

Face Detection in Digital Image: A Technical Review

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Abstract

Face detection is the method of focusing faces in input image is an important part of any face processing system. In Face detection, segmentation plays the major role to detect the face. There are many contests for effective and efficient face detection. The aim of this paper is to present a review on several algorithms and methods used for face detection. We read the various surveys and related various techniques according to how they extract features and what learning algorithms are adopted for. Face detection system has two major phases, first to segment skin region from an image and second to decide these regions cover human face or not. There are number of algorithms used in face detection namely Genetic, Hausdorff Distance etc.

Keywords— Face detection, Face Localization, Edge detection, Segmentation

I. Introduction

Face detection is a technique that refers to the detection of the face mechanically by digital camera. [1] Face detection is virtually unique biometric identity. It used in biometrics, facial reorganization system, video surveillance, Human Computer Interface (HCI) and image database management. Segmentation plays an important role in Digital image processing. It is the first step afore applying to images higher-level processes.

In [17] Skin detection plays major role in face detection. Nowadays this methodology based on the skin color, robust information against rotations, scaling and partial occlusions. Color of skin can also be used complimentary information.

There are very few chances of having two same faces. In existing face detection algorithms, various face detection algorithms and methods used namely knowledge based method, feature invariant approaches, template matching method and appearance based methods [8].

It detects facial features and ignores anything else such as bodies, trees. In Genetic algorithm, template matching face detection method is proposed. Knowledge based methods are already programmed characteristics to detect the face and encode knowledge of human facial features.

Template based method uses the active template comparison, which provides the most perfect results in case of face detection. [8]Face detection has become progressively main role in the direction of content based video processing, fraud detection,

computer vision, neural network etc. It is used in many places nowadays a day particularly the websites hosting images like Picassa, Photobucket, Google⁺ Photos and Facebook [13][5].

Section II includes image segmentation and usage of face for detection. Section III includes literature review of Process of Face Detection System. Section IV includes comparison study of Knowledge-Based Methods and Template matching methods. Section V contains Genetic Algorithms used for Face detection and finally Section VI contain conclusion.

II. Image Segmentation

A. Segmentation

It is a procedure of extracting and representing facts from an image is to group pixels together into regions of similarity. The aim of segmentation is to simplify and reform the representation of an image into something that is more significant and easier to study.

B. Image Segmentation

It is the procedure of segmenting the image into different segments. It is used for Image understanding model, Robotics, Image analysis, Medical diagnosis, etc. Image segmentation means assigning a label to all pixel in the image so same labels share common visual features. Digital image having various operation like Image processing, image analysis and image understanding. In Low-level operation done by image processing and it works with pixel. Middle-level operation done by image analysis and works

with expression and description of image. High-level operation is done by image understanding and works with data symbol [24].

C. Categories of Segmentation Techniques

Two technique used namely Edge-Based and Region Based Segmentation. Both can be based on following

- **Discontinuity:** It means to partition an image based on immediate changes in intensity [19], this includes image segmentation algorithms like edge detection.
- **Similarity:** It means to partition an image into regions that are similar according to a set of predefined criterion [19]. This includes image segmentation algorithms like thresholding, region growing, region splitting and merging.

1) Edge-Based Segmentation:

An edge is a set of connected pixels that is lying on the boundary between two regions that differ in grey value. The pixels on the edge are called edge point. Edge-Based segmentation is also called as a Boundary based methods. It is used for finding discontinuities in gray level images. It is the best approach for detecting meaningful discontinuities in the gray level. Two types of Edge-Based Segmentation may use namely following.

a) Parallel Edge Detection

In [20] parallel edge detection technique decide of whether or not a set of points are on an edge is independent. There are different types of parallel differential operators such as first difference operators and the second difference operator. The key difference between these operators is the weights allocated to each element of the mask.

b) Sequential Edge Detection

In Sequential edge detection technique, the result at a point is dependent on the result of the before examined points. The act of a sequential edge detection algorithm will depend on the choice of a good initial point, and it is not easy to define termination criteria [20].

2) Region-based Segmentation

Region based segmentation techniques split the entire image into sub regions depending on some rules. Rules like all the pixels must have the same gray level. Region-based segmentation methods attempt to group regions allowing to common image properties [19]. Edge based methods partition an image based on rapid changes in intensity nearby edges whereas region based methods, partition an image into regions that are related according to a set of predefined criteria [22].

a) Region Growing

Region growing is a procedure that group's pixels in whole image into sub regions based on predefined standard [22]. Region Growing is used to group a collection of pixels with related properties form a region.

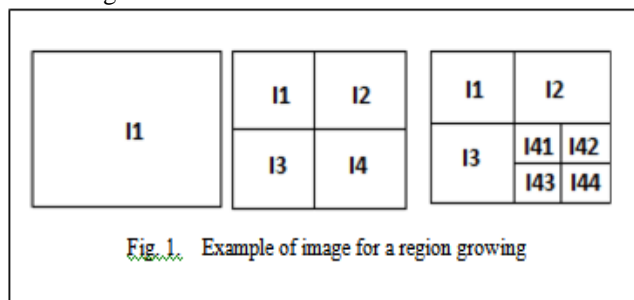


Fig. 1. Example of image for a region growing

Steps for Region Growing

- Select a group of seed pixels in original image [23].
- Select a set of similarity criterion such as grey level intensity or colour and set up a stopping rule.
- Grow regions by appending to each seed those neighbouring pixels that have predefined properties similar to seed pixels.
- Stop region growing when no more pixels met the criterion for inclusion in that region.

b) Region Splitting and Merging

In Region Splitting and Merging technique, the image is split into a set of arbitrary unconnected regions and merge/split the region according to the condition of the segmentation. The region split into four equal parts. Merge any adjacent regions when no more splitting is possible (see figure 2).

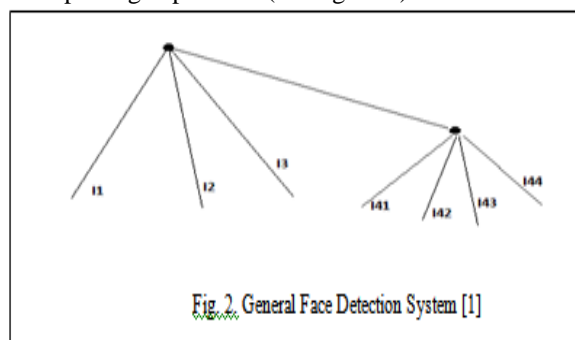


Fig. 2. General Face Detection System [1]

III. Process of Face Detection System

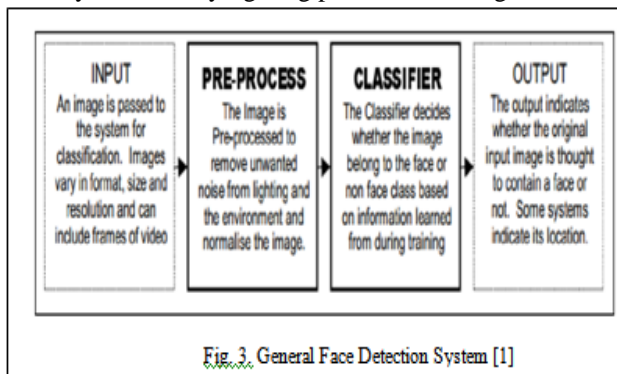
Face detection includes body part and that each part is different to the others. It is computer technology using the some algorithms distributes humans face in the digital image. It takes image of human face and locates face area in image [5].

Then it will discrete the face from annoying background from the image. It's also detecting position of eyes, mouth, nose, eye-brow etc. face

analysis task like face simulations, and face expressions that detect in face detection [1].

Face detection divide images into two parts: first one is face contain and second one is background contain.

Face detection is difficult to manage because in face contains part we must know about face skin color, expression, age. In face detection must detect any faces in any lighting position on background.



In the Face Detection System Steps Like:

1. Input any image which contains one face or more faces and we can include frames of video.
2. In the pre-process remove noise of image like brightness, normalize, lighting conditions, image qualities and geometries using the method contrast stretching, Gaussian filter, Noise Removal and etc.
3. In the classifier separate images face or non-face with using the method Knowledge-Based Method, Template matching method, etc.
4. In output we get faces image from the inputted image [1].

Human vision system can easily detect and recognize faces in images and detect not only single face but multiple faces in the scene having different pose, facial expression, lightening conditions, etc.

D. Face Localization

It determines the image position of a Single face from capture image.

E. Edge

An edge is a set of connected pixels that lies on the boundary between two regions that differ in grey value.

F. Face Detection Approaches

There are two types of Approaches namely Future-based approaches and Image-based approaches.

In Future-based approach, there are three types of analysis. First one is Low level, second one is Feature analysis and third one is Active sharp analysis. Low level analysis contains Edges, Gray-levels, Color, Motions and Generalized measure

methods. Feature analysis methods contain methods like Feature searching and Constellations. At last Active sharp analysis support following methods namely Snakes, Deformable templates, Point distributions models (PDMs).

An image-based approach contains three method namely Linear Subspace methods, neural networks, Statistical approaches [18].

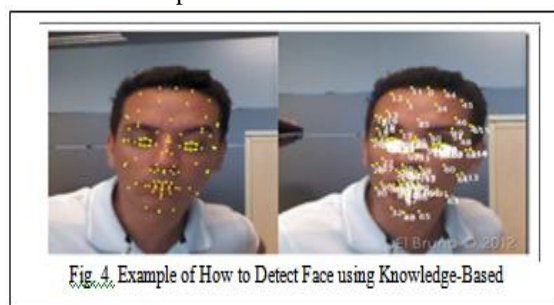
The aim of face detection procedure is to define whether or not there are in any face in the digital image and return the face location in the image. Methods are divided into following two categories.

1) Knowledge-based methods

This method encodes human Knowledge. Rule based method encode human knowledge of different type of human face. The rules capture the relationships between the facial features. These methods are used for face localization. The relationships between facial features can be signified by their relative distances and locations [2]. Based on the defined rules, facial features in an input image are extracted first, and face candidates are recognized.

Problem with this method is difficult to translate human knowledge into meaningful and well-defined rules. If the rules are strict than they may be fail to detect human faces that do not pass all the defined rules. If the rules are general than there may be many false detections. It is quite difficult to detect faces in different poses.

Hierarchical knowledge-based method used to detect faces. Structure contains three stages of rules. At the highest level, all possible faces are found from input image and applying rules at each location. Lower levels depend on details of facial features.

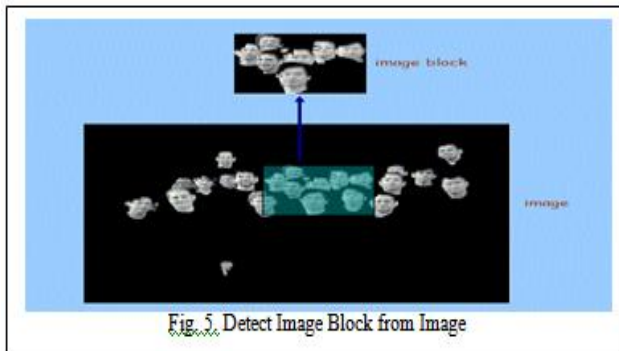


2) Template matching methods

In this method Input images compare with stored patterns of faces or facial features. These methods find the similarity between the input images and the template images. These methods can use the relationship between the input images and stored standard patterns in the whole face features, to determine the presence of whole face detection. [1] This method can be used for face locations and face detection. The advantage of this method is that it is easily to determine the face location (nose, eyes)

based on the correlation values. A Sobel filter is used to extract the edges.

Template is used to adjust for dissimilar lighting conditions and agree for suitable correlation. Template matching is the primary face detection method due to its conceptual simplicity and its characteristic extensibility to more general images. It is basically the two-dimensional cross-correlation of a grayscale image with a grayscale template. The result from the template matching is white oval template with a black background.



Edge Detector:

- Prewitt operator:

The Prewitt operator takes the central difference of the neighboring pixels. The Prewitt approximation using a 3 X 3 mask is as follows:

$$f = |(z7 + z8 + z9) - (z1 + z2 + z3)| + |(z3 + z6 + z9) - (z1 + z4 + z7)|$$

- Sobel operator:

The Sobel operator depends on central differences. This can be viewed as an approximation of the first Gaussian derivative.

$$f = |(z7 + 2z8 + z9) - (z1 + 2z2 + z3)| + |(z3 + 2z6 + z9) - (z1 + 2z4 + z7)|$$

IV. COMPARATIVE STUDY OF KNOWLEDGE-BASED AND TEMPLATE MATCHING MEHTHOD

Method Name	Method Component	Advantages	Disadvantages
Knowledge Based Methods	Face Localization	i). Methods use simple rules to define facial features of a face (two	i). Problem with this method is hard to convert human knowledge

		eyes that are symmetric to each other).	into defined rules.
		ii). Verification process is usually applied to reduce false detection.	ii). Hard to enumerate all possible cases.
			iii). Do not work very well under various pose or head orientation.
Template-matching methods	Face Localization, Face detection	i). It is easily to determine the face location (nose, eyes) based on the correlation values.	i). Template matching method uses several templates with different scales and rotations.
		ii). estimates become quite good with enough data.	ii). Need to incorporate other methods to improve the performance .
		iii). Simple to implement	

V. Genetic Algorithm

In [21] Genetic Algorithms technique application makes the algorithm strong and fast and easy to change in environment. Algorithm can be characterized as a search technique based on Theory by Darwin. GA's algorithm is strong and fast, being designate to a determined type of optimization.

GA's powerful feature is that they result as set of solutions and not only one solution. When the search area is too big and conservative methods become inefficient. GA's result is not only single solution but a number of solutions [14].

GA's algorithm mostly used for find image sub-windows that contain faces and also specific interested face area. Each of the sub-windows can be evaluated using fitness function. Fitness function contains two terms namely favors sub-windows which contains faces while the second one the favors sub-windows contains similar with face of the

interest. Terms of favors sub-windows have been derived using theory of Eigen-spaces.

In [14] GA's algorithm described below:

1. Start a population of N size, with chromosome generate randomly.
2. Apply strength to each chromosome of population.
3. Make new chromosomes through crossings of selected chromosomes of this population. Apply recombination and mutation in these chromosomes.
4. Eliminate members of old population, in order to have space to insert these new chromosomes, keeping the population with the same N chromosomes.
5. Apply fitness in these chromosomes and insert them in the population.
6. If the ideal solution will be found or, if the time (or generation number) depleted, return the chromosome with best fitness. Otherwise, come back to the step c.

This system has three main steps. Firstly denote each pixel as skin-pixel or non-skin pixel in given image. Second step is in the skin detected image classify dissimilar skin region. Final step is come to a decision to identify face region is detected or not. At last using Genetic Algorithm human face detection is done [15].

VI. Conclusion

This research paper includes summary review of literature studies related to face detection using skin segmentation and edge detection. Face detection is difficult to develop a complete robust detection due to different light conditions, face orientations, skin colors, face sizes and backgrounds in color. Different architecture, approach, programming language, processor and memory requirements in face detection system were used in face detection.

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