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Skin Color Segmentation based Face Detection Using Canny Edge Detection Method

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Abstract: Skin segmentation aims to locate skin regions in an input image. An algorithm for segmenting skin regions and non-skin regions in color images using color space and edge information has been used here for face detection. We propose a face detection method based upon the edge and skin tone information of the input color image. A pre-processing method uses color segmentation to achieve high performance in face detection. First, it consists of skin color information collection and segmentation. After skin color detection next step is to finding face among skin color detected region by using the golden ratio of face i.e. ratio of width and height of the human face. Here the first color image from input color space to RGB color space and then transferred into YCbCr and after this transformation, we have applied edge detection method to separate skin region and non-skin region. Here we have used two edge detection operators Canny and Sobel to find which operators detect better edges and we found that the performance of canny edge detection operator is much better than Sobel.

Keywords: Skin Segmentation, Canny Edge and Sobel Edge Detection, Color Model, the Golden Ratio of Face=1.5

I. INTRODUCTION

Edge detection is at the forefront of image processing for object detection. An edge is defined by a discontinuity in gray level values. In other words, an edge is a boundary between an object and the background. The shape of edges in images depends on many parameters, geometrical and optical properties of the object, the illumination conditions, and the noise level in the images. Edge detection has been a major concerning issue in image segmentation and for the researchers. The purpose of image segmentation is to partition an image into meaningful regions concerning a particular application where edges in digital images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create a major variation in the picture quality and image segmentation. It has been observed from the present study that the performance of the Canny edge detection operator is much better than Sobel.

A. *Canny Edge Detection*

Canny edge detection is called an "optimal" edge detector means, good detection i.e. should mark as many real edges in the image as possible and good localization i.e. edges marked should be as close as possible to the edge in the real image. This detector finds edges by looking for local maxima of the gradient of f(x, y). The gradient is calculated using the derivative of a Gaussian filter The method uses two thresholds to detect strong and weak edges and includes the weak edges in the output only if they are connected to strong edges.

The algorithm runs in 5 separate steps:

- *Smoothing*: Blurring of the image to remove noise.
- *Finding gradients*: Edges should be marked where gradients of the image have large magnitudes.
- *Non-maximum suppression*: Only local maxima should be marked as edges.
- *Double thresholding*: Potential edges are determined by thresholding.
- *Edge tracking by hysteresis*: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

B. *Sobel Edge Detection*

Sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3X3 neighborhood. The Sobel operator is based on convolving the image with a small, separable, and integer-valued filter.

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+1	+2	+1
0	0	0
-1	-2	-1

Gx

-1	0	+1
-2	0	+2
-1	0	+1

Gy

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

Approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \arctan(Gy/Gx)$$

Face detection applications have been developed to enhance human-computer interaction with new non-traditional interfaces. Here we focus on skin color. Color is the most significant feature which we can use to differentiate between face region and background region in the head-and-shoulders image of the human individuals.

C. *Skin Segmentation*

Skin segmentation aims to locate skin regions in an input image. It plays an important role in many computer vision tasks such as face detection, face tracking, hand segmentation for gesture analysis, and filtering of objectionable web images. Results of skin segmentation enable subsequent object detection to focus on reduced skin regions instead of the entire input image.

It is a very effective tool because skin regions can be located fast with a usually minimal amount of added computation. Here, we propose an algorithm that combines color and edge information to segment skin regions in color images. There are two methods of skin detection i.e. Pixel-Based Methods which classify each pixel as skin or non-skin individually, independently from its neighbors and Region-Based Methods try to take the spatial arrangement of skin pixels into account during the detection stage to enhance the performance of the methods. Pixel-wise color segmentation is not sufficient for skin detection purposes because pixels in the image background (i.e. Non-skin pixels) may also have skin colors and this leads to false detection. Another issue is that the true skin regions may be blended with the nearby skin-colored background, and this can have an effect on the subsequent processing of skin regions. That's the reason there is a clear need to reduce the number of false detections and to separate true skin regions from possible false detection.

The remainder of the paper is organized as follows: Section II describes Problem statement. The research methodology described in section III. The results and discussion of the research conducted are explained in section IV. Section V explains the conclusions and suggestions from research that has been done.

II. PROBLEM STATEMENT

Face detection is difficult mainly due to a large component of non-rigidity and textural differences among faces. The great challenge for the face detection problem is the large number of factors that govern the problem space The factors include the pose, orientation, facial expressions, facial sizes found in the image, luminance conditions, occlusion, structural components, gender, ethnicity of the subject, the scene and complexity of image's background. The scene in which the face is placed ranges from a simple uniform background to highly complex backgrounds. Faces appear different under different lighting conditions. Not only do different persons have different sized faces, faces closer to the camera appear larger than faces that are far away from the camera. Even facial proportions, angles, and contours vary with age, sex, and race so an exact ratio of width and height of the face is difficult.

Edge detection is necessary for face detection since it is used as an initial step in object recognition, image segmentation. It reduces significantly the amount of data, filter out useless information and preserves the important structural properties. Skin segmentation aims to detect human skin regions in an image, there are several issues for skin segmentation and detection such as:-

- Skin and Non-skin colors are not easily separable
- Illumination changes over time.
- Skin tones vary dramatically within and across individuals.
- Different cameras have different outputs for the identical image.
- Movement of objects cause blurring of colors.
- Ambient light, shadows change the apparent color of the image.

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Approach: The objective of this study is to find a face in an image by using edge and color based techniques. Skin detection is the process of finding skin-colored pixels and regions in an image which is used as a pre-processing step to finding regions that potentially have human faces. Skin detectors typically transform a given pixel into an appropriate color space and then use a skin classifier to label the pixel whether it is a skin or a non-skin pixel. An efficient method for skin color segmentation on color photos is implemented. Then the first color image from input color space to RGB color space and then transferred into YCBCR. After this transformation, we have applied the Canny edge detection method to separate the skin region and non-skin region.

III. METHODOLOGY

The edge detecting an image significantly reduces the amount of data and filters out useless information while preserving the important structural properties in an image. Here Canny and Sobel edge detection operators are used to finding edges.
Canny edge detector finds edges by looking for local maxima of the gradient of f(x, y). The gradient is calculated using the derivative of a Gaussian filter The method uses two thresholds to detect strong and weak edges and includes the weak edges in the output only if they are connected to strong edges.
Sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3X3 neighborhood. The Sobel operator is based on convolving the image with a small, separable, and integer-valued filter.
Comparative analyses of edge detection operators in image processing are presented. It has been observed from the present study that the performance of the Canny edge detection operator is much better than Sobel.
Skin segmentation approaches are based on skin color. Skin regions are detected by looking for pixels that have skin colors. Here we propose a skin segmentation algorithm that combines color and edge information to segment skin regions in color images. An efficient method for skin color segmentation on color photos is implemented then the first color image from input color space to RGB color space and then transferred into YCBCR. After this transformation, we have applied the edge detection method to separate the skin region and the non-skin region. After detection of the skin region, we have applied the Golden Ratio of the face i.e. 1.5 to detect the actual face in the image. Thus face is detected in an image.

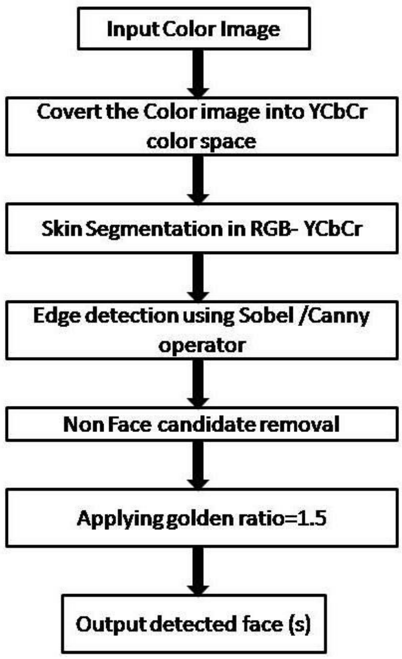

Fig 1: Block diagram of the face detection system

STEP 1: *Converting Color Image to Ycbcr*

- The YCbCr color space is commonly used in image processing as it separates the luminance, in Y component, form the chrominance described through Cb and Cr components.
- The luminance Y is constructed as a weighted sum of RGB components, and the Cb and Cr components are obtained by subtracting Y from respectively blue and red RGB components as:

$$Y=0.299R+0.587G+0.11B$$

$$Cb=B-Y$$
$$Cr=R-Y$$

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- The Cb and Cr components are used to characterize the skin color information. The formulae for converting from RGB to YCbCr are given below.

$$Y = 0.299R + 0.587G + 0.114B$$
$$Cb = -0.169R - 0.332G + 0.500B$$
$$Cr = 0.500R - 0.419G - 0.081B$$

STEP 2: *Skin Color Detection*
- Face detection is done through color-based identification. Firstly we have to resize an input image and then if needed we will perform some color balance operation for a better detection rate.
- Skin detection has been performed pixel-wise and used only the color information of individual pixels.
- Skin color thresholds θ are determined for each image region using edge-based region homogeneity measures.
- A low threshold *of* $\theta = 0.8$ is used.

STEP 3: *Binary Image Processing*
- Using the Cb and Cr thresholding, a resulting black and white "mask" is obtained.
- This mask is then refined through binary morphological operations to reduce the background contribution and remove holes within faces.
- The outputs of image segmentation using binary image processing are images that represent probable faces and nonfaces.

STEP 4: *Edge Detection*
- Apply edge detectors (Sobel and Canny) on the color channels of the input image to find edge pixels.
- The Canny method finds edges by looking for local maxima of the gradient of the image. The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges.
- Sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3X3 neighborhood. The Sobel operator is based on convolving the image with a small, separable, and integer-valued filter.
- We find that the Canny edge detector is suitable for detecting strong edges between homogenous regions whereas the Sobel edge detector is better at detecting non-homogenous blocks within a skin-colored region.

STEP 5: *Using Golden Ratio to Find the Face in the Image*
- Sum of columns in an image
- Get Dimension of a row to find height up to which we need to locate the face.
- Sum of columns for finding the width of the face.
- Using golden ratio 1.5 on the skin region to detect actual face
- Using imcrop function we can detect the required portion of the face.

IV. RESULT AND DISCUSSION

The methods are implemented on various images using canny and Sobel edge detection operators. We find that the Canny edge detector is suitable for detecting strong edges between homogenous regions whereas the Sobel edge detector is better at detecting non-homogenous blocks within a skin-colored region. The YCbCr space was chosen because bitmap images used the R-G-B planes directly to represent color images. But medical research proved that the human eye has different sensitivity to color and brightness. Thus there came about the transformation of RGB to YCbCr. The luminance component (Y) of YCbCr is independent of the color, so it can be adapted to solve the illumination variation problem and it is easy to program. The skin color cluster is more compact in YCbCr than in other color space and YCbCr has the smallest overlap between the skin and non-skin data under various illumination conditions Golden ratio 1.5 is applied on various image and we found that it finds the actual face in the image.

The input images are obtained from the Internet. Using the YCbCr color space as on RGB the accuracy is found to be 92.0% which is far better than results from RGB color space. Quality of input image though if not also very good but our skin model has detected all skin regions with little deviation concerning an expected result. The experiment result also shows that as there is no false positive and no false-negative in so the detection rate is near to 100%.

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Outputs of Skin Based and Face Detection:-

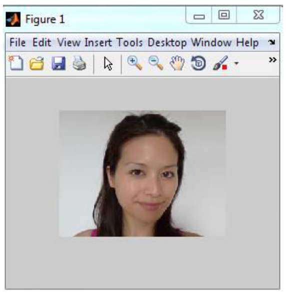

Fig. 2 Input image of a lady

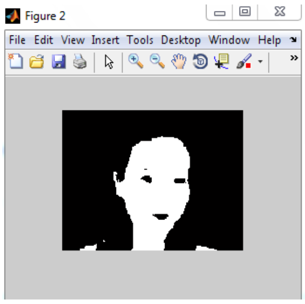

Fig.3 image using YCbCr color model

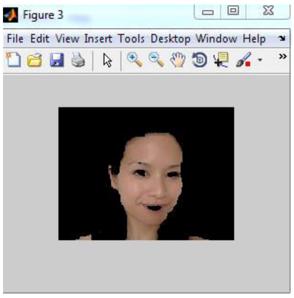

Fig. 4 Skin is detected in image (ø=0.8)

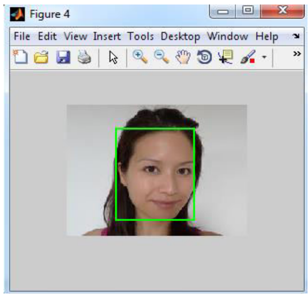

Fig. 5 Face detected using golden ratio=1.5

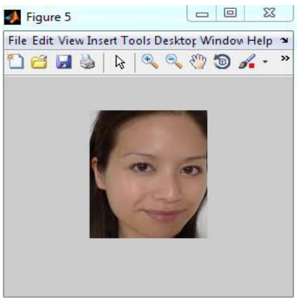

Fig. 6 Actual face detected in an image

Edge Detection Operators Output Comparison

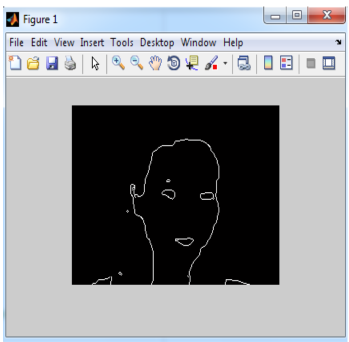

Fig. 7 Sobel edge detector output

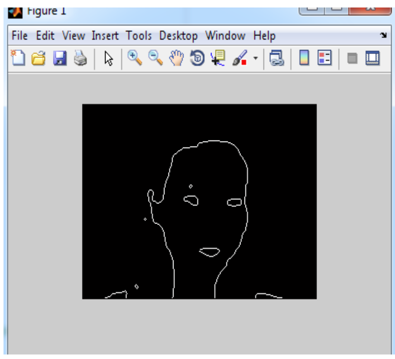

Fig. 8 Canny edge detector output

V. CONCLUSION

In this paper, we proposed a segmentation algorithm for face detection in colour images with skin tone regions using Canny Edge operator and Sobel operator. To apply canny edge and Sobel edge detection algorithm to YCbCr color space providing the better result to segment input image as compare to previous research methodology. The proposed segmentation procedure is found to reduce the search space for the face detection. Using the golden ratio we have found maximum faces are detected appropriately. Using the YCbCr color space as on RGB the accuracy is found to be 92.0% which is far better than results from RGB color space.

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