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A Review of Various Face Detection Methods

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ABSTRACT
Skin identification assumes an imperative part in an extensive variety of image processing algorithm applications extending from face detection, tracking, and content-based image retrieval, gesture detection, and facial expression detection. Skin detection systems based on the face color play the import role to make algorithm computationally more effective even for image rotation, scaling and translation. However, the skin color object identification is a troublesome assignment as it is influenced by different elements like intensities, frame background, camera qualities, and ethnicity. In this paper, a basic survey of the different skin model and face detection systems has been explained in detail. The paper is explained in three parts. In first part, the skin color detection techniques have been explained, in second part the face detection techniques has been presented.
Keywords **-** Face detection, face recognition, facial feature, HSV, texture based face detection.

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I. INTRODUCTION

Face detection is one of the essential computer vision systems which are additionally utilized as a part of the authentication procedure in numerous applications. There are different computer vision algorithms from skin color detection to the facial model estimation. The human faces are complex for feature extraction. Hence the face detection module is computationally difficult [1]. The process of face detection is complex due to variations in the face position, orientation, glasses and hairy faces, different intensities and resolution of the image [2]. In this manner, as per the complexity of face detection process, the applications have been developed like faced based video surveillance, monitoring, robotics, notebooks and PC cameras.

The difficulties related to the face detection are explained below.

1) Facial Position: The images of a face change due to the relative camera-face posture and some facial highlights for example an eye or nose may turn out to be halfway or completely occluded.
2) Presence of structural components: The structural components like glasses, beard, mustaches etc may affects the face detection.
3) Facial expression: The positions of the facial landmarks like nose points, eyebrow, lips corner etc. are changes according to the expression.
4) Occlusion: It is one of the important factor which affects face detection where, the faces are occluded by different objects. It is occur mostly in crowd.
5) Image orientation: The facial features are varying with different rotation. Angle of rotation changes the relative pixel position.

The rest of the paper is organized as takes after: Section 2 gives brief explanation on the Generalized block diagram of face detection. Section 3 gives description of various face detection methods. Section 4 on Summary of face detection.

II. BLOCK DIAGRAM

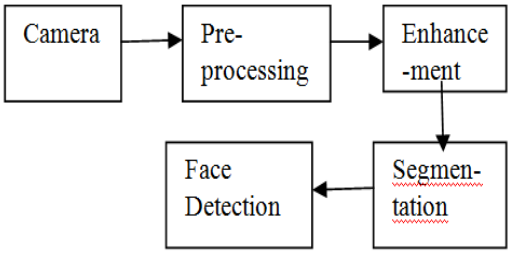

Fig.1.Generalized block diagram of face detection

The basic flow of the face detection has been presented in Fig. 1. In this process the activity begin with the capturing video from the camera. The input video stream consists of frames which are extracted using frame extraction technique. Each extracted frames are preprocessed with noise removal techniques like median, Gaussian filters etc. There are different enhancement techniques available in the image processing and computer vision like histogram equalization, winner filtering, linear contrast adjustment, Contrast-limited adaptive histogram equalization [3]. Such an image enhancement algorithm used to remove the artifacts in the image and help to enhance the results of the

algorithm. Segmentation is the procedure of omitting unnecessary part of the image and select only significant. There are different segmentation algorithms are existing. The application of the segmentation algorithm is depend on the nature of an In this section, we discussed different existing techniques to detect faces color image. We categorize single image detection methods into four categories;

a) Knowledge-based
b) Feature invariant approaches
c) Template matching methods
d) Appearance-based methods

Each method is explained in detailed below:

3.1 Knowledge -based face detection

In knowledge-based face detection approach, the rules are developed for knowledge of human faces. It is simple to describe the facial feature and the relation between them. Simple examples the distance between two eyes are symmetrical with respect to the nose. The relationships between features can be represented by their relative distances and position.

The main problem of this approach is to converting human knowledge into well define rules. If the rules are strict then it is a possibility of failure below.

3.2.1 Facial Features

Sirohey et al. [5] proposed the face segmentation approach. They used canny edge map and heuristic to collect the useful facial boundaries and remove unwanted part from the image and preserve only single strong facial contour. After this, the elliptical contour is applied over the boundary between head region and background.

3.2.2 Skin Color

The goal of the skin color detection is to discover skin regions in an image. Skin color recognition is the procedure of division amongst skin and non-skin pixels. It is found that the unique method for skin color detection is difficult because of color tone of the human changes person to person. For example the skin color of the Asians is totally different from the European or Africans.

The skin region detection and segmentation is used in many applications like video surveillance, motion monitoring, face detection and recognition, gesture recognition etc.[6] The skin detection can be divided into two classes pixel-based and region based. In the pixel-based skin detection method, the image is classifying into skin Vs non-skin regions. The non skin region is treating as a background and skin region is used for the analysis.

image. The segmented image is further provided to the face detection algorithm.

III. FACE DETECTION METHODS

because the test case has to pass the entire test. Single test failure cause the complete failure of the algorithm likewise if the rules are simple then there may be chances of false alarm. Hence there is a need of generalized algorithm which is the trade off between these two approaches. Such approach is presented by Yang and Huang [4].

3.2 Feature invariant approaches

In this approach the invariant features were carried out from the face using knowledge-based top-down method. The features which cannot vary with adverse condition like lighting, contrast are considered as features. The facial parts like eyes, nose, eyebrows, mouth etc. are commonly used to detect the face. Based on the features extracted from these landmarks, the statistical model is built and which is used to detect the face. The only disadvantage associated with this method is illumination, noise, occlusion and shadow.
The different feature invariant approaches are enlisted and explain in detail

In previous decade, many algorithms are used to segment skin object from video. The best application of skin color detection is the face detection.

3.2.2.1 HSV Color Space

Hue, Saturation and Value (HSV) [7] are the color models are utilized to quantize the color properties. In HSV, Hue represents the true color information such as Red, Green, Yellow and Purple. Saturation measures the contrast of the image and Value measures the lightness, intensity of the image. The HSV color model is represented by the cylindrical model as shown in Fig. 2.

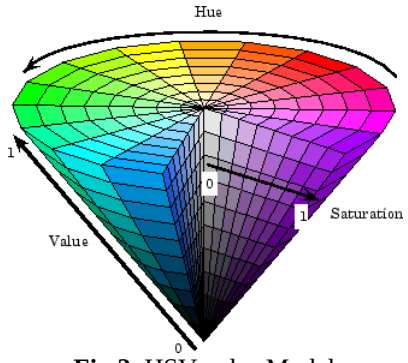

Fig.2. HSV color Model

The value of Hue is express in angle which is varying from 0 to 360o. In some application it is taken as 0 to 180o. Saturation has a radius which has

a radius ranging from 0 to 1. The value of saturation is varies from 0 to 255. Third parameter is Value which is represented in intensity level. It is varies along the Z-axis. The min value 0 represent the black color and higher value 255 represent the bright. The hue value vary the true color from red color 0o to green 120o to blue 240o to red 360o. Skin color can be segmented in HSV is based on the value of Hue (H), Saturation (S) and Value (V). The skin color can be segmented by following set of equations [8]:

$$H = \arccos \frac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{((R-G)^2+(R-B)(G-B))}} \quad (1)$$

$$S = 1 - 3\frac{\min(R,G,B)}{R+G+B} \quad (2)$$

$$V = \frac{1}{3}(R+G+B) \quad (3)$$

Many applications use the HSV color model. Histogram operations, intensity transformations and convolutions these are application operate on an intensity image. These operations are performed on an image in the HSV color space.

3.2.2.2 YCbCr color space

YCbCr is one of the well-liked color models in computing. It represents the color information in terms of luminance (Y), and chrominance component (Cb and Cr). This color space convert RGB image into luminance and chrominance format [9]. These are useful in compression applications however the condition of colors is somewhat unintuitive. The YCbCr color model is as shown in Fig. 3.

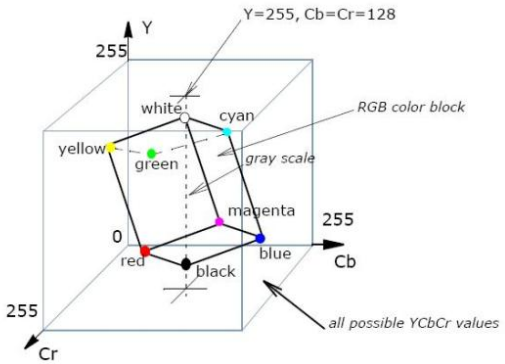

Fig. 3. YCBCR color model

The RGB image can be converted to YCbCr and vice-versa. The formula for conversion from RGB to YCbCr is as explain in Equation:

$$Y = 0.299R + 0.587G + 0.114B \quad (4)$$

$$Cb = 128 - 0.168736R - 0.331264G + 0.5B \quad (5)$$

$$Cr = 128 + 0.5R - 0.418688G - 0.081312B \quad (6)$$

YCbCr representation separates the luminance and chrominance, so that the computing system should allocate the fewer bits to chrominance by using color sub-sampling.

3.2.3 Texture

The Human faces have different textures that are useful to distinguish the non-face objects from faces. Augusteijn and Skufca presented face detection method which distinguish face using face-like textures. The texture features are extracted by using second order statistical features. A method that infers the occurrence of a face through the recognition of face-like textures [10]. The textures are computed using second-order statistical features called spatial gray level dependence (SGLD) [11] on sub-images of 16 X 16 pixels. Three types of features are considered: skin, hair, and others.

3.3 Template matching methods

Template matching is the simplest method to detect the face. In this method the face patterns are stored as a function. The image is taken as a input and the correlation between the facial parts like eyes, nose, facial contour, mouth etc and standard function is calculated. The face existence is calculated by the correlation value. This approach is simple to implement but it is failed to detect face for variation like scaling, rotation and shape [12].

3.4 Appearance-based methods

The appearance-based methods are differing from template matching where the model is learnt from different input images. In simple word, the appearance based method uses statistical and machine learning based approaches for differentiate facial and non facial images [13]. In this approach, the models are formed by learning different characteristics of the face and meanwhile the dimensionality reduction techniques are used to reduce the performance time. Different appearance-based method is uses probabilistic frameworks.

3.4.1 Direct correlation

The direct correlation method is similar to the template matching [14]. In this method, direct pixel to pixel intensities difference is taken from the facial images. The image of size mxn is converted into mn element. By measuring the distance between these pixels point image similarity can be calculate. The similar images can located nearer to each other within the image space and dissimilar images are separated with space.

This idea can be extended by calculating the distance (Euclidean) d between the two facial vectors. Then the threshold is then applied to make the final verification decision. Euclidean distance formula:

$$d = \|q - g\| \quad (d \leq th \rightarrow accept) \wedge (d > th \rightarrow reject) \quad (7)$$

Where, d is the Euclidean distance between two facial images

q is the query template image and
g is the input image
th is the predefine threshold

3.4.2 Eigen-face method

Most of the researcher uses eigen based method to detect the face [15]. In this method eigen value and eigen vectors of the covariance matrix (C) is calculated using standard linear method and M eigen vectors which having highest eigen values are selected to formulate the projection matrix (μ). A face key ω can be generated by the formula:

$$\omega_k = \mu_k^T(\tau - \varphi) \qquad for\ k = 1\ to\ M \quad (8)$$

Where, M is the number of images,
μ is the projection matrix
T is the training images

The face key can be compared using Euclidean distance.

3.4.3 Fisher-face method

Fisher face method is explained by Belhumeur et al [16]. Similar to that used in the eigen-face method, this method uses both PCA and LDA to produce a subspace projection matrix. This method has a advantage of within classification information, minimum variation and maximum separation. To achieve this goal, the number of samples with maximum variations, different lighting conditions, different facial expression and orientation is provided to the learning algorithm.

IV. SUMMARY

Table.1. Different Face Detection Methods

Paper title	**Year of Publication**	**Method**	**Accurcy**
Commonsense Knowledge-Based FaceDetection [17]	1997 IEEE	Preprocessing (image conversion, color operation, image restoration, and image enhancement. face components extraction Final decision making (Neural Network)	89% on 100 images
Face Detection and Facial Feature Extraction Based on a Fusion of Knowledge Method and [18]	AICERA-2014 IEEE-2014	Eye candidate detection by finding dark regions Face detected by the location of eyes and their distance.	80%
Facedetectio-nsystem using HSV colormodel, morphing op.0[19]	NCWSE 2013	Segment skin region from an image, decide these regions contain human face or using HSV	Accuracy = 82%
Human Face Detection Using Skin Color SegmentatioWatershed Algorithm [20]	AmericJournal of Artificial Intelligence, 2017	Conversion of RGB to YCbCr Skin threshold Watershed algorithm	97.22%
Face Recognition using Template Matching [21]	2013	Image enhancement segmentation of face image detection of face boundary facial features, Face matching of extracted features against the features in a database	Accuracy = 84%

Face Recognition: A Comparison of Appearance-BasedApproaches [22]	2003	Direct Correlation method, Eigenface method Fisherface method	direct correlation=18.0% eigenface = 20.4% fisherface= 17.8%

V. CONCLUSION

In this article, we present survey of face detection methods. Now days in real world face detection techniques increasingly used in applications and products. For instance, digital cameras are used for face detection. In this survey, various face detection methods are described. Maximum accuracy of face detection occurs in RGB to YCbCr color model and segementation with watershed algorithm is 97.22%.

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