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Skin Detection Based on Color Model and Low Level Features Combined with Explicit Region and Parametric Approaches

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Abstract: -
Skin detection is active research area in the field of computer vision which can be applied in the application of face detection, eye detection, etc. These detection helps in various applications such as driver fatigue monitoring system, surveillance system etc. In Computer vision applications, the color model and representations of the human image in color model is one of major module to detect the skin pixels. The mainstream technology is based on the individual pixels and selection of the pixels to detect the skin part in the whole image. In this thesis implementation, we presents a novel technique for skin color detection incorporating with explicit region based and parametric based approach which gives the better efficiency and performances in terms of skin detection in human images. Color models and image quantization technique is used to extract the regions of the images and to represent the image in a particular color model such as RGB and HSV, and then the parametric based approach is applied by selecting the low level skin features are applied to extract the skin and non-skin pixels of the images. In the first step, our technique uses the state-of-the-art non-parametric approach which we call the template based technique or explicitly defined skin regions technique. Then the low level features of the human skin are being extracted such as edge, corner detection which is also known as parametric method. The experimental results depict the improvement in detection rate of the skin pixels by this novel approach. And in the end we discuss the experimental results to prove the algorithmic improvements.
Keywords: - Skin detection, Color Models, Machine Learning, Image Processing, Computer Vision.

I. INTRODUCTION

Skin detection is active research area in computer science which is highly focused by the researchers since the historical days of computers. It is a very popular and useful technique for detecting and tracking human body parts [14].Skin detection aim to select the skin regions in the human image which is helpful in many computer applications in the field of computer vision. Computer vision, pattern recognition, image processing are the computer domains which is directly linked with the skin detection [11]. Currently, skin detection technology is greatly used in the field of face detection, sensitive image detection, eye detection, eye state determination and many other fields [1]. Colors are relatively different between the face and skin-color background on the same image and on that fact skin segmentation is done [12].

Traditional Skin detection algorithms which are based on the variety of color models and which can clearly distinguish the skin and non-skin pixels in color model, however they are not so accurate to detect information that similar with the color information [2]. In this paper, we propose skin detection algorithm which combines the techniques Known as explicit region based selection and parametric based approaches [3].

Introduction of color space and skin detection:

Color space is also known as color model or also called color system and main purpose of it to illustrate the color in some standard which is acceptable in representation of the human image [4]. The color models mainly used in skin detection are RGB, YCbCr, HSV, and YIQ, etc.

RGB color space

RGB (Red, Green, Blue), this color model is the most commonly used color space. The Red, Green and Blue (RGB) model is based on physical interpretation of color [13]. But if we look at the scientific way, it is not majorly accepted by the researchers and majorly not adopted color model because it is difficult to adjust the details in digital. In this color model, the tonal, brightness and saturation are put together which is difficult to separate them. Thereby the Researchers mostly choose other color space which converse through the RGB color space after linear or nonlinear mostly.

YCbCr color space

This color model is widely adopted in many in color means in many video compressions coding, such as MPEG, JPEG, etc. YcbCr color space (or IQ, YUV color space) is derived from the transmission of color TV signal of the NTSC system. It separates the color into three components, namely brightness Y, blue chromaticity Cb, red chromaticity Cr. YcbCr color space is the linear conversion of RGB color space, and its transformation formula is as follows:
Ycbcr color space is the linear convolution of RGB color space, and its transformation formula is as follows:

$$\begin{bmatrix} Y \\ Cb \\ Cr \\ 1 \end{bmatrix} = \begin{bmatrix} 0.2990 & 0.5870 & 0.1140 & 0 \\ -0.1687 & -0.4187 & -0.0813 & 0.5 \\ 0.5000 & -0.4187 & -0.0813 & 0.5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \\ 1 \end{bmatrix}$$

HSV color space

HSV color space is come up for better digital processing color, and H is Hue, S is Saturation, V represents Value. It is the nonlinear transform of RGB color space. Hue defines the dominant color as defined by wavelength, Saturation is the measures of colorfulness area in proportion to the brightness on the area, value indicates the color luminance [15].

In terms of research, the skin detection technology is attracting the attention of many researchers and is becoming the important research area. In this paper, we adopt a method called color regional boundary fixed for skin detection. So-called color regional fixed method is to establish the color distribution which defined by several simple inequality in a color space through the experimental observation offline [5]. The greatest strength of this method is to realize simply and fast. At present, the most commonly used color spaces are RGB,YcbCr and HSV, etc. This paper selected a relatively optimal color space through experiment among these three color spaces [6].

During the history of the computer science, the computer vision is one of the active research areas which attract researchers from early days of computer history till now. Skin detection is one of primitive computer task which is used in different applications such as face detection. During past years, different skin detection methods are proposed. These methods can be divided into three main categories: explicitly defined skin regions, non-parametric methods and parametric methods as shown in figure 1.

In explicitly defined skin detection methods, a series of rules such as "If Red>100 and Green<150, then pixel with color RGB is skin" are created. If a skin pixel color matches one of these rules, it will be marked as skin pixel. The main advantage of these methods is their speed, while these methods usually have poor performance.

The other two categories are machine learning approaches. In these methods, the skin detection problem is defined as a learning problem and the skin detector is trained by a training set. The goal of these methods is usually to calculate p(skin|RGB), which is the probability that a pixel with color RGB be a skin pixel. After learning the p(skin|RGB), these values are used to create a skin probability map for image.

The structure of the remaining paper is: sections 2 discuss the proposed system design in detail and approaches implemented which is basically the hybrid approach for skin detection after the selection of skin regions. It discusses the proposed system design which includes the algorithmic development and flowchart of the implemented system. Section 3 discusses the experimental results in terms of detection of the developed skin classifier. And finally the conclusion and future of the research is being discussed in the end.

II Proposed Approach/Algorithm

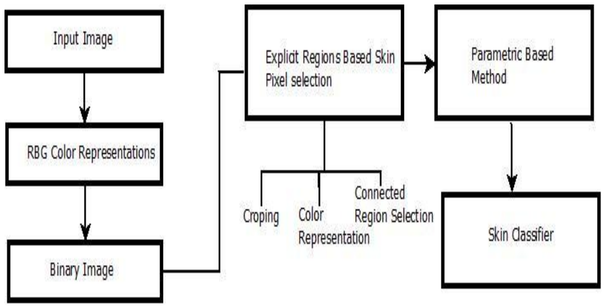

Figure 1: Building processes of proposed system

A. Detailed System Architecture:

Following are the major modules of the implemented system:

1. Image Input
   a. Image enhancement
   b. Crop the image to select skin regions
   c. Color representation

2. Skin Region selection
   a. Explicit Region Based Selection
   b. Croping and selection of connected components
   c. Color Thresolding

3. Feature Extraction
   a. Low level feature selection
      i. Corner Features

ii. Edge Feature
iii. Color feature

Novelty of the algorithm:

The implementation is completely relying on the color model as a representation of the human image and then applying the threshold based selection of region of the image and discard the other pixels lying in the representation of the image in that particular color model. The implementation approach combine both the techniques of the state-of-art template based in terms of representation of human image in color models and elimination of blurring effect in the image. Then the parametric based approach in terms of selection of low level features of the image such as edge detection, corner detection etc.

The proposed method discussed above is to combine the two methods known as explicit region based and template based methods in a systematic way to overcome the weaknesses of the individual methods and result that is more accurate than each of the individual methods. In the proposed method, firstly the skin region is selected based on the representation and conversion of human image in a color model.

The proposed scheme is implemented in MATLAB software which includes the development of code for template based matching of skin pixels. For the development skin classifier, we have used the Weka tool which is most popular tool in terms of feature optimization, data labeling and applying the classification algorithm on the selected data set. Weka machine learning classifiers works with numerical and categorical features. Before using weka with images, you need to extract features from your images. According to your needs, simple features like average, maximum, mean may be enough. Or you may need to use some other algorithms for your images.

Feature Selection: If the image is represented in RGB color space, then the feature selection will be accordance of RGB color as well.

Feature extraction algorithms.

- Edge detection
- Corner detection
- Blob detection
- Ridge detection
- Scale-invariant feature transform

The different low level features are:

- Gaussian blur
- Sobel filter.
- Hessian
- Difference of Gaussians
- Membrane projections: In every image
  - sum of the pixels
  - mean of the pixels
  - standard deviation of the pixels
  - median of the pixels
  - maximum of the pixels
  - minimum of the pixels in

- Mean Variance, Median, Minimum, and Maximum
- Anisotropic diffusion
- Bilateral filter
- Lipschitz filter
- Kuwahara filter: which is another noise-reduction filter that preserves edges?

- Gabor filter: at the moment this option may take some time and memory because it generates a very diverse range of Gabor filters .
- Derivatives filter: calculates high order derivatives of the input image (from the second to the 5th derivative) using FeatureJ [7].
- Laplacian filter: computes the Laplacian of the input image using FeatureJ. It uses smoothing scale $\sigma = 1, 2, 4...2^n$.
- Structure filter: calculates for all elements in the input image, the eigenvalues (smallest and largest) of the so-called structure tensor using FeatureJ[7]. It uses smoothing scale $\sigma = 1, 2, 4...2^n$ and integration scales 1 and 3.

When using grayscale images, the input image will be also included as a feature. In the case of color (RGB) images, the Hue, Saturation and Brightness will be as well part of the features.

Feature options

- Membrane thickness: expected value of the membrane thickness, 1 pixel by default. The more accurate, the more precise the filter will be.
- Membrane patch size: this represents the size NxN of the field of view for the membrane projection filters.
- Minimum sigma: minimum radius of the filters used to create the features. By default 1 pixel.
- Maximum sigma: maximum radius of the filters used to create the features. By default 16 pixels.

Algorithm and Flowchart:

Generic Steps of the algorithms:

1. Start
2. Input : Image
3. Convert Image into RGB Color Model
4. Image Pre-processing
5. Skin Segmentation in color model
    a. Removal of non-skin pixels of the image
    b. Removal of blurring effects
    c. Image enhancements
6. Binary Image conversion
7. For each pixels of the image :
    a. New Pixel : Pi
    b. If Pi match range of pixels
        i. It lies in regions of pixels of image.
        ii. Else Pi does not lie in the regions of images.
    c. Repeat for each image map in various color models.
8. Selection of Low level features
    a. Data Set Creation of Processed Image
        i. Edge detection
        ii. Corner Detection
        iii. Gaussian blur
        iv. Sobel filter.
        v. Hessian
        vi. Difference of Gaussians
9. Data Labelling
10. Building Classifier
11. Validation
12. End

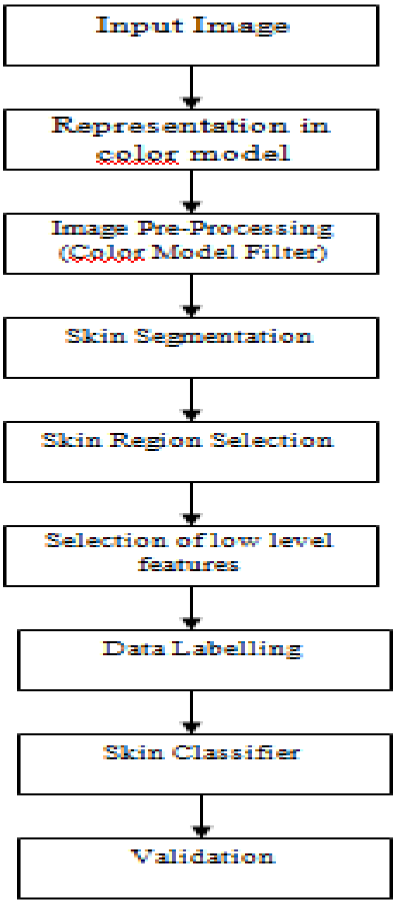

Figure 2: Flowchart

III Experimental Results and Outcome

1. Outcome of the template based Phase (outcome : human image with removal of blurring effect towards accurate and optimized low level feature selection)

See the following outcome of the skin images:

Figure 3: original Image

Figure 4: Black & white image with noise effect

Figure 5: RGB black & white image without noise effect

Figure 6: RGB color image after removal of noises

Here we discuss the experimental results and performances of Naïve Baye's Classifier models, after the removal of noise effect in human image, the low level feature selection for building of skin classifier is applied, we can say that the second approach for skin segmentation known as parametric based approach have been applied.

For the purpose of development of skin classifier which use these low level features as training data set, we have used a Weka which is a popular machine learning and data mining tool.

The performance of the proposed method is measured by the following two criterions: TP (true positive) and FP (false positive). TP is defined as the ratio of the number of the truth skin color image blocks identified to the total number of skin color image blocks. FP is defined as the ratio of the number of misclassified as skin color image blocks, to the total number of non-skin color image blocks. Comparison results between the proposed method and parametric based method alone (machine learning based) in the pixel domain which is conducted with the original image and with the image after applying the noise effect.

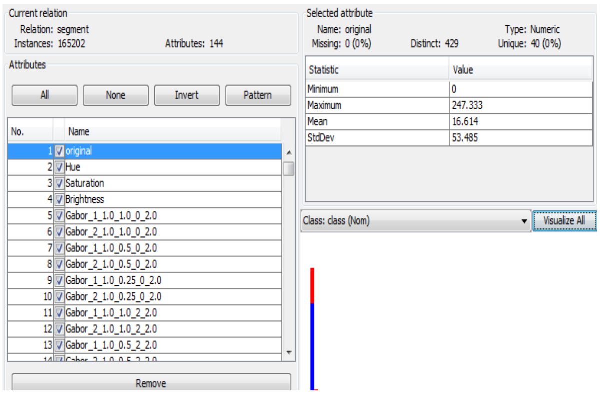

Figure 7: Loading data set in Weka

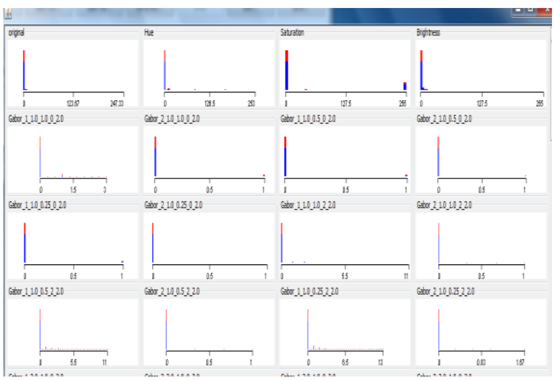

Figure 8: Visualization of all attributes

Performances/Detection measurements:

Here we test the trained classifier and discuss the results, in order to understand the results it is important to define some performance parameters which help to assess the gains and limitations of this work. Weka output returns various statistics and calculations as results to evaluate the models prediction accuracy and performance. These techniques not only indicate the performance of a classifier, but can also be used as the basis of comparison to other classifiers.

Performance Metrics:

- **Number of Correctly/Incorrectly classified instances** output displays the number of instances classified correctly and the number of instances those are not.
- **Accuracy** is the overall prediction accuracy which can be measured as:- **Accuracy = number of correctly classified instances ÷ Total number of instances**
- **Error rate** if the classifier predicts the class of an instance correctly, it is counted as a success if not it is an error. The error rate is the proportion of errors made over a whole set of instances which could be used to measure the overall performance of the classifier.
- **Confusion Matrix:** A single prediction can have four outcomes namely True Positives (TP), True Negative (TN), False Positive (FP) and False Negative (FN).TP and TN are correct classifications where class 'A' is predicted as 'A' and class 'B' is predicted as 'B' where as FP is when class 'A' is predicted as 'B' and FN is when class 'B' is predicted as 'A'. A confusion matrix is displayed as a table with a row and column for each class. The row denotes the actual value of a class would have a ROC curve pointing towards the top right, whereas the column denoted the predicted value of a class. Ideal results would have large numbers down the main diagonal and small or 0 on the off-diagonal.
- **True Positives (TP) and False Positive (FP) Rate** TP rate is TP divided by the total number of positives where as FP rate is FP divided by the total number of negatives. Ideally a good performing model would have a higher TP rate and a low FP rate.
- **Receiver Operating Characteristic (ROC) curve** The ROC curves plot the TP rate on the vertical axis against the FP rate on the horizontal axis to form bowl shape curve. The area under the ROC curve (AUC) denotes the classifiers performance. The bigger the area, the better the performance of the classifier therefore a well performing classifier would have a ROC curve pointing towards the top right.

Confusion Matrix:

a b ← classified as
117964 | a = skin-class
47238 | b= non skin-class

Table 1: Classification Rates

Correctly classified Instances	117964	71.4059 %
Incorrect Classified Instances	47238	28.5941 %

Table 2: Detection rates and comparison

Algorithm Used	Correctly Classified	Incorrectly Classified
Naïve-Bayes – with Template Based Method	70.4814 %	29.5186 %
Proposed Method- Naïve Bayes with combined Template based and Parametric Based	71.4059 %	28.5941 %

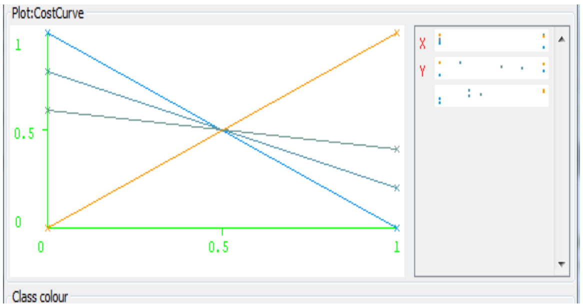

Figure 9: ROC curve of cost/benefit

As we can see that in the above experimental results, there is a significant improvement in detection rate after the removal of noise and other blurring effects in the human image which enhance the overall detection rates of the skin classifiers. Thereby we can say that if the image regions are already selected with the help of explicit regions of pixels and the pixels which are not related to the skins are discarded and then apply the parametric based approach on the human image generated after the template based approach, then the detection rate of the Bayesian classifier will be higher.

Figure 10: ROC curve of threshold

IV Conclusion and future work

In this research implementation, we discuss the novel hybrid approach for skin pixel detection and development of skin classifier based on the combination of techniques. The proposed research is novel in terms of detection rates which improve the accuracy of skin classifier if we apply the algorithm on the human images which is selected through the template based approach. Experimentally, we proved the significant increase in detection rates which is showing we can achieve the 71.4% detection rate if we apply the classification algorithm on the human image without the effect of noise, but there is a developmental module required through which the system can be completely automated. Presently, both the module are independent in which second phase known as parametric based phase is taking the inputs from the first phase known as explicit region based approach. Once the system is automated, we will plan to test it on a large data set through automated selection of low level features of the human image.

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