### Supervisor

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### Contact

The proposers of this grant lead the Machine Learning and Artificial Intelligence group, an inter-departmental research group including researchers from the Department of Engineering (DE) and the Department of Mathematics and Computer Science (DMI) of the University of Ferrara. More details in: https://ml.unife.it/

### Context of the research activity

Artificial Intelligence (AI, for short) techniques are increasingly applied in many sectors, which have used - until a few years or months ago - only human intervention, or traditional IT technologies. The ambition of AI is to make machines able to perform typical human activities. Machine learning (ML, for short) and deep learning are hot topics in AI, and have brought exceptional results in many areas, especially in the so-called Internet Economy.

ML is the set of automatic data analysis techniques with which “models” can be learned from (labelled) data. These models can then be used for classifying tasks, for making predictions, or for grouping data and identifying relevant patterns. Image analysis and classification are often based on deep learning and Deep Neural Networks (DNN), which have been proven very effective in these two tasks, with extensive applications especially on the Internet, e.g. for classifying or grouping images.

Nowadays, by the term “Industry 4.0” one also refers to the potential of ICT technologies for Industry. AI and ML techniques could be effective in this setting in driving many applications by automatically analyzing the huge amount of data produced by manufacturing machines, e.g., for analyzing production tools, for maintenance planning, for predicting and preventing faults, and for product quality control by vision inspection.

### Objectives

Mixing symbolic and neural ML techniques (also deep) could bring the benefits of the two ML approaches: the capability of providing symbolic learned models of the former, and the effectiveness of deep networks in many tasks of the latter, including image analysis and computer vision. The aim of the PhD research theme is to develop integrated approaches combining Probabilistic Logic Programming (PLP) with Deep Neural Networks. A first approach was proposed by De Raedt et al. and involves mixing the PLP language ProbLog with DNN, obtaining DeepProbLog. However, the approach suffers from scalability issues due to the high cost of probabilistic inference.

One of the main goal of this PhD proposal is to mix symbolic and neural ML techniques, and develop techniques for supporting probabilistic neural-symbolic languages, also improving their scalability. The developed techniques will produce a system that can be applied to real world problems such as those of Industry 4.0, in particular product quality control by vision inspection and predictive maintenance. The system will be able to exploit sensor data, including images, in order to produce a classifier for the input data that can take into account background knowledge and is able to explain the decisions made.
The skills and competencies that the candidate to this PhD activity should have are:

- good interpersonal skills
- good programming skills
- knowledge of linear algebra, probability and statistics
- good communication and problem-solving skills
- competence on the application of machine learning and deep learning systems