Karlsruhe Institute of Technology

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Constellation Shaping for Integrated Sensing and Communications

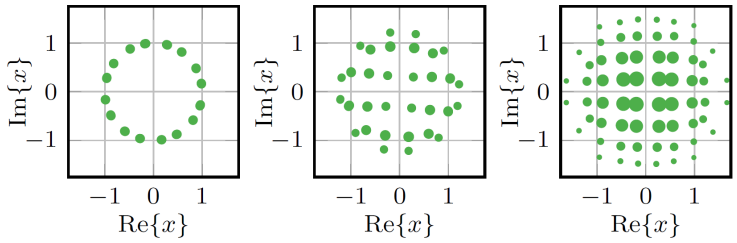
Bachelor's Thesis/Master's Thesis

Project

Next-generation 6G wireless systems are expected to integrate radar-like sensing capabilities, enabling applications such as environmental mapping, localization, and object detection. This concept, known as integrated sensing and communications (ISAC), reuses the same waveform and hardware resources for both tasks, improving spectral and hardware efficiency.

However, jointly using a waveform for communications and sensing creates a fundamental trade-off because the optimal constellations for the two tasks differ. Conventional modulation formats, such as quadrature amplitude modulation (QAM), are primarily designed to maximize communication rates and are therefore not necessarily optimal for sensing tasks such as target detection or parameter estimation.

Constellation shaping addresses this trade-off by adapting the positions or probabilities of the constellation points to optimize both communication and sensing performance. In this thesis, you should investigate constellation shaping for ISAC systems.



Tasks

1. Analyze the impact of constellation properties on communication and sensing performance
2. Identify and characterize the resulting communication-sensing trade-offs
3. Optimize constellations for different system requirements
4. Compare the optimized constellations with conventional modulation schemes using suitable communication and sensing metrics

Requirements

✔ There are no strict requirements for this thesis. Much more important is the motivation to independently familiarize yourself with complex topics

✔ Helpful is prior knowledge of programming, (Python, PyTorch), as well as communications engineering, radar, information theory, and signal processing

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