Sindh Univ. Res. Jour. (Sci. Ser.) Vol.49 (1) 229-234 (2017)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

A Hybrid Face Detection Approach Based on Facial Features and Skin color Information

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Received 20th July 2016 and Revised 21st February 2017

Abstract- Face is the primary identity of an individual and the differences in faces of individuals can be used in automatic visual identification system for identification of people. This work is based on an improvement of Viola-Jones face detection in color images. A hybrid face detection approach is employed by merging the Viola-Jones face detection technique with the skin detection technique. It has been observed that the performance of Viola-Jones detection technique is mostly affected due to background complexity, non-standard illuminations, camera quality, distance from camera, multiple faces in the image, and variations in poses and expressions and because the facial features are not accurately extracted in such conditions. In such cases, facial skin information is provided as an additional feature to Viola-Jones classifier, on the base of which face detection is carried out. The experiment showed that the proposed hybrid approach outperforms the Viola-Jones face detection technique.

Keywords: Face detection, skin detection, hybrid approach

1. INTRODUCTION

Face detection in images is an important and fascinating task in many applications. The detection of face in a scene is the first step in the development of automatic face recognition systems. Besides face recognition, it also has many other real life applications. A number of techniques have been developed for the face detection in images. The researchers are able to detect faces in a constrained environment but the goal is to construct a straightforward and context-free approach for face detection. This motivated the researchers to develop algorithms which can accurately detect the human face(s) in color images in a real world environment.

Face detection technique takes image as an input and locate face region within the image. This is achieved by separating the facial region from non-face background region. Skin color has been used as an effective tool for skin detection (Zarit *et al*. 1999). A number of published researches are presented for detection of human skin and various skin modeling techniques (Zarit *et al*. 1999, Brand and Mason. 2000, Terrillon *et al.* 2000). Pixel based skin recognition (Albiol *et. al.*, 2001) uses RGB color space. Another model known as region based approach has also been used (Yang and Ahjuha. 1999, Kruppa *et al*. 2002, Gomes and Morales. 2002).

By far, the Viola-Jones (Viola and Jones. 2001) face detection technique is the most widely used technique for face detection in color images. In Viola-Jones technique, face detection is performed based on the extraction of facial features such as nose, eyes, lips etc. This technique has been able to detect faces in the entire However, the accurate extraction of these features is affected by a number of factors that include occlusion or invisibility of features, background complexity, camera quality, non-standard illumination, various poses and facial expressions. The complex 3-dimensional shape of one's face is another source of difficulty in face detection.

There is a need for a face detection approach that can be trusted to detect face(s) for a wide range of complex object shapes. Face detection using facial features is not enough and efficient in all such environments. The aim of this research is to improve the performance of Viola-Jones face detection technique in cases of the above mentioned variations. The hybrid approach is to incorporate the skin color information into the Viola-Jones face detection framework along with its typical features so as to make it independent of issues arising during complex situations. This merging strategy of Viola-Jones face detection approach and skin detection technique will be able to dodge environmental tricks and traps.

The rest of the paper is organized as follows. The next section describes the proposed hybrid face detection approach. Section 3 discusses the integration mechanism of the Viola-Jones and skin information. The results obtained from the experiments are presented in section 4, while section 5 concludes the findings of this research.

2. STEPS IN THE PROPOSED APPROACH

The hybrids face detection approach proposed in this work brings the Viola-Jones face detection technique and skin detection technique together. This merging of

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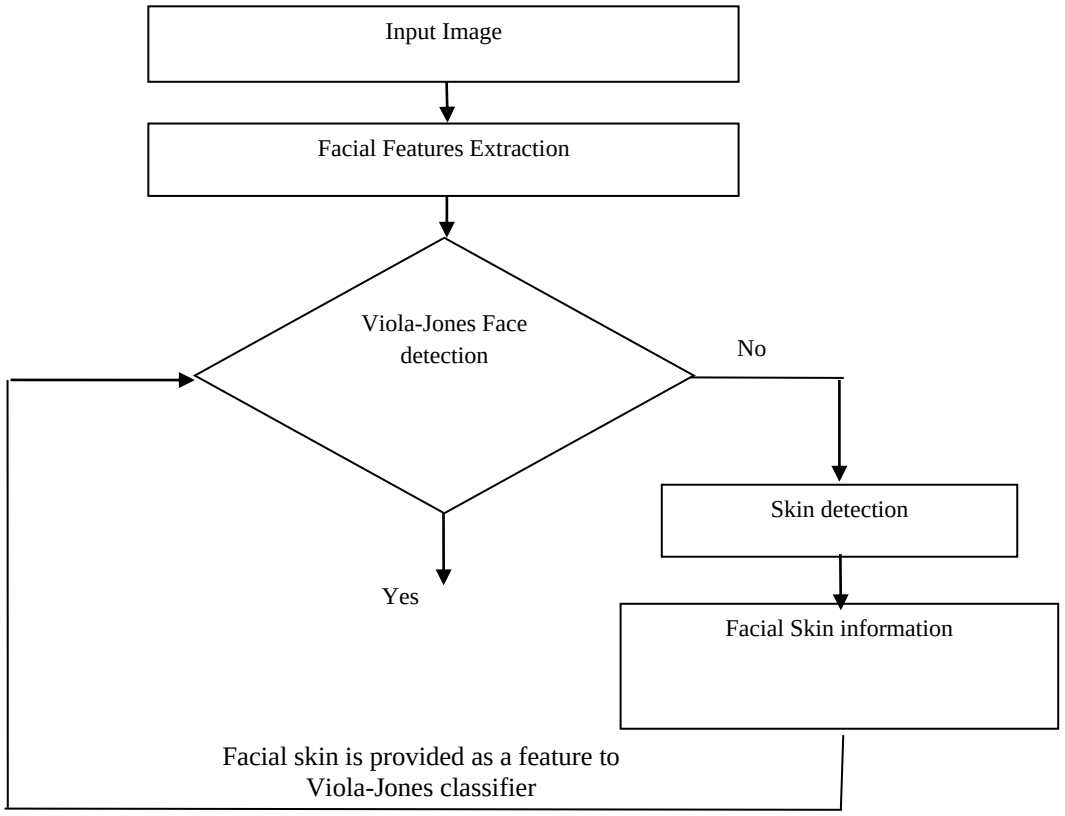

Fig. 1. The Hybrid approach

Viola-Jones face detection approach and skin detection technique will be able to dodge tricks and traps due to various facial variations. The working of the proposed technique is depicted in **(Fig. 1).**

Fig. 2. Results of Color segmentation

The query image is provided to the system as an input. All the prominent features from the input image are extracted and provided to the Viola-Jones classifier. Face is detected in the image based on these facial features and a rectangle is drawn around the facial region. However, if the relevant features from the face are missed or not extracted clearly the Viola-Jones classifier will not be able to give the desired results. In such conditions, the facial skin information will be provided to the Viola-Jones classifier as an additional feature. The various steps involved in the proposed hybrid system are discussed bellow in details.

Viola-Jones Face Detection:

Viola-Jones face detection algorithm presented in Jones and Viola. 2001, provides competitive detection rate. It is a real time face detection approach and is robust to a range a variations. The main goal is to distinguish between face and non-face by using facial features. The Voila-Jones technique mainly consists of four stages which include Haar features selection, creating an integral image, AdaBoost training and Cascading classifiers.

Skin Detection:

The first step in color based face detection is the suitable representation of the color image. This can be achieved by representing the image in one of the color representations such as RGB, YCbCr etc. In this work, the YCrCr space has been used due o its better results. In order to transform RGB color space to YCbCr color space,

$$77 \leq -0.148R - 0.291G + 0.439B + 128 \leq 127$$
$$133 \leq 0.439R - 0.368G - 0.071B \leq 177$$

YCbCr is an absolute color space providing useful clues about the color information. It is luma independent and thus gives comparatively better results. In the YCbCr color space, all the pixels having values in the ranges bellow are marked as skin pixels (Velho *et al*. 2009),

$$77 \leq Cb \leq 127$$
$$133 \leq Cr \leq 177$$

Skin region appears brighter as compare to the remaining parts of an image. By using the adaptive thresholding technique, all the face candidate regions are extracted. The more likely facial regions are then isolated by discarding the low likelihood regions. The results of segmentation process are shown in Figure 2.

Morphological Processing

Morphological operations are carried out to locate facial regions. These include erosion, closing, image dilation and image filling. Face detection based on human skin color has been a challenging task due to various issues occurring during skin detection. Lightening variations, background complexity, variations of human skin color depending on race and area and also different objects having identical color as skin are some serious issues which greatly affect the skin detection process. In this work a mathematical morphology (Velho *et al*. 2009) has been carried out to find the face like objects in the input image in order to save the computational time. By using the following equation the input image is eroded at first.

$$X \ominus B = \{(x, y) \in X : B(x, y) \subset X\}$$

Next to erosion, image dilation is carried out by using the following mathematical equation.

$$X \oplus B = \{ (x, y) \in R2 : B(x, y) \cap X \neq \emptyset\}$$

The resultant image obtained after the morphological processing is shown in Figures 04.

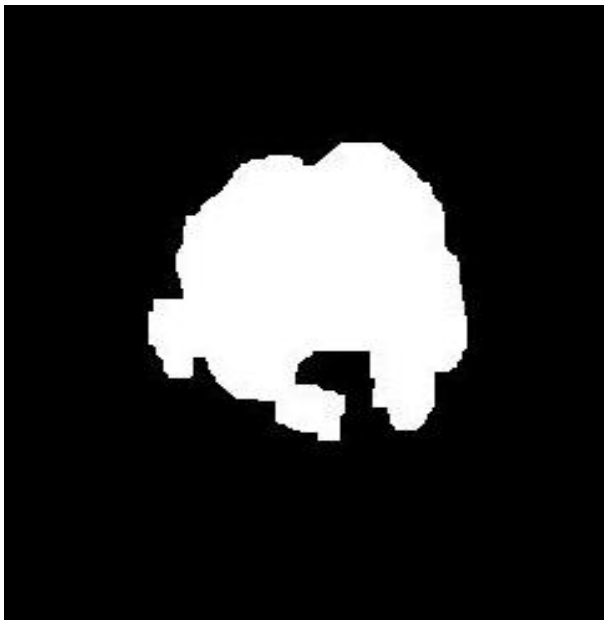

Fig. 3 Result of morphological processing

Connected Region Analysis and Region of Interest

Connected region analysis has been carried out to locate the face region of interest (ROI). In this process various candidate objects in the image have been analyzed. The objects include the components with skin content such as hands, legs and other body parts. The ROIs are selected based on object geometry and the remaining unwanted objects are discarded. The components with an area less than 300 pixels have been rejected. Similarly, narrow and tall objects are also discarded to isolate the interested region for the classifier to work with. In this way the facial skin has been isolated and is provided to the Viola-Jones face detector for face detection.

Fig. 1 Face detection Results using Viola-Jones and Hybrid approach

3. INTEGRATION STRATEGY

The hybrid face detection approach described above has been implemented using MATLAB. The input image is provided to the Viola-Jones face detector. A new image, called the integral image has been calculated. It allows the detector to compute the features quickly thus saving the computational time. During this process a small numbers of critical features have been selected and all the weak classifiers are combined in a cascade which discard the background quickly and compute the face like region for face detection which is the required output. But in case of invisibility of the typical facial features, the classifier generates the output showing no detection. In such scenarios facial skin information has been provided to the classifier.

Facial skin detection has been carried out in a separate module using MATLAB. This module generates the facial skin as discussed earlier and has been considered an important feature that is provided to the main classifier of Viola-Jones detection technique. Based on this prominent feature, face(s) have been detected that were considered as non-face by the Viola-Jones features based technique.

4. RESULTS AND ANALYSIS

The hybrid face detection approach has been tested on a collection of images including images with background complexity, zooming issues (distance of the target), non-standard illumination and many faces in a single image.

The results of the hybrid face detection approach are shown in Figure 4 where the blue rectangle represents the result of Viola-Jones face detection based on facial features extraction while the red rectangle represents the result of our hybrid face detection approach after incorporating skin information. In most of the collected images, the existing Viola-Jones technique based on facial features fails to detect face(s) while the hybrid approach accurately detect the entire face(s) in the input image. The simulation results shows that the hybrid approach overcomes the limitations of Viola-Jones detection technique. The hybrid face detection approach can easily cope with background complexity, Zooming issues (distance of the target), pose and expression variations and non-standard illuminations. In case of in images with many faces, it clearly outperforms the Viola-Jones detection.

5. CONCLUSION

In this paper a new hybrid approach for the detection of human faces in color images has been presented. The hybrid approach incorporates the skin color information into the Viola-Jones face detection framework along with its typical features. This merging strategy of Viola-Jones face detection approach and skin detection technique has been be able to overcome the environmental tricks and traps. The hybrid face detection approach is more robust having high detection rate compared to the existing Viola-Jones detection technique.

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