Modular Robots for Unstructured Environments

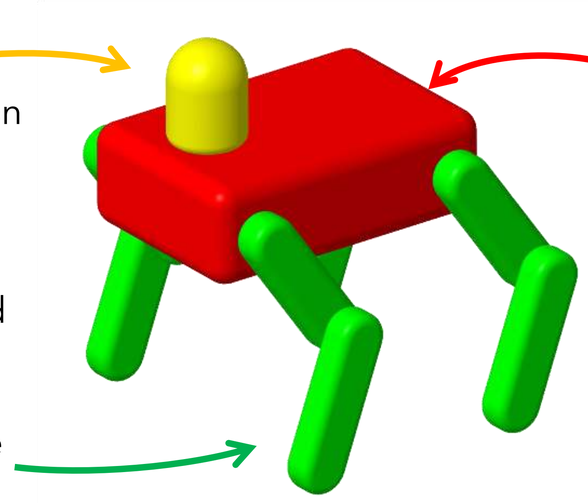
PhD project in Industrial Innovation

Objective
Replace the human operator in dangerous situations, such as: emergency response, exploration and inspection in unsafe environments, construction, heavy-work, repetitive tasks, security, space applications

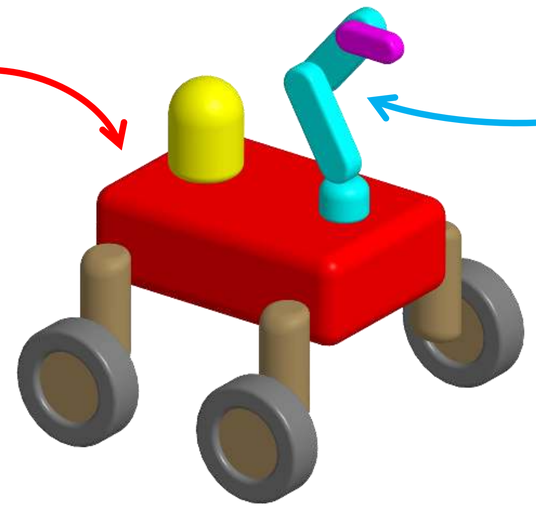
Requirements
- agile, fast, dynamic locomotion on all terrains
- high-force manipulation and payload capabilities
- resistance to wet, dirty environments
- extended operation time
- capability to carry a significant payload

customisable inspection and sensing systems

highly dynamic legged locomotion modules ideal for scouting uneven, unpredictable terrains



common, lightweight mobile base providing power supply and management, exteroceptive sensing, computation and communication



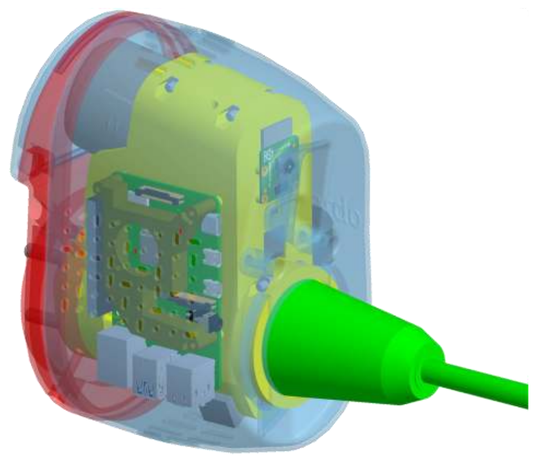
plug-and-play manipulation systems with smart end-effectors

energy-efficient wheeled mobility systems enabling high payload and low energy consumption

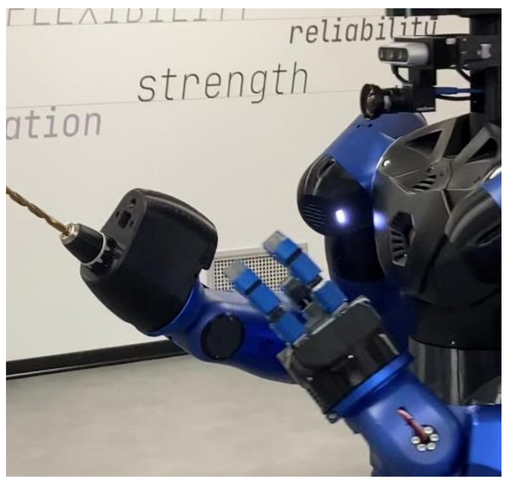
State-of-the-art and methods
Current actuator tech allows for either fast, dynamic motions [1] or high force manipulation [2]. Switching from case to the other requires investment in a completely different platform.
The proposed approach introduces modularity as a key feature: on a common mobile base, modules can be installed for tuning the platform performances to the required use-case.

Expected benefits
- Initial investment can be repurposed to other tasks
- Much of the hardware and software remains the same in all applications, making maintenance easy and lowering downtime
- New applications can be targeted with little mechatronic and software development (hence little investment)
- Modules can be upgraded independently

Initial developments



Smart-drill
- Robotic drill obtained reusing components of a commercial power tool
- Smart: featuring RGB camera, distance sensor and a Raspberry Pi directly processing sensor data
- Robot-independent: features its own battery and mechanical connection for multiple robotic arms
- Fast setup: controlled via Wi-Fi and the ROS framework



Dynamic quadruped leg
- Integrating low-cost commercial actuators into a custom design
- High-performance EtherCAT capable electronics
- Impact-capable lightweight bearings
- Mechanical design optimised for low inertia and efficient heat dissipation
- To be soon manufactured

High-force 1DoF gripper
- Using high torque SEA from IIT's portfolio, providing toque control
- Designed for sturdiness and jaw shape reconfigurability
- Integrating Camera and distance sensor controllable through Raspberry Pi
- Initially integrated on the CENTAURO platform
- Capable of a pinching force at tip of 15 kgf

Contacts and references (limited selection)

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[1] B. Katz, J. Di Carlo, and S. Kim, "Mini Cheetah: A Platform for Pushing the Limits of Dynamic Quadruped Control," in 2019 International Conference on Robotics and Automation (ICRA). IEEE, 2019, pp. 6295–6301
[2] N. Kashiri, L. Baccelliere, L. Muratore, A. Laurenzi, Z. Ren, E. M. Hoffman, M. Kamedula, G. F. Rigano, J. Malzahn, S. Cordasco et al., "CENTAURO: A Hybrid Locomotion and High Power Resilient Manipulation Platform," IEEE Robotics and Automation Letters, vol. 4, no. 2, pp. 1595–1602, 2019

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