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Review of Different Approaches for Face Detection

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Abstract: Due to size, location and intensity variations, it is provocative and computationally vigorous task for a computer to capture face from the given image, but for human beings it provides minor complications. The distinctiveness of facial biometrics are comparatively low as there are different number of factors like variation in posture, delicate face, temporarily deferred, changed illumination etc. which have little or no control. In this paper we are discussing a review of different approaches for detection of human face. The skin color segmentation of color image in combination with identification of facial features, neural network classifiers, HOG with SVM classifiers, AdaBoost algorithm with cascade classifiers, Eigen face images and approach based on heuristic algorithms are some of the techniques that are discussing in this paper. These approaches include image processing for extracting some meaningful data. It also discusses different challenges associated with human face detection and proposes some solutions. There are number of practical applications like authentication, criminal face detection, intelligent human- machine interfaces, e-commerce etc. for human face detection.

Keyword: AdaBoost algorithm, ANN, Eigen, face, HOG, Segmentation, SVM

I. INTRODUCTION

A digital image is represented by a matrix with finite numbers of bits. Digital Image Processing include image acquisition, image enhancement, image restoration, compression, segmentation, morphological operations etc. Face Recognition is one of the important parts of digital images processing. This paper covers an overview of different approaches for the extraction of human face with the help of various digital image processing techniques. The most usual approach for identification is to detect various discontinuities in intensity values. For face detection, the first step is to capture image by using suitable camera. Then captured color image is then converted to a skin color likelihood image by using segmentation. Edge detection is a method of image segmentation which is based on the range of discontinuance. The variation in the physical aspects reveals themselves as changes in intensity, color and texture. Whenever an image is captured, the components like projection, unnaturalness and distortions will add as blur. So it is not possible to extract the image efficiently. As a result pixel values do not reflect the true intensities of the actual scene. So at first we have to remove noise from the image for better performance. There are different types of filters available for removing noise. These include filters such as median filter, mean filter, FFT etc. There is a problem with mean filters and FFT for removing noise because some important edge information may get lost. So a median filter is an optimum choice for noise removal in face recognition processing. After removing the noise the image is searched for identifying the face region. The features relevant to the face such as skin color, eyes, noise, ears, mouth etc. can be used as identifier for this purpose. It is possible to locate actual face domain by using appropriate classifiers such as SVM, cascade classifier, ANN etc. Figure shows block diagram of a general face detection system.

There are various complexities to detect human face due to its non- rigid structure. With the addition of a number of facial feature information, huge attention is required. Due to variation in size, shape, color and texture of an image face detection is most challenging task during these days. The researchers have proposed different methods such as Knowledge based method, Feature invariant method, Template matching methods, Appearance based methods and Color based methods for detecting human face. It is very efficient and convenient to recognize face regions and select facial features from the single face image. The face detection is the most useful task and it is an important part of automatic face recognition.

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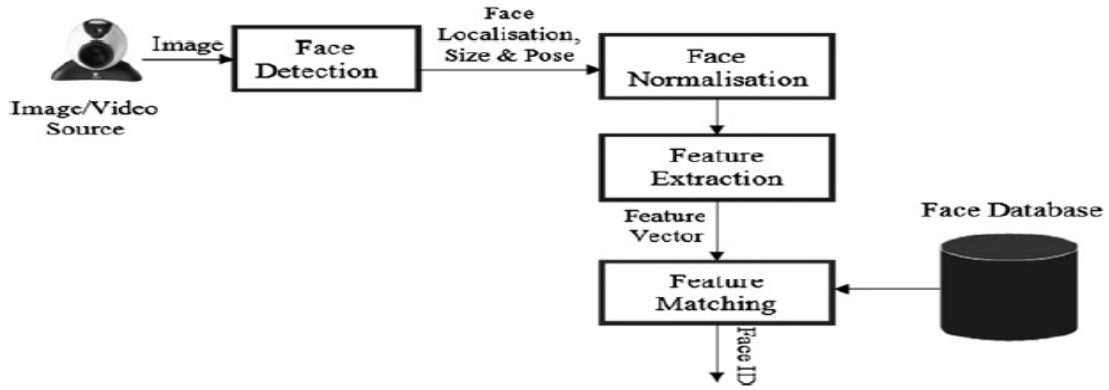

FIGUREI.1: Block Diagram of general Face Detection system

Nowadays due to enhancements in the technology, face processing from an image depends on extracting information about person's identity and state .Depending on these factors, the computer gives the required output. The face detection has attracted much consideration for the last few years and its research has rapidly expanded by not only engineers but also by neurologist since it has many potential applications in the computer vision applications, automatic access control system,tracking service, outdoor surveillance camera service, smart captcha, secured access, video chat service, authentication purpose, criminal face detection etc. The remaining section is organized as follows. The sections two briefly describes basic concepts used and face recognition algorithms. The section three gives Literature Review. The section four discusses major challenges and proposes some solutions. The section five concludes the paper by telling more research is needed to avoid challenges in face detection techniques.

II. BASIC CONCEPTS USED AND FACE RECOGNITION ALGORITHM

2.1 Haar like Features

The positioning of nose, eyes, mouth etc. on the face, the relative size of these features and contrast/intensity of these features are almost similar. It is possible to replicate uniformity of these features using Haar like features. The Haar like feature includes rectangular windows at specific locations. It adds pixel intensities at adjacent region and then computes the difference of both regions. The specific location can be categorized using output value.

2.2 AdaBoost

It collects the few essential features which is then combined together contributes a administer that is very selective for the classification of face in an image. The AdaBoost is applicable in many scenarios and it is adaptive in nature.

2.3 Annotation of face using ellipse

Three features are necessary to be extracted for annotating face in shape of ellipse. They are head-top, chin and pair-of-eyes. The distance between chin and head-top can be considered as the length of major axis. The length of two eyes from one end point to the other and some other value added to it contributes length of minor axis. We create ellipse by using the length of major and minor axis which is then almost accurate to circumscribe human face. This technique requires modification when dealing with irregular face poses.

2.4 Principal Component Analysis (PCA)

This face recognition technique, known as Eigen face technique uses a feature space that reduces the dimensions of the actual data space. This reduced data space is sufficient for face recognition. PCA can perform in a better way over many other methods when the size of database is limited. But low discerning power within the class and enormous calculations are the notable common troubles with increase in data size.

2.5Linear Discriminant Analysis (LDA)

LDA is generally used algorithms for feature collection in appearance based methods. But most of the LDA based face recognition system first adopted PCA to decrease dimensionality. Then LDA is used to exaggerate the discerning power of feature selection. This is because LDA has the limited sample size dilemma

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in which dataset collected should have bigger samples per class for good discerning of facial characteristics and thus causes poor extraction of discerning features.

2.6 Support Vector Machine (SVM)

Support Vector Machines (SVM) is very useful facility in analysis problems and one of the applications is face recognition. But the SVM cannot be used in situations when the feature vectors characterizing samples have misplaced entries. SVM can be adapted to the actual appearance space or a subspace if it retrieved after implementing a feature extraction technique. The dominance of SVM classifier is that it can achieve better universality performance.

2.7 Independent Component Analysis (ICA)

Independent component analysis (ICA) is a technique for selecting elemental factors from complex statistical data. The face recognition system is implemented using ICA for facial images which have different face orientations and different illumination conditions. It searches for components which are both statistically independent and non-Gaussian. While considering statistically independent images and statistically independent coefficients, ICA had improved recognition rate .Each face image is converted into a vector before calculating the independent components and provides more powerful data representation.

2.8 Gabor wavelet

The high intensity feature vectors derived from Gabor wavelet transformation of front face images mixed together with ICA input for enhancing face recognition. Gabor features had been perceived as one of the best representations of facial image. They contribute more detailed knowledge about the local image features. The Gabor phases could work likewise well with the magnitudes since its awareness to misalignment and local variations can be recouped deliberately.

2.9 Fisher face based algorithm

This algorithm tries to find the projection direction. By using this algorithm the images belonging to different classes are separated maximally. Fisher face algorithm is a clarification of the Eigenface algorithm to furnish the illumination variation. Fisher face algorithm behaves better than Eigenface in a situation where the lighting condition is changed. This technique needs several training images for each face. Hence it cannot be used to face recognition problems in which only one example image per person is available for training.

2.10 Skin color based algorithm

Skin color is the most important features of human faces. One of the transparent algorithms for identifying skin pixels is skin color algorithm. Each pixel is separated as skin color and non-skin color. This separation depends on its color component. The color component is modeled by Gaussian probability density and then threshold is used to mask the skin region. At last, a bounding box is tried to extract the face from the input image. But the skin color method is time consuming as it needs to scan the target image.

2.11 Artificial neural networks based algorithm

Artificial neural network (ANN) is generally used as a technique for face recognition process. ANN will be used in such a situation where a face has been detected to identify and recognize who the person is .This is done by calculating the weight of the facial information. Essentially, ANN resembles human brains' biological neuron system. A neuron accepts a signal from the preceding layer. Then it transmits the signal to all the neurons in the adjacent layer. The signal had been multiplied by a separate multi weight value before transmitting the signal to the adjacent layer and then weighted output is summed. This eliminates the difficult task of manually selecting non-face trainingexamples .Training a neural network for the face detection task is challenging because of the difficulty in characterizing prototypical "non- face" images.

III. LITERATURE REVIEW

In this paper, we present a review on the most successful existing algorithms or methods for face recognition technic to inspire researchers to commence on this topic. S. Yadav and N.Nain in [8] have discussed an algorithm for detection of the human face in real time. This algorithm was based on segmentation of the skin color and the skin region properties. The **YCbCrcolor image** was used for skin color segmentation. It has the advantage of removing illumination component. Thresholding was the first step in the segmentation of the skin region. Then segmentation was done to partitioning the image into regions that are similar in accordance with some predefined rules. From this segmented image it was very easy to detect skin regions. According to the previous knowledge about the face, the algorithm easily found the face region. This technique gave best result

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under good lighting conditions. This approach worked well even when faces were tilde, having varying skin color and having adverse lightning environment. According to the given data base this algorithm achieved an average accuracy of 96.73%.Fig.3.1 shows the framework for this face detection algorithm.

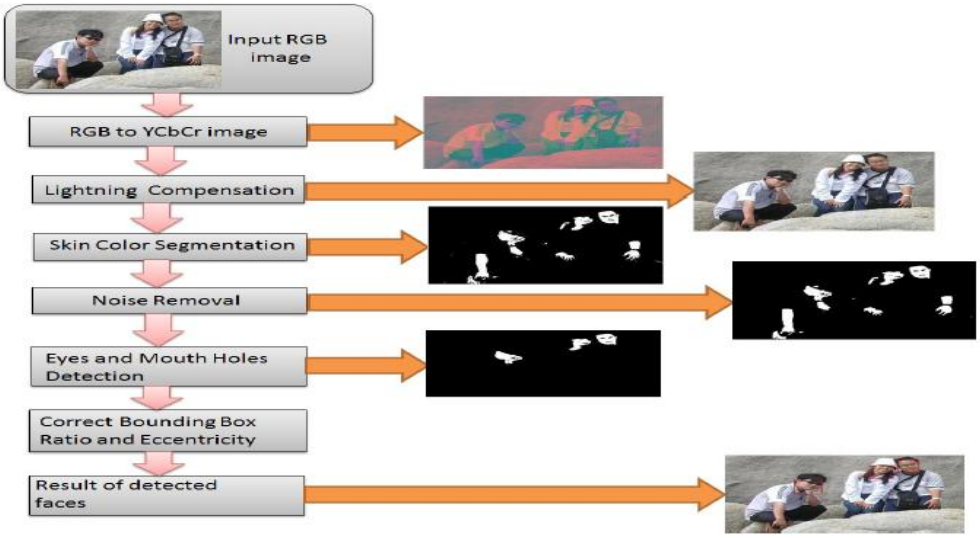

FIGURE 3.1 Framework for the face detection algorithm

Prahlad Vadakkepat and LiLi Ling in [9] have described a neural network to learn the skin and non-skin colors. For skin classification and morphology based pre-processing, the skin color probability map was utilized. This method used rational rules for identifying the face and the label Bayesian cost analysis for classifying the human face region. They selected a face detection module, based on 2-D color model. For detecting the face a skin color model was included in the identification module. To make the skin color models, YCrCb and YUV color spaces were used. These color models were used for the identification of both moving and stationary human faces having different skin colors and they were under varying illumination conditions. The fig.3.2 shows UV 2D Color Space. The skin color covers a small part of the UV plane .The influence of luminance signal is low. In these systems, the facial skin color models were more adaptive and efficient to adapt it automatically to suit variations in ambient light and new environment factors. To remove noise and enhance the quality of the source image Gaussian Pyramid decomposition was used. To remove noisy pixels median filters were used. To extract the face contour morphological operations of dilations and erosions were used. Then some analytical rule based on the geometric analysis of human face was applied .Actually it was based on relationship between width and height of the human face. The skin color feature in combination with geometry feature made the tracking process more efficient. According to the given data base the maximum success rate was 98.8%.

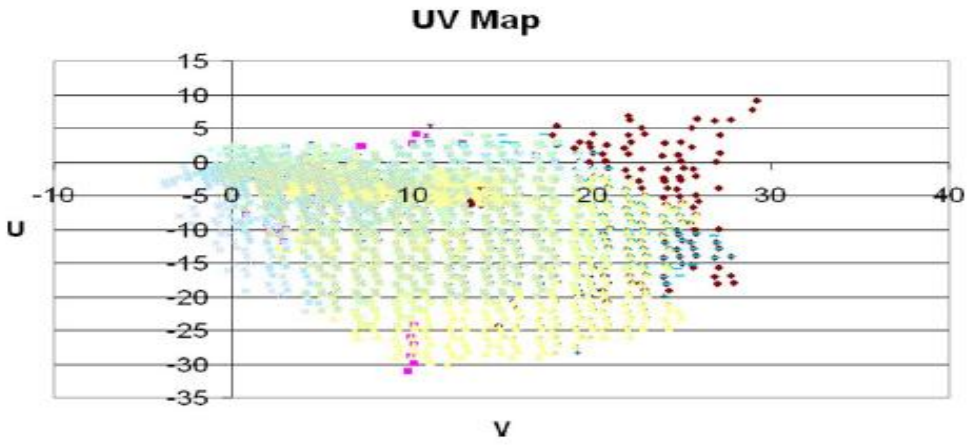

FIGURE 3.2 UV 2D Color Space

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S. Lamba, N. Nain and H. Chahar in [3] have discussed an approach for face detection in crowd by combining the **skin color segmentation** and a **Histogram of Oriented Gradients (HOG)** along with **Support Vector Machine (SVM)**. Initially, image enhancement was performed to improve the detection rate. For multi scale representation of image, an edge preserving pyramidal approach was applied. Skin color segmentation was done by using combination of YCbCr and RGB color model. HOG features were extracted from the segmented skin region. The most important advantage of HOG was that it had describedlocal shape and appearance of an object by distribution of local intensity gradient and edge direction without much knowledge of gradient positions. HOG provided robust feature set to differentiate and detect human faces under different illumination conditions, complex backgrounds, a wide variety of poses etc. The fig.3.3 shows HOG based frame work for face detection.

The main aim of SVM was to determine an optimal function of hyper-plane which classify or separate the extracted features into different class. SVM was a fast classifier as it did not include all data in training phase. The data involved in the training phase was called as support vectors which lie closest to optimal hyper plane. In the testing phase, skin color segmentation was applied on the testing image to extract foreground area in which probability of human face existence was high. For each skin color region component, a gradient oriented feature was calculated which then fed to SVM.

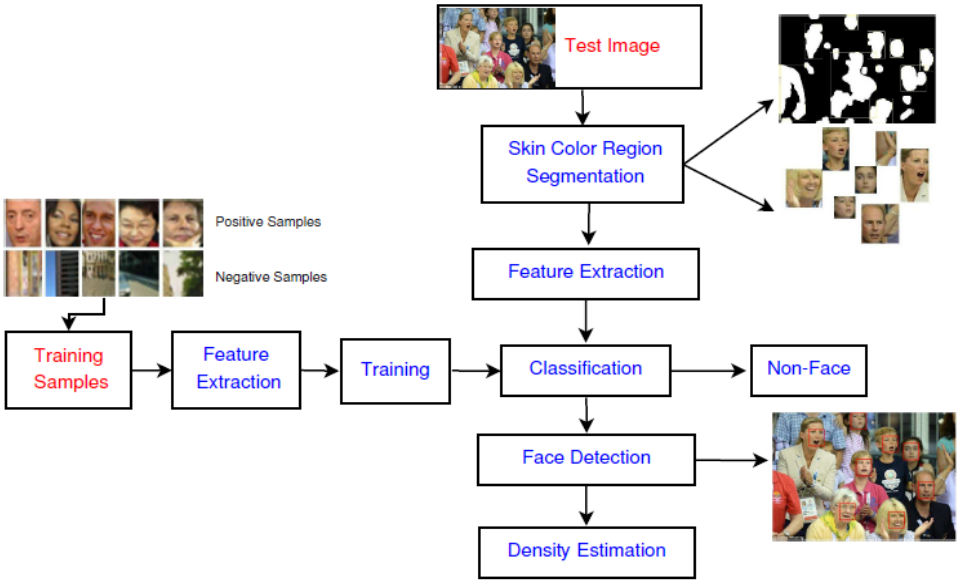

FIGURE 3.3 HOG based framework for face detection using Skin color segmentation

The **SVM classifier** categorizes it into a face or non-face. A bounding box was fixed over all the classified faces in the image to localize a face. Hence by using this approach, we got good detection rate in diverse varieties of images captured in unconstrained illumination conditions. The SVM classifier was trained by Muct and FEI databases which consist of 751 and 2800 face images respectively. The accuracy of this approach was evaluated by testing it on BAO multiple face databases and on various manually collected images captured in surveillance areas.

Though, experimental results demonstrated that the supplementary skin color segmentation along with HOG was better for increasing the detection rate than using HOG features only. This method achieved 98.02% detection rate while image had contained much variation of poses, existence of occlusion etc.

R. Manjhil and A. Priyam in [10] have suggested **view-based approaches** based on the property of **Eigen space**. Here images of the face were projected into a feature space (face space) that was able to encode variations among known face images. The face was defined by the Eigen faces which were Eigen vectors of the set of faces. The main aim was to execute a system model of human face. Also it was necessary to differentiate it from large a number of stored human faces. The method was based on decomposing human face images into a set of 'Eigen faces'. The face identification was achieved by projecting the new image into the space traversed by the Eigen faces .The classification was achieved by comparing position of the face in the face space with the positions of the predetermined human faces. The Eigenface method gave an efficient way to identify human face and Principal Component Analysis (PCA) algorithm was used for the recognition of the human face images.

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Li, Zhengming, LijieXue, and Fei Tan in [5] have discussed a face detection method based on **skin color segmentation** and **improved Ada Boost algorithm**. It made use of skin color of the human face and grey feature of the skin to do identification of the human face.

The segmentation was done to partitioning the image into regions that are similar. Then morphological operations were done to detect face regions in the image. The geometrical characteristics of the human face were used to screen face region from other image.

A self-adaptive algorithm known as **Ada boost** was not enough to classify the face region because it was a poor classifier. For detecting more promising regions of the human face accurately a cascade classifier was used. It had the ability of eliminating the background area very easily. The author showed that this technique could efficiently decrease the error detection rate. This method could provide efficient face detection in terms of quality and speed. Also this technique was able to provide good performance on face detection under complex background because the cascade classifier and Ada Boost algorithm together functioned as a strong classifier. The maximum correct detection rate was 92.86%.The fig.3.4 shows a cascade classifier.

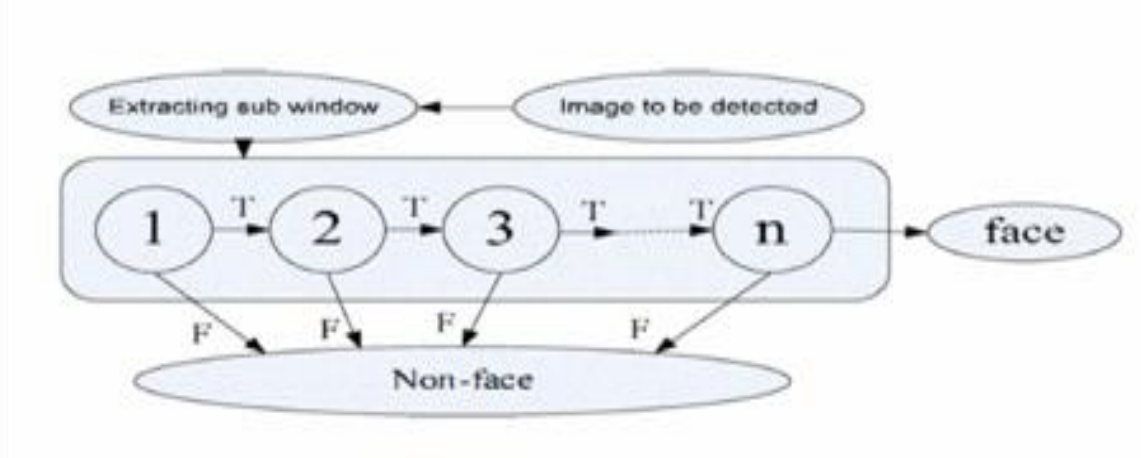

FIGURE 3.4 cascade classifier

Y. K Singh and V. Hruaia in [6] have suggested a method in which a color image was captured with a digital camera. The color image was then transformed in to a grey level image. A low pass filter was used for the purpose of removing the noise. Since the requirement was to retrieve facial features, it was very essential to extract local variations. So the spatial filter based on calculating standard deviation of the sliding window was used. The main aim was to get a binary image corresponding to the generated grey image. For this purpose an efficient thresholding technique known as adaptive thresholding was used. The binary variations of the grey image that were extracted using sliding window was obtained using adaptive thresholding. The created image in binary had apparent boundary. The created binary image had many features of the human face like mouth, nose eyebrows, eyes etc. With the help of morphological operators, it was very easy to extract features of the human face. The created binary image was then searched from top to bottom in order to determine the probable face region. Actual face location could be accessed by searching from left to right. It was possible to search for location of eyebrows in the probable face region and thus it was very easy detect actual location of the human face. The algorithm used for this was very simple and convenient as it did not contain much data to learn. This process was fast and did not contain learning or training anything. The fig. 3.5 shows flow chart of face detection algorithm.

P.P Paul and M. Gavrilova in [7] have discussed Principal Component Analysis method for face detection. The PCA method adopted feature extraction and selection technique. It was actually based on geometrical structure of the human face. The PCA technique used canny edge detection method for boundary extraction of the human face. The higher face detection accuracy was provided by fusion of PCA based geometric modeling and SCM method. This method improved the face detection rate and limited the search space. This method provided filtering of image in term of pixel values to get the face location. Heisele, T. Serre and T. Poggiod in [8] have discussed component based frame work for finding human faces in the complex environment.

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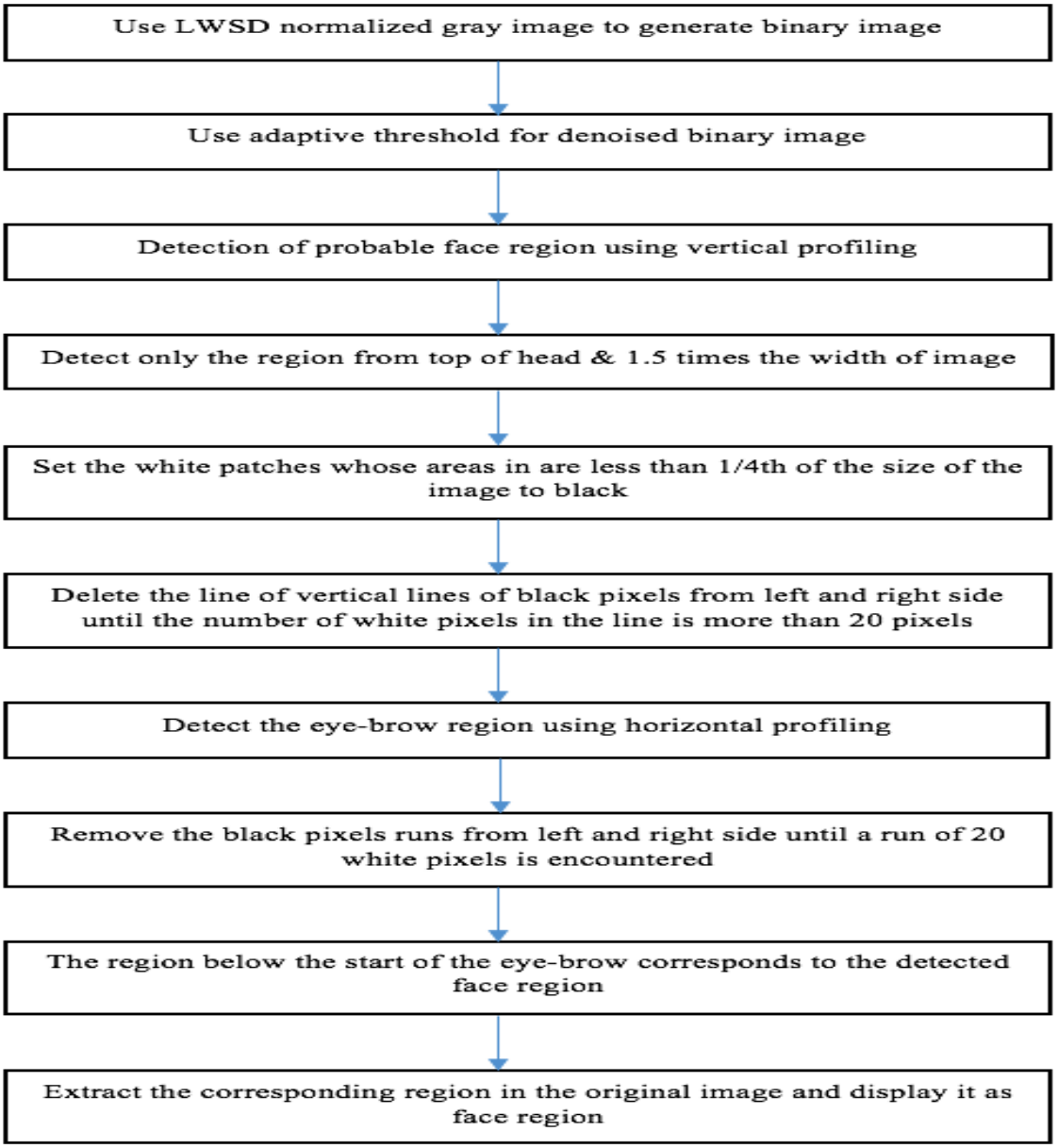

FIGURE 3.5 Flow chart of face detection algorithm

In this technique each component detector had done a search over some portion of the image to find the most suitable matching component. At first a resolution pyramid was computed from the input image. By sliding a fixed sized object window across each image, the pyramid was scanned pixel by pixel for locating a face. The component classifiers had located the components of the face inside the object window on the first level of the detection module. The SVMs were used as component detectors. They were trained on a set of extracted facial components and on a set of non-face pattern scale of the face. By using this information the components were identified. These components were then classified by using a component classifier. The combination classifier was used for final identification of the face. The most of the methods discussed above were based on skin color segmentation and used classifiers for identification of human face and they were computationally very complex.

IV. MAJOR CHALLENGES IN FACE DETECTION AND SOLUTIONS

Detecting face is the vigorous task due to large pose variations, facial expressions, makeup or images from moving camera. As a result of all these problems, we face number of challenges and in future we will get several opportunities to overcome these problems. Various known applications for face detection are law

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enforcement, security surveillance, biometric applications and other communication applications. There is variety of challenges associated with face detection. Several of these challenges are classified as:

IV.1Variation of Radiance

Two factors: intensity of light and camera characteristics which affects manifestation of human Face. Radiation/ luminance variations are due to skin reflectance properties and also with the internal camera control .For efficient face detection system; the major challenge is the problem of lighting/ radiance variations.

FIGURE IV.1.1 Challenges due to variation of radiance

IV.2 Pose Variation

There are different camera face pose i.e. frontal, 45 profiles, upside and downside. Due to these the images of faces vary and resultant of this is the occlusion is added in some facial features. As the variations in poses in an image result wrong detection of face and it becomes very critical task to identify the face from an image.

FIGURE IV.2.1 Challenges due to pose variations

IV.3 Ageing and Wrinkles

The performance of face detection also depends on ageing factor. The ageing can be categorized into two types: one is natural and it is because of the age variations and the other one is artificial or using makeup. To detect face from these types is also a challenging task for face detection.

FIGURE IV.3.1 Challenges due to ageing and wrinkles

For example, to collect face image for a particular person for his/her life at different ages in the dataset is difficult task.

IV.4 Facial expression

Let us consider an example; a particular smiling face image of a person was saved in the database. But after some times, he/she want to detect her/his face image. But now this time without any expression, so there might be problem in detecting face and another challenge for the face detection system is considered. As the appearance of face is totally dependent on the various facial expressions that a person carries or face detection

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also concentrate over the various features of the face like face hair, moustache, beard etc. So number of factors affect face detection techniques.

FIGURE IV.4.1 Challenges due to facial expressions

IV.5 Occlusion

Occlusion is defined for the obstacles that affect for detecting face image correctly. Occlusion occurs when the face is covered with some objects and we cannot find the various facial features. This is the most challenging task for face detection systems.

FIGURE IV.5.1 Challenges due to occlusion

IV.6 Solutions

Computer automated face detection system must focus on morphological comparisons region by region. It is also necessary to evaluate discriminative characteristics such as distance from people's mouth to the nose, nose to eyes, mouth to eyes etc. This adds robustness into face recognition systems in the case of modification of some facial patterns. Once the face is detected and the facial feature are extracted, actions to crop the face, to correct its alignment by rotating it, etc. must be performed to reduce the challenges described above before passing the facial features into the next stage. The fusion of several informations such as audio, text, close captions, color etc. help to overcome challenges. By combining several methods discussed above also helps to reduce challenges.

V. CONCLUSION

Face recognition is a challenging problem and it has received a great deal of attention over the last few years. There are so many research had been done to achieve mature face detection systems in all of the constrained environments. But they were not able to achieve the goal of performing accurately in different scenario particularly in real world situations. In this paper we had reviewed some of the algorithms and technologies used in face detection systems. Also we had reported several challenges and key factors that could crucially affect the performance of the face recognition systems. We had suggested a few possible research directions for improving face recognition systems. Finally this paper concludes by insisting that the next step in the evaluation of face recognition algorithms will need thorough and valiant research in terms of face representations as well as learning algorithms used.

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