Indian Institute of Technology, Delhi
Dept. of Computer Science

COL 783 : Image Enhancement
Assignment 1

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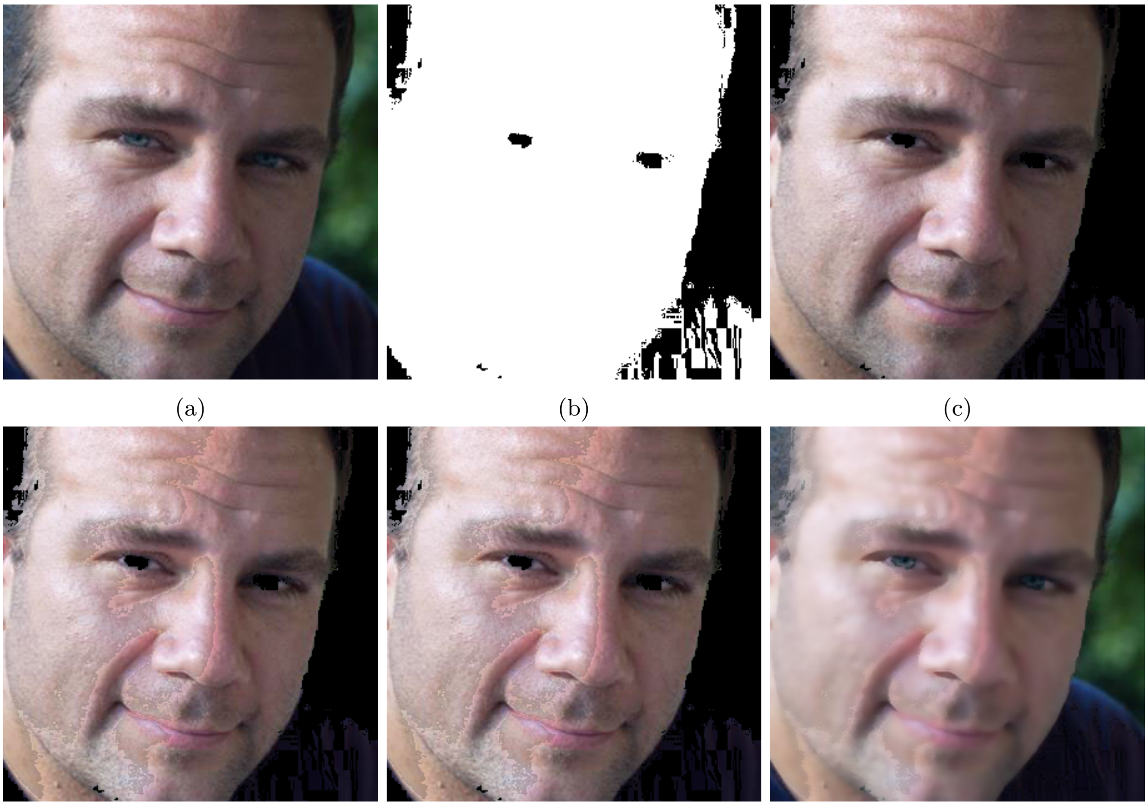
Contents

1 Part-A: Face enhancement

The aim of this section is to reduce shadows from a partially lit face. The following steps have been performed to achieve the same

- Face detection
- Skin detection
- Enhancement
- Restoration of enhanced skin into the image



(a) (b) (c)

(d) (e) (f)

Figure 1: (a) Face detected from image (b) Mask for skin detection (c) Result o bitwise AND operation of mask with face (c) Result of face enhancement (d) Result of bilateral filtering

1.1 Face detection

In order to detect the face from the entire image, an existing face detector using haar cascades in OpenCV is used.

1.2 Skin detection

The output of the face detected is shown in Fig. 1a. Since the enhancement is to be performed on the skin alone, the skin needs to be detected for which a mask is created. As per the research paper, all points that lie inside the ellipse in AB plane given by Eq. 1

$$(\frac{A-143}{6.5})^2 + (\frac{B-148}{12})^2 < 1 \tag{1}$$

On analysing the thresholding operation results using the ellipse equation, it was observed that on normalising the values of the LHS of Eq. 1 to a range of 0 to 255, all values less than 137 detect the skin. The mask generated after this thresholding is shown in 2a. On performing bitwise AND operation on the mask and the detected face, the skin is detected as shown in Fig. 1c.

1.3 Face enhancement

As per the research paper, all the pixels on the face needs to be multiplied bye a factor f given by Eq. 2. Where b is the intensity of the bright mode , d is the intensity of the dark mode and m is the intensity at the local minima between b and d. The values of b,d,m are calculated by monitoring the change in slopes and the values obtained are shown in Table 1.

$$f = \frac{b-d}{m-d} \tag{2}$$

Table 1: Parameters for face enhancement

b	**m**	**d**	**f**
65.26	168.66	198.78	1.29126214

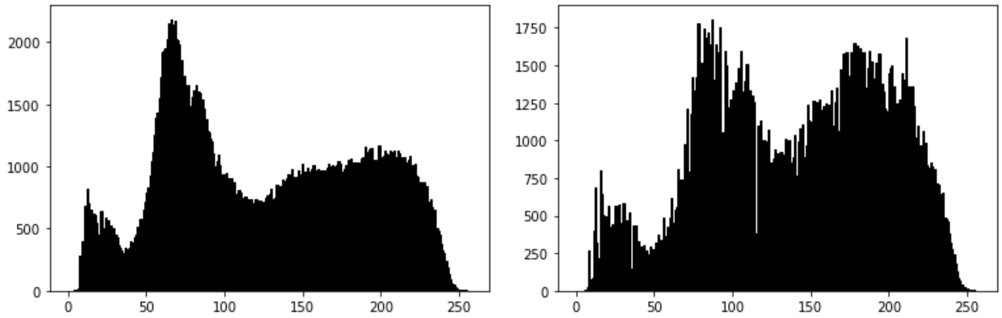
The result of multiplying f with each of the pixels of the skin is an enhanced skin as shown in Fig. 1d. It is also observed that new edges are formed between the dark and bright sides of the face. The histogram of the skin pixels before and after enhancement are shown in Fig. 1e. We can observe that some of the pixel values in the darker range have shifted towards the bright side [1].

(a) (b)

Figure 2: (a) Side lit input image (b) Face enhanced output image

1.4 Bilateral filtering

In order to remove the edge formed between the two sides of the face, we perform bilateral filtering that preserves strong edges and smoothens weaker edges. The output of the bilateral filter is shown in Fig. 1e.



(a) (b)

Figure 3: (a) Histogram of side lit skin (b) Histogram of enhanced skin

1.5 Restore the enhanced skin into image

Bitwise AND operation is performed between the enhanced skin image and the inverse of the mask in Fig. 1b to produce the restored face as shown in Fig. 1f. The face image is then put back into the face detected area of the entire image.

1.6 Result analysis

The final result of all the operations are shown in Fig. 2. On comparing the final output with the input image, we can see that the face has been enhanced and the shadow on the face has brightened. Also since the face detector used detects a rectangle box, the enhancement has only occurred within the box. The skin pixels outside the box remain the same. This can be overcome if the skin enhancement is performed on the entire image.

2 Part-B: Sky enhancement

The aim of this section is to brighten the color of the sky and clouds. The following steps have been performed to achieve the same

- Sky and cloud detection
- Histogram matching with reference image

2.1 Sky and cloud detection

The experiment is performed using a reference and target image. The images used in this work are shown in Fig. 4. To detect the sky and cloud separately in the reference and target images, thresholding based on the hue , saturation and intensity value ranges. The hue saturation value ranges used for the cloud and sky parts are shown in Table. 2

(a) (b)

Figure 4: (a) Reference image (b) Target image

Table 2: Hue saturation intensity ranges used for detecting sky and cloud

Item	Hue	Saturation	Intensity
Reference sky	**80-115**	**175-240**	**104-230**
Reference cloud	**75-115**	**2-125**	**155-255**
Target sky	**104-110**	**49-125**	**130-170**
Target cloud	**100-125**	**13-60**	**145-180**

Images obtained after detecting the sky and the cloud separately from the reference and target images are shown in Fig. 5.

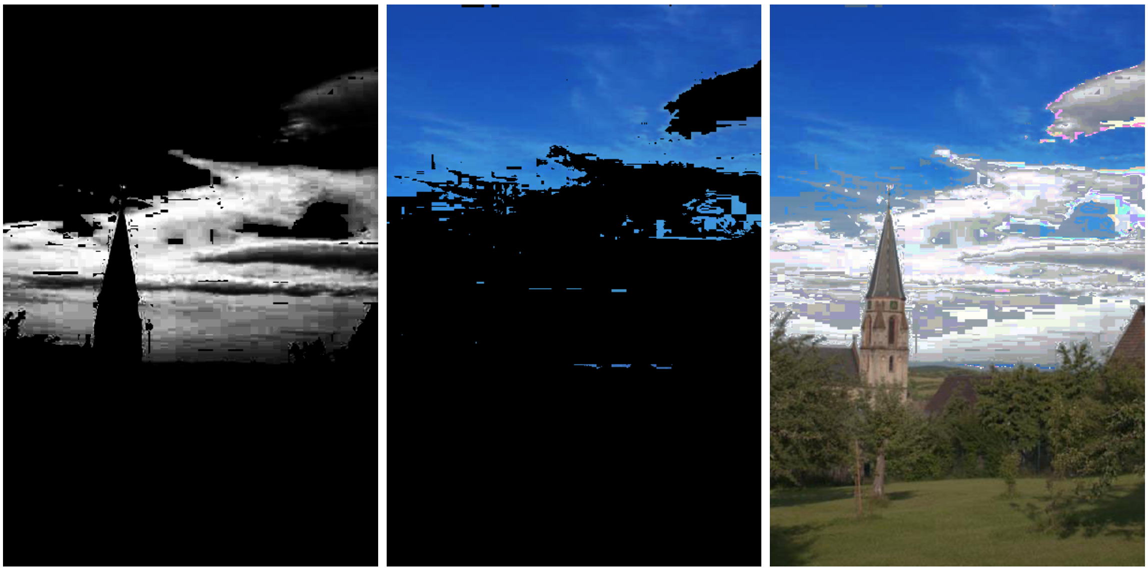
2.2 Histogram matching

Histogram equalisation is performed in all the 4 images and histogram matching is done between the corresponding areas of the reference and target images. The bright blue sky from the reference image is matched

(a) (b) (c) (d)

Figure 5: (a) Detected clouds in reference image (b) Detected sky in reference image. (c) Detected cloud in target image (d) Detected sky in reference image

with the sky in our target image and the white clouds of the reference image are matched to the clouds in the target. The result after histogram matching are shown in Fig. 6. We can observe from the results that



(a) (b) (c)

Figure 6: (a) Cloud of target image after histogram matching (b) Sky of target image after histogram matching (c) Result of combining sky and cloud.

the clouds have become whiter and the sky has developed a beautiful shade of blue as in the reference image. However we can see some distortions due to errors in thresholding [2]

3 Part-C: Shadowed saliency enhancement

The aim of this section is to remove the shadow from images. The following steps have been performed to achieve the same.

- Computing saliency map
- Computing multiplication factor fsal
- Updating the image luminance

3.1 Computing saliency map

Saliency map gives the importance of the different section of the image based on factors like color, greyscale gradient, skin pixels , etc. The obtained saliency map is shown in Fig. 8b. Since the saliency map has a lot of sharp changes , it has been smoothened to give Fig. 7c

(a) (b) (c)

Figure 7: (a) Input image (b) Saliency map (c) Smoothened saliency map

3.2 Computing Fsal

For computing the Fsal, the image is first divided into two sections. One containing the dark pixels and one containing the light pixels as shown in Fig. 8. Now the number of pixels in both the images are computed and Fsal is calculated as per the Eq. 3. The values obtained are shown in Table. 3.

$$fsal = min(2, \frac{PT(BRIGHT, 35\%)}{PT(DARK, 95\%)}) \tag{3}$$

Table 3: Fsal parameters

No. of bright pixels	No. of dark pixels	Fsal
322927	62073	1.9166643349468835

(a) (b)

Figure 8: (a) Light pixels (b) Dark pixels

3.3 Updation of luminance

Now the image is split into its LAB components and its luminance in the L frame is updated as per the Eq. 4

$$B_new(i) = fsal * Saliency(i) + (1 - fsal) * B(i)) \tag{4}$$

The obtained results aere shown in Fig. 9.

(a)

Figure 9: (a) Output image

4 References

References

[1] L. Kaufman, D. Lischinski, and M. Werman, "Content-aware automatic photo enhancement," in *Computer Graphics Forum*, vol. 31, no. 8. Wiley Online Library, 2012, pp. 2528–2540.

[2] T. Welsh, M. Ashikhmin, and K. Mueller, "Transferring color to greyscale images," in *Proceedings of the 29th annual conference on Computer graphics and interactive techniques*, 2002, pp. 277–280.