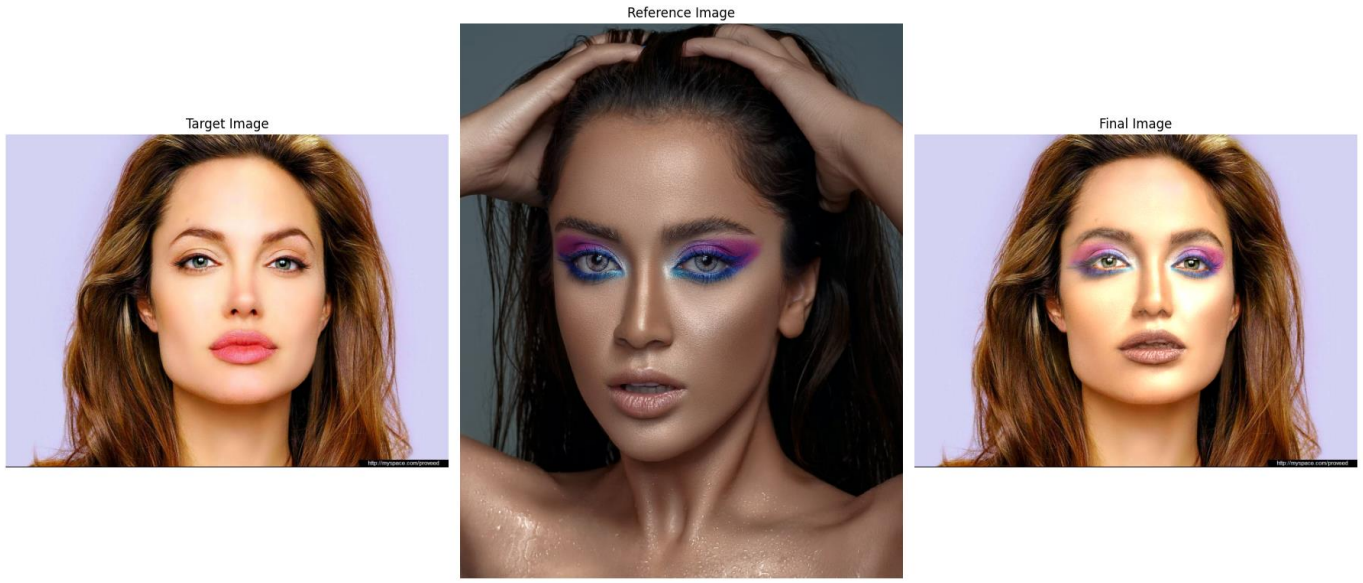
Digital Makeup Generation

notskinnydip

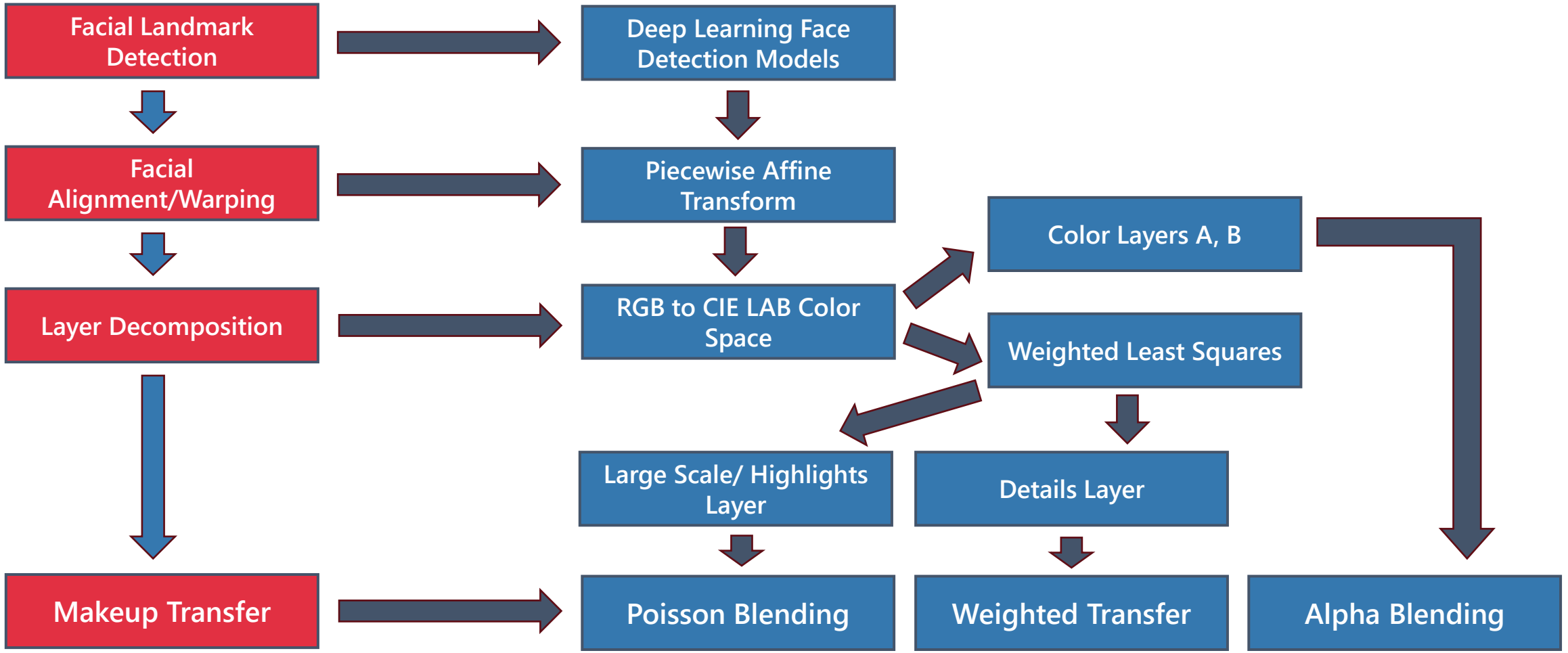
Introduction

This project aims to transfer makeup from a reference face to a target face

- Automatic processing and makeup transfer.
- No need to manually customize makeup using editing tools!
- Reference paper



Makeup Transfer Flow Diagram



Facial Landmark Detection

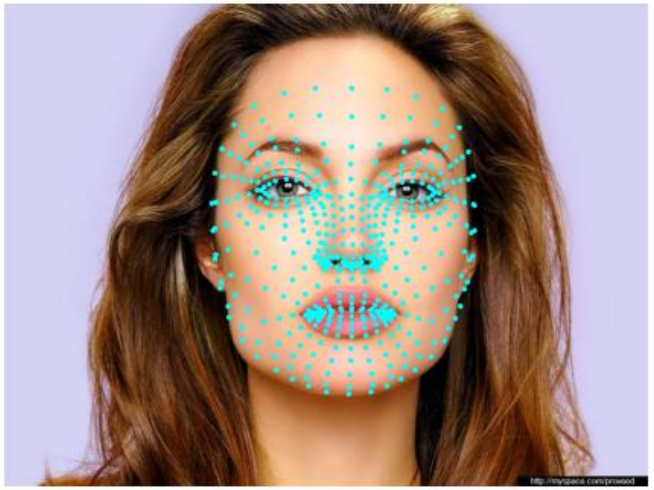
Facial Landmark Detection

Done using pretrained deep learning models

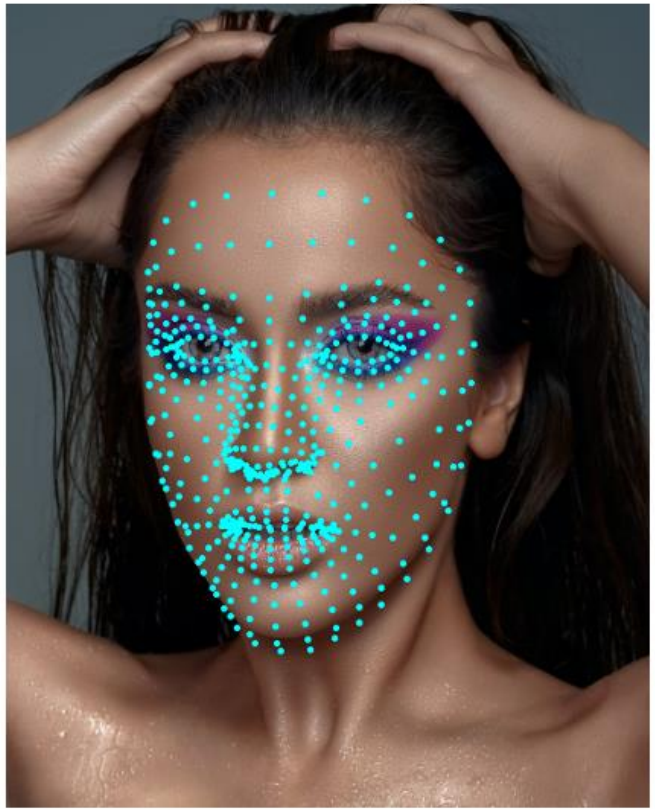
- Tried and tested multiple face detection models – Google MediaPipe, Dlib.
- Google MediaPipe face detection model is too complex for our task and often gives bad results.
- We chose a mix between two pretrained Dlib face detection models combining the best landmarks of each model.
- The following landmarks are detected –
    - Lower lip
    - Upper lip
    - Left eye
    - Right eye
    - Left eyebrow
    - Right eyebrow
    - Nose
    - Face Hull

Google MediaPipe Face Detection

Target Image

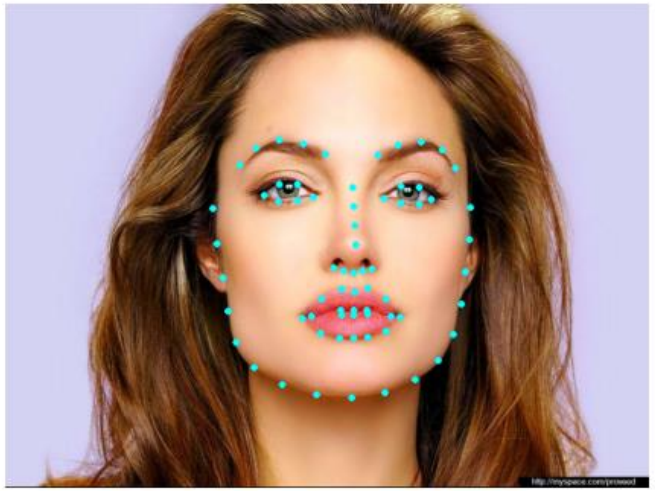


Reference Image

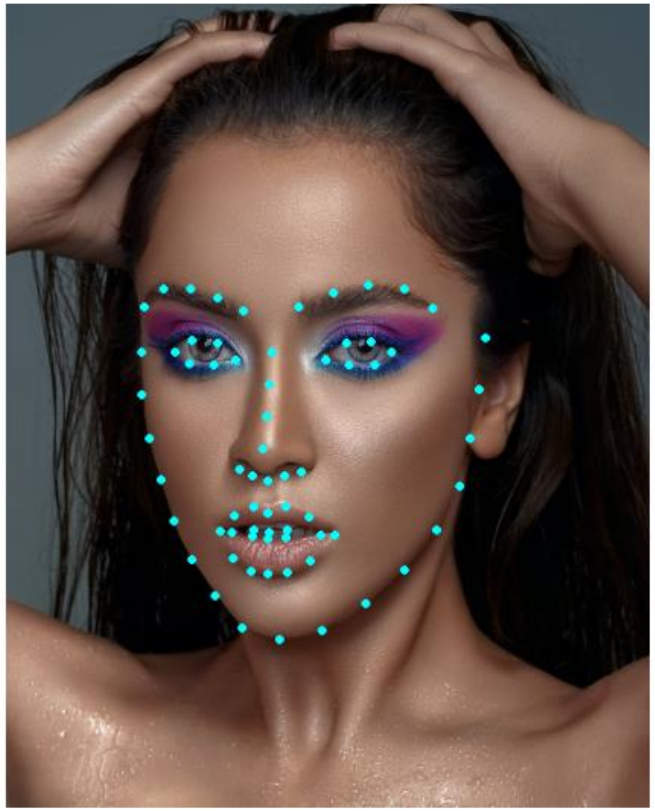


Dlib Face Detection 1

Target Image

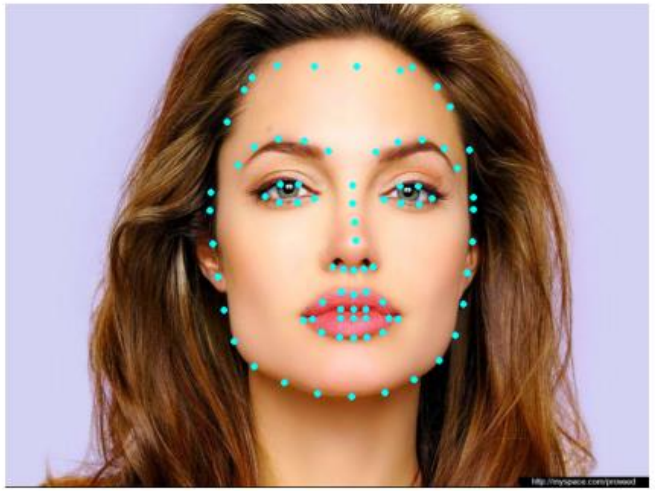


Reference Image

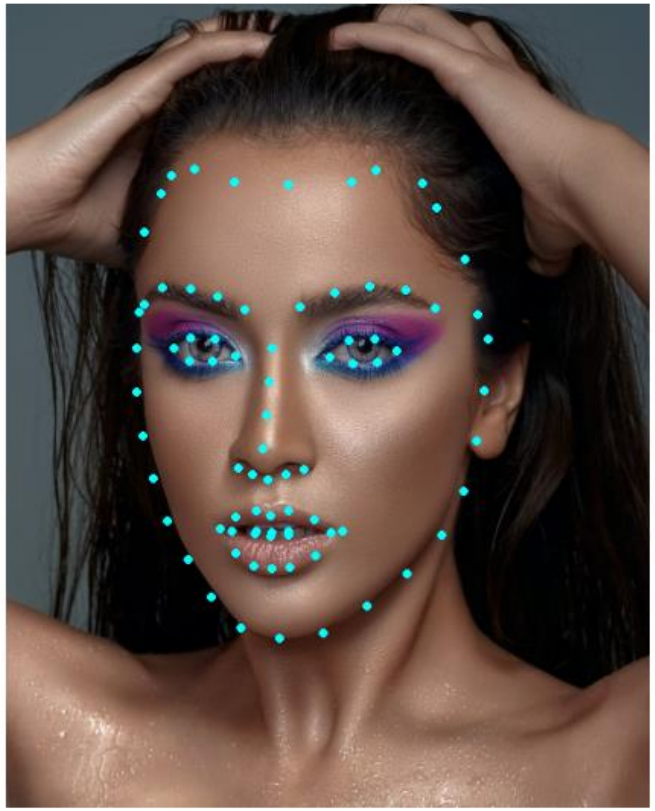


Dlib Face Detection 2

Target Image



Reference Image



Facial Alignment/Warping

Facial Alignment/Warping

Piecewise Affine Transformation

- Each facial landmark on the reference face is warped as per the target face.
- The reference paper uses thin plane splining for warping, but we chose to use piecewise affine transformation due to its versatility and lesser computational complexity.

Target Image

Reference Image

Target Face

Reference Face

Warped Reference Face

Warped Reference Face on Target Image

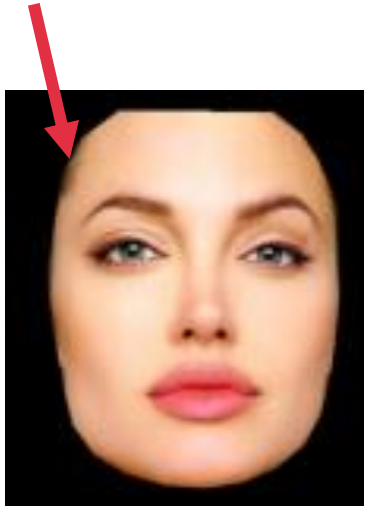
Preprocessing

Preprocessing

Before layer decomposition, it is important to preprocess the warped reference face.

- The skin color of the reference face is best matched to the target face.
- Any hair obstructing the target face is removed.

This hair should be removed!



Reference face skin tone does not match target skin tone!

Hair Removal

Otsu's Adaptive Thresholding

- Otsu's method is used to find the best cutoff intensity between hair and other regions.
- This removes eyebrows and eyes etc., but these are added back later.

This hair should be removed!

Removed Hair

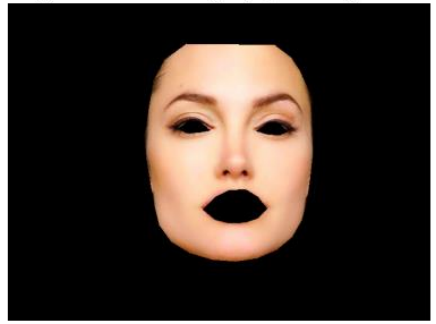
Skin Color Matching

Least Squares Linear Scaling

- The R,G,B color channels in the cut areas of warped reference image were individually scaled linearly by a factor to have the least minimum mean squared error with the corresponding color channel in the target face.
- Eyes and lips are removed beforehand to get the best skin tone matching!

Warped Reference Face without eyes, lips and eyebrows

Target Face without eyes, lips and eyebrows



Warped Reference Face without eyes, lips and eyebrows (scaled)

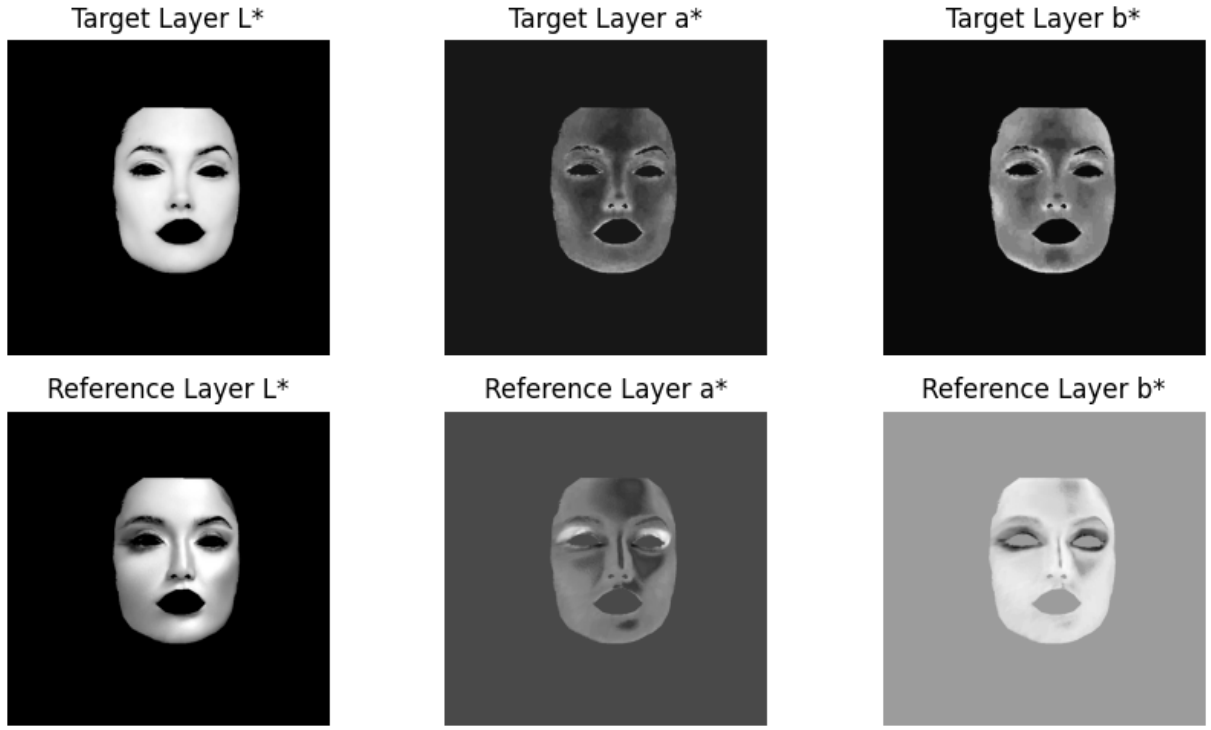
Warped Reference Face without eyes, lips and eyebrows (scaled) on Target Image

Layer Decomposition

Layer Decomposition

Highlights, Color Layer Decomposition

- Layer decomposition is the most important step! It separates facial characteristics from the actual makeup.
- The RGB color space is transformed into CIE L ∗ a ∗ b space where L refers to lightness (highlight) and a and b are the color channels. CIE L ∗ a ∗ b space allows for easy separation between highlight and color layers.



Layer Decomposition

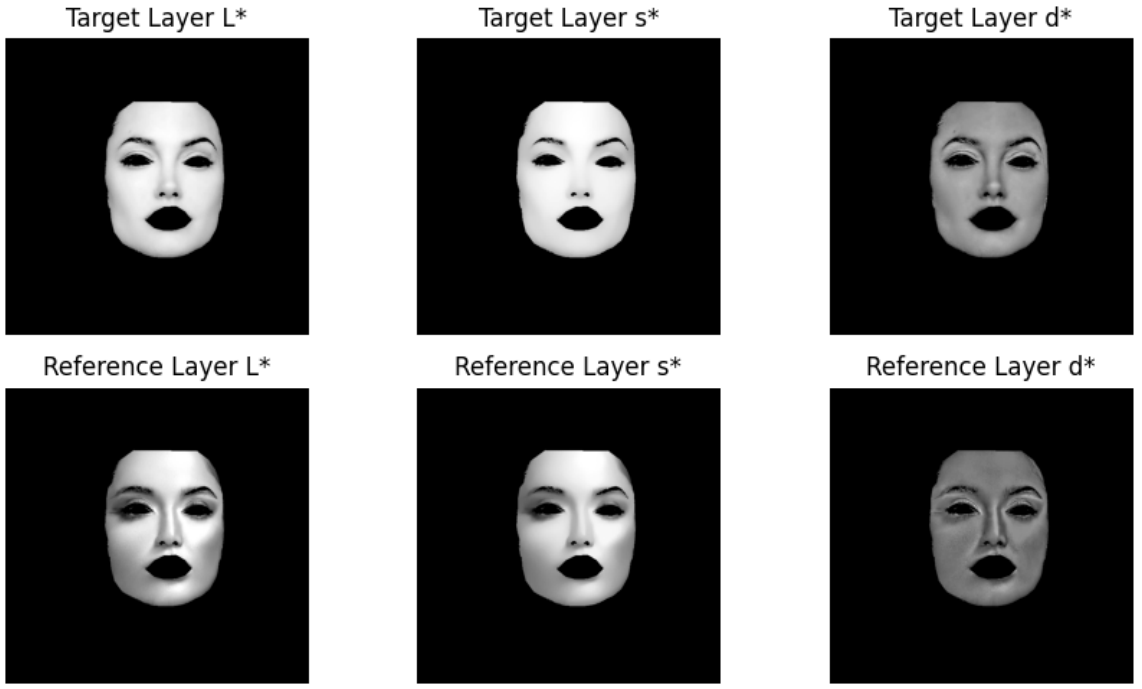
Smoothness (large scale) layer extraction by WLS filter

- The Lightness (highlight) layer $\boldsymbol{L}$ is given by,

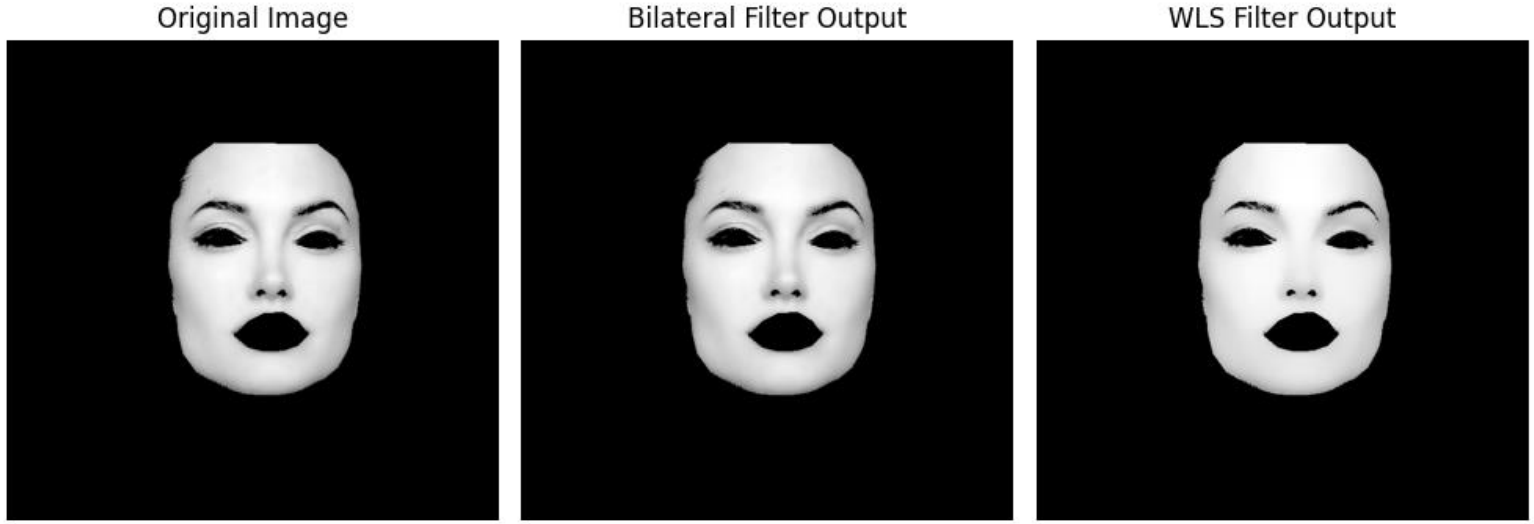
$$\boldsymbol{L} = \boldsymbol{s} + \boldsymbol{d}$$

where $\boldsymbol{s}$ is the large scale layer and $\boldsymbol{d}$ is the detail layer.

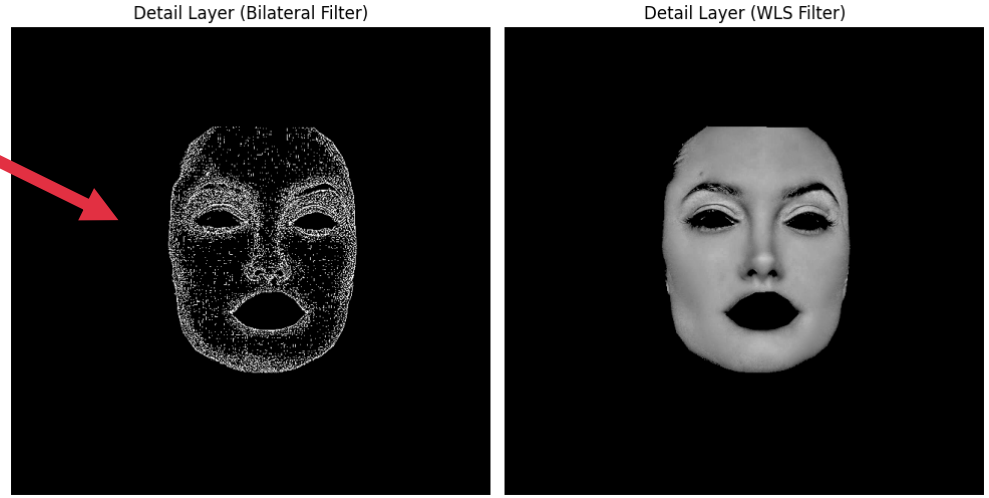
- $\boldsymbol{s}$ is obtained from $\boldsymbol{L}$ by applying a Weighted Least Squares (WLS) filter. The detail layer $\boldsymbol{d}$ is obtained by subtracting $\boldsymbol{s}$ from $\boldsymbol{L}$.
- WLS filter is a type of edge-preserving filter, and it was chosen over other filters such as bilateral filter because the former can maintain the shading information and preserve the details and structure of the face well.



WLS Filter vs. Bilateral Filter



Clearly, bilateral filter does not extract details properly!



Makeup Transfer

Makeup Transfer

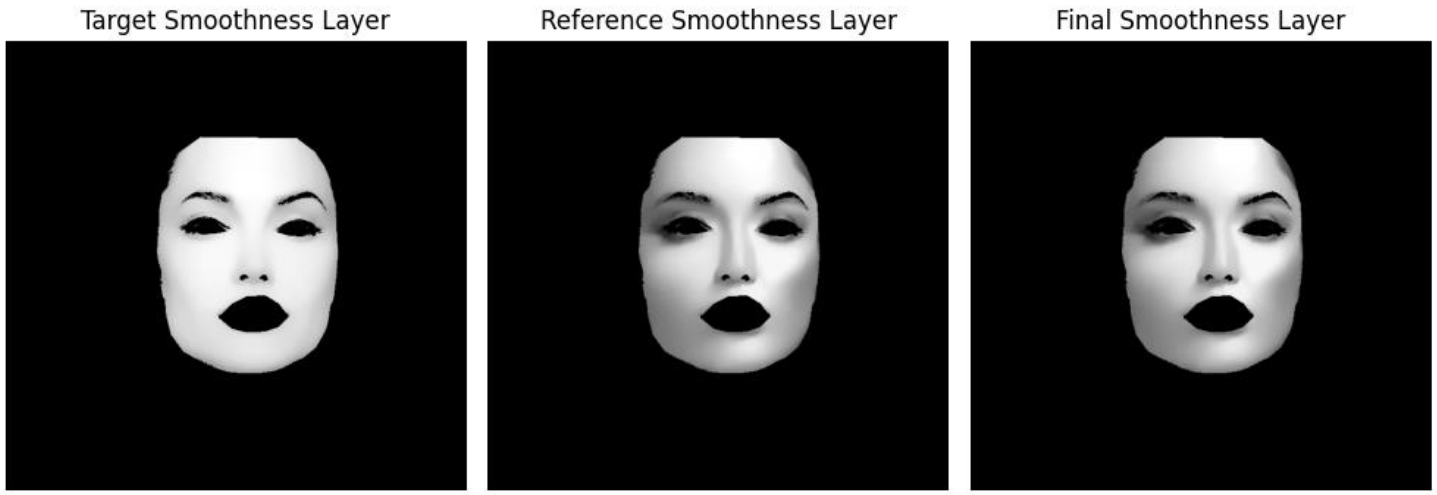
Combining of target and reference layers

- The final smoothness, detail, highlight, and color layers are obtained using various blending methods.
- Each layer requires a specific blending method as the information present in each layer is different.
- Proper selection of blending method is required to obtain proper makeup transfer

Makeup Transfer

Poisson blending for final smoothness layer

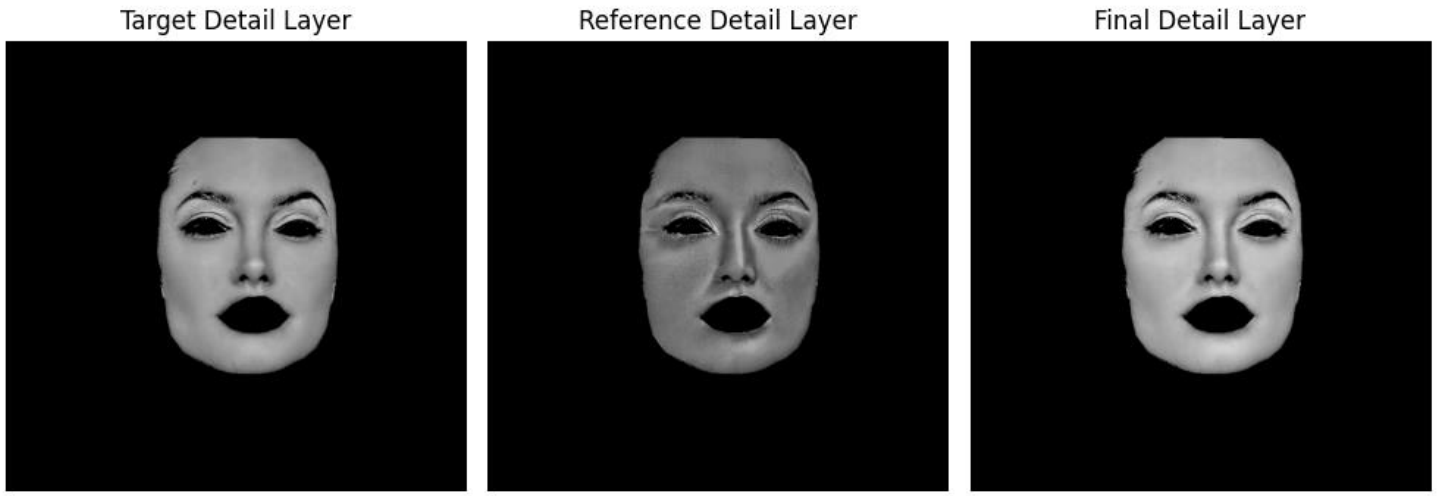
- Unlike other image blending process, the makeup from the reference cannot be directly copied and pasted onto the target.
- The target still needs to maintain its facial information while getting highlights and colors from the reference due to target.
- Therefore, only the gradients of each image need to be edited and thus Poisson blending is done.



Makeup Transfer

Weighted summation for detail transfer

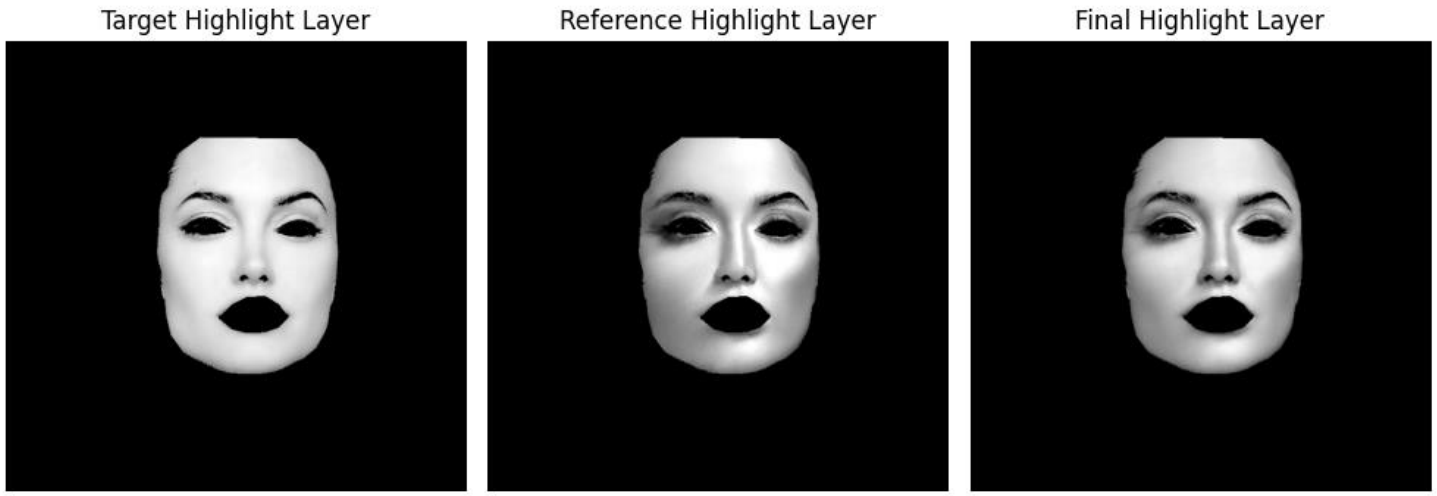
- Detail layer is not affected by makeup and describes the inherent facial characteristics of the target and the reference.
- Details layer can be obtained by the weighted sum of the target's detail and the reference's detail layer.



Makeup Transfer

Final highlight layer

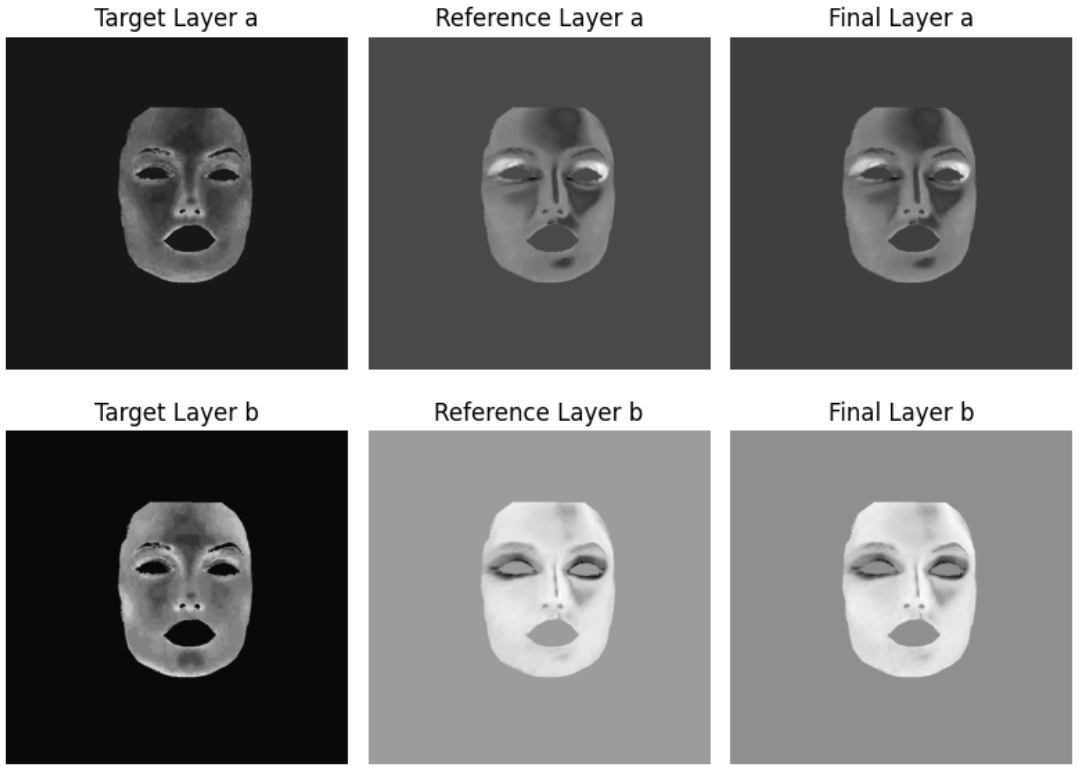
- The L layer is obtained by direct summation of final smoothness and detail layer.



Makeup Transfer

Alpha blending for color transfer

- .The a, b layers are obtained by alpha blending the respective a and b channels of the target face and reference face.



Makeup Transfer

Final RGB layer

- .The final RGB layer is obtained by LAB to RGB conversion.

Final Layer L*a*b*

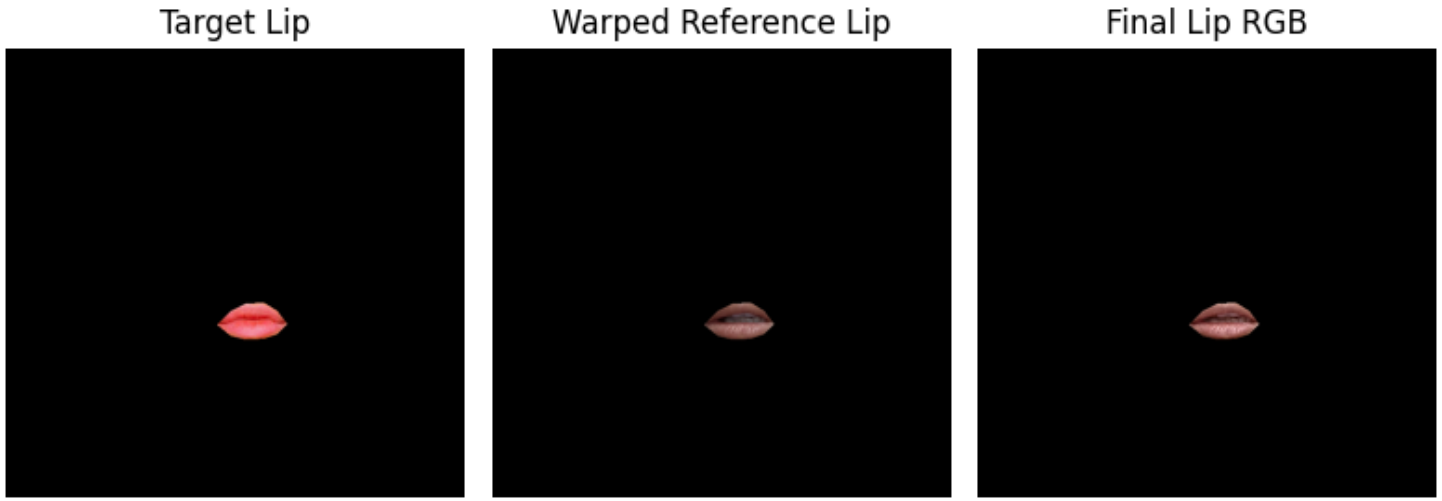
Final Layer RGB

Lip Makeup Transfer

Lip Makeup Transfer

Separate processing for lip makeup transfer

- .The same processing steps are followed separately just for the lips to obtain lip makeup transfer.



Face Blending

Face Blending

Foreground-background blending

- It is vital to blend the foreground face and background properly to obtain a proper output.
- OpenCV's seamlessClone is used to properly blend the foreground and background together to obtain a seamless stitch!
- The reference paper proposes Gaussian circular masking, but seamlessClone is more versatile when the illumination of target and reference faces are different.

Target Image

Final Image Without Blending

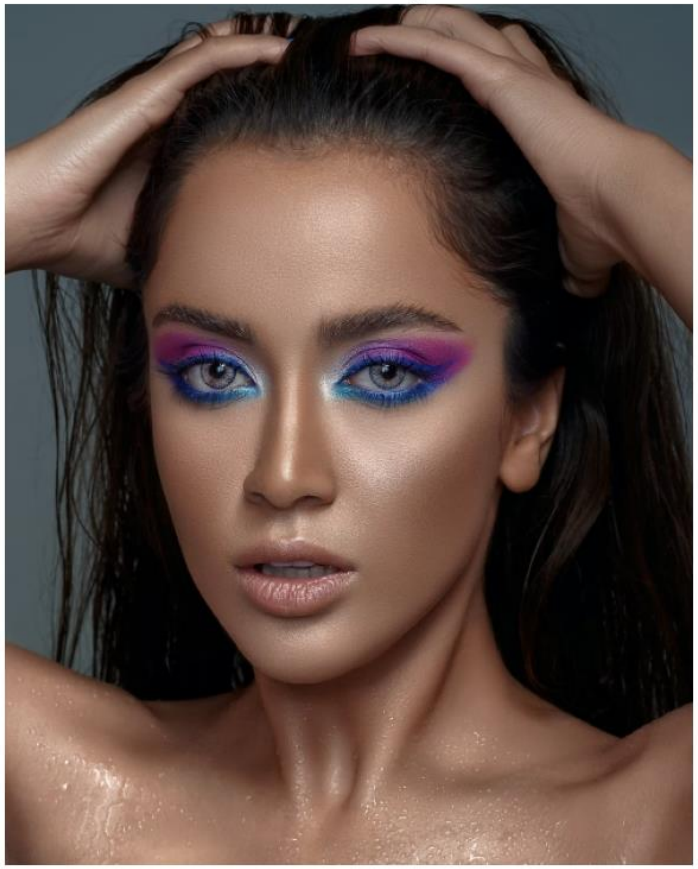
Final Image With Blending

Final Output

Output 1

Target Image

Reference Image



Final Image

Output 2

Target Image

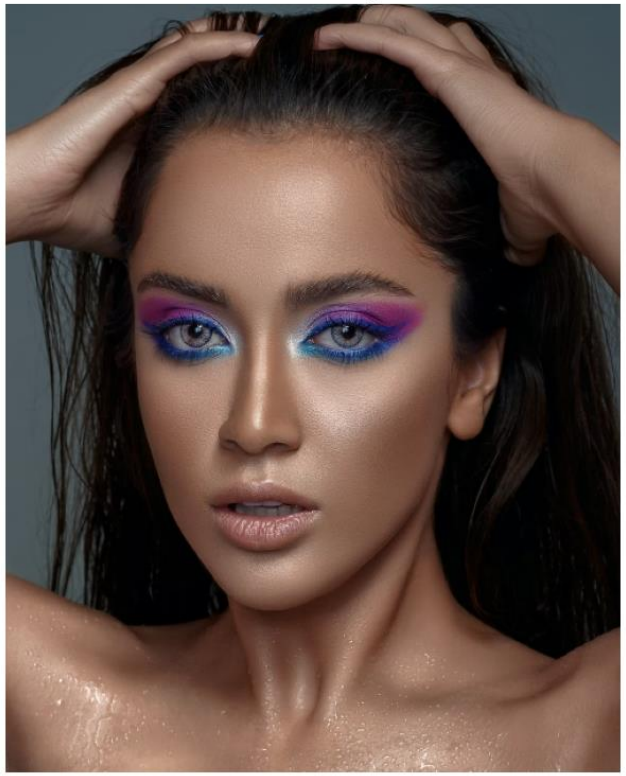
Reference Image

Final Image

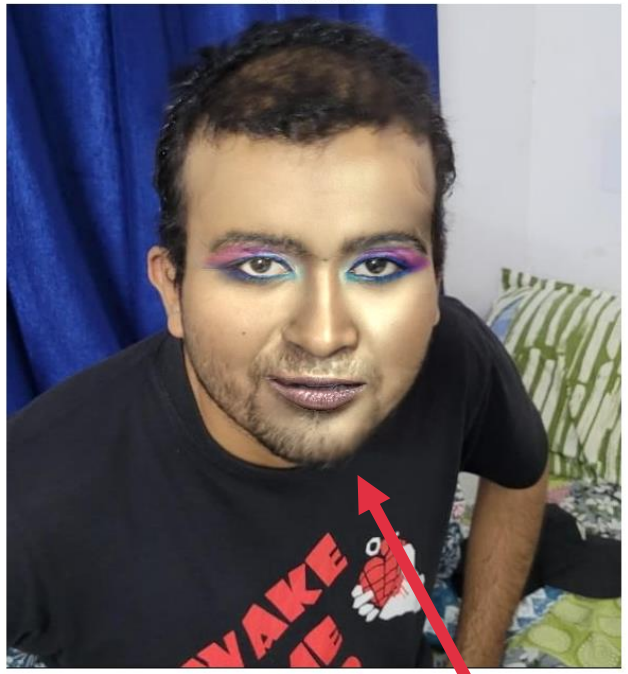
Output 3

Target Image

Reference Image



Final Image



Notice how facial hair is retained!

Improvements

Custom Lip Color

- Instead of transferring the reference lip color, we provide a custom lip color to be transferred!

Target Image

Reference Image

Final Image with Reference Lip

Final Image with Custom Lip Color

Face Blending

seamlessClone over circular masking

- The reference paper proposes Gaussian circular masking, but seamlessClone is more versatile when the illumination of target and reference faces are different.

seamlessClone Blending

Circular Mask Blending

seamlessClone Blending

Circular Mask Blending

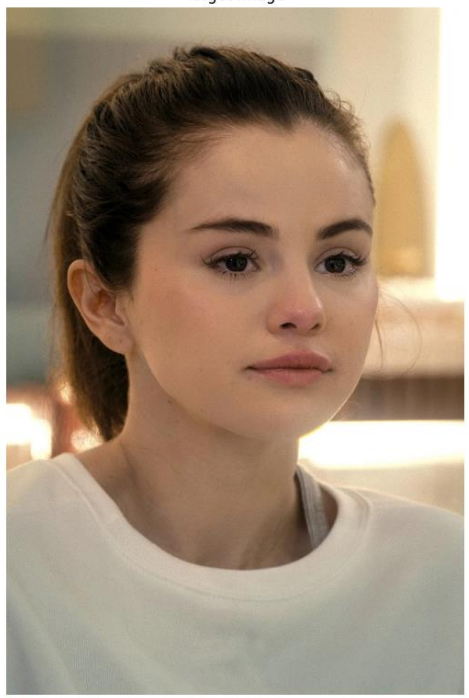
Scope of the Project

Only As Good As the Face Detection Model!

- Proper warping and alignment is crucial for proper makeup transfer.
- This depends on how well the model can detect the facial landmarks.
- Improper landmark detection can affect the result.

Notice how this part is not proper.

Target Image



Reference Image

Final Image

Thank You