



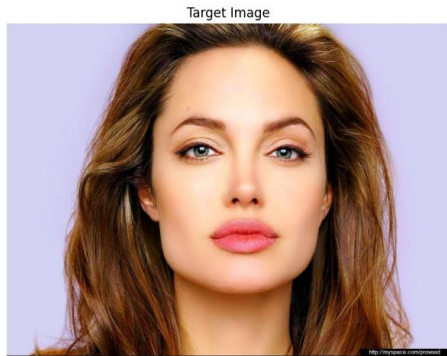
Digital Makeup Generation

notskinnydip

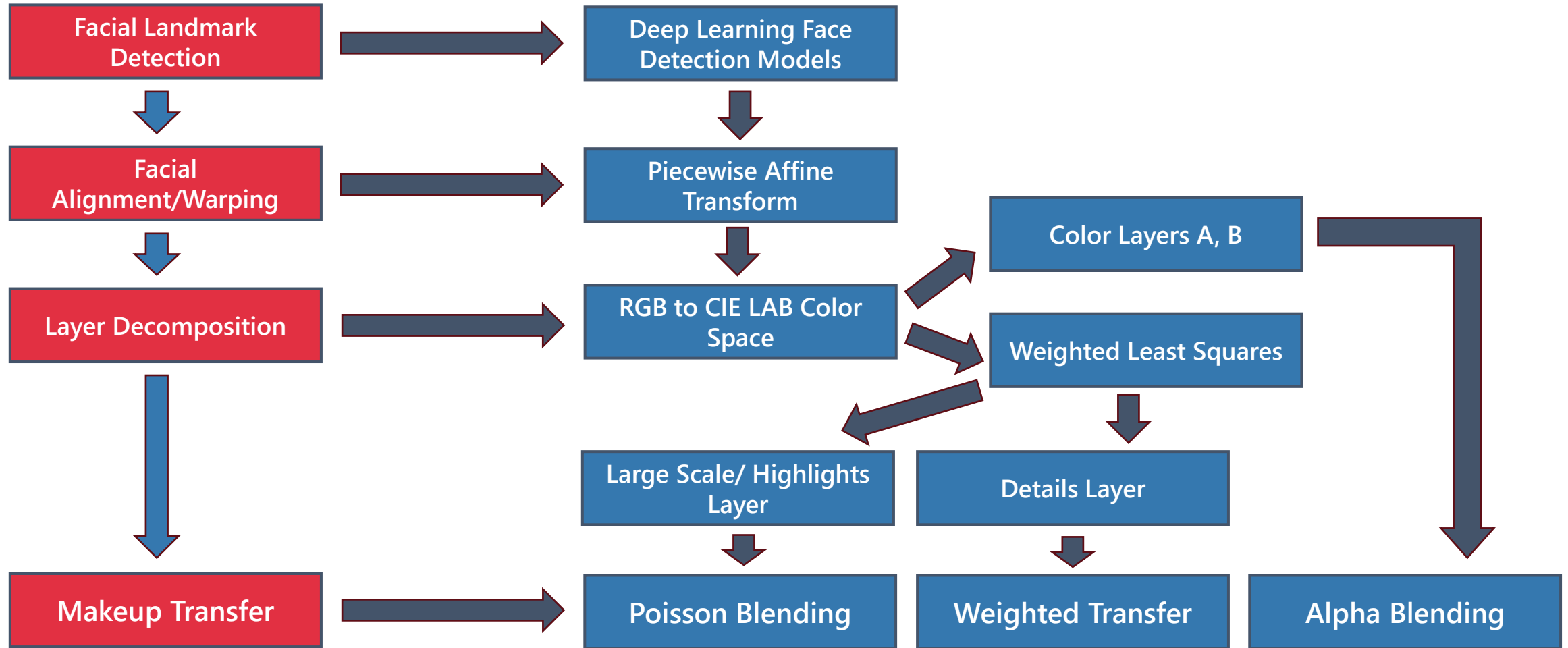
Introduction

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



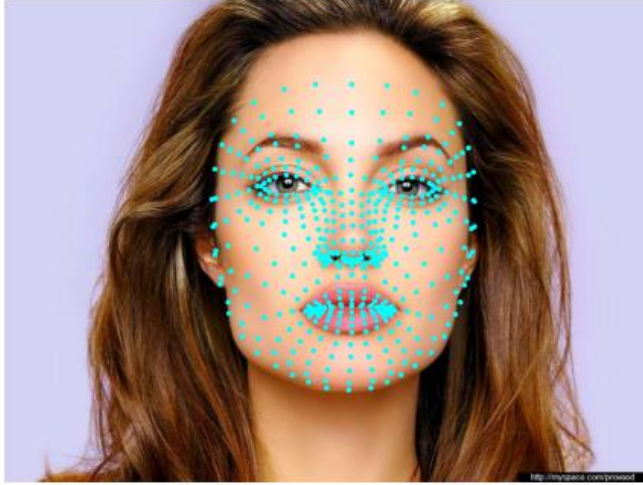
Facial Landmark Detection

Done using pretrained deep learning models

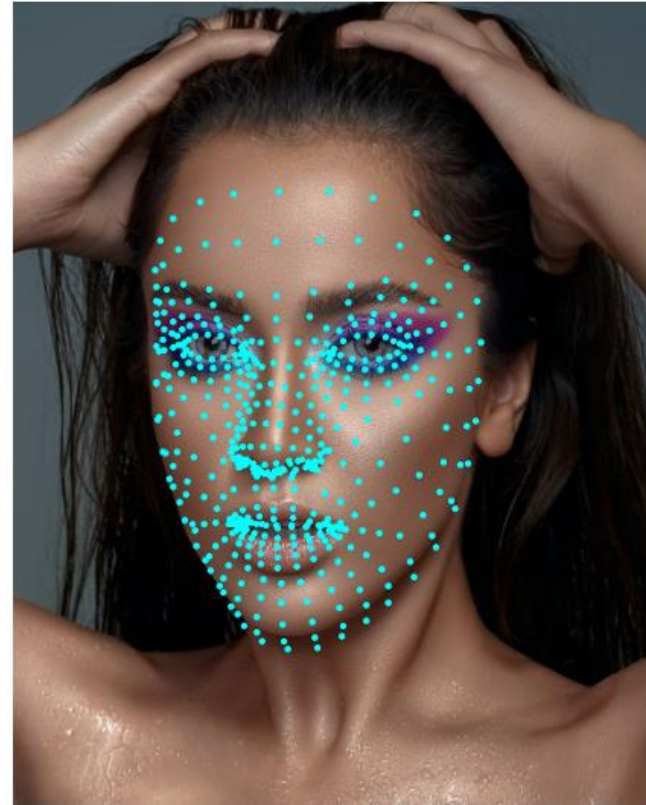
- Tried and tested multiple face detection models – Google MediaPipe, Dlib.
- Google MediaPipe face detection model is too complex for our task and often gives bad results.
- We chose a mix between two pretrained Dlib face detection models combining the best landmarks of each model.
- The following landmarks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

Google MediaPipe Face Detection

Target Image

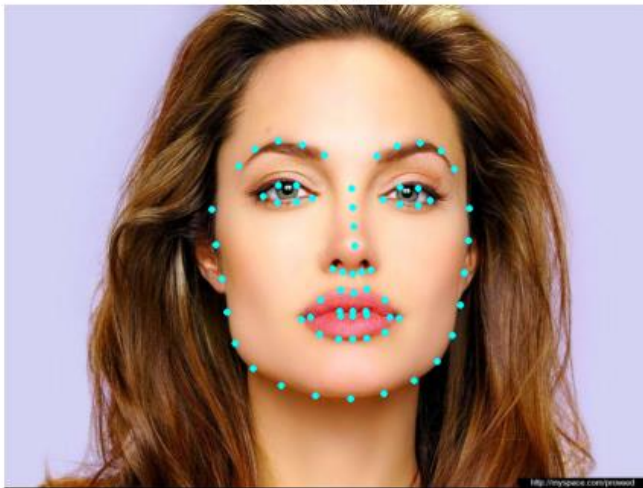


Reference Image

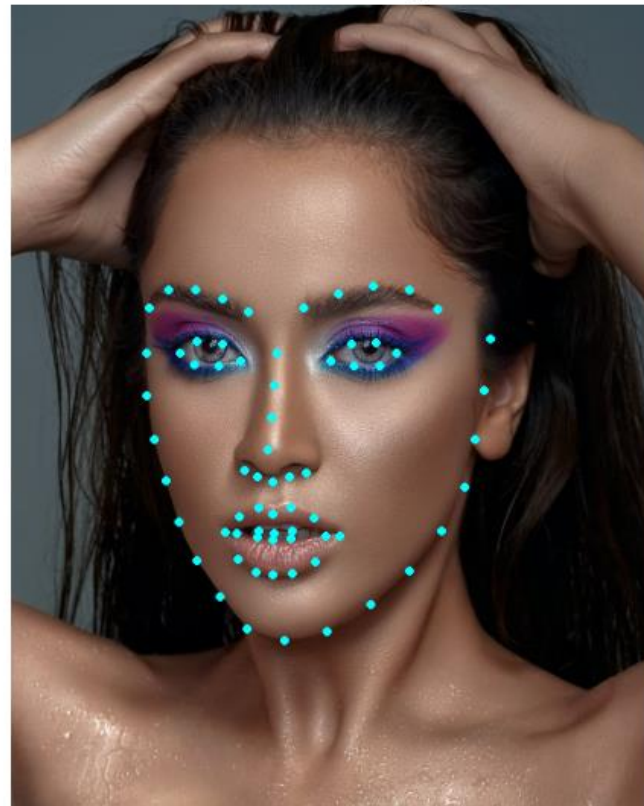


Dlib Face Detection 1

Target Image

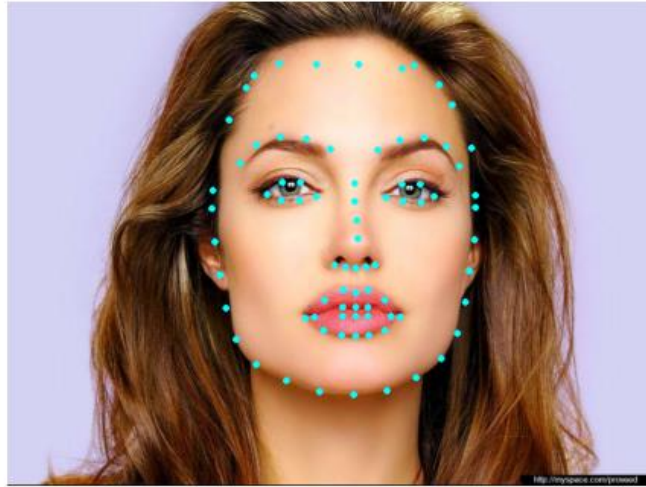


Reference Image

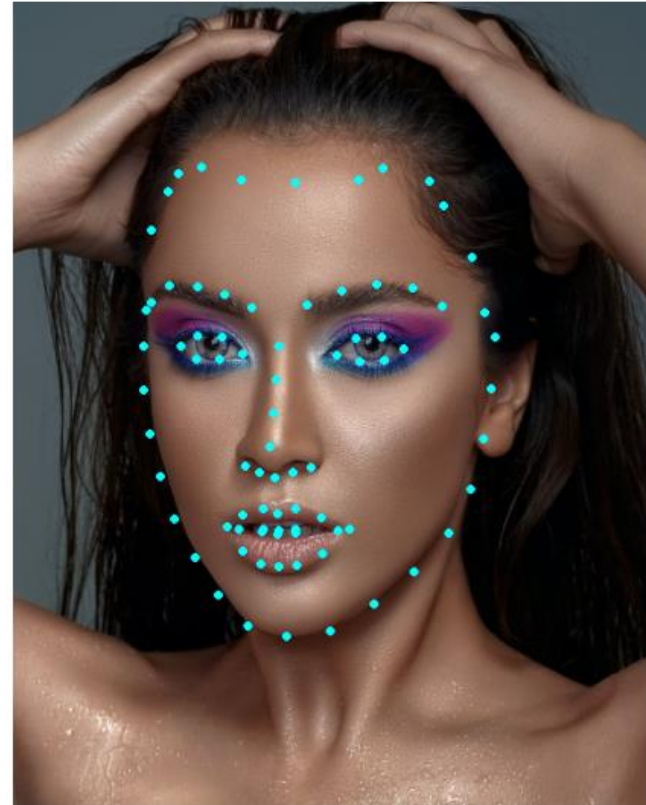


Dlib Face Detection 2

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





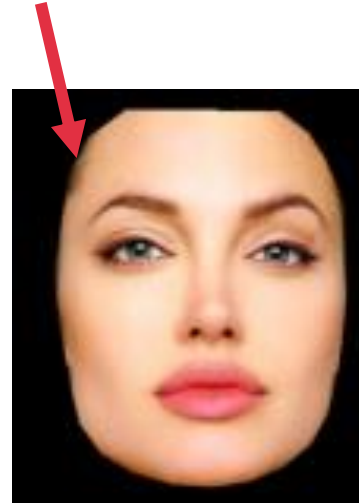
Preprocessing

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!

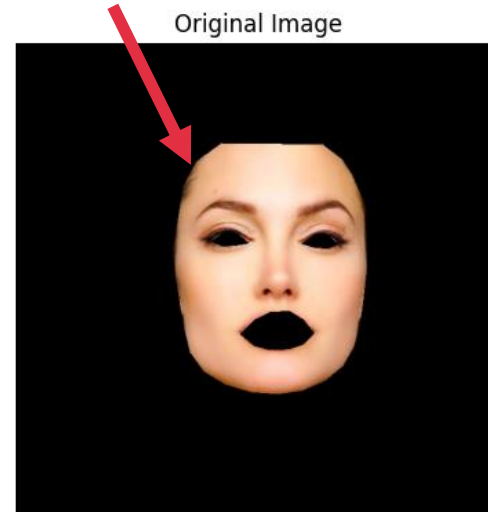


Hair Removal

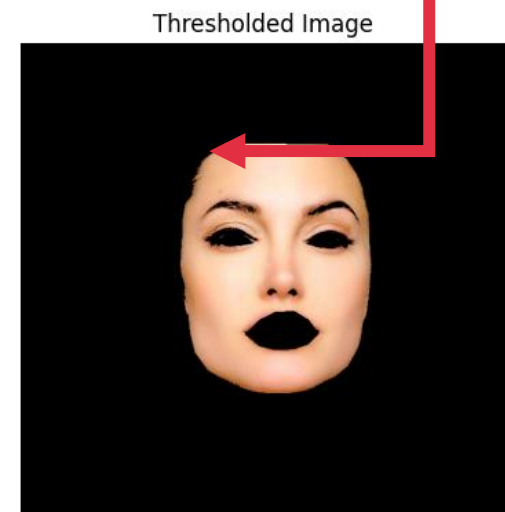
Otsu's Adaptive Thresholding

- 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

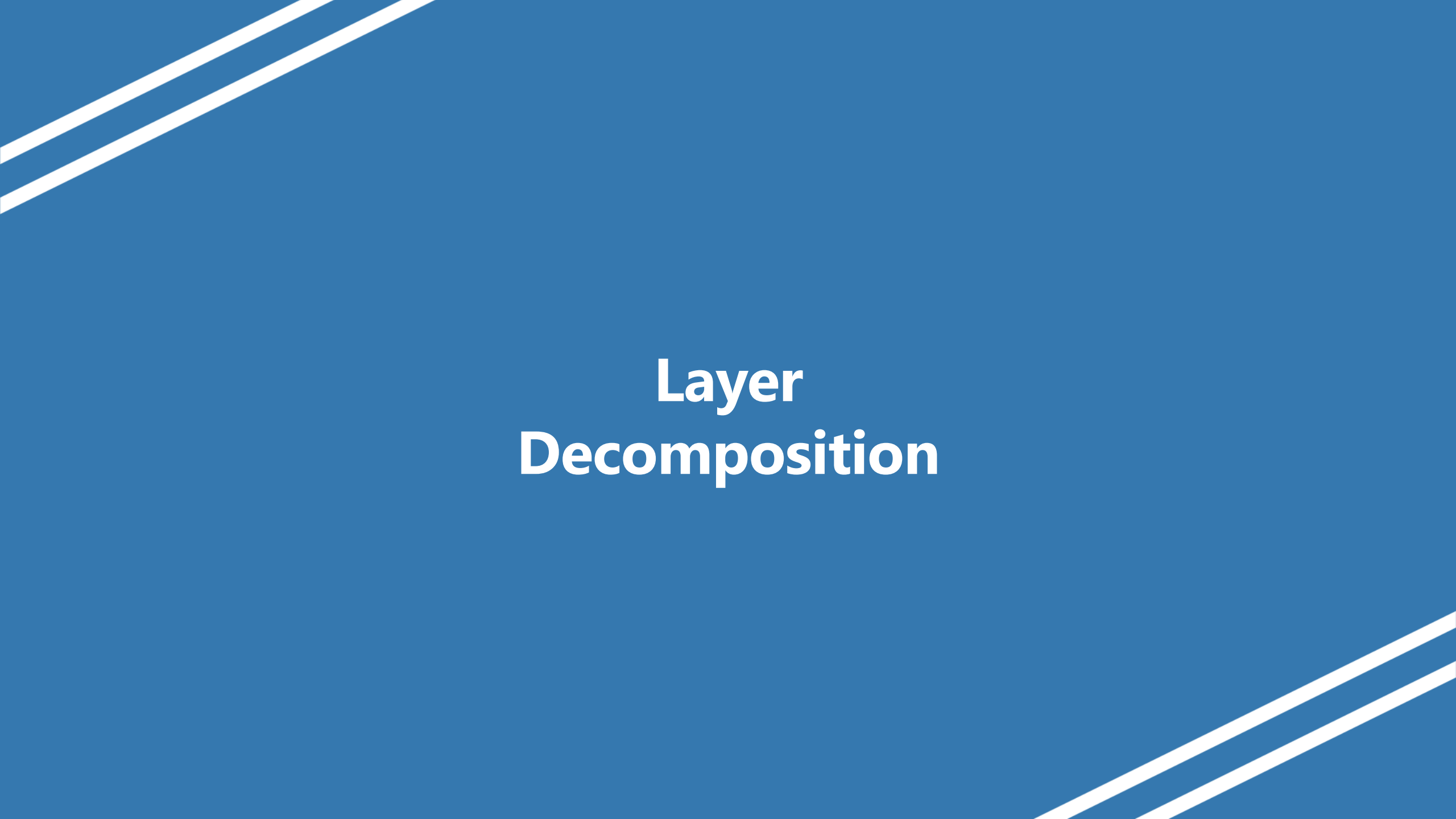


Warped Reference Face without eyes, lips and eyebrows (scaled)



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





Layer Decomposition

Layer Decomposition

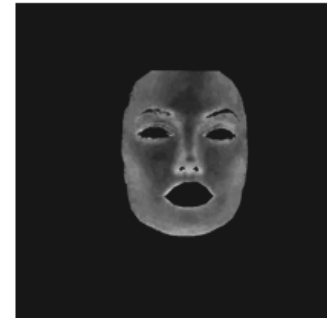
Highlights, Color Layer Decomposition

- 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.

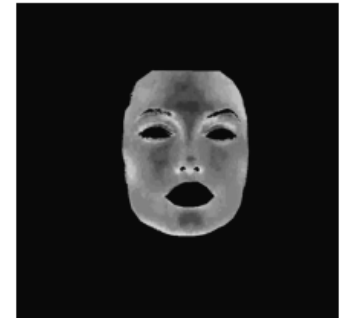
Target Layer L^*



Target Layer a^*



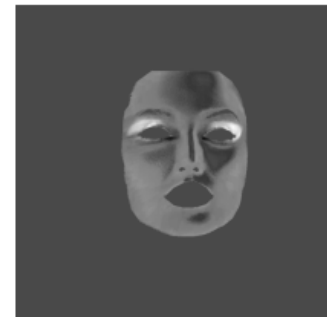
Target Layer b^*



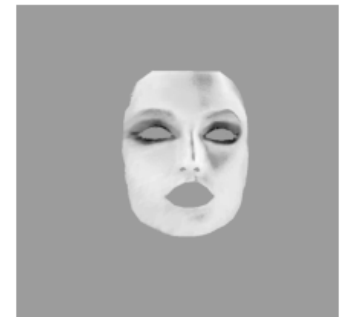
Reference Layer L^*



Reference Layer a^*



Reference Layer b^*



Layer Decomposition

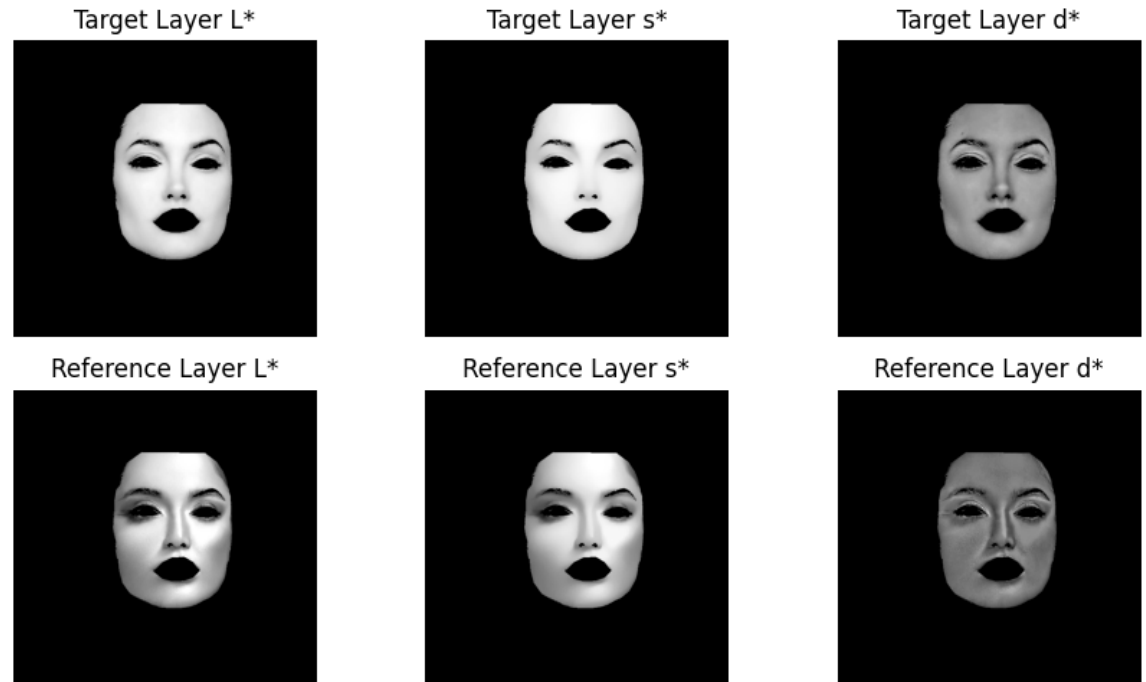
Smoothness (large scale) layer extraction by WLS filter

- The Lightness (highlight) layer L is given by,

$$L = s + d$$

where s is the large scale layer and d is the detail layer.

- s is obtained from L by applying a Weighted Least Squares (WLS) filter. The detail layer d is obtained by subtracting s from 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.

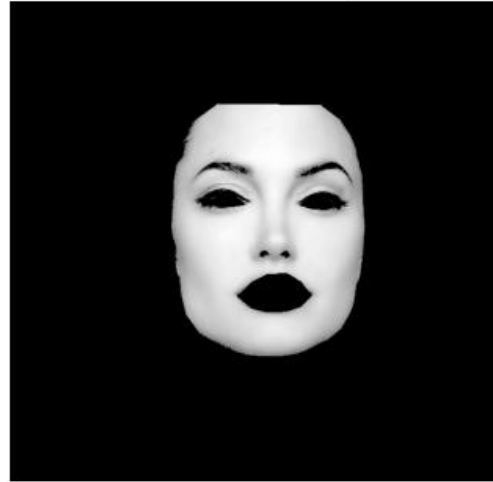


WLS Filter vs. Bilateral Filter

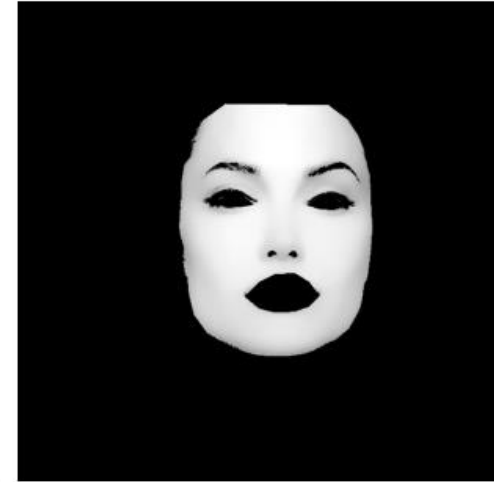
Original Image



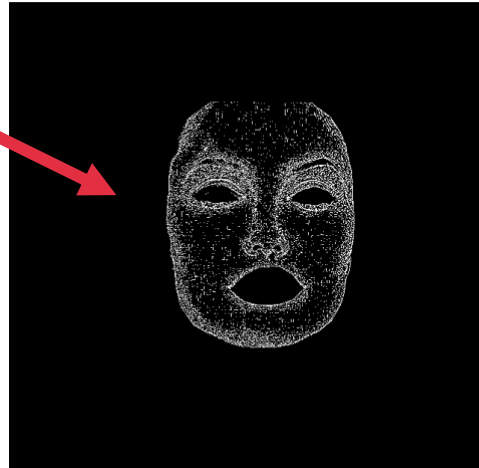
Bilateral Filter Output



WLS Filter Output



Detail Layer (Bilateral Filter)



Detail Layer (WLS 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

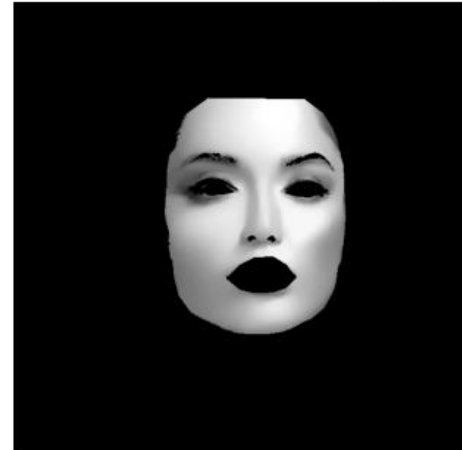
Poisson blending for final smoothness layer

- 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.

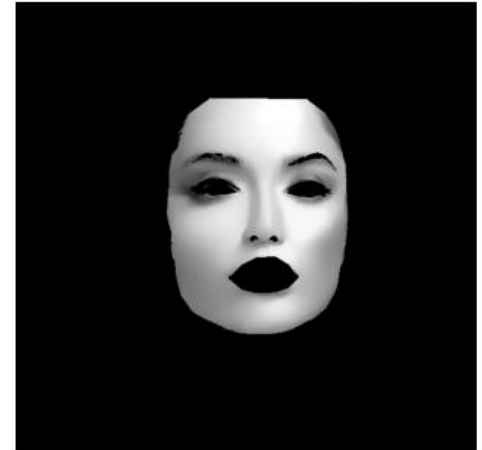
Target Smoothness Layer



Reference Smoothness Layer



Final Smoothness Layer



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.

Target Detail Layer



Reference Detail Layer



Final Detail Layer



Makeup Transfer

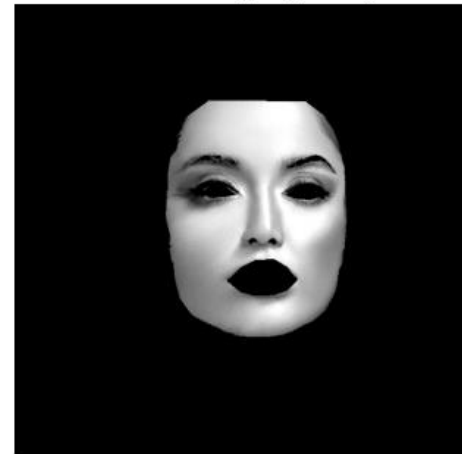
Final highlight layer

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

Target Highlight Layer



Reference Highlight Layer



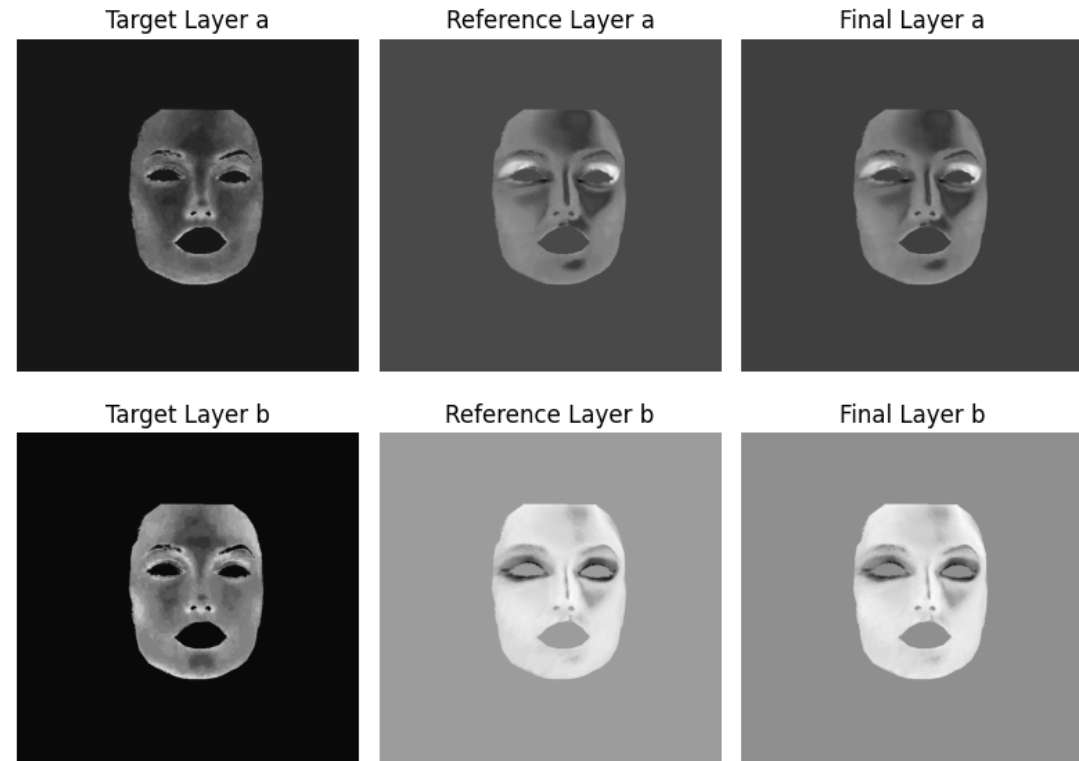
Final Highlight Layer



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





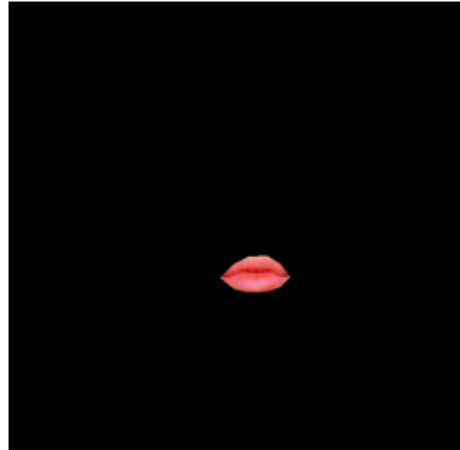
Lip Makeup Transfer

Lip Makeup Transfer

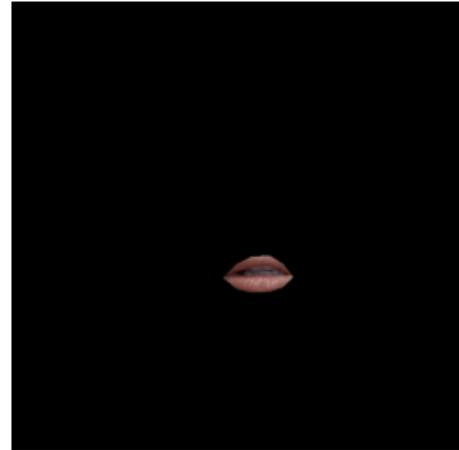
Separate processing for lip makeup transfer

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

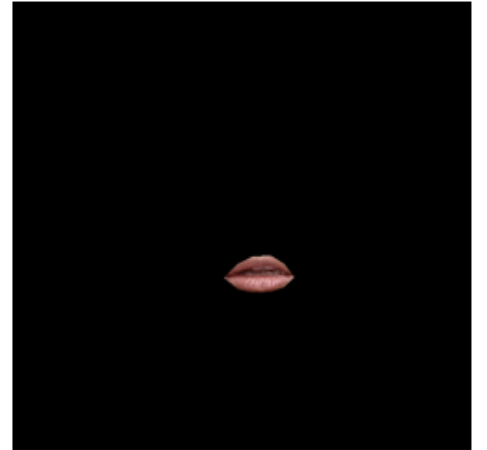
Target Lip



Warped Reference Lip



Final Lip RGB





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





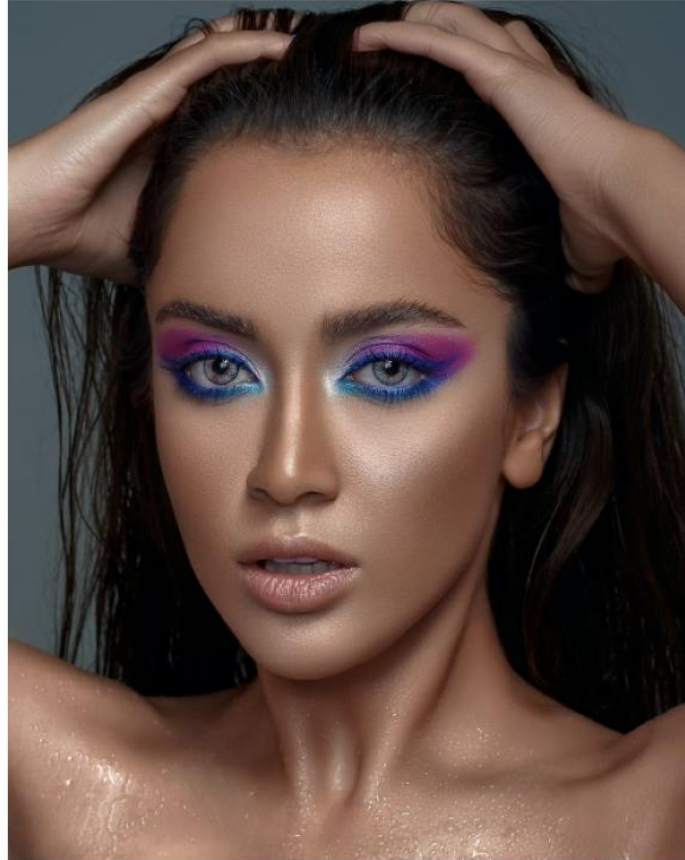
**Final
Output**

Output 1

Target Image



Reference Image



Final Image



Output 2

Target Image



Reference Image



Final Image

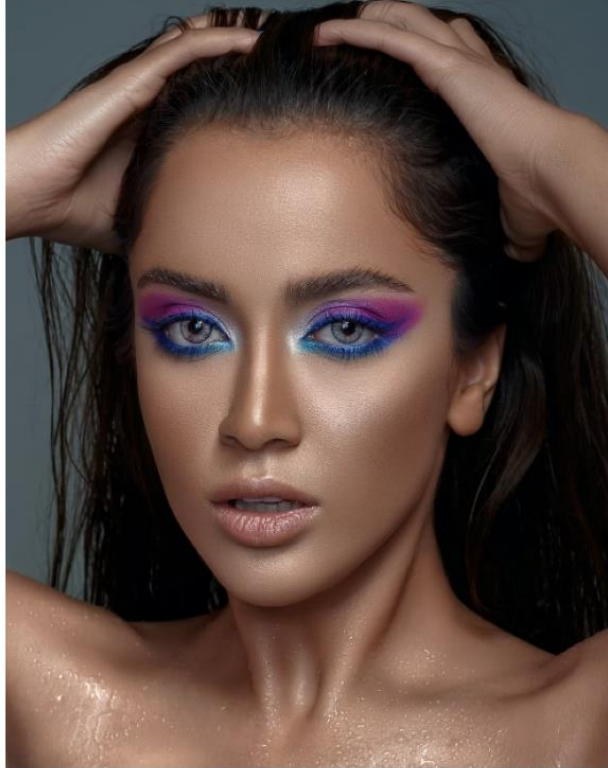


Output 3

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



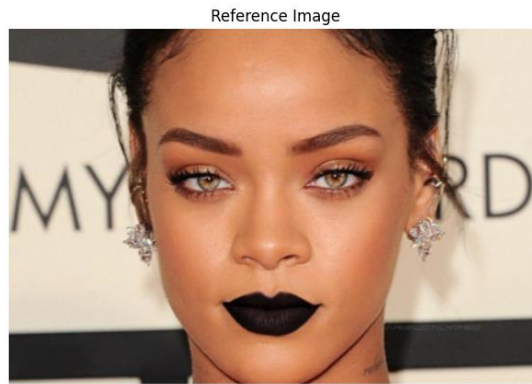


Scope of the Project

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.





**Thank
You**