ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

DET - Efficient Radar Perception at the Edge for Service Robotics

Funded By	Dipartimento DET
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Context of the research activity	This PhD project focuses on edge-AI methods for real-time radar signal processing, enabling efficient 3D/4D point cloud generation from raw radar data used for robust SLAM and navigation in service robotics.
Objectives	This PhD project investigates radar-based perception for autonomous service robotics, with a strong focus on edge-AI techniques for transforming raw radar signals into rich 3D/4D point clouds suitable for SLAM, mapping, and navigation. The research addresses the limitations of traditional optical sensors (LiDAR and RGB cameras) in degraded conditions such as darkness, fog, dust, smoke, or adverse weather, where radar offers superior robustness and reliability. The core objective is to design efficient radar signal processing and learning-based pipelines that operate close to the sensor (“at the edge”), enabling real-time perception under tight computational, energy, and latency constraints typical of mobile robots and drones. Starting from raw or minimally processed radar data (e.g., I/Q samples, range–Doppler or range–azimuth cubes), the project will explore advanced methods for radar imaging, digital beamforming, and 3D/4D point cloud generation, preserving spatial and Doppler information critical for motion estimation and scene understanding. A key research direction is the integration of edge-AI and learning-based approaches—including lightweight deep networks, self-supervised learning, and model compression—to enhance point cloud quality, denoise radar artifacts, mitigate multipath effects, and improve angular resolution beyond hardware limits. Particular attention will be given to architectures and algorithms that are deployable on embedded platforms (e.g., SoCs, GPUs, NPUs), balancing accuracy with computational efficiency. The generated radar point clouds will be leveraged for radar-centric SLAM and odometry, potentially combined with inertial sensing and other complementary modalities. The project will investigate how radar-specific

	properties (e.g., Doppler velocity, material-dependent reflectivity) can be exploited to improve robustness, loop closure, and long-term localization, especially in environments where vision-based SLAM fails. Validation will be carried out using state-of-the-art open radar datasets and, where possible, real robotic platforms, with emphasis on service robotics scenarios such as indoor navigation, logistics, inspection, and human-aware environments. The expected outcomes include novel algorithms, open-source tools, and design guidelines for deploying efficient radar perception and SLAM at the edge, contributing to the next generation of robust autonomous service robots.

Skills and competencies for the development of the activity	Deep Learning, Edge-AI experience, strong Embedded systems experience, PyTorch, C++