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Overview and Comparative Analysis of Human Face Detection

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Abstract

Face recognition has been one of the current trends in challenging and interesting research area. Face detection is a necessary and important first-step in face recognition systems, it localize and extract the face region from the background image. Face detection technique detects human faces which might then be used for recognizing a particular face. Nowadays the identification, verification and authentication of face has been used in a variety of disciplines i.e. biometrics-facial recognition system, road surveillance, military, video conferencing, intelligent human-machine interface, image database management system, photo album, marketing, easy people tagging, online gaming, banking price comparison, image search and etc. The human face is a dynamic and complex object and has a high degree of variability in its physical appearances, which makes a face detection challenging problem in computer vision application. A wide variety of algorithms are proposed to solve this problem. The primary goal of this paper is to present a comprehensive survey of face detection.

Keywords: face detection, face recognition, localization, extraction, biometric, background.

1. Introduction

In the modern world, man-made computer machines are more and more intelligent. Machines occupy a human's day-to-day routine work, and fulfill human's daily needs the main reason is high accuracy and low time consuming of particular task. Many research projects and commercial products have demonstrated the capability for a computer to interact with human [1] in a very natural way by looking at peoples through cameras, listening to people through microphones, understanding these inputs, and reacting to people in a friendly real time manner. Face detection is a computer vision technology that identifies human faces in digital images. One of the fundamental techniques that enable such natural human-computer interaction is face detection. Face detection is a method by which any one can able to extract faces from the given photo. Face detection is the step stone to all facial analysis algorithms [2]including face alignment, face modeling [3] [4] [5], face relighting, face recognition, face verification, face authentication, head pose tracking, facial expression tracking, facial emotion recognition [6], gender classification, age recognition, and many more. Only when computers can understand face well then only they begin to truly understand people's thoughts and intentions in a real time communication. Face detection [7] and face recognition are two distinct items in the computer vision technology [8]. The primary goal of face detection is to determine whether or not there are any faces in the image and if present, return the image location and extent of each face. It searches general human face like segment [9] in the whole image. Output may be one or more than one faces. The output will be a rectangle or rectangles on the faces in the image. Face recognition: Recognize input face from the already trained database [10] with highest match score i.e. a single face should be given as input, and the output will be a name or class name or unknown face. Face detection is a two classification i.e. face vs. nonface [11] [12] but face recognition is multi classification i.e. one person vs. all others in the face recognition database. Face detection must discriminate between complex backgrounds and human faces but face recognition must discriminate between the subtle differences of human faces. Typically, face detection is first performed in image to obtain the locations of the faces followed by face recognition is performed in order to determine the identity of each face. Detection of face is very easy for human but it very complicated in artificially.

2. Stages in Face Detection

Detection of human face from image is performed by different stages it includes.

2.1 Image Capture

The first step in face detection is capturing an image. This would be normally done using a still or video camera.

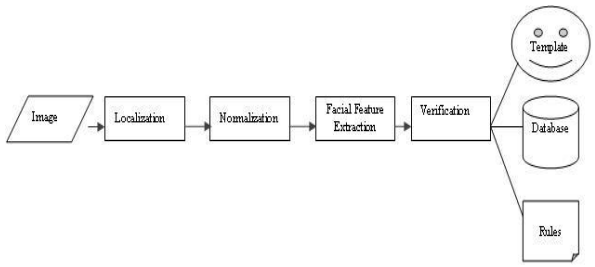

Fig. 1Face detection architecture [67]

2.2 Image Pre-processing

Technique of enhancing data images prior to computational processing. Image pre-processing techniques make the image easier to process the data and increase the chances of getting correct matches. Better chances of success with change in illumination, pose, and picture quality. Decrease the processing time. Common pre-processing methods are

2.2.1 Resampling

Technique to change the Dimension of the pixels, Used to create a new image with a different with and and/or height in pixels. Increasing the size of an image is called upsampling; reducing its size is called downsampling.

2.2.2 Image Enhancement

Image enhancement is to improve the image quality so that the resultant image is better than the original image for a specific application or set of objectives. Image intensities are enhanced by using smoothing or deblurring operations. Smoothing operations reduce noises in an image achieved by filtering various filtering methods are median filtering, mean filtering and Gaussian filtering. Deblurring is the process of inverse filtering, used to reduce image blur caused by camera defocus.

2.2.3 Edge Detection

Technique to detect the sharp changes in image brightness, can capture the important events and properties. Maximum performance of edge detection based on the filtering method of input image. The idea of edge detection is to find the difference between two neighborhoods pixels.

2.3 Localization

In this stage, Detected Edges are localized. Canny Edge detection algorithms [13] [14] works better to detect the edges. Localization process involves determining the exact location of the edge. Based on intensity changes edges are classified in to four types, Step edge, Ramp edge, Spike edge, and Roof edge. In addition, this stage involves edge thinning [15] [16] and edge online linking [17] steps to ensure that the edge is sharp and connected. Edge thinning is a morphological operation used to remove irrelevant foreground pixels present in binary images. The aim is to tidy up all the lines to a single pixel thickness. Performance of the thinning algorithm is depends on the nature of the structuring element. Thinning operation expressed as thin (A, B) = A – X (A, B) where X is a Hit-or-miss transform. Thinning algorithm classified into iterative and non-iterative. Non iterative algorithms are faster than iterative algorithms but they do not always produce accurate result.

Thinning algorithm	Iterative (pixel based)[65]	sequential	Ex. stentiford, zhang-suen
		parallel	
	Non iterative (not pixel based)[61]	medial axis transform	Ex. neusius-olszewski
		line following	
		other	

Table 1 Comparative of Edge Thinning Algorithm

The sharp and connected edges are then displayed. Good localization must be as close as possible to the true edges.

2.4 Normalization

Face Normalization is a process to preparing images for feature extraction. Normalization [18] [19] is a process that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching or histogram stretching [20] [21]. Intra class differences are minimized. Geometric normalization [22], Lighting normalization [23] [24], Constant normalization consists of Constant image size, fixed eye positions, frontal orientation etc. geometric normalization is necessary for larger image because it consume more time for execution. Lighting conditions affect effectiveness. It consists of Histogram fitting, Brightening filters [25] [26]. The local normalization of f(x, y) is computed as follows: $g(x, y)=(f(x, y)-m_f(x, y))/(\sigma_f(x, y))$ where f(x, y) is the original, image $m_f(x, y)$ is an estimation of a local mean of f(x, y), $\sigma_f(x, y)$ is an estimation of the local variance, and g (x, y) is the output image.

2.5 Facial Feature Extraction

Automatic facial feature extraction [28] [62] is one of the most important and attempted problems in computer

vision. It is necessary step for so many applications for example face recognition, expression recognition, face detection, facial image compression and automatic image morphing. Facial feature extraction methods [27] [63] are sensitive to various non-idealities such as variations illumination, noise, orientation, time-consuming and color space used. Also a good feature extraction will increase performance of face recognition system. It is a process to extract various facial features like eyes, nose, mouth, etc. from the detected face region. Generally feature extraction methods consists of four types: (1) Generic methods [29] based on edges, lines, and curves; (2) Feature template [30] based methods that are used to detect various facial features by previously designed standard face pattern template is used to match with the located face components; (3) Color segmentation based methods [32] [33] that use face color instead of the intensity values; (4) Appearance based methods that are able to manage changes in illumination conditions, shape, pose and reflectance and even to handle translation and partial occlusions.

2.6 Verification

Verification is a process of Confirming the truth, accuracy, or validity of face. Classifier technique used [34] [35] to verify the face captured from camera. Standard database used to verify the face. Database contains large number of sample faces. Rule based techniques are used i.e. correlation-used to improve the recognition rate accuracy. In template matching every pixels and degree of similarity is measured- biggest disadvantage of this method is no variation in scale or orientation is permitted. In template matching model template image is matched with input image to find out face regions that fits into this model.

3. Challenges in Face Detection

Result in difficulties of face detection consists of several factors [36] [37] except the possible low quality driven from the image acquisition system, focus on the angle of human faces taken by the camera and the environment of photo acquisition. Mainly following six factors are concern.

3.1 Illumination

Fig. 2 Illumination

Illumination is a light. Sun is the primary light sources of the world. Moon provides light by reflection. Image pixels values are varies by intensity of light i.e. brightness of image. The illumination variation has been widely discussed in many face detection and recognition researches. This variation is caused by various lighting environments and is mentioned to have larger appearance difference than the difference caused by different identities. Fig.2 shows the example of illumination changes on images of the different faces, and it's obviously that under some illumination conditions, we can neither assure the identification nor accurately point out the positions of facial features.

3.2 Face Pose

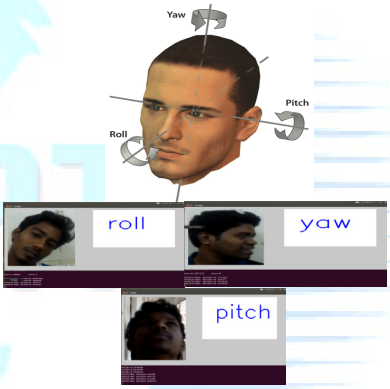

Fig. 3 Pose Variation

A pose is a particular way of standing or sitting. Once Face is detected from the video, then pose is estimated for the every detected face image. The pose variation [38] results from different angles and locations during the image acquisition process. This variation changes the spatial relations among facial features and causes serious distortion on the traditional appearance-based face recognition algorithms such as eigen faces and fisher faces. Three types of pose estimation such us pitch, yaw and roll. In each class the pose estimation will be positive and negative degree.

3.3Facial Expression

Human face can change very much during short periods of time. Human Emotion composed of thousands of facial expressions. Emotions play a major role in human life. At different kinds of moment or time human face reflects that how he/she feels or in which mood he/she is. Detection of Emotion is easy in human-human direct interaction but it very complicated in Artificial. A facial expression of human is one or more motions or positions of the muscles in the face skin. Human uses different facial expressions [41] [42] [43] [44] [45] to express their feelings or

tempers. The expression variation results in not only the spatial relation change, but also the facial-feature shape change. Facial characteristics display a high degree of variability due to a number of factors, such as difference across people (arising from age, illness, gender, or race, for example), growth or shaving of beards or facial hair, make-up, blending of several expressions, and superposition of speech-related (articulatory) facial deformation onto affective deformation.

Fig. 4 Facial Expression

3.4 RST Variation

The RST (Rotation, Scaling, and Translation) variation [39] [40] is also caused by the variation in image acquisition process. It results in difficulties both in face detection and recognition, and may require exhaustive searching in the detection process over all possible RST parameters.

Fig. 5 Rotation

3.5 Cluttering

Fig. 6 Clutter scene

To consider the above four variations which result in changes in facial appearances, we also need to consider the influence of environments and backgrounds around people in images. The cluttering background affects the accuracy of face detection, and face patches including this background also diminish [46] the performance of face recognition algorithms.

3.6 Occlusion

The occlusion is possibly the most difficult problem in face recognition and face detection. It means that some parts of human faces are unobserved i.e. overlapping by another Face [47] [48] [49] [50] or any other object due to some property of our sensor setup or some event. Approach to handling occlusion is to define them as regions where forward and backward motions are inconsistent.

Fig. 7 Occlusion

4. Face Detection Approaches

Yan, Kriegman and Ahuja presented well defined functions classification methods [51]. Those Methods are divided into four categories. Template-matching methods [52], [53] are used for face localization and detection by computing the correlation of an input image to a standard face pattern. In a template matching system there is a training phase, in which a directory of image examples is processed by a digital computer to derive component vectors. As well there is a search phase, in which a digital computer processes a target image with vectors selected using component vectors to determine the presence of one or more image examples in the target image. The feature invariant approaches are used for feature detection [54], [55] of eyes, mouth, ears, nose, etc. The appearance-based methods are used for face detection with Eigen face [56],

[57], neural network [58] have been used to solve a wide variety of tasks that are hard to solve using ordinary rule-based programming, including computer vision and speech recognition used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. Advantages include Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience. Self-Organization: An Artificial Neural Network (ANN) can create its own organization or representation of the information it receives during learning time. Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability. Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage. This expert can then be used to provide projections given new situations of interest and answer "what if" questions., and information theoretical approach [59] [60]. Nevertheless, implementing the methods altogether is still a great challenge. Knowledge-rule-based methods encode human knowledge of what constitutes atypical face. Usually, the rules capture the relationships between facial features. These methods are designed mainly for face localization. The classes of face and non-face images are decidedly characterized by multimodal distribution functions.

Method	Advantage	Disadvantage
Geometry-based	-Small database -Simple manner -Recognition rate 95%	-Large number of features are used
Template-based	-Simple manner -Recognition rate 99%	-Computational complexity -Description between template and images has a long time -Effective only at that time of when query and model images have the same scale, orientation and illumination properties
Colour Segmentation-based	-Small database -Simple manner	-Recognition rate 85% -Illumination, hue, rate of quality are effective an recognition rate -Discontinuity between colours
Appearance –based	-Small number of features -Recognition rate 98%	-Needs -good quality images -Large size of database -illumination

Table 2 Comparative analysis of Advantage and Disadvantage in different methods [64]

Table 3 gives the detailed classification of face detection approaches with relevant example.

Approach	Representative Works
Knowledge based	Multi resolution rule based method
Feature invariant - Facial Feature - Texture - Skin Color - Multiple Features	 Grouping of Edges Space Gray-level Dependence matrix of face pattern Mixture of Gaussian Integration of skin color, size and shape
Template matching - Predefined face Templates - Deformable Templates	 Shape Template Active Shape model

Table 3 Taxonomy of face detection

6. Conclusion

Authentication and identifications are two major issues in the today modern digital world. Face detection is a challenging problem in the field of image processing and computer vision. The main reason is lots of application in different field the face recognition has achieved great attention. In this paper, we have covered a detail discussion on the human face detection with different applications, major challenging and stages in face detections which are also the subject to be focused on this paper. It is our hope that by reviewing the numerous existing technique, we will see yet better development to solve this fundamental computer vision problem. In conclusion, before developing any kind of method based on choice, if you go through this paper, you will definitely get an overview of various ways and application used in human face identification.

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