A Survey of Face Detection Techquines Using YC_bC_r Color Model & Novel Techniques

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ABSTRACT

Digital Image processing has found a number of applications in various fields such as Biometric Identification, Medical Imaging, Remote Sense, Industrial Assessment and Agricultural Processing etc. Biometric Digital Image Processing refers to technologies for measuring and analyzing a person's physiological or behavioral characteristics. These characteristics are unique to individuals hence can be used to verify or identify a person. Digital Image Processing has been established as an effective means for analyzing purposes in various biometric applications like Face Detection, Face Recognition, and Fingerprint Recognition, etc.

KeyWords: Facedetection Techniques, Methodologies of Face detection, YCbCr color Model, MATLAB.

I.INTRODUCTION

A biometric system is a pattern recognition system that makes a personal identification by determining the authenticity of a specific physiological or behavioral characteristic possessed by the user. One of the most popular biometric techniques is face recognition to identify the users. In general, an automatic face recognition system is based on extracting a set of features from the user's face, either geometric characteristics or some information of textures and shapes of the different elements that constitute a human face. Before the recognition algorithm is applied, faces must have been detected in an image using some detection method. Therefore, face detection is the primary step for the face recognition process [2].

Face detection may also refer to the mental process by which human can locate visual scenes in real life. Face detection is a particular case of class-object detection. In class-object detection, the main task is to look for the sizes and locations of all objects in a picture that are from a given class.

Human face detection is an important research area having wide application in Public security, Electronic commerce, Video conferencing, Smart cards, Law enforcement & surveillance, human machine interface, advertisement industry, content-based image retrieval, gesture recognition, crowd surveillance and face recognition, entertainment services, etc. There may be many problems like, different lighting conditions, glasses, facial hair or mustache on face, skin color, different orientation pose or occlusion of face [3].

Face detection techniques can be classified into Image Based Method and Knowledge Based Method [4]. Face detection methods are divided into Knowledge Based Method, Feature Invariant Approach, Template Matching Method and Appearance Based Method [5].

The several face detection techniques are recently available. It includes Detecting faces in the images with mono-color (controlled) background, Detecting faces by color, Hybrid Algorithms, Finding faces by motion, Skin color model for Face Detection and Viola Jones Face Detection [6].

An automatic face detection technique is to detect the face regions from the human image is proposed. The existing Viola Jones Face Detection algorithm and skin color segmentation are applied to detect the face location and then suitable color models are proposed to detect the face regions. In this novel algorithm, the unwanted regions like background and hairs are eliminated by the selection of color model which is the main problem in the existing techniques.

II.LITERATURE SURVEY

A literature survey on Digital Image Processing Techniques to detect face regions from the human images is provided below:

RosaliMohanty (2016) et al., proposed face detection technique by using multi-color space based skin segmentation and region properties. First, skin regions are extracted from an image by the application of group of color models RGB, HSV and YCgCrand thresholding concept. Then facial features are used to locate the human face based on the knowledge of geometrical properties of human face by testing each segmented skin region [7].

Narayan T.Deshpande (2016) et al., proposed a technique to recognize human face by calculating the features present in the image and identifying the person using these features. Face detection and identification is performed in two stages. In the first stage, attendance of face in a given image is detected using Viola-Jones algorithm and in the next stage, the detected face is identified using Linear Discriminative Analysis (LDA) and Artificial Neural Network (ANN). The Viola- Jones algorithm with fusion of ANN and LDA provided an identification accuracy of 92%. This method provides better identification accuracy in comparison with the other existing methods [8].

NeetuSaini (2015) et al., presented a multiple face detection algorithms in color images. The First algorithm combines HSI and YC_bC_r color models along with morphological operations. In the second algorithm, RGB color model with Viola-Jones algorithm is used. It is observed that the first algorithm is suitable for simple background and different lightening conditions of images and the second algorithm is suitable for simple as well as complex background of images [9].

Rajeshwari D G (2015) et al., presented Viola Jones classifier method, Background subtraction method and skin color detection on HSV color spaces. The Viola Jones classifier method gives good results for detecting frontal faces but for finding faces in motion, it takes more time to detect and does not give accurate results. Background subtraction method and Skin color detection on HSV color space are more efficient compared to the first method by giving accurate results for detecting faces in motion [2].

Wen-cheng Wang (2015) et al., proposed an approach that realizes the face detection through the combination of skin color segmentation and geometric features. Firstly, some common color models are analyzed, and a huge amount of skin images are used to create an YC_bC_r color model for region segmentation. Then, the morphological processing is executed on the binary image, and the facial regions' filtering is conducted by adopting some geometry constraints such as Euler number, the ratio of width and height, centroid. Finally, the face region is placed and labeled with a rectangle [10].

AnishaAnchit (2014) et al., presented a comparative analysis for face detection in Haar Classifier and Skin color detection method. Using Viola Jones the Haar detection rate for the facial features like nose, eye and mouth is calculated. The efficiency achieved by Haar for face is 89.42% which is higher than 84.61% from skin color model is 84.61%. But the speed of skin color model is faster than that of Haar[11].

Divya (2014) et al.,used different color spaces (RGB, HSV, and YC_bC_r) to identify the color model suitable for human skin detection. YC_bC_r color model gives an efficient output compared to RGB and HSV skin color detection methods. [12].

Mehul K Dabhi (2013) et al., presented Haar feature based Adaboost algorithm to extract the facial region from the image [13].

KamathAashish et al., presented a face detection comparative methods. The methods are Viola-Jones and Kanade-Lucas-Tomasi. Viola-Jones method gives better detection rate compared to kanade-Lucas-Tomasi method in looking front, left, right, up and down portions of the image [14].

From these review, it has been identified that the Viola Jones algorithm enriched with YC_bC_rskin color segmentation technique can locate and detect the face regions from the human image with higher efficiency.

III. METHODOLOGY OF FACE DETECTION

Face Detection is a computer technology that determines the locations and sizes of human face in digital images. It detects facial features and ignores other things, such as buildings, trees and other parts of the body. Various departments are now actually more motivated to improve security data systems centered on body or behavioral characteristics, often called biometrics [15].

3.1 Biometrics

A biometric is a unique, measurable characteristic of a human being that can be used to automatically recognize an individual or verify an individual's identity.

Biometrics can measure both physiological and behavioral characteristics.

- **Physiological biometrics:** This biometrics is based on measurements and data derived from direct measurement of a part of the human body.
- **Behavioral biometrics:** This biometrics is based on measurements and data derived from an action.

3.1.1 Types of Biometrics

The types of biometrics and their techniques are given below.

Table 3.1 Types of Biometrics and their Techniques

Physiological	Behavioral
Finger-scan	Voice-scan
Facial Recognition	Signature-scan
Iris-scan	Keystroke-scan
Retina-scan	
Hand-scan	

3.2 Need for Face Recognition

- Face recognition technology is the least intrusive and fastest biometric technology. It works with the most obvious individual identifier the human face.
- It requires no physical interaction on behalf of the user.
- It can use your existing hardware infrastructure, existing cameras and image capture Devices will work with no problems
- It is only Biometric that allow you to perform passive identification in many environments. (e.g. identifying terrorist in a busy airport terminal)
- It does not require an expert to interpret the comparison result.

3.2.1 Face Recognition

Face recognition system is an application to verify a person's identity by comparing pictures taken recently from a digital camera or Video Cassette Recorder (VCR), and compare with the images stored in the system database. Face recognition system has been widely used in recent years for security and access control, like other security systems that rely on biometrics such as fingerprint or eye Iris. In Facial recognition there are two types of comparisons:

- **Verification:** The system compares the given individual with whom that they are and give a yes or no decision.
- **Identification:** The system compares the given individual to all other individuals in the database and gives a ranked list of matches. All identification or authentication technologies operate by using the following four stages:
  - **Capture**
  - **Extraction**
  - **Comparison**
  - **Match/non-match**

Face detection is the first and important problem for face recognition. Face detection can be used both as an independent task for some practical applications, such as face registration, preliminary part of face recognition and face expression analysis etc .

3.3 Face Detection

In modern years, images containing human faces are becoming more and more important in different security and intelligent systems. Face detection is a process that aims to locate a human face in an image. The task of face detection is so trivial for the human brain, yet it still remains a challenging and difficult problem to enable a computer to do face detection. This is because human face is a dynamic object and has a high degree of variability in its appearance, which makes face detection a difficult problem.

3.3.1 History of Face Detection

In the early stage, face detection algorithms are mainly focused to detect the frontal human face. However, newer algorithms try to consider the different view of face as a core of face detection.

Initially the face detection system has been developed in early 1970's. Due to the limitations of computation, system didn't satisfy the requirement of users that is to identify the passport size photograph in real time. At the beginning of 1990's, techniques are proposed to focus on face recognition in which there is an increase in the need of face detection. Many systems were constructed to deal with video streaming. In the past few years, lots of methods were developed at least more than 150 methods.

3.3.2 Importance for Face Detection

However, the following items are explained how the important of face detection[16]:

1. Face recognition: Face recognition consists in the meaning of identification and verification of the people. These considerations are the security issues.
2. Human Computer Interaction (HCI): Human Computer Interaction is the study of interaction between human and computer. It is important that it is increased the user experience with machine, as a result intelligent human computer interaction system is construct. For example, facial expression recognition, helping the disabled people.
3. Facial Expression Recognition: This technique tries to figure out the meaning of expression from detected people.

3.4 Face Detection Applications

As face detection is the first step of any face processing system, it finds numerous applications in face recognition, face tracking, facial expression recognition, facial feature extraction, gender classification, clustering, attentive user interfaces, digital cosmetics, biometric systems. In addition, most of the face detection algorithms can be extended to recognize other objects such as cars, humans, pedestrians, and signs, etc.

The following Table 3.2 shows the applications of face detection and their research areas.

Table 3.2 Face Detection Application

Application Area	Research Area
Immigration Management	Public Security
Monitoring sensitive characters (spies, terrorists, etc.)	
Automated Login System	Human Computer Interaction(HCI)
Realistic virtual games	
E-commerce authentication	Financial Security

The following research areas are the summary of Face detection:

- Video surveillance
- Security control system
- Biometric identification
- Intelligent human computer interface
- Face recognition
- Content-based image retrieval
- Multimedia applications on the web like video conferencing
- Face database management.

3.4.1 Video Surveillance Applications

The application domain where most interest in face recognition is being shown is probably surveillance. Video is the medium of choice for surveillance because of the richness and type of information that it contains and naturally, for applications that require identification, face recognition is the best biometric for video data though gait or lip motion recognition have some potential. Face recognition can be applied without the subject's active participation, and indeed without the subject's knowledge. Automated face recognition can be applied 'live' to search for a watch-list of 'interesting' people, or after the fact using surveillance footage of a crime to search through a database of suspects. The deployment of face-recognition surveillance systems has already begun, though the technology is not accurate enough yet. The US government is investing in improving this technology and while useful levels of recognition accuracy may take some time to achieve, technologies such as multiple steerable zoom cameras, non-visible wavelengths and advanced signal processing are likely to bring about super-human perception in the data gathering side of surveillance systems. Video surveillance is used to tell whether or not a specific person is presented in a surveillance area.

3.4.2 Photography

Face detection is also useful for selecting regions of interest in photo. In recent, cameras are using face detection for autofocus.

3.4.3 Mobile Applications

Recently, the face-detection technology is being adopted in the mobile phone applications because of the pros in easy installation, low-cost, non-contacting method. Much like fingerprints, face recognition is part of a larger category of biometrics now being leveraged for mobile apps which provide a frictionless authentication option to enhance security and improve the user experience. VASCO® Data Security International, a global leader in authentication, electronic signatures, and identity management, has extended their biometric authentication capability with DIGIPASS® for Apps Face Recognition – adding to an already comprehensive library of mobile app protection solutions. The enrollment process for DIGIPASS® for Apps Face Recognition is as simple as taking a selfie.

1. The user takes a few selfies to create a highly accurate biometric template
2. The selfies are encrypted for protection and stored
3. To authenticate, the user simply takes a selfie which is compared with the stored biometrics
4. A proper match, based on an accuracy score, completes the secure authentication process

3.4.4 Lecture Attendance System

It is possible to estimate automatically whether each student is present or absent and where each student is sitting by using face recognition technology. It is also possible to know whether students are awake or sleeping and whether students are interested or bored in lecture if face images are annotated with the students' name, the time and the place.

3.5 Face Detection Challenges

Although many of the algorithms have been proposed and improved within a few years, Face detection is still limited by some uncollected factors e.g. (variant poses, illumination condition, expression, hairstyle and different camera equipment). Either one of the problems can decrease the performance of face detection. At the worst case, it should be the combination of the above problem. However, this situation often happens in our real worlds examples (surveillance with low quality).

In addition, occlusion is another one factor to affect the result of the face detection rate e.g. (make-up, sunglasses). In other words, occlusion sometime will greatly change the appearance of the faces. The following items are the summary of the main challenges in face detection:

- Head Pose
- Facial Expression
- Image Orientation
- Obstruction in Front of the Face
- Illumination
- The Computational Time and Speed

3.5.1 Head Pose

As the human head is somewhat like a sphere in 3D space, it is difficult to get the image of the face facing towards the viewer and at the center position all time as shown in Figure 3.1 Due to this, sometimes an eye, partial nose would be blocked. Hence the face may appear in half profile and would make it difficult to extract the features that would rather make it easy to detect a face.

Figure 3.1 Head Rotated in Horizontal Direction

3.5.2 Facial Expression

Sometimes in face recognition, a prerecorded face pattern may not match with the current facial expression. This ambiguity is due to slight variation in the facial expression. Figure 3.2 represents some of the facial expressions from the database collected from the University of Minnesota.

Figure 3.2 Facial Expression of a Person

3.5.3 Image Orientation

An image may be upside-down, rotated or mirror image of original image. This foils the process of face detection. Figure 3.3 shows the orientation of the face in a 3D space.

Figure 3.3 Orientation of the Face in a 3D Space

3.5.4 Obstruction in Front of the Face

Viola Jones method uses Haar features to classify that detected objects is a face or not based on the difference in the intensity level of the different part of the face. The presence of another object in front of the face hinders the detection of the required feature to possibly detect a face. Hence more features with more data points are incorporated in the basic face detection method to increase the efficiency. Figure 3.4 shows some of the occlusions such as a sunglass on the face, mouth covered and eyes coved. Apart from these factors hairs in front of the face or else an object in front of the face can also affect the face detection.

Figure 3.4 Simple Occluded Face Images

3.5.5 Illumination

It is the most crucial factor in deciding the quality of an image and also decides the evaluation time to detect a face. A bright image impedes the detection of certain set of features of the face. Similarly, a dark image produces low contrast image making it difficult to detect the variation in the intensity level along the face as shown in Figure 3.5.

Figure 3.5 Illumination Variation

3.5.6 The Computational Time and Speed

Face detection method must be robust and accurate to detect a face. At the same time it must be fast enough to be applied in the real time applications like security and industry applications. Neural Networks are used to increase the detection speed and accuracy.

3.6 Classification of Face Detection Techniques

The face detection techniques are classified into Image based and Knowledge based techniques. The classification is shown in Figure 3.6.

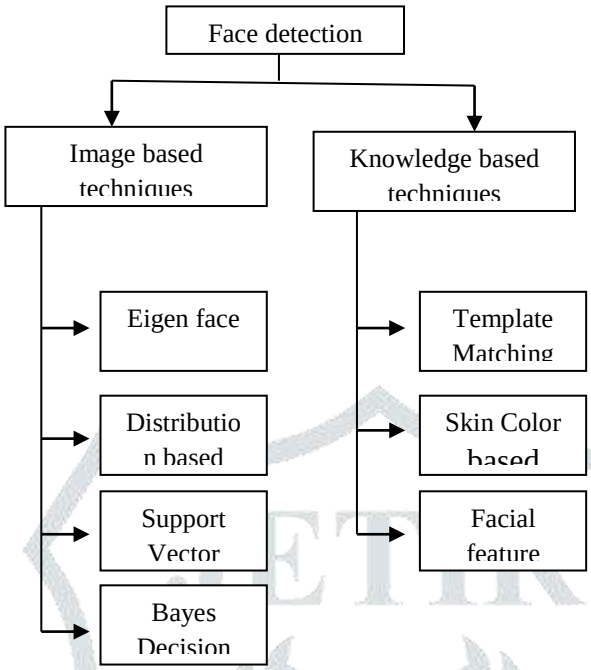

Figure 3.6 Classification of Face Detection

3.6.1 Image Based Techniques

Image based methods use training/learning methods to make comparisons between face and non-face images. For these methods, a large number of images of faces and non-faces should be trained to increase the accuracy of the system. Eigen face, Neural Networks and Support Vector Machines are kinds of methods that are used commonly in image based face detection algorithms.

3.6.2 Knowledge Based Techniques

Knowledge based techniques use information about facial features, skin color or template matching. Facial features include eyes, mouth, nose or other facial features to detect the human face. Skin color is different from other colors, and its characteristics do not change with respect to changes in pose and occlusion. Because of this, skin color detection is often the first step of a knowledge based face detection algorithm.

Table 3.3 Comparison between Image Based & Knowledge Based Methods

	Image Based	**Knowledge Based**
Phases of the systems	The system usually contains two phases a. Training phase b. Detection phase	The system usually contains two phases a. Skin Detection b. Face detection from the segmented skin
Designing Complexity	These systems are more complex as this involved designing neural network to predict the face.	These systems are comparatively simpler than Image based techniques.
Speed	Computationally complex	Usually faster than Image based techniques.

Performance	Performance Depends on the training or learning images	Performance depends on the criterion used to detect skin, face, face features etc

3.7 Face Detection Methods

Different categories of face detection methods are given below:

- Feature based
- Knowledge based
- Appearance based
- Template matching

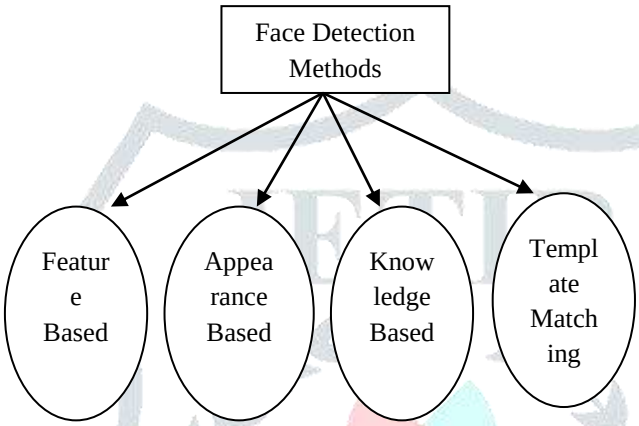

Figure 3.7 Common Face Detection Methods

3.7.1 Feature Based

Feature invariant approaches aim to find structural features that exist even when the viewpoint or lighting conditions vary and then use these to locate faces. Different structural features are being used: facial local features, texture, and shape and skin color. Local features such as eyes, eyebrows, nose, and mouth are extracted using multi-resolution or derivative filters, edge detectors, morphological operations or thresholding. Statistical models are then built to describe their relationships and verify the existence of a face. Neural networks, graph matching, and decision trees were also proposed to verify face candidates. Skin color is another powerful cue for detection, because color scene segmentation is computationally fast, while being robust to changes in viewpoint, scale, shading, to partial occlusion and complex backgrounds. The color-based approach labels each pixel according to its similarity to skin color, and subsequently labels each sub-region as a face if it contains a large blob of skin color pixels. It is sensitive to illumination, existence of skin color regions, occlusion, and adjacent faces. There are also techniques that combine several features to improve the detection accuracy. Usually, they use features such as texture, shape and skin color to find face candidates and then use local facial features such as eyes, nose and mouth to verify the existence of a face. Feature invariant approaches can be problematic if image features are severely corrupted or deformed due to illumination, noise, and occlusion.

3.7.2 Knowledge Based

Knowledge-based methods are based on human knowledge of the typical human face geometry and facial features arrangement. Taking advantage of natural face symmetry and the natural top-to bottom and left-to-right order in which features appear in the human face, these methods find rules to describe the shape, size, texture and other characteristics of facial features. A hierarchical approach may be used, which examines the face at different resolution levels. At higher levels, possible face candidates are found using a rough description of face geometry. At lower levels, facial features are extracted and an image region is identified as face or non-face based on predefined rules about facial characteristics and their arrangement. The main issue in such techniques is to find a successful way to translate human knowledge about face geometry into meaningful and well-defined rules. Another problem of such techniques is that they do not work very well under varying pose or head orientations.

3.7.3 Appearance Based

Face detection can be viewed as a pattern classification problem with two classes: “face” and “non-face”. The “non-face” class contains images that may depict anything that is not a face, while the “face” class contains all face images.

3.7.4 Template Matching

It is commonly used in the systems where there is a high possibility of getting a human face. A template is predefined structure of a uniform size and shape that makes detection of desired object easy just by comparing the template with the objects. In case of face detection, the template matching finds the relation between the input image or video and the face patterns or the features. Figure 3.9 shows a template for face detection.

Figure 3.9 Template of Human Face Shape Oriented in Vertical and Rotated Form

Template matching method is deformable and based on the facial contours. Unlike the appearance based method which uses neural network, templates are hand coded (not learned) and uses correlation to locate the faces.

IV. CONCLUSION

In this paper various face detection techniques are reviewed and survived. From the review of various techniques Viola Jones, K-means clustering and skin color segmentation techniques can be used for Face Detection. Viola Jones and Skin color segmentation techniques give better results and are the simplest ones. The face regions can be better extracted by YC_bC_r color model. From this review it has been decided to propose YC_bC_r color model and Viola Jones techniques to locate and detect the face region from the human image.

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