IRTLab Presentation Summary

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Note: *The summary is an important outline of the abstract to be shared with other participants, therefore, any confidential information must be excluded due to the Intellectual Property Protection policies.*

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Research Theme:	Stability control of autonomous module transition for transformable module Grieel

Have you ever wondered what hides inside of volcanic craters, the depth of the sea or remote celestial bodies? The **exploration of areas not accessible by humans** is crucial for scientific development in several fields: from mining to terraforming but also for climate change insight and to acquire new knowledge. To overcome dangerous and inaccessible environments, **autonomous or teleoperated intelligent robotic systems**, usually called "rovers" are deployed [1]. Different environment calls for **different form of locomotion** and realizing a robot as adaptable as possible helps a lot in the task of exploration.

Imagine that your robot is sent to a volcanic area or a celestial body, considering energy efficiency and speed, wheeled locomotion is the most common choice, as several past space exploration missions demonstrate [1]. But **wheels** are not always the best solution, what if the terrain is extremely rough or with big slopes and walls? In those cases, bio inspired solutions help us to conceive that **legged** locomotion can achieve robust motion in presence of uneven terrains and even **climbing** motion to reach locations inaccessible by wheels [2]. Unfortunately, legged robot requires more complex control system and autonomous navigation algorithm, coming also with worse energy efficiency and motion speed. That's why this approach is not used a lot in space exploration missions especially because, due to the huge investment it is necessary to guarantee robustness and efficiency of the system. So, why not **exploiting both locomotion systems?** Here comes into play **Grieel**.

Grieel (**gri**pper + wh**eel**) is a transformable module developed at SRL, with the ability of **transitioning** between two functional modes: **wheeled locomotion** system and **versatile gripper** for manipulation and legged motion. Mounting Grieel as end effector (final link of the robot arm) of a legged rover allows to realize both forms of locomotion explained above. In fact, it guarantees and avoids the previously mentioned advantages and drawbacks by transforming accordingly to the terrain characteristic through the usage of visual terrain estimation.

Currently the transition of all Grieel modules is achieved by lowering and laying the robot body on the ground and rising all legs. Even though this method is simple and practical, it is not robust for two main reasons. In the first case, highly uneven terrain can damage the robot surface. In the latter, the overall procedure is not flexible especially when transforming only one module into gripper mode for manipulation while keeping the others in wheel mode for locomotion. That's why the focus of my research is Implementing a **different transitioning algorithm** to better exploit Grieel characteristics. This is done with a new algorithm that considers the possibility of **transforming while performing the desired motion** [3] (for instance, in case of wheeled-to-wall climbing locomotion, the rover can transform the front wheels into grippers and cling on the wall, without losing additional time).

For the new algorithm, **legged robot stability** is crucial [4]. This is tested on the 4-legged robot LIMBERO (implemented by SRL) with Grieel mounted as end effector. First, the procedure places the body's center of mass in a stable position by using three end-effectors as points of contact to keep the body above the ground. After that, it performs the transformation of the 4th module and positions it back on the ground. This is done iteratively for every single leg by either following a predefined or more flexible order.

Overall, the goal of this project is to have a smoother transition of the modules to enable better flexibility and improved exploration possibility and capabilities.

Reference:

[1] NASA rovers' missions: Spirit and Opportunity (2004), Curiosity (2012), Perseverance (2022), CADRE (2024, future project)

[2] Kentaro Uno, "Autonomous Limbed Climbing Robots for challenging Terrain Exploration", pp. 2-13, 2021

[3] Shigeo Hirose et all. "Quadruped walking robots at Tokyo institute of technology, design analysis and gait control methods", 2009

[4] Warley Francisco Rocha Ribeiro, "Reaction-aware robotic locomotion in microgravity", pp.34-37, 2023