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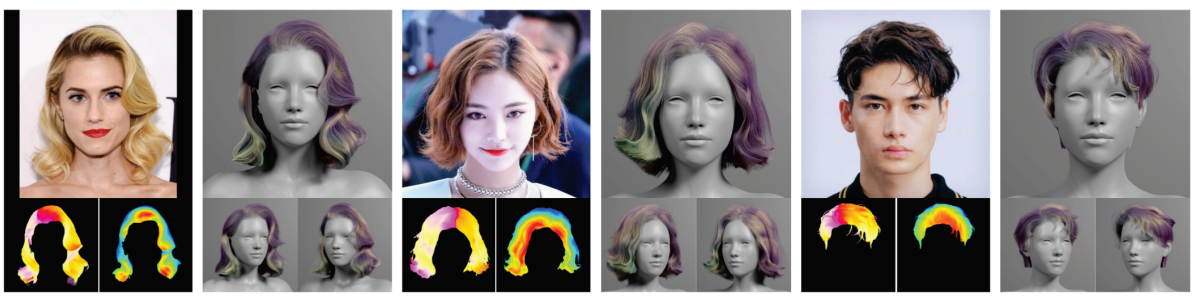
3D HAIR MODELING

HairStep: Transfer Synthetic to Real Using Strand and Depth Maps for Single-View 3D Hair Modeling

CVPR2023 Highlight

Yujian Zheng, Zirong Jin, Moran Li, Haibin Huang, Chongyang Ma, Shuguang Cui and Xiaoguang Han

Introduction

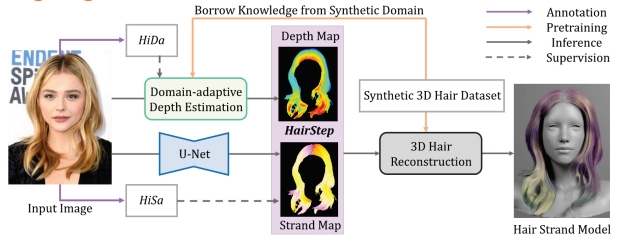


High-fidelity 3D hair modeling is a critical part in the creation of digital human. A hairstyle of a person typically consists of about 100,000 strands. Due to the complexity, high-quality 3D hair model is expensive to obtain. Although high-end capture systems are relatively mature, it is still difficult to reconstruct satisfactory 3D hair with complex geometries.

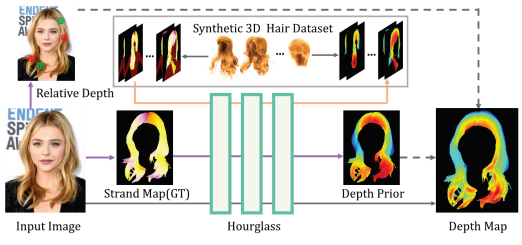
Single-View 3D Hair Modeling is more user-friendly to amateur users. Due to the great difficulty of collecting paired real image and 3D hair data, using synthetic data to provide prior knowledge for real domain becomes a leading solution. This unfortunately introduces the challenge of domain gap. existing methods typically use orientation maps instead of hair images as input to bridge the gap. However, orientation map using the dominant filtering-based methods is sensitive to uncertain noise and often leads to poor reconstruction result.

we first raise this issue up and propose a novel intermediate representation, termed as HairStep, which consists of a strand map and a depth map. It is found that HairStep not only provides sufficient information for accurate 3D hair modeling, but also is feasible to be inferred from real images. Our experiments show that HairStep narrows the domain gap between synthetic and real and achieves state-of-the-art performance on single-view 3D hair reconstruction.

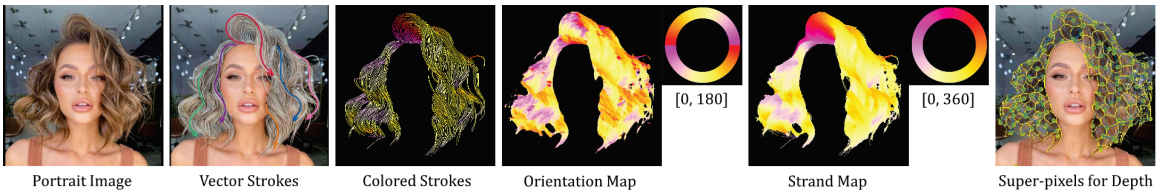
Highlight



(a) The pipeline of single-view 3D hair reconstruction using *HairStep*



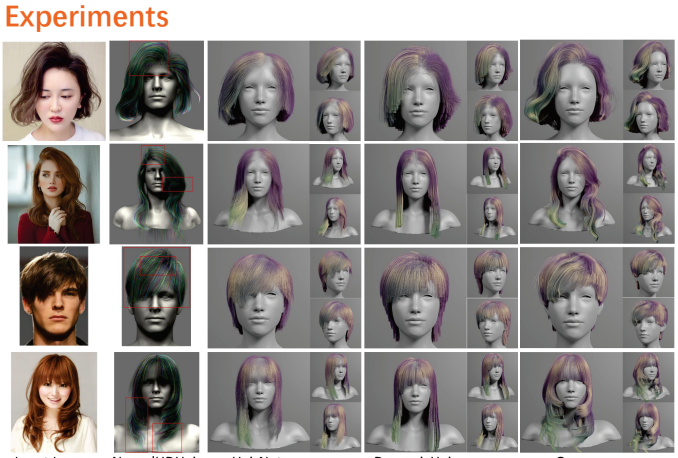
(b) Domain-adaptive depth estimation



(c) Annotation of *HiSa* & *HiDa*

- We first re-think the issue of the significant domain gap between synthetic and real data in single-view 3D hair modeling, and propose a novel representation HairStep. Based on it, we provide a fully-automatic system for single-view hair strands reconstruction which achieves state-of-the-art performance.
- We contribute two datasets, namely HiSa and HiDa, to annotate strand maps and depth for 1,250 hairstyles of real portrait images. This opens a door for future research about hair understanding, reconstruction and editing.
- We carefully design a framework to generate HairStep from real images. More importantly, we propose a weakly-supervised domain adaptive solution for hair depth estimation.
- Based on our annotations, we introduce novel and fair metrics to evaluate the performance of single-view 3D hair modeling methods on real images.

Experiments



Method	Orien. err. ↓	Occ. acc. ↑
NeuralHDHair* (Orientation map)	0.1324	82.59%
NeuralHDHair* (Strand map)	0.0722 (-41.7%)	84.18%
NeuralHDHair* (HairStep)	0.0658 (-50.3%)	86.77%
DynamicHair (Orientation map)	0.1352	78.19%
DynamicHair (Strand map)	0.1185 (-12.4%)	79.62%
DynamicHair (HairStep)	0.1174 (-13.2%)	79.78%
HairNet (Orientation map)	0.02349	/
HairNet (Strand map)	0.02206 (-6.1%)	/
HairNet (HairStep)	0.02184 (-7.0%)	/

Method	IoU ↑	*HairSale* ↓	*HairRida* ↑
NeuralHDHair* (Orientation map)	77.56%	19.6	70.67%
NeuralHDHair* (Strand map)	77.6%	**16** (-18.4%)	72.37%
NeuralHDHair* (HairStep)	77.22%	16.36 (-16.5%)	**76.79**%
DynamicHair (Orientation map)	56.39%	32.66	74.08%
DynamicHair (Strand map)	59.51%	26.53 (-18.8%)	73.42%
DynamicHair (HairStep)	59.14%	27.51 (-15.8%)	73.58%
HairNet (Orientation map)	57.15%	31.97	75.65%
HairNet (Strand map)	57.48%	28.6 (-10.5%)	74.81%
HairNet (HairStep)	57.01%	27.68 (-13.4%)	74.97%

Based on HairStep, we achieves state-of-the-art performance on single-view 3D hair reconstruction. Our HairStep benefits different frameworks on both synthetic data (upper right table) and real data (lower right table).