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Research Paper

An affine view and illumination invariant iterative image matching approach for face recognition

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Abstract

Feature detection and image matching constitutes two primary tasks in photogrammetric and have multiple applications in a number of fields. One such application is face recognition. The critical nature of this application demands that image matching algorithm used in recognition of features in facial recognition to be robust and fast. The proposed method uses affine transforms to recognize the descriptors and classified by means of Bayes theorem. This paper demonstrates the suitability of the proposed image matching algorithm for use in face recognition appli-cations. Yale facial data set is used in the validation and the results are compared with SIFT (Scale Invariant Feature Transform) based face recognition approach.

Keywords: *Face Recognition; Iterative Approach; Bayes; Yale; SIFT.*

1. Introduction

One computer application that has garnered much attention recently is the automatic face recognition from digital still images, due to its multi-purpose nature. [1], [2].Here, using an face image of some known people and their database, the identity of the face is determined. Although, there is an availability of wide range of literature, including some recent works with good output on difficult datasets, face recognition still remains an unsolved problem [3].The face recognition methods are categorized as holistic based and feature based methods. The method that uses global information from the images to recognize face identity is classified as holistic face recognition methods. The global information is nothing but a set of features, derived directly from the pixels of the images that capture variance among distinct faces. The methods such as the Eigen faces method [4] and the Fisher's Linear Discriminate (FLD) [5] are holistic based face recognition methods. An alternative approach to this method was proposed, known as the local feature based face recognition method. This method is now an active area of research in this field. Out of the various local features used, the local binary patterns, histogram of oriented gradients and Gabor wavelets [6] are some of the prominent ones. The Lowe's work on an object recognition using SIFT (Scale Invariant Feature Transform) descriptors[7] have been used by multiple authors in fields like robot navigation [8], scene classification [9], and also face recognition [10], [11], [12], [13], [14].
A general approach to all these methods is quite same; first, a number of key points from the images are extracted, then each key point is computed using a local descriptor, finally, each point descriptor in the test image is matched with all the descriptors extracted from the image database, to recognize the identity of the test image. The class to which the input image is to be assigned depends on the output of the matching procedure. One of the most important problem that need special attention while using local features for face recognition is the possibility of false matched key-points. This problem is tackled by most of the local feature approaches; by adopting a grid based matching strategy for face recognition. It works by establishing sub-regions on the face images, so that only the descriptors in between these sub- regions are compared for matching. By this way the number of wrong matches can be reduced(without elimination). However, the images need to be preregistered and it makes the application of this method a bit difficult for datasets with random views [15]. The variable illumination still significantly affects the identification of key points, as the key point detector intrinsic to the SIFT techniques may change to with the illumination [13].
In this approach an iterative based image matching approach is used in the application of face recognition. At the beginning it finds the affine invariant data points in all mages. Then descriptors are assigned and the calculation of maximum disparity range is followed. Next the area around all key points is selected Bayes theory is applied for assigning the initial probabilities. Then match the key points in two images. This method is applied on facial images from Yale's facial database. The results are compared with a face recognition approach employing SIFT.

2. Feature detection in scale-space

SIFT key points play an important role in computer vision due to their stability to scale changes, dependency to the illuminations and rotations of images [7]. These features make SIFT key points strong enough against the affine distortions and change of poses. The SIFT [16] process is carried out in 2 steps; first step includes detection of key points in scale-space pyramid and then key point description. Since the SIFT features are less expensive features [17] and [18] have been proposed.

3. Yale face data base

The Yale face data face [19] comprises 165 grayscale images in GIF format of 15 individuals. It has 11 images per subject having different facial expression or configuration which includes center-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, and sleepy, surprised, and wink. In this work 10 images per subject are considered for testing and analysis. Different images from a single subject used in the work are illustrated in the Fig.1.

Fig. 1: Sample Images from the Yale Face Data Set.

In the test images, the feature detection algorithms extract features from the back ground and other objects that are not related to face. These background features can result in false matches. In order to avoid this, the face part of the image is cropped using Viola Jones Object Detection algorithm [20]. The object detection trained using OpenCV trained classifiers [21]. This algorithm locates the face region and then crops that particular region. This results in the reduction of unwanted features and also the number of features / descriptors. This eventually increases the matching speed as well the accuracy of matching. Features identified for cropped and uncropped images are illustrated using the Fig.2 and Fig.3

Fig. 2: Uncropped Image and Descriptors Identified for the Image.

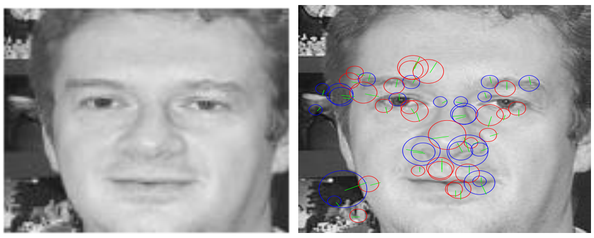


Fig. 3 : Cropped Image and Decriptors Identfied.

4. Proposed method

The steps of the proposed method are as follows.
Step 1: Select key points using ASIFT in both images.
Step 2: Compute the descriptor for every key point.
Step 3: Select an area around every right key point node.
Step 4: Find all the key points in the area selected in step 3.
Step 5: The above two steps are accomplished for all the key points in both images.
Step 6: Pair up the left key point node b_i with every right key point node d_i .
Step 7: Calculate the Euclidean distance between key point pair.
Step 8: Calculate the weight to all key points d_i as

$$w_i(d) = \frac{1}{l \times \varepsilon_i(d)+1}, d \neq \bar{d} \tag{1}$$

l is a positive constant. $w_i(d)$ will be in the the range of 0 to 1 and weight is inversely proportional to Euclidean distance.
Step 9: For every category set d, $\bar{d}$ is undefined disparity category.
Step 10: Initial probability for undefined category is given as

$$\mathring{p}_i(\bar{d}) = 1 - \max_{d \neq \bar{d}} (w_i(d)) \tag{2}$$

Step 11: Apply Bayes rule

$$\mathring{p}_i(d) = p_i(d|i) \times \left(1 - \mathring{p}_i(\bar{d})\right), d \neq \bar{d} \tag{3}$$

$p_i(d|i)$: Conditional probability that b_i has category d as matching, given that b_i is matchable $\left(1 - \mathring{p}_i(\bar{d})\right)$: prior probability that b_i is matchable
Step 12: Estimate $p_i(d|i)$ as below

$$p_i(d|i) = \frac{w_i(d)}{\sum_{d'=1, d' \neq \bar{d}}^{L} w_i(d')} \tag{4}$$

The new probability $p_i^{k+1}(d)$should tend to increase when descriptors with highly probable category consistent with d are found nearby the key point region. Categories are considered consistent if they represent nearly the same disparity i.e.

$|d(d_i) - d(d_m)| < T$:

Where T is threshold
The threshold has to be decided through trial and error method.

$$q_j^{k}(d) = \sum_{m=1,\ m \neq j}^{L} P(d_m) \tag{5}$$

$|d(d) - d(d_m)| < T$

$q_{i_j}^{k}(d)$: Estimated likelihood considering the neighborhood of d_j,
L: Number of neighbors in the category set.
Step 13: Update probability as

$$p_{i_j}^{k+1}(d) = \frac{p_i^k(d) q_{i_j}^k(d)}{\sum_{d=1}^{L} p_i^k(d') q_{i_j}^k(d')} \tag{6}$$

$$p_i^{k+1}(d) = \sum_{j=1}^{N} \alpha_j p_{i_j}^{k+1}(d) \tag{7}$$

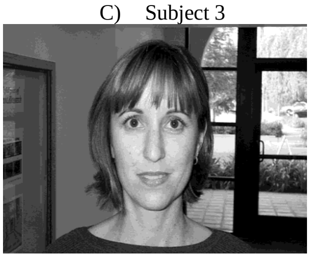
5. Results and discussion

In order to validate the image matching capabilities of the proposed approach, 4 subject images having 10 different facial configurations and expressions were tested.

A) Subject 1

B) Subject 2

C) Subject 3



D) Subject 4

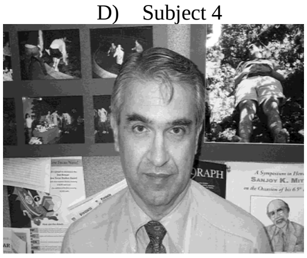


Fig. 4: Images of the Subjects from the Yale Face Data Set Considered for Testing in this Work.

The face recognition algorithm implemented in this work is borrowed from code provided by Lowes [7].A classification approach based on K-d tree algorithm has been implemented. The training setis comprised of 100 images from 10 different subjects. The features of the training images are extracted and stored in a database for the purpose of recognition. A group number is assigned to training images so that an image from same person has the same group number. To further match the image from the test set to the training images, the feature are extracted and each feature of the test image is compared individually with those in the training database. The group number indicates the user on which person has the closest match with the test image. The table 1 to table 4 lists the results of key points identified by SIFT and the proposed image.

Table 1: Key Points Identified By SIFT and the Proposed Approach for Subject 1 for Different Facial Configurations and Expressions

Subject - Pose	Number of key points identified by SIFT	Number of Key points identified by the proposed approach
Subject 1- Pose 1	119	441
Subject 1- Pose 2	204	605
Subject 1- Pose 3	801	379
Subject 1- Pose 4	102	320
Subject 1- Pose 5	135	358
Subject 1- Pose 6	244	461
Subject 1- Pose 7	129	344
Subject 1- Pose 8	127	217
Subject 1- Pose 9	126	194
Subject 1- Pose 10	122	227

Table 2: Key Points Identified By SIFT and the Proposed Approach for Subject 2 for Different Facial Configurations and Expressions

Subject –Pose	Number of Key points identified by SIFT	Number of Key points identified by the proposed approach
Subject 2- Pose 1	118	384
Subject 2- Pose 2	148	314
Subject 2- Pose 3	199	456
Subject 2- Pose 4	108	289
Subject 2- Pose 5	114	216
Subject 2- Pose 6	120	251
Subject 2- Pose 7	131	356
Subject 2- Pose 8	127	419
Subject 2- Pose 9	105	359
Subject 2- Pose 10	122	463

Table 3: Key Points Identified By SIFT and the Proposed Approach for Subject 3 for Different Facial Configurations and Expressions

Subject - Pose	Number of key points identified by SIFT	Number of Key points identified by the proposed approach
Subject 3- Pose 1	113	222
Subject 3- Pose 2	117	287
Subject 3- Pose 3	126	367
Subject 3- Pose 4	139	365
Subject 3- Pose 5	113	369
Subject 3- Pose 6	130	368
Subject 3- Pose 7	130	300
Subject 3- Pose 8	98	198
Subject 3- Pose 9	134	360
Subject 3- Pose 10	149	373

Table 4: Key Points Identified By SIFT and the Proposed Approach for Subject 4 for Different Facial Configurations and Expressions

Subject –Pose	Number of Key points I identified by SIFT	Number of Key points identified by the proposed approach
Subject 4- Pose 1	163	385
Subject 4- Pose 2	171	441
Subject 4- Pose 3	112	548
Subject 4- Pose 4	176	272
Subject 4- Pose 5	167	310
Subject 4- Pose 6	187	218
Subject 4- Pose 7	176	475
Subject 4- Pose 8	142	450
Subject 4- Pose 9	178	353
Subject 4- Pose 10	182	247

Subsequently the images are matched and the results of the identifications are presented here

Table 5: Performance Comparison of the Proposed Detector and the Detector Based on SIFT

Subject	SIFT based detection		Proposed method based detection	
	Number of True identifications	Number of False identifications	Number of True identifications	Number of False identifications
Subject 1	10	0	10	0
Subject 2	10	0	10	0
Subject 3	10	0	10	0
Subject 4	10	0	10	0

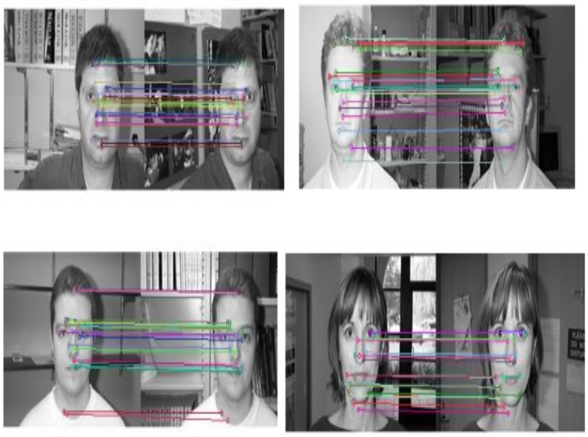


Fig. 5: Results of Image Matching by the Proposed Approach for Different Subjects.

Fig. 6: Sample Display of Result for Image Recognition Using the Proposed Approach.

It can be observed from the results that the proposed approach performs well in comparison to SIFT based detection of facial images. The performance is visible across the spectrum. This is especially visible in regard to the number of key points being identified. It can be inferred from the table 1to table 4 the number of key points identified by the proposed approach is significantly higher than the SIFT descriptor. Similarly in order to validate the performance a test data set was formed with images from the training data and also images which are not part of the training data set. The results of this classification are illustrated with the help of the following table. This data set is comprised of a total of 10 images with 4 images which are part of training data and 6 images which are not part of training data. For those images which are part of training images, a correct match is counted when the image is matched correctly. For those images which are not part of the data set, a correct match is when the algorithm identifies that it's not part of the heterogeneous dataset.

Table 6: Performance Comparison of the Proposed Detector and the Detector Based on SIFT for Images in Which 4 Images are Part of Training Data and 6 are Not Part of Training Data

Method	Number of Correct Matches	Number of False Matches	Accuracy % of recognition
SIFT Based Detection	4	6	40
Proposed Approach	9	1	90

Table 5 presents the matching results for SIFT and the proposed approach for face recognition of the subjects. This table 5 incorporates the results for the images which are in the training set, for this case the face recognition accuracy by both the approaches are very high. In fact both the approaches have exhibited 100 percent accuracy in recognizing the faces. In order to establish the robustness of the approach in identifying the images that are not part of training data the experiments were carried out and results tabulated in table 6. It can be observed from the results that for this case there is a significant fall in the accuracy of face recognition for this test set for SIFT. On the other hand the proposed approach delivered an accuracy of 90 %. This can be attributed to the high number of descriptor points identified by the proposed approach. This automatically enhances the chances of accurate matching.

6. Conclusion

A new frame work for view and illumination invariant image matching has been designed and effectively presented for application in face matching. The performance of the proposed algorithm was evaluated with images from Yale face data set. It can be clearly inferred from the results that the proposed approach has outperformed the SIFT in terms of identifying the number of image matches and deliver an enhanced accuracy for detection in a heterogeneous data set. Even though it was not explicitly documented, it was clearly observed during the execution the proposed approach had a much smaller execution time. This can be attributed to the reduced computational complexity making it suitable for real time applications like face recognition.

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