Digital Make Up Transfer and Stylization

Sanket Sanjaypant Hire Yash Malviya

1 Implementation

The program is by taking two arguments subject image and example image as such python digital_makeup.py -lc -lf input/subject1.png input/example1.png

The program has option for 3 flags

- -si or show interactive to display output of intermediary steps like face alignment and various face masks extraction
- The other two flags -lc and -lf are explained in Observations section

Repository has the 3 inputs provided -
Subject image is an image on which make is applied.

Figure 1: Subject 1

Figure 2: Subject 2

Example image used as reference when applying digital makeup on subject image.

Figure 3: Example 1

1.1 Face Alignment

1.1.1 Face landmark points extraction

1. 68 facial landmarks are extractor using dlib's implementation. However these do not contain landmark points for the forehead
2. For those points first a simple automated process is used to locate the points. Forehead points are new points add at the location of the eyebrow landmark points. 5 additional points are added 1 in between eyebrows 2 between each of eyebrow and jaw end points
3. Then interactive mode is displayed to user to modify those points. in interactive mode only the y coordinate of landmark points can be changed

1.1.2 Example face warping

1. Triangles for warping are extracted using Delauny's method
2. Bounding boxes for individual triangle are cropped out. Rectangles containing corresponding triangles are warped. After that warped triangle is cropped using triangular mask
3. Reconstructing warped face example by adding pixel onto and empty image. A fix for adding edges twice is implemented. A mask of partially reconstructed warped example face is applied on the triangle to be added.

1.1.3 Face component mask extraction

1. Various components are extracted in this step such as -
   - Lip
   - Eyes
   - Skin
   - Entire face
   - Nose contours
2. Points from pre-computed face landmark points are selected to fill polygons for each building block component. This is the general strategy to make masks. Nose contour requires drawing a line
3. More complicated mask are addition subtraction of basic building block masks. These masks are used in subsequent functions in case some transformation is only to be applied for particular component region

1.2 Layer Decomposition

1. Decompose Subject Image and Warped Example Image into color and lightness layers (i.e. convert from BGR space to LAB space.)
2. Apply Bilateral Filter on luminance layer of Subject Image (say this bilateral filtered Subject Image as bilateral_filter_subject). Then compute face structure layer and skin detail layer of Subject Image as:
   - face structure layer of subject = bilateral_filter_subject
   - skin detail layer of subject = (luminance layer of subject) - bilateral_filter_subject
3. Apply Bilateral Filter on luminance layer of Warped Example Image (say this bilateral filtered Warped Example Image as bilateral_filter_example_image_warped). Then compute face structure layer and skin detail layer of Warped Example Image as:
   - face structure layer of Warped Example Image = bilateral_filter_example_image_warped
   - skin detail layer of Warped Example Image = luminance of Warped Example Image - bilateral_filter_example_image_warped

1.3 Color Transfer

1. Resultant color layer can be computed as:

$$\mathcal{R}_c(p) = \begin{cases} (1-\gamma)\mathcal{I}_c(p) + \gamma\mathcal{E}_c(p) & p \in \mathcal{C}_3 \\ \mathcal{I}_c(p) & \text{otherwise} \end{cases}$$

   Parameters:
   - γ - controls blending effect of two color layers. In this assignment, gamma is generally set to 0.8
   - C_3 - eyes region
   - I_c - color layer of Subject Image
   - $_c$ - color layer of Warped Example Image

1.4 Skin Detail Transfer

1. Resultant Skin detail layer can be computed as:

   $\mathcal{R}_d = \delta_{\mathcal{I}}\mathcal{I}_d + \delta_{\mathcal{E}}\mathcal{E}_d$

   Parameters:
   - weights:
     - δ_I - weight for Subject Image
     - δ_ϵ - weight for Warped Example Image

- I_d - skin detail layer of Subject Image
- E_d - skin detail layer of Warped Example Image

1.5 Highlight and shading transfer

1. Highlight shading information is for area around eyes lips and nose contours is specific to person so a special is created to avoid this region. Dilation of eyes, nose contour and outer mouth is used for mask creation.
2. Highlight and shading information is present in the face structure layer. Face structure layer is decomposed laplacian and gaussian. Resultant face structure is laplaician of example added to gaussian of subject

1.6 Lip Makeup

1. Compute luminance remapping of Warped Example Image with respect to Subject Image
2. Get all Lip points from Lip mask.
3. Lip makeup is applied as follows:
   $\mathcal{M}(p) = \mathcal{E}(\tilde{q})$

   Mapping color values at co-ordinate p (Lip point) in M with the color values at co-ordinate *q_tilda* (computed in next step) in Warped Example Image
4. *q_tilda* is computed as:
   $\tilde{q} = \arg\max_{q \in \mathcal{C}_2} \{G(|q-p|)G(|\mathcal{E}(q) - \mathcal{I}(p)|)\}$

   Parameters:
   - G - Gaussian function
   - C_2 - Lip region
   - q - randomly sampled Lip point
   - p - lip point from ordered lip point list
5. In order to reduce excessive matching with all the pixel in Warped Example Image, we are shuffling the Lip points randomly and finding the best acceptable match with threshold value $argmax\_q\_tilda$ close to 1 (in this assignment, $argmax\_q\_tilda = 0.9$)

1.7 XDoG Thresholding

1. Setting parameters
   - $\gamma = 0.98$
   - $\Phi = 200$
   - $\epsilon = -0.1$
   - $k = 1.6$
   - $\sigma = 0.8$
2. Apply edge preserving filter in order to reduce noise in image by smoothening (with the edges being preserved).
3. Apply Gaussin Filter on image with $sigma = 0.8$, call this filtered image as G_1.
4. Apply Gaussin Filter on image with $sigma = 0.8 * k$, call this filtered image as G_2.
5. Compute Difference of Gaussian as: $DoG = G_1 - (\gamma * G_2)$
6. Now, compute XDoG thresholding as:
   $$T_{\varepsilon,\varphi}(u) = \begin{cases} 1 & u \geq \varepsilon \\ 1 + \tanh(\varphi \cdot (u - \varepsilon)) & \text{otherwise.} \end{cases}$$
   Here, T is the thresholding function and u is DoG(Difference of Gaussian)
7. To improve XDoG thresholding we can perform binarisation with mean filter (where mean value is mean of all pixels in XDoG thresholded image)

1.8 Apply makeup mask

1. LAB channels are recombined similar to how they where decomposed. for applying makeup mask from inner mouth eyes and entire face was used to change pixel value of required regions only
2. Contours of certain thickness is drawn around eroded entire face mask. Along this contour pixels from Gaussian blurred final image are chosen

1.9 XDoG Makeup Showcase

1. LAB space of XDoG is modified for only the region where makeup is applied as so
   - $XDoG\_makeup\_ab = makeup\_ab$
   - $XDoG\_makeup\_l = 0.25 * face\_structure\_l + 0.75 * XDog\_l$ for skin region
   - $XDoG\_makeup\_l = 0.75 * face\_structure\_l + 0.25 * XDog\_l$ for lip region

2 Observations

There are two flags for two modification to makeup. They are as follows

- -lf or light foundation. Skin details aren't hidden when foundation is light. Weight of subjects' for transferring skin detail (δ_I) is 1 instead of 0
- -lc or light makeup color. Weight while doing color transfer are more in favor of subject image, $\gamma = 0.5$ instead of $\gamma = 0.8$ or weight of subject color 0.5 instead of 0.2

There are 4 configurations possible from 2 flags (on off each). Below are these 4 configurations are shown for two 2 input images.

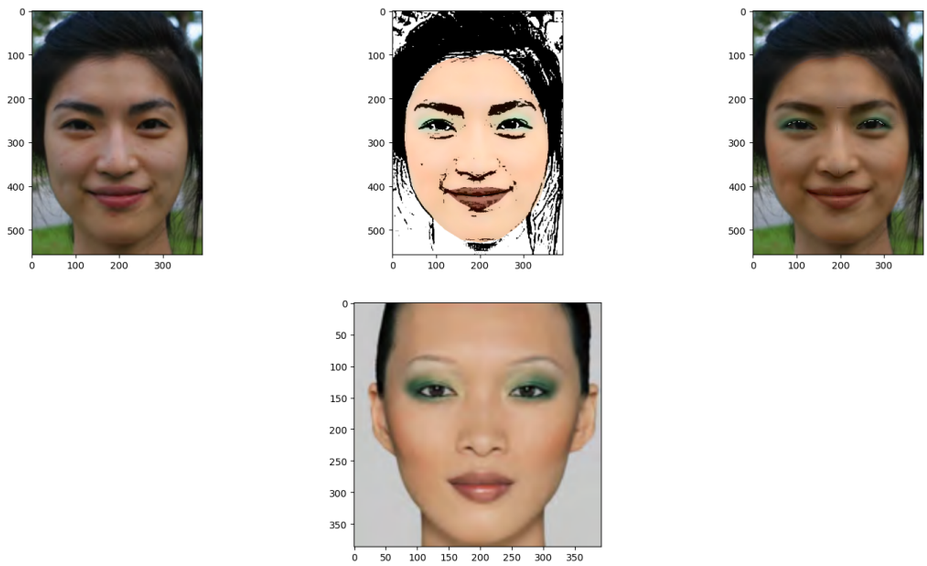

Figure 4: Example 1 makeup done on Subject 1

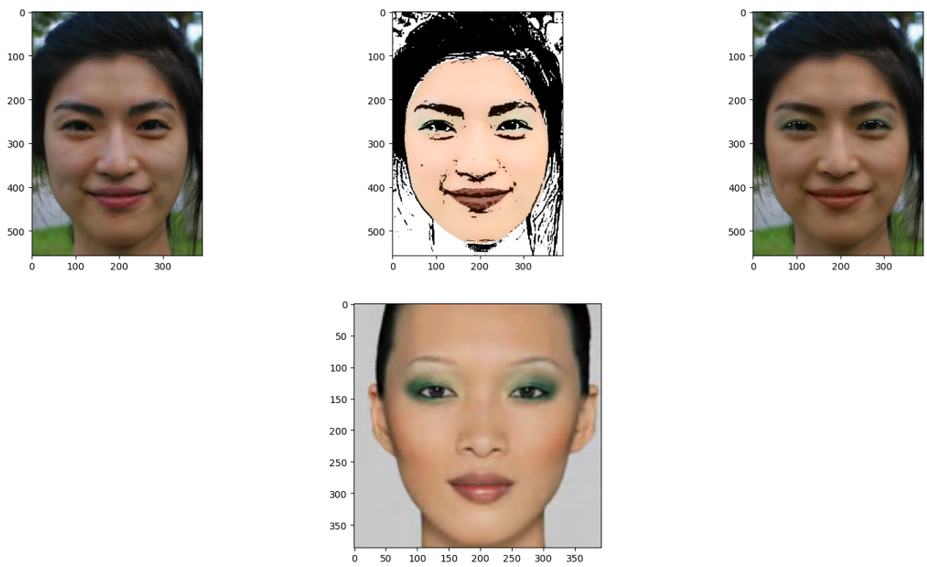

Figure 5: Example 1 makeup done on Subject 1 with light makeup color

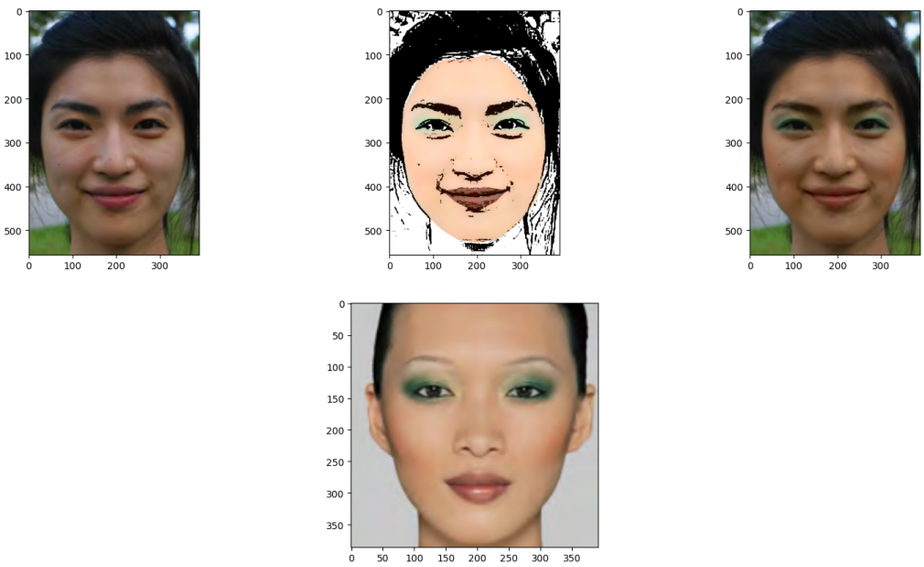

Figure 6: Example 1 makeup done on Subject 1 with light makeup foundation

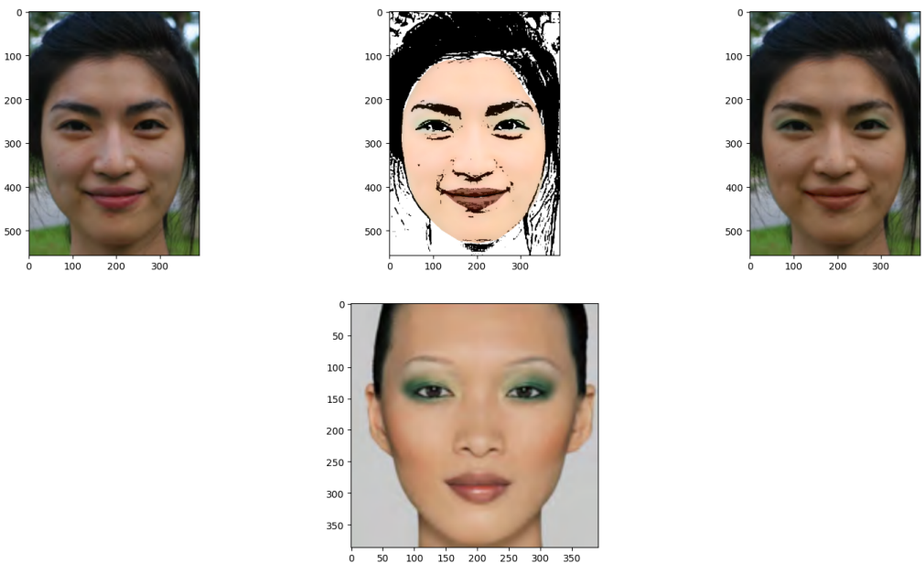

Figure 7: Example 1 makeup done on Subject 1 with light makeup color and light foundation

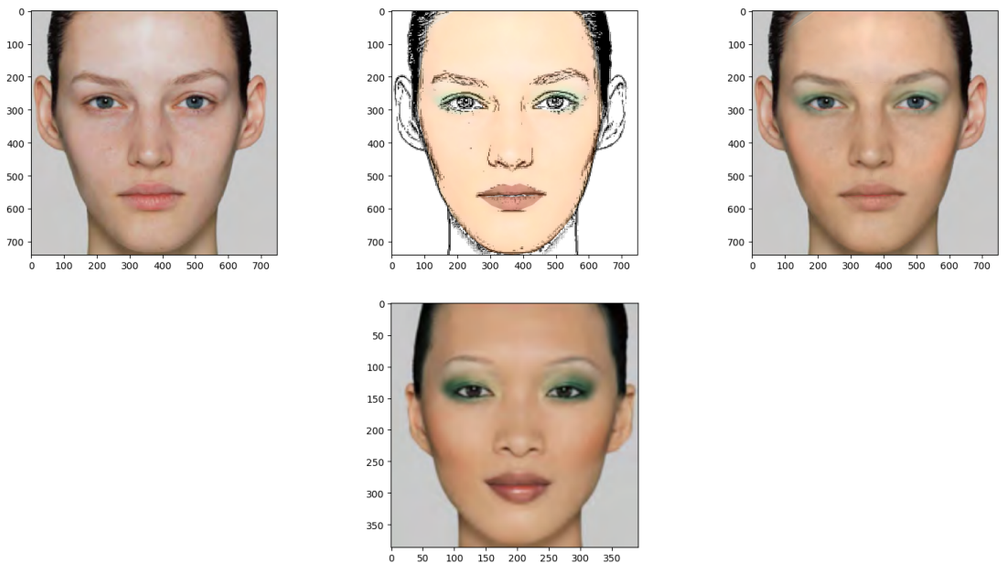

Figure 8: Example 2 makeup done on Subject 1

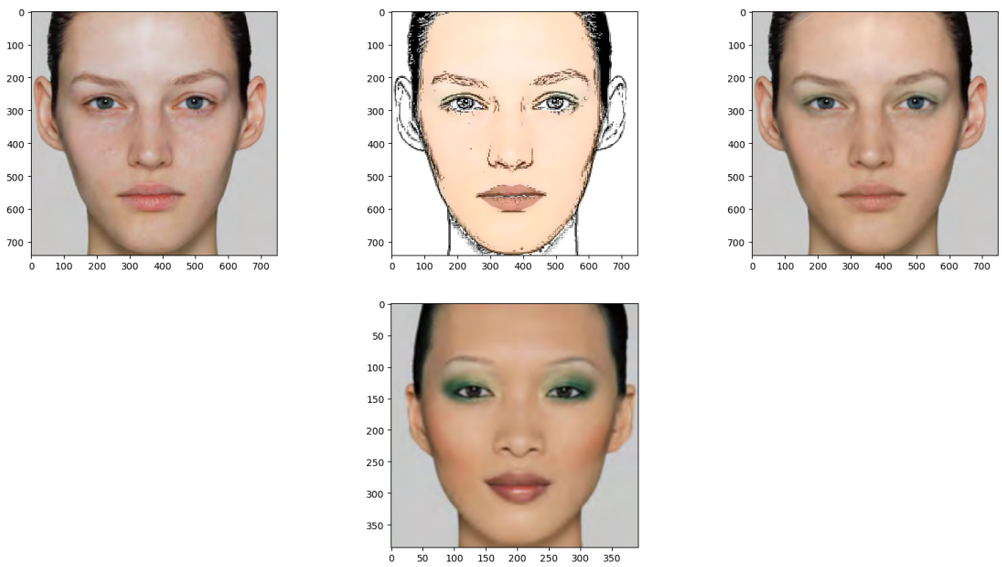

Figure 9: Example 2 makeup done on Subject 1 with light makeup color

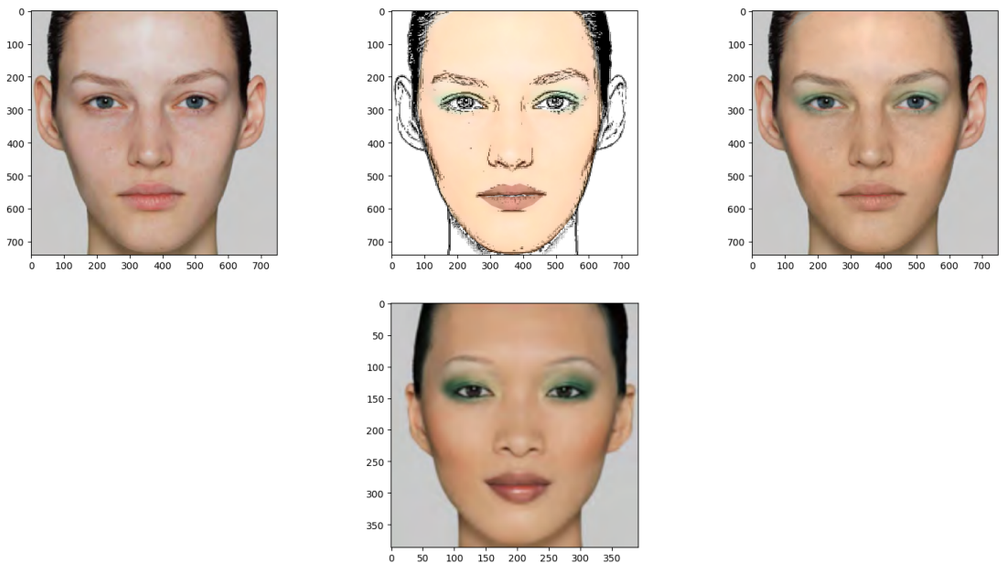

Figure 10: Example 2 makeup done on Subject 1 with light makeup foundation

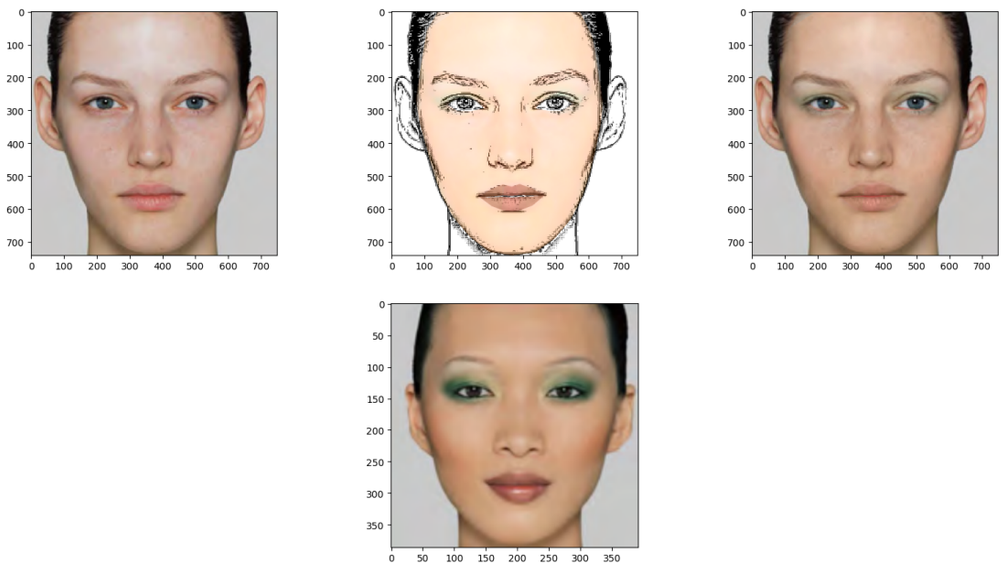

Figure 11: Example 2 makeup done on Subject 1 with light makeup color and light foundation

References

[1] Digital Face Makeup By Example: `https://ieeexplore.ieee.org/document/5206833`