



LightDepth

Single-View Depth Self-Supervision from Illumination Decline





J Rodriguez-Puigvert*, VM Batlle*, JMM Montiel, R Martinez-Cantin, P Fua, JD Tardós, J Civera

Take away

- The first single-view self-supervised method for depth estimation.
- Light and camera co-located + dark environment (e.g.: endoscopy)
- We outperform multi-view self-supervision and match supervision with ground truth

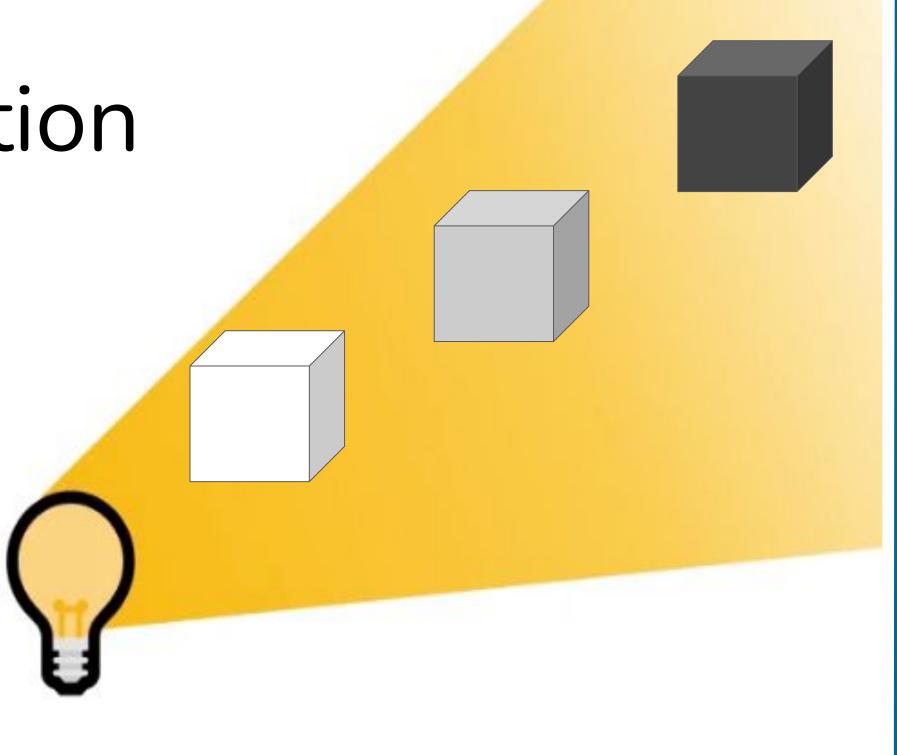
Motivation

Single-View Depth in Endoscopy

- Monocular camera
- Varying illumination
- Untextured surface
- Deformable environment

Illumination decline as single-view self-supervision

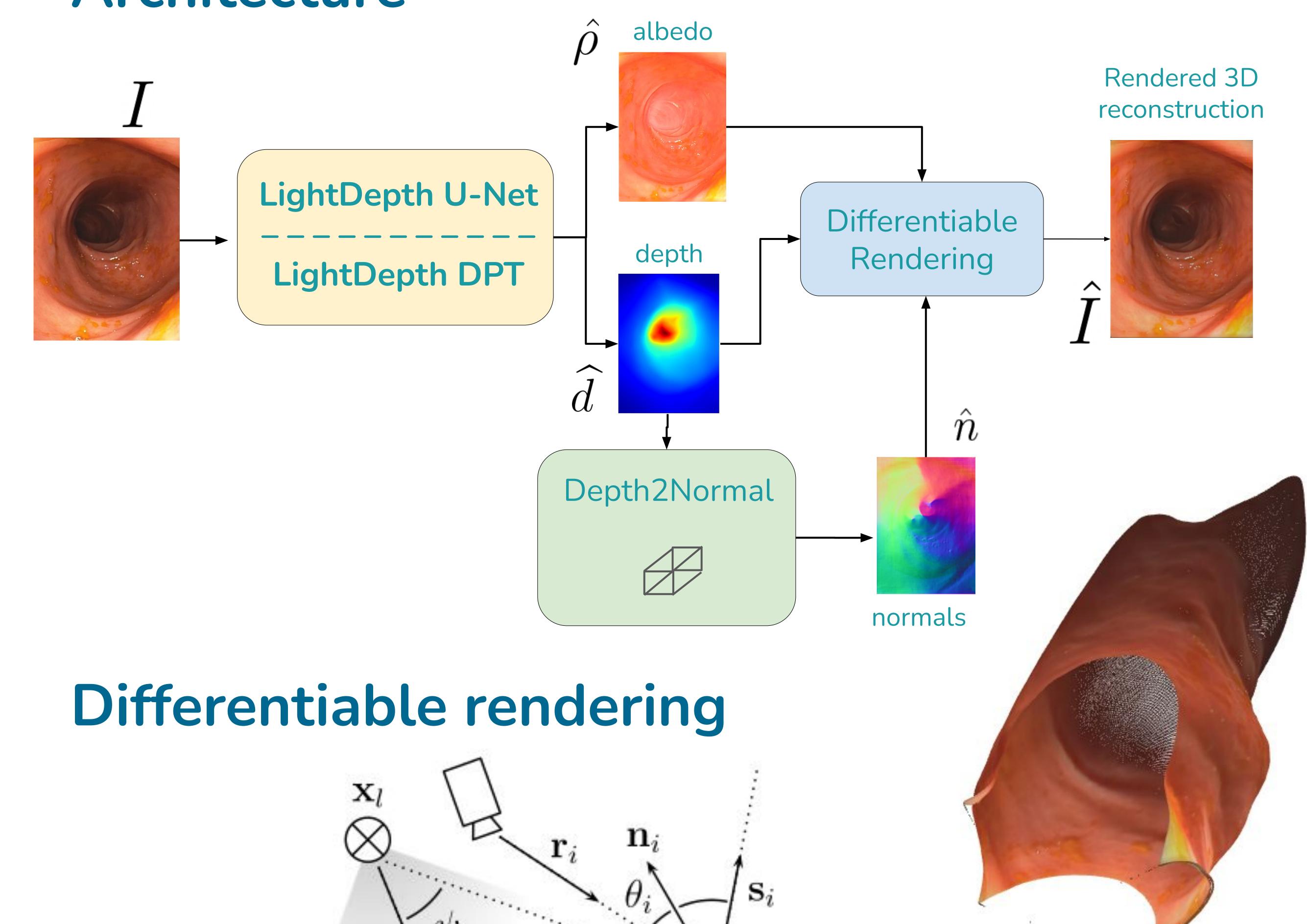
- The further, the darker
- No need for depth GT
- No need for camera motion estimation
- Single architecture for training and test-time refinement (TTR)





This work was supported by the EU Comission (EU-H2020 EndoMapper GA863146), the Spanish Government (PID2021-127685NB-I00, FPU20/0678, PID2021-125209OB-I00, PGC2018-096367-B-I00 and TED2021-131150BI00) and the Aragon Government (DGA-T45 23R)

Architecture



 $\mathcal{I}(d_i, \rho_i, g) = \left(\frac{\sigma_0}{\|d_i \mathbf{r}_i - \mathbf{x}_l\|^2} R(\psi_i) \cos(\theta_i) \rho_i g\right)$

Losses

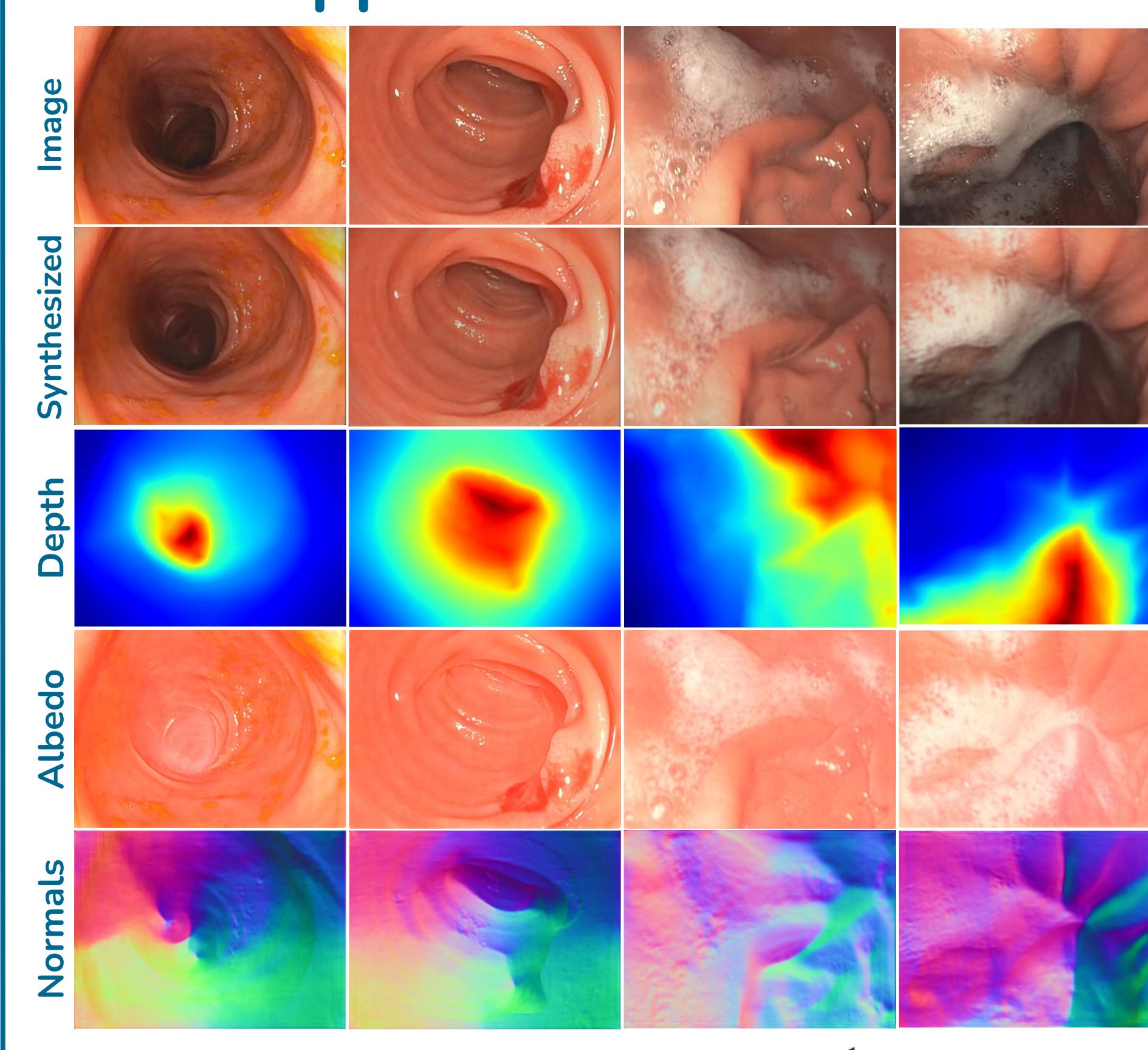
- ullet Single-view photometric $\mathcal{L}_p = \sum_{i \in \Omega} (I_i \widehat{I}_i)^2$ consistency
- Specularity consistency
- $\mathcal{L}_{sp} = \sum_{i \in \Omega} (\cos \alpha_i 1)^2$

- Smoothness
- $\mathcal{L}_s = |\partial_x \widehat{d}| e^{-|\partial_x I|} + |\partial_y \widehat{d}| e^{-|\partial_y I|}$

Experiments

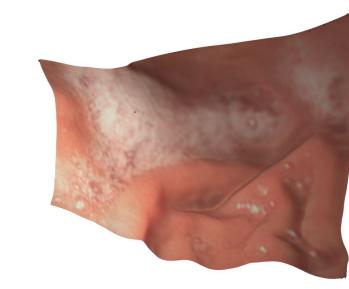
- Metrics match supervised methods
- Significant better performance than multi-view self-supervision

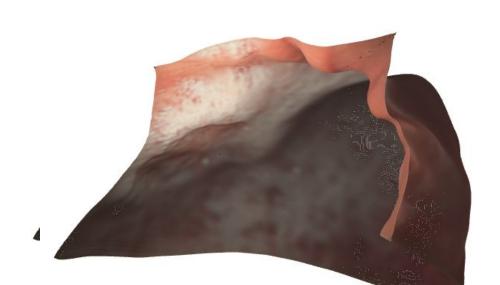
EndoMapper dataset











Architecture	Backbone	Supervision	MAE↓	$MedAE \downarrow$	RMSE ↓
U-Net	ResNet18	Depth GT	4.15	3.29	5.52
DPT-Hybrid [48]	ResNet50	Depth GT	3.22	2.77	4.10
Monodepth2 [20]	ResNet50	Multi-View	14.27	9.59	18.64
CADepth [64]	ResNet18	Multi-View	52.35	17.04	87.43
XDCycleGAN [42]	ResNet	Cycle	17.16	11.91	22.43
LightDepth U-Net	ResNet18	Light	4.37	2.92	6.31
LightDepth DPT	ResNet50	Light	3.94	2.67	5.60
LightDepth U-Net	ResNet18	Light (TTR)	3.72	2.59	5.43
LightDepth DPT	ResNet50	Light (TTR)	<u>3.70</u>	2.58	<u>5.27</u>