

Course guides 270658 - KMLMM - Kernel-Based Machine Learning and Multivariate Modelling

Last modified: 12/07/2021

Unit in charge:	Barcelona School of Informatics		
Teaching unit:	715 - EIO - Department of Statistics and Operations Research.		
	723 - CS - Department of Computer Science.		
Degree:	MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Optional subject).		
Academic year: 2021	ECTS Credits: 6.0 Languages: English		

LECTURER				
Coordinating lecturer:	PEDRO FRANCISCO DELICADO USEROS - LUIS ANTONIO BELANCHE MUÑOZ			
Others:	Primer quadrimestre: LUIS ANTONIO BELANCHE MUÑOZ - 10 PEDRO FRANCISCO DELICADO USEROS - 10			

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CEC1. Ability to apply scientific methodologies in the study and analysis of phenomena and systems in any field of Information Technology as well as in the conception, design and implementation of innovative and original computing solutions. CEC3. Ability to apply innovative solutions and make progress in the knowledge that exploit the new paradigms of Informatics, particularly in distributed environments.

Generical:

CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.

Transversal:

CTR4. INFORMATION LITERACY: Capability to manage the acquisition, structuring, analysis and visualization of data and information in the area of informatics engineering, and critically assess the results of this effort.

CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

TEACHING METHODOLOGY

Learning is done through a combination of theoretical explanations and their application to practising exercises and real cases. The lectures will develop the necessary scientific knowledge, including its application to problem solving. These problems constitute the practical work of the students on the subject, which will be developed as autonomous learning. The software used will be primarily R.



LEARNING OBJECTIVES OF THE SUBJECT

1. Understand the foundations of Kernel-Based Learning Methods

2.Get acquainted with specific kernel-based methods, such as the Support Vector Machine

3.Know methods for kernelizing existing statistical or machine learning algorithms

4.Know the theoretical foundations of kernel functions and kernel methods

5.Know the structure of the main unsupervised learning problems.

6.Learn different methods for dimensionality reduction when the standard assumptions in classical Multivariate Analysis are not fulfilled

7.Learn how to combine dimensionality reduction techniques with prediction algorithms

STUDY LOAD

Туре	Hours	Percentage
Hours large group	54,0	36.00
Self study	96,0	64.00

Total learning time: 150 h

CONTENTS

Introduction to Kernel-Based Learning

Description:

This topic introduces the student the foundations of Kernel-Based Learning focusing on Kernel Linear Regression

The Support Vector Machine (SVM)

Description:

This topic develops Support Vector Machine (SVM) for classification, regression and novelty detection

Kernels: properties & design

Description:

This topic defines kernel functions, their properties and construction. Introduces specific kernels for different data types, such as real vectors, categorical information, feature subsets, strings, probability distributions and graphs.

Kernelizing ML algorithms

Description:

This topic reviews different techniques for kernelizing existent algorithms

Theoretical underpinnings

Description:

This topic reviews the basic theoretical underpinnings of kernel-based methods, focusing on statistical learning theory



Introduction to unsupervised learning

Description:

Unsupervised versus supervised learning. Main problems in unsupervised learning (density estimation, dimensionality reduction, latent variables, clustering).

Nonlinear dimensionality reduction

Description:

- a. Principal curves.
- b. Local Multidimensional Scaling.
- c. ISOMAP.
- d. t-Stochastic Neighbor Embedding.
- e. Applications: (i) Visualization of high- or infinite-dimensional data. (ii) Exploratory analysis of functional data in Demography.

Dimensionality reduction with sparsity

Description:

- a. Matrix decompositions, approximations, and completion.
- b. Sparse Principal Components and Canonical Correlation.
- c. Applications: (i) Recommender systems. (ii) Estimating causal effects.

Prediction after dimensionality reduction.

Description:

- a. Reduced rank regression and canonical correlation.
- b. Principal Component regression.
- c. Distance based regression.

ACTIVITIES

Introduction to Kernel-Based Learning

Specific objectives:

1

Related competencies :

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Full-or-part-time: 10h

Theory classes: 4h Self study: 6h



The SVM for classification, regression and novelty detection

Specific objectives:

2

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CTR4. INFORMATION LITERACY: Capability to manage the acquisition, structuring, analysis and visualization of data and information in the area of informatics engineering, and critically assess the results of this effort.

Full-or-part-time: 9h Theory classes: 3h Self study: 6h

Kernels: properties & design

Specific objectives:

1,3

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Practice class (I): the SVM

Specific objectives:

1,2

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Theory classes: 3h Self study: 6h



Kernelizing ML algorithms

Specific objectives:

3,4

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Full-or-part-time: 10h

Theory classes: 4h Self study: 6h

Practice class (II): kernel design & other KBL methods

Specific objectives:

3, 4

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Full-or-part-time: 9h

Theory classes: 3h Self study: 6h

Theoretical underpinnings

Specific objectives:

1,4

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Full-or-part-time: 10h Theory classes: 4h Self study: 6h



Introduction to unsupervised learning

Full-or-part-time: 9h Theory classes: 3h Self study: 6h

Nonlinear dimensionality reduction 1

Full-or-part-time: 10h Theory classes: 4h Self study: 6h

Nonlinear dimensionality reduction 2

Full-or-part-time: 9h Theory classes: 3h Self study: 6h

Dimensionality reduction with sparsity 1

Full-or-part-time: 10h Theory classes: 4h Self study: 6h

Dimensionality reduction with sparsity 2

Full-or-part-time: 9h Theory classes: 3h Self study: 6h

Prediction after dimensionality reduction 1

Full-or-part-time: 10h Theory classes: 4h Self study: 6h

Prediction after dimensionality reduction 2

Full-or-part-time: 8h 12m Theory classes: 2h Guided activities: 0h 12m Self study: 6h



Evaluation quiz

Specific objectives: 1, 2, 3, 4, 5, 6, 7

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CTR4. INFORMATION LITERACY: Capability to manage the acquisition, structuring, analysis and visualization of data and information in the area of informatics engineering, and critically assess the results of this effort.

Full-or-part-time: 15h Guided activities: 3h Self study: 12h

GRADING SYSTEM

The course evaluation will be based on the marks obtained in the practical works delivered during the semester plus the mark obtained in the written test for global evaluation.

Each practical work will lead to the drafting of the corresponding written report which will be evaluated by the teachers resulting in a mark denoted P.

The exam will take place at the end of the semester and will evaluate the assimilation of the basic concepts on the whole subject, resulting in a mark denoted T.

The final mark will be obtained as:

60% x P + 40% x T

BIBLIOGRAPHY

Basic:

- Shawe-Taylor, J.; Cristianini, N. Kernel methods for pattern analysis. Cambridge University Press, 2004. ISBN 0521813972.

- Schölkopf, B.; Smola, A.J. Learning with Kernels: support vector machines, regularization, optimization, and beyond. The MIT Press, 2002. ISBN 0262194759.

- Deng, L.; Yu, D.. Deep learning: methods and applications (pp.197-387). Now Publishers Inc., 2014. ISBN 9781601988140.

- Goodfellow, I.; Bengio, Y.; Courville, A. Deep learning (Vol. 1). The MIT Press, 2016. ISBN 9780262035613.

- Hastie, T.; Tibshirani, R.; Friedman, J. The Elements of statistical learning: data mining, inference, and prediction. 2nd ed. New York [etc.]: Springer, cop. 2009. ISBN 9780387952840.

- Hastie, Trevor; Tibshirani, Robert; Wainwright, Martin. Statistical learning with sparsity: the lasso and generalizations [on line]. Boca Raton: CRC Press, 2015 [Consultation: 19/11/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4087701. ISBN 9781498712170.

Complementary:

- Cherkassky, V.S.; Mulier, F. Learning from data: concepts, theory, and methods. 2nd ed. John Wiley, 2007. ISBN 0471681822.



RESOURCES

Hyperlink:

- http://cran.r-project.org/
- http://videolectures.net/Top/Computer_Science/Machine_Learning/