Robust Face Detection using Fusion of Haar and Daubechies Orthogonal Wavelet Template

Chirag I Patel
Research scholar, Institute of Technology,
Nirma University, Ahmedabad, Gujarat, India

Sanjay Garg
Professor, Institute of Technology,
Nirma University, Ahmedabad, Gujarat, India

ABSTRACT
Face detection is fundamental step in the process of face recognition. This work presents a robust approach for Face detection. Orthogonal wavelet considerer details of images and its multi-resolution representation. Template making procedure consider lots of face images. After that orthogonal wavelet transform is applied on that each image and make one template of face after averaging all wavelet transform images coefficients, and using matching algorithm that template is matched with test images and thus face is detected in images. Experimental results indicate that this approach is more efficient and accurate for robust domain.

General Terms
Image Processing and Computer Vision

Keywords
Image Processing and Computer Vision

1. INTRODUCTION
Face detection tasks are becoming required more necessary in the modern world. It is also an important task in many computer vision problems. Basically its goal is to decide where face is situated in image and further it can give position or coordinate of face in image. Face detection means Identify and locate human faces in an image regardless of their position, scale, in-plane rotation, orientation, pose (out of-plane rotation) and illumination. Recent advance in face detection is due to its usefulness in many highly secure and intelligent systems. Basically Face is a highly non-rigid structured object and it's having lots of application in many surveillance system, automatic face recognition system, automatic target or object recognition system etc.

2. PREVIOUS WORK
Oliver et al [1] present a method for robust frontal face detection based on Hausdorff distance. Approach uses predefined edge model of human face is used to find face candidate in image. But it is simple to use ellipse as a model, the performance of face detection can be improved by using a more detailed and complex edge model of human face. Further same authors [2], in their previous work, they presented a model-based approach to perform robust, high-speed face localization based on the Hausdorff distance. A crucial step during the design of the system is the choice of an appropriate edge model that fits for a wide range of different human faces. In this approach they present an optimization approach that creates and successively improves such a model by means of genetic algorithms. To speed up the process and to prevent early saturation they use a special bootstrapping method on the sample set.

Viola et al [3] has proposed approach contains three main ideas that make it possible to build a successful face detector that can run in real time: the integral image, classifier learning with AdaBoost, and the attentional cascade structure. Rainer Lienhart and Jochen Maydt [4] have extended approach used in [3] based on boosted cascade of simple features. Proposed technique represent image by set of rotated Haar like features which enhance the performance of object detection compare to simple Haar like features and it can be calculated very efficiently.

Rein-Lien Hsu et al [5] has proposed a face detection algorithm for color images in the presence of varying light condition as well as complex backgrounds. The approach is based on novel lighting compensation technique and nonlinear color transformation which detect skin regions over entire image and then generate face candidate based on spatial arrangement of these skin patches.

Hossein Sahoolizadeh et al [6] has proposed new hybrid approaches for face detection. Gabor wavelets representation of face images is an effective approach for both facial action recognition and face detection. Perform dimensionality reduction and linear discriminate analysis on the down sampled Gabor wavelet faces can increase the discriminate ability. Nearest feature space is extended to various similarity measures. In their experiments, proposed Gabor wavelet faces combined with extended neural net feature space classifier shows very good performance.

Avinash Kaushal et al [7] has proposed their approach based on classifications of the features of a face detected using Gabor filter feature extraction techniques. The feature vector based on Gabor filters used as the input of the classifier, which is a Feed Forward Neural Network (FFNN) on a reduced feature subspace learned by an approach simpler than Principal Component Analysis (PCA). The effectiveness of their proposed method is demonstrated by the experimental results on testing large number of images and comparisons with state of the art method. But further this approach can be optimized so that it can be less time consuming real time domain.

Liming Wang, Jianbo Shi, Gang Song, and I-fan Shen [8] have proposed object detection method using improved shape context features which is more robust to object deformation and background clutter. First feature set is computed from shape context the combine with object mask both are used to build codebook for training images. Top down recognition is used to match features and voting input image. Finally verification is performed between top down recognition result and bottom up segmentation. But this method fails when object is so small in size.

H Schneiderman, T Kanade [9] have present statistical approach for 3D face detection. Approach describes images with face and without face by statistics which is calculated

form histogram. Each histogram represent joint statistic of wavelet coefficient and their position on object. Wide varieties of histogram are used for representing different attributes. Erik Hjelmas et al [10] proposed survey of recent advances in face detection is presented. They survey various techniques according to how face detection algorithm extract features and what learning algorithms are adopted. One can refer this survey for detail study on face detection approaches. Sami

Romdhani [12] has proposed a technique for face detection. Foundation of technique is considering window with all variation in scales, positions and orientation within an image calculating features from that. Calculated feature set is classified used to determine whether or not a face is in window using support vector machine. Comparative analysis of this technique is done with our proposed approach at end of paper.

3. MATHEMATICAL BACKGROUND

3.1 Wavelet Transform

Wavelet transform gives time-frequency localization. It is multi-resolution technique because at different scale, i.e. inverse of frequency, it will give different information [13] [14]. Coefficients of wavelet transform give multi-resolution analysis of image.

When scale is higher wavelet transform will give coarse details and when scale is low it will give fine details. Wavelet has several types of basis function that can be used for various analysis of image. This type of family of transformation is resolving the signal into approximation as well details [15][19].

The continuous wavelet transform is defined as

$$(W_a f)(b) = \int f(x)\psi_{a,b}(x)$$

Where

$$\psi_{a,b}(x) = \frac{1}{\sqrt{a}}\psi\left(\frac{x-b}{a}\right)$$

$\Psi_{a,b}(x)$ is mother wavelet function. a is scaling function and b is translation function.

3.2 Haar Wavelet Transform

Haar wavelet is simplest possible wavelet. The basis functions of Haar wavelet are the oldest and simplest known as orthonormal wavelet which is sequence of rescaled "square-shaped" functions [16][17][18]. Haar wavelet is used because its local statistics are relatively constant and can be easily modelled. Both coarse and fine resolution approximation of the image can be easily extracted. With various shifts and stretches Haar wavelet transform cross-multiplies a function against the Haar wavelet.

Haar wavelet function can be described as

$$\psi(t) = \begin{cases} 1, 0 \le t \le 1/2 \\ -1, 1/2 \le t \le 1 \\ 0, otherwise \end{cases}$$

3.3 Daubechies Wavelet Transform

Daubechies wavelet belongs to family of orthogonal wavelet. As it is orthogonal there is a scaling function which generates multi resolution analysis [19]. Any Daubechies wavelet is defined by its vanishing moments or no of zero moments. Haar transform has some limitation [17] which can be overcome by Daubechies wavelet transform. Even though Haar wavelet is being simple to compute and easy to understand we have also used Daubechies due to its nature of picking up details which is missed by Haar wavelet. Figure 1 shows Haar and Daubechies 6, 10 and 26 respectively.

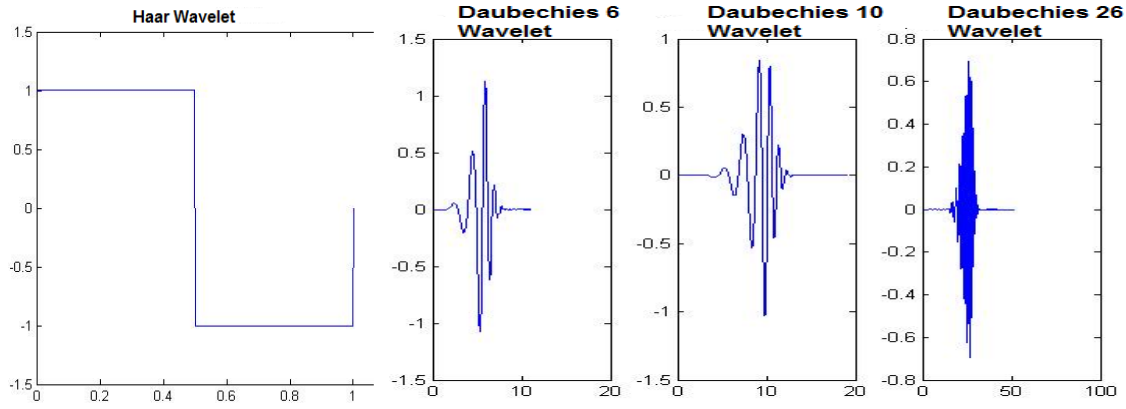


Fig. 1: (a).Haar wavelet (b). Daubechies 6 (c). Daubechies 10 (d). Daubechies 26

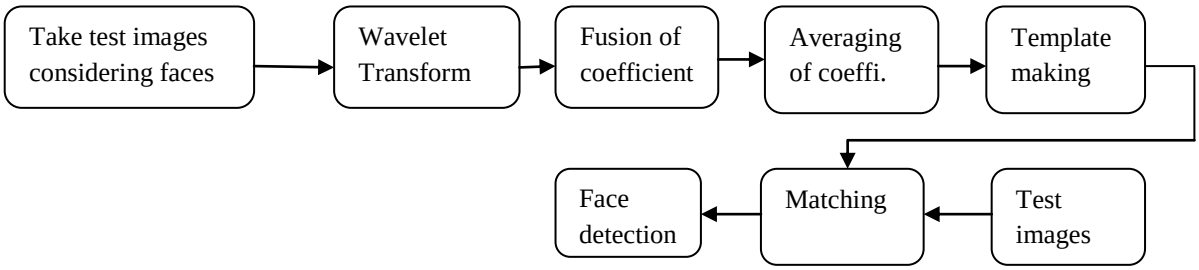


Fig. 2: Block diagram of proposed Approach

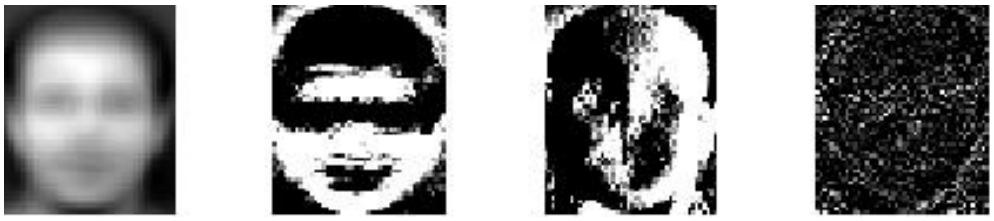


Fig. 3: Template from approximation and detail coefficient horizontal vertical and diagonal respectively

4. THE PROPOSED APPROACH

An attempt has been made to develop a robust face detection system; block diagram of the same is shown in figure 2. The proposed approach is based on Haar and Daubechies wavelet transform and both transforms are orthogonal wavelet transform. Face images collected of various types then Haar and Daubechies wavelet transform is performed on all images and finally after averaging out all images wavelet transform coefficients, which contain vertical edges information, we have make template shown in the figure 3.

Following are stepwise detail information about our methodology:

- Depending on the level of the haar and daubechies , we find the average of two adjoining region of the gray scale image , we then find the difference in the average of the two regions and save it in the place of original image pixel.
- The haar and daubechies transform can be computed using basis functions of a varying number of shapes, however we have restricted our use to only rectangular haar and daunechies features like horizontal, vertical and diagonal haar and daubechies features.
- In case of vertical haar and daubechies transform we find the difference between two adjoining blocks placed in difference row, horizontal haar and daubechies are obtained by finding the difference between the two adjoining blocks placed in different columns. Diagonal haar and daubechies were computed in similar way for blocks in different row and columns.
- We then found the average image of all the haar and daubechies then saved the image so obtained; this was repeated for different size haar and daubechies. We computed the haar and daubechies for levels 1 to 3 and saved them. And that template we are using for face detection in other test images.
- Matching is done with cross correlation between template and test image and localization of face is done using maximum response we get after applying normalize cross correlation.

Need of robustness for our approach against any types of face images we have consider various types of images. As our approach is simple and its need bit of calculations compare to others. To verify accuracy of our approach results are shown on images which are not used to make template image. In section 4 brief introductions about wavelet transform, Haar wavelet and Daubechies transform is defined. Later on in section 5 is describing information related with images which we have used for making template and finally experimental results are shown in next section.

5. EXPERIMENTAL RESULTS AND DISCUSSIONS

5.1 Sample Images

Figure 4 shows images, taken from The ORL Database of Faces [20], which we have used to build up the template image. There are ten different images of each of 40 distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses).

All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement).We have consider all types of images considering Presence or absence of beards, moustaches, and glasses as well as facial expression because face appearance is directly affected by a person's facial expression and imaging conditions like lighting i.e. source distribution and intensity and camera characteristics like sensor response, gain control, lenses and resolution. Because of that our method does not depend on specific constraints. In our system 40 types of persons each having 10 different pose

images means total 400 sample images are considered for template making.

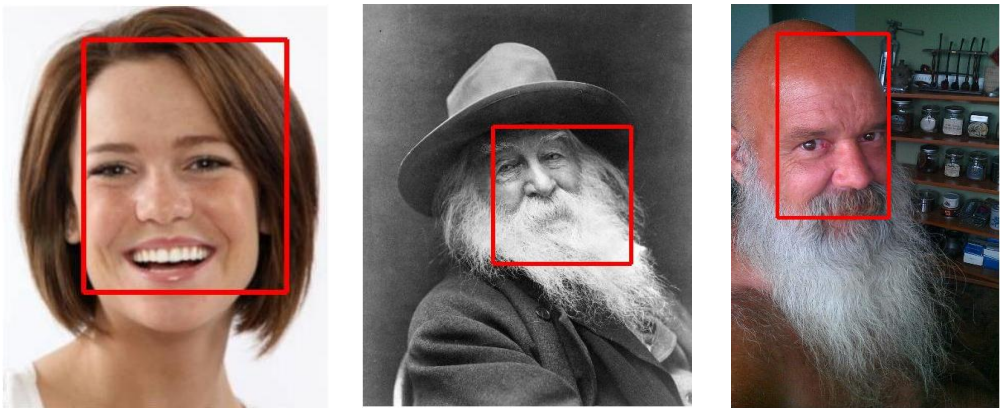
5.2 Experimental Setup

Experiment on test image is performed using Matlab R2010a on 64 bit operating system with Intel Core2 Duo CPU at 1.50GHz having RAM of 2.5 GB.

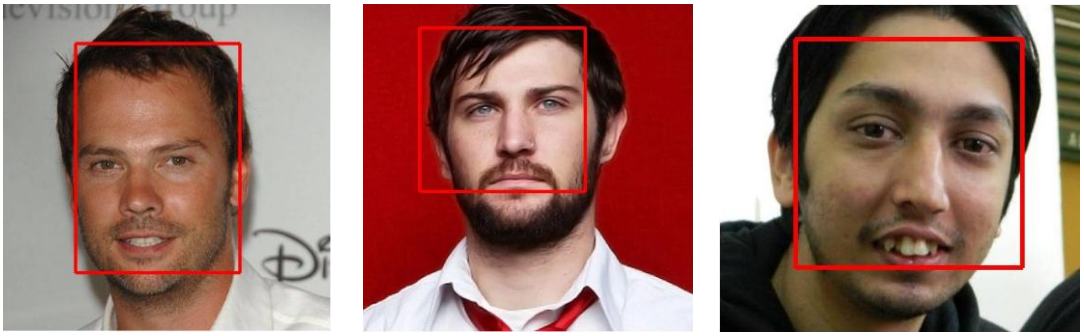
Fig. 4: Various Images for building up template [20]

5.3 Experimental Results and Discussion

Figure 5 is showing result for our approach and in all figure the detected face is defined by red bounded box. In figure 5(a) face having smile on face and still our approach gives good result. Figure 5(b) and 5(c) shows both the persons having different structured parameters like beard but still face is detected properly. Even figure 5(b) the person wear hat but our approach doesn't affected by that.



(a)[21] (b)[22] (c)[23]



(d)[24] (e) [25] (f)

(g) (h) (i)

(j) (k) (l) (m)[26]

Fig. 5: Experimental Results of our face detection Approach

Table 1. Accuracy table for our approach

Sr.No	face images types	No. of test images	True positive	False positive	Accuracy in %
1	Simple face images	475	467	12	98.31
2	with beard	247	234	23	94.73
3	With spectacles	320	316	04	98.75
4	Images with different age of person	400	398	02	99.5
5	Images with different shape and size of face	680	669	11	98.38
6	With different face emotion	266	257	09	96.61
7	With different skin color	796	785	11	98.62
8	**Total**	**3184**	**3112**	**72**	**97.74**

Figure 5 (d), 5(e) and 5(f) are images with different persons with different area covered by face in total image; our approach works properly and gives batter results. Figure 5(g), 5(h) and 5(i) are of same person but under different lighting condition as well under different background face detection is well performed by our approach. Figure 5(j), 5(k), 5(l) and 5(m) are results with different person. In figure 5 (l) even though face is having sad expression give accurate result means our algorithm does not depend on expression.

Accuracy also found for our face detection approach. We have taken different 3184 test images with different predefine characteristics for checking experimental results as well accuracy are given in following table 1. True positive is defined by correct results means face detected by our approach and false detection is defined by wrong results means face is not detected properly.

5.4 Comparative Analysis

Comparison of proposed approach is done with Romdhani approach proposed in [12] as shown in figure 6. Percentage accuracy or detection rate is compared between both of approach. As our approach is far better than romdhani's approach as it gives good face detection rate compare to romdhani's approach.

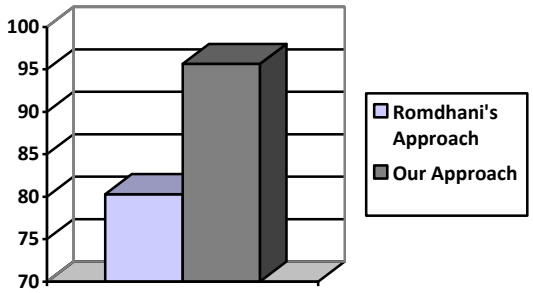


Fig. 6: Comparative Analysis

6. CONCLUSIONS

As orthogonal wavelet transform emphasize directional details of image which we have use as key feature in our approach. Our experimental results shows that even though there are transformation of skin color, style of hair, spectacles, beard ,age and face shape and size in test images of face leave the face recognition performance relatively unaffected. Thus the orthogonal wavelet transform provide good and excellent face detection from its multi-resolution representation. As the accuracy of our approach is 95.63 % and that is good enough to define that our approach is giving good result.

As a future extension if there is rotation and orientation means pose change will be there in face then the approach should detect face. Even the approach should be extending for multiple face detection by small changes in matching algorithm. Another extension is identification of pose of face in image.

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