Facial De-Morphing: Extracting Component Faces from a Single Morph

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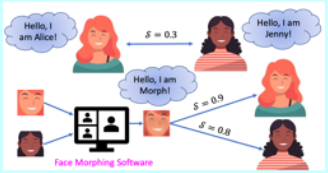
Introduction

Objective: Given a face morph, recover the component face images used to generate it (de-morphing)



Morphed face image matches to both people (security concern!)

Value

Can you tell the morphs from non-morphs?

Application: De-morphing aids in forensic analysis

Scenario: No reference image is available

Proposed Method

Methodology:
Apply a generative model to decompose a morphed face image into two identities used in creating the morph
Need crossroad losses for unordered outputs

Components:

Can we design a de-morphing technique that simultaneously recovers both IDs from a single image? Existing methods require reference image to obtain second image

$\mathcal{G}$: Generator
$\mathcal{D}_{\mathcal{C}}$: Separation critic
$\mathcal{D}_{\mathcal{M}1}, \mathcal{D}_{\mathcal{M}2}$: Markovian discriminators
$\mathcal{R}$: Reconstructor
$\mathcal{B}$: Biometric comparator

1. Generator (Decomposes morphed image) 2. Separation Critic (Separates decomposed and original images) 3. A pair of Markovian Discriminators (Local perception)

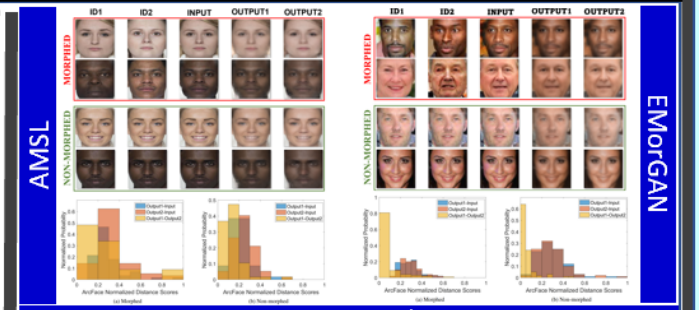
Experiments and Results

Morph Dataset	#Subjects, #Images
AMSL Face Morph (LMA)	102, 1059
EMorGAN (GAN)	301, 699
ReGenMorph (GAN)	113, 1286

Model: Generator - U-Net 128, **Separation Critic** - 4-layer Fully Convolutional Network (FCN) , **Markovian discriminators** - 3-layer FCN
#Epochs: 300; **LR**: 0.0001; ADAM solver
Loss: Min-max between G and D_C, G and $D_{M1,M2}$, Crossroad L-1 loss and Crossroad Biometric loss

$$\mathcal{L}(G, D_C, D_{Mi}) = \underbrace{\mathcal{L}_{cross}(G)}_{\text{Crossroad L1-loss function}} + \underbrace{\beta_C \mathcal{L}_{critic}(G, D_C)}_{\text{Min-max G}} + \underbrace{\beta_{biom}\mathcal{L}_{crossbiom}(G)}_{\text{Crossroad biometric loss function}} + \underbrace{\beta_M \sum_{i=1,2} \mathcal{L}_{Mi}(G, D_{Mi})}_{\text{Conditional min-max}}$$

$\beta_C = \beta_M = 0$ First 10 epochs
$\beta_C = \beta_M = 0.001$ Remaining 290



Findings

- **Biometric results (TMR):**
  AMSL: ~78%
  EMorGAN: ~53%
  ReGenMorphs: ~90%
  Non-morphed: ~100%
- **Summary:**
  1. De-morphed images are visually compelling
  2. Reasonable biometric matching with original images

Future Work

Improve matching utility of de-morphed outputs by using attention guided networks
Adapt our method to also detect morphs

REFERENCES
Ferrara et al., TIFS 2018
Scherhag et al., TIFS 2020
Banerjee and Ross, IJCB 2021
Zou et al., CVPR 2020