An Efficient Algorithm for Face Localization

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Abstract

Detecting and localizing a face in a single image is the most important part of almost all face recognition systems. Face localization aims to determine the image position of a face for verification purpose of documents such as passport, driving license, ID cards, etc. In this paper an entropy-based method is proposed for detecting the high information region of the image which may include eyes, mouth, nose, etc. The derived regions in this stage of recognition are sent to feature extraction and classification phase. The method has been tested on the ORL database. The results show the effectiveness and robustness of the proposed method for face detection and localization in presence of white additive Gaussian noise up to 25 dbw. We have achieved localization rate 99.75% for detection of faces in the ORL data set that we had which means 1 miss over 400 ORL faces.
Keyword: Image processing, Face localization, Recognition, Entropy.

I. Introduction

In recent years, face recognition has attracted much attention. Many research demonstrations and commercial applications have been developed from these efforts [1,2]. A first step of any face processing system is detecting the location of faces in images. This task however, is complicated because of orientation, scaling, rotation, illumination, etc. which are present in most images.
We have shown in this paper that entropy calculation of the image can determine the location of the face in the given image. As an example it can be viewed those areas of the face such as forehead, eyes, hair, mouth can be extracted through entropy calculation even in the presence of high level of noise from the overlapping stripes chosen in our image.
This paper is organized as follows: In Section 2, we give a review of techniques to detect faces in an image. In the next section the proposed strategy will be presented in details. Section 4 presents the numerical results on the selected database. Finally, results will be discussed in the section 5.

II. Detecting and Localizing Faces in a Single Image

The ultimate goal of the face localization is finding an object in an image whose shape resembles the shape of a face. Many algorithms have been proposed for face localization and detection, which are based on using shape [3, 4, 5], color information [6], motion [7]. These methods can be classified into four categories [1].

A. ***Knowledge-based methods***

These rule-based methods encode human knowledge of what constitutes a typical face. Usually, the rules capture the relationships between facial features. These methods are designed mainly for face localization.

B. ***Feature invariant approaches***

These algorithms aim to find structural features that exist even when the pose, viewpoint, or lighting conditions vary, and then use these to locate faces. These methods are designed mainly for face localization.

C. ***Template matching methods***

Several standard patterns of a face are stored to describe the face as a whole or the facial features separately. The correlations between an input image and the stored patterns are computed for detection. These methods have been used for both face localization and detection.

D. ***Appearance-based methods***

In contrast to template matching, the models (or templates) are learned from a set of training images, which should capture the representative variability of facial appearance. These learned models are then used for detection. These methods are designed mainly for face detection.

The proposed method is a new method in this area. This method uses information theory concept and will be capable to localize the high information region in the faces, i.e., eyes, nose and lips. In the following, the method will be discussed in details.

III. Proposed Face Localization Strategy

In this paper we will propose an entropy-based method for face localization. The entropy measurement yields a set of values based on the high and low level information corresponding to regions where the face is located. Implementation results show the effectiveness and robustness of proposed method in presence of noise. In the following, entropy theory and method of applying to faces will be presented in more details.

A. Entropy Theory

Given events $e_1,..,e_m$ occurring with probabilities $p_1,..,p_m$, the Shannon entropy is defined as [8]:

$$H = \sum_{i=1}^{m} p_i \log \frac{1}{p_i} = -\sum_{i=1}^{m} p_i \log p_i$$

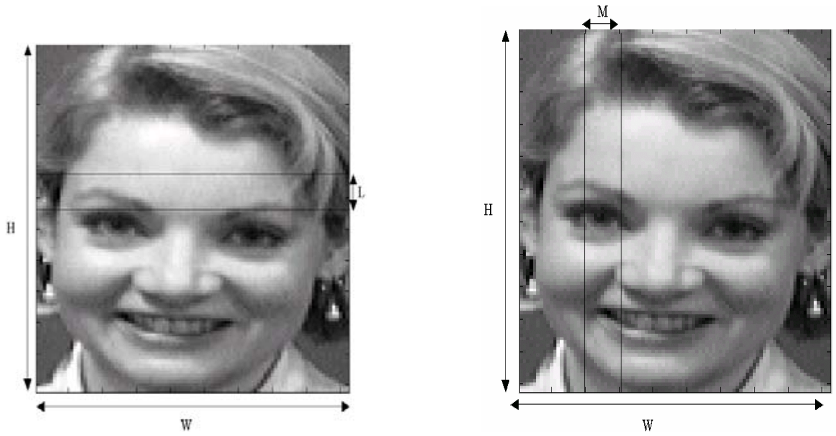
The Shannon entropy can also be computed for an image, where the probabilities of the gray level distributions are considered in the Shannon Entropy formula. A probability distribution of gray values can be estimated by counting the number of times each gray value occurs in the image and dividing those numbers by the total number of occurrences. An image consisting of a single intensity will have a low entropy value; it contains very little information.

A high entropy value will be yielded by an image, which has much different intensity. In this manner, the Shannon entropy is also a measure of dispersion of a probability distribution. A distribution with a single sharp peak corresponds to a low entropy value, whereas a dispersed distribution yields a high entropy value.

B. Applying Entropy to Faces

In face detection and recognition area we are interested in high information areas such as eyes, nose, mouth etc. These areas convey fundamental information needed for face recognition.

In this study, each face is scanned with vertical and horizontal stripes respectively. In vertical scan, image of height H and width W is divided into overlapping frames of height L and width W. The amount of overlap between consecutive frames is P (Fig.1-a). We repeat this for horizontal scan, where $H \times M$ frames are used (Fig.1-b).



(a) (b)

Fig.1. (a). $L \times W$ vertical scanning frames with P pixel overlap, and (b). $H \times M$ horizontal scanning frames with Q pixel overlap

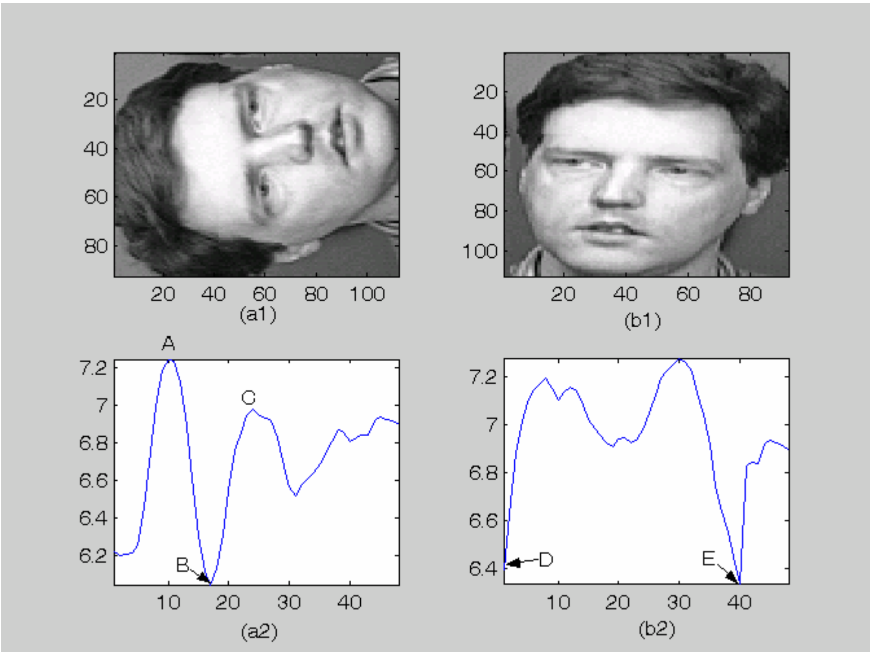


Fig.2. (a). Vertical scanning entropy with 2 pixel overlap, and (b). Horizontal scanning entropy with 2 pixel overlap

Calculating the entropy for each stripe yields a value, which corresponds to high or low level information in that region. The results of this process points to regions of importance for face localization when the entropy value is high or low which corresponds to eyes, nose, mouth, forehead, or hair respectively as shown in Fig. (2).

According to extracted entropy functions, 5 points are essential in face localization. These points are called as follows (fig.2); (1)Point A: assigned to hair area, (2)Point B: assigned to forehead area, (3)Point C: assigned to eyes area, (4)Point D: assigned to leftmost part of the face, (5)Point E: assigned to rightmost part of the face. Moreover, distance between points D and E, which is called Δ, is used as a measure of face size in the second stage.

C. Face Localization Procedure

Proposed algorithm has two stages. In the first stage, i.e. vertical scanning, search is started for finding the deepest valley on the vertical entropy function. This valley will determine the forehead area (point B). The peaks after and before entropy minima are related to hairs and eyes region respectively (points A and C). Then face is cut from forehead and sent to the next stage. In the second stage (horizontal scan), two side minimas (points D and E), which are related to the rightmost and leftmost part of face, are extracted. Then the face is cut from these two areas. The distance between these points, which called Δ, is used as a measure for the face width.

IV. Numerical Results

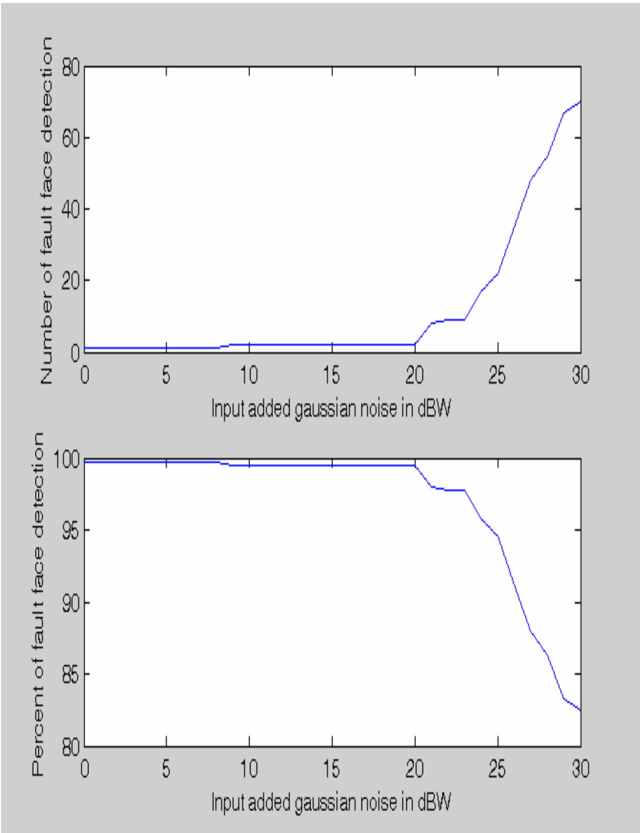


Fig.3.Face localization rate (a) number of miss-detected faces versus noise power, and (b) Face detection percent versus noise power

To check the performance of the proposed algorithm, experimental studies are carried out on the ORL database images of Cambridge University. The ORL database contains 400 face images from 40 individuals in different states. The total number of images for each person is 10. None of the 10 samples is identical to any other sample. They vary in position, rotation, scale and expression. The changes in orientation have been accomplished by rotating the person a maximum of 20 degree. For the same subject; each person has also changed his/her facial expression in each of 10 samples (open/close eye, smiling/not smiling). The changes in scale have been achieved by changing the distance between the person and the video camera. For some individuals, the images were taken at different times, varying facial details (glasses/no glasses). Each image was digitized and presented by a 112 × 92 pixel array whose gray levels ranged between 0 and 255.

The method is applied to ORL database and its noisy versions. In this way, white gaussian noise with power 0 to 40 dbw has been added to database. Proposed strategy is capable to localize faces in the ORL database. The best localization rate in the original ORL faces is 99.75%, which means 1 misdetected face over the 400 ORL faces. Fig.3 presents the localization rate versus added noise power. Fig.3-a shows the number of missed-localized faces versus noise power in dbw, and Fig.3-b shows the localization percent versus the noise power. As can be seen in Fig.3, the localization rate is no less than 94.5% in presence of 25 dbw additive white gaussian noise.

V. Conclusion

This paper described an efficient method for face localization. Entropy value has been used to find the high information regions in faces, i.e., eyes, nose and lips. The proposed method has been implemented and tested on the ORL database. The results indicate the high localization rate on the selected database even in presence of noise. Best localization rate is 99.75% or equally 1 miss localized image. We have also added the white gaussian noise up to 40 dbw. The results indicate 94.5% localization rate in presence of 25 dbw additive white noise.

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