FACE DETECTION USING SKIN COLOR MODEL SEGMENTATION

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ABSTRACT

Face detection is used in a variety of applications that identifies human faces in digital images. It plays a very important role in various biometric applications, photography and security application. Thus we plan to implement a novel algorithm for face detection using multi-color space based skin segmentation and region properties. First, skin regions are segmented from an image using a combination of RGB and YCbCr color models with the help of thresholding concept. Then, facial features are used to locate the human face based on knowledge of geometrical properties of human face by testing each segmented skin region. Our implemented algorithm works well in both single and multiple faces images. This technique also takes into account the variation in background, lighting variations, different human facial expressions, and different sized images. The results are quite good in the case of single as well as multiple faces images with the same thresholds.

***Index Terms*—** Face detection, skin segmentation, RGB, YCbCr

1. INTRODUCTION

In recent years, face detection has become a popular area of research among engineers and researchers. Faces contain one of the most important aspect of human visual system. Face detection has wide areas of application like in tracking, photography, target recognition and areas where security is an important concern. Face detection technique is used to identify human faces in an image. Our implementation works well in all kind of images, whether single face or multiple faces with noisy background. There are many techniques to extract facial features from images but skin color based is most popular because of advantages associated with it. Skin color based techniques are simple, easy to process color information, much faster than other techniques and robust. So, we have proposed and implemented a skin color segmentation based approach to identity human faces in images. Skin color is a very effective feature of a human face which does not depend on facial expressions and orientations. Skin color based technique is not as simple as it looks like because skin colors vary with luminance and brightness component of a pixel. So, we have also implemented the technique for lightning compensation before image segmentation. There are different skin color segmentation models like RGB, HSV, YCgCr, YCbCr and YUV proposed over the years. Each model has its advantages depending on the context so it is extremely important to choose most effective model to improve performance in a particular situation. In our implementation we have used the RGB and YCbCr model and result associated with it is quite good.

2. SKIN COLOR MODELS AND THRESHOLDS

In order to eliminate dependency of skin color on luminance and brightness components we have used different skin color models. In this algorithm we used colo*r spaces namely YCbCr and RGB.

2.1. RGB color space

The RGB color model is very simple to use and understand. This color model is an additive colour in which red, green and blue light are added together in various ways to reproduce a broad array of colours. This model bears closest resemblance to how we perceive color. The main purpose of the RGB color model is for the sensing, representation and display of images in electronic systems, such as televisions and computers. This color model has been used extensively in conventional photography. Before the electronic age, the RGB color model was extensively used and already had a solid background based on our perception of colors. We have used RGB color model to threshold the image obtained after light compensation.

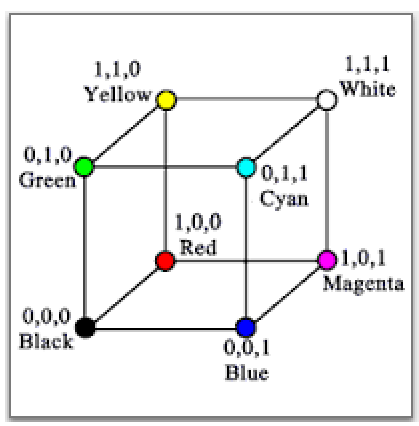

Figure 1: RGB color space [Source: Internet]

2.2. YCbCr color space

The YCbCr color space is widely used for digital video. In this format, luminance information is stored as a single component (Y), and chrominance information is stored as two color-difference components (Cb and Cr). Cb represents the difference between the blue component and a reference value. Cr represents the difference between the red component and a reference value.

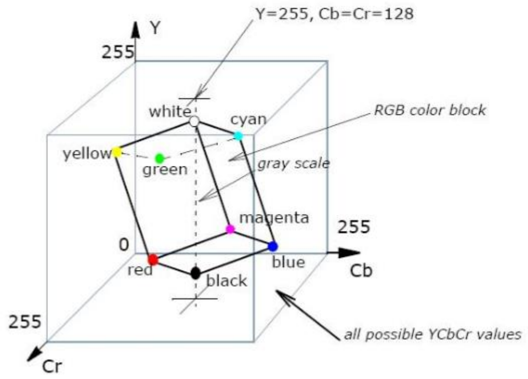

Figure 2:YCbCr color model [Source: Wikipedia]

2.3. Threshold conditions for skin color detection

We segmented the image into facial and non-facial regions using skin model. According to the skin model [1], the pixel values which satisfies the below restrictions are classified as skin pixel and given the value 1 during implementation. The conditions for skin pixel are as follows:-

RGB color space

$$R > 95 \text{ and } G > 40 \text{ and } B > 20 \text{ and } (\max\{R,G,B\} - \min\{R,G,B\}) > 15 \text{ and } R-G > 15 \text{ and } R > G \text{ and } R > B \quad (1)$$

YCbCr color space

$$75 < Cg < 250 \text{ and } 10 < Cr < 100 \text{ and } Y > 80 \quad (2)$$

3. PROPOSED ALGORITHM

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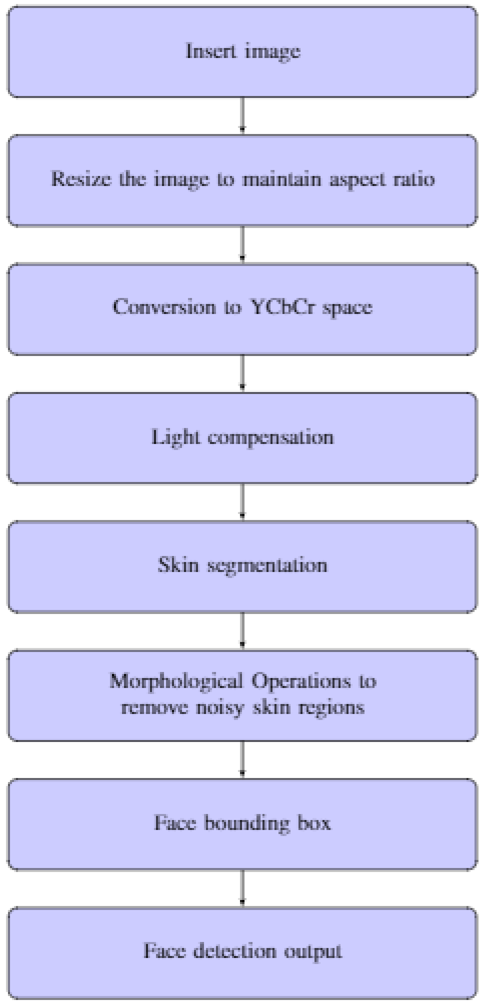


Figure 3: Algorithm Flowchart

4. IMPLEMENTATION STEPS

We have implemented the following steps.

4.1. Image acquisition and pre-processing

We have used the FERET database[4], which is publicly avail-able to execute our proposed algorithm. Then, we resized the image so that aspect ratio of the image is maintained. The height of every image is set to 500 pixels and the width is changed according to the height/width ratio in the original image. This is an important step because it ensures that the face doesn't get distorted.

4.2. Lighting Compensation

Then we converted the RGB image into YCbCr image using '*rgb2ycbcr*' matlab function. This Y component is used for normalizing the RGB components of the image. The normalization is done in such a way that the Red and Green component of the image gets enhanced for smaller Y component in the image and vice-versa.

4.3. Skin Extraction

Then we extracted skin color regions using above mentioned thresholding conditions on RGB image. In the segmented image, any pixel of the input image which satisfies the above mentioned conditions will be assigned the value 1(skin pixel), otherwise the value 0(non-skin pixel). We had also tried experimenting the thresholding conditions in other color spaces as mentioned in some of the papers but the results were not satisfactory enough.

4.4. Morphological Operations

The image thus obtained after skin segmentation is very noisy. To remove the noise we eroded it using 3*3 structural element. Thus the small noisy areas which were earlier wrongly classified as 1 now got removed.

4.5. Edge Detection

We apply sobel edge detector in the original image which detects all the edges including the human face. After this we take the logical AND between the skins segmented image and the complement of edge detector output. This essentially removes the non-face skin region that may be connected to the face in the skin segmented image.

4.6. Removing some black and white regions

Face also contains regions of eyes and eyebrows which will not get detected in the skin region segmentation. We remove all black regions having area lesser than 500. Hence, the output segmented image after this step doesn't contain any black discontinuities in the face region. This fixed threshold was chosen by tuning and it works for the multi face images as well as single faces mainly because of the fact that images are resized maintaining their aspect ratio. Also, we remove all the white regions with area lesser than 500 which removes the noisy non face regions that could not be completely removed by erosion in the previous step.

4.7. Face bounding box

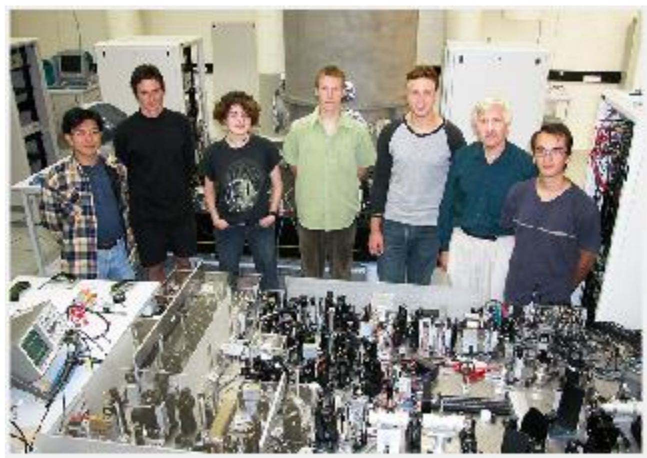
There is still a possibility that the regions detected may be non-face like hands or legs. Thus we use *regionprops* function of matlab to measure properties of all the regions detected and eliminate regions with eccentricity lesser than 0.9. We also discarded regions using the fact that human face has height to width ratio usually in 0.8-2 range. This works also because we have ensured that the image doesn't get distorted in the resizing step.

5. EXPERIMENT AND RESULTS

We took an image from FERET database[4] containing multiple faces and clutter in background. The image and the output after implementation is shown below.

5.1. Image Resize

The image shown below is obtained after resizing the original image.



5.2. YCbCr color space

The image shown below is obtained after converting the resized image in YCbCr color space.

5.3. Lightning compensation

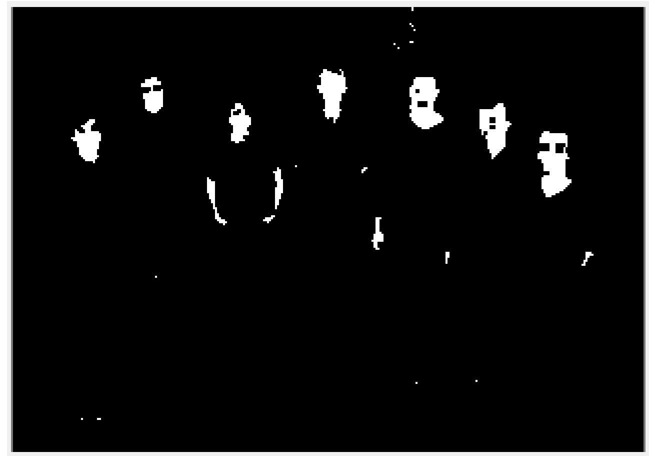
After resizing the image, we did the light compensation on it. Although, the effect is not very clear in this image as lightning compensation was not needed in the original image but, in some cases it improved the final output. The image after lightning compensation is shown below.

5.4. Skin Region Extraction

After the last step, we applied the threshold on the RGB values and got the segmented image as shown below. We can clearly see that, non-face regions were also segmented as facial regions after this step. So, we removed the noisy points by erosion and putting the restrictions on area.

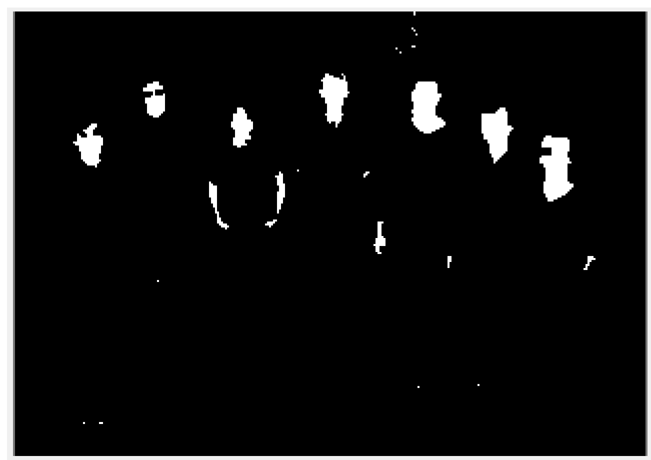
5.5. Erosion on segmented image

Once we got the segmented image, we eroded the image using (3*3) structuring element. It removed many noisy points, but some points were still there. The image obtained after erosion is shown below.



5.6. Removing some black regions

The image obtained after removing black region having area less than 500 is shown below. We can see that it removed the black regions associated with eye and some other facial parts.

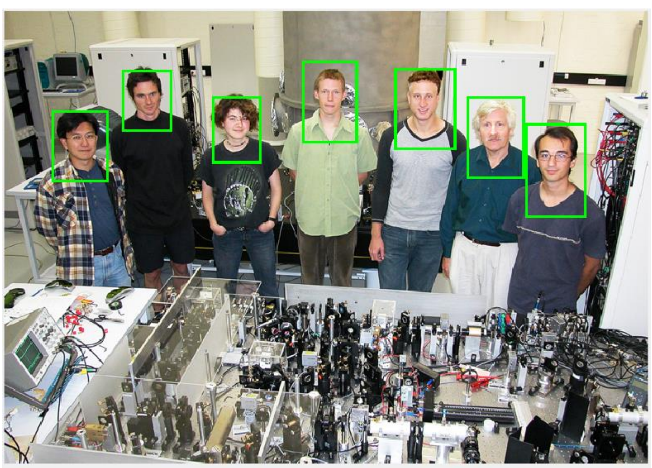


5.7. Removing white regions

After the last step, there were still some noisy points. So, we removed these noisy points by putting restriction on white region. The output after this step is shown below.

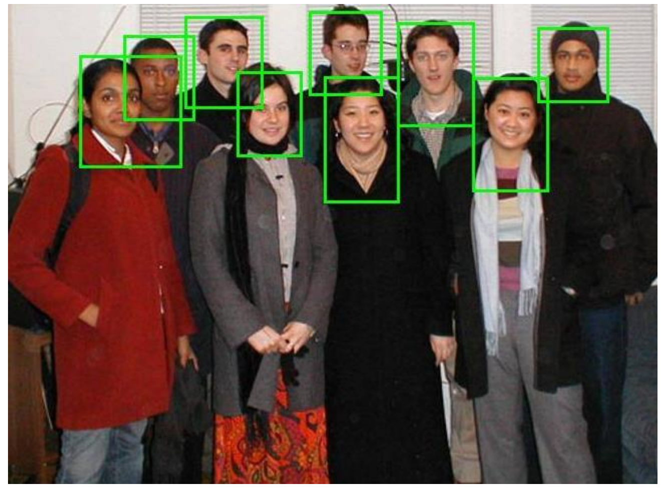
5.8. Bounding box and output

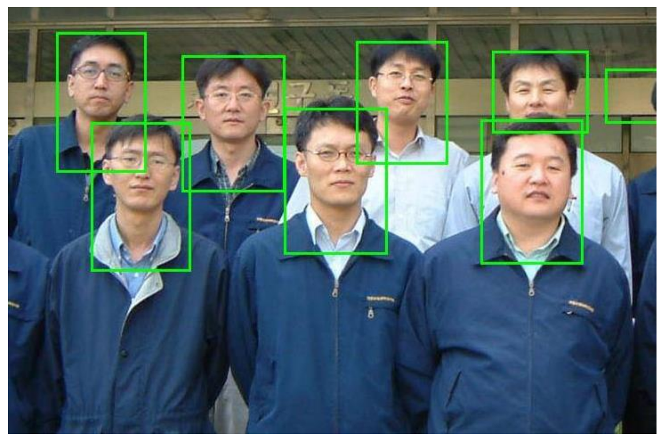
After the last step, there may be some regions which are not faces. So, we put the restriction on eccentricity and height/width ratio to obtain the final output which is shown below

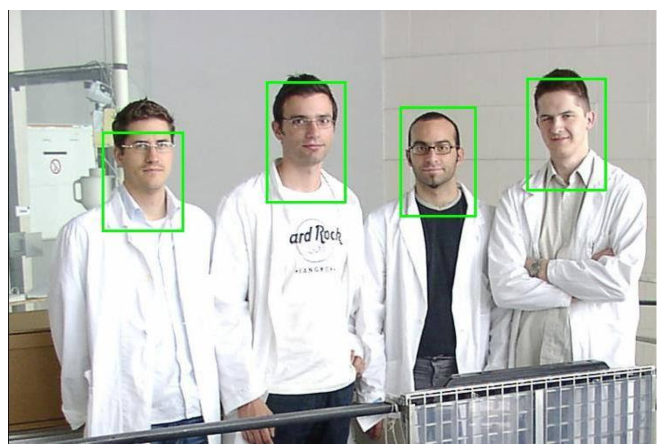


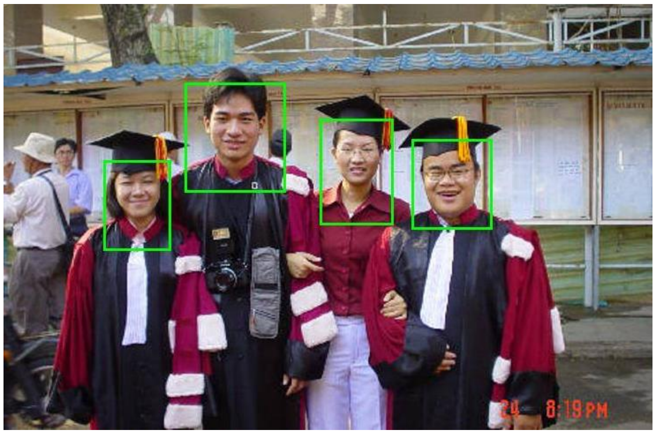
6. SOME MORE RESULTS

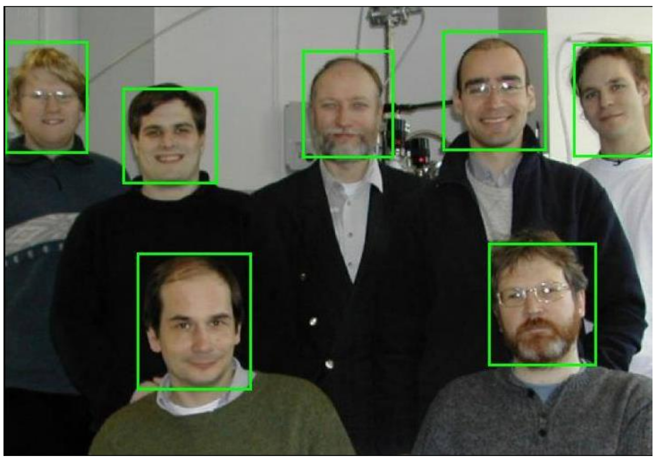
We run on the images of FERET database and the output obtained is attached in the mail. Some of the other outputs are shown below.

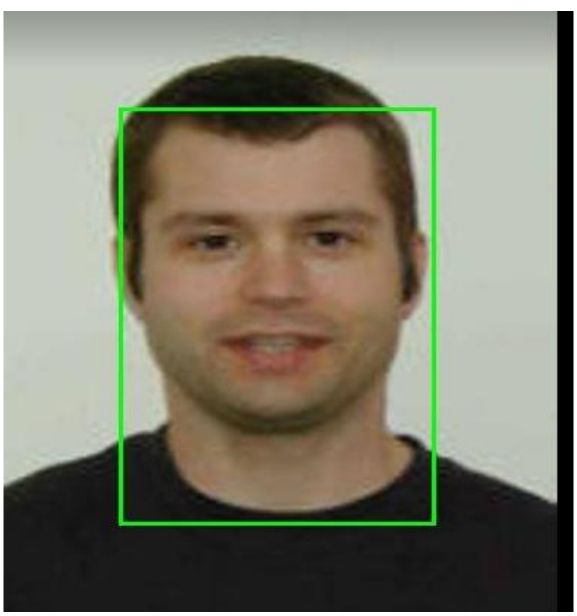












7. REFERENCES

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