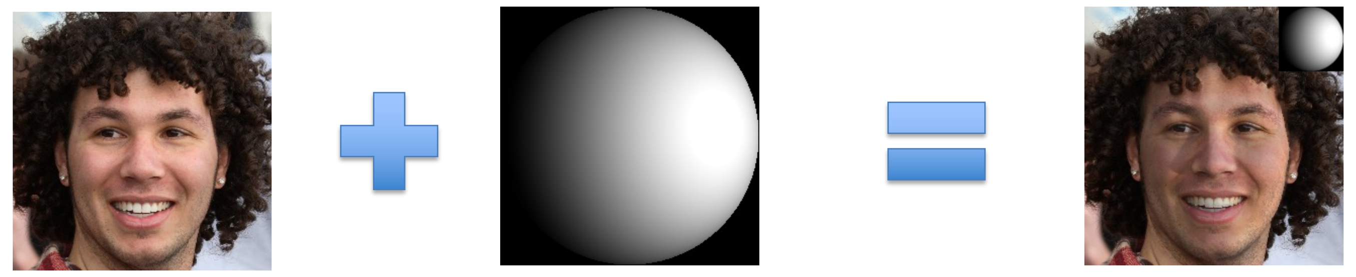
Face Relighting with Geometrically Consistent Shadows

Andrew Hou[1], Michel Sarkis[2], Ning Bi[2], Yiying Tong[1], Xiaoming Liu[1]
Michigan State University[1], Qualcomm Technologies Inc.[2]

Github

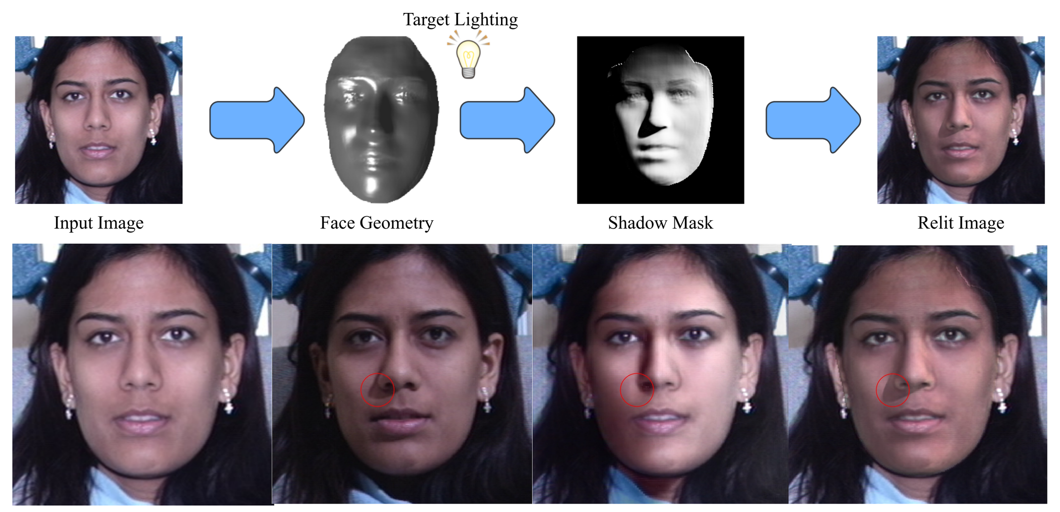
Problem Overview



- Face relighting: transform source image of subject's face into new image under novel desired lighting.

Challenges

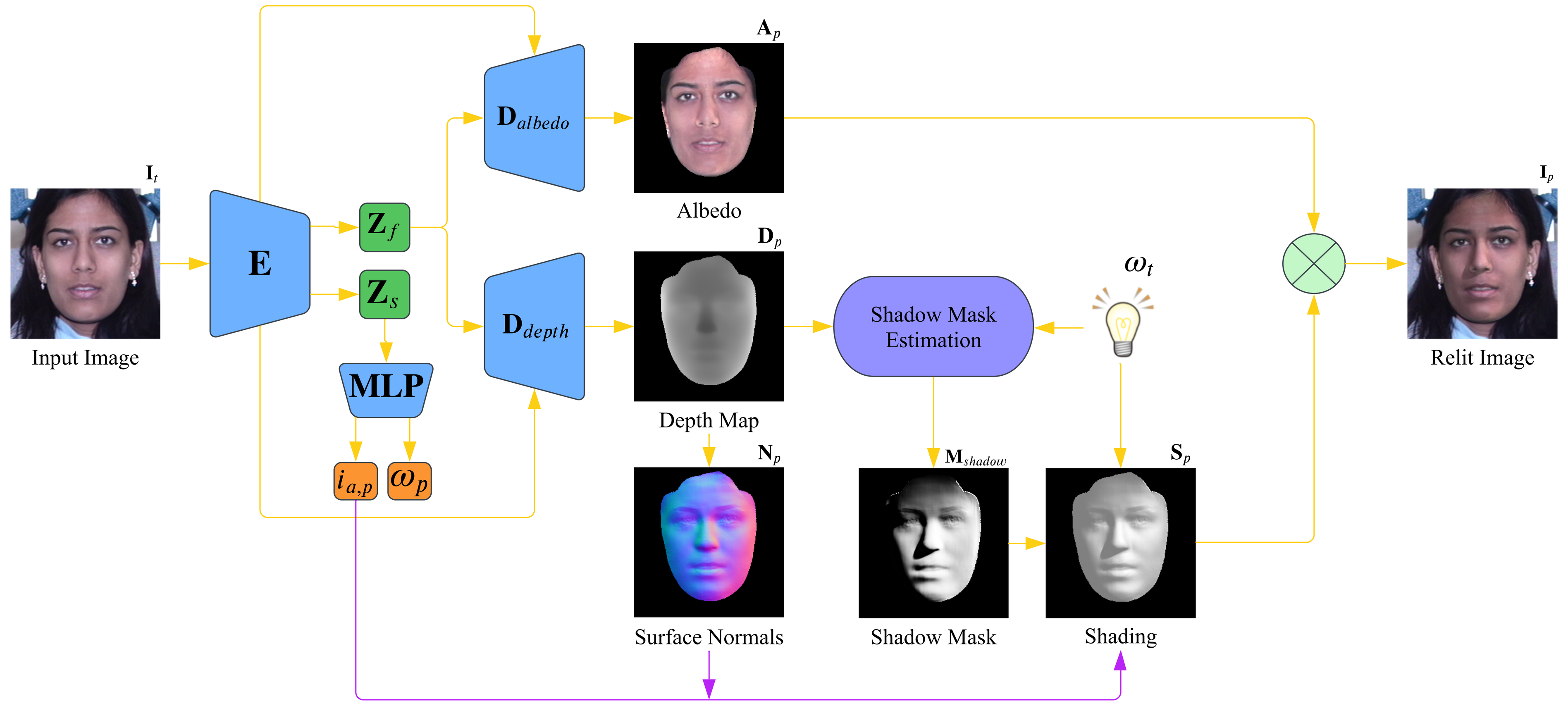
- Most face relighting methods: diffuse lighting and soft shadows.
- Modeling hard shadows/directional lights: more recent and challenging problem.
- Prior methods for hard shadows/directional lights: proper shadow shape and geometric consistency w.r.t. face are problems.



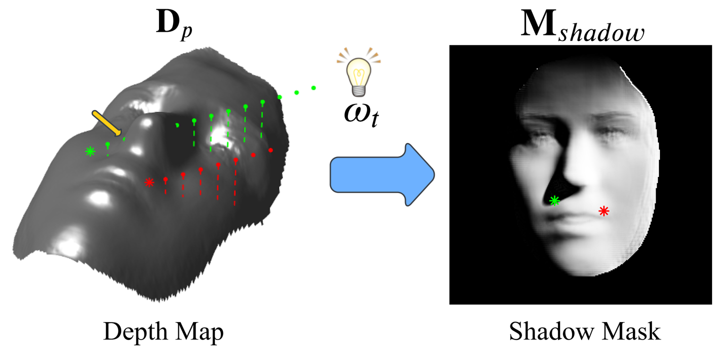
Contributions

- Single image face relighting method that can produce geometrically consistent hard shadows.
- Novel differentiable algorithm based on ray tracing to estimate facial hard shadows based on estimated geometry.
- SoTA relighting performance on 2 benchmarks quantitatively/qualitatively under directional lights.
- Our differentiable hard shadow modeling improves estimated geometry over models that use diffuse shading.

Model Architecture

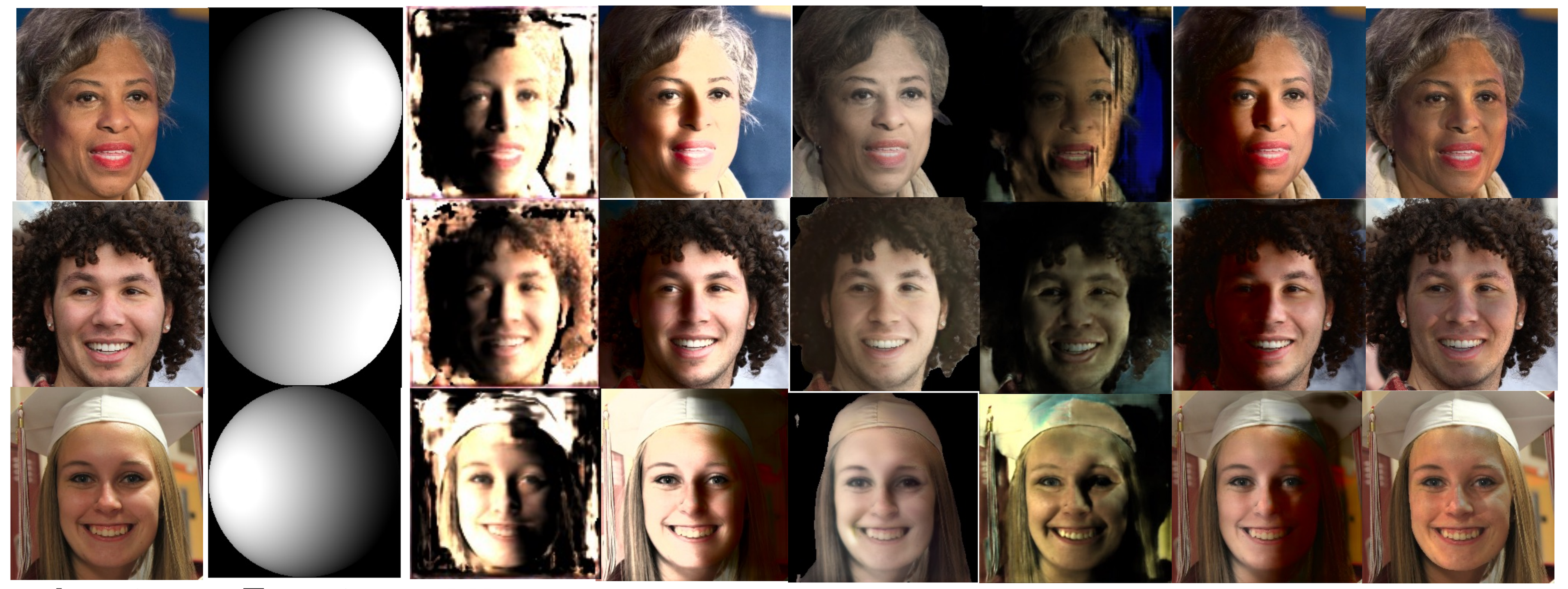


Shadow Mask Estimation



- For each point **x**, sample points from $\mathbf{D_p}$ along direction to $\boldsymbol{\omega_t}$.
- **x** is under hard shadow if any sampled point's distance to ray formed by **x** and $\boldsymbol{\omega_t}$ is close to 0.

FFHQ Relighting Performance (In-the-Wild)

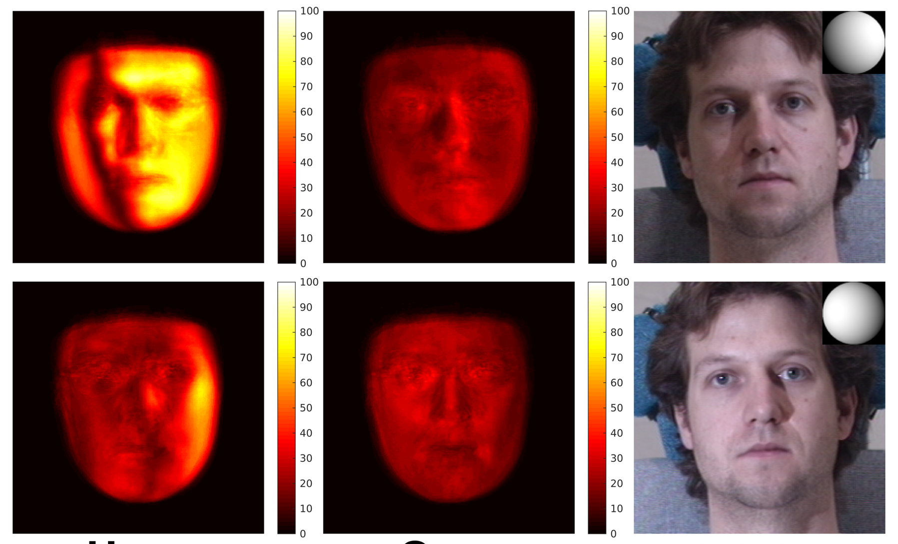


Multi-PIE Relighting Performance (Target Lightings)

Method	SfSNet [35]	DPR [54]	SIPR [43]	Nestmeyer [29]	Hou [10]	Proposed
LPIPS	0.5222 ± 0.0743	0.2644 ± 0.0808	0.2764 ± 0.0736	0.3795 ± 0.2294	0.2013 ± 0.0676	$\mathbf{0.1622 \pm 0.0490}$
MSE	0.0961 ± 0.0495	0.0852 ± 0.0515	0.0166 ± 0.0107	0.0588 ± 0.0538	0.0303 ± 0.0162	$\mathbf{0.0150 \pm 0.0112}$
DSSIM	0.2918 ± 0.0375	0.1599 ± 0.0558	0.1539 ± 0.0452	0.2226 ± 0.1356	0.1186 ± 0.0388	$\mathbf{0.0990 \pm 0.0381}$

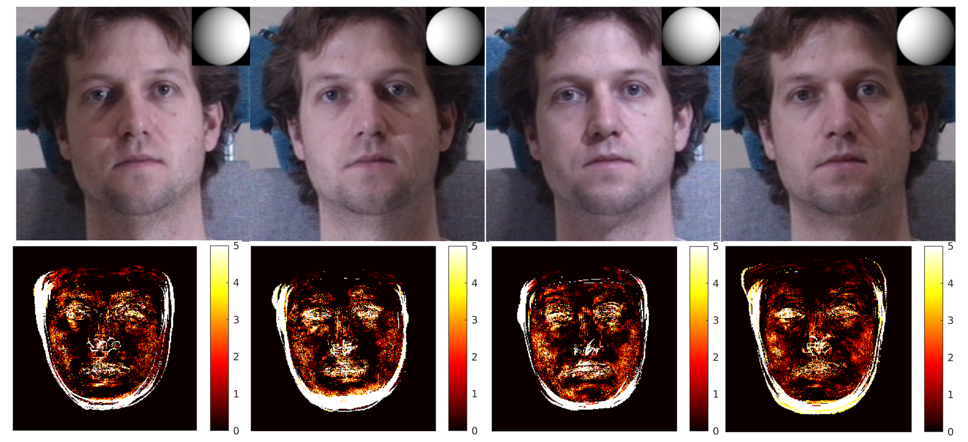
Relighting Evaluation (mean $\pm$ standard deviation)

Hard Shadow Geometric Consistency



- Visualize average L_1 error for each Multi-PIE lighting separately.
- Our error around hard shadows is very low, Hou's error is high.
- Superior hard shadow geometric consistency to Hou.

Geometry Improvements



Method	Surface Normal Angular Error (Degrees)
SfSNet [35]	14.2796 ± 2.1442
DFNRMVS [4]	12.4505 ± 2.3939
Proposed	$\mathbf{11.0672 \pm 1.9489}$

- Visualize surface normal improvement over shape supervision (DFNRMVS).
- Improve in regions that cast hard shadows (e.g. nose and face boundary).
- Our normals improve over DFNRMVS and a diffuse shading baseline (SfSNet).