ISTITUTO ITALIANO
DI TECNOLOGIA
DYNAMIC LEGGED SYSTEMS

Model-Based Motion Planning for Quadruped Robots

Keywords

motion planning, legged locomotion, optimal control, numerical optimization.

1 Description

The aim of this student project (6 months duration) is to support the team's effort to extend of the motion capabilities of the HyQ robot to adapt its gait to complex geometry environments using nonlinear optimization.
Model-based optimization approaches in motion planning have gained large success over the last decade because they have allowed to find feasible and optimal solutions in complex environments where classical heuristic approaches have failed. The current challenge consists in finding the most appropriate trade-off between accuracy of the Optimal Control Problem (OCP) formulation and computational efficiency, in order to be able to continuously re-plan new trajectories online in the case of unexpected disturbances/events.
In this internship project we propose to support the team in the writing of new formulations for online motion re-planning and/or Model Predictive Control (MPC) for hybrid (switching dynamics) nonlinear systems starting from the latest results in this field [1, 2]. Depending on the time availability, the student may also be asked to contribute to the synthesis of a new optimization solver tailored for legged locomotion applications.

Figure 1: HyQ2max robot.

2 Tasks

- implement an online motion planning algorithm for quadruped robots on complex terrains;
- integrate the map perceived by the robot inside the OCP formulation in order to avoid obstacles;
- verification of the proposed approach in simulation and on the hardware (HyQ robot).

3 Requirements

The candidate should have at least a bachelor degree in systems and control, robotics, mechanical engineering or electrical engineering.
The successful candidate will be involved to work with DLS Lab robotic platforms and will be encouraged to publish his research in an international peer-reviewed conference/journal paper.

Further mandatory requirements include:

- Strong mathematical background, experience with operational research and optimal control;
- good C++ and/or Python programming skills;

- Strong communication skills (written and spoken) in English language;
- Strong team player
- Willingness to integrate into a multidisciplinary, dynamic, international research group

Further desirable skills:

- Experience with ROS.
- Experience in navigation of mobile platforms, or legged robotic systems;

4 Duration

Minimum 6 months, with the possibility of extension depending on achieved results.

5 How to apply

To apply send an e-mail including your detailed CV, university transcripts and cover letter outlining motivation, experience and qualifications for the position to **romeo.orsolino@iit.it** and **michele.focchi@iit.it** stating "[Intern2019] Model Based Planning Position" in the subject of the e-mail.

References

[1] A. W. Winkler, C. D. Bellicoso, M. Hutter, and J. Buchli, "Gait and Trajectory Optimization for Legged Systems through Phase-based End-Effector Parameterization," *IEEE Robotics and Automation Letters*, pp. 1–1, 2018.

[2] D. E. Orin and A. Goswami, "Centroidal momentum matrix of a humanoid robot: Structure and properties," *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 653–659, 2008.