RUSplatting: Robust 3D Gaussian Splatting for Sparse-View Underwater Scene Reconstruction

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Contributions

- We propose a novel framework, **RUSplatting**, for 3D representation of deep underwater scenes under sparse-view conditions.
- RUSplatting enables more accurate colour estimations through **colour-channel decoupling**.
- We introduce a novel **Edge-Aware Smoothness Loss** (ESL) to suppress noise commonly encountered in deep-sea, low-light conditions while preserving structural details.
- We introduce Intermediate **Frame Interpolation** (IFI) and **Adaptive Frame Weighting** (AFW) to address viewpoint sparsity.
- We present **Submerged3D**, the first dataset captured in deep underwater environments, highlighting real-world challenges such as limited lighting and severe turbidity.

Acknowledgement

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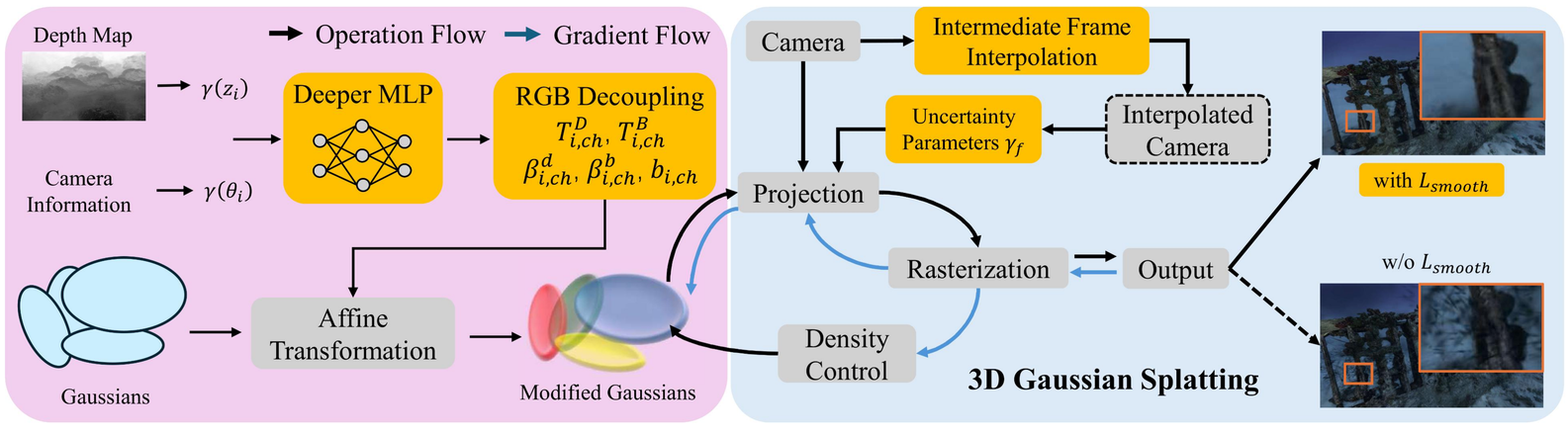
The Submerged3D can be found on both the **Zenodo** and the **Huggingface**

Huggingface Zenodo

Method

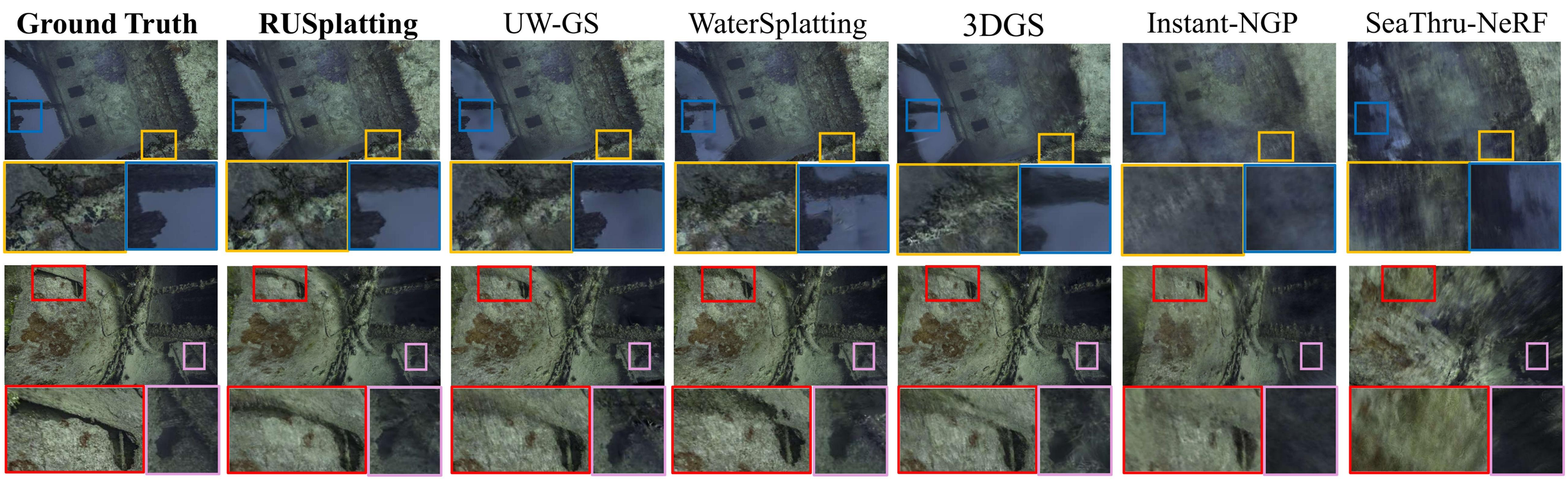


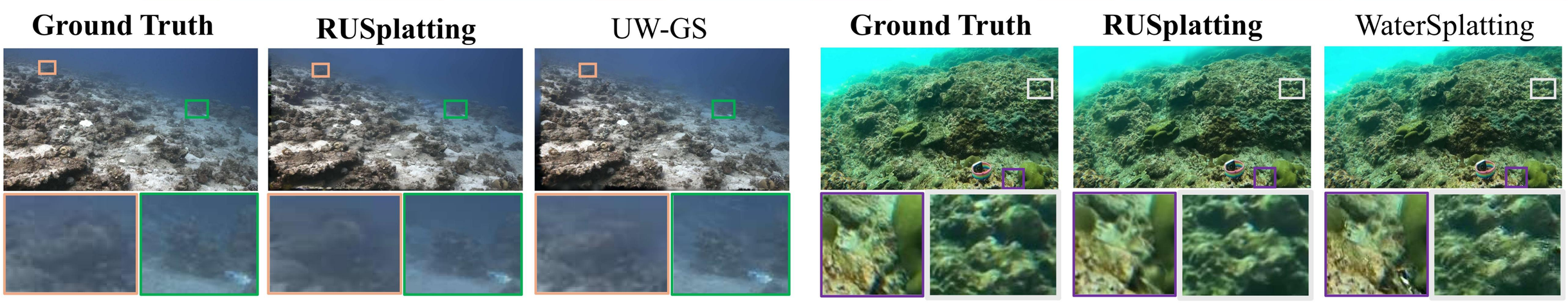
Pipeline of **RUSplatting**. Yellow highlights indicate the proposed contributions:
(1) colour-channel decoupling with a deeper MLP for improved estimation of underwater medium parameters
(2) IFI to enrich representations and enhance frame overlap
(3) an AFW strategy to suppress contributions from poorly interpolated frames
(4) an ESL to reduce noise while preserving fine structural details

Quantitative & Qualitative Results

Dataset	SeaThru-NeRF			S-UW			Submerged3D		
Method	PSNR ↑	SSIM ↑	LPIPS ↓	PSNR ↑	SSIM ↑	LPIPS ↓	PSNR ↑	SSIM ↑	LPIPS ↓
Instant-NGP (Müller et al., 2022)	23.7944	0.6317	0.4434	18.9001	0.4693	0.3966	19.0266	0.5107	0.4977
SeaThru-NeRF (Levy et al., 2023)	26.0604	0.7806	0.3398	21.2253	0.5948	0.4104	19.1967	0.4967	0.5685
3DGS (Kerbl et al., 2023)	26.8353	0.9011	0.1826	23.7563	0.7745	0.2231	22.6551	0.7544	0.3288
WaterSplatting (Li et al., 2025)	27.3924	0.8475	0.1870	24.8788	0.7915	0.2159	24.5832	0.7517	0.3172
UW-GS (Wang et al., 2025)	28.2557	0.9105	0.1750	24.1833	0.7838	0.2050	24.3409	0.7723	0.3107
RUSplatting (ours)	**29.2928**	**0.9163**	**0.1665**	**25.5955**	**0.8138**	**0.1964**	**25.7990**	**0.7724**	**0.3008**

Red colour with bold denotes the best result and yellow denotes the second best. RUSplatting achieves consistent improvements across all underwater datasets, boosting PSNR by up to **3.84 dB**, SSIM by **19.19%**, and reducing LPIPS by **37.29%** over prior state-of-the-art methods.





The first two rows show results from the Cormoran, and Tokai scenes from Submerged3D, respectively. The left side of the third row shows the result from IUI-Reasea (SeaThru-NeRF), while the right side shows the Seabed from S-UW.