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Course guide
230331 - APA - Machine Learning

Last modified: 25/05/2023

Unit in charge:	Barcelona School of Telecommunications Engineering
Teaching unit:	739 - TSC - Department of Signal Theory and Communications.

Degree:	BACHELOR'S DEGREE IN TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES ENGINEERING (Syllabus 2015). (Optional subject).
	BACHELOR'S DEGREE IN ELECTRONIC ENGINEERING AND TELECOMMUNICATION (Syllabus 2018). (Optional subject).

Academic year: 2023   **ECTS Credits:** 2.0   **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer:	Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura
Others:	Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Stochastic processes. Signal processing.

REQUIREMENTS

BACHELOR'S DEGREE IN TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES ENGINEERING (GRETST)
PROBABILITY AND STATISTICS - Prerequisite
BACHELOR'S DEGREE IN ELECTRONIC ENGINEERING AND TELECOMMUNICATION (GREELEC)
PROBABILITY AND STOCHASTIC PROCESSES

TEACHING METHODOLOGY

Time will be shared by theory lectures and labs in Python.

LEARNING OBJECTIVES OF THE SUBJECT

The subject gives a review of the pattern classification and recognition from the mathematical point of view and at the same time, applies the methods to several areas of signal processing.

The structure of the general problem of pattern recognition (i.e, pre-processing, feature extraction and classification), can be applied to different areas, such as quality control, biomedical applications and diagnosis, communication systems, image processing, and speech recognition.

The subject, will give a general view of the bayesian desision theory, maximum likelihood estimation, non parametric classification techniques and non supervised learning, with application to different areas of signal processing, such as classification of biomedical signals, images, signal detection, signal modulation, etc.

For each of the selected applications, the work done in class, will deal with different classification criteria, in order to analyze the compromise between good performance and computation efficiency of each classifier.

The 6 credits of the subject are divided between theoretical classes, and at the same time, practical classes at the laboratory (MATLAB), where the student will develop the selected applications, with emphasis in the applications on medical diagnosis, image possessing, and communications. In each of the theoretical parts, the methods and algorithms will be developed so that they can be understood and programmed at the same time. Some advanced techniques will also be presented. In the last weeks of the course all the students will participate in a machine learning competition proposed by the teacher.

STUDY LOAD

Type	Hours	Percentage
Hours small group	6,0	12.00
Hours large group	14,0	28.00
Self study	30,0	60.00

Total learning time: 50 h

CONTENTS

1. Introduction

Description:
1.1 Introduction to pattern classification
1.2 Feature extraction
1.3 Classes and models

Full-or-part-time: 6h
Theory classes: 2h
Laboratory classes: 2h
Guided activities: 1h
Self study : 1h

2. Decision theory

Description:
2.1 Minimization of the Bayesian risk
2.2 Gaussian model
2.3 Linear and quadratic discriminants
2.4 Máximum likelihood estimation

Full-or-part-time: 10h
Theory classes: 4h
Laboratory classes: 4h
Guided activities: 1h
Self study : 1h

3. Feature selection

Description:
3.1 Principal components analysis
3.2 Multiple discriminants analysis

Full-or-part-time: 10h
Theory classes: 4h
Laboratory classes: 4h
Guided activities: 1h
Self study : 1h

4. Non-parametric techniques for supervised learning

Description:
4.1 Parzen windows and k-nearest neigbours
4.2 Support vector machines
4.3 Neural networks
4.4 Decision trees

Full-or-part-time: 24h
Theory classes: 11h
Laboratory classes: 11h
Guided activities: 1h
Self study : 1h

5. Evaluation, combination and selection of classifiers

Description:
5.1 Lack of superiority of any classifier
5.2 Complexity
5.3 Bias and variance
5.4 Resampling for classifier design
5.5 Combining classifiers
5.6 Comparing classifiers
5.7 Lauching a ML project

Full-or-part-time: 6h
Theory classes: 2h
Laboratory classes: 2h
Guided activities: 1h
Self study : 1h

6. Unsupervised learning

Description:
6.1 Parametric methods: EM i k-means
6.2 Non-parametric methods: clustering

Full-or-part-time: 8h
Theory classes: 3h
Laboratory classes: 3h
Guided activities: 1h
Self study : 1h

ACTIVITIES

Laboratories

Description:
PRAC0: Exploratory data analysis
PRAC1: MAP for Gaussian data
PRAC2: Data basis and feature selection
PRAC3: K-Nearest
PRAC4: SVM
PRAC5: Neural networks
PRAC6: Tree classifiers
PRAC7: Competition

Material:
Matlab code and data bases will be available in Atenea.

Delivery:
Every second week, a report of the laboratory will have to be uploaded to Atenea.

Full-or-part-time: 26h
Laboratory classes: 26h

GRADING SYSTEM

Quizzes: 50%
Competition: 50%

EXAMINATION RULES.

The use of calculators, mobile phones or class notes is not allowed.

BIBLIOGRAPHY

Basic:
- Duda, R.O.; Hart, P.E.; Stork, D.G. Pattern classification [on line]. 2nd ed. New York [etc.]: John Wiley & Sons, 2001 [Consultation: 18/07/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=699526. ISBN 0471056693.

Complementary:
- Stork, D.G.; Yom-Tov, E. Computer manual in MATLAB to accompany pattern classification. 2nd ed. Hoboken: Wiley, 2004. ISBN 0471429775.
- Hastie, T.; Tibshirani, R.; Friedman, J.H. The elements of statistical learning: data mining, inference and prediction [on line]. 2nd ed. New york [etc.]: Springer, 2009 [Consultation: 18/07/2023]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-0-387-84858-7. ISBN 9780387848570.
- Bishop, C.M. Pattern recognition and machine learning. New York: Springer, 2006. ISBN 0387310738.
- Kuncheva, L.I. Combining pattern classifiers: methods and algorithms [on line]. 2nd ed. Hoboken (NJ): J. Wiley & Sons, 2014 [Consultation: 21/09/2018]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118914564. ISBN 9781118914564.

RESOURCES

Other resources:
For the development of the laboratories, applications in Matlab will be provided through Atenea.