Machine Learning (part II)

Introduction to the course

Prof. Angelo Ciaramella

The course

- 12 training credits (CFU)
  - Part I (6 CFU)
    - Teacher – Prof. Francesco Camastra
  - Part II (6 CFU)
    - Teacher – Prof. Angelo Ciaramella
- Theoretical part
  - Frontal lectures
  - Practices
    - theoretical
    - laboratory

The course

- Examination
  - Theoretical/practical project
    - Topic chosen by the student or theachers
    - Term paper
  - Oral interview
    - Presentation
    - Project explenation

Lecture timetable

- Lecture Timetable
  - Monday
    - 2:00 p.m. - 4:00 p.m. – Lab 1
  - Friday
    - 2:00 p.m. - 4:00 p.m. – Lab 1
- Office hours
  - Tuesday
    - 2:00 p.m. – 4:00 p.m.
  - “On demand”
    - via e-mail

Objectives of the course

- The course aims to provide the theoretical and practical foundations of Machine Learning, Computational Intelligence and Deep Learning
  - Pre-processing and features extraction
  - Unsupevised learning
  - Supervised learning
  - Deep learning
  - Validation methods

Teaching materials

- Recommended books
  - J. C. Bishop, «Neural Networks for Pattern Recognition», Oxford University Press, 1995
  - J. C. Bishop, «Pattern Recognition and Machine Learning», Springer, 2006
  - I. Goodfellow, Y. Bengio, A. Courville, «Deep Learning», MIT Press, 2016
  - A. Geron, «Hands-on Machine Learning with Scikit-Learn, Keras, and TensorFlow», O'Reilly, 2019
- Lecture notes
  - e-learning material

Syllabus

- Introduction
  - Artificial Intelligence and Computational Intelligence
  - Deep Learning vs. Machine Learning
- Taxonomy of Deep Learning
- Foundations of Neural Networks
  - Biological Neuron vs. Artificial Neuron
  - Hebb's rule

Syllabus

- Self-organizing Neural Networks
  - Oja's and Sanger's rules
  - Neural Network for Principal and Independent Component Analysis
  - Neural networks based on competition mechanisms
    - Kohonen's Maps
    - Self Organizing Maps
    - Adaptive Resonance Theory

Syllabus

- Supervised Neural Networks
  - Single-Layer Networks
  - Multi-Layer Perceptron (MLP),
    - properties of Universal Approximation
    - Kolmogorov theorem, Back-propagation algorithm
    - MLP vs Radial Basis Functions
    - Error functions
    - MLP and Vapnik – Chervonenkis dimension
- Supervised Neural Networks and optimization algorithms
  - Descending gradient, conjugate gradient, scaled conjugate gradient, Newton method, Levenberg-Marquardt algorithm, constrained optimization

Syllabus

- Pre-processing and extraction of features
  - Whitening
  - Fisher's linear discriminant
  - criteria for selecting features
- Learning and generalization
  - bias-variance dilemma
  - regularization
  - NNs committee
  - mixture of experts
  - cross-validation

Syllabus

- Deep Neural Networks
  - Convolutive Neural Networks
  - Recurrent Neural Networks
  - Recursive Neural Networks
  - Echo State Networks
  - Long Short-Term Memory
  - Linguistic and Vision Transformers

- Methodologies for Deep Learning
  - Autoencoders
  - Sparse Coding
  - Dictionary Learning
  - Representation Learning
  - Generative Models
  - Generative Adversial Neural Network

Syllabus

- Validation methods
  - Confusion matrix and indices
  - ROC curve
  - Statistical significance