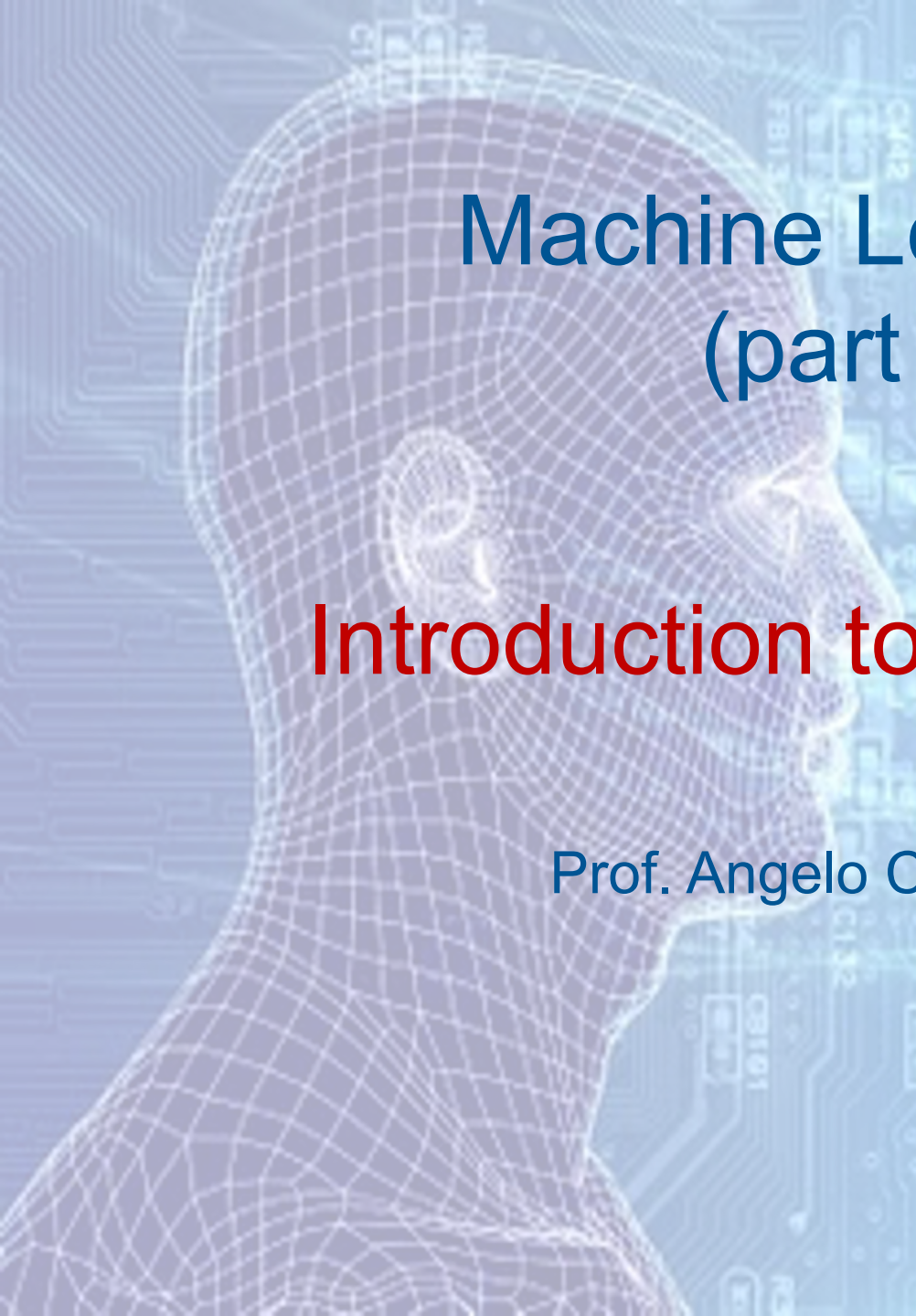
UNIVERSITÀ PARTHENOPE
DiST
Dipartimento di Scienze e Tecnologie



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
    - 11:00 a.m. - 01:00 p.m.
  - Wednesday
    - 11:00 a.m. - 01:00 p.m.
- Office hours
  - Monday
    - 9:00 a.m. - 11:00 a.m.
  - “On demand”
    - via e-mail

Objectives of the course

- The course aims to provide the theoretical and practical foundations of Deep Learning methodologies for Artificial Intelligence applications
  - Computational Intelligence
  - Deep Neural Network
  - Unsupevised learning
  - Supervised learning
  - Validation methods

Teaching materials

- Reccommended books
  - Deep Learning, Foundations and Conpcepts
    - C. M. Bishop, H. Bishop, Springer, 2023
    - Available on-line: https://www.bishopbook.com
  - Deep Learning
    - I. Goodfellow, Y. Bengio, A. Courville, MIT Press, 2016
    - Available on-line: https://www.deeplearningbook.org
  - Pattern Recognition and Machine Learning
    - J. C. Bishop, Springer, 2006
    - Available on-line: https://www.microsoft.com/en-us/research/uploads/prod/2006/01/Bishop-Pattern-Recognition-and-Machine-Learning-2006.pdf
  - Neural Networks for Pattern Recognition
    - J. C. Bishop, Oxford University Press, 1995

Teaching materials

- Practical books
  - Hands-on Machine Learning with Scikit-Learn, Keras, and TensorFlow
    - A. Geron, 2nd edition, O'Reilly, 2019
    - Python notebooks: https://github.com/ageron/handson-ml2

Teaching materials

- Books for further study on the subject
  - Probabilistic Machine Learning: An Introduction
    - Kevin P. Murphy, MIT Press, 2022
    - Available on-line: https://probml.github.io/pml-book/book1.html
  - Understanding Deep Learning
    - S. J. D. Prince, 2024
    - Available on-line: https://udlbook.github.io/udlbook/
    - Python notebooks available
  - Manuale sulle reti neurali
    - D. Floreano, C. Mattiussi, Il Mulino, 2002

Syllabus

- Introduction
  - Artificial Intelligence and Deep Learning
  - Computational Intelligence vs. Machine Learning
- Foundations of Neural Networks
  - Biological Neuron and Artificial Neuron
  - Hebb's rule
- Probability and Distributions
  - Bayes' theorem
  - Information theory
  - Standard Distributions
    - Discrete variables
    - Multivariate Gaussian

Syllabus

- Hebbian and 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
    - Adaptive Resonance Theory
- Supervised Neural Networks
  - Single-Layer Networks
  - Multi-Layer Perceptron (MLP)
    - Universal Approximation
    - Kolmogorov theorem
    - Back-propagation algorithm
    - MLP vs Radial Basis Functions
    - MLP and Vapnik – Chervonenkis dimension

Syllabus

- Supervised Neural Networks and optimization algorithms
  - Descending gradient, conjugate gradient, scaled conjugate gradient, Newton method, Levenberg-Marquardt algorithm, constrained optimization
- Pre-processing and feature extraction
  - Whitening
  - Fisher's linear discriminant
  - criteria for selecting features

Syllabus

- Learning and generalization
  - bias-variance dilemma
  - regularization
  - NNs committee
  - cross-validation
  - mixture of experts
  - drop-out

Syllabus

- Deep Neural Networks
  - Convolutive Neural Networks
  - Recurrent Neural Networks
    - Echo State Networks
    - Long Short-Term Memory
  - Recursive Neural Networks
- Transformers
  - Attention
  - Multimodal Transformers
- Graph Nerual Networks
  - Neural Message-Passing
  - General Graph Neural Networks

Syllabus

- Autoencoders
  - Deterministic Autoencoders
  - Variational Autoencoders
- Diffusion Models
  - Forward encoder
  - Reverse Decoder
  - Score matching

Syllabus

- Deep Generative Models
  - Deep Belief Networks
  - Deep Boltzmann Machines
- Sampling Methods
  - Need for Sampling
  - Basic Sampling Methods
  - Markov Chain Monte Carlo Sampling
  - Gibbs Sampling

Syllabus

- Reinforcement Learning
  - Q-Learning
    - Deep Reinforcement Learning
- Explainable AI
  - Neuro-Symbolic models
    - Neuro-Fuzzy models
- Validation methods
  - Confusion matrix and indices
  - ROC curve
  - Statistical significance

Syllabus

- Python and Machine Learning frameworks
  - Scikit-Learn
  - Keras
  - TensorFlow
  - Notebooks on the e-learning platform