Face Recognition by Partial Input of Unshaped Images Using Condense -SURF Feature Extraction Algorithm

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Abstract—Face recognition by partial input strategy based on Condense-SURF extraction algorithm is proposed in this paper. In real-world face recognition applications such as investigation or forensics images, only a small part of face image is available. In the proposed approach, instead of comparing the small sub-image to the full picture of the images in the database, condense-SURF matching technique finds face parts on gallery samples in the database with the best match to query image. The feature extraction is applied on the small sub images of the probe and gallery sets to find the identity of the partial probe face. LFW database is employed to evaluate the performance of the proposed approach. Based on the experimental results, proposed leads to the best recognition accuracy. Also, reducing the size of sub-image to less than 50% of the complete image size decreases searching time with increased identification accuracy considerably.

Key words: Face recognition, unshaped partial input image, Viola-Jones face detector, Condense-SURF.

I. INTRODUCTION

Recognition of human faces is applied in a wide range of applications such as surveillance images, law enforcement, forensic and investigative environments, access control and social networking. In recent years many face recognition technologies with acceptable recognition accuracies in constraint conditions has been proposed. However, accurate face recognition under degradation conditions in uncontrolled environments such as occlusion, illumination variation, low resolution and head pose variation is still under investigation by researchers in this area. In some applications such as images captured by surveillance cameras or mobile devices without the human cooperation, the face recognition system suffers from the lack of access to the image of the complete face where some areas are occluded by external objects or there are only partial face images available. The aim is to identify people by using partial face image. The main challenge is to detect the face area where we require searching for the similarity in the available gallery set. Therefore, the first step is a face detection process to localize the probe area to find the best match for the partial face template in the sample images of each individual in the entire gallery set.

The rest of this paper is organized as follows: Section II gives the overview and reviews of the related works in Face recognition. Detailed working of proposed system architecture is presented in section III. In section IV the methodology is explained. The experimental results are analyzed in Section V. And section VI presents the conclusion and future work.

II. RELATED WORKS

Soodeh Nikan and Majid Ahmadi [1] proposed a method that finds the parts of gallery faces in the database, which have the best match to the partial probe image. ZNCC and NSSD template matching approaches are applied to find the best matches. Then, by using feature extraction and classification approaches on the probe sub-image and its best matches on the gallery samples to recognize the identity of the probe sample. The proposed approach is applied on the AR, LFW and FERET databases with cropped eyes, mouth and nose images as partial probe sets. Reducing the size to less than 6.25% of complete image size, decreases the identification accuracy drastically.

Huu-Tuan Nguyen and Alice Caplier [2] presents a technique for Face Recognition using Local Patterns of Gradients (LPOG), unified, single sample per person FR framework called LPOG. The Whitened Principal Components Analysis (LPOG WPCA used for dimension reduction. k-NN and weighted angle-based distance function for classification. The method achieves stable, consistent and outstanding performance with respect to various challenges such as SSPP, illumination, facial expressions, occlusion, timelapse, pose variations and low resolution probe images. LPOG is robust when applying to face verification, a one vs. one matching problem usually requires a dedicated
K. V. Arya, Abhinav Adarsh, [3] proposed a technique for Efficient Face Detection and Recognition Method. The detection has been carried out by combining the skin models. The Haar like filter for each individual, which gives the information of multiple faces for single individual. Then PCA has been used to identify the desired single face. The feature extraction has been carried out by estimating and selection of sub-space [11]. The experimental results shows that the proposed method detects and recognizes faces efficiently, giving recognition accuracy from 83% to 99% by varying the number of vector space. There is a trade-off between recognition rate and timing efficiency.

III. PROPOSED SYSTEM ARCHITECTURE

A new method have been proposed for Face Recognition with higher accuracy that work on partial input of face region as a query image, retrieves query matched image with minimal time. Figure 1 shows the block diagram of the proposed Face Recognition system.

The operation of architecture is explained as follows:

Here the Image database contains organized collection of digital images in jpg format of resolution of 250 X 250. The proposed method is to retrieve images similar to the query image as the following step:

Input: partial input of face region - color image and dataset of images
Output: single image retrieved same as that of the query image

1. Face Detection: When a user provides a query image which is of unshaped and partial input face region of image. The face detection algorithm detects the face part of the query image and also detects face region of the image from the database.

2. Condensing Image: In this step, the detected faces need to be condensed when the images need to be compared are dissimilar in size.

3. SURF Feature Extraction for similarity measurement: The system computes the similarities between the query image and the database images by using the extracted features of an image.

4. Retrieval: The image retrieval is based on the matched points with the query image. In the proposed system the matched point is equal or more than one based on trial and error method. The system retrieves and displays a single target image as a result, the user is able to visualize the best matches to his/her query image.

Aim of the proposed system is to provide better accuracy compared to the existing systems. The computation time is reduced by comparing only partial input of the query image in a reduced search space that is within the face region of the detected face from the database.

IV. METHODOLOGY

The implementation can be preceded through Matlab 8.3.0.532 (R2014a) [12] will be more suitable for image processing concepts and Java 1.7.0_11-b21 with Oracle Corporation Java HotSpot(TM) 64-Bit Server VM mixed mode.

By providing the partial unshaped input as query image, the proposed system detects the face part of both query image and target images from the database.

The condensing operation is required only when the images to be compared are dissimilar in size. Finally SURF feature extraction is applied for finding the best match of the query image. The algorithm is given below:

Algorithm for Condense-SURF Feature Extraction

Given a query image, the search for the most similar images in the database is implemented as follows.

Step 1: Detect the face part of the query image
Step 2: Read image from the database. Find face part of the target image.
Step 3: Compare the dimension of query image with the dimension of target image.
Step 4: if dimension of query image less than the dimension of target image then change the
dimension of the target image similar to the query image then go to step 6.
Step 5: if dimension of query image greater than the dimension of target image then change the
dimension of the query image similar to the target image then go to step 6.
Step 6: Compute SURF feature extraction algorithm to find the matched points. If a single matched
point occurs go to step 7 otherwise repeat steps 2 to 6 until termination condition met.
Step 7: Display the retrieved image if exists in the database otherwise display the error message.

The individual step of this approach is explained below:

1.1 Face detection

The Viola and Jones face detection algorithm is used as the basis for the proposed design. It
looks for specific Haar features of a human face. When one of these features is found, the algorithm
agrees the face candidate to pass to the subsequent stage of detection.

1.1.1 Integral Image

Scale Invariant Face Detector: The first step is to find out input integral image of the input
image in Viola-Jones face detection algorithm. Figure 2(a) and 2(b) shows the computation of Integral
image.

The integral image of a region at the point \((x,y)\) in the summed area table is the sum of all
pixels above and to the left of \((x,y)\) including \(i(x,y)\), shown in equation (1).

\[
II(x, y) = \sum_{x' \leq x, y' \leq y} i(x', y')
\] (1)

The computation of the integral image \(II(x,y)\) recursively can be made as shown in equation (2):

\[
\Pi((x,y) = \Pi(x,y) - \Pi(x-L,y-L) + \Pi(x,y-L) + \Pi(x-L,y))
\] (2)

2(a) Point \((x,y)\) of the integral image stores the
sum of pixels in grey region of the original image.
2(b) The pixel sum in grey region of the original
image = A+D+B+C, where A,B,C,D are values
taken from the integral image.

Fig.2. The Integral Image

This is used for calculation of sum of all the pixels which are given in the four values of rectangle.
These values are the pixels of the integral image with the corners of the rectangle in the input image.
Table 1 and table 2 shows sample input image and its corresponding Integral image values.

<table>
<thead>
<tr>
<th>TABLE 1: INPUT IMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4</td>
</tr>
<tr>
<td>5 6 7 8</td>
</tr>
<tr>
<td>1 2 3 4</td>
</tr>
<tr>
<td>5 6 7 8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2: INTEGRAL IMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 3 6 10</td>
</tr>
<tr>
<td>6 14 24 36</td>
</tr>
<tr>
<td>7 17 30 46</td>
</tr>
<tr>
<td>12 28 48 72</td>
</tr>
</tbody>
</table>
1.1.2 \textit{Haar Features}

Either two or three rectangles are composed for to find Haar features. There are a variety of forms of features as shown in figure 3:

![Fig. 3. Examples of Haar features.](image)

The value of each this feature is calculated by taking the area of every rectangle, multiplying each by their corresponding weights, and then summing the results. The area $R$ is the rectangle area, specified as the rectangle integral. This can be computed as shown in figure 4 by the locations of the integral image: $L_4-L_3-L_2+L_1$.

![Fig. 4. Computing the area of a rectangle](image)

$R$ is done by the corner of the rectangle: $L_4-L_3-L_2+L_1$. A Haar feature classifier uses the rectangle integral to compute the value of a feature.

1.1.3 \textit{Cascade}

The face candidates can be removed quickly via a cascade of stages by using Viola and Jones face detection algorithm. A face is detected if a candidate permits all stages. The classifier cascade is a chain of filters. Image subregions that make it through the entire cascade are classified as "Face." All others are classified as "Not Face". This process is shown in figure 5.

![Fig. 5. Cascade of stages.](image)

1.2 \textit{Condensing Image}

The detected faces need to be condensed when the images need to be compared are dissimilar in size. Condensing operation gets the sub-image of the original image using the getSubimage() function. The function returns a new image that is a sub image of the current image, the width and height will be clamped to the left/bottom margins is implemented through BufferedImage getSubimage(x, y, w, h) function. The returned sub image well-defined by a stated rectangular region and also the returned
1.3 SURF feature extraction

a) Interest Point Detection:
To find out the interesting points we are using Hessian matrix approximation. So as given by Viola and Jones it is apparent to use integral images.

b) Integral Images:
As shown in equation (3) [10], summation of all pixels in the input image I surrounded by a rectangular region made by the origin and x represented by it.

\[ I_{\sum(x,y)} = \sum_{i=0}^{x} \sum_{j=0}^{y} I(x,y) \]  

(3)

Where 0<\text{i}≤x \text{ and } 0<\text{j}≤y;

c) Hessian Matrix-Based Interest Points:

![Hessian Matrix](image)

Fig. 6. To calculate the summation of intensities inside a rectangular region of any size.

The performance of Hessian matrix detector is good in terms of accuracy. It is also for the scale selection. Let us about a point \text{x}=(\text{x}, \text{y}) in an image I, the Hessian matrix in \text{x} at scale \text{r} is defined as follows –

The Hessian matrix, \( \mathbf{H} \), is the matrix of partial derivatives of the function \( f \) shown in equation (4) [10].

\[
\mathbf{H}(f(x,y)) = \begin{bmatrix}
\frac{\partial^2 f}{\partial x^2} & \frac{\partial^2 f}{\partial x \partial y} \\
\frac{\partial^2 f}{\partial x \partial y} & \frac{\partial^2 f}{\partial y^2}
\end{bmatrix}
\]  

(4)

The determinant of this matrix is recognized as the discriminant and is calculated by using equation (5) [10]:

\[
\det(\mathbf{H}) = \frac{\partial^2 f}{\partial x^2} \frac{\partial^2 f}{\partial y^2} - \left(\frac{\partial^2 f}{\partial x \partial y}\right)^2
\]  

(5)

We can now calculate the Hessian matrix \( \mathbf{H} \), as function of both space \( \mathbf{X} = (\mathbf{x}, \mathbf{y}) \) and scale \( \mathbf{\sigma} \) is shown in equation (6) [10].

\[
\mathbf{H}(\mathbf{X}, \mathbf{\sigma}) = \begin{bmatrix}
L_{xx}(\mathbf{X}, \mathbf{\sigma})L_{yy}(\mathbf{X}, \mathbf{\sigma}) \\
\end{bmatrix}
\]  

(6)

Here \( L_{xx}(\mathbf{x}, \mathbf{\sigma}) \) is the convolution of second order derivative \( \frac{\partial^3 f}{\partial \mathbf{x}^3} \) with the image at point \( \mathbf{X} \) = (\text{x}, \text{y}) and similarly for \( L_{xy}(\mathbf{x}, \mathbf{\sigma}) \) and \( L_{yx}(\mathbf{x}, \mathbf{\sigma}) \)

d) Interest Point Description and Matching:
The SURF descriptor describes how the pixel intensities are distributed within a scale dependent neighborhood of each interest point detected by the Fast –Hessian. Haar wavelets are simple filters which can be used to find gradients in the x and y direction.

e) Detector – Descriptor Scheme:
This can be decomposed into three parts

---Fixing a reproducible orientation founded on information from a circular area around the interest point.

---Construct a square area aligned to the selected orientation and mines the SURF descriptor from it.

---Lastly features are matched between the two images.

f) Representation of Scale Space:

Interest points are essential to find out at different scales, not least because the search of correspondences which often needs their comparison in images where they show at different scales.

Descriptor Component:

To extract the SURF descriptor, build a square window around the interest point.

1) Feature Matching:

The sign of the trace of Hessian matrix for the underlying interest point is included for fast indexing during the matching stage. The candidate is not considered a valuable match if the contrast between two interest points is different.

2) Keeping Feature Vectors:

The vectors of key points and descriptors related to each and every image of the testing color LFW data set are need to be stored.

V. EXPERIMENTAL RESULTS AND ANALYSIS

The Labeled Faces in the Wild (LFW) dataset is a group of JPEG pictures of well-known people collected over the internet. Every picture is centered on a single face.

The Face Recognition by partial input image method is implemented and tested on Debra_Messing_0003.jpg image. Following figures 7(a) and 7(b) shows the detected face by using face detection algorithm which is going to be used as a part in the proposed method.

![Image 7(a) Original image with dimension 250 X 250. Image 7(b) detected face of image with dimension 108 X 108.](image.png)

Fig.7. Image results of each step of the proposed system.

The Face detection algorithm crops face region of different sizes. Figures 8(a) and 8(b) shows the results of applying face detection algorithm to few sample images in the database.

![Image 8(a) Original images from database of dimension 250 X 250 Image 8(b) detected face images of sample images from database of various dimensions.](image.png)

Fig. 8. Sample detected faces from database
Following figures 9(a) and 9(b) shows the image results of each step of the proposed method.

![Image](image1.png)

9(a) partial input of an unshaped query image of dimension 250 X 250.

![Image](image2.png)

9(b) detected face in partial input of an unshaped query image of dimension 90 X 90.

Fig. 9. The image consequences

While cropping, one cropped image is larger than the other cropped image, either the query image size or detected face from database set. Having different sizes of the images requires condensing operation for any one of the images before feature extraction.

Below figure 10(a)-10(d) shows different sizes of query image and sample image taken from dataset. In that query image size lesser or greater than the image sample taken from the dataset. Here either the query image or image sample taken from the dataset need to be condensed to the size of an image that have lesser size.

![Image](image3.png)

10(a) query image of dimension 90 X 90 and detected face of an image from database with dimension 108 X 108 for which dimension need to be changed

![Image](image4.png)

10(b) Image from database which changed to dimension 90 X 90

![Image](image5.png)

10(c) query image of dimension 122 X 122 for which dimension need to be changed because the detected face of an image from database with dimension 114 X 114

![Image](image6.png)

10(d) Query image changed to dimension 114 X 114
The proposed system is tested using LFW database and the results are recorded shown in table 1. In which, the dataset of various sizes for to retrieve Cropped Unshaped ROI whose original image is placed in the last position in the database is shown. It consists of various Image set size and Elapsed time for retrieval specified in both seconds and minutes.

In the Face recognition, the most commonly applied performance measures recognition accuracy.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Image set size</th>
<th>Elapsed time for retrieval (in seconds)</th>
<th>Elapsed time (in minutes)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>60.21</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>88.56</td>
<td>1.47</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
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<td>4</td>
<td>400</td>
<td>174.79</td>
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</tr>
<tr>
<td>5</td>
<td>500</td>
<td>227.51</td>
<td>3.79</td>
</tr>
<tr>
<td>6</td>
<td>600</td>
<td>273.62</td>
<td>4.56</td>
</tr>
<tr>
<td>7</td>
<td>700</td>
<td>324.32</td>
<td>5.40</td>
</tr>
<tr>
<td>8</td>
<td>800</td>
<td>361.71</td>
<td>6.02</td>
</tr>
<tr>
<td>9</td>
<td>900</td>
<td>409.60</td>
<td>6.82</td>
</tr>
<tr>
<td>10</td>
<td>1000</td>
<td>437.69</td>
<td>7.29</td>
</tr>
</tbody>
</table>

The proposed system approximates or even outperforms previously proposed schemes with respect to partial unshaped probe image, yet can be computed and compared much faster.

The proposed system gives best recognition accuracy when the subimage dimension ranges between 95 to 106 in x-axis, and in y-axis 97 to 100 yields one to one match. Also, reducing the size of subimage below the ranges or increasing above the ranges, decreases the identification accuracy drastically.

Fig. 10. The Effects of condensing dimensionality and final result of proposed method

Fig. 11. The comparison of Template Matching with Condense –SURF
A Face Recognition by partial input approach to find the identity of small partial image which is available from surveillance cameras or criminal scenes in forensic environments, where only a small portion of target face is uncovered and non-occluded. The proposed method first finds the face part of gallery faces in the database. Then, by using feature extraction approaches on the probe sub-image and the detected face from the gallery samples to recognize the identity of the probe sample. The proposed approach is applied on the LFW database. The proposed technique has significant performance despite of very small size of sub-image.

In this paper we have presented a novel Face recognition using partial input image of unshaped images the performance of the approach is evaluated using LFW image set and it compared some of other well-known approaches in terms of recognition accuracy but limited to work on only JPEG images and dataset of substantial size.

There are various interesting future researches are in progress. In addition to addressing current restrictions of our system, we would like to create a system that recognizes face while providing partial noisy image as input.

VI. CONCLUSION

REFERENCES
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