Ph.D. in Information Technology
Thesis Defense

June 26th, 2026
At 10:00 a.m.
Aula Alpha - Building 24

Mattia Giovanni POLISANO – XXXVIII Cycle

COHERENT PROCESSING METHODS FOR INTEGRATED SENSING AND COMMUNICATION
Supervisor: Prof. Stefano Tebaldini

Abstract:

This doctoral thesis investigates coherent signal processing methods as a foundational enabler for Integrated Sensing and Communication (ISAC) systems. This work adopts coherent processing as a unifying framework for implementing sensing and communication capabilities across heterogeneous platforms and operational scenarios. In this context, Synthetic Aperture Radar (SAR), interferometric processing, and backscatter-based communication naturally emerge as specific instances of a broader coherent processing paradigm.

A central theme of the thesis is the dual role of phase coherence: on one hand, it enables high-resolution sensing, accurate motion estimation, and information embedding; on the other hand, it is highly sensitive to platform motion, synchronization errors, and hardware non-idealities. This inherent trade-off motivates the development of advanced processing strategies for preserving and recovering coherence under realistic operating conditions. This has been explored into different applications.

The first part of the thesis addresses coherent processing for Unmanned Aerial Vehicles (UAV)-borne sensing systems. A factorized backprojection framework, called Flexible \& Seamless Factorized BackProjection, is proposed to reduce the computational complexity in UAV-borne SAR focusing scenarios. Building upon this framework, an ISAC application based on Orthogonal Frequency Division Multiplexing (OFDM) waveforms is investigated, demonstrating that communication-compliant signals can sustain coherent imaging and target detection in SAR images.

The second contribution focuses on coherent processing within telecommunication infrastructures for Structural Health Monitoring (SHM). An image-domain strategy based on backprojection is introduced to suppress aliased dynamic clutter, extending the sensing capabilities of existing communication hardware beyond conventional Doppler-based methods and validated through experimental data.

The third contribution, focused on coherent processing in distributed and unsynchronized systems is then studied in an automotive multistatic scenario. The impact of clock offset and clock drift on coherent image formation is analyzed. A two-stage compensation strategy combining image-domain alignment and interferometric refinement is proposed. Numerical simulations show that coherence can be recovered even in the absence of hardware synchronization, highlighting the potential of

signal-processing-based solutions for cooperative ISAC systems. It is worth noting that, at this stage, the proposed methodology has been validated through numerical simulations only. The experimental data proposed in this chapter are meant to validate two fully programmable 80GHz automotive radar prototypes.

Finally, a communication-centric ISAC paradigm based on coherent backscattering is explored using a Space-Time Reconfigurable Intelligent Surface, demonstrating that coherent processing can be exploited not only for sensing but also for information transmission through radar echoes.

Overall, the results presented in this thesis demonstrate that coherent processing is the common ground to exploit phase, delay, and Doppler information across sensing and communication tasks. Across the considered case studies, coherent processing proved itself to be an essential tool to preserve phase integrity, enable accurate motion compensation, and support reliable sensing using communication waveforms. The results in this doctoral thesis confirm that coherent processing is a fundamental layer for ISAC systems, paving the way toward the next generation of telecommunication systems.

PhD Committee

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