Group-wise Feature Orthogonalization and Suppression for GAN based Facial Attribute Translation

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Outline

1. Background
2. Methods
3. Experimental Results
4. Conclusions

Background

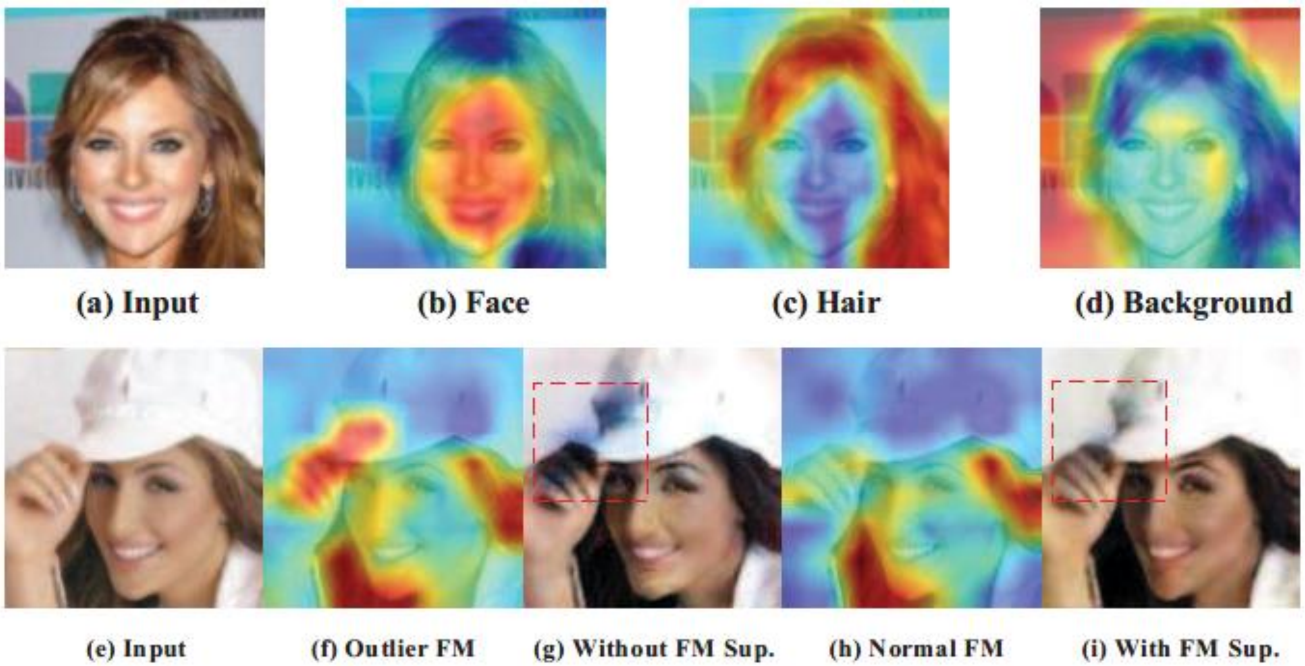
- Attribute entanglement
  - Poor generalization ability

input

output

Motivation

- Excavate semantic attributes
- Outlier feature maps



Methods

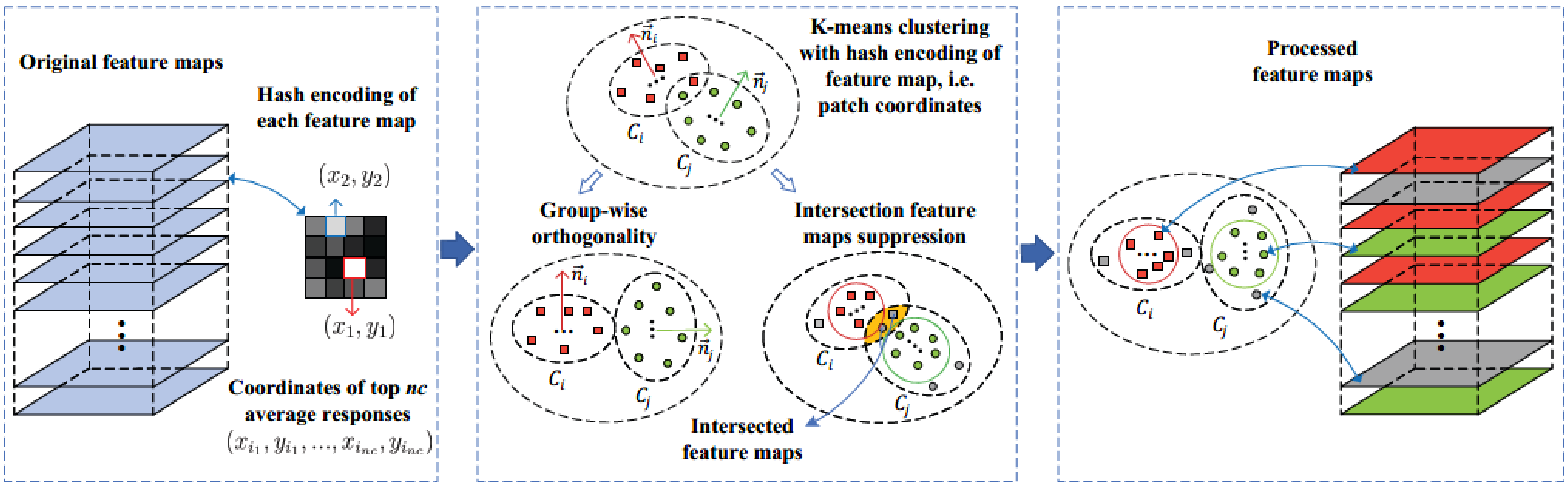
1. Group-wise feature orthogonality

2. Intersection feature suppression

3. Constrained by the two methods

Methods

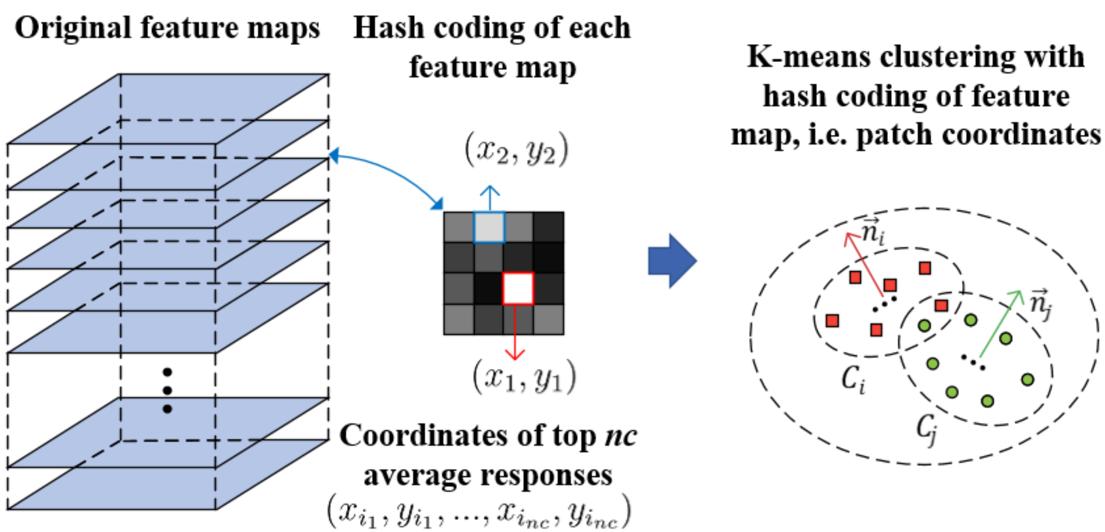
The framework of the proposed methods



(a) (b) (c) (d)

Methods

- Feature Map Encoding and Clustering
  - the runtime costs largely reduced
  - excavate semantic attributes



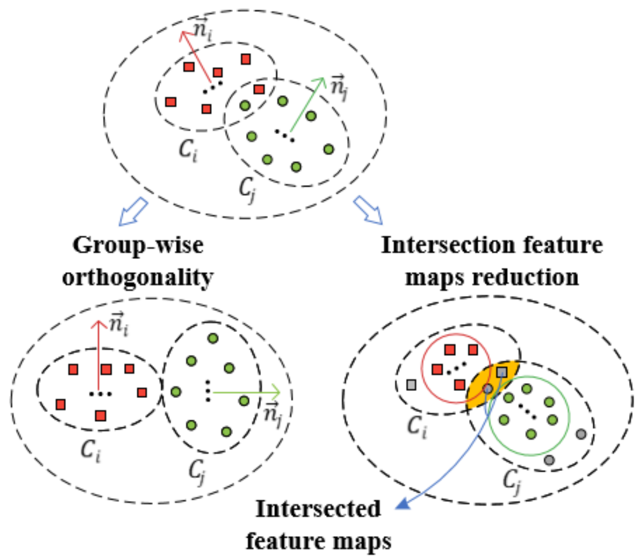
Methods

Group-wise Feature Orthogonality and Suppression

(1) $$\mathcal{L}_{GO} = \frac{2}{m(m-1)} \Sigma_i \Sigma_j g_i^T g_j.$$

(2) $$d_i = ||f_i - \frac{1}{N^{(r)}} \sum_j f_j||_2 \sim \mathcal{N}(0, \frac{\gamma}{\sqrt{2n} N^{(r)}})$$

(3) $$d_i > \kappa \frac{\gamma}{\sqrt{2n} N^{(r)}}$$



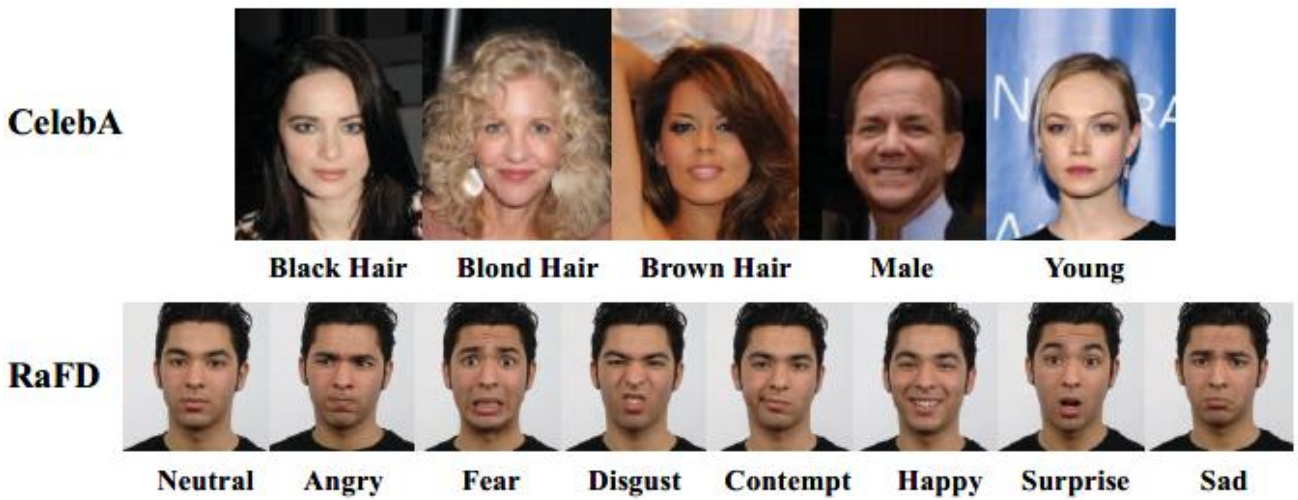
Methods

Network loss function

$$
\begin{cases}
\mathcal{L}_{drop} = E_{x,c'}[||G(x,c') - G_{drop}(x,c')||_1], \\
\mathcal{L}_{rec} = E_{x,c,c'}[||x - G_{drop}(G(x,c'),c)||_1], \\
\mathcal{L}_{G} = \mathcal{L}_{OriG} + \lambda_{drop}\mathcal{L}_{drop} + \lambda_{rec}\mathcal{L}_{rec} + \lambda_{GO}\mathcal{L}_{GO}, \\
\mathcal{L}_{D} = \mathcal{L}_{OriD}.
\end{cases}
$$

Experiment

- Baselines and Dataset
  - StarGAN[1], AttGAN[2]



[1] Stargan: Unified generative adversarial networks for multi-domain image-to-image translation. In: CVPR (2018).

[2] Zhenliang He, et al.: Attgan: Facial attribute editing by only changing what you want. In: TIP (2019).

Experiment

- Hash Encoding
  - Does not cause Information degradation
  - The runtime costs largely reduced

Based on StarGAN+GO+IFS for RaFD
- GO(Group-wise orthogonality), IFS(Intersection feature suppression)

Method	Accuracy ↑	IS ↑	FID ↓	RT ↓
Hash encoding	98.41%	**2.770**	**43.51**	**0.102**
PCA	98.21%	2.769	44.71	0.261
Direct vectorization	**98.81%**	2.759	46.92	1.289

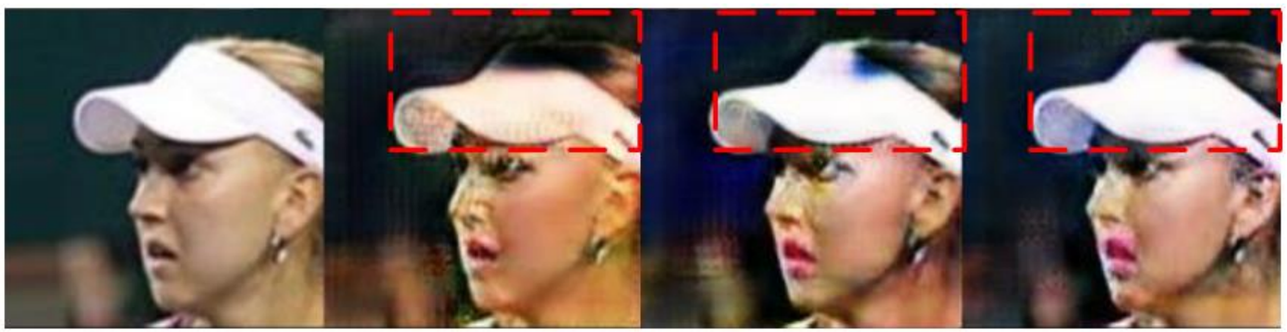
↑ means larger numbers are preferred, ↓ means opposite.

Visual Results

- Two orthogonality strategies

(a) Input (b) StarGAN (c) Feature map-wise orthogonality (d) Group-wise orthogonality

- Intersection feature suppression



(a)Input (b)StarGAN (c)Offline (d)Online

Visual Results

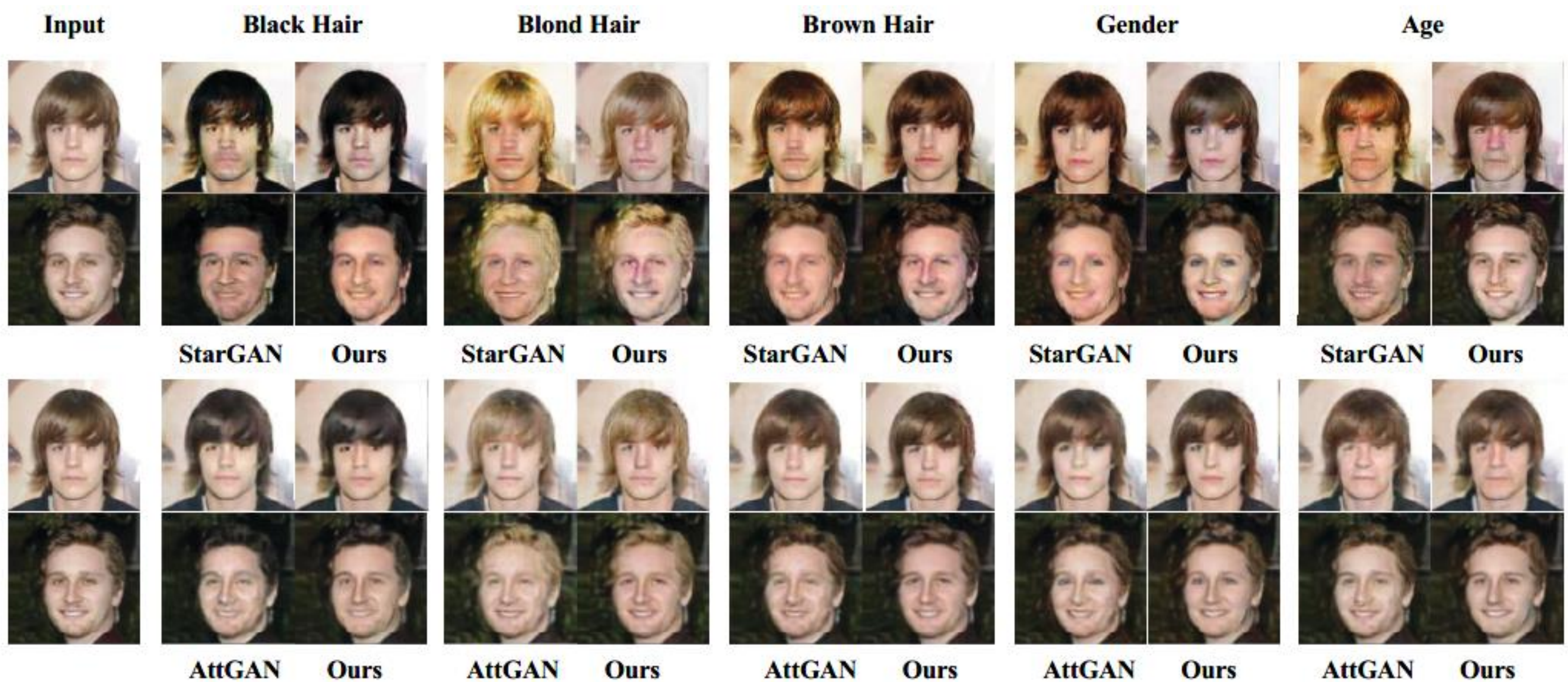
- Ablation study
  - IFS (intersection feature suppression)
  - GO (group-wise orthogonality)

Visual Results

- Hair color translation

Visual Results

- Comparison with StarGAN and AttGAN



Quantitative Results

- CelebA and RaFD

Meas.	Method	Black	Blond	Brown	Gender	Age
Acc. ↑	*StarGAN*	66.77	**78.98**	55.96	60.06	**63.46**
	Ours	**78.08**	71.37	**63.76**	**63.06**	63.36
	AttGAN	50.55	31.23	34.33	63.96	58.16
	Ours	**55.16**	**42.14**	**36.04**	**65.97**	**69.37**
IS ↑	*StarGAN*	1.178	1.182	1.014	1.200	1.122
	Ours	**1.204**	**1.237**	**1.033**	**1.221**	**1.127**
	AttGAN	1.317	1.329	1.131	1.310	1.111
	Ours	**1.331**	**1.344**	**1.157**	**1.325**	**1.121**
FID ↓	*StarGAN*	65.90	93.06	71.28	105.06	85.58
	Ours	**58.86**	**79.92**	**64.86**	**101.73**	**76.68**
	AttGAN	62.29	84.94	66.41	101.03	82.56
	Ours	**56.63**	**82.51**	**60.97**	**98.78**	**78.06**

↑ means larger numbers are preferred, ↓ means opposite.

Method	Accuracy ↑	IS ↑	FID ↓
StarGAN	97.62%	2.516	46.59
StarGAN+IFS	97.02%	2.673	46.53
StarGAN+GO	97.62%	2.617	44.56
StarGAN+IFS+GO	**98.41%**	**2.770**	**43.51**
AttGAN	65.48%	2.785	60.39
AttGAN+IFS	69.84%	2.803	51.02
AttGAN+GO	70.63%	2.827	**50.01**
AttGAN+IFS+GO	**73.02%**	**2.918**	53.24

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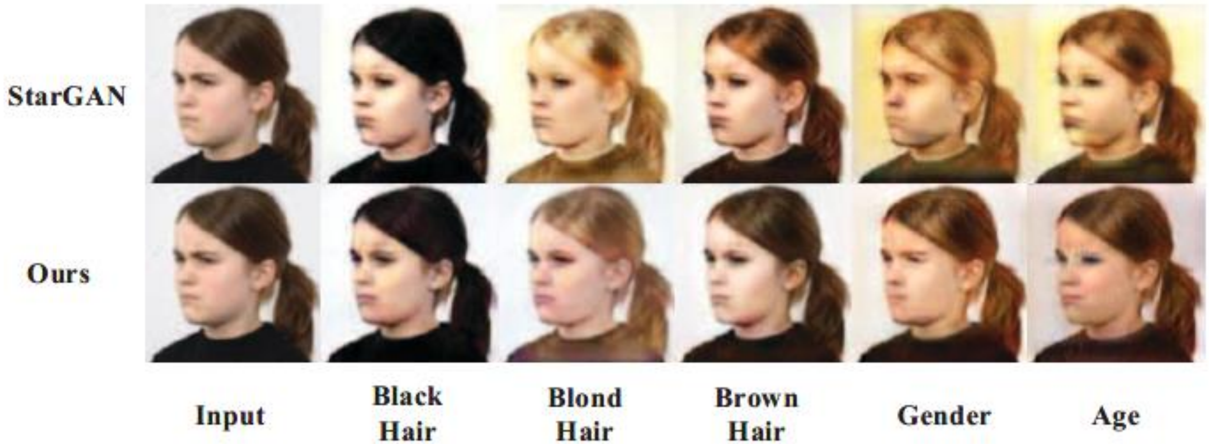
Generalization Performances

- Visual and quantitative results

CelebA and RaFD are used for training and testing



Metric	Method	Black	Blond	Brown	Gender	Age
Acc. ↑	*StarGAN*	53.75	**62.50**	57.29	70.63	66.67
	Ours	**80.42**	50.63	**60.63**	**74.79**	**77.50**
	AttGAN	56.46	**15.83**	43.33	41.04	50.42
	Ours	**59.17**	11.46	**49.58**	**44.38**	**74.38**
IS ↑	*StarGAN*	1.192	1.083	1.003	1.126	1.067
	Ours	**1.211**	**1.087**	**1.024**	**1.176**	**1.078**
	AttGAN	1.238	1.050	1.180	1.028	1.069
	Ours	**1.276**	**1.052**	**1.183**	**1.050**	**1.082**
FID ↓	*StarGAN*	138.74	169.35	150.26	176.01	188.59
	Ours	**136.85**	**163.49**	**142.78**	**161.10**	**172.46**
	AttGAN	**138.97**	191.56	**152.34**	184.23	171.03
	Ours	139.43	**184.73**	154.79	**170.23**	**156.69**

↑ means larger numbers are preferred, ↓ means opposite.

Conclusions

1. group-wise orthogonalization and intersection feature suppression.
2. semantic attribute disentanglement improve network generalization ability.
3. synthesize much more genuine images and significantly less abnormality.