

Dottorato di Ricerca in Informatica – XL Ciclo A.A. 2024/2025

## **Perceptive Deep Learning and Generative AI for Industrial and Legal Applications**

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### **Abstract**

This course, “**Perceptive Deep Learning and Generative AI for Industrial and Legal Applications,**” preliminarily explores how bio-inspired Deep Learning architectures and Generative AI can be effectively applied to real-world contexts in the industrial, automotive, and legal/forensic fields. By examining scalable AI solutions, hybrid perceptive–generative models, and multi-modal data analysis, participants will gain preliminary insight into cutting-edge techniques and the explainability requirements needed for safe and robust deployment.

### **Program Overview:**

#### **1. Bio-Inspired AI and Deep Learning**

- **Biological Principles:** The course begins by preliminarily recall of biological concepts embedded in human brain.
- **Core Concepts:** Participants will explore (briefly) foundational concepts such as neural network structures (feedforward, convolutional, recurrent, transformer, hybrid, etc..), activation functions, optimization strategies, etc...

#### **2. Industrial and Embedded Applications**

- **Scalable AI Solutions:** Participants will understand how to scale AI applications for small, embedded devices. This includes how to optimize deep neural networks for power efficiency and real-time performance (introduction to Knowledge Distillation Approaches).
- **Semiconductor Industry:** The course addresses how AI aids in semiconductor manufacturing, design optimization, quality inspection (reducing defects), device modeling, device lifetime monitoring, etc..
- **Automotive Applications:**
  - **Engine Control:** Deep Learning can be applied to engine management systems for improving performance and real-time adjustments.
  - **Driver Assistance:** Participants will learn about perceptive and generative models for driver assistance features (e.g., ADAS).
  - **Environmental Understanding:** Advanced neural networks and saliency based processing for scene analysis enable partial or full autonomy, identifying road elements, pedestrians, and other vehicles.

### 3. Generative AI in Industrial Systems

- **Generative Models:** The course covers some insights about algorithms based on new concept of Generative-AI for simulating, generating, or augmenting data.

### 4. Applications in the Legal/Forensic Field

- **Document Analysis:** Leveraging perceptive Deep Learning to identify patterns within large archives of documents, contracts, and evidence. Embeddings and Indexing.
- **Hybrid Approaches** (Perceptive + Generative): The course explores how combining perceptive (recognition/classification) and generative (creation/synthesis) models can aid in evidence synthesis, document summarization, contract checking and detecting anomalies.
- **Explainability Requirements:** The forensic environment often demands transparent decision-making. Participants will learn about methods to interpret and explain model outputs, ensuring that deep learning systems are legally defensible and ethically sound.

### 5. Multi-Modal Data Analysis

- **Definition and Techniques:** The course introduces how to integrate and process multiple data types (images, text, audio, sensor data) to gain richer insights.
- **Case Studies:** Participants will learn from real-world examples in both automotive and semiconductor manufacturing, as well as legal and forensic applications.