, as their values are nearly not affected by the object rotation. Second, they are also invariant to object translation, i.e. their values will not going away if the object position in the underlying image or window is not the same. Third, if the object size is different their values also will not be destructed. In addition, they are also robust against object mirroring.

4 Results

The usefulness of the proposed set of moment invariants features is demonstrated using Yale Face Database that contains 165 grayscale images of 15 individuals. There are 11 images per subject, one per different facial expression or configuration: center-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, sleepy, surprised, and wink, [2], see fig. 2.

Fig.2: the 15 subjects of Yala face database.

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In the experiment, the seven moment invariants described in eq. 4 to eq. 10 are calculated and preprocessed as shown in Table 1. Where each value is scaled using eq. 11:

$$round\left(-1000.\log_{10} abs(\phi)\right) \quad (11)$$

Where: log is used to increase the dynamic range of the values, multiplying by 1000 and then rounding to eliminate the fractions and also increasing the dynamic range.

TABLE 1
THE VALUES OF MOMENT INVARIANTS OF THE 15 SUBJECTS OF FIG1

	Φ_1	Φ_2	Φ_3	Φ_4	Φ_5	Φ_6	Φ_7
Face1	1260	4752	8015	7283	15047	9694	15728
Face2	1382	5048	8254	7817	15956	10397	16690
Face3	1217	4587	8219	7777	15815	10073	17056
Face4	1260	4616	8115	7712	15719	10026	16514
Face5	1317	4913	8234	7637	15598	10186	17077
Face6	1319	4853	8505	8121	16807	10715	16754
Face7	1145	4203	8542	8664	17268	10842	20830
Face8	1304	4691	11086	13918	27517	16864	26480
Face9	1410	5079	10764	11063	21985	13841	23994
Face10	1213	4493	7904	7447	15190	9695	16158
Face11	1101	4379	7255	6773	13798	8976	15727
Face12	1363	4989	8466	8115	16406	10635	23388
Face13	1276	4775	9386	9409	18967	12494	19453
Face14	1303	4919	8576	7943	16270	10408	17230
Face15	1204	4454	9638	10045	19949	12329	20962

5 CONCLUSIONS AND DISCUSSION

In this research work the role that could be played by moment invariants in face detection and recognition is investigated. These values show that they could be very useful in the detection and recognition phases for faces. But these values need to more experimental tests to truly proof their benefits in this area of research. They could be very useful if the images are without any facial expressions and without glasses and with ambient light. But, their role will be degraded much if these problems exist especially with the dynamic nature of human faces.

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