UNIVERSITÀ DI PAVIA

Anno Accademico 2021/2022

COMPUTATIONAL LEARNING IN BIOMEDICINE

Enrollment year	2021/2022
Academic year	2021/2022
Regulations	DM270
Academic discipline	ING-INF/06 (ELECTRONIC AND INFORMATION BIOENGINEERING)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	BIOENGINEERING
Curriculum	Cellule, tessuti e dispositivi
Year of study	1°
Period	2nd semester (07/03/2022 - 17/06/2022)
ECTS	9
Lesson hours	80 lesson hours
Language	Italian
Activity type	WRITTEN TEST
Teacher	BELLAZZI RICCARDO - 6 ECTS RAMAT STEFANO - 3 ECTS
Prerequisites	Basic knowledge of statistics and probability theory. Basic knowledge of informatics and statistical software tools
Learning outcomes	The course aims to provide students with methodological skills and techniques to: * use in biomedical applications a large class of algorithms that are able to learn decision rules from data and automatically improve their performance based on experience. In the first part of the course, basic methods of machine learning will be introduced. At the end of this part, the student should be able to: * soundly apply machine learning approaches to learn decision rules from data * use machine learning software tools and statistical packages The course will include both lectures and practical hands-on computer lessons. In the second part of the course a specific focus will be given to two

widely used methodologies in the field of Artificial Intelligence: neural networks and deep learning on the one hand and genetic algorithms on the other. The former represent a computational learning tool for both static and dynamic recognition and classification tasks, the latter are an extremely versatile stochastic-based optimization method. At the end of the course, students should be able to implement the main "shallow" and "deep" network architectures for classification and approximation, as well as generational and steady state genetic algorithms in the Matlab environment.

Course contents

Part 1.
Learning decision rules - supervised learning
Introduction: Machine Learning and Data Mining in the biomedical sciences.
Areas of application of automatic methods for classification: diagnosis, prognosis, research
The basic concepts: examples, instances, attributes, and representation of decision rules
Decision Trees: learning techniques for pruning
Bayesian methods: Naive Bayes discriminant analysis
Regression models: linear model, logistic regression, neural networks, support-vector machines
Method and k-nearest distance measures
Random forests, Boosting
Techniques of feature selection. Information gain and Relief
Evaluation of learning algorithms and problems of evaluation in the biomedical field
Training and Testing. Accuracy, calibration, sensitivity and specificity, precision and recall, F measure
Methods for performance evaluation. Cross Validation, Bootstrap and ROC curves.
Unsupervised learning
Association Rules
Clustering methods: K-means, K-medoids, hierarchical clustering, self-organizing maps
Evaluation of the results of the clustering methods
Applications of data mining in bio-medicine: diagnosis, prognosis, classification, functional genomics
Practical Activities
The CRISP methodology for data mining in bio-medicine.
Hands-on with computer programs: Orange, Python and Matlab for the solution of classification problems.
Part 2.
Introduction to neural networks.
The perceptron and adaline, networks based on a single neuron for classification and linear approximation.
Multilayer perception and radial basis function networks.
Self organizing maps for unsupervised clustering.
Dynamic networks: the Hopfield network, the Elman network and its evolutions, the state-space model network. Recurring networks and Long Short Term Memory network. Convolutional networks, autoencoders, generative networks.

Teaching methods

Teaching about theory, exercises and computer classes

Reccomended or required readings

T. Mitchell. Machine Learning. Mc Graw Hill..
P. Tan, M. Steinbach, V. Kumar. Introduction to data mining. Addison Wesley..
I. Witten, E. Frank. Data mining. Morgan Kaufmann.
Riccardo Bellazzi. Course Slides.
S. Haykin, Neural Networks and Learning Machines, Prentice Hall, 3rd Ed., 2009
D.E. Goldberg, Genetic Algorithms in search, optimization and machine learning, Addison Wesley, 1989
Stefano Ramat. Course Slides.

Assessment methods

Written test and discussion about two essays on data analysis problems, one on machine learning methods and one on neural networks and deep learning

Further information

Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile