

PhD in Computer and Control Engineering

Research Title: Machine learning and HMI methods for the analysis and interpretation of images and other multi-dimensional data

Supervisor	Fabrizio Lamberti, Dipartimento di Automatica e Informatica
Contact	fabrizio.lamberti@polito.it , https://grains.polito.it

Context of the research activity	<p>Machine learning and deep learning models such as convolutional neural networks have consistently obtained unprecedented results in the analysis and interpretation of images and multi-dimensional data. Within the above context, the objective of this research is to advance the state of the art in fine-grained data analysis, unsupervised / semi-supervised / transfer learning as well as model “transparency” (through the adoption of new paradigms for interaction and visualization) while focusing on the specific needs and problems of application domains with strong performance requirements like, e.g., the industrial and medical ones.</p> <p>Developed methods will be applied in the field of Industry 4.0 (focusing on additive manufacturing and the monitoring of the printing processes through computer vision techniques) as well as to medical image and video analysis. Activities will fit in the context of projects (Smart3D - Filiera Produttiva Dispositivi Polimerici, for 1 year) and private grants.</p>
Objectives	<p>The overall objective of this research proposal is to propose novel techniques for learning fine-grained object detection, classification and characterization. Compared to generic object recognition, fine-grained analysis benefits from learning critical parts of the objects that can help discriminate between neighboring classes.</p> <p>Automated visual systems that can perform fine-grained object recognition and characterization can provide significant support to many applications, especially those requiring specialized domain knowledge, robust and reliable performance, or a richer semantic grounding (manufacturing, ecology, image forensics, retail, social sciences, medical applications, image captioning, etc.).</p> <p>The candidate will focus on research issues related to automatically learning fine-grained object recognition and classification with minimal training data required. The candidate is expected to provide contributions to the state of the art in one or more of the following research areas, where existing solutions are mostly targeted at object recognition or classification.</p>

	<p>a) Transfer learning: learning from limited labeled training can be significantly improved by transferring information learned from one task to another one (transfer learning) or when learning multiple tasks simultaneously (multi-task learning).</p> <p>b) Domain adaptation: real-life datasets can exhibit differences in terms of image acquisition, including background, location, pose, illumination or even different types of image acquisition systems or parameters; domain adaptation include a variety of techniques to transfer a given task to a variety of different domains exploiting unlabelled or small quantities of labeled data.</p> <p>c) Fine-grained image analysis in specialized domains: developing robust and flexible machine learning techniques in specialized applications requires to tackle specific problems, such as satisfying strong performance requirements (high precision, reproducibility and robustness), combining multiple sources of multidimensional data to extract both qualitative and quantitative information, and coping with relatively small training sets. Examples of problems that will be tackled, based on ongoing research projects and contract of the proposer include automatic monitoring of industrial processes (precisely, additive manufacturing), medical image interpretation and video analysis.</p> <p>d) Interactive (human-in-the-loop) learning approaches: by integrating a human-in-the-loop, algorithms that interact with agents and can optimize their learning behavior through this interaction can leverage the relative strengths of both automated machine learning and human cognition; interactive ML approaches can be of particular interest to solve problem where we are lacking big data sets, deal with complex data and/or rare events.</p> <p>During the PhD, new solutions will be studied and developed to address the issues listed above, and they will be evaluated and compared with state-of-the-art approaches to assess their performance and improvements. Experimental evaluation will be performed on realistic datasets (e.g., obtained by industrial monitoring vision-based setups, medical equipment, etc.) and on available public datasets for benchmarking purposes.</p>
--	---

Skills and competencies for the development of the activity	<p>Applicants should have previous experience in the field of machine learning or data science. Skills in the areas of image processing, computer vision, deep learning, GPU programming would be positively evaluated as well. Applicants should have strong programming skills, with a focus on languages commonly used in these domains (e.g. Python, C++)</p>
--	---