Article 8

3D Face Candidate Region Detection Using Background Subtraction

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Abstract
In this paper, we have explored 3D face candidate region detection using background subtraction. Our focus is to solve the first challenge in face registration, which is to detect and identify face region. From the experiment, it shows some promising results related to using background subtraction in face candidate region detection algorithm. Firstly, we have succeeded in generating an oval shape for boundary region detection. Secondly, our face candidate region detection rate in percentage using background subtraction is 72.5% higher compared when background subtraction is excluded, which achieved only 60% of success rate.

Keywords: 3D face recognition; feature extraction, image registration

Introduction

Human face for detection and recognition is an active research area in computer vision. Three main stages in implementing automatic face recognition system are; (i) face registration, (ii) face feature extraction, and (iii) face matching. Face registration can be defined as a mapping process of two interest point's position at same point location from two different images of same scene taken at different times, from different viewpoints, and/or by different sensors (Brown, 1992; Zitová & Flusser, 2003; Crum, Hartkens & Hill, 2004; Wyawahare, Patil & Abhyankar, 2009; Boughorbel, Mercimek, Koschan & Abidi, 2010).

Face registration is the most important and crucial stage as to achieve good performance in face recognition. Three main challenges in face registration are; first is to detect and identify face region. Second is to extract facial feature points from the face region detected. Third is to establish correspondence of facial feature points extracted from the face region. In this paper, our focus is to solve the first challenge in face registration, which is to detect and identify face region. Our objective for face detection is to prepare face candidate region. In doing so, we proposed to use background subtraction on skin colour as our face detection method.

Previous Work

Research on detecting and identifying face region demands a lot of time and effort. This has been justified by (Li, 2005), which has listed much of the works in face detection by summarizing the problems as shown in Figure 1, and methods to resolve it as shown in Table 1.

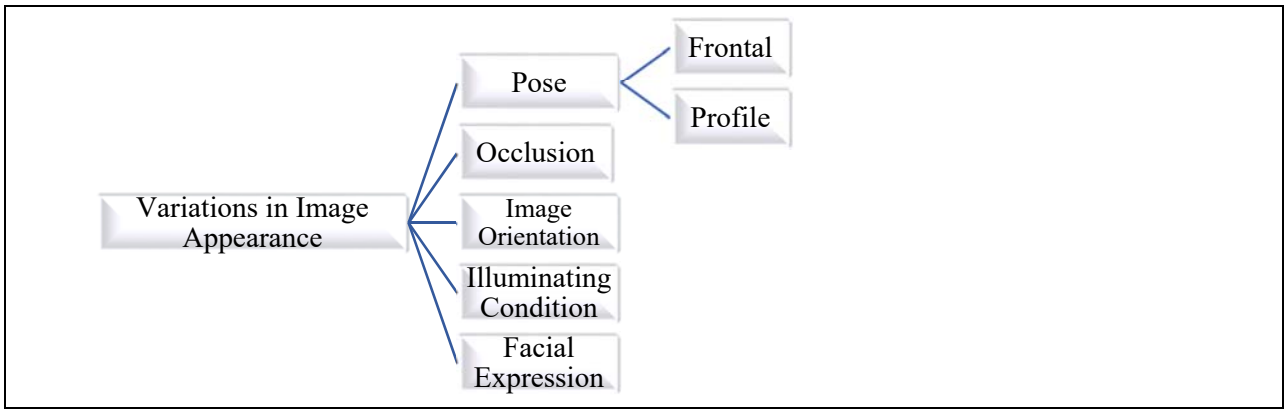


Figure 1: Problems in face detection caused from variations in image appearance (Li, 2005)

Table 1. Face Detection Methods

METHODS	**PURPOSES**
Template-matching methods	Used for face localization and detection by computing the correlation of an input image to a standard face pattern
Feature invariant approaches	Used for feature detection of eyes, mouth, ears, nose, etc
Appearance-based methods	Used for face detection with eigenface, neural network, and information theoretical approach

Other method that has been actively exercised in face detection is based on colour space detection. Several new approaches in face detection are lighting compensation (Hsu, Abdel-Mottaleb, & Jain, 2002), colour distance map (Abdullah-Al-Wadud, Shoyaib, & Chae, 2008), adaptive skin colour segmentation algorithm based on Gaussian Mixture Model (Hassanpour, Shahbahrami, & Wong, 2008), and combination of skin colour detection with background subtraction(Li, Suhr, Kim, Jung, & Kim, 2010).

Methods

In this paper, we are proposing to use background subtraction on skin color for face detection. Based from previous face detection algorithm in (Hsu et al., 2002; Li et al., 2010; Wei & Lee, 2010), we propose to implement face candidate region detection algorithm as shown in Figure 2.

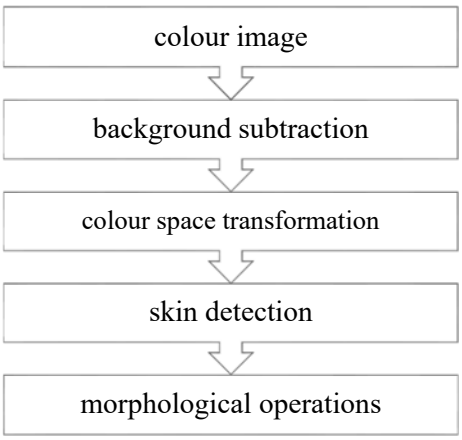


Figure 2: Face candidate region detection algorithm

Experiments

We performed portions of the research in this paper using the CASIA-3D FaceV1 collected by the Chinese Academy of Sciences' Institute of Automation (CASIA). In this experiment, we have select 10 individuals with eight models each. Most of the face models selected is frontal pose image. Facial expressions exist on each models are; neutral, smile, laugh, anger, surprise, and eye close. Illumination variation control is under office light. Figure 3 shows a sample of 3D face image from CASIA database.

Figure 3: CASIA 3D face image frontal view with neutral expression.

The 3D face image is taken from frontal views with some unnecessary regions such as shoulder, neck, and ears. Using face candidate region detection algorithm as in Figure 2, we run the experiment to obtain only the face candidate region. The first step in executing the algorithm is to read the colour image as input data. In second step, we extract the foreground and background image. The background image is subtracted from its colour image to produced image as in Figure 4.

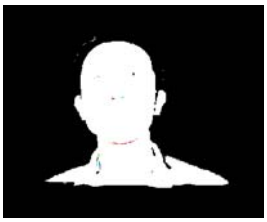


Figure 4: Background subtraction image

The third step in the algorithm is to transform the image colour space. We follow approaches by (Hsu et al., 2002) to execute this step. The result of the image is as shown in Figure 5.

Figure 5: Lighting compensation

The fourth step is to detect the skin colour image. The image is shown in Figure 6.

Figure 6: Skin detection

The fifth step in the algorithm is to implement the morphological operations. In this step, we have executed three morphological operations in sequences as follows: fill holes, erosion and dilation. The image outputs from the operations are as shown in Figure 7.

Filling Erosion Dilation

Figure 7: Morphological operations

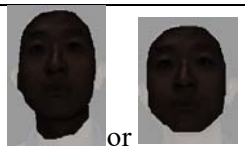
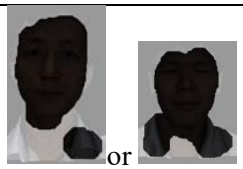
The output for face candidate region detection is as Figure 8.

Figure 8: Face candidate region detection

Results

We have gathered output from the above experiments for image analysing. Before we start analysing the output, we have made some categorization on successful and unsuccessful face candidate region detection. Four categories have been identified and listed as in Table 2.

Table 2. Categorization for Successful and Unsuccessful Face Candidate Region Detection

CATEGORY	IMAGE
Successful region candidate detected	
Successful with additional unwanted region/extension	
At least one feature point component is detected	
Unsuccessful region candidate detected	
	Zero region is detected

We also have prepared another face candidate region detection experiment using the same algorithm, excluding the background subtraction step. This other set of experiments is prepared for comparison purposes. Some output examples from both experiments for comparison are shown as in Figure 9 and Figure 10.

Figure 9: Face candidate region detection without background subtraction

Figure 10: Face candidate region detection using background subtraction

We have analysed the image based on two factors; specifically in region boundary detection and percentage of a successful detection. Comparing the face candidate region detection output in Figure 9 and Figure 10, we found that face candidate region detection using background subtraction have captured the face boundary more specifically. The almost oval like or ellipse-like shape boundary created while using background subtraction have given advantages for next level feature point extraction processing. Compared to the algorithm that are not using background subtraction, we have found that most of the neck area is still been detected. This unnecessarily and unwanted region might give uncorrected result during extracting facial feature point stages.

For measuring the success rate on face candidate region detection, we have followed Table 2 rule on categorization for successful and unsuccessful face candidate region detection and combined it with results as in Figure 9 and Figure 10. Based on the finding, we can measure the success rate

between both face candidate region detection using background subtraction and the excluded background subtraction as follows; the success rate for face candidate region detection using background subtraction is 72.5% and face candidate region detection without background subtraction is 60%.

Conclusion

In this paper, we have explored 3D face candidate region detection using background subtraction. Our focus is to solve the first challenge in face registration, which is about detecting and identifying face region. Results from the first challenge are then been used for the second challenge, which is to extract facial feature points from the face region detected.

Methodologically, we have designed an algorithm for background subtraction to be executed at the early steps of the algorithm. We have also created face candidate region detection without inserting background subtraction function. This other set of experiments is prepared for comparison purposes.
From image analysis, two factors on detecting specifics region boundary and percentage of a success rate have been identified. Based on those two factors, we found that face candidate region detection using background subtraction have given some promising results to be used for the next level of feature point extraction processing.

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