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A Case Study of various Face Detection Methods

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Abstract: ***This paper provides a brief insight of some famous and particularly important algorithms used for face detection. Face detection is a technology used by computer systems to detect faces in a given digital image. Face detection is currently an active research area in the computer vision literature, not only because of the challenging nature of face as an object, but also due to the countless applications that require the application of face detection as a first step. The goal of this paper is to present a critical survey of existing literatures on human face detection systems. Face detection is a difficult task in image analysis which has each day more and more applications. We can define the face detection problem as a computer vision task which consists in detecting one or several human faces in an image. It is one of the first and the most important steps of Face analysis. Face detection is not Straight forward because it has lots of variations of image appearance, such as pose variation (front, Non-front), occlusion, image orientation, illuminating condition and facial expression. In this paper we presented three methods of face detection, which are commonly used. As the number of proposed techniques increases, survey and evaluation becomes important.***

Keywords: Face detection method, RCNN, Computer vision, YCbCr, Adaboost algorithm

I. INTRODUCTION

Given an input image, the 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. While this appears a difficult task for human beings, it is a very challenging task for computers and it has been one of the most heavily studied research topics in the past few decades. The difficulty associated with face detection can be attributed to many variations in skin color, scale, location, orientation (in-plane rotation), pose (out-of-plane rotation), facial expression, lighting conditions, occlusions, etc., [1][2]

The applications of face detection are so many, so face detection is the backbone of many high level computer vision tasks such as face recognition. Face detection by itself can be a main stream line and incorporating it with other small pre-processing and post-processing steps, researchers can develop numerous beneficial applications such as smart phones, security, robotics and more. Face detection is becoming an active research area spanning several disciplines Such as image processing, pattern recognition, computer vision, neural networks, Cognitive science, neuroscience, psychology and physiology. It is a dedicated process, not merely an application of the general object recognition process. It is also the representation of the most splendid capacities of human vision. Automatic face detection is the cornerstone of all applications revolving around automatic facial image analysis including face recognition and verification, face tracking for surveillance, facial behavior analysis, facial attribute recognition, gender/age recognition etc. The goal of face detection is to determine whether or not there are any faces in the image and if the image is present then it return the image location and extent of each face. While this appears as a trivial task for human beings, it is an extremely tough task for computers, and has been one of the top studied research topics in the past few decades. In this paper we provide a critical review of three methods used in face Detection [3].

II. FACE DETECTION METHODS

A. Shape Based face Detection Method

In this method, a special template containing directional information of edges is used along with previously used shape based face detection method [4][5][6]. Extensive experiments show this is very efficient when processing images with a simple background regardless of variations on size, head pose (moderate head rotation) and lighting condition.

1) *Image Enhancement:* In this system histogram equalization is used to improve the contrast of the original image because input images may be of very poor contrast because of the limitation of lighting conditions. 2. Median filtering: median filter is used to remove noise.
2) *Edge Detection:* Considering computational cost and performance, zero-crossing detector is used [6].
3) *Edge Linking:* In this step edges linking is carried out to improve the information of the face contour. Noise is also reduced.

4) *Template Matching:* The various methods have not sufficiently used the global information of face images in which edge direction is a crucial part, so Jianguo Wang,Tieniu Tan present a deformable template based on the edge information to match the face contour [4].

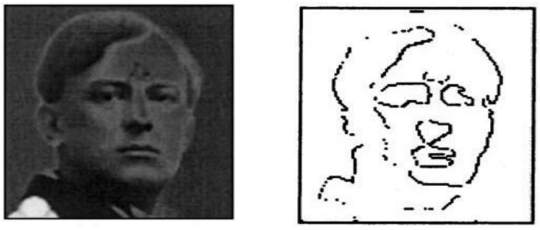

Fig.1.Effectiveness of histogram equalization

a) Advantages

i) The algorithm is able to correctly detect all faces in the images with Simple and complex backgrounds.

ii) More robust to noise and shape variations.

b) Disadvantages

i) For multiple face detection the number of faces should be known before.

ii) The detection faces do not overlap each other in images.

iii) Templates used in this method does not include enough information to distinguish faces in very complex backgrounds this is why the false rate is high in test set with complex backgrounds.

iv) It cannot accurately locate faces with large rotation angles

Fig.2. Face detection output of images with complex background

B. Face Detection Method based on YCbCr Color Space

The choice of color space is considered as the primary step in skin detection/classification. This is an orthogonal color space in which the color is represented with statistically independent components. Because luminance and chrominance components are explicitly separated, color spaces of this type (orthogonal) are a favourable choice for skin detection [7]. The luminance (Y) component is computed as a weighted sum of RGB values while the chrominance (Cb and Cr) components are computed by subtracting the luminance component from B and R values [8]. This is shown in below:

$Y = 16 + 65.481R + 128.533G + 24.966B$

$Cb = 128 - 37.797R - 74.203G + 112B$

$Cr = 128 + 112R - 93.786G - 18.214B$

where R, G, and B components ranges from 0 to 1[9].

1) *Skin Detection:* The color space is converted from RGB to YCbCr or YCgCr so that we can segment the image into skin-like regions and non-skin regions in this space. Same skin detection technique is applied to both methods. Thresholding segmentation is the simplest method, which has better computing performance than the Gaussian skin color model. We regard a pixel as skin if it satisfies the following conditions:

a) $Y > 80$

b) $77 < Cb < 127$

c) $135 < Cr < 175$

The result of thresholding segmentation is a binary image where white represent the skin-like regions and black represent the non-skin regions. Then we use the median filter to remove noise. The median filter can remove noise with less attenuation of edges [6] [11]. Fig. 3 is the results of skin color segmentation.

2) *Morphological Operation:* After threshold segmentation a binary image is obtained. For better performance, it is necessary to use morphological operations. The morphological close and open operation is applied. Moreover, holes filling operation is also needed because the facial regions may contain holes which represent eyes, mouth, facial hair, etc[9][10].

a) Advantages

i) This method is able to correctly locate all faces in the images with almost at right scale.

ii) More robust to noise and shape variations

iii) Accuracy 80-82% [7]

b) Disadvantages

i) Moderate false detection rate.

ii) Sometimes non face skin color region is also detected.

iii) Many objects in the real world have skin-tone colors, such as some kinds of leather, sand, wood, fur, etc., which might be mistakenly detected.

Fig.3.Results of YCbCr color space based face detection method

C. Face Detection Method Based On Viola Jones Algorithm

The AdaBoost algorithm was firstly proposed by Freund and Schapire in 1995. In 2001, Viola and Jones applied this algorithm to detect faces and successfully constructed a detection system which can detect human face in real time [11] [12]. They use the integral image to solve the speed problem and uses cascade classifier to achieve high detection rates. The details of this algorithm are described as the following subsections.

The Viola–Jones object detection framework [11] is an object detection framework which provide robust and competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones. Even though it can be trained to detect a variety of object classes, it was motivated mainly by the task of face detection. This face detection framework is capable of processing images extremely rapidly and achieving high detection rates. There are three main stages of face detection framework.

1) *Haar Like Features:* Haar-like feature are rectangular digital image features. A rectangular Haar-like feature is defined as the difference of the sum of pixels in white rectangles and the sum of pixels in black rectangles [11]. The typical rectangular features are as shown in Fig. 1:

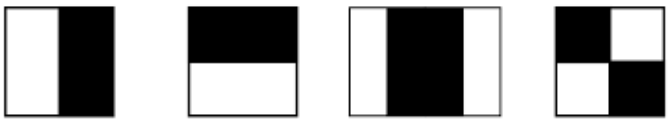

Fig.4. Haar-like features.

Viola and Jones use integral image to calculate the value of rectangular features. The value of coordinate (x, y) in an integral image is the sum of all pixels which located on the up and left region of the original image at coordinate (x, y).

$$ii(x,y) = \sum_{x' \le x, y' \le y} i(x', y')$$

Where ii (x, y) and i (x', y') respectively are the value of integral image at coordinate (x, y) and the pixel value of original image at coordinate (x, y). Due to the use of the integral image, the value of Haar-like feature can be calculated very fast only by using addition and subtraction operation [9].

2) *Adaboost Algorithm:* There are a lot of Haar-like features in an image and the AdaBoost algorithm is used to select the best of them as weak classifiers. In this stage classifiers are constructed by selecting a small number of important features (rectangle features) using Adaboost algorithm. From vast number of features computed in stage 1 we are interested in only selected few features that would enable us to detect face with great accuracy. For this, we use Adaboost Algorithm [12] to select principal features and to train classifiers that would be using them. Aim of this algorithm is to create strong classifier from linear combination of weak classifier. AdaBoost provides an effective learning algorithm.
3) *Cascading:* The third major stage of this method is a combining successively more complex classifiers in a cascade structure [8] which dramatically increases the speed of the detector by focusing attention on promising face like regions of the image. This cascade structure consists of classifiers. It works in a manner that initial classifiers are simpler and they are used to reject majority of sub-windows and at end complex classifiers are used to achieve low false positive rates. After skin color segmentation, the image is sent to the cascaded classifier to detect faces. If the first strong classifier judges the image as no face, then terminate the detection process. Otherwise the image will be sent to the next strong classifier for further verifying.

D. Face Detection Method Based on retinal connected neural network (RCNN)

In the recent years, different architectures and models of ANN were used for face detection. Rowley, Baluja and Kanade [16] presented face detection system based on a retinal connected neural network (RCNN) that examine small windows of an image to decide whether each window contains a face. Figure.5 shows this approach [13] [14][15].

This system operates following steps:

1) It first applies a set of neural network-based filters to an image.
2) It uses an arbitrator to combine the outputs.
3) The filters examine each location in the image at several scales, looking for locations that might contain a face.
4) The arbitrator then merges detections from individual filters and eliminates overlapping detections.

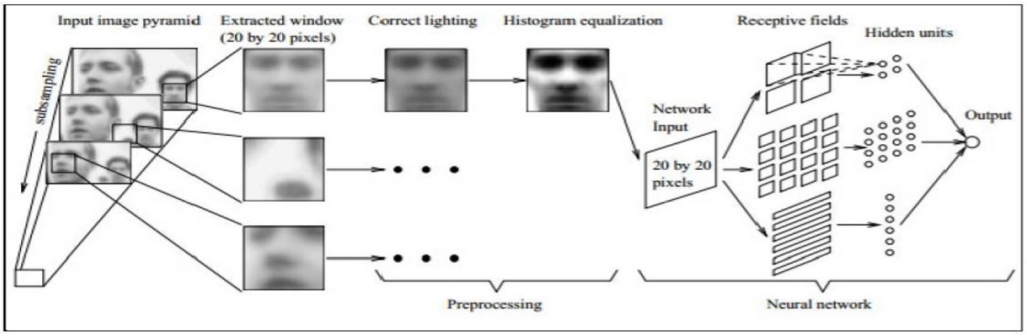

Fig.5. RCNN for face detection[16]

a) Advantages

i) This method produces good detection rates (77.9% and 90.3%) with an acceptable number of false positives.
ii) Depending on the application, the system can be made more or less conservative by varying the arbitration heuristics or thresholds used.
iii) We have also applied the same algorithm for the detection of car tires and human eyes.

b) Disadvantages

i) It only detects upright faces looking at the camera.
ii) The methodology is complex.

Fig.6.Output of RCNN system[16]

III.CONCLUSIONS

On referring various methods, we come to understand the challenges faced in Face Detection. From this case study we have conclude that, it is very important to remove background information. Removing irrelevant information, such as noise, non-face part and background would make face detection less complicated. We also conclude that following things make face detection more complicated. 1. Different Facial poses 2. Complex background 3. Varied facial expression 4. Overlapping Faces. Shape based Face detection system gives the effectiveness of used algorithm in the images with simple or complex background. The algorithm is able to correctly detect all faces in the images with simple backgrounds. Compared with other similar algorithms, this algorithm appears to be more robust to noise and shape variations. Face detection system based on YCbCr gives the effectiveness of used algorithm in the images with simple or complex background. The algorithm is able to correctly detect all faces in the images. Viola jones presented an approach for face detection which minimizes computation time while achieving high detection accuracy. The Haar like features used in this method are very simple and effective for frontal face detection, but they are less ideal for faces at random poses. RCNN method gives good result with an acceptable number of false detections rate. Depending on the application, the system can be made more or less conservative by varying the arbitration heuristics or thresholds used.

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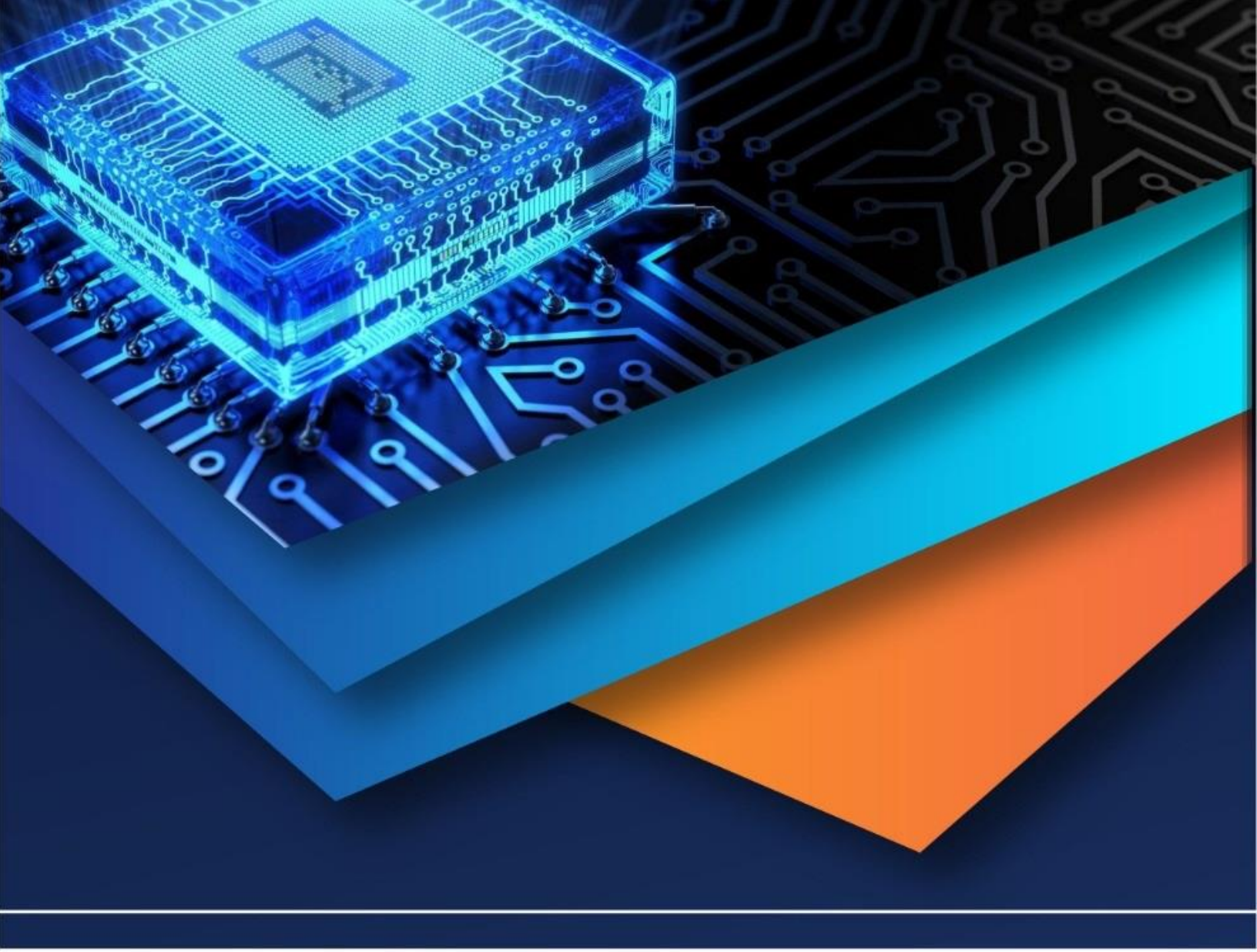

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