UC-NERF: Neural Radiance Field for Under-calibrated Multi-view Cameras in Autonomous Driving

Kai Cheng, Xiaoxiao Long, Wei Yin, Jin Wang, Zhiqiang Wu, Yuexin Ma, Kaixuan Wang, Xiaozhi Chen, Xuejin Chen

ICLR

Overview

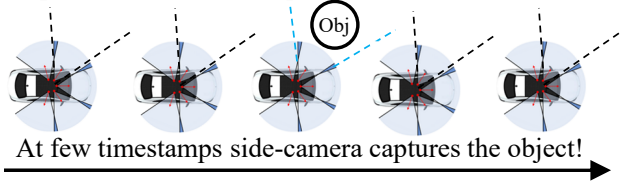
Illustration of a multi-camera system in autonomous driving

Problem: Rendering degradation when combining images captured from multi-camera systems into NeRF's training

Analysis: Under-calibration of multi-view cameras

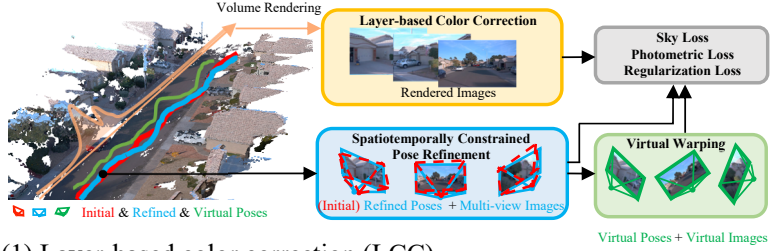
(1) **Inconsistent color supervision** between images

(2) **Sparse observation** (especially side-cameras)



(3) **Relative pose errors** between different cameras

Method



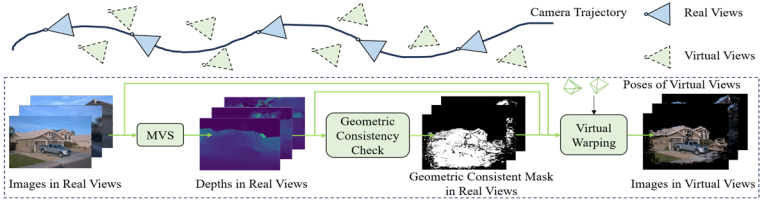
(1) Layer-based color correction (LCC)

Learning independent affine transformation for foreground and sky

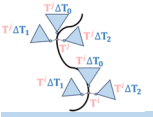
$$\mathbf{I}(\mathbf{r}) = \mathbf{A}\mathbf{I}_{\text{fg}}(\mathbf{r}) + \mathbf{x} + (\mathbf{1} - \mathbf{o}_{\text{fg}})(\mathbf{C}\mathbf{I}_{\text{sky}}(\mathbf{r}) + \mathbf{y})$$

(2)Virtual Warping (VW)

Generating viewpoint-diverse yet color-consistent observations



(3) Spatiotemporally Constrained Pose Refinement (SCPR)



$$L_{rpj} = \sum_{((i,k),(j,l))\in\varepsilon} \left\| \mathbf{p}_l^j - \Pi_l((\mathbf{T}^j\Delta\mathbf{T}_l)^{-1}\mathbf{T}^i\Delta\mathbf{T}_k\Pi_k^{-1}(\mathbf{q}_k^i)) \right\|^2$$

Results

Quantitative and qualitative results

Method	Waymo PSNR ↑	Waymo SSIM ↑	Waymo LPIPS ↓	NuScenes PSNR ↑	NuScenes SSIM ↑	NuScenes LPIPS ↓
Mip-NeRF (Barron et al. (2021))	22.42	0.698	0.471	23.31	0.758	0.489
Mip-NeRF 360 (Barron et al. (2022))	24.46	0.769	0.406	25.15	0.809	0.436
Instant-NGP (Müller et al. (2022))	23.84	0.702	0.494	23.81	0.777	0.476
S-NeRF (Xie et al. (2023))	24.89	0.772	0.401	26.02	0.824	0.415
Zip-NeRF (Barron et al. (2023))	26.21	0.815	0.389	27.06	0.831	0.435
UC-NeRF (Ours)	**28.13**	**0.842**	**0.356**	**30.20**	**0.876**	**0.374**

Effectiveness of each proposed module

Application: Enhance training data of depth estimation (* refers to adding rendered data)