Human Face Recognition from Part of a Facial Image based on Image Stitching

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Summary
In the human community, because of the high rates of crime and the multiplicity of methods, some public institutions and markets have planted surveillance cameras. These cameras utilized to photograph crimes and their perpetrators and help the police track down the offenders. From these images, the investigators are able to identify them. However, a major problem facing investigators is when only a part of the perpetrator's face appears in the image, which makes it difficult to capture the culprits. This work proposes an improved algorithm for human face recognition by using two approaches Eigenfaces and geometrical methods from part of a facial image based on image stitching. Image stitching is the process during which distinctive photographic images combined to make a complete scene or a high-resolution image. Several images integrated to form a wide-angle panoramic image. The quality of image stitching determines by calculating the similarity among the stitched image and original images, and by the presence of the seam lines through the stitched images. The Eigenfaces approach utilizes PCA calculation to reduce the feature vector dimensions. It provides an effective approach to discovering the lower-dimensional space. In addition to enabling the proposed algorithm to recognize the face, it also ensures a fast and effective way of classifying faces. The phase of feature extraction was followed by the classifier phase. Displacement classifiers using square Euclidean and City-Block distances were used. The test results demonstrate that the proposed algorithm gave a recognition rate of around 95%.
Keywords:
Face recognition, Image stitching, Principal Component Analysis, Eigenfaces Distance Classifier, Geometrical approach.

1. Introduction

Image stitching is the method used for consolidating various photographic images with overlapping manner – joining a lot of different image parts- of view to deliver a sectioned display or high-resolution image. It is otherwise called image mosaicing. Most regular methodologies of image stitching require correct covers amongst images and indistinguishable exposures to create consistent results. What is more, utilizing image stitching in computer vision and PC design applications, some digital cameras are able to stitch their photographs together internally [1]. Arrangement of the images may comprise at least two digital images taken of a solitary scene in various circumstances, from various sensors or from various perspectives. The objective of enrolment is to build up a geometric correspondence between the images so they might be changed, scrutinized, and analyzed. Image stitching strategies can be classified into two general methodologies: [2] feature-based techniques and direct techniques. Feature-based techniques expect to identify a connection between the images through unmistakable features separated from the prepared images, whereas direct techniques compare all the pixel forces of the images with each other. The feature-based strategy has the benefit of being more robust against scene development, and can naturally find the overlapping connections among an unordered arrangement of images. Image stitching comprises three stages: Image Acquisition, Image Registration, and Image Blending.

Face recognition has broad applications in security, validation, observation, and criminal distinguishing proof. Ordinary recognizable proof strategies based on ID cards and watchwords are not considered as reliable as previously thought because of the utilization of different propelled systems of fake and secret key hacking. As a choice, biometrics, which is characterized as a fundamental physical or social identification mark of an individual, is now being used for personality to get to administration. Distinguishing the uniqueness of an individual from a database of known people is the focal point of face recognition. It is predicted that face recognition will oversee unlimited unpretending frameworks, such as access control for airplane terminal security, smart applications in the home, structures, and faces, as well as for checking and observation of buildings and vehicles, and for intelligent human-PC collaboration and discernment interfaces. In recent years, confront recognition has established boundless application fields, from confirmation and recognizable proof to the collaboration and correspondence of the human and PC gadgets through face-based video applications. The standing face recognition algorithms are regularly sorted

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into three categories depending on the idea of connected features. These are holistic methods, feature-based methods, and hybrid methods.

The holistic methods category symbolizes the entire facial region as a high-dimensional vector that contributes to a classifier. Principle Component Analysis (PCA) is a successful agent technique for all-encompassing face recognition strategies, including Linear Discriminant Analysis (LDA) and Independent Component Analysis (ICA). Local methods, on the other hand, extract neighborhood characteristics from facial territories; for example, the eyes, mouth, nose, and cheeks. These features are then utilized to characterize faces. Finally, in the hybrid method, both the holistic and local methods are utilized to perceive and distinguish a face [3]. The essential challenge confronting any calculation for facial recognition is the deficit in the appearance of the face that is expected to be perceived. The motivation behind this work is to construct complete face images by utilizing the stitching image algorithm.

2. Related Work

Over the last two decades, numerous analysts have proposed and executed different display image stitching frameworks. In [4] the authors have introduced new systems on image stitching based on the histogram matching algorithm. Histogram coordinating is utilized for image adjustment so the images to be stitched have a similar level of brightness. At this point, the paper embraces the SIFT algorithm to separate the key features of the images and plays out the harsh coordinating procedure. This is followed by the RANSAC algorithm for fine matches, finally ascertaining the most suitable scientific mapping model between the two images and, as indicated by the mapping relationship, a straightforward weighted normal algorithm is utilized for image blending.

Authors in [5] have provided a specialized examination of fast image stitching calculation based on SIFT. Firstly, the images are separated into squares. The component sorts these neighborhood image squares are resolved. The element purposes of the nearby image squares are removed utilizing diverse streamlined techniques adaptively. Secondly, we utilize coordinating to achieve the changed framework, and the RANSAC algorithm is connected to expel incorrect coordinating point sets. Finally, the stitched image can be achieved by image blending.

Another proposal [6] have provided a new approach for image stitching technique using (DTW). This work proposes a novel technique that uses the Dynamic Time Warping (DTW) algorithm to coordinate sets of images for image stitching. They additionally perform a measurement-reducing plan that shrinks the computational multifaceted nature of the standard DTW algorithm without influencing its execution. The viability of their proposed technique is shown in the stitching of 50 sets of restorative X-beam images, and its execution is contrasted with those of standardized cross-relationship (NCC), minimum average correlation energy (MACE) channels, total of-square-contrasts (SSD), and the entirety of absolute-contrasts (SAD). Their technique likewise beats two generally utilized stitching programs accessible on the web called Hugin and Autostitch.

The work in [7] gives an in-depth review of the current image mosaicing algorithms by ordering them into a few classes. For each class, the principal ideas are first clarified, and afterward, the adjustments made to the fundamental ideas by various analysts are clarified. Moreover, this paper additionally discusses the focal points and burdens of all the mosaicing classes. A number of previous investigations have led the field of face detection and recognition in settled images through a different scheme of frameworks. Shahin and EL-SAYED proposed a face recognition system based on the Geometrical Approach. The geometrical approach consists of two phases, namely, the detection phase and the recognition phase. The edge of the tested face is detected in the first phase after some pre-processing operations have occurred on the tested image. The second phase attempts to identify the angles of the face outline. After calculating the angle vector of the tested face, it is then compared with the training set angle vectors via a neural network to identify the face [8].

In this work [9] proposed a discriminative feature-learning approach to recognize the face using convolution neural networks (CNNs). The proposed center loss algorithm needed for the task of face recognition. In this algorithm, they train robust CNNs to obtain the deep features with two key learning objectives, intra-class compactness, and inter-class dispensation, as much as possible, which are necessary to the process of face recognition. Kasar et al [10] proposed a strategy for face recognition using artificial neural networks (ANN). They examined the face recognition methods proposed by numerous specialists utilizing ANN, which used as a part of the field of pattern recognition and image processing.

Furthermore in [11] proposed a strategy for face detection and recognition based on (PCA) – (LDA) and square Euclidean distance with the Viola-Jones algorithm. Their proposed strategy is based on the appearance-construct features that concentrate on the whole face image as opposed to neighborhood facial features. The initial phase in the face recognition framework is face location. The Viola-Jones' face location technique equipped for handling images to a great degree while accomplishing high identification rates is utilized. Feature extraction and measurement-reducing strategy are connected after face recognition. The principal component analysis (PCA) technique is generally utilized as a part of pattern recognition. The Linear Discriminant Analysis (LDA) technique, used to overcome the disadvantages of PCA, has been effectively connected to face recognition. It is accomplished by projecting the image onto the Eigenface space by PCA and then applying unadulterated LDA over it. Subsequently, Square Euclidean Distance (SED) is utilized. This distance classifier is required to identify the similarity between the tested face image with those located in the training set.

Finally, in [12] conducted a comprehensive survey on pose-invariant face recognition (PIFR). They discussed the intrinsic challenges in PIFR and exhibited a complete audit of built-up systems. They characterized the current PIFR strategies into four classes, namely, pose-robust feature extraction methodologies. They described and assessed the inspirations, systems, geniuses/cons, and the execution of agent approaches.

3. Image Stitching Techniques

Image stitching is the method utilized for obtaining a more extensive field-of-perspective of a scene from a succession of halfway perspectives. It is an alluring exploration zone in view of its extensive variety of applications, including movement identification, determination upgrade, checking worldwide land use, and face insertion. These procedures can be ordered into two groups: direct techniques and feature-based systems as shown in Figure 1.

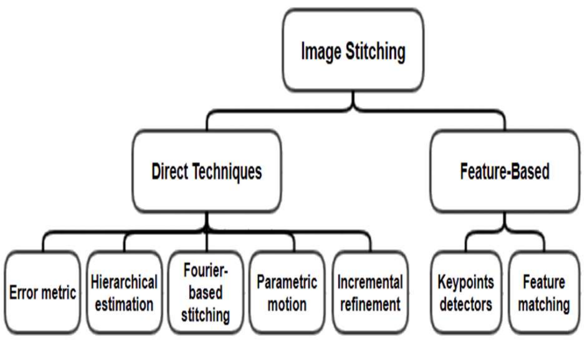


Fig. 1 Images stitching methodology

In a direct technique, every pixel located in the image is compared with each other, which is an exceptionally complex method. The direct way to perform an alignment between two images is to shift one image that corresponding to another by comparing pixels of the two images under testing. This comparison will depend on the rows or columns of each image, and the mean square error (MSE) for each row or columns will be calculated and will be taken as a reference to compare the given images. However, MSE is an example of the error metric. The principal obstacle of direct methods is that they have a constrained scope of union [13].

The direct method utilizes data from all pixels. It iteratively refreshes a gauge of homography with the goal that a specific cost work is limited. To speed up the error metric search process, hierarchical motion estimation should be used. In hierarchical motion, an image pyramid is first created, and a search process over a fewer number of discrete pixels will perform at coarser levels [14].

Thirdly, Fourier-based stitching depended on performing a convolution in the spatial domain resembles the summation of one signal with its conjugating of the other [15]. In a parametric motion, a single constant translation vector with a correspondence map will be used. Finally, due to the feature points that may not be accurately located, a more accurate matching score can be calculated by an incremental motion refinement algorithm. However, incremental motion refinement needs more calculations than other algorithms, so they consider time-consuming, which reflects a decrease in its performance [16].

In contrast, feature-based systems are progressively more prominent and broader in mosaicing. This is particularly the result of the quality of new calculations and types of invariant features that have evolved over recent years. In [17] Schmid represent a survey on a keypoints detection and implements an experimental comparison to determine the repetitive features of detectors and the information content available at each detected keypoints. The feature matching process will occur after detecting the features and keypoints. In addition, the feature matching process will determine which features come from locations in different images [18]. The fundamental qualities of strong locators incorporate invariance to image scale invariance, interpretation invariance, and turn changes [19].

4. Face Recognition Techniques

Face Recognition has been an interesting topic for many computer science engineers who deal with artificial intelligence. The computer first detects the face and then for recognition step will be performed. Face recognition is considered as a pattern recognition task performed precisely on human faces [8]. The outcome of this process is to classify a face as either "known" or "unknown", this is done by comparing the given unknown face with stored known faces. The face image must be with the uniform background to avoid problems because the surrounding plays an important role in human face recognition system, and it is also affected by the change in facial expressions as for example laughter and crying changes the mouth and eyes opening size and the aging also plays an important role as the face details changes. Much researches in computer recognition of faces have focused on identifying individual face features such as the nose, eyes, head outline, and mouth. The closest match between stored data and face image achieves recognition.

PCA is a standard technique used to distinguish patterns and signal processing. It is a statistical method employed to reduce data dimensions and to extract features, which is an essential step in facial recognition. The analysis of basic compounds involves a mathematical procedure that converts a number of interrelated variables into a number of non-interrelated variables called basic components. These components are linked to the original variables by orthogonal transformation and are defined in such a way that the first primary component has the highest variance and the second fundamental component has the second-highest contrast, and so on. Go back to Osama Shahin [8] present a face recognition approaches that depend on the geometry of the head, this is done by calculating the angles for the head circumference and then storing these readings in a vector that describe a given face and will be used for comparison with other vectors that represents other cases.

5. Methodology

The proposed system developed in this paper is divided into two phases. The first phase is stitching the face image for the face that needs to be identified, while the second phase is face recognition. Figure 2 illustrates the scheme of the proposed system.

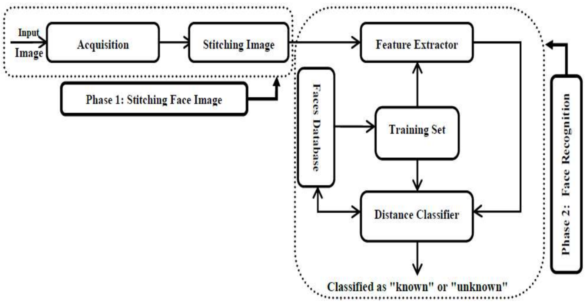


Fig. 2 Outline of typical face recognition system

5.1. Phase 1: Stitching the Face Image

In this phase, the process of stitching face image will be accomplished and completed according to the steps summarized in Table 1.

Table 1: Proposed Approach For Face Stitching
1: Tested Image Acquisition: the image of the face to be identified is processed. The facial image in this work is assumed incomplete face, which represents the main challenge in any face recognition system.
2: Nose Area Detection: the human face is symmetric around a certain line. To find such a line, the process of the nose detector is required. Here, the Viola-Jones Nose Detection Algorithm was used [20]. Then the centroid of the nose region is equivalent to the centroid of the rectangle that surrounds it. The centroid lies at the intersection point of the rectangle diagonals. The diagonals intersect at height $(\frac{h}{2})$ from reference y-axis and at width $(\frac{b}{2})$ from reference x-axis.
3: Vertical Line Drawn: A vertical line is drawn on the perpendicular to rectangle width (b) passing through the centroid. The whole face is symmetric around this vertical line.
4: Cropped Image: The image of the uncompleted tested face image is cropped to obtain cropped image I_1. The dimension of the cropped image I_1 from pixel that has coordinate $x = 0$ to width equals $(x_0 + \frac{b}{2})$ from reference x-axis, and from pixel that has coordinate $y = 0$ to height equals the height of the vertical line that drawn in the previous step, which is equal to the height of the original tested image from reference y-axis. Where (x_0, y_0) represent the origin, i.e., coordinate of the first pixel in the cropped nose detector image [21].
5: Flipped Image: A horizontal reflection of I_1 is performed to generate the missing part of the face, this part will be denoted as I_2.
6: Stitched Image: The stitching process is achieved by using image translation. The applied strategy can be alluded to as stitching. The initial step is the age of relative places of obtained images and the production of a vacant image cluster in PC memory where these images will be set. The following stage is identifying the purpose of best correlation, which is performed by sliding contiguous image edges in the two headings until the point where the best match of edge features is found. The normalized cross-correlation coefficient for the case above is defined as in equation (1): $$\textbf{Cross Correlation} = \frac{\sum_{x=0}^{L-1}\sum_{y=0}^{K-1}(w(x,y)-\bar{w})(f(x+i,y+j)-\bar{f}(i,j))}{\sqrt{\sum_{x=0}^{L-1}\sum_{y=0}^{K-1}(w(x,y)-\bar{w})^2}\sqrt{\sum_{x=0}^{L-1}\sum_{y=0}^{K-1}\left((f(x+i,y+j)-\bar{f}(i,j))\right)^2}} \quad (1)$$ Where $w(x,y)$ represents a pixel value of the image to be placed; $\bar{w}$ is the mean value of all pixels included in the selected – cropped -box area $f(x+i,y+j)$ represents a pixel value of the composite image inside the box area. However, $\bar{f}(i,j)$ is the mean value of all pixels of the composite image within the box area and parameters K, L represent the box dimensions in the number of pixels included [21].
7: Image Blending: After all the input images have been aligned with respect to each other, we will use a multi-band image blending approach to produce seamless panoramic views by choosing a suitable compositing surface.

Figure 3 below was depicted the outline of the image stitching process.

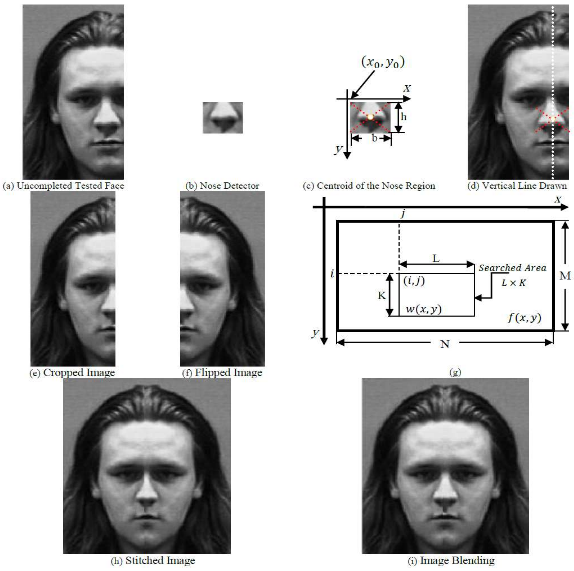


Fig. 3 Outline of image stitching process

5.2. Phase 2: Face Recognition Algorithm

The idea of the proposed system is to identify human faces if they are recorded in the database of the system, as well as categorizing individuals whose image is not recorded in the database as unqualified or as strangers through the process of automatic identification and identification of persons. In this phase, Eigenfaces for recognition algorithm [22], and Geometrical Approach for Face Detection and Recognition [8] will be used.

6. Experimental Results

The system was tested on database FACES94. The training dataset contains a total number of 3080 images of 123 individuals grouped and classified into three categories (male, female, and male_staff) taken with a little variation in head position. The image had a resolution of 180×200 datasets [23]. The training sample is shown in Figure 4. The normalized face images are utilized to minimize blunders caused by lighting conditions and are shown in Figure 5.

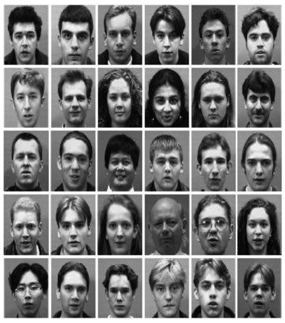


Fig. 4 Initial Training

Fig. 5 Normalized training image set

Figure 5 shows the tested image requiring classification fed into the proposed system. After the process of an image, stitching identified before the input image will be ready to recognize as shown in figure below. The quality of the image stitching process is located by observing the seam lines between the stitched images.

(a) Tested Image (b) Left Half (c) Flipped Image (d) Stitched Image

Fig. 5 Tested and stitched image

As previously mentioned, the experiments performed on the FACES94 database with various numbers of training images. The percentage of discrimination calculated using the method of analyzing only the basic compounds in the extraction of properties and neural networks in discrimination and depending on the mainframe. The percentage of the recognition rate depended on the number of Eigenfaces with the highest value of Eigenvalues [24]. When 100 Eigenfaces taken, the recognition rate was 94.2% with the Euclidean distance classifier and was equal to 92.3% when the City-Block classifier used. When taking 150 Eigenfaces, the recognition rate rose to 94.6%, with the Euclidean distance classifier, and 93.1% with the City-Block classifier. This percentage then dropped to 92.2% and 91.8% respectively, and then to 91.7%, and 90.4% with the Euclidean and City-Block classifiers respectively when 200 and 250 Eigenfaces taken. On taking 300 Eigenfaces, the percentage increased again to 95.1% and 93.7% respectively when Euclidean and City-Block classifiers were used. Figure 6 and Table 2 shows the result of the recognition process using Eigenfaces.

Recognized Image Input Image

Fig. 6 Correct Face Recognition Result for FACES94 database.

Table 2: Recognition rates for the proposed algorithm

No. of Eigenfaces	Recognition Rate % Euclidean Distance	Recognition Rate % City-Block Distance
100	94.2	92.3
150	94.6	93.1
200	92.2	91.8
250	91.7	90.4
300	95.1	93.7

A comparative recognition error rates for glasses- persons are wearing glasses- and no glasses – persons are not wearing glasses- recognition using the eigenfaces and geometrical approaches methods depicted in Table 3.

Table 3: A comparative recognition error rates

Approach	Error rate % for glasses	Error rate % for no glasses
Eigenfaces approach	45.2	20.2
Geometrical approach	25.5	7.7

After the process of the recognition will be performed, the calculation of Image Quality Metrics (IQM) between the stitched image and the original one is needed. In this work, MSE and CR and are chosen as quality factors [25].

6.1. Mean Square Error (MSE).

MSE is needed to measure image quality. Mean Square Error must be zero in a perfect case because it is the difference between the original images and the stitched one. However, in a practical case the smaller the value of MSE the better the quality of the stitched image.

$$\mathrm{MSE} = \sum_{i=1}^{m}\sum_{j=1}^{n}\frac{\mathrm{OI}(i,j)-\mathrm{SI}(i,j)}{m*n} \qquad (2)$$

Where "OI" is the original image, "SI" is the stitched image, "M" & "N" are the numbers of rows and columns in both images respectively.

6.2. Correlation Coefficient (CR).

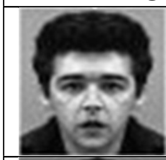
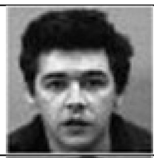
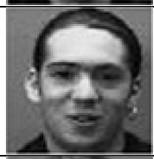
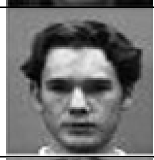
CR is used in measuring closeness between the original image and the stitched one. The correlation Coefficient should equal 1 in a perfect case. However, in a practical case value of CR near one is a significant figure.

$$C_r = \frac{\sum_m\sum_n(Xi-\overline{X})(Yi-\overline{Y})}{\sqrt{(\sum_m\sum_n(Xi-\overline{X})^2)(\sum_m\sum_n(Yi-\overline{Y})^2)}} \qquad (3)$$

Where "$\overline{X}$" & "$\overline{Y}$" is the original image & stitched image average values respectively, "M" & "N" are the numbers of rows and columns in both images respectively.

Table 4 depicted MSE and Cr are calculations for a sample of stitched and original images.

Table 4: MSE and Cr are calculations for a sample of stitched and original images.

Cases		MSE	Cr
Stitched Image	Original Image		
		7.2011	0.9902
		13.2465	0.9734
		12.3301	0.9855
		9.3312	0.9977
		8.2135	0.9924

7. Conclusion

This work proposes an improved algorithm for human face recognition by using two approaches Eigenfaces and geometrical methods from part of a facial image based on image stitching. The geometrical approach was accurate especially when the person wears glasses than Eigenface, but the Eigenface approach is quick and simple for the face recognition problem. Face recognition from the perspective of PCA was connected on two distance classifier systems with a certain training dataset. The training dataset contained a total number of 3080 images of 123 individuals grouped and classified into three categories (male, female, and male_staff) and was taken with a little variation in head position. The test results identified that PCA gave the best results with the squared Euclidean distance methodology, with a recognition rate of 95.1%, which was more noteworthy than the City-Block distance strategy. The recognition rate also varied with the number of Eigenfaces used in the experiment.

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