Collaboration with “MIPT” the Moscow Institute of Physics and Technology on Microwave Holographic Imaging

Robust image reconstruction algorithms for the microwave spintronic holographic vision system

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Abstract. We present a robust image reconstruction algorithm suitable for a spin diode-based microwave holographic vision system with several spin-diode sensors (detectors) and a single emission source. An objective is, by reconstructing the spatial microwave scattering density on the scene, to detect the presence and the nature of road obstacles impeding driving in the near vehicle zone. The idea of holographic visualization is to reconstruct the spatial microwave scattering density of an object by detecting an amplitude and phase of a reflected signal by lattice of sensors. We discuss versions of an algorithm, determine and analyse its resolution limits for various distances with different number of sensors for a one-dimensional test problem of detecting two walls (or posts) separated by a gap at a fixed distance. The maximal interval between sensors needed for a reliable reconstruction equals approximately Fresnel zone width. We show that maximal resolution achieved by our algorithm with an appropriate number of sensors was about 40% of Fresnel zone width for wall detection and about 30% of zone width for gap detection.

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Resolution Limits in Near-Distance Microwave Holographic Imaging for Safer and More Autonomous Vehicles

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Highlights: High sensitivity spin diodes as wave sensors are compact and cost effective devices for objects detection in different scenarios and weather conditions. Holographic reconstruction allows seeing the 3D density of the objects, indicating different materials—stone, flesh, metal, wood, etc. A computationally efficient holographic imaging and obstacle detection algorithm were targeted for use in a non-optical setting with a single coherent emitter and few detection sensors. The detection distances and spatial resolution proved sufficient for near-vehicle object detection purposes.

Abstract: We present a robust and computationally efficient image reconstruction and object detection algorithm suitable for a microwave holographic vision system with several microwave sensors and a single emission source to detect the presence and the nature of road obstacles impeding driving in the near vehicle zone. The holographic visualization technique allows reconstructing the spatial microwave scattering density in non-optical setting, detecting by lattice of sensors both amplitude and phase of a reflected signal. We discuss versions of an algorithm, determine and analyze its resolution limits for various distances with different number of sensors for a one-dimensional test problem of detecting two walls (or posts) separated by a gap at a fixed distance. The interval between sensors needed for a reliable reconstruction equals about one Fresnel zone width. We show that detection distances and spatial resolution achieved (better than 20 cm on distances up to 4.5 m) were sufficient for near-vehicle object detection purposes.

Key words: Spin diodes, microwave holography, image reconstruction, Tikhonov regularization, object detection.