1) Title of the tutorial

Combining model-based and data-driven statistical processing for radar detection

2) Instructors name and affiliation

Prof. Angelo Coluccia, PhD
Department of Engineering, University of Salento, Lecce, Italy

3) a 300 word abstract describing the proposed topic and including an outline of the contents

There is a recent trend in adopting data-driven techniques, namely machine learning (in either shallow or deep flavors), to design novel solutions for signal processing problems traditionally addressed by model-based approaches.
On the other hand, domain-specific modeling has been proving its effectiveness for decades, providing control and interpretability.
A promising alternative is the combination of both approaches. The tutorial will give an overview on some recent work in this respect, with focus on radar systems. It will be first illustrated the case of detection of an unstructured signal. Space-time adaptive detection (STAP) of a structured signal will be then addressed by revisiting classical robust or selective hypothesis testing approaches, namely based on GLRT, under the lens of machine learning.
The case study of drone detection/classification using (frequency modulated) continuous-wave radars will be also discussed.

> Radar detection: classical approach vs machine learning
- Unstructured signal: Neyman-Pearson, energy detector, eigenvalue-based detector
- Structured signal: one-step and two-step GLRT approaches
- Performance characterization: PFA, PD, CFAR property
- Signal classification, linear/nonlinear classifiers, feature space
- Neural networks and shallow/deep learning

> Hybrid model-based and data-driven detection
- Restricted neural network architecture for CFAR detection (analysis&design)
- Application to robust CFAR detection
- Application to CFAR rejection of unwanted signals
- Application to CFAR detection of drones through (FM)CW radar
  Discussion and open issues

4) target audience and assumed knowledge

The intended audience includes PhD students with a background in electrical engineering, as well as researchers from academia or industry interested in the new possibilities brought by data-driven approaches to the statistical problem of radar detection.