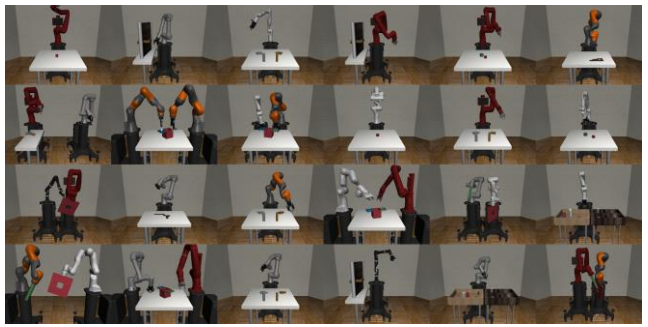
Master Thesis Project:
Simulation Environment for Robot Learning via Wireless

Description:
A key research goal for the scientific community is to use robotic systems effectively not only in industrial production lines, but also in service applications such as healthcare, logistics, and domestic.
When robots are required to perform complex tasks in unstructured and dynamic environments, the computational power required is typically not fully available onboard. Therefore, complex planning and control algorithms can run on an edge cloud, which is a high-performance computer installed in the same local network as the robot, provided with a wireless connection.
The general goal of the master thesis project is to develop a simulation environment (e.g., based on robosuite or similar approaches) that includes a robotic *mobile manipulator connected via a 5G or WiFi6 communication channel to an edge cloud*.



Tasks:

- Review of simulators for robotics
- Simulator implementation
- Test in the simulation a simple robot learning algorithm via wireless

Prerequisites:

- Programming skills in C++ / ROS2
- Fundamentals of robotics
- Fundamentals of wireless communication

References:

- Groshev, Milan, et al. "Edge robotics: Are we ready? An experimental evaluation of current vision and future directions." *Digital Communications and Networks* 9.1 (2023): 166-174.
- https://robosuite.ai/

For more Information:

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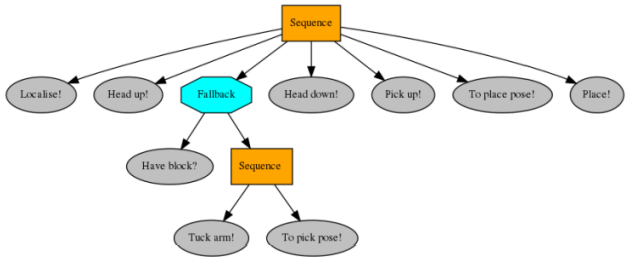
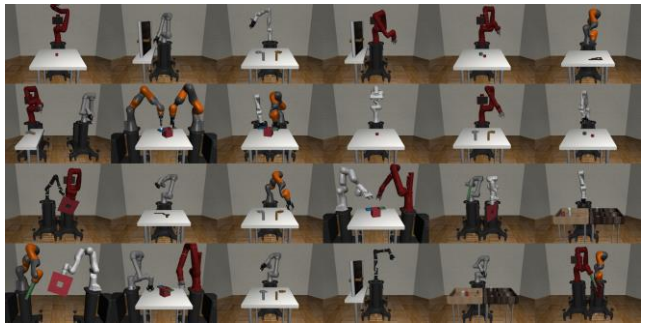
Master Thesis Project: Simultaneous Learning of Low-level Policies and High-Level Strategies using Behavior Trees

Description:

Modern applications require robots to be able to operate in unpredictable environments, and programs to be created with a minimal effort, as there may be frequent changes to the task. Genetic programming can be effectively used to learn the structure of a behavior tree (BT) to solve a robotic task in an unpredictable environment. BTs allow to decide in a reactive way the required sequence of actions, assuming usually that the control laws are known. Learning both sequence of action and low-level policies related to each action is an open research challenge. The goal of this thesis is to develop a novel approach to address this challenge.





Tasks:

- Review of literature about simultaneous learning of control policies and high-level strategies
- Develop and implement novel approaches for simultaneous learning of BT structure and policies
- Test in the simulation

Prerequisites:

- Programming skills in C++ / ROS2
- Fundamentals of robotics

References:

- https://robosuite.ai/

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Master Thesis Project:
Reinforcement Learning in Robotics Robust to Irreversible Events

Description:
A key research goal for the scientific community is to use robotic systems effectively not only in industrial production lines, but also in service applications such as healthcare, logistics, and domestic.
Reinforcement learning methods can potentially allow the robot to acquire new skills in unstructured environments and improve existing ones autonomously by a trial-and-error process.
However, open problems that limit the introduction of reinforcement learning in real applications are the lack of safety guarantees and robustness to irreversible events. In particular, irreversible events prevent the robot from continuing the learning process. As an example, during an in-hand manipulation task, the object may fall down and break. As a consequence, the trial-and-error process cannot continue.
The main objective of this thesis is to develop algorithms to increase the robustness and avoid irreversible events.

Tasks:

- Literature review on irreversible events in robot learning
- Set up a simulation environment
- Implement algorithms for reinforcement learning robust to irreversible events

Prerequisites:

- Programming skills in C++
- Fundamentals of Robotics

References:

- Falco, Pietro, et al. "On policy learning robust to irreversible events: An application to robotic in-hand manipulation." IEEE Robotics and Automation Letters 3.3 (2018): 1482-1489

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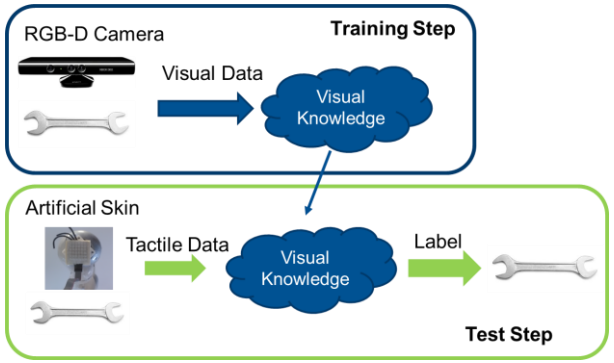
External collaborations: **Dr. Matteo Saveriano, UNI TRENTO**

Master Thesis Project:
Cross-modal Learning for Robotic Manipulation

Description:
A key research goal for the scientific community is to use robotic systems effectively not only in industrial production lines, but also in service applications such as healthcare, logistics, and domestic.
Reinforcement learning methods can potentially allow the robot to acquire new skills in unstructured environments and improve existing ones autonomously by a trial-and-error process.
However, one of the main challenges that limit the usage of robots in the mentioned domains is the lack of flexibility in exploiting different sensing modalities such as vision and touch.
The main goal of this thesis is to develop algorithms for crossmodal learning.
In crossmodal learning, we acquire information with one sensing modality such as vision and use it with a completely different sensing modality such as touch. This way, the robot can switch in a transparent fashion between different sensing modalities during learning and execution.



Tasks:

- Literature review on crossmodal learning for robotics
- Set up a simulation environment
- Implement algorithms for crossmodal learning
- Test on a real robotic system (optional)

Prerequisites:

- Programming skills in C++ / ROS2
- Fundamentals of Robotics

References:

- Falco, Pietro, et al. "On policy learning robust to irreversible events: An application to robotic in-hand manipulation." IEEE Robotics and Automation Letters 3.3 (2018): 1482-1489

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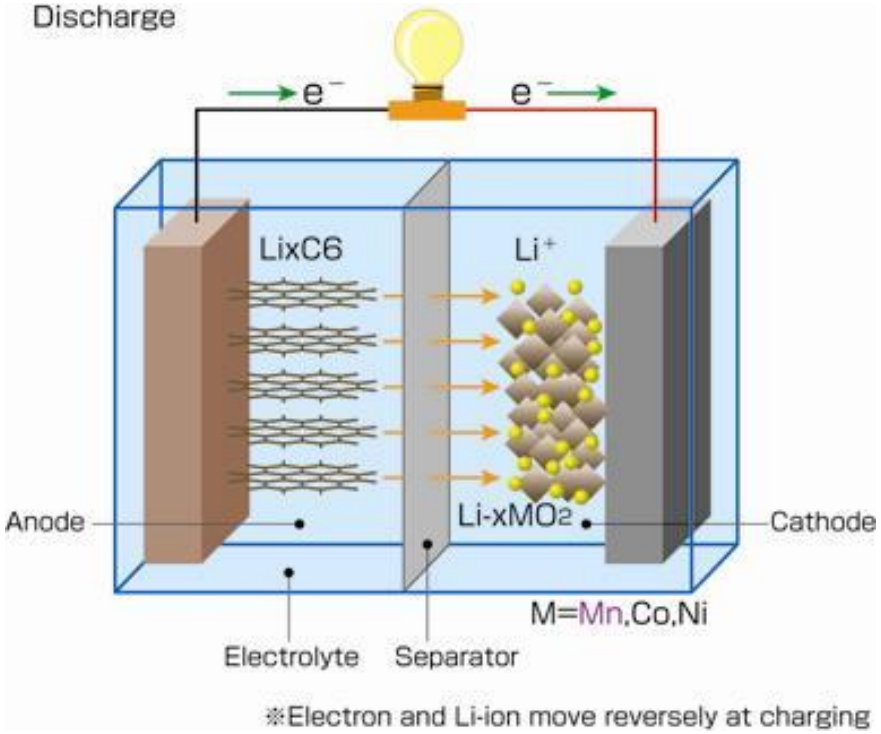
Collaboration: Prof. Ciro Natale, UNI Campamia

Master Thesis Project:
Temperature estimation for LI-ion battery using ML

Description:



Tasks:

- Define an architecture and training deep neural networks for overtemperature prediction with a large dataset

Prerequisites:

- Programming skills in C++, Python or MATLAB

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Collaboration: Prof. Luigi Rubino, UNI Campania