



UNIVERSITÀ
DI PAVIA

Ph.D. Program in Electronics, Computer Science and Electrical Engineering

COURSE

Causal Deep Learning

Prof. Marco Piastra

COURSE DESCRIPTION: Modern AI excels at pattern recognition but often fails under distribution shifts because it lacks an understanding of underlying mechanisms. To build systems that are explainable "by design" and capable of "what-if" reasoning, we must move beyond curve-fitting toward **Structural Causal Models (SCMs)**.

This course bridges formal causal logic with the high-dimensional power of **Deep Learning**. We treat neural networks as **instrumental tools** to identify and parameterize invariant structures hidden in raw data. Students will master three pillars:

1. **Foundations of SCMs:** Exploring the hierarchy of **observation, intervention, and counterfactuals**, alongside *do*-calculus and the formal requirements for identifying causal effects.
2. **Instrumental Deep Learning:** Leveraging Normalizing Flows to map complex inputs into orthogonal, causal latent spaces.
3. **Counterfactual Reasoning:** Simulating rigorous interventions and answering counterfactual queries—the key to human-like AI.

This study aims to evolve Deep Learning from an opaque statistical tool into a verifiable framework for robust, out-of-distribution generalization.

EVALUATION: Each student will select a topic of interest, review a relevant research paper within that area, and deliver a brief presentation to the class summarizing their analysis.

ATTENDANCE: The course will be held in the MAGENTA Seminar Room. Students are encouraged to bring their own laptops to participate in hands-on exercises using Python and Google Colab. All course materials will be made available on KIRO.

LECTURES: 8 hours; **CREDITS (with evaluation):** 2.6 CFU

DATES AND TIMES:

- Thursday, May 21, from 4:00 PM to 6:00 PM
- Thursday, May 28, from 4:00 PM to 6:00 PM
- Thursday, June 04, from 4:00 PM to 6:00 PM
- Thursday, June 11, from 4:00 PM to 6:00 PM

Ph.D. Coordinator

Prof.ssa Ilaria Cristiani

Seminar in English

KIRO: <https://elearning-excu.unipv.it/course/view.php?id=1000>

EMAIL: marco.piastra@unipv.it