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COL 783 : Assignment 2 Report

This assignment is an implementation of the paper 'Digital Face Makeup by example' by Dong Guo & Terence Sim.

> **Reference**: *Guo, Dong, and Terence Sim. "Digital face makeup by example." Computer Vision and Pattern Recognition, 2009. CVPR 2009. IEEE Conference on. IEEE, 2009.*

INTRODUCTION

In this assignment, an approach of creating face makeup upon a face image with another image as the style example, has been implemented. This is similar to physical makeup as the color and skin details are modified while preserving the face structure. More precisely, the two images are first decomposed into three layers: face structure layer, skin detail layer, and color layer. Thereafter, information from each layer of one image is transferred to corresponding layer of the other image. The experimentation results at the end, demonstrate the effectiveness of this approach in faithfully transferring makeup.

Original (I)

Reference (Ɛ)

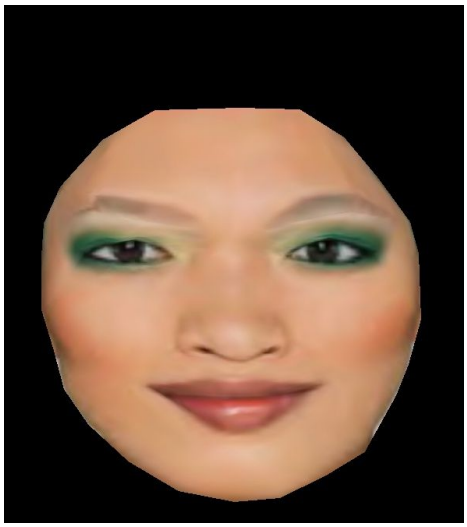
IMPLEMENTATION

Face Alignment

For face alignment, the reference image(Ɛ) has been warped to the subject original image(I).

- A MATLAB library was initially used, which using deep learning techniques to model the location of control points on the face, which include eyes, eyebrows, nose, lips and face boundary. But due to inaccuracies in the landmarks identified, 80 points have been **manually** taken over the complete face. This manual intervention ensures that both the faces have equal number of control points, since the library doesn't ensure that.
- After this, using OpenCV and Python, the control points obtained above are used to obtain the **Delaunay Triangles** in any of the images. The idea is to warp the content of each triangle in reference image to corresponding triangle in original image. Delaunay triangles are obtained using SciPy library, while the warping is done using affine

transformation. This python code is integrated with MATLAB code using system commands, and the resultant image is now used as reference image($\mathfrak{E}$) for further steps.



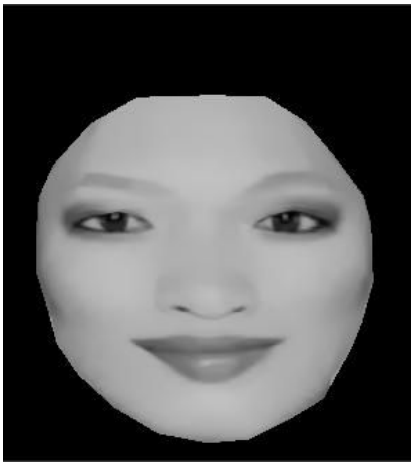
Warped Image of $\mathfrak{E}$ to I

Layer Decomposition

Now, both the images (I and $\mathfrak{E}$) have been decomposed into color and lightness layers by converting them to CEILAB colorspace. The L* channel is the *lightness layer* and a*, b* channels form the *color layer*. Further, the lightness layer is decomposed to *face-structure layer* and *skin detail layer* using **WLS filter**.

1. **Lightness Layer :** WLS filter is used to decompose the image to face-structure (base) and skin detail layers.
2. **Color Layer :** The a* & b* channels obtained in CEILAB colorspace are together called the color layer.

Face Structure Layer (I_s)



Face Structure Layer ($\mathfrak{E}_s$)

Skin Detail Layer (I_d)

Skin Detail Layer ($\mathcal{E}_d$)

Color Layer (I_c) : a*

Color Layer ($\mathcal{E}_c$) : a*

Color Layer (I_c) : b*

Color Layer ($\mathcal{E}_c$) : b*

Skin Detail Transfer

The detail layer is modified to obtain R_d, which is the weighted sum of details layers of I and $\mathcal{E}$.

$$R_d = \Delta_I I_d + \Delta_\mathcal{E} \mathcal{E}_d,$$

where $0 \leq \Delta_I, \Delta_\mathcal{E} \leq 1$. The values of Δ_I and $\Delta_\mathcal{E}$ control the contribution of each component.

1. **$(\Delta_I, \Delta_\mathcal{E}) = (0,1)$** I_d is concealed and $\mathcal{E}_d$ is transferred ⇒ Complete foundation transfer.
2. **$(\Delta_I, \Delta_\mathcal{E}) = (0.5,0.5)$** $\mathcal{E}_d$ is partially transferred ⇒ Partial foundation transfer.
3. **$(\Delta_I, \Delta_\mathcal{E}) = (1,0)$** I_d is retained and no $\mathcal{E}_d$ is transferred ⇒ No foundation transfer.

For the assignment, complete foundation transfer [$(\Delta_I, \Delta_\mathcal{E}) = (0,1)$] has been used.

Resultant Skin Detail Layer (R_d)

Color Transfer

The color layer is modified to obtain R_c, which is an alpha-blending of color layers of I and $\mathcal{E}$. For each pixel p, inside the face region, we have

$$R_c(p) = (1 - \gamma) I_c(p) + \gamma \mathcal{E}_c(p)$$

The value of γ is to control bending effect of two color layers.

1. **$\gamma = 1$** : $\mathcal{E}_c$ is transferred completely ⇒ Complete color transfer.
2. **$\gamma = 0.8$** : $\mathcal{E}_c$ is partially transferred ⇒ Partial color transfer.
3. **$\gamma = 0$** : I_c is retained and no $\mathcal{E}_c$ is transferred ⇒ No color transfer.

For the assignment, as specified in paper, partial color transfer (γ = 0.8) has been used.

Resultant Colored Image
(Complete Foundation & Partial Color Transfer)

Shading & Highlight Transfer

After the skin detail layer and color layer, the face structure layer has been modified in this part. We adapt a gradient-based editing method. Only the large changes of $\mathcal{E}_s$ have been added to I_s, since they represent highlights and shades. Uniform illumination of $\mathcal{E}$ has been assumed here.

$$\beta(p) = \min_q (1 - k(q).\exp(-(q-p)^2/2\sigma^2))$$

$$\nabla R_s(p) = \nabla \mathcal{E}_s(p) \quad \text{if } \beta(p)\|\nabla \mathcal{E}_s(p)\| > \|\nabla I_s(p)\|$$

$$= \nabla I_s(p) \quad \text{otherwise}$$

where k(q) is 0.7 for eyebrows, 0 for skin area, 1 for other facial components. The value of σ^2 is set to min(height, width)/25.

Beta (β)

Shaded Image

Gradient-based editing can preserve the illumination of I, transfer the highlight and shading effects, and meanwhile yield smooth result. The resultant face structure layer R_s is restored using Poisson equation with Dirichlet boundary equation, which is solved using Gauss-Seidel method.

Lip Makeup

The above steps don't suffice for lip makeup transfer, since in physical makeup, cosmetics on lips preserve or highlight the texture of lips, and not conceal it. The result should have the makeup effect similar to $\mathfrak{E}$ and the texture similar to I. To achieve this, for each lip pixel p in I, a pixel q has been searched in $\mathfrak{E}$ so that $\mathfrak{E}$(q) and I(p) are as similar as possible, while q and p are as close as possible. The luminance value of pixel q has been added to p, for each lip pixel p, while the color channels of q have been simply borrowed, which have replaced the color channels of p.

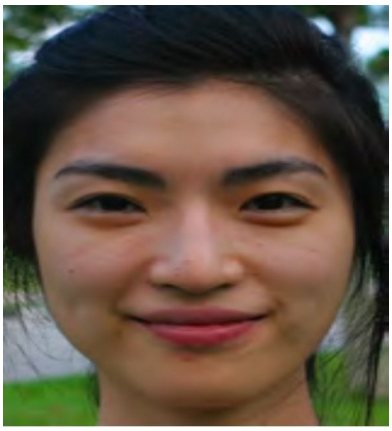
Final Image

EXPERIMENTATION & RESULTS

Playing with Parameters

1. No Foundation & Partial Color Transfer


2. No Foundation & Complete Color Transfer




3. Partial Foundation & No Color Transfer


4. Partial Foundation & Partial Color Transfer [**Final Image**]


5. Partial Foundation & Complete Color Transfer


6. Complete Foundation & No Color Transfer


7. Complete Foundation & Partial Color Transfer

8. Complete Foundation & Complete Color Transfer

9. Shading & Highlight : Scaling to 40

10. Shading & Highlight : Scaling to 60 [**Final Image**]

11. Shading & Highlight : Scaling to 100

12. Lip Makeup : Factor 2.8

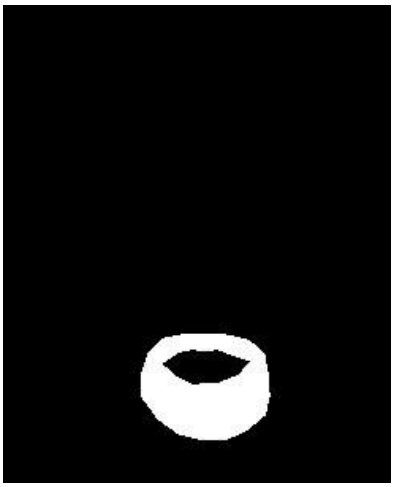
13. Lip Makeup : Factor 3.1 **[Final Image]**

Beard Transfer

Beard Transfer has been carried out by applying the makeup transfer only in the beard region. Control points have been manually marked on both the images, and a mask for beard (which excludes the lip region) has been created. Now makeup transfer only for beard region is carried out.

Original Image

Reference Image



Beard Mask

Warped Image

Final Image

REFERENCES

- Face Alignment :
  - https://github.com/spmallick/learnopencv
  - https://www.ics.uci.edu/~xzhu/face/
- Highlight & Shading :
  - http://web.media.mit.edu/~raskar/photo/code.pdf
- Beard :
  - http://dongguo.org/makeup/