

Master Thesis

Optimization of Near-Field Integrated Radar Imaging and Downlink Communication Systems

As integrated sensing and communication (ISAC) emerges as a key enabler for sixth-generation (6G) wireless systems [1], efforts to refine its design and optimize its performance have intensified in recent years. Discussions on waveform design for multiple-input multiple-output (MIMO) ISAC remain ongoing, mainly due to the differing performance requirements of sensing and communication [2]. In this context, orthogonal frequency-division multiplexing (OFDM), used in fourth- and fifth-generation (4G/5G) networks [3], can achieve a decent communication performance for communication-centric ISAC systems.

This thesis investigates a MIMO-OFDM system that jointly enables radar imaging and communications. Similar to extremely large-scale MIMO (XL-MIMO) arrays, the proposed system operates in the near-field, allowing range-dependent focusing for high-resolution radar imaging. As shown in Figure 1, the radar imaging performance is optimized while satisfying downlink communication quality-of-service (QoS) requirements for single-antenna user equipment (UEs). Whereas most existing works emphasize classical performance metrics such as sensing rate (SR) [4], Cramér–Rao bound (CRB) [5, 6], Fisher information matrix (FIM) [5, 6], and beampattern-based surrogates [7], this thesis evaluates the practical image quality through the point spread function (PSF), a key metric for assessing the focusing performance of a radar imaging system.

Guidelines for the thesis:

- Conduct targeted literature review.
- Model the system described above and identify the relevant degrees of freedom of the system (such as antenna positions, array geometry, and beamforming strategy) as well as an appropriate PSF-related performance metric.
- Formulate an optimization problem to optimize the radar imaging quality under downlink QoS constraints for the UEs.
- Propose a solution for the formulated optimization problem.
- Assess the solution quality via numerical simulations.

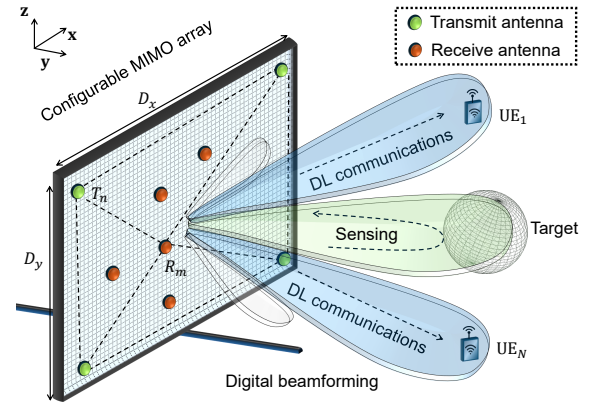


Figure 1: Fully configurable MIMO antenna array for joint downlink (DL) communications and radar imaging.

PREREQUISITES

Scientific skills	Interest in MIMO ISAC. Basic knowledge of sensing, wireless communications, and convex optimization.
Programming skills	Experience in programming languages (Python and/or Matlab).
Language skills	English fluency

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STUDENT

Start date: TBD

End date: TBD + 6 months

(Prof. Dr.-Ing. Robert Schober)

References

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