An Unsupervised Approach towards Varying Human Skin Tone Using Generative Adversarial Networks

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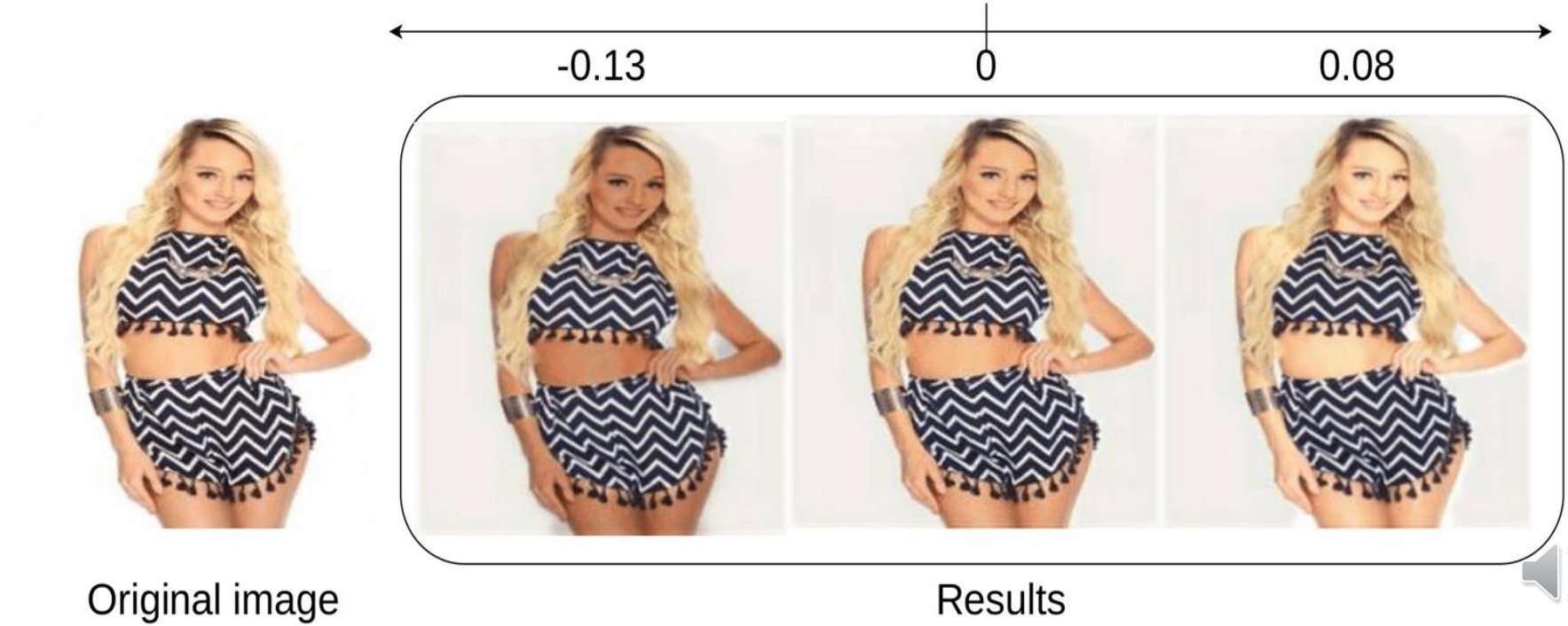
Objective

Synthesize images of a person over a varying scale of skin tone, where the tone can vary from dark to fair.



Contributions

- We trained a cGAN which takes the **image as input**, along with the value of a **conditional variable** and synthesizes **a new image** with the **skin tone of the persons in the image** changed in accordance with the **value of the variable**.
- Inspired from the concept of perceptual loss function **we propose a skin color distance based loss function** to train the cGAN.
- Our approach is **unsupervised** and **unconstrained** in terms of **pose**, **illumination**, **number of persons** in the image.

Proposed Method

- Skin segmentation
  - Objective -
    - Segmentation - skin, non-skin classification of given image
    - Skin color estimation - Estimating rgb value indicating skin tone
- Image synthesis
  - Objective -
    - Synthesizes images of varying human skin tone given a source image as input
    - Leverages the skin segmentation result from the previous stage
    - Employs the skin color estimation network as part of the loss function

Skin segmentation

- The skin segmentation network is a Convolutional Neural Network (CNN)
- Contains two subnetworks
- First subnetwork - skin, non-skin classification of image pixels.
- Loss functions - Count loss, VGG Perceptual loss, SSIM loss
  - Count loss -
    - measures the absolute difference between the counts of the skin pixels of the predicted and the ground truth image.
    - Observed to be effective in predicting binarized output

Input image

Segmentation results

Skin segmentation

- Second subnetwork - skin color estimation network
  - Training is unsupervised

Proposed Method

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Image Synthesis

- We formulate the problem as a conditional image generation problem.
- We trained a **conditional GAN** (cGAN) with inputs **- source image**, **skin segmentation**, **control variable z**
  - z = 0 -> no change of skin color
  - z < 0 -> change towards darkness
  - z > 0 -> change towards fairness

Loss function for training the cGAN

$$L_{cGAN} = l^1 + l^2 + \lambda(m \times z + l^3 - \epsilon) + L_{ADV}.$$

Where considering $\hat{x}_{z=0} = f_g(x, z = 0, \hat{x}_{seg})$ and $\hat{x}_{z\neq 0} = f_g(x, z \neq 0, \hat{x}_{seg})$, we define,

$$l^1 = L_p(\hat{x}_{z=0}, x)$$

$$l^2 = L_p(\hat{x}_{z=0} \times \hat{x}'_{seg}, x \times \hat{x}'_{seg})$$

$$l^3 = \log(0.5 - L_{color})$$

$$L_{color} = L_p^{color}(\hat{x}_{z\neq 0}, x).$$

Generator network

VGG-perceptual loss

Similar to perceptual loss but the underlying network is the skin color estimation network

Quantitative Analysis

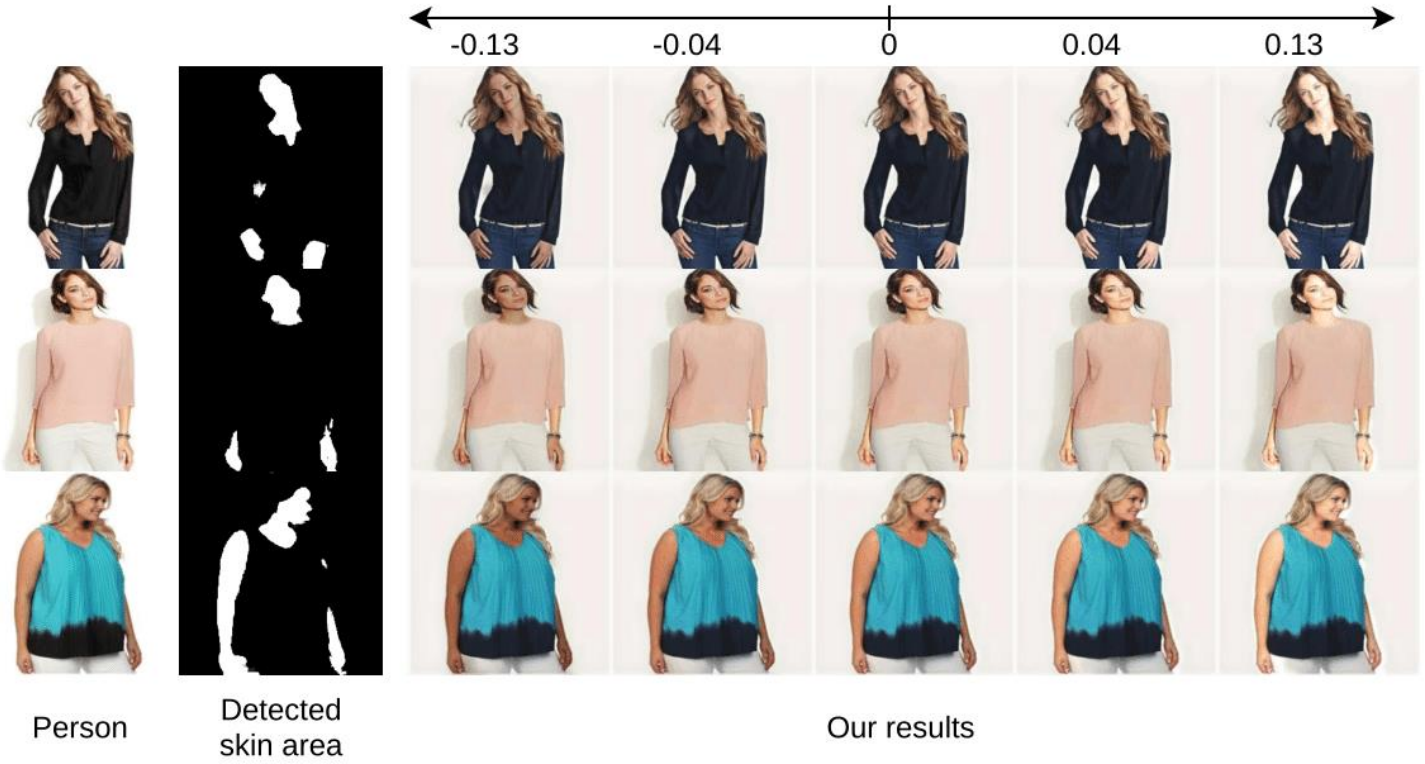
TABLE I: Values of Incepion Score (IS) and Frechet Inception Distance (FID) and SSIM on results of different data sets.

Dataset	IS↑	FID ↓	SSIM↑
In Shop	3.21 ± 0.17	38.33	0.93
Category-and-Attribute	3.58 ± 0.19	36.19	0.95
MPV	3.03 ± 0.23	42.56	0.92

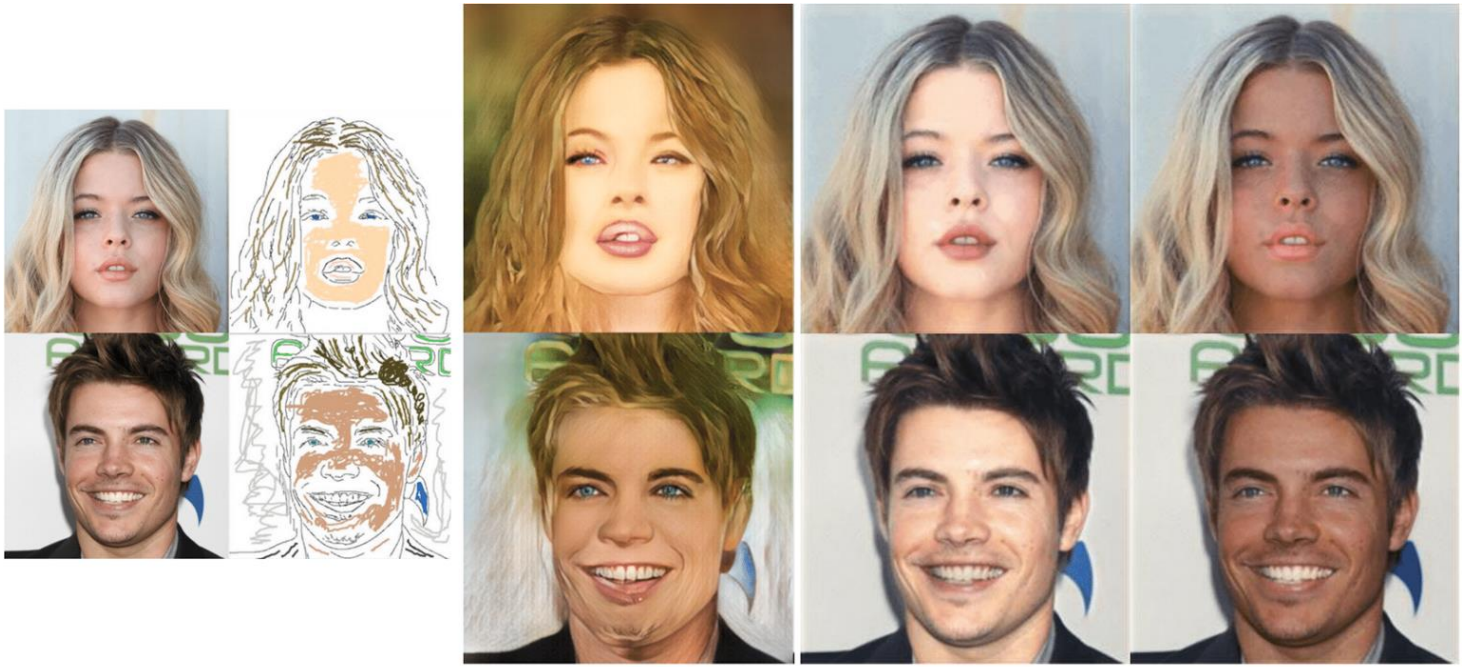
TABLE II: Values of Kolmogov-Smirnov test (KS test) statistic along with the corresponding P-values on results of different data sets.

Dataset	KS statistic ↓	P-Value↑
DeepFashion (Category-and-Attribute)	0.0249	0.5545
MPV	0.0450	0.0837

Results

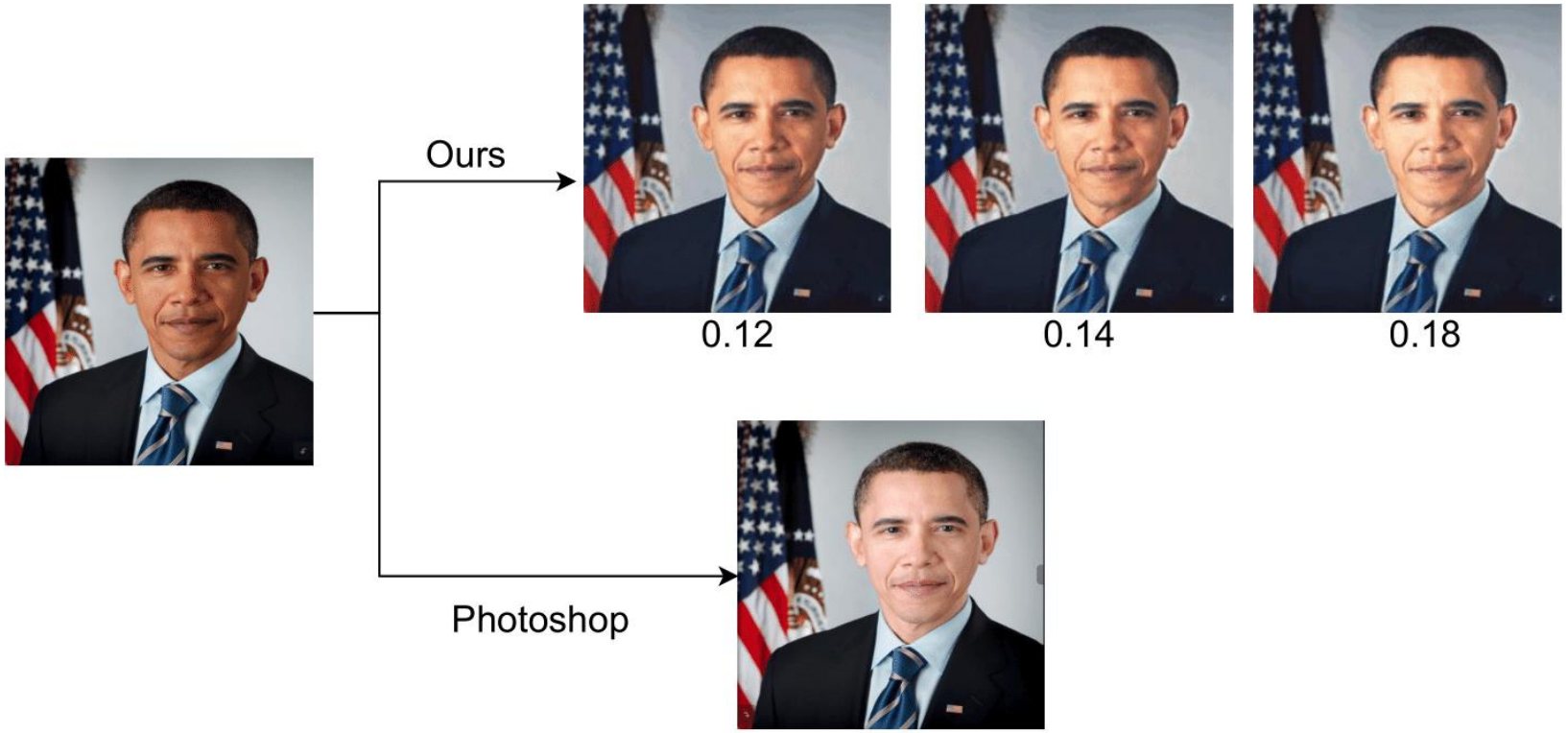


Comparison with SC-FEGAN



Person | Free-form Input | SC-FEGAN | -0.11 | Ours | 0.11

Comparison with the results of photo editor



Result on images with persons of different skin tones

Result on in-the-wild images

Source Image

Segmentation results

Result (-0.11)

Result (0.11)

Failure Case

Source Image

Segmentation result

Result (-0.13)

Thank You