Machine Learning: Fundamentals (AA1)

Master Programme in Computer Science
Master Programme in Business Informatics
Master Programme in Digital Humanities

Code: 320AA ECTS: 6 Semester: 1 Acronym: AA1

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Machine Learning

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"*The problem of learning is arguably at the very core of the problem of intelligence, both biological and artificial*"

[Poggio, Shelton, AI Magazine 1999]

- ***Machine Learning*** has emerged as an area of research combining the aims of creating *computers that could learn* (AI) and new *powerful adaptive/statistical tools* with rigorous foundation in computational science
  - *Learning as strategic way to provide intelligence into the systems*
  - *Central/methodological role due to changing of paradigm in science: data-driven*

Machine Learning Aims

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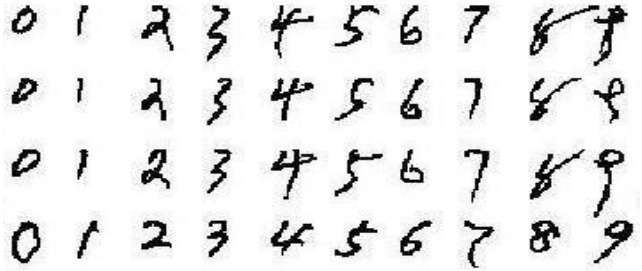
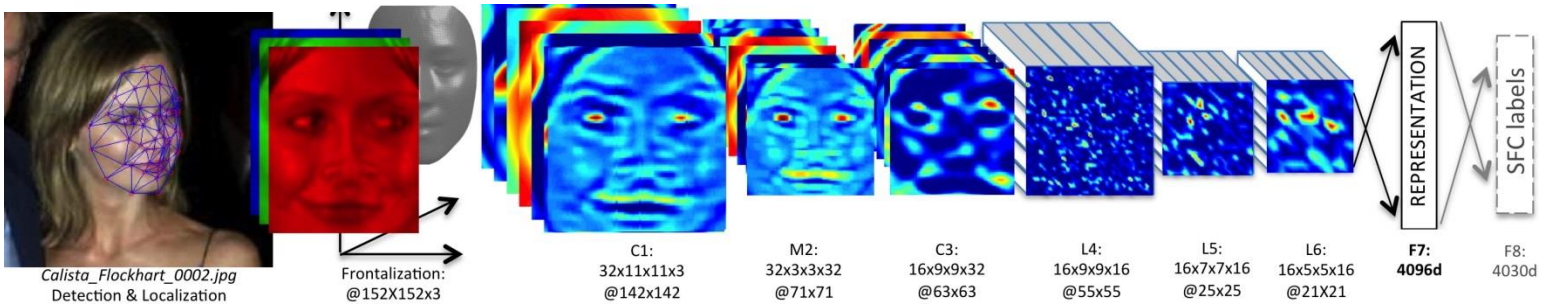
- As AI methodology → Build Intelligent/Adaptive Systems
- As statistical learning → Build powerful predictive systems for Intelligent Data Analysis
- As computer science method for innovative application areas
  → Using models as a tool for complex (interdisciplinary) problems

Applicative and related areas:

- Real-World computing systems (pervasive, from OCR to search engines)
- New interdisciplinary areas, encompassing:
  - **Pattern Recognition** (e.g. face and speech recognition), Computer Vision, **Robotics**, **Natural Language Processing**, **Data Mining**, **Information Retrieval**, Analysis of complex data (Med, **Bio**, Chem, Web, Marketing), Financial forecasting, Adaptive Systems and Filters, **Intelligent Sensor Networks**, Personalized components, …





Face recognition (Facebook)

Go winner (DeepMind - Big G)

Self-driving cars

Sensor data
Smart *
IoT

- Pave the way to a new AI era
- Open huge application area and opportunities

Machine Learning in the Master Degree

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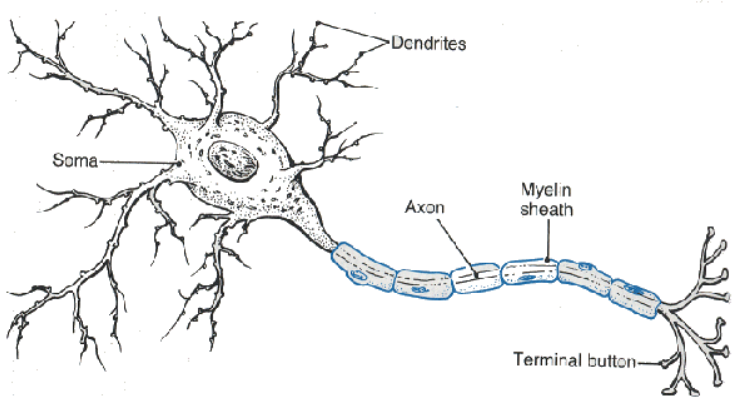
Why study *Machine Learning* ?

- To know the basic principles of learning processes (computational aspects)
- To know new computing paradigms

  e.g. natural inspired models: **Neural Networks**
  - Studied as computing paradigms since the 40 '
  - Neurobiological inspiration
  - Nowadays: set of powerful computing models for function approximation and with predictive capabilities supported by a rigorous theoretical ground (*learning theory*)
  - Models for Deep Learning
- To be able to rigorously apply them



AA1 Course: Aim Synthesis

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- Introduction to the machine learning principles and to the main paradigms (models and algorithms) for learning from data
- Method
  - The concepts are progressively introduced starting from simpler approaches up to the state-of-the-art models
  - Models focus on **Neural Networks, SVM, Graphical models, …**

A specific focus to

- general conceptual framework of modern machine learning
- critical analysis of the characteristics for the design and use of the algorithms for real problems
- rigorous experimental evaluation
- **Competition: AA1 CUP**

Formal Info – AA1

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- **Prerequisites:**

Elements of mathematical analysis: functions, differential calculus; elements of matrix notation and calculus; algorithmics; elements of probability and statistics.

- **Exam:**
  - Typically a project with a report, see the AA1 competition
  - Oral exam

Syllabus – AA1

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We introduce the **principles** and the critical analysis of the **main paradigms for learning from data** and their applications.

The concepts are progressively introduced starting from simpler approaches up to the state-of-the-art models in the general conceptual framework of modern machine learning. The course focuses on the critical analysis of the characteristics for the design and use of the algorithms for learning functions from examples and for the experimental modelization and evaluation.

Introduction: Computational learning tasks, prediction, generalization.

Basic concepts and models: structure of the hypothesis space, discrete and continuous spaces, linear models, nearest neighbour, propositional models, inductive bias.

Neural models: Perceptron and computational properties. Introduction to multilayer feedforward Neural Networks architectures and learning algorithms. Recurrent models. Deep learning.

Rule based models.

Principles of learning processes and general practical aspects: Validation, Bias-Variance analysis. Elements of Statistical Learning Theory, VC-dimension. Ensemble learning.

Support Vector Machines: linear case, kernel-based models.

Bayesian and Graphical models.

Unsupervised learning.

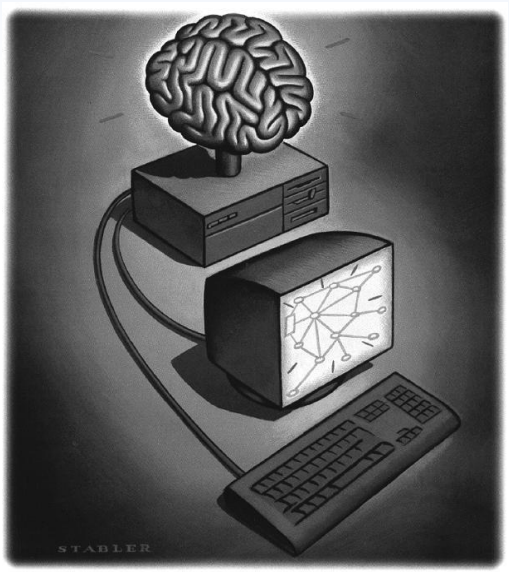
Introduction to applications and advanced models.

More Information

- **Program**: see Master Degree site

- **"What is ML?"**

Introductive enjoyable reading, see:
http://www.di.unipi.it/~micheli/DID/



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