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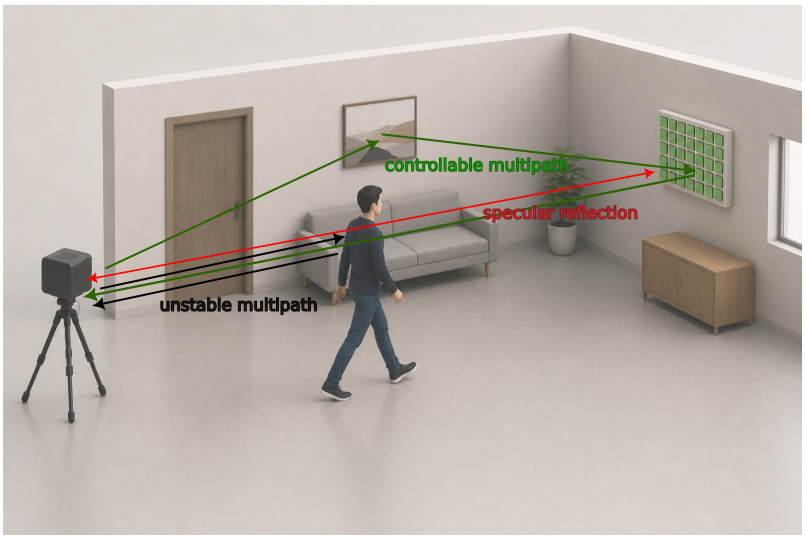
Bachelor's

MIRROR: Mobility-Induced and RIS Reflections for IndOor Reconstruction

Abstract

Optical sensors can be used for robust indoor scene understanding, however, they fail under severe blockages and are not concerned with privacy. Millimeter-wave (mmWave) radar can penetrate certain visually opaque indoor materials, is less sensitive than optical sensors to lighting, smoke, dust; and is also privacy-preserving. However, mmWave radar is characterized by limited spatial resolution, especially in the angular domain, and by the near-specular reflection behavior of many indoor surfaces. As a result, a single static radar observes only the subset of surfaces that reflect sufficient energy back toward the receiver, leading to sparse and incomplete reconstructions of indoor environments. Recent works exploit mobility to stir up multipath and recover otherwise-suppressed ghost reflections. MIRROR, building on top of that, will jointly exploit two complementary sources of geometric information: (i) mobility-induced multipath and (ii) a reconfigurable intelligent surface (RIS) that acts as a steerable secondary anchor, providing controllable angular scanning and illumination.



Content

The aims of this work are performing a thorough literature review on indoor environment reconstruction and then developing and evaluating MIRROR, via ray-tracing based simulations. The central objective is to demonstrate that combining RIS-steered beams with target mobility reconstructs the room more completely and accurately than any of the methods alone. Metrics similar to Chamfer distance, and object detection IoU will be used (see [1]).

Requirements

It is helpful to have a basic understanding of wireless communications (mmWave propagation, antenna arrays, beamforming, multipath etc), radar signal processing basics, and Python. Familiarity with Sionna RT is a big plus. Any missing prerequisites can be learned during the thesis.

[1] Kaichen Zhou, Laura Dodds, Sayed Saad Afzal, and Fadel Adib, "RISE: Single Static Radar-based Indoor Scene Understanding", arXiv preprint arXiv:2511.14019, 2025.

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