COMMUNICATION ENGINEERING AND ELECTRONIC TECHNOLOGIES

(Lecce - Università degli Studi)

Teaching LABORATORY OF WIRELESS COMMUNICATIONS AND RADAR

GenCod A006431

Owner professor ALESSIO FASCISTA

Reference professors for teaching
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Teaching in italian LABORATORY OF WIRELESS COMMUNICATIONS AND

Teaching LABORATORY OF WIRELESS COMMUNICATIONS AND RADAR

SSD code ING-INF/03

Reference course COMMUNICATION ENGINEERING AND ELECTRONIC

Course type Laurea Magistrale

Credits 6.0

Teaching hours Ore-Attivita-frontale: 54.0

For enrolled in 2021/2022

Taught in 2022/2023

Course year 2

Language INGLESE

Curriculum Telecom Applications

Location Lecce

Semester Secondo-Semestre

Exam type Orale

Assessment Voto-Finale

Course timetable
https://easyroom.unisalento.it/Orario

BRIEF COURSE DESCRIPTION

General Background:

- A brief introduction to Matlab programming.

Wireless Communications Module:

- Introduction to modeling and simulation of wireless communication systems.

List of potential laboratory experiences:

- Lab Experience #1: *Simulation and Analysis of 5G Wireless Communication Systems*

1. Transmitted signal generation (single-carrier and multi-carrier technologies);
2. Multiple-input multiple-output (MIMO) and Multiple-input single-output (MISO) radio channel modeling;
3. Downlink and Uplink mmWave communications;
4. Channel Estimation (LOS and NLOS) and Performance Analysis.

- Lab Experience #2: *Use of Software-Defined-Radio (SDR) Platforms*

1. Signals acquisition and analysis using SDRAngel and RTL-SDR;
2. Implementation of algorithms for spectrum sensing (energy detector vs machine learning);
3. Other applications/examples with SDRAngel and RTL-SDR;
4. Airplane Tracking using aviation signals ADS-B and RTL-SDR.

- Lab Experience #3: *Prototype of a Real Wi-Fi Communication System using ESP-32 Development Boards*

1. Setup and configuration of the experimental testbed;
2. Real-time data acquisition;
3. Analysis and processing of Wi-Fi Channel State Information (CSI).

Radar Module:

- Review of pulsed radars and brief introduction to continuous wave (CW) and frequency-modulated CW (FMCW) radars.

List of potential laboratory experiences:

- Lab Experience #1: *CFAR Radar Detection using Matlab*

1. CFAR detection techniques: motivation and basic strategies;
2. Coherent and Incoherent detection;
3. Implementation of different CFAR detection schemes: cell averaging (CA) CFAR, greatest of (GO) CFAR and smallest of (SO) CFAR, censored CA-CFAR, and ordered statistic (OS);
4. Analysis under ideal and non-ideal conditions (clutter edges and multiple targets).

- Lab Experience #2: *Target Detection using Real Radar Data*

1. Statistical analysis and processing of real radar data;
2. Estimation of the power spectral density and model fitting;

3. Design and implementation of detection algorithms to reveal the presence of targets embedded in real clutter.

- Lab Experience #3: *CW and FMCW Radars*

1. Design of algorithms for target detection and parameter(s) estimation;
2. Performance analysis based on synthetic and real data.

REQUIREMENTS

Prerequisites: statistical signal processing and learning, digital communications.

COURSE AIMS

Overview.

This laboratory course offers to students the possibility to deepen and put in practice the knowledge on the design and analysis of wireless communication systems and radars. The lab sessions will be preceded by lectures to describe the experiments that will be performed and the procedure to implement them.

Learning Outcomes.

Knowledge and understanding

After the course the student should know the tools necessary 1) to fit a statistical model to data and 2) to design algorithms to retrieve information chosen according to the adopted model.

Applying knowledge and understanding

After the course the student should be able to

*fit a statistical model to data in terms of first order distribution and autocorrelation function;

*solve detection and estimation problems for the selected applications.

*Evaluate the performance parameters and discuss complexity issues associated with different solutions.

Making judgements

Students should acquire the ability to compare pros and cons of different approaches to the solution of a specific problem (laboratory experiences).

Communication

The ability to communicate on technical topics should be acquired by reporting on laboratory experiences.

Learning skills

Laboratory experiences will require elaborating on techniques introduced in previous courses, also with the help of selected readings suggested by the instructor. Identifying solutions to non trivial problems will be important to be ready for autonomous lifelong learning.

TEACHING METHODOLOGY

Lectures and computer/experimental projects. Most of the activity is performed in the laboratory, where students can setup experiments regarding radar signal processing and wireless transmissions in Matlab and/or using Software Defined Radio (SDR) platforms. To attend the course, the student is NOT required to have knowledge of these tools in advance.

ASSESSMENT TYPE

The exam will be composed of an *oral part* (30%) and a *practical part* (70%), where some modifications to the software and experiments developed during the course will be required; the objective of the practical part is not to focus on programming skills, but to verify the knowledge level of the discussed topics.

OTHER USEFUL INFORMATION

By appointment; contact the instructor by email or at the end of class meetings.

REFERENCE TEXT BOOKS

1) Handouts (in progress).
2) M. C. Jeruchim, P. Balaban, K. S. Shanmugan, "*Simulation of Communication Systems*," Plenum Press, 1992.
3) R. B. D'Agostino and M. A. Stephens, "*Goodness of Fit Techniques*," Marcel Dekker, 1986.
4) J. Proakis: "*Digital Communications*", McGraw Hill, 2000.
5) D. Tse and P. Viswanath: "*Fundamentals of Wireless Communication*" Cambridge University Press, 2005.
6) R. W. Stewart, K. W. Barlee, D. S. Atkinson, and L. H. Crockett: "*Software defined radio using MATLAB & Simulink and the RTL-SDR',* University of Strathclyde Engineering (free ebook), 2015.