

Tutor: Prof. Marco GORI
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Title of the course: Variational Laws of Learning.

Summary: By and large, most studies of machine learning and pattern recognition are rooted in the framework of statistics. This is primarily due to the way machine learning is traditionally posed, namely by a problem of extraction of regularities from samples of a probability distribution. This course promotes a truly different way of interpreting learning processes that relies on system dynamics. We promote a view of learning as the outcome of laws of nature that govern the interactions of intelligent agents with their own environment. We reinforce the underlying principle that the acquisition of cognitive skills by learning obeys information-based laws on these interactions, which hold regardless of biology. These laws are derived in a variational framework that is very much related to the principle of least action in physics, that is reformulated in a truly causal framework. A preliminary application to visual perception is given where the emergence of visual features is only driven by visual interactions with no supervision.

Syllabus:

16 September - morning

1. The principle of Least Action in Physics
2. Causality and minimum issues
3. The principle of Cognitive Action

16 September - afternoon

1. Exercises on Euler-Lagrange equations
2. Simulation of fourth-order models of non-causal mechanics
3. Experiments on “approaching causality”

17 September - morning

1. Lagrangian functions in different learning tasks
2. Incorporation of architectural constraints
3. Learning as a dissipative process
4. Boundary conditions, causality, and information overloading

17 September - afternoon

1. Visual perception and open issues
2. Laws of focus of attention
3. Laws of motion invariance
4. Experimental session on visual feature learning

References:

- Marco Gori, "Machine Learning: A Constraint-Based Approach," Morgan Kaufman (Elsevier), 2018 (560 pp.)
- Marco Gori, Stefano Melacci, and Dario Zanca, "Gravitational Laws of Focus of Attention," IEEE Trans. on Pattern Analysis and Machine Intelligence (to appear)
- Alessandro Betti, Marco Gori, and Stefano Melacci, "Cognitive Action Laws: The Case of Visual Features," IEEE Trans. on Neural Networks and Learning Systems, to appear
- Dario Zanca and Marco Gori, "Variational Laws of Visual Attention for Dynamic Scenes," Proceedings of NIPS 2017
- Marco Gori, Marco Maggini, and Alessandro Rossi, "Neural Network Training as a Dissipative Process", Neural Networks, 2016
- Alessandro Betti and Marco Gori, "The principle of Cognitive Action," Theoretical Computer Science, 2015