

水中ロボットによる探索のための音響画像におけるマルチパス反射除去

Multipath Reflection Suppression in Imaging Sonar for Underwater Robot Exploration

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Abstract

Multipath reflections in imaging sonar degrade image interpretability and can introduce large errors in downstream robotic tasks such as 3D mapping and localization. Because a multipath-free image is not uniquely determined from a single observation—especially when multipath effects cause partial occlusions—multipath suppression is an ill-posed inverse problem. This paper addresses the problem by combining a physics-grounded forward simulator with conditional generative learning. We construct paired sonar images with and without multipath by modeling acoustic propagation as a large set of rays and integrating returned energy over elevation angles according to the imaging principle of an acoustic camera. Multipath is modeled as the combination of backscattering and indirect reflections, and ray-wise travel distance and intensity are recorded to synthesize realistic artifacts. Using the paired simulated dataset, we train an image-to-image translation network to map multipath-contaminated inputs to multipath-suppressed outputs. Experiments on simulated data show that the proposed approach recovers images that closely match the multipath-free ground truth. When applied to real sonar images, the model substantially suppresses strong multipath artifacts and reduces background noise to some extent, indicating the potential of simulation-driven generative learning for practical underwater perception.