Synthetic Photogrammetric Dataset for Two-Media 3D Reconstruction: Shipwreck & Terrain

Frederik Schulte[1], Markus Brezovsky[2], Anatol Günthner[3], Boris Jutzi[3], Gottfried Mandlburger[2], Lukas Winiwarter[1]

[1] Unit of Geometry and Surveying, Faculty of Engineering Sciences, University of Innsbruck, Innsbruck, Austria (frederik.schulte, lukas.winiwarter)@uibk.ac.at

[2] Department of Geodesy and Geoinformation, TU Wien, Vienna, Austria - (markus.brezovsky, gottfried.mandlburger)@tuwien.ac.at

[3] Institute of Photogrammetry and Remote Sensing, Karlsruhe Institute of Technology, Karlsruhe, Germany - (anatol.guenthner, boris.jutzi)@kit.edu

About the Dataset

The data in this repository serves as a benchmark for the development of new image-based processing pipelines that consider two separate optical media, i.e., water and air, including refraction effects. Ground truth datasets representing the true geometry form the basis of the simulation.

The synthetic scene showcases an environment constructed from both real-world laser scanning data (Jamtal glacial valley - WGS84: 46.90° N, 10.17° E) and a synthetic CAD model of a sailing ship[1]. Although the Jamtal scan depicts a riverbed, the original data were not acquired underwater and is only synthetically flooded. The ship was chosen because of the fine details of the ropes, which are well-suited for determining the quality of the reconstruction, and larger structured areas on the hull, where classic

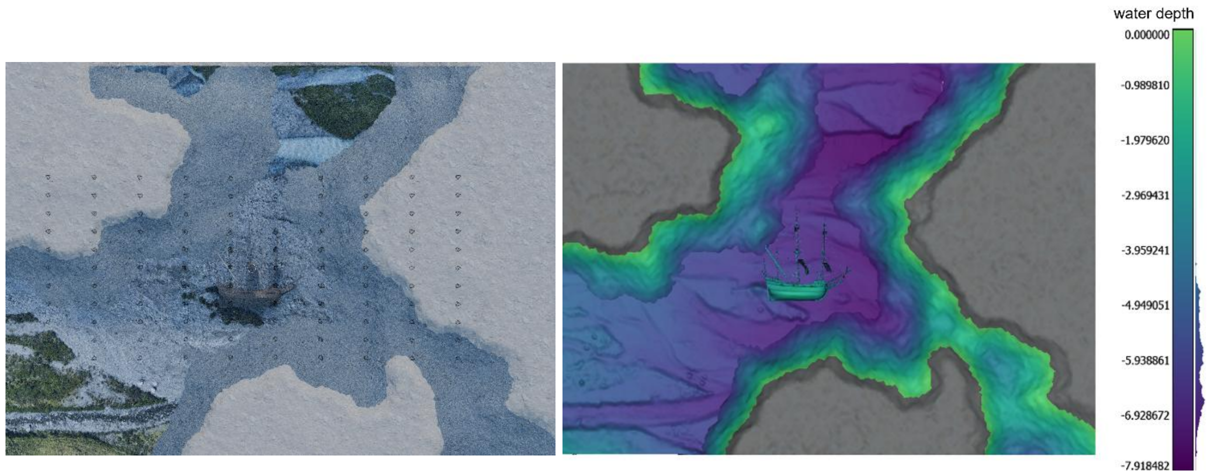

Figure 1: An RGB render of the Blender scene is depicted on the left-hand side and the water depth on the right-hand side.

[1] © user m23ldx0191. Dutch ship is licensed under CC BY 4.0. No changes were made. (10.02.2026) Available at: https://sketchfab.com/3d-models/dutch-ship-6e1a27f4db4c48e6adc53f6a3528ac9d

photogrammetric methods should perform well. In the simulation dataset the entire ship is submerged and large parts of the scene are submerged (up to 8 m depth), therefore the influence of refraction must be taken into account for an accurate reconstruction of these areas. The planar water surface serves as an idealized baseline to evaluate geometric refraction correction without the interference of dynamic wave patterns.

The ship already had a texture, which was adopted unchanged. The land areas were colored in a high-contrast stone texture[2] and the background was colored with images from the original area. Further details on data acquisition and processing can be found in Schulte et al. (2025).

All images were created using the physically-based path-tracing *Cycles* engine in Blender (V4.5). This ensures that the rendered images accurately model complex light interactions, including refraction, reflection and absorption. While reflection and volumetric absorption are physically simulated, their influence remains limited due to the low absorption coefficient and planar surface geometry. No volumetric scattering model was applied.

Content

The dataset contains synthetically rendered images of the scene. These are provided at 1024 x 768 resolution to facilitate rapid prototyping of neural rendering architectures. Additionally, binary masks are included to mask out areas without water coverage.

Since interior and exterior orientation parameters are required for accurate scene reconstruction based on Structure from motion, these are included along with the acquisition parameters (see Technical Details). An idealized pinhole camera model (distortion-free) was employed and no denoising was applied to better isolate refractive error from other influences.

To evaluate the reconstruction quality, a colored reference mesh and a 1 x 1 m² grid of the water surface are provided. The Blender project is included in this repository to allow for full reproducibility of the simulation settings.

[2] The texture is licensed under CC0. No changes were made. (10.02.2026) Available at: https://polyhaven.com/textures/terrain

Repository

- camera_orientation
  - parameters.txt – Camera and scene parameters
  - poses_realitycapture.csv – Interior and exterior orientation of all cameras in RealityScan file format (Ready for Nerfstudio import: *ns-process-data realitycapture …*)
- images – Rendered images of the scene
- reference
  - scene_reference_mesh.ply – Ground truth with $2.3*10^6$ faces
  - water_surface_mesh.ply – 1x1 m mesh of water surface (constant at z=5 m with 30k faces)
- underwater_scene.blend – Blender file containing all information of the simulation
- water_masks – (Land=Black, Water=White)

Technical Details

The simulation was designed to mimic a realistic survey by an uncrewed aerial vehicle (UAV). The key technical parameters are listed below.

Category	Parameter	Value	Notes
Camera	Sensor Resolution	1024 x 768	0.8 MP
	Sensor Size	20.5 x 15.4 mm	APS-C size
	Focal Length	25 mm	Fixed intrinsics
	Pixel size	20 µm	-
	Distortion	None	Idealized pinhole model
	Channels	3	RGB
	Color depth	8-bit	256 colors
Flight	Flying Height	42.5 m	37.5 m above water surface
	GSD	0.03 m	-
	Overlap	80% / 60%	Front / Side
	Number of photos	130	-
	Study site dimensions	150 x 100 x 10 m^3	-
Water	Index of Refraction	1.333	Freshwater approximation
	Volume Absorption	0.01 m^{-1}	Very clear water
	Surface Geometry	Planar	Constant z = 5 m (No waves)
Render	Samples	Max. 4096	Adaptive sampling
	Bounces	Max. 12	Reflection/Refraction/Scatter
	Denoising	Disabled	To avoid artifacts

Important Usage Notes

- Coordinate System: The dataset uses a local coordinate system. The vertical axis is Z=up.
- Camera Model: The simulated camera is a perfect pinhole model. When processing, lens distortion parameters (k1, k2, etc.) must be fixed to zero to avoid introducing synthetic errors.
- File Format: Images are provided as PNGs.
- Masks: The masks are generated by rendering the land (black) and water surface (white) geometries.

Acknowledgments

This dataset was created within the research project BathyNeRF, funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 538522540 and by the Austrian Science Fund (FWF) 10.55776/PIN1353223. It is a collaboration of the Karlsruhe Institute of Technology, TU Wien, and the University of Innsbruck.

Corresponding Article

Details concerning the scene creation and processing can be found in:

Schulte, F., Brezovsky, M., Günthner, A., Jutzi, B., Mandlburger, G., & Winiwarter, L. (2025). Simulation and validation of underwater scenes for two-media optical 3D reconstruction. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVIII-2/W10-2025, 271–278. https://doi.org/10.5194/isprs-archives-xlviii-2-w10-2025-271-2025