Class of

**Multidimensional Signal Processing**
(6 ECTAS)

Master Degree in “Ingegneria delle Telecomunicazioni”
Dipartimento di Ingegneria Elettrica e Informazione (DEI)
A.A. 2016-2017
(D.M. 270)

**Lecturer: Pietro Guccione, PhD**

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**Class goals**

Goal of the class is twofold: (1) to provide the scholars with some mathematical and engineering methods to investigate, understand, process and predict behavior or hidden patterns in multivariate data; (2) to have a view of the main methods of machine learning (mainly dimensionality reduction, source separation, clustering and classification), applied to large volume of data.

The class is provisionally organized in 16 lectures where basic concepts, in-depth analysis and case study are illustrated and laboratory activities (8 sessions) where specific examples of data processing are carried on by the scholars.

It is expected that the students have proficiency in signal theory, basics of probability and random processes, signal processing and MatLab® programming.

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**Approximate organization of lectures**

1. Introduction to the class: what is the multidimensional signal processing and what problems can be solved. The main elements of multidimensional signal processing: supervised/unsupervised learning and the main techniques.
3. Traditional pre-processing steps: feature selection, normalization or z-scoring. Missing data, outliers detection.
6. Bayesian inference, distance between pdf and ANOVA. **Laboratory**: statistics applications.
7. **Laboratory**: simulation of multivariate Gaussian data; application of Student test, ANOVA. Statistic distance between pdf.
8. Linear Dimensionality Reduction: Principal Component Analysis, Canonical Correlation Analysis, M-CCA.
9. **Laboratory**: PCA / CCA on multidimensional signals (hyperspectral remote sensing image).
10. Further focus on dimensionality reduction: OCCR and NNMF.
11. Basics on Blind Source Separation: Independent Component Analysis – **Laboratory**: ICA applied on hyperspectral remote sensing image
12. The general problem of statistical learning. Regression vs. Classification – **Laboratory**: ICA
14. **Laboratory**: comparison of MLR and PLS on specific datasets I.
15. **Laboratory**: comparison of MLR and PLS on specific datasets II.
17. Hierarchical clustering and density based clustering. Selection of the number of clusters
18. Introduction to classifiers: linear discriminant analysis. Bayes rule classifier, Gaussian LDA, Logistic Discrimination, Multiclass LD.
19. Basics of k-NN (k Nearest Neighbors) and Support Vector Machines.
20. **Laboratory**: build a classifier for hyperspectral remote sensing dataset I.
21. Distance geometry, Nonlinear Dimensionality Reduction, Manifold Learning and IsoMap. Regularization and Bootstrap.

22. Basics on nonlinear and complex systems and recurrence. Recurrence Plot and Recurrence Quantitative Analysis. Case Study on fMRI data.

23. Laboratory: summary laboratory on previous topics.

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References


Examination:
Oral, but projects developed during the lectures can be illustrated at the examination time