In several industrial and robotic applications, sensing physical phenomena by many sensors paves the way for a deep analysis of the system and for the achievement of a suitable level of autonomy and reliability. Possible targets are robotic arms, automatic machines or autonomous and intelligent systems in general. A characterization of data and tasks of interest, as well as the identification of the corresponding latent space structure (LaSS), can enable to extract information on the system status and, thus, to optimally and safely control it. Moreover, exploiting data in their latent space could enable further system optimization and learning. Nevertheless, to infer information, a heterogeneous and varied dataset is required. Building such a dataset is a fundamental step with many theoretical and practical aspects to be investigated. Once data are available, the proposed research activity will explore innovative tools able to identify the LaSS. Possible references are neural network architectures, such as either autoencoders or adversarial models. Reinforcement learning strategies could be also of large interest.

For such systems to be practically of interest, in particular for industrial applications, the learning process cannot be started from scratch but needs to be initialized with a priori knowledge and models about the system, the environment and the tasks. Moreover, safety of the system must be guaranteed at any time. Typical industrial applications concern the transport and cooperative assembly, possibly with human-robot interactions, or the manipulation of deformable objects using fixed or mobile robotic platforms.

Processing data in the latent space reduces their dimensionality and makes the inference stage less computationally demanding. This degree of freedom can be exploited during training by
adopting techniques addressing the trade-off between system capacity and quality of service, and with respect to a priori knowledge, e.g., based on available system models. An important objective of this research activity consists in exploiting this trade-off for the deployment of processing blocks close to the monitored system. Also the research activity aims at exploring how LaSS and a priori knowledge can be employed in the system design for the optimization of needed resources or achievable real time performances.

The designed system should learn and optimize its behavior based on how the environment or objects are modified by the performed actions, by making hypotheses on the effect of future actions, and by considering uncertainty about the environment and limited measurements.

The designed system must guarantee safety, optimality and compliance with appropriate constraints, including time requirements. Cooperative scenarios can also be studied in which the interaction among robots and/or with humans can improve the learning process.

Skills and competencies for the development of the activity

- MSc in Engineering, (Automation, Controls, Robotics, Electronics, Informatics, …)
- Experience with programming languages (C++, Python, …)
- Framework for ML method design (e.g., Tensorflow, Scikit-learn, PyOD, …)
- Basic knowledge of:
  - Robot Operating System (ROS)
  - Statistical Signal Processing
  - Elements of Machine Learning and Neural Network