An Algorithm for Face Detection and Feature Extraction

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***Abstract:* - Face detection is the technique to locate various faces in an image, so that the face region will be extracted from the background. Face detection is considered as the backbone of topics like face recognition, face tracking, expression recognition etc. as if faces could be located exactly in any scene; recognition process would not be too much difficult. Recognition is mainly used for the purpose of verification and identification. The limitation of existing face detection algorithms is that it is difficult to locate faces within images having variation in illumination, poses and angles of faces, together. An algorithm to locate faces in the given image is proposed which uses the concept of Segmentation. Also an algorithm is proposed to find out the features from images just after detecting faces. The proposed algorithm locates faces within image with low illumination better than existing algorithms.**

***Keywords:* - Biometrics, Face Detection, Features Extraction, Segmentation.**

I. INTRODUCTION

Biometrics is a vast growing technology used in forensics, cryptography and security. Some examples of biometrics are thumb impression, palm impression, face, retina scan etc. For face, face recognition is a technique used in security purposes like banking, user authentication etc [1].

In recent years, face recognition is considered as an interesting area of research for the purpose of security [2]. The purpose of face recognition systems is to verify the faces of individuals from a set of faces for the need of authentication or security. For recognizing a face, the first step to do is face detection.

Face detection is the process which extracts all the faces from an image and gives their location. Face detector determines the size and location of the human faces and detects facial features. It ignores the things in background like trees, buildings etc.

The latest work done [3] on face detection includes different steps as shown in Figure 1.

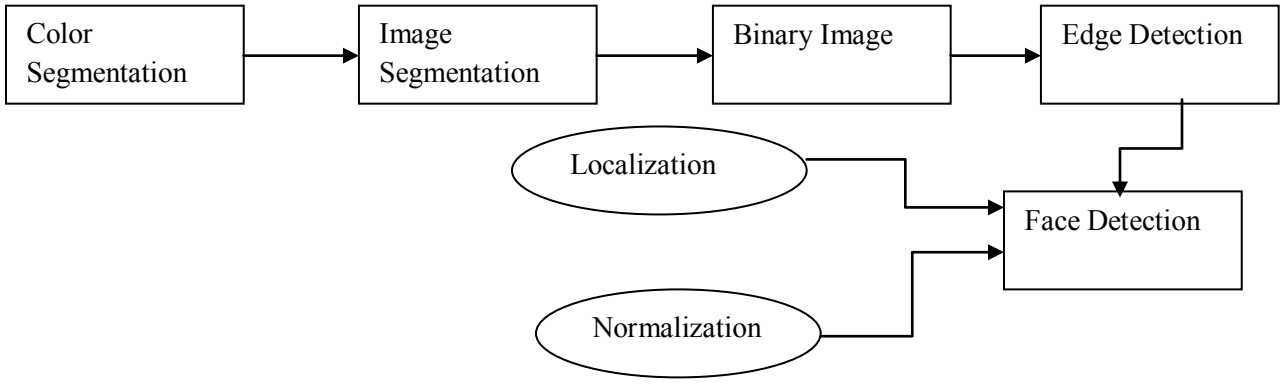

Figure1. Steps in face Detection

The detection of faces also includes *Localization* as well as *Normalization*. Localization means to simply get the region where there is face to be located and Normalization is to align, scale and rotate the image so that all features will be in their exact location.

This paper is organized as follows: Section II discusses Related Work. Section III describes Proposed Method. Section IV shows Results. Section V includes concluding remarks.

II. RELATED WORK

2.1. Face Detection

Face detection is a technique to detect the area where the face is located in an image. The various fields of applications for face detection are in face recognition, facial expression recognition, face tracking, detecting facial feature expressions etc.

By using a face detection algorithm, one can easily identify different faces present in a digital image. The output of face detection algorithm is an image in which only the face of different individuals is shown by any bounding box or any method of representation, for example, asterisks, dots, circles etc.

The related work done in face detection includes various techniques. Each and every technique includes different methods for finding or detecting faces from an image such as:

* Finding faces with controlled background.
* Finding faces by color.
* Finding faces by motion.
* Finding faces in unconstrained scenes.

2.1.1. Knowledge Based Methods: - This method is considered as a top-down approach, in which a face is represented by using some set of human coded rules. The rules may be like: "The center part of face has uniform intensity values", or "The difference between the average intensity values of the center part and the upper part is significant" etc.
The advantages of this method are:-

- Easy to come up with simple rules to describe the features of a face and their relationships.
- Based on the coded rules, facial features in an input image are extracted first, and face candidates are identified.
- Work well for face localization in uncluttered background.

The disadvantages are as follows:-

- Difficult to translate human knowledge into rules precisely: detailed rules fail to detect faces and general rules may find many false positives.
- Difficult to extend this approach to detect faces in different poses: impossible to enumerate all the possible cases.

2.1.2. Feature Based methods: - Unlike knowledge-based, this is a bottom-up approach i.e. detect facial features first. The different pixel properties for this method are edge, intensity, shape, texture, color etc. This method aims to detect invariant features. According to Leung et.al's algorithm [4], the faces are detected by a random graph matching in which the correct geometric arrangement between facial features is find out.

The advantage of using this method is that features are invariant to pose and orientation change.
The disadvantages include: Difficult to locate facial features due to change in illumination or noise and also, difficult to detect features in complex background.

2.1.3. Template based Methods: - In this method, the faces are detected by matching with a template. The template may be predefined i.e. based on edged or regions or it may be deformable i.e. based on facial contours. The templates should be store in the database. The method of correlation is used to locate faces. This method used relative pair wise ratios of the brightness of facial region and also used the average area intensity values rather than absolute pixel values.

The advantage of this method is that this is a very simple method to use.
Disadvantages are:-

- Templates need to be initialized near the face images.
- Difficult to enumerate templates for different poses (similar to knowledge based methods).

2.1.4. Appearance based Methods: - In this method, a classifier is trained using some positive and some

negative examples of faces. The various techniques [9] used in this method are:

- Representation(Holistic and block-based approaches)
- Pre-Processing
- Train a classifier
- Search Strategy
- Post-Processing
- View based (Human faces are detected without any knowledge of geometry) [10].
- Neural Networks(To detect frontal and non-frontal faces with variation in poses)
- Principal Component Analysis [12]
- Support Vector Machine [11].
- Hidden Markov Model etc.

The advantages of this method are:

- Use of powerful machine learning algorithms.
- Has demonstrated good empirical results.
- Fast and fairly robust.
- Extended to detect faces in different pose and orientation.

The disadvantages are:

- Usually needs to search over space and scale.
- Need lots of positive and negative examples.
- Limited view-based approach.

2.2. Finding Features

The main idea for finding features includes two things. One is Identification and the other is Verification. Verification means to check whether the person is authenticated to use the service for which he is claiming and Identification means to find out identity of an individual by comparing his face with a database of images of individuals. The related work done in this area includes:

2.2.1. Geometric Feature Based Methods: - In geometric feature based methods [13, 14], the main emphasis is given on the facial features like eyes, nose, mouth etc. The distance between the features get detected which is used to represent a face. This is the earliest and the simplest technique for face recognition. The problem with this technique is that this technique is unable to identify faces with variations in illumination and viewpoint as well as not reliable with respect to time.

2.2.2. Template Based Methods: - In the template based methods [15], the entire face template is represented by using a feature vector instead of the significant facial features. There are various algorithms which are based on template based approaches like Hough transform methods [16], Reisfeld's symmetry operator [8] etc.
Since, this technique is more reliable as compared to the previous one but the problem is that a tolerance value should be given to the models because they can never fit the structures in an image perfectly. Also, the subspace for searching of face is restricted only with geometrical constraints.

2.2.3. Correlation Based Methods: - In these methods, a correlation coefficient [6, 7] needs to be computed. For this, the first step is to determine the location of the significant facial features such as eyes, nose or mouth. A set of templates are used to detect the position of eyes in an image. This method gives accurate results but is really complex. The drawback with this approach is that this is very much expensive and do not work properly with variation in illumination.

2.2.4. Support Vector Machine Approach: - Support vector machines (SVM) are a binary method [5] to classify different number of known individuals. There occur dissimilarities between two facial images if they are captured in different space. The dissimilarities may be between faces of same person or may be faces of different people. A similarity metric between faces is generated by modifying the

result generated by SVM. The SVM based algorithm performs better than the principal component analysis based method with respect to identification of faces and also has less error rate with respect to verification.

2.2.5. Feature Based Methods: - The feature based methods include various algorithms like Kernel Direct Discriminant Analysis Algorithm, Features Extracted from Walshlet Pyramid, Hybrid Color and Frequency Features Approach, Multilevel Block Truncation Coding Approach, Partial Least Square Based Method, Multi-Resolution Local Appearance Approach. These techniques produce excellent results in performance and having low error rate.
Only local features are taken into account for these techniques and even for a small set of features, results are comparatively good.
The advantages of these methods are:

- Before matching an image to that of an individual, the extraction of features id done which makes this method more robust with variation in positions in an input image.
- These methods are invariant to size, orientation and light.
- Performance is high.

The disadvantages are:

- Difficulty in automatic feature detection.
- Some arbitrary decisions need to be taking about which features are important and which are not.

2.2.6. Holistic Based Methods: - Unlike feature based methods, these methods emphasize on global features i.e. description based on entire image rather than local features. These methods can be subdivided into statistical and AI approaches. The statistical methods work on 2D information of images and include PCA, LDA such techniques. The AI methods include neural networks and some machine learning techniques for recognizing a face.
The advantage is that these methods include each and every information in an image and do not destroy any data by concentrating only on limited regions.

The disadvantages are:-

- These are very much time consuming.
- These are expensive.
- These methods do not work effectively under large variation in pose, lightning etc.

III. PROPOSED ALGORITHM

An overview of our Face Detection algorithm is shown in Figure 2.

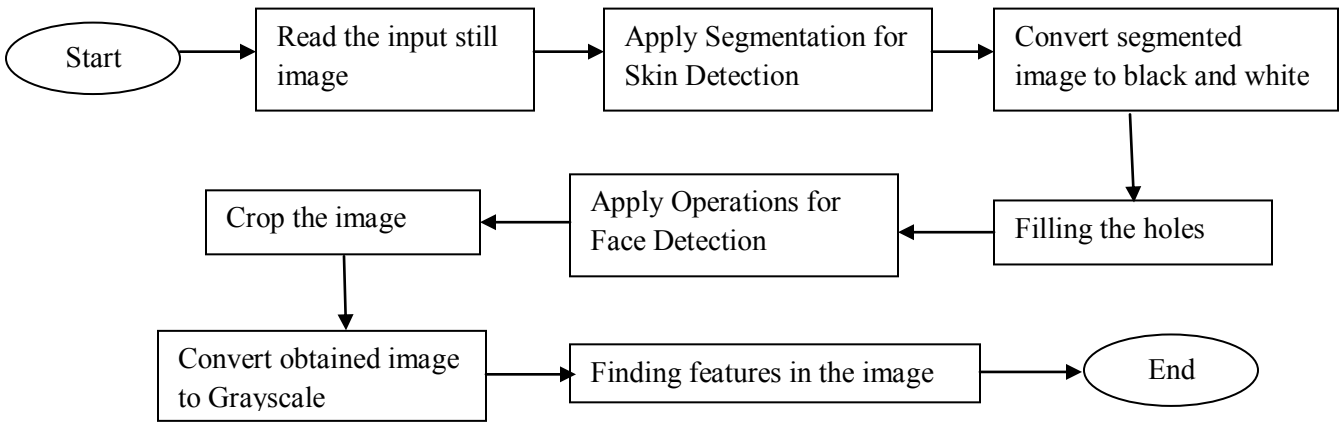

Figure2. Architectural Diagram of the System

The steps involved in the algorithm includes:-

I. EXTRACTING FACES FROM A STILL IMAGE

(a) Loading of pictures
(b) Skin Detection and Segmentation
(c) Conversion from RGB to BW
(d) Erosion (filling of holes)
(e) Morphological operations
(f) Drawing of box around detected faces
(g) Show image with face detected inside rectangular boxes.

RESULT: - Cropped different faces in different images (in rectangular boxes).

II. ALGORITHM FOR FINDING FEATURES

(a) Convert obtained colored image into gray image.
(b) Represent the binary gradient mask for the image for edge detection.
(c) Dilate the image to represent the image more specifically.
(d) Erode the image (filling holes).
(e) Segment it.
(f) Show image with outlines of features.

RESULT: - The original image with outline on their features will be shown.

IV. RESULTS

4.1. For Face Detection

Figure3. Input Image

Figure4.Output Image

4.2. For Features Extraction

Figure5. Input Image

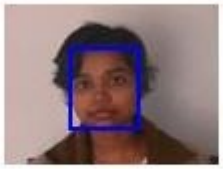

Figure6. Face Detected

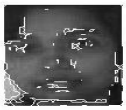

Figure8. Outline of Features

Figure7. Cropped Image

V. CONCLUSION

The main problem in face detection is that due to variation in illumination, the existing systems are unable to detect the faces. Thus, an algorithm is proposed here which can easily detect the faces in the images, captured in varying lighting conditions. Also, an algorithm is proposed for finding features in the image after face detection. The algorithm includes some morphological operations like dilation, erosion etc. and may be used for face recognition. The result of face detection algorithm is an image in which the face is shown by a rectangular box and that of the features extraction algorithm is an image in which the outlines of basic features of a human face like eyes, nose, mouth etc. are represented. As a part of future work, we planned to implement the algorithm with training database in order to improve the accuracy in detecting the human faces and to compare its performance with different images of varying background and intensity.

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