Sindh Univ. Res. Jour. (Sci. Ser.) Vol.43 (1-A) 25-28 (2011)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Extraction of Face in Color Images in Complex Environments

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Abstract: Face recognition has remained a flourishing field of image processing for the last few years. The face recognition systems entirely depend upon the quality of extracted face image provided to the system. The paper presents a model, developed by combining statistical methods and different logical techniques, to extract the human face from an image. The model can extract face images in real world scenarios, such as, natural and complex backgrounds, outdoors and lightening conditions. The model has the capability to extract faces from multi face images. The results indicate that the system can perform considerably well in real world scenarios.

Keywords: Face Extraction; Statistical Method; Logical Techniques; Complex Environments

INTRODUCTION

The Image Processing is one of the most flourishing fields in the modern engineering (Choi, 2009). The most popular implementation of the image processing is in face recognition systems. With the increasing security problems and growing terrorist threats, the scientists and authorities are now encountered with the question of building cheep, effective, reliable and easy to use security and human recognition systems (Rowly, 1996). The image processing recognition systems seem to provide the answer. With the immense decrease in the prices of the computer technology, it has become easier to build cheap and effective face recognition systems for the security purposes using image processing techniques. The images of the face have a far greater effect on recognition system than other image recognition techniques.

One must have a reliable method to extract a human face from an image. The extraction process requires a lot of hard work as it is effected by a lot of factors. The recognition system is useless if the extraction phase is not efficient enough to provide quality data to the recognition system. Unfortunately very little concentration has been given to the extraction phase by the scientists and most of the stress was laid on the recognition phase. The main task is to provide quality results to the recognition system by simply mounting a camera on a road way or in the building. So face recognition systems will be able to recognize persons walking on the roads or inside a building without the knowledge and adjustment of the subject. The paper presents a model for face extraction which uses components of YC_bC_r color space, in combination with different statistical and logical techniques for face extraction.

TRAINING PHASE IN YC_BC_R COLOR SPACE

In the paper the YC_bC_r color space (Kaiser, 1996) has been used instead of RGB color space. The YC_bC_r color space was basically developed to cope with the transmission requirements of color and black and white televisions. The 'Y' component of the space is used by the black and white television after filtering out other two components. The 'C_b' and 'C_r' are the croma components which represents the pure color. The color televisions make use of these croma components along with 'Y' components to display color pictures. 'Y' component of YC_bC_r component contains majorly the lightening effects of the image (Poynton, 2002). The C_b and C_r component of the YC_bC_r component contains almost pure color information. Hence utilizing only C_b and C_r components of the YC_bC_r color space for the extraction of human face will reduce the lightening effects in the face images. In figure 1 the probability of appearing RGB color space components in the skin image is displayed, by using samples of 250 skin images of different sizes. Figure 2 shows the probability calculated of appearance of YC_bC_r color space component levels in the skin image.

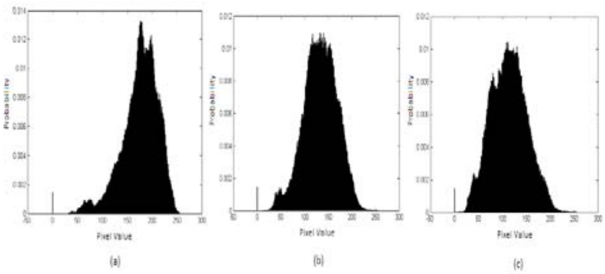

Fig. 1: (a) Probability of appearance of different pixel values in R component of RGB color space.(b) Probability of appearance of different pixel values in G component of RGB color space.(c) Probability of appearance of different pixel values in B component of RGB color space.

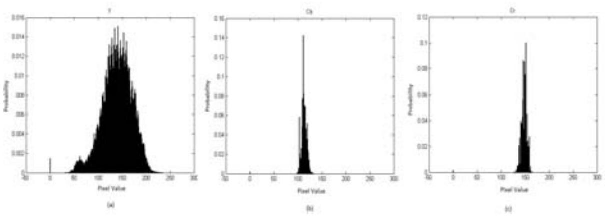

Fig. 2: (a) Probability of appearance of different pixel values in Y component of YC_bC_r color space.(b) Probability of appearance of different pixel values in Cb component of YC_bC_r color space.(c) Probability of appearance of different pixel values in Cr component of YC_bC_r color space.

From **(Fig. 1 and Fig. 2)**, it can be seen that the entire illuminant factor has converged in the 'Y' component of the YC_bC_r model. Here C_b and C_r components represent the pure colors i.e. croma-blue and croma-red components respectively. It can be seen that these components have converged in the graph due to the elimination of the illuminant factor **(Fig. 2a and Fig. 2b)**. The statistics thus obtained are then stored in the memory for future use, which will prove to be the backbone of the system.

MATERIAL AND METHOD

FACE EXTRACTION PHASE

The extraction phase of the human face from an image includes various steps which are discussed in the subsections. Flow diagram of the system is shown in **(Fig. 3)**.

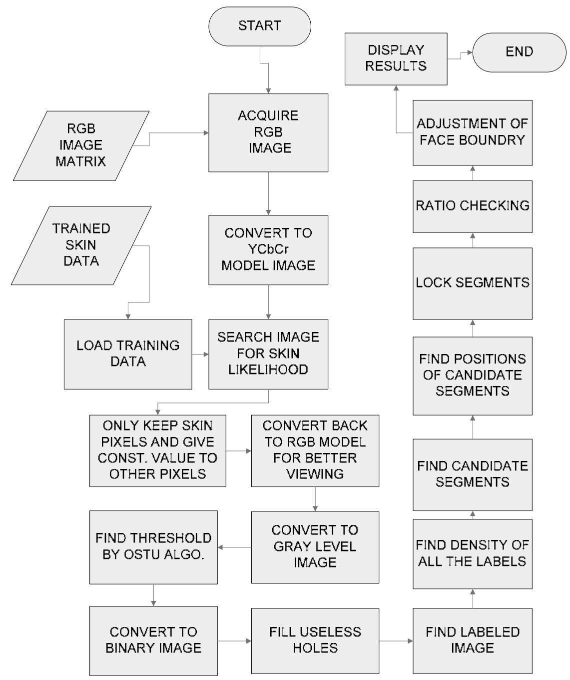

Fig. 3: Flow Diagram of the Model

A. *Acquiring RGB Image*

In the first step, the image of the subject is taken from the camera and loaded into the system. The camera usually acquires the image in RGB color format. The sample image in natural background is shown in **(Fig. 4a)**. In the initial stage any filter can be used to remove noise, shown in **(Fig.4b)**. We have used median filter in the model for this purpose.

B. *Conversion to YC_bC_r Color Model*

In this step the image acquired is converted from RGB color space to YC_bC_r color space using the following formulae.

$$Y = 0.2989 \times R + 0.5866 \times G + 0.1145 \times B$$
$$Cb = -0.1688 \times R - 0.3312 \times G + 0.5000 \times B$$
$$Cr = 0.5000 \times R - 0.4184 \times G - 0.0816 \times B$$

The image in YC_bC_r space is displayed in **(Fig. 4c)**.

C. *Loading Trained Data*

In this step the statistics obtained from the training phase is loaded into the system which were previously saved in the memory. This data will decide the quality of the performance of the overall extraction phase.

D. *Search Image for Skin Likelihood*

In this part a search is made on the overall image, pixel by pixel, for the likelihood of the skin on the basis of the preloaded statistics gathered from the training phase. A critical part in this step is to set a “Skin Threshold Value” which will determine whether the pixel encountered is a skin part or something else. The preloaded data contains the probability of a certain value of the pixel falling in the skin region. While searching, if the value of the pixel is above or equal to the threshold value, the pixel is marked as the pixel belonging to the skin region otherwise the pixel is considered to be the non-skin pixel and it is given a constant value(Figure 4(d)), preferably of white color i.e.

$$p_i \geq \text{Threshold then skin pixel}$$

$$p_i < \text{Threshold then non-skin pixel}$$

E. Convert to Gray Level Image

After searching for the skin likelihood, the image is converted to gray level image for further processing. Conversion to gray level is used here to facilitate further processing and thresholding. The result obtained from this step is shown if **(Fig. 4f)**.

F. Thresholding

The next step is to find the binary image from the gray level image after thresholding. There are many suggested techniques which can be used to obtain a binary image. In the paper, OTSU algorithm (Otsu, 1994) is used to obtain the binary image **(Fig. 4g)**.

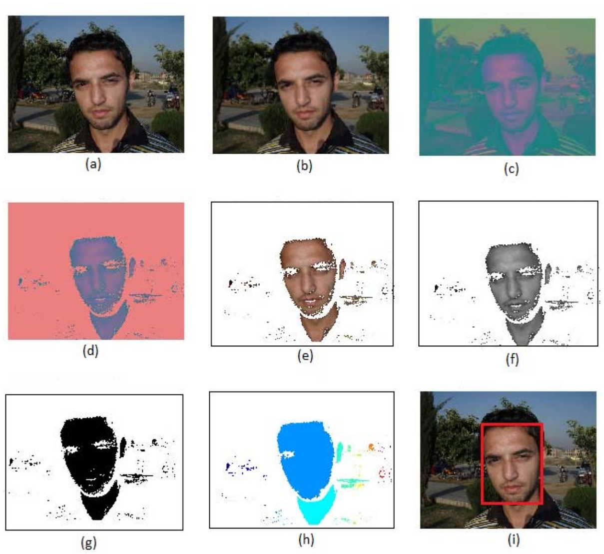

Fig. 4: (a) original image (b) image after noise removal (c) image in YC_bC_r color Space (d) Detected skin region in YC_bC_r color space (e) Detected skin region in RGB color space (f) Detected skin region in gray scale image. (g) Binarized skin image (h) Segmented skin image (i) Detected face image.

G. Filling Holes

In this step the holes present in the binarized image are filled, again to facilitate the further processing. Holes are defined as the patches of the closed region of the lighter pixels surrounded by the dark pixels. By doing this, patches within the skin regions which were, some way or the other, ignored by the system can be recovered.

H. Image Labeling

In this step labeled image is obtained. The system scans the whole image and groups its pixels into components which are based on the pixel connectivity. Once the components are found, they are assigned a value to identify them. The connected regions or components are then assigned arbitrary colors for better viewing and identification. The labeled image has been shown in **(Fig. 4h)**.

I. Density of Image Labels

Until this step, the system has found labeled image. Now the next task is to find the density of the each label. Number of pixels in each component is counted to find its density. These densities are stored in the memory, which will be used in the next steps to find out the exact face region and removing the noise.

J. Finding Candidate Segments

This is one of the most important steps in the process. The image obtained until this step has got a lot of noise. It includes many such segments which are just noise i.e. it does not belong to the skin region but has been mistakenly considered as skin region by the system due to its similarity with the skin color. These regions must be removed and only the major regions which are likely to be the human face must be found. In other words, the candidate segments for the face must be found. For this propose a “Candidate Threshold” is set which determines if the encountered segment is noise or the expected human face. If the density of the segment is above the Candidate Threshold, it is taken as a candidate to perform further checking and processing. Otherwise the segment is ignored i.e.:

$$\text{If } D_i \geq \text{Candidate Threshold then Candidate Segment}$$

$$\text{If } D_i < \text{Candidate Threshold then Ignore}$$

Where

D_i is the density of the arbitrary segment S_i.

K. Lock Segmants

After getting the max and min points of the segments, on x-axis and y-axis, the segments are locked into a square in the memory. At this step the system gets close to the required results but sometimes there can be an error, which can affect the results. So further checking must be done.

L. Raitio Checking

This is an extra step to remove any kind of error from the result. It is observed that in images the human faces are usually oriented vertically. It has been observed that the vertical to horizontal ratio of the human face is ideally 1(Nallaperumal, 2006). Therefore at this step, the ratio checking will be performed on all the candidate segments. For further precaution a range of the ratio can be set from 0.8 to 1.2. If the vertical to horizontal ratio of the candidate segment falls in this range the segment is considered to be a confirmed face. Otherwise the segment is ignored considering it as an arm or some other part of the body. This case is shown in **(Fig. 5)**.

(a)

(b)

Fig. 5: Example of ratio correction.(a) Image of candidate face regions containing non-face candidate. (b) Selection of correct face candidate after ratio correction.

M. Display Results

In this step, the face obtained is cropped or a red square is drawn around the face and displayed, to show the final result of the processing. Figure 4(i) shows the image obtained from this step. It can then be fed to other systems for use.

RESULTS AND DISCUSSION

The performance of the system was evaluated using 525 face images collected in natural backgrounds, natural lightening and indoors. The correct extraction rate of the system was estimated to be 95.6 %. The sample of the extracted faces is shown in **(Fig. 6)**.

Fig. 6: Sample of results obtained from the model.

CONCLUSION

The paper presented a method for extracting a human face from the images. The extracted face can be used in face recognition systems. The model used in the paper employs a combination of statistical and logical methods to extract the human face. The results show that the system can extract the human faces efficiently and can be employed in real world natural environments.

ACKNOWLEDGMENT

This is the extended version of our own paper presented and published as Conference proceedings in “International Conference on Computers and Emerging Technologies” (ICCET 2011) held on 22-23 April 2011 at Shah Abdul Latif University, Khairpur, Sindh Pakistan.

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