GAN with Multivariate Disentangling for Controllable Hair Editing

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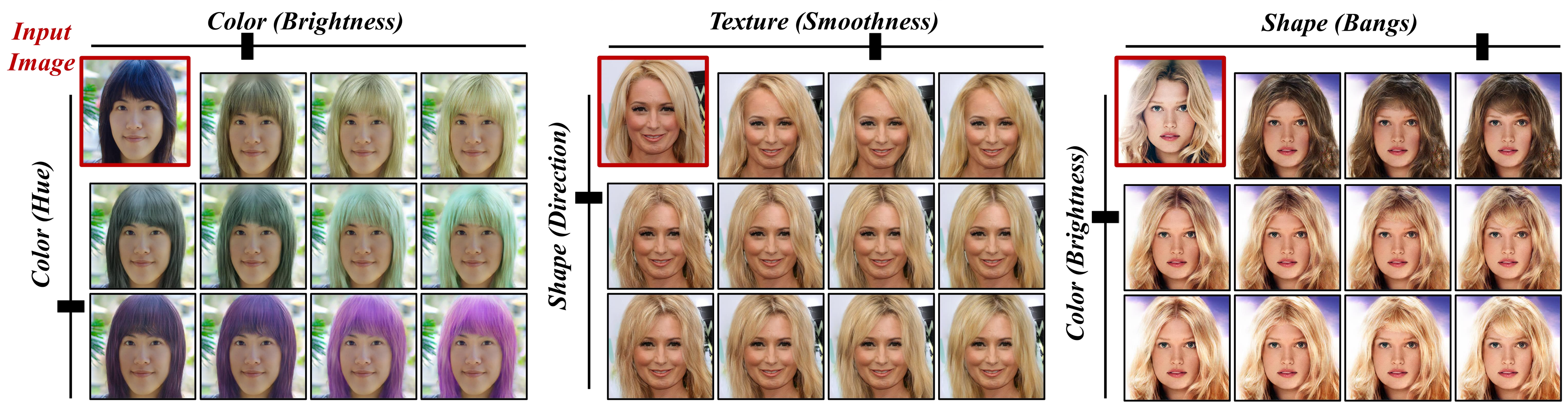
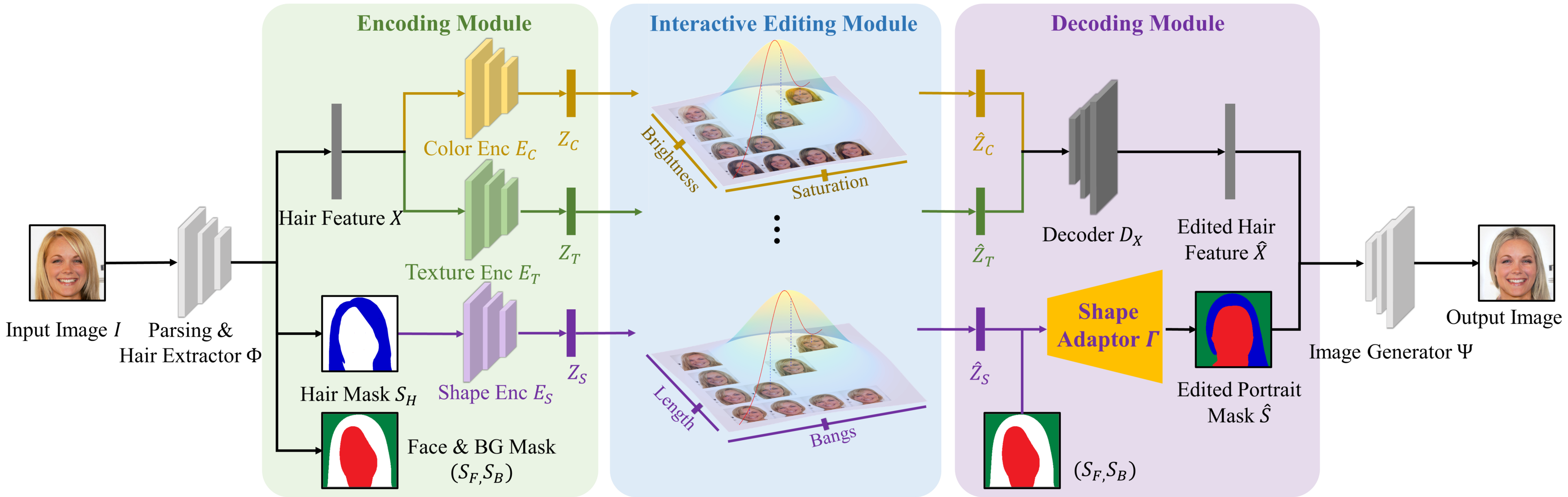
1. Task – controllable hair editing: continuous, fine-grained



2. Method

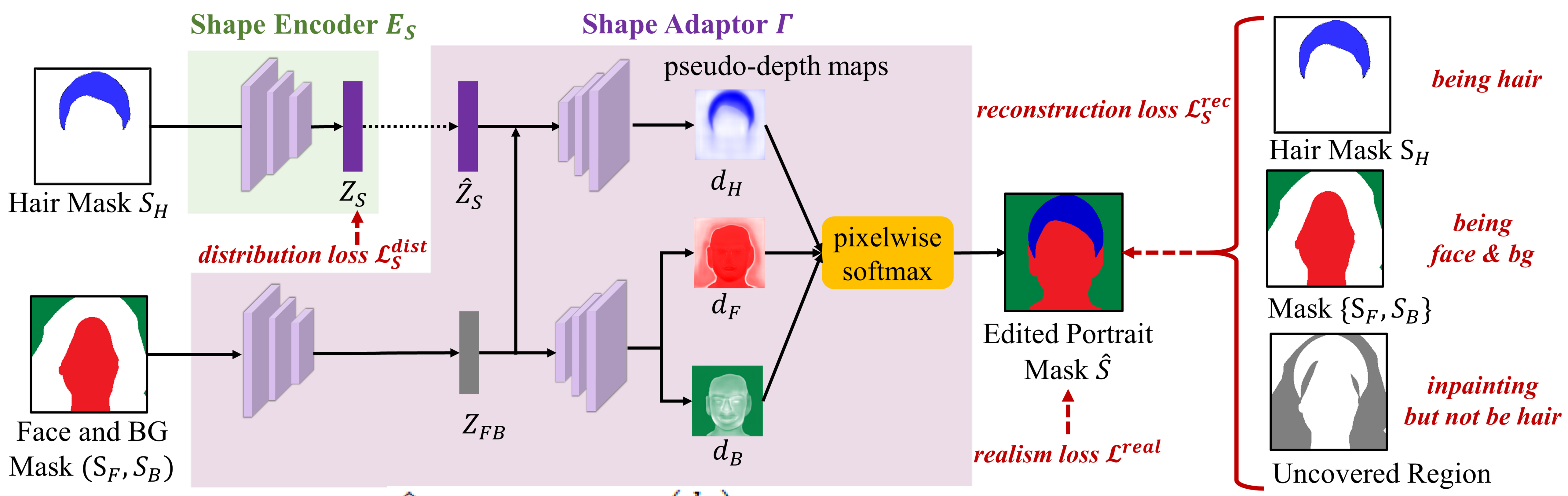
- **Disentangle** hair into three attribute representations: **color Z_C**, **texture Z_T** and **shape Z_S**. Model each representation as a **standard multivariate Gaussian distribution** for continuous editing within a reasonable range of values



- **Interactive editing**

$$(Z_C, Z_T, Z_S) \xrightarrow{f_{\text{sliding bars}};\ f_{\text{references}};\ f_{\text{painted mask}}} (\hat{Z}_C, \hat{Z}_T, \hat{Z}_S)$$

- **A learning-based shape adaptor** for hair alignment and face inpainting



$$\hat{S}_k = \frac{\exp(d_k)}{\sum_{m \in \{H,F,B\}} \exp(d_m)} \quad (k \in \{H, F, B\})$$

3. Training Objectives

Realism (GAN) Loss

Reconstruction Loss: constrain the correctness of the attribute editing

Distribution Loss: model each representation as a Gaussian

$$\mathcal{L} = \lambda^{real}\mathcal{L}^{real} + \sum_{k\in\{C,T,S\}} (\lambda_k^{rec}\mathcal{L}_k^{rec} + \lambda_k^{dist}\mathcal{L}_k^{dist})$$

Different forms respecting to the natures of each attribute

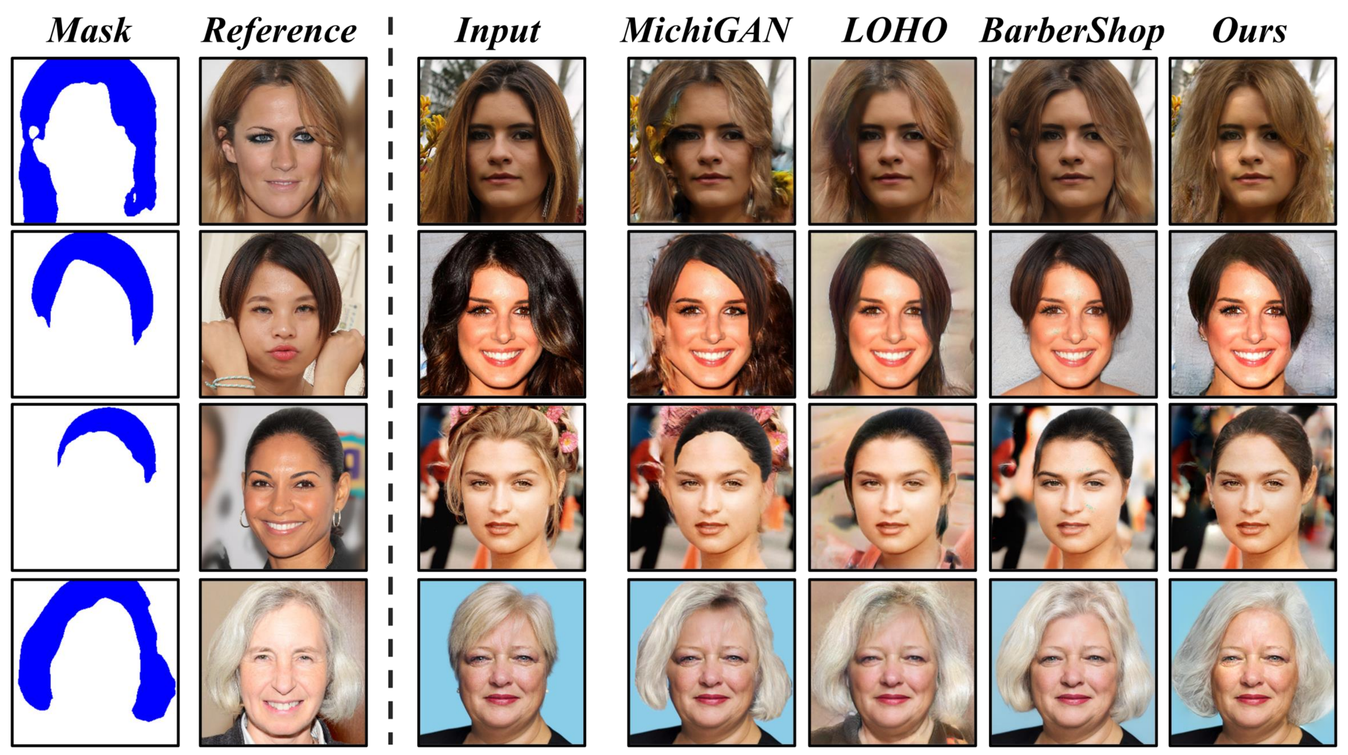
- Color: supervised
- Texture: unsupervised
- Shape: supervised with shape adaptor

4. Experiments

Comparison of **Functionality** of different methods

Functionality	MichiGAN [24]	LOHO [21]	BarberShop [28]	CtrlHair (ours)
Interaction Mode	references painted mask sketch	references	references painted mask	references painted mask sliding bars
Editing Flexiblity	coarse, discrete			fine-grained, continuous
Shape Editing	replace directly			shape adaptor

Comparison on transfer with a reference image



A wide variety for a single person

Continuous and **fine-grained** editing