UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II

itee PhD
information technology
electrical engineering

DIETI. UNINA

Marco Boddi

Novel algorithms for Direction-of-Arrival estimation in radar and communication problems

Tutor: Prof. A. De Maio

Cycle: XXXVII Year: 1

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My background

- **Master Science degree:** Telecommunications Engineering at the University of Pisa
- **Research group/laboratory:** Radar Signal Processing and Electronic Defense Research Group (RSPRG) at UniNa, DIETI
- **Tutor:** Prof. A. De Maio
- **PhD start date:** 01/11/2021, XXXVII Cycle
- **Scholarship type / Partner organization:** ad-hoc agreement with the Italian Government, Presidency of the Council of Ministers

Research field of interest

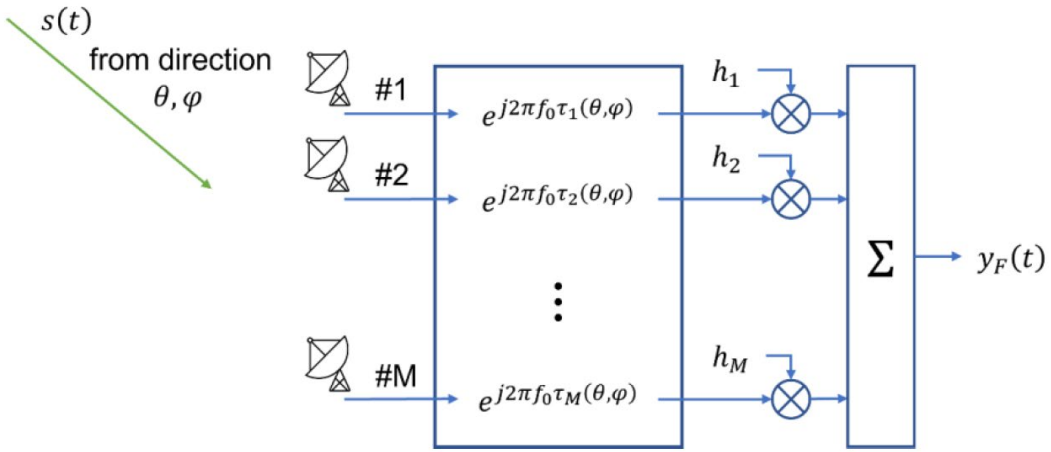
- **Radar and digital communication signal processing**
  - Antenna array / multi-channel processing
  - Non cooperative radio-localization
  - Direction-of-Arrival estimation
  - Signal recognition and classification
  - Compressive sensing

Summary of study activities

- **Study activities**
  - Optimum array processing
  - Conventional Direction-of-Arrival estimation and beamforming techniques
  - Model order selection criteria
- **Ad hoc PhD courses / schools**
  - Software Defined Radio Applications for Radar and Localization Systems
  - Machine Learning for Science and Engineering Research
  - Matrix Analysis for Signal Processing with MATLAB Examples
- **Courses borrowed from MSc curricula**
  - Radar Systems
  - Terrestrial and satellite radio-localization
- **Other courses and seminars**
  - “5G network architecture, RAN, core and xHaul technologies” by CNIT Rome
  - “2022 virtual distinguished lecturers series”, by IEEE AESS
  - “Numerical methods for electromagnetic fields”, by Free Space S.r.l. / UniPi

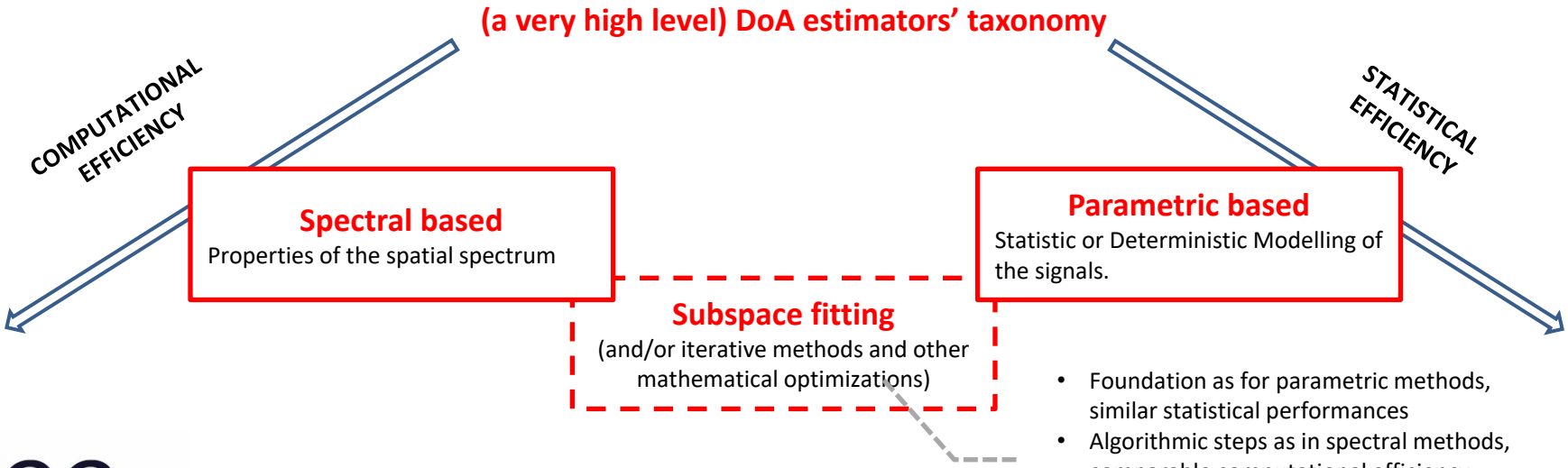
Research activity: Overview (1)

- **Problem of interest**
  - Estimate the **Direction-of-Arrival (DoA)** of radio signals. Main assumptions:
    - Non cooperative emitters and unknown signal formats;
    - Processing based on signal samples available at a receiving antenna array.
  - (some) Areas of applications:
    - Electronically-Scanned-Array (ESA) radars;
    - Search&Rescue operations, natural disasters relief;
    - Environmental protection and spectrum management authorities;
    - Military strategic and tactical situation awareness;
    - Radio navigation and air/maritime traffic monitoring.



Research activity: Overview (2)

- **Research objectives**
  - Extend and optimize known estimators (with special focus on **subspace fitting** and iterative methods) and processing architectures so as to:
    - Maintain a reduced computational complexity;
    - Exploit modern multi-channel and high-rate commercial-grade Software Defined Radios;
    - Exploit and extend **matrix-sparsity characterization** of the signal space, stemming from novel methods (SLIM, B-SLIM, etc…) recently devised within the RSRPG;
    - Deal with noisy, multi-path radio environments and broadband applications (such as in the HF spectrum);
    - Achieve a joint estimation of azimuth and elevation, and leverage info from cross-pol antenna arrays.



Research activity: Overview (3)

- **Near future directions, methodologies and intended contributions:**
  - Extend the theoretical framework of subspace fitting models and sparse methodologies (starting from SLIM, B-SLIM) to jointly deal with additional multiple dimensions of interest (range, azimuth, elevation, frequency, polarization, etc.)
  - Adapt theoretical models to deal with radio scenarios of specific interest (starting from passive direction finding in HF)
  - Explore different array geometries so as to enforce convenient forms of the data matrices involved in the mathematical optimization problem
  - Initial performance assessment through Monte Carlo computer simulations. Machine learning methods also look attractive for model and parameter optimization.
  - Model and architecture validation through on-field measurements with commercial-grade SDRs

Thanks for your attention

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