



**POLITECNICO**  
MILANO 1863

## **Supervisor Expression of Interest MSCA - Marie Skłodowska Curie Action - (PF) Postdoctoral Fellowship 2024**

**Supervisor name: Marcello Restelli**

**Email address: [marcello.restelli@polimi.it](mailto:marcello.restelli@polimi.it)**

**Link “Pagina docente”: <https://restelli.faculty.polimi.it/MyWebSite/index.shtml>**

**Department Name: Dipartimento di Elettronica, Informazione e Bioingegneria**

**Research topic:**

- ENG\_Information Science and Engineering

**Brief description of the Department and Research Group (including URL if applicable):**

The Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB, <https://www.deib.polimi.it/>) is one of the largest European ICT departments. With more than 1000 members (researchers, collaborators, PhD students, technical staff, and administrative staff) the Department is a vital institution capable of promoting education, fundamental and applied research, and technology transfer to companies.

The RL3 (Real-Life Reinforcement Learning Research Lab, <https://rl.airlab.deib.polimi.it/>), led by Prof. Marcello Restelli, comprises 4 faculties, 2 post-doc researchers, >10 Ph.D. students, and >30 M.Sc. students. RL3's research activity focuses on reinforcement learning with a strong commitment to addressing real-world challenging problems and approaching them with a rigorous theoretical and methodological framework. RL3 has an intense and regular presence with publications in top-tier conferences and journal venues, including ICML, NeurIPS, IJCAI, AAI, ICLR, JMLR, and MLJ. RL3 has established several international collaborations with other important (academic and industrial) research groups in the reinforcement-learning field (e.g., the Intelligent Autonomous Systems at TU Darmstadt, the Paris-based research group at FAIR). The research activities of RL3 are funded by participation in prestigious European research projects (CLINT, I3LUNG, AI4REALNET, iBeChange) and by collaboration with some of the most important Italian and multinational companies (e.g., Pirelli, Magneti Marelli, Ferrari, Eni, Leonardo, Siemens, Intesa Sanpaolo, Baker Hughes).



**POLITECNICO**  
MILANO 1863

**TITLE of the project: REINFORCEMENT LEARNING VIA  
REPRESENTATION LEARNING**

**Brief project description:**

*Representation learning* [1] is a machine learning technique that involves automatically discovering and learning *patterns* or *features* from raw data. In this sense, the goal of representation learning lies in transforming complex and high-dimensional data into simpler, more compact, and informative representations that capture the underlying *structure* of the data. In traditional machine learning, such as supervised learning, the input data is typically hand-engineered, with the features selected by human experts. In contrast, representation learning algorithms automatically discover features that serve the purpose of helping, e.g., the classification of raw-data inputs.

*Reinforcement learning* (RL) [2] is a general and flexible framework for modeling and training agents in charge of solving sequential decision-making problems. In the context of RL, representation learning techniques are currently adopted to learn *state space representations* for complex domains that involve *continuous, highly dimensional* observations. In particular, when function approximators are embedded in RL agents [3], representation learning methods have shown empirical success in automatically extracting features from raw state observations that helps simplify the learning process of complex and non-linear control policies.

This research line aims at fruitfully merging representation learning with reinforcement learning following a novel perspective. In this sense, representation learning faces the problem of the *automatic discovery of mappings* between different Markov Decision Processes (MDP), with the ultimate goal of reducing complex sequential decision-making problems to ones in which finding a (nearly)optimal solution is simpler. In recent years, similar ideas have been applied in the field of linear MDPs [4, 5]. More concretely, the focus lies in reducing a *generic MDP* without any particular structure to an MDP in which the environment dynamics and rewards are expressed by *linear* functions of the learned representation, which are more accessible to be solved effectively. Under this peculiar perspective, the research goal is to simplify the search for nearly-optimal representations by directly exploiting the properties of a simpler class of control problems (e.g., linear MDPs). In other words, via representation learning techniques, the agent *projects* the original, unknown, and complex MDP in a class of environments for which finding a solution is provably efficient.

**References**

[1] Bengio, Yoshua, Aaron Courville, and Pascal Vincent. "Representation learning: A review and new perspectives." *IEEE transactions on pattern analysis and machine intelligence* 35.8 (2013): 1798-1828.

[2] Sutton, Richard S., and Andrew G. Barto. *Reinforcement learning: An introduction*. MIT press, 2018.

[3] Jin, Chi, et al. "Provably efficient reinforcement learning with linear function approximation." *Conference on Learning Theory*. PMLR, 2020.



**POLITECNICO**  
MILANO 1863

[4] Papini, Matteo, et al. "Reinforcement learning in linear MDPs: Constant regret and representation selection." *Advances in Neural Information Processing Systems* 34 (2021): 16371-16383.

[5] Tongzheng Ren, et al. "Latent Variable Representation for Reinforcement Learning." *The Eleventh International Conference on Learning Representations* . 2023.