I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Inspection and Maintenance of Infrastructures

Research themes

The main goal of the Robotics and Intelligent Machines Inspection and Maintenance of Infrastructures curriculum is to train scientists and researchers capable of working in multidisciplinary teams on topics related to state-of-the-art solutions for Inspection and Maintenance of Infrastructures tasks. Robotics has a high potential in the technological innovation process of inspection and maintenance processes to reduce costs, improve the quality of services, as well as safety and environmental impact. The impossibility of adapting existing plants and infrastructures to the capabilities of common industrial robots, combined with the growing autonomy of the most advanced technological solutions, has created the right conditions for the development of specific service robotics solutions for civil and industrial inspection and maintenance applications.

The students will perform their research project at the Hosting Institution (described in the research project sheet).

International applicants are encouraged and will receive logistic support with visa issues, relocation, etc.

1. AI-driven optimisation and explainability for enhanced training of neural networks in human-AI applications– Istituto Italiano di Tecnologia

Curriculum:

Inspection and maintenance of infrastructures

Hosting Institution
Istituto Italiano di Tecnologia (www.iit.it)

Department:
Industrial Robotics Facility (https://inbot.iit.it/)

Tutors:
Ferdinando Cannella and Gabriele Marchello

ISTITUTO ITALIANO DI TECNOLOGIA

Description:
Neural networks have become a cornerstone of modern artificial intelligence, driving advancements across various fields such as image recognition, natural language processing, and autonomous systems. Despite their success, the quest for optimizing neural network performance remains a critical area of investigation. Also, basic AI Ethics concepts like explainability and bias detection are part of the process of acceptation of modern AI techniques in our society. The central challenge in training neural networks lies in the search for properly tuned weights. Current state-of-the-art algorithms, such as deterministic gradient descent and stochastic gradient descent, present significant limitations. The first one, while reliable, incurs a high computational cost due to the necessity of calculating the exact gradient, while the second one suffers from slow convergence and requires careful tuning. Furthermore, given the emergence of new neural network architectures with learnable weights (such as Kolmogorov-Arnolds methods), new optimization methods are necessary to meet the demands of these novel approaches. In the same line new explainability methods need to be studied for a set of novel network architectures focusing on different explainable framework and concepts that are emerging in the recent AI ethics state of the art.
In order to address these issues, several innovative approaches are proposed. One potential solution involves the use of preconditioning techniques, where a preconditioner is estimated to improve the conditioning of the gradient matrix. Another promising direction is the application of genetic algorithms, which are adept at exploring the search space broadly and avoiding local minima traps.
One of the optimization techniques that has proven to be a powerful tool in the solution of similar problems, which has yet to be explored in this specific field, is the use of recursive approaches leveraging machine learning principles and neural network architectures for weight optimization. By recursively refining the weights, these methods can potentially enhance the training process, leading to faster and more reliable convergence.
Therefore, this project aims to investigate these novel strategies to overcome the current limitations in neural network training and trasparency. We seek to develop more efficient and effective optimization techniques, contributing to the advancement of neural network performance and applicability and novel AI Ethics methodologies

Requirements:
The ideal candidate should hold a degree in mathematics, physics, or computer science, with experience in optimization both in theoretical and applied contexts, and a strong quantitative background. A working knowledge of Python and MATLAB is required.

Experience with optimization softwares, such as ModeFrontier, is appreciated.

References:

[1] Y.-c. Wu e J.-w. Feng, «Development and Application of Artificial Neural Network,» Wireless Personal Communications, vol. 102, 2018.

[2] C. Legaard, T. Schranz, G. Schweiger, J. Drgoňa, B. Falay, C. Gomes, A. Iosifidis, M. Abkar e P. Larsen, «Constructing neural network based models for simulating dynamical systems,» ACM Computing Surveys, vol. 55, 2023.

[3] O. I. Abiodun, A. Jantan, A. E. Omolara, K. V. Dada, N. A. Mohamed e H. Arshad, «State-of-the-art in artificial neural network applications: A survey,» Heliyon, vol. 4, 2018.

[4] S. Nokhwal, P. Chilakalapudi, P. Donekal, S. Nokhwal, S. Pahune e A. Chaudhary, «Accelerating neural network training: A brief review,» Proceedings of the 2024 8th International Conference on Intelligent Systems, Metaheuristics & Swarm Intelligence, 2024. [5] Y. Tian, Y. Zhang e H. Zhang, «Recent advances in stochastic gradient descent in deep learning,» Mathematics, vol. 11, 2023

Number of positions available:
1

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Funding Scheme: This doctorate is fully funded by internal funds of IIT *Industrial Robotics Facility*

Scolarship Amount:

- Fascia 2: 17,500 €/year