Attributes Aware Face Generation with Generative Adversarial Networks

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Task: Attribute to Facial Image

blond hair
female
mouth slightly open
arched eyebrows
heavy makeup

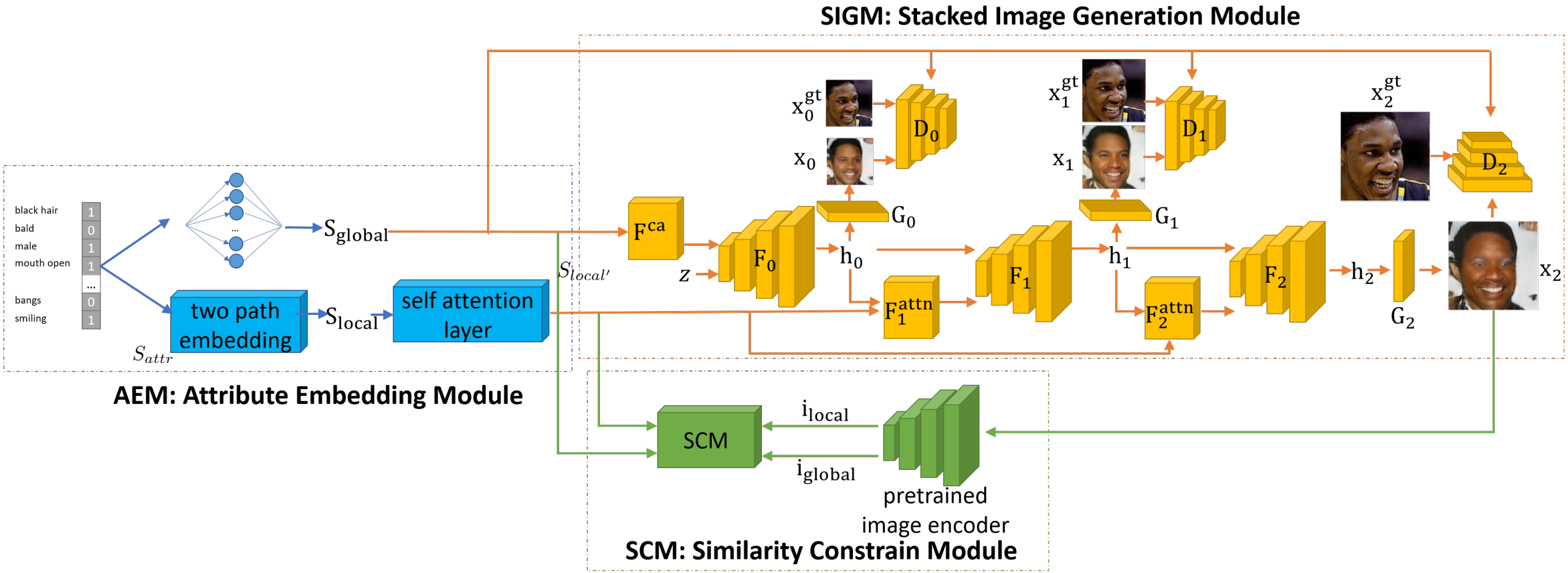
Related Work

- Text to image
  - StackGAN++, AttnGAN, MirrorGAN, etc.
  - the input is different: text vs attribute
  - can not well embed the attribute label

- Attribute to image
  - Attribute2sketch2face, Lu et al., Wang et al., etc.
  - the generated images are always low resolution
  - do not consider the relationship between different attributes

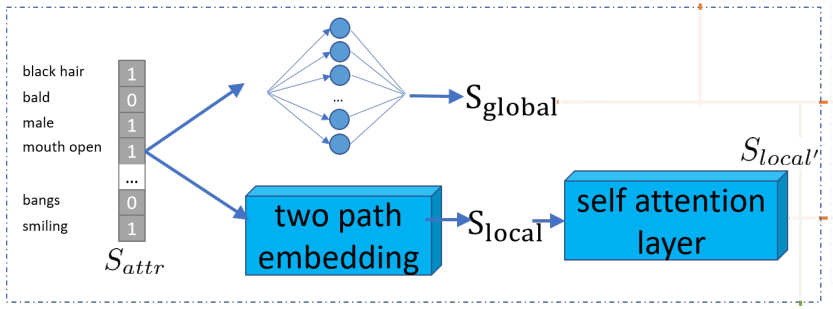
Method: AFGAN

- Attributes Aware Face Generation with Generative Adversarial Networks

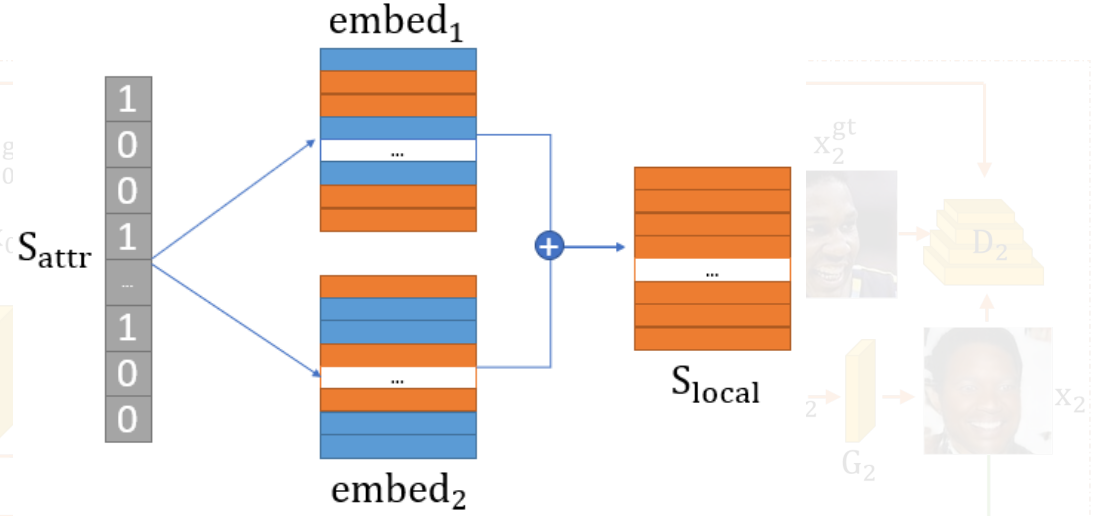


Method

- AEM: Attribute Embedding Module
  - ➢convert the input face attributes into global and local features respectively
  - ➢two path embedding: well reflect their meanings of the input attribute



AEM: Attribute Embedding Module

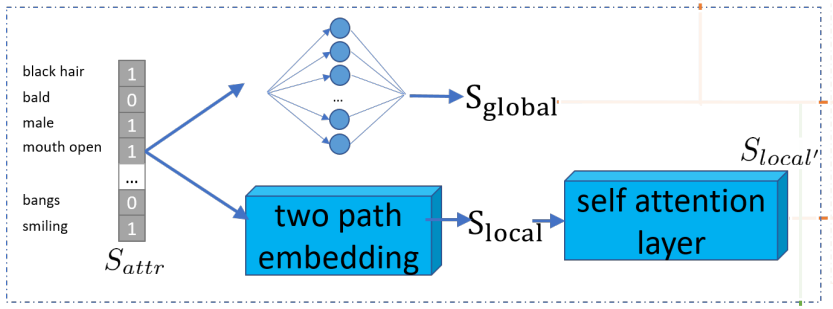


$$S_{local} = embed_1 * S_{attr} + embed_2 * (1 - S_{attr})$$

two path embedding

Method

- AEM: Attribute Embedding Module
  - ➢convert the input face attributes into global and local features respectively
  - ➢self attention layer: model the relationships between different attributes



AEM: Attribute Embedding Module

$$f(x) = W_f * S_{local} \qquad g(x) = W_g * S_{local}$$

$$s_{ij} = f(x_i)^T g(x_j) \qquad \beta_{ij} = \frac{\exp(s_{ij})}{\sum_{i=1}^{N} \exp(s_{ij})}$$

$$h(x) = W_h * S_{local} \qquad S_{local'_j} = \sum_{i=1}^{N} \beta_{ij} h(x_i)$$

$$S_{local'} = (S_{local'_1}, S_{local'_2}, \cdots, S_{local'_N}) \in \mathbb{R}^{C \times N}$$

self attention layer

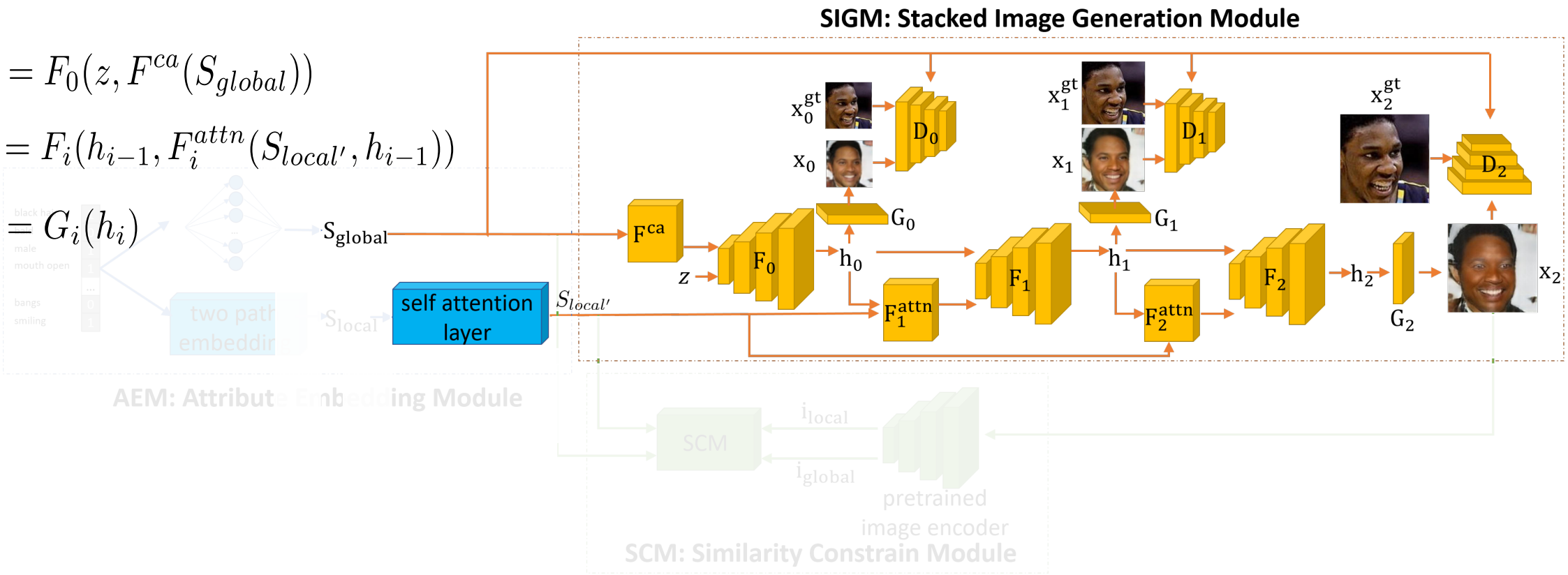
Method

- SIGM: Stacked Image Generation Module
  - ➢gradually generate faces with more details through a three-stage generator
  - ➢can generate images with high resolution

$$h_0 = F_0(z, F^{ca}(S_{global}))$$

$$h_i = F_i(h_{i-1}, F_i^{attn}(S_{local'}, h_{i-1}))$$

$$x_i = G_i(h_i)$$



Method

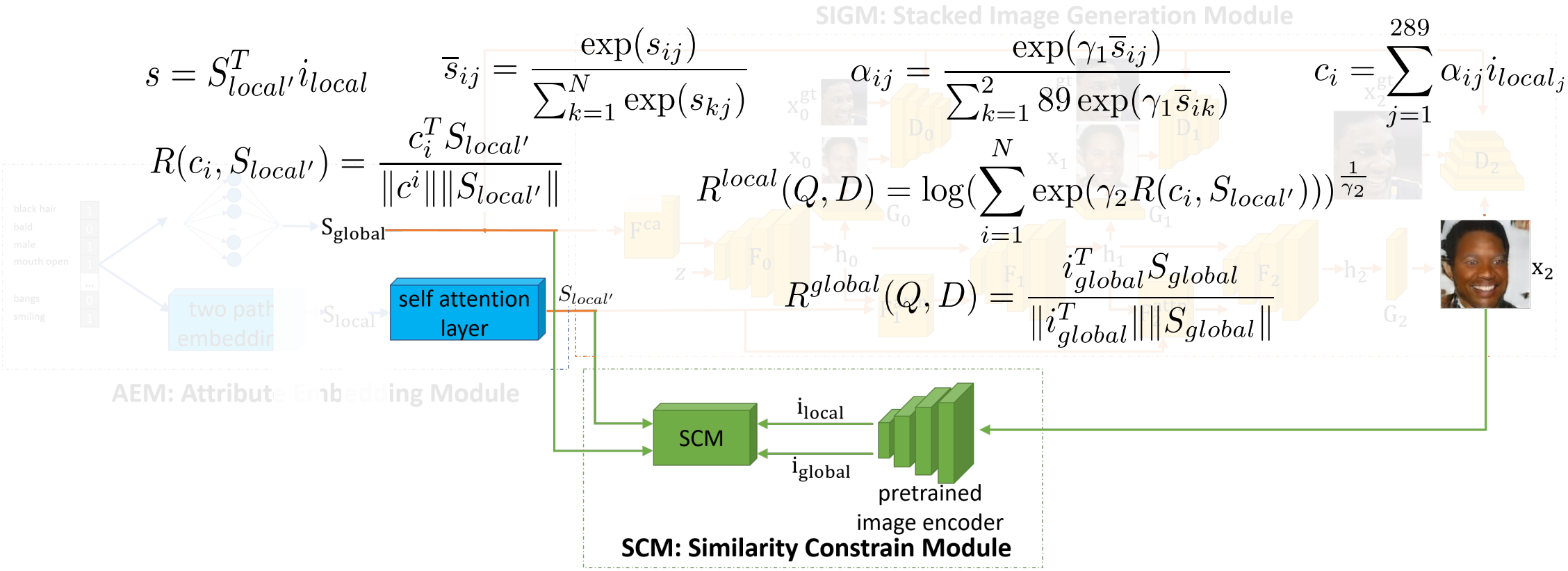
- SCM: Similarity Constrain Module
  - ➢encode the generated images with a pretrained model: i_{local} and i_{global}
  - ➢calculate the matching degree between attribute features and image features
  - ➢the generated images can match the input attributes well

$$s = S_{local'}^{T} i_{local} \qquad \overline{s}_{ij} = \frac{\exp(s_{ij})}{\sum_{k=1}^{N} \exp(s_{kj})} \qquad \alpha_{ij} = \frac{\exp(\gamma_1 \overline{s}_{ij})}{\sum_{k=1}^{2} 89 \exp(\gamma_1 \overline{s}_{ik})} \qquad c_i = \sum_{j=1}^{289} \alpha_{ij} i_{local_j}$$

$$R(c_i, S_{local'}) = \frac{c_i^T S_{local'}}{\|c^i\| \|S_{local'}\|}$$

$$R^{local}(Q, D) = \log(\sum_{i=1}^{N} \exp(\gamma_2 R(c_i, S_{local'})))^{\frac{1}{\gamma_2}}$$

$$R^{global}(Q, D) = \frac{i_{global}^T S_{global}}{\|i_{global}^T\| \|S_{global}\|}$$



Formulation

- Generator
  - Overall objective function

$$\mathcal{L} = \mathcal{L}_G + \mathcal{L}_{SCM}$$

  - In SIGM

$$\mathcal{L}_G = \sum_{i=0}^{2} \mathcal{L}_{G_i} \qquad \mathcal{L}_{G_i} = -\frac{1}{2}\mathbb{E}_{x_i \sim p_{G_i}} \left[\log\left(D_i\left(x_i\right)\right)\right] - \frac{1}{2}\mathbb{E}_{x_i \sim p_{G_i}} \left[\log\left(D_i\left(x_i, S_{global}\right)\right)\right]$$

unconditional conditional

  - In SCM

$$\mathcal{L}_{SCM} = \mathcal{L}_1^{local} + \mathcal{L}_2^{local} + \mathcal{L}_1^{global} + \mathcal{L}_2^{global}$$

$$\mathcal{L}_1^{local} = -\sum_{i=1}^{M} \log P^{local}\left(D_i|Q_i\right) \qquad \mathcal{L}_2^{local} = -\sum_{i=1}^{M} \log P^{local}\left(Q_i|D_i\right)$$

$$\mathcal{L}_1^{global} = -\sum_{i=1}^{M} \log P^{global}\left(D_i|Q_i\right) \qquad \mathcal{L}_2^{global} = -\sum_{i=1}^{M} \log P^{global}\left(Q_i|D_i\right)$$

Formulation

- The matching degree between generated images and input attributes

$$P^{local}\left(Q_i|D_i\right)=\frac{\exp\left(\gamma_3 R^{local}\left(Q_i,D_i\right)\right)}{\sum_{j=1}^{M}\exp\left(\gamma_3 R^{local}\left(Q_j,D_i\right)\right)} \qquad P^{local}\left(D_i|Q_i\right)=\frac{\exp\left(\gamma_3 R^{local}\left(Q_i,D_i\right)\right)}{\sum_{j=1}^{M}\exp\left(\gamma_3 R^{local}\left(Q_i,D_j\right)\right)}$$

$$P^{global}\left(Q_i|D_i\right)=\frac{\exp\left(\gamma_3 R^{global}\left(Q_i,D_i\right)\right)}{\sum_{j=1}^{M}\exp\left(\gamma_3 R^{global}\left(Q_j,D_i\right)\right)} \qquad P^{global}\left(D_i|Q_i\right)=\frac{\exp\left(\gamma_3 R^{global}\left(Q_i,D_i\right)\right)}{\sum_{j=1}^{M}\exp\left(\gamma_3 R^{global}\left(Q_i,D_j\right)\right)}$$

- Discriminator

$$\mathcal{L}_D=\sum_{i=0}^{2}\mathcal{L}_{D_i}$$

$$\begin{aligned}\mathcal{L}_{D_i}=&-\frac{1}{2}\mathbb{E}_{x_i^{gt}\sim p_{data_i}}\left[\log D_i\left(x_i^{gt}\right)\right]-\frac{1}{2}\mathbb{E}_{x_i\sim p_{G_i}}\left[\log\left(1-D_i\left(x_i\right)\right)\right] \quad \text{unconditional}\\ &-\frac{1}{2}\mathbb{E}_{x_i^{gt}\sim p_{data_i}}\left[\log D_i\left(x_i^{gt},S_{global}\right)\right]\\ &-\frac{1}{2}\mathbb{E}_{x_i\sim p_{G_i}}\left[\log\left(1-D_i\left(x_i,S_{global}\right)\right)\right] \quad \text{conditional}\end{aligned}$$

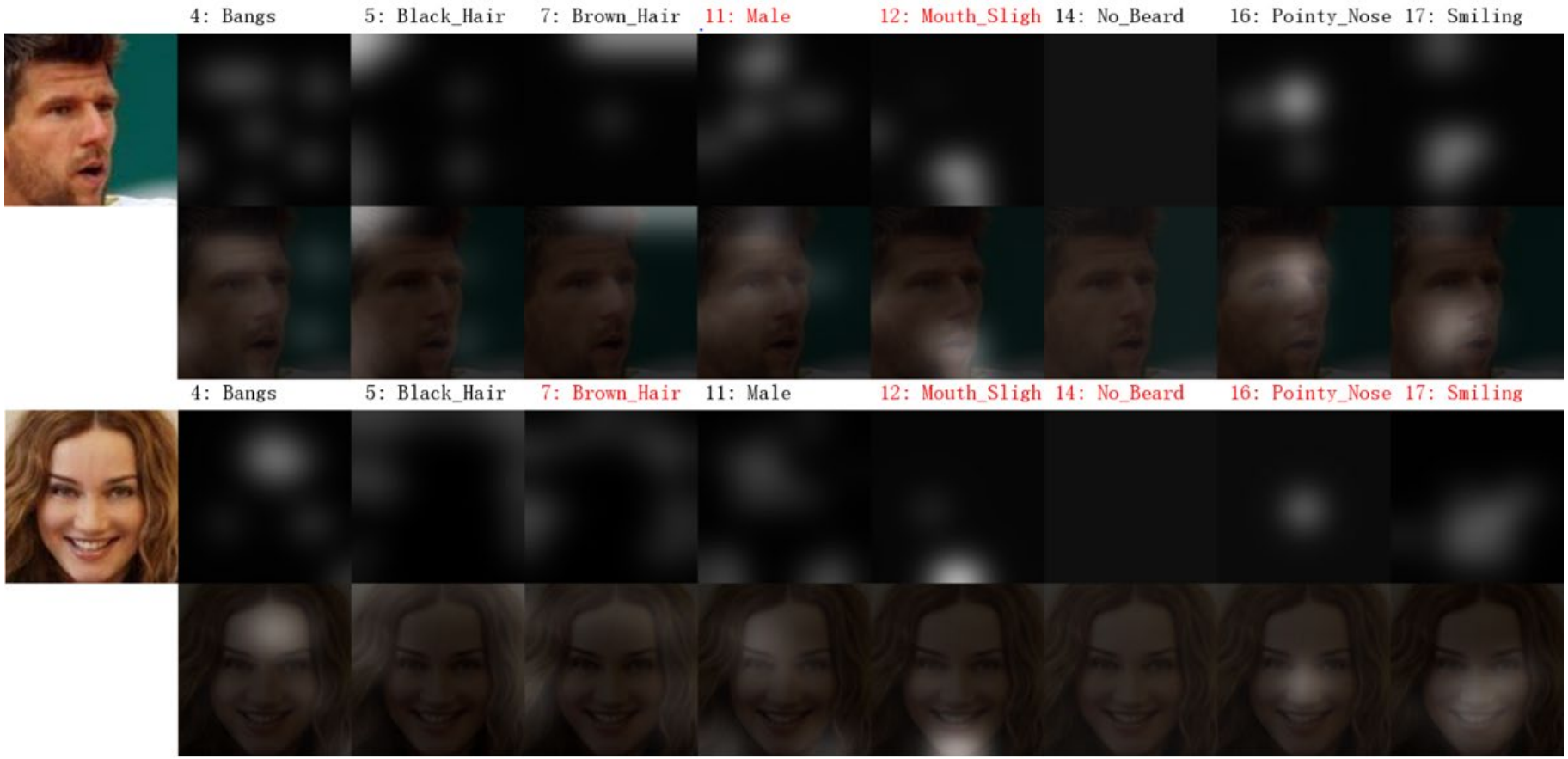
Experiment

- Dataset: CelebA
- Attribute: 18 attributes selected from full 40 attributes

No.	Attribute	No.	Attribute
0	5 o'clock Shadow	9	Eyeglasses
1	Arched Eyebrows	10	Gray Hair
2	Bags Under Eyes	11	Male
3	Bald	12	Mouth Slightly Open
4	Bangs	13	Narrow Eyes
5	Black Hair	14	No Beard
6	Blond Hair	15	Pale Skin
7	Brown Hair	16	Pointy Nose
8	Bushy Eyebrows	17	Smiling

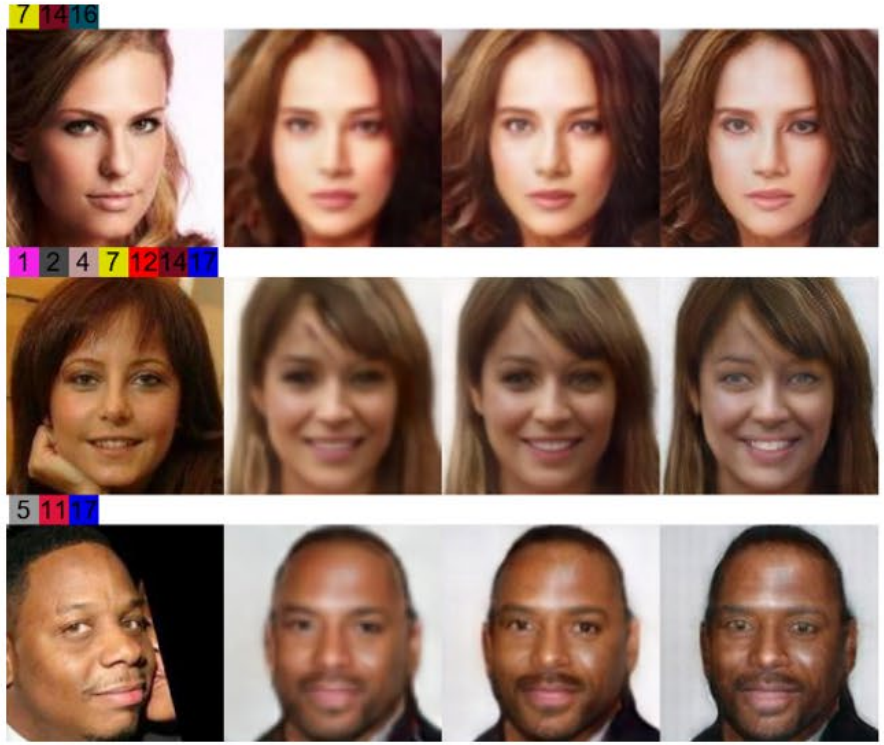
Experiment

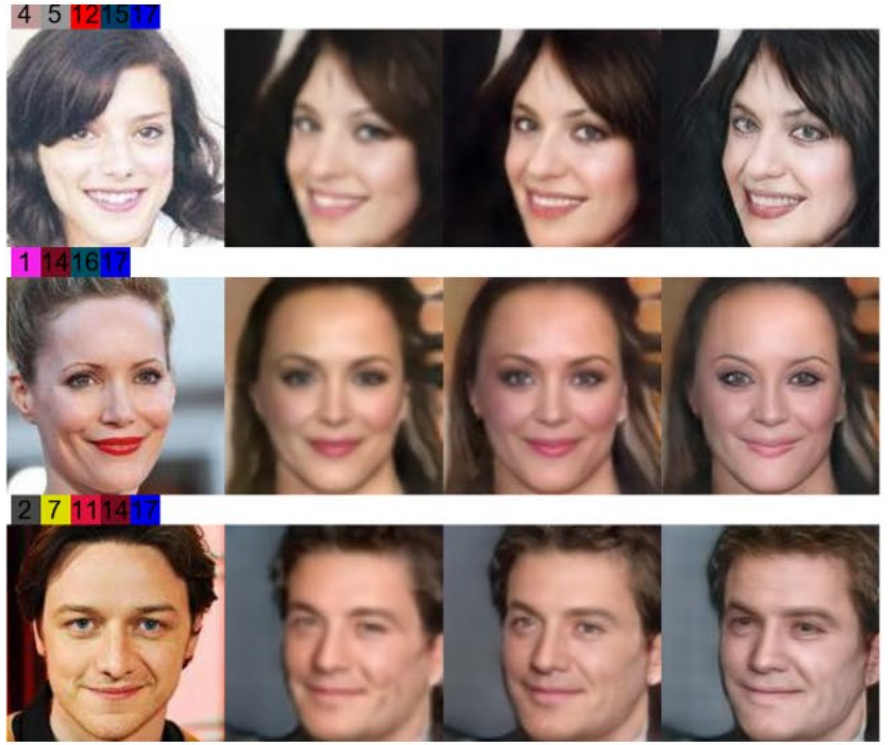
- The attention maps in SCM module
  - ➢the response areas of different attributes are consistent with common sense

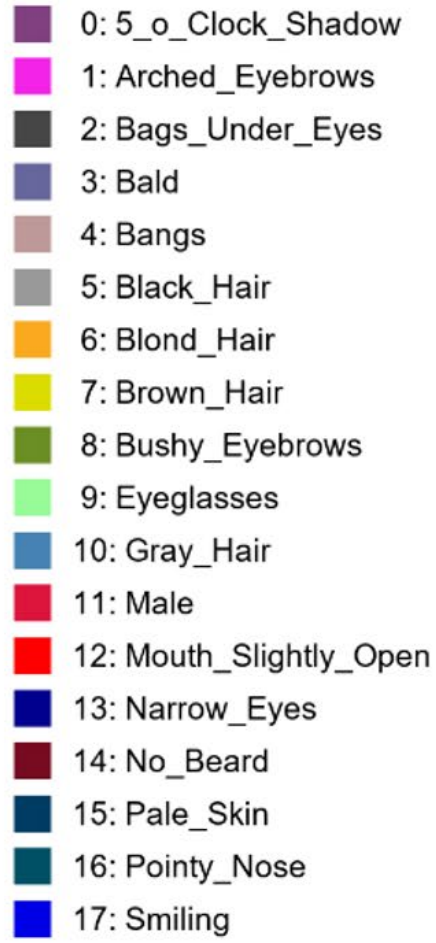


Experiment

- The generated face images of three stages in SIGM module
  - ➢the faces generated in the three stages are consistent
  - ➢more details in higher resolution images







Experiment

- The generated face images in ablation study of AFGAN model
  - ➢the quality of the images generated by AFGAN is clearer and more realistic

Setting	Classification accuracy
AttnGAN	0.902
AFGAN w/o AEM	0.924
AFGAN w/o SCM	0.940
AFGAN(ours)	**0.955**

- The quantitative evaluation of generated images

	BRISQUE↓	IS↑	FID↓	MS-SSIM↓
AttnGAN	62.843	5.124	40.254	0.398
Wang et al.	——	2.2	43.8	——
AFGAN(ours)	**35.979**	**5.853**	**36.607**	**0.347**

Project Code

Thank you!

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