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Real-Time Implementation of Face Detection and Tracking

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Abstract. Face detection is a major problem in the field of image processing, and especially the requirement for speed and reliability. In this paper, we present algorithms of face detection and tracking in a stream of video, which work in real time. The first stage is about face detection; it has based in detection the color of human skin. In this stage, we are going to locate the faces using tow techniques of localization: projection and labeling. The second stage is the tracking of the detected face in the following frames. The tracking operation is done using the algorithm of measurement of similarity SAD (the Sum of absolute differences).
Our contribution in this article concentrates in the ameliorations of the algorithms used. Other thing is the implementation of these algorithms on the TMS320DM6437 EVM DSP platform, and the optimization level of implementation so that the system is an autonomous system, worked in real-time.

Keywords. Face detection and tracking, Real time, Skin color, SAD, DSP TMS320 DM6437.

INTRODUCTION

The face detection consists in detecting a human face in an image. It has very many direct applications in video surveillance, biometrics, robotics, photographs, etc…
The face detection is a difficult subject, in particular due to the great variability of appearance of the faces under not forced conditions. The problems, which are associated with the detection of face, can be allotted to the following factors:
- intrinsic Variability of the human faces (neck them, size, form).
- presence or absence of particular characteristics (hair, moustache, bores, glasses…).
- facial Expressions modifying the geometry of the face (to smile, wink, wrinkling of the eyebrows, the yawn…).
- screening by other objects or other faces.
- orientation and poses (of face, of profile).
- illumination Conditions and the image's quality.

In the literature, there exist several methods to solve the problem of face detection. The method of Viola Jones (VJ) (Viola and Jones, 2010] is the most known method; it is used by several researchers.
The method of skin color is among the methods based on invariant characteristics (Aamer et al., 2008) by using the color of the human skin like an effective characteristic used by many researchers (Wu et al., 1996; Ming-Hsuan et al., 2002; Aamer et al., 2008).

FACE DETECTION BY THE SKIN COLOR

This method is among the methods based on invariable characteristics by using the color of the human skin like an effective characteristic used to detect areas contain faces.

Skin color detection

For this spot we carry out several tests on some spaces of color, and we choose YCbCr space because the brightness Y takes almost all the possible values ranging between 0 and 255, which shows well that brightness is not discriminating information to detect the skin, and the distribution in the plan (Cb, Cr) is concentrated enough (narrow) (Fig. 1). First, we make a classification the skin color by a thresholding:

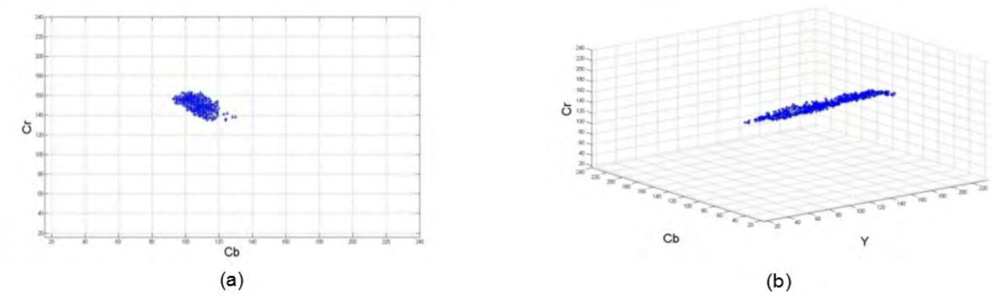
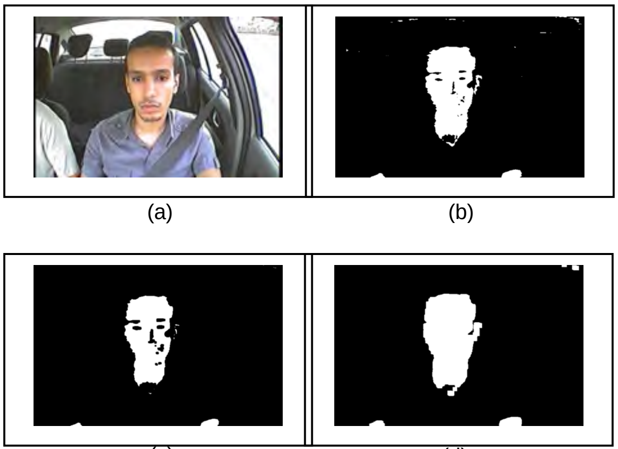


Fig 1. Skin color distribution in YCbCr space, (a) in the plan Cb, Cr, (b) in space 3D. YCbCr.

$$\begin{aligned} Cb_{min} \leq Cb < Cb_{max} \\ Cr_{min} \leq Cr < Cr_{max} \end{aligned} \quad (1)$$

We propose an optimized method for a faster classification. Instead of making four tests “if” on each pixel of the image, we propose a matrix SKIN of size 256 X 256 of which the coordinates and the X-coordinates are Cb and Cr respectively, this matrix filled with “1” for the pixels of skin and “0” of those not-skin.
For each pixels I (i,j) of image I, we take its values Cb and Cr. one assigns to the mask M the value of SKIN (Cb (I (I, J)), Cr (I (I, J))).



(a) (b)

(c) (d)

Fig 2. Morphological operations on the mask of skin color, (a) Image original, (b) Mask M of skin color detection, (c) Erosion, (d) Dilation.

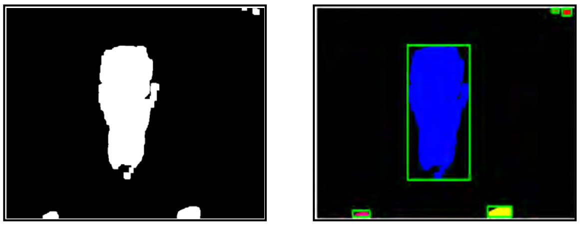
We improved the mask obtained by using the morphological operations: erosion to eliminate all small zones from non-significant skin color, and dilation to fill the perforated zones of skin color (Fig. 2).

Localization of face

In this section, we will locate the faces by the application of two different techniques: 1) Labeling, 2) Projection.

Localization by labeling

The technique of labeling consists in separating the areas in the mask obtained from detection (Fig. 3.a).We associate with each area an integer value (label) by using an 8-connected neighborhood. The figure 3.b shows the result of localization by labeling.

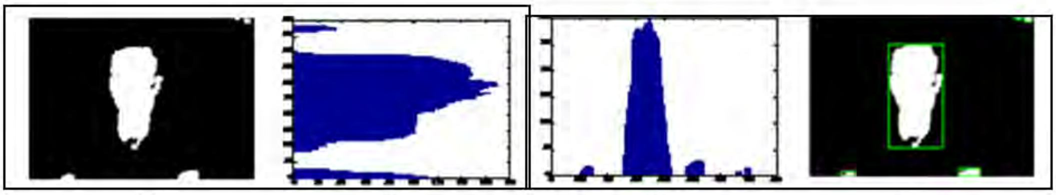


(a) (b)

Fig 3. Localization by labeling. (a) The mask M, (b) Localization of the candidates.

Localization by projection

The localization by projection will follow the following stages:



(a) (b) (c) (d)

Fig 4. Localization by Projection. (a) The mask M, (b) Horizontal projection, (c) Vertical Projection, (d) Localization of the candidates.

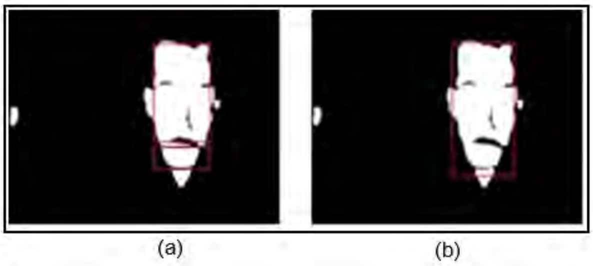


Fig 5. Effect of regrouping ~~of~~ the areas.

First, we determine the signals of projection P_v and P_h by vertical and horizontal projection in the mask M.

$$P_v(j) = \sum_{i=1}^{h_{image}} M(i,j)$$
$$P_h(i) = \sum_{j=1}^{l_{image}} M(i,j) \quad (2)$$

$$P(j) = \begin{cases} 1 \; si \; P(j) \geq \; threshold \\ 0 \; si \; P(j) < threshold \end{cases} \quad (3)$$

Then, we extract the areas located in the intersection from two projections that contain the pixels of skin. Figure 4 illustrates the result of localization by projection.
The areas, which are separated by a distance lower than a threshold (Fig. 5), we gather them in only one common area.

Verification

The objective principal of this stage is to check each area candidate if it is a face or not by respecting certain criteria that we proposed:
1) The size of the detected face must be limited; therefore, we remove the areas not-face by the elimination of areas, which are out the interval of size of face estimated according to the application.

Fig 6. Elimination of the neck area from the face. (a) Result before the operation, (b) Result after the operation.

Fig 7. Verification of the frontal position of the face. (a) Face is not accepted for tracking (not-frontal), (b) Face accepted for tracking (frontal).

$$\begin{matrix} h_{min} & \leq & h\_area & \leq & h_{max} \\ w_{min} & \leq & w\_area & \leq & w_{max} \end{matrix} \quad (4)$$

2) Each remaining area must observe the following conditions:

$$\boldsymbol{Threshold_{min} < Ratio1 \leq threshold_{max}}$$

$$\boldsymbol{Ratio1 = \frac{height\ of\ face}{width\ of\ face}} \qquad (\mathbf{5})$$

$$Ratio2 = \frac{S}{surface} \geq threshold \ (6)$$

Where S is the sum of the white points in the area, and surface = (height × width) of face.

3) After several test experimental, we noticed that the neck of the person is detected with the face if rapport1 is higher than a threshold, then we decided to eliminate 20% from the bottom of the face detected to eliminate the neck area (Fig. 6).

4) Verification of the frontal installation of the face: The face detected perhaps inclined or poses not frontal, which gives us a bad model to use it in the stage of tracking, therefore we must check the frontal installation of the face detected by adding a condition to say that the detected face is opposite or not. This condition is based on the presence of the ears in the mask resulting by skin detection, by using the logical OR exclusive operation tracking of a negation $\left(\overline{\mathrm{XOR}}\right)$ between the two areas of left and right side of the detected face. Figure 7 shows the effectiveness of this stage.

FACE TRACKING

The method of tracking described in this section is based on the block matching technique. The principal idea is to measure at a moment given 't', the difference between a model M predetermined of the stage in detection, and a possible position (zone of interest) of this model in image I at the moment 't+1'. For that, we use the algorithm of measurement of similarity SAD (the Sum of absolute differences):

$$\mathrm{SAD}(x, y) = \sum_{j=1}^{N} \sum_{i=1}^{M} | \, \mathrm{I}(x + i, y + j) - \mathrm{M}(i, j) \, | \ (7)$$

In the measurement the zero is the identical one, therefore the value minimal of SAD corresponds to the tracked face.

IMPLEMENTATION AND RESULTS

We implement this algorithm of detection and tracking of face on the TMS320DM6437 EVM DSP platform, we treat video sequences provides by a mini-camera (CCD) using the standard NTSC whose its video contains 30 frames per second; each frame has a dimension of 720 X 480 pixels.

We applied our system in a vehicle to three subjects as a first stage of a system for driver's somnolence detection in real-time based on the vision, and it is gave good performances (Fig. 8) in term of effectiveness and complexity in real-time with 20 to 25 frames by seconds.

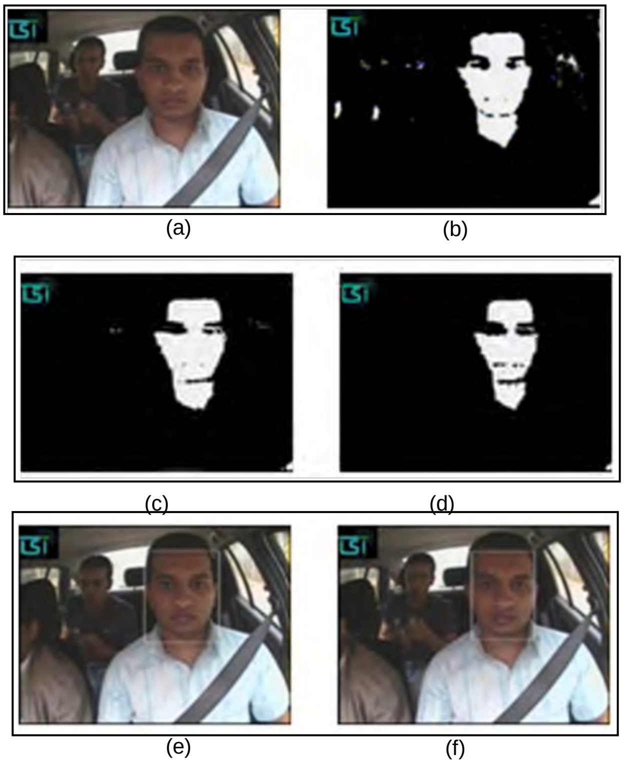


Fig 8. Detection of face per skin color; (a) Original image, (b) Skin color detection, (c) Erosion, (d)Dilation, (E) Localization by labeling, (F) Localization by projection.

CONCLUSION

We presented a system of face detection based on the skin color, thus the faces detected were tracked using the SAD algorithm.

The human skin color is detected by using the chrominance part from YCbCr space. The localization of face is made by two techniques; labeling and projection. Several conditions of verification must be respected to determine the faces in the image, thus the verification of frontal installation of the faces. The stage of tracking comes directly after detection by seeking the faces detected in the frames, which are followed.

The using of the DSP had advantage of being powerful in this type of the autonomous systems because of its effectiveness and its low costs and a reduced size.

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