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Prediction of Full Face from Half Face Template using Machine Learning: A Survey

Kapil Rawal[1], Shreya Srivastava[2]

[1]Student, School of Computing Science and Engineering(SCSE), Galgotias University, Uttar Pradesh, India
[2]Student, School of Computing Science and Engineering(SCSE), Galgotias University, Uttar Pradesh, India

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Abstract - *Nowadays face recognition is no more a tough assignment rather it is one of the easiest tasks of machine learning. Technology has advanced so much that full face can be recognized and verified but still is not 100% accurate and yet requires high computation time moreover requires high storage capacity. There has been much advancement in this field to increase accuracy and decrease computation time and also reduce storage required but all these can be solved using half-face templates. Research has found that using a half-face template, face recognition process can be fastened with higher accuracy and lesser computational time. Since the Human face is symmetrical and feature extraction is a major step in face recognition using half template. As it will help in identifying people in public or detecting faces with depth rotation or incomplete images (when the only half face is visible). For image compression, we have proposed a technique that can be used like PCA (Principal Component Analysis). Human Face has rich features which provide a high chance to identify people and increase security. Many different problems such as illumination, occlusion and rotation which makes identification more harder. In the proposed research paper we have shown how a half-face template is a better method than using a full face for recognition.*

Key Words: ***Feature Extraction, Half-face Template, PCA, Computational Time, Occlusion.***

1. INTRODUCTION

Face Recognition System was designed to identify people by the analysis of characteristics of their facial features. There are various biometric systems available such as Iris Scanner, Fingerprints, Signatures to identify people precisely but they all fail at a point where people have to be identified on a large scale and without any physical contact. Face Recognition System is very helpful in identifying individuals and even people in large groups and crowds that can also be identified easily, moreover this system is also beneficial in finding criminals or lost people. The Face Recognition System indeed is much faster and accurate than other systems. This system is highly secure as it does not require any key or password for using it in surveillance to monitor and guard organizations. One of the important features that can be added for enhancing security is by identifying individuals on the basis of their half-face only. Using a half-face template method will have its own various benefits.

The Face Recognition System is one of the best biometric Systems for identification and security concerns but still it requires lots of research to reduce computational time, accuracy and storage. The Half-Face template uses only half-face for identification and verification of a person. This method is highly efficient and research has shown that using a half-face template gives higher accuracy and lesser computation time than that of full-face.

There are various problems in facial recognition systems, which make machines hard for identifying people precisely like rotation, occlusion, illumination, different poses of a person. Rotation in images makes it incomprehensible for machines to process them and extract facial features from them as machine algorithms are trained in a way to extract features when images are properly oriented. But this issue can be solved with the help of ANN. Varying illumination makes it difficult to extract all required facial features to identify if two people are the same or different.

Occlusion is a problem when a part of the images are blocked or is not visible due to any reason. If faces are occluded then the half-face template method would still work up to its full potential and would yield better results than full-face recognition conditional half-face must be visible else accuracy will decrease. For extraction of facial features, images have to be properly oriented but different variable poses cause a lot of trouble in identifying people as all their features are not visible. The major challenge in the face recognition system is to reduce computational cost and storage required which can be achieved by using half-face as the human face is symmetrical in nature discussed in Figure 1, so why to store information of full-face when only half-face information is enough for the identification process. In this research paper we have divided the paper in following sections: In section1 we have discussed the introduction of the topic and problems in identifying face and computation process. In section 2, we have discussed related work in this area and highlighted the existing methods and techniques used. In section 3, we have proposed our methods followed by conclusions in section 4.

2. RELATED WORK

Yi Zhu et al.[1] have focused on the detection of the face and extraction of a half-face template with large depth rotation. As their result showed that a full-face template

with significant depth rotation would be less effective in detecting faces. Their algorithm was designed to estimate the candidate face regions by converting the input image into the binary image by intensity thresholding as this helped in eliminating regions that did not correspond to the face regions. With the help of intensity thresholding, first they identified the eyes and then formed elliptical regions around the eyes which are used to identify the average-half-face and depth rotation.

In figure 1. they concluded that using a large template showed better results than using a small template as the large template could be scaled down.

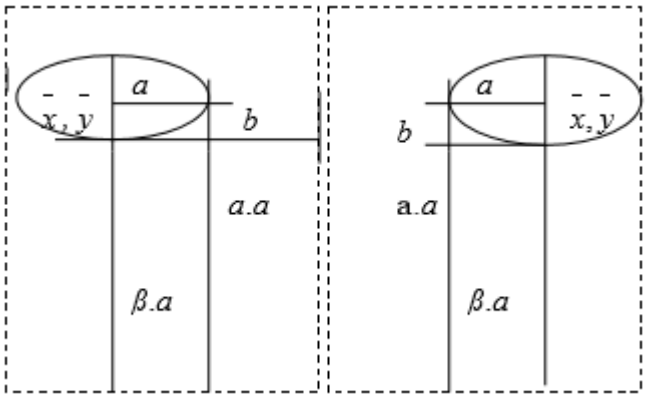

Figure 1: Candidate half-face region corresponding to left and right eye ellipses. Based on an ellipse fitted to the candidate eye regions the bounding box of the half face is calculated. The length of the half-face is proportional to the minor ellipse semi axis(alpha*a) and the width of the half-face is proportional to the major ellipse semi axis.

Harguess et al.[2] was the first researcher to present the idea of using an average half-face. Using a half-face template method has various advantages like storage required for computation is significantly reduced to half moreover features extracted are also reduced directly reducing computation time hence increasing the efficiency of the face recognition system. To extract half-face it is very important to split face and discard redundant parts which can be done with the help of vector split method and then use Principal Component Analysis (PCA) for the recognition process. The average half-face is formed from the full-frontal face in two steps:

1. Face has to be positioned at the center
2. Split the face in half and then the two halves are averaged together.

Now the input for the face recognition algorithm is the new average half-face. The precision of the face recognition using Eigen faces with the average half-face is remarkably better than using the full face. They also compared the results of half-face and full-face using 6 recognition methods MPCA, EIGENFACES, MPCALDA, LDA, ICA and SVM. Their results showed that using half-face is a better choice than full-face. The ends of this discovery result in plentiful savings in storage and computation time[2].

Table 1: Rank accuracy results using the full-face and the average-half-face

Database	A(Yale)	B(AR)	C(3D)
Algorithms	AHF | FF	AHF | FF	AHF | FF
PCA	86.7 | 77.8	52.3 | 49.4	80.4 | 72.8
MPCA	93.3 | 80.0	57.6 | 59.4	81.3 | 81.0
MPCA-LDA	68.9 | 66.7	88.1 | 91.9	93.8 | 91.8
LDA	97.8 | 91.1	78.0 | 54.1	82.6 | 79.8
ICA	100 | 93.3	60.0 | 65.3	84.8 | 76.9
SVM	91.1 | 91.1	36.1 | 44.8	51.4 | 50.8

Gnanaprakasam et al.[3] in 2010 came up with an idea to reduce storage requirements and computational cost by using wavelets with the half-face[c]. This recognition method can efficiently handle processing of images that are partially clear and give applauding results as wavelets are used to extract facial features. He also used various compression techniques that can be applied like PCA, LDA, etc to reduce size requirements as they reduce dimensions from 3D to 2D and remove noise and unwanted information and store only relevant data which can be used in identification process. Gnanaprakasam et.al [3] in his research used Harguess's et.al [2] work and the concept of average-half-face and helped to overcome problems resulting from expression, illumination or pose variation. He used the wavelet transformation method in which signals are spread across various divisions of the space and frequency and only those signals are selected which gathers most of the facial features and then 3D geometries are measured and 3D characteristics are calculated.

Discrete wave transform is used to keep useful information intact by decomposing face image into multi-resolution representation. Their face recognition method used only a 3D range of images and is able to recognize faces from different angles[3].

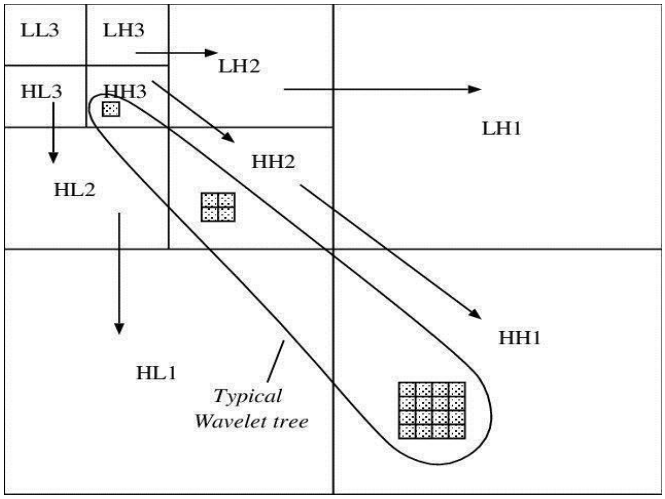

Figure 3: space and frequency structure of wavelet transform.

Muhammad Imran Shehzad et al. [4] in his proposed model, divided process into 4 steps: Face Detection, Face Registration, Face Splitting, Face Recognition. To reduce computational time and storage requirements he also used the concept of average-half-face. They used the Viola-Jones method in combination with intensity-based registration for real-time face detection and registration. For splitting the face Vector split method was used. At last, PCA was used to compress the multi-dimensional data space and recognition. His methodology experimental results produced much better results as compared to the full-face recognition and other previously proposed half-face recognition models.

According to their results it took less than 3 seconds to identify a person by using MATLAB and their methodology was highly beneficial for the surveillance system.

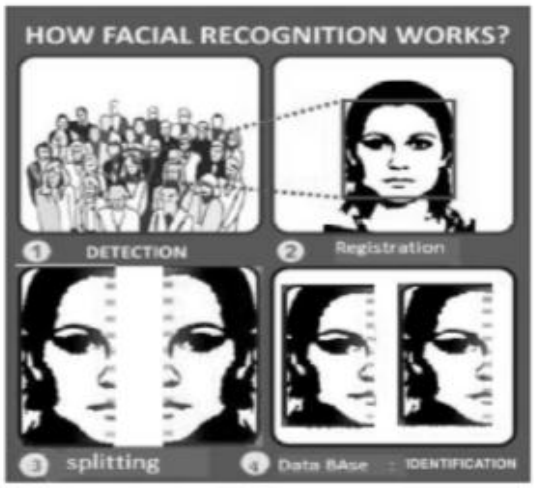

Figure 4: 1) Face Detection 2) Face Registration 3) Face Splitting (Average Half Face) 4) Face Recognition

They also compared accuracy and computational time of the full-face template and the half-face template[Table 2,3].

Table 2: Recognition results accuracy comparison

Section	Total images	True Results	Accuracy
Half-Face	182	175	96.15%
Full-Face	182	168	92.00%

Table 3: Comparison of Computational time

Section	Computational Time
Half-Face	2.84 sec
Full-Face	4,54 sec

Something which is common to all their work was splitting faces into halves and most important they used PCA for compression of high dimensional data.

Hemashree et al.[5] showed that if there is any tilt present in the image that can be detected and corrected by using ANN. They also used PCA to train ANN which detects if there is any rotation in the input image and if there is any rotation then it is corrected using some operations by another ANN. Generalized Feed Forward Artificial Neural Network (GFFANN) is what they used to identify various features of human faces like eyes, nose, etc. These all features are combined to give a reinforced decision to verify a person's identity despite illumination variations[5].

Table 4: Average Performance of a GFFANN after 3000 epochs considering only facial feature section.

S. No.	Image Size	Feature Length	Time(s)	Success rate(%)
1	32x32	20	12.1	92
2	64x64	40	22.3	94
3	64x32	20	13.1	92
4	64x50	34	20.2	93

Table 5: Average Performance of a GFFANN after 3000 epochs considering complete image features.

S. No.	Image Size	Time(s)	Success rate(%)
1	32x32	155.9	93

2	64x64	215.3	95
3	64x32	201.6	94
4	64x50	189.8	95

In table II we can see that computational time is reduced significantly more than 90% on an average when we consider using only facial features not the whole image. This also helps in reducing the amount of storage used in the process.

Hongjun Jia et al.[6] came with the idea to overcome the partial occlusion problem by reconstructing the whole image. In this approach, all of the test images are described as a linear combination of the training sample and each class provides "best construction" which means that they use the appropriate metric to compare the reconstructed and the test image.

Before reconstruction of the face we need to extract all the features and the rest of the occluded part is reconstructed with the test and training samples[6]. Criminals usually hide their faces or sometimes only some part of their face is hidden at that place. This method is very useful as it enhances the process of identification by reconstructing images.

3. PROPOSED WORK

In our proposed work we have used accurate orientation of input images, else we will need to identify if there is any rotation in the image and use algorithms like PCA to extract facial features and apply them to GFFANN with an associated class node. This will help us to recognize the angle of rotation. We have used GFFANN (Generalized Feed Forward Artificial Neural Network) to detect the rotation angle of the input image and if the rotation angle is known then easily we can rotate the image in its correct position. Once the image is in correct orientation and then we can easily identify all facial features from the image. Once we have our input image in the required position then we can look for other issues like occlusion or illumination[5].

1. For occlusion first we need to see if we can extract a half-face template else we will need to construct a face as one Hongjun Jia [6].

2. For illumination problem methods like PCA, LDA are not sufficient as they make things very complex in this case rather we can take help from the OPPM framework as they help in transforming pixels as described by Jamal Hussain Shah[7].

After these steps, we will get a processed image from which facial features can be extracted but we need only a half-face template. This can be achieved either by converting the input image into binary image by intensity thresholding method which helps in identifying facial features through selecting eyes initially and removing unwanted details to select required facial regions or we can use wavelets method for extraction of facial features as discussed by Gnanaprakasam et.al [3] to analyze the effects of occlusion or illumination and then extract facial features(full front part of the face).

The next step is very crucial as we have generated an average-half-face from the extracted facial features. For this step, we have split the face to get the half-face template and for this we can use the Vector split method to get a half-face template or an average-half-face template. Now this half-face template will be used for the process of face recognition. PCA is one of the most efficient algorithms which is used for image recognition and compression. The processed input image features are calculated and represented as eigen faces and then PCA uses this information to find matching faces or information.

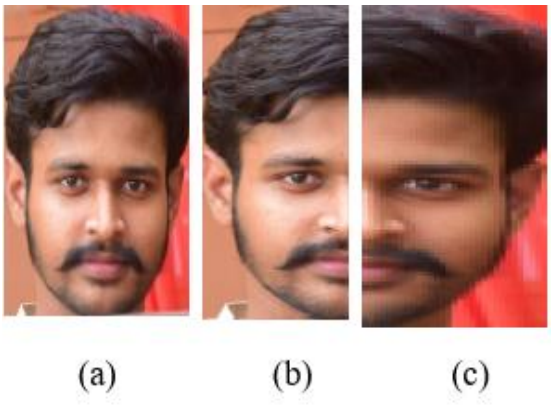

Figure 2: Face Template (a) Full-Face Template (b) Right-Half Face Template (c) Left-Half Face-Template

4. CONCLUSION

This research paper focuses on how to improve the efficiency of the Face Recognition System as major advances can be seen in making lesser use of storage as we directly halved the stored information of faces by using a half-face template. The concept moreover helps us in decreasing computational time and storage in facial recognition systems using half face templates. This method will overcome various problems such as occlusion, illumination and rotation along with affecting the performance of the facial recognition system and can be deployed in various applications and areas.

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