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Supervisor Expression of Interest MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2024

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Department Name: Dipartimento di Elettronica, Informazione e Bioingegneria
• ENG_Information Science and Engineering

Research topic:

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).



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**TITLE of the project: ASSISTIVE HUMAN-IN-THE-LOOP
REINFORCEMENT LEARNING**

Brief project description:

In the last decade, thanks to both public and private investments, research in the field of *Artificial Intelligence* (AI) has undergone a stunning acceleration, significantly impacting numerous industries, obtaining impressive results, and achieving superhuman performance in several tasks where humans were thought to be unmatchable. Among the numerous *Machine Learning* (ML) sub-fields, *Reinforcement Learning* [RL, 1] is the one that arguably has allowed the most resounding results. The ability to solve complex sequential decision-making problems in unknown, uncertain, and possibly hostile environments makes RL relevant to several applications such as autonomous driving, smart-grid control, robotics, and trading.

However, despite the impressive results obtained in games, video games, and simulated problems, the use of RL techniques in real-world problems is still quite limited [2, 3]. Indeed, RL algorithms are based on a trial-and-error process that is not compatible with many critical applications where taking exploratory actions is risky and not acceptable outside the simulation.

This project focuses on sequential decision-making problems where an RL agent interacts with humans, a scenario known as *Human-in-the-Loop* RL (HLRL). In particular, the project addresses *Assistive* HLRL, where the RL agent is meant to support the human decision-maker in tasks where the frequency and complexity of the decisions are too high for human capabilities. The ultimate goal of the project is to design, develop, and analyze theoretically and experimentally *adjustable autonomy* algorithms, where the level of intervention of the RL agent dynamically adapts according to the performance of the human operator, determined by their level of stress, cognitive fatigue, or tiredness. By observing some physiological measurements (e.g., blood pressure, heart rate, moist skin) or monitoring the quality of the human decisions, the RL agent needs to detect the worsening of the performance and determine the best way to support the human in carrying out the task. The RL autonomy may result in taking control of the system to reduce the human control frequency (e.g., in a freeway driving scenario, the RL agent could take full control and ask for human intervention only in specific situations), or in supporting the decision-maker to limit the number of decision variables on which they have to operate (e.g., in a driving task, the human controls the steering, while acceleration and braking are managed by the RL agent).

The project will generate novel algorithms that are validated from both theoretical and empirical perspectives. It holds the potential to establish the foundation for a new generation of RL agents that foster a beneficial role for AI in a human-centered ecosystem.

References

- [1] Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2018.
- [2] Mnih, Volodymyr, et al. "Human-level control through deep reinforcement learning." Nature 518, no. 7540 (2015): 529-533.
- [3] Silver, David, et al. "Mastering the game of Go with deep neural networks and tree search." nature 529, no. 7587 (2016): 484-489.
- [4] Wu, Xingjiao, et al. "A survey of human-in-the-loop for machine learning." Future Generation Computer Systems 135 (2022): 364-381.