AN ILLUMINATION INVARIANT FACE DETECTION BASED ON HUMAN SHAPE ANALYSIS AND SKIN COLOR INFORMATION

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ABSTRACT

This paper provides a novel approach towards face area localization through analyzing the shape characteristics of human body. The face region is extracted by determining the sharp increase in body pixels in the shoulder area from neck region. For ensuring face area skin color information is also analyzed. The experimental analysis shows that the proposed algorithm detects the face area effectively and it's performance is found to be quite satisfactory.

KEYWORDS

Color Space, Face detection, skin color information, sharp transition ,Threshold.

1. INTRODUCTION

Human face detection and localization is an inherent part of the areas like Human Computer Interface and Video Surveillance now a days. For tracing the human emotion and recognition of a face , face detection is to be done in priori. Several face recognition algorithm assumes that face area is readily available for processing. It is a challenging task to detect the face areas as the human faces change in presence of beard, moustache and mostly because of facial expression. The other external factors like scale, illumination conditions , contrast between face and background and orientation of face also enhances the challenge to a high degree.

Human face detection is an ongoing research topic, a lot of research is done on this area[1,3]. Hjelmas[2] pointed out some different techniques used in face detection which is mainly of two types and they are feature based and image based approaches. skin color, symmetry measure are some of the key techniques in feature based technique whereas the image based techniques focus on neural networks [7], machine learning techniques such as Support Vector Machines (SVM)[6]. The constrained generative model(CGM)[9] is a neural network based approach that is auto-associative, fully connected multilayer perceptron (MLP) with three large layers of weights, trained to perform nonlinear dimensionality reduction in order to build a generative model for faces. Multiview face detection was achieved by measuring the reconstruction errors of multiple CGMs, combined via a conditional mixture and an MLP gate network. Abramson and Steux [4] proposed to use the relative values of a set of control points as features. Such pixel-based feature can be computed even faster than the Haar-like features, however, their discrimination power is generally insufficient to build high performance detectors.

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The highly successful Viola-Jones face detector [5] contains three main ideas that make it possible to build a successful face detector that can run *in real time*: the integral image, classifier learning with AdaBoost, and the attentional cascade structure. The detector has grabbed the attention of several researchers for its efficient use. A face detection scheme based on a convolutional neural architecture was proposed in [8].Compared with traditional feature-based approaches, convolutional neural network derives problem-specific feature extractors from the training examples automatically, without making any assumptions about the features to extract or the areas of the face patterns to analyze.

In the present work shape based detection methodology together with skin color have been utilized to develop a face detection algorithm. The basic idea of shape based detection has been presented in section 2. Section 3 deals with the methodology of utilizing skin color features. The proposed algorithm together with the necessary techniques has been presented in section 4. A performance analysis of the proposed algorithm is presented in section5 and a few concluding remarks in section 6.

2. PRINCIPLES FOR SHAPE BASED FACE DETECTION

The various algorithms used for face area localization is using skin color information are severely influenced by illumination factor. In case of HSI model which is the most suitable for skin Color based face detection. HSI model incorporates three parameters namely hue, saturation and intensity. The intensity(value) factor is dependent on illumination level. Hence, the skin color based algorithms need the illumination to be good enough.

The proposed algorithm detects face by analyzing the geometrical configuration of human figure and provides a method for face detection which is illumination invariant in the sense that it uses preprocessing techniques to remove background and for detection of facial region it does not use skin color information rather it uses human shape information. Though for verification skin color information is used but the proposed architecture mainly focuses on human shape information. Human figure has a unique geometrical shape. The shoulder area is much more wider than the neck and face area in modern two dimensional image representation. This information is the key factor of the proposed algorithm. The proposed algorithm identifies the sharp increase in the shoulder region and then finds the chin area boundary by going some pixels upper .

The forehead region can be found by scanning horizontally from the leftmost top corner and getting the first face pixel from which a no of connected face pixel exceeds a particular threshold value(threshold1) which will be varying with the scale of the image.

The width can be found by scanning horizontally through the middle of the forehead and the chin region.

3. BACKGROUND OF FACE DETECTION USING SKIN COLOR

The algorithms that use skin color information prefer mostly the HSI color space. In this Color space hue, saturation and Intensity are three properties used to describe color. The HSI color model decouples the intensity component from the color-carrying information (hue, saturation) in a color image. For the HSI being modeled with cylindrical coordinates, refer to Figure 1. The hue (H) is represented as the angle 0, varying from 0^o to 360^o. Saturation(S) corresponds to the radius, varying from 0 to 1. Intensity (I) varies along the z axis with 0 being black and 1 being white. When S = 0, color is a gray value of intensity 1. When S = 1, color is on the boundary of top cone base. The greater the saturation, the farther the color is from white/gray/black (depending on the intensity). Adjusting the hue will vary the color from red at 0^o, through green at 120^o, blue at 240^o, and back to red at 360^o. When I = 0, the color is black and therefore H is undefined. When S = 0, the color is grayscale. H is also undefined in this case. By adjusting I, a color can be made darker or lighter. By maintaining S = 1 and adjusting I, shades of that color are created.

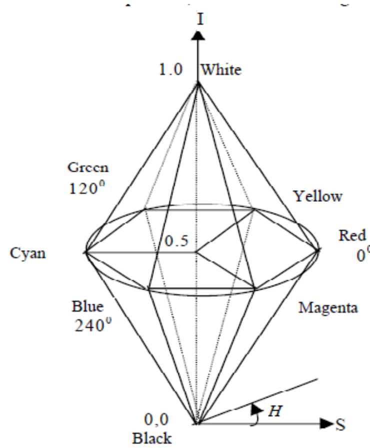

Figure 1 :Double Cone model of HSI Color Space

4. PROPOSED ALGORITHM

Input : RGB image of size N× N , scale S.

Data structures: Array- MEAN of size N

Output: Segmented face area

Begin

1. Preprocess and binarize the given image
2. **For** each horizontal scan line L_i from top-left location (x_0,y_0) **do Begin**

   If no. of connected face(white) pixels > $threshold_1$

   Then Y_1:= y_i and Goto step 3.

   Endif

   EndFor

3. Obtain SHAPE-GRAPH of the input image
4. **For** every y_i in Shape-Graph **do Begin**

Calculate the mean of human figure pixels for

Successive $y_i, y_{i+1}, y_{i+2}, \ldots\ldots y_{i+(20*S)-1}$.

Store the mean value in MEAN[i]

If (MEAN[i+1] – MEAN[i])>$threshold_2$

Then $Y_2 := y_i - 10*S$ and Goto step 5.

EndFor

5. $J := (Y_1+Y_2)/2$
6. **For** each pixel(x_i,y_i) along the horizontal scan-line L_j

   from left location (x_0, y_j)

   If from location (x_i,y_i) the no. of connected white

   Pixels exceeds $threshold_3$

   Then $X_1 := x_i$ and Goto step 7 .

   EndFor
7. **For** each pixel(x_i,y_i) along the horizontal scan-line L_j

   from right location (x_{N-1}, y_j)

   If from location (x_i,y_i) the no. of connected white

   Pixels exceeds $threshold_3$

   Then $X_2 := x_i$ and Goto step 8.

   EndFor
8. Segment the rectangle starting from location (X_1,Y_1) with Height:=$(Y_2 – Y_1)$ and

   Width := $(X_2 – X_1)$.
9. Check the segmented area by PROCESS-SKIN-COLOR procedure whether it is a face area or not.

End

In the above algorithm three thresholds are considered; $threshold_1$ is used to ensure forehead area detection which will vary with scale (S) of the image. And $threshold_2$ is used to identify the sharp transition in the SHAPE-GRAPH. I have taken a window of size (20*S) to compute the men of every successive 20*S pixels and then comparing the mean with the mean of it's previous and next window; $threshold_3$ is used to ensure that the skin area through a scan line is the face area.

4.1. Preprocessing

Before giving input to the proposed algorithm, the RGB images are needed to be preprocessed to make them suitable for the proposed algorithm .The morphological operations like opening and closing is done and then the background is separated ,all these operations are done in MATLAB 8.0.It is not a tough ask as most of the databases contain uniform background. Then the brightness of the image is adjusted. The enhanced image is then binarized such that the human body and face pixels become white and the other pixels become black.

4.2. Obtaining SHAPE-GRAPH

The Shape-Graph can be obtained by plotting the image pixels i.e. human figure pixels against the vertical Y-axis. The process of obtaining the Shape-Graph becomes easier once preprocessing is done in priori. It is observed that the Shape-Graph of human figures are similar . Some specimens are shown below:

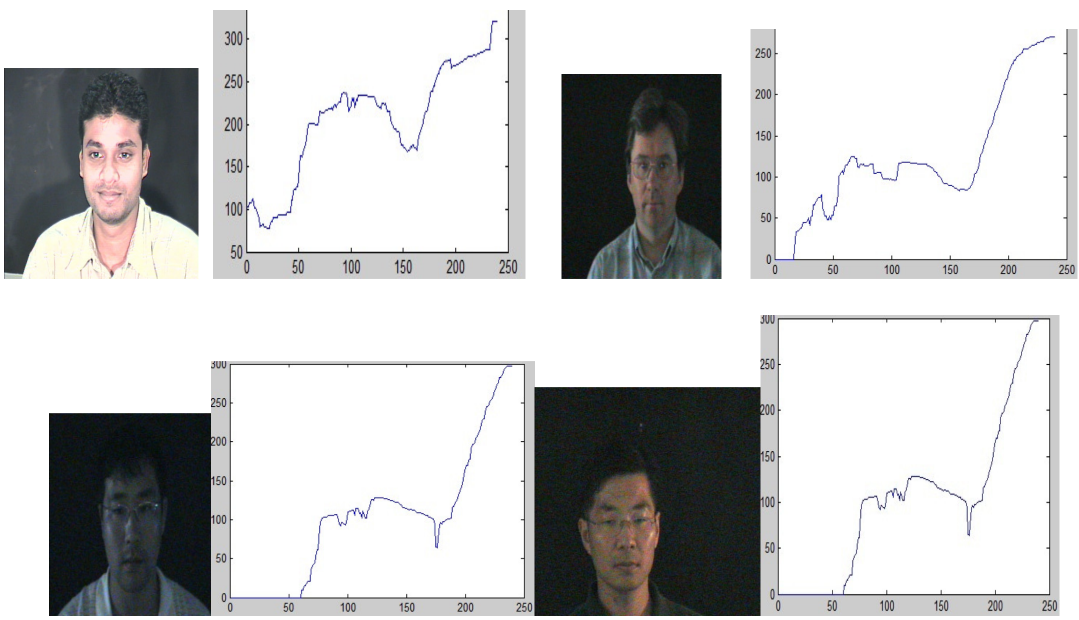

Figure 2: Some sample SHAPE-GRAPHs of test images

4.3. Identifying sharp Transition in SHAPE-GRAPH

The sharp increase in the neck region is fond from the Shape-Graph. For this I have taken a window of size 20 which is formed of successive 20 pixels and the mean of the window is taken and stored in MEAN. The elements of mean are calculated as follows:

$$MEAN[i] =(y_i,y_{i+1},y_{i+2},\ldots\ldots y_{i+(20*S)-1})/20 \text{ , } 0\leq i \leq N-1$$

In the following figure 3 the identified sharp transition in neck area is shown by the bold straight line.

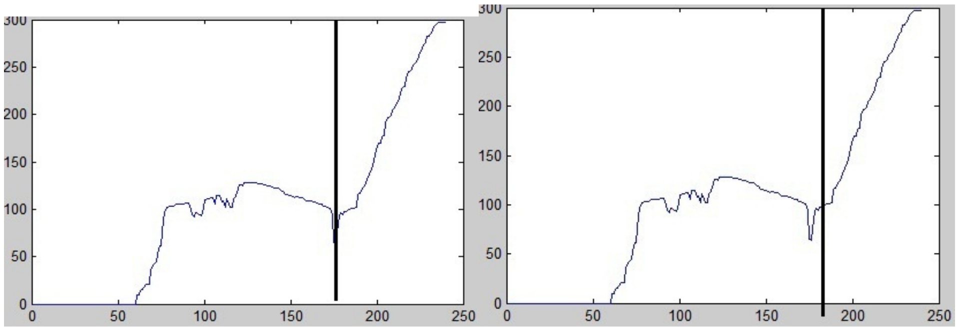

Figure 3: Identifying sharp transition in the neck region

4.4. Ensuring Face Area by PROCESS-SKIN-COLOR

After some experiments on test images it is observed that two parameters P1 and P2 have a deep impact on skin region segmentation. They can be found out from the H,S,V values of the HSI color image

$$P1= 0.148*H – 0.291*S +0.439*V$$

$$P2= 0.439*H-0.368*S-0.071*V$$

For all the pixels these two factors are calculated and a range is assumed which is determined on the basis of some experiment. If the parameters P1 and P2 and the hue(H) factor of HSI lies in the predefined ranges then the pixel is classified as a skin pixel.

$$12 \leq P1 \leq 37$$

$$12 \leq P2 \leq 67$$

$$0.01 \leq hue \leq 0.1$$

Then the ratio of height to width is checked, if the ratio falls within the following range [((1+√5)/2) - 0.65, ((1+√5)/2) + 0.65] which is also known as the golden ratio range, then the respective segment can be classified as a face region.

5. PERFORMANCE ANALYSIS

In this section the experimental results are presented. As the algorithm uses both the shape information and skin color information for segmenting face areas, images with all lightening conditions and different backgrounds are applied. Various parameters used in the implementation is given in table1

Table1: various parameters

parameters	Values
Scale(S)	With respect to a 50×50 image
$Threshold_1$	50*S
$Threshold_2$	4*S
$Threshold_3$	40*S

The algorithm is implemented in MATLAB 8.0 on a Core2Duo 1 GB RAM machine. For a 50×50 image. The test set contains people of different races. Some of the results are shown in figure 4. The accuracy of the proposed algorithm is 97.5%.

6.CONCLUSION AND FUTURE SCOPE

In this paper a novel idea is presented to identify and segment the face area from the RGB images. Experiments over large number of test images confirms the effectiveness of the proposed algorithm in efficiently segmenting the face area under dark and bright lightening conditions. And the accuracy is found to be 97.5%. In my future work I'll try to recognize the faces with this one as a module.

Figure 4: Sample results of proposed algorithm

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