Laboratory: LAAS-CNRS (Gepetto), Toulouse, France

Thematic: Robotics

Keywords: Motion generation, humanoid robotics, dynamic balance, optimal control

Contact : A Del Prete, N. Mansard **e-mail:** nmansard@laas.fr, adelpret@laas.fr

Title: Balance for complex robots "in the blink of an eye"

We are interested in the generation and the execution of dynamics movements for complex legged robots (e.g. humanoid robots, quadrupeds) evolving in nonflat terrains. Typical situations of interest are humanoid robots climbing stairs using the handrail, standing up after a fall while making contact with nearby obstacles (table, walls) or quadrupeds evolving in unstructured environments, typically outside or in a blasted industrial plant. While the state of the art is quite complete for locomotion on flat terrains, there is yet no definitive formalism to characterize or control the balance when performing dynamic movements on such nonflat terrains. The objective of this project is to build a methodology to face this problem and validate it on the humanoid robots of the lab.
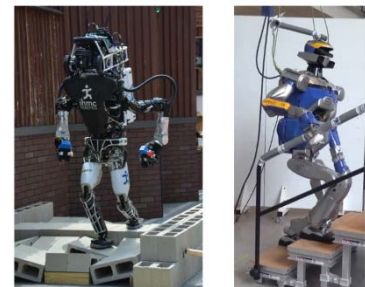
On flat terrains, a classical method to represent the balance uses the concept of capture point: the capture point is such that if the center of pressure is constantly maintained on this point, the robot will converge and stop with its center of mass also atop this point. A direct consequence (quite easy to catch when looking at the formal description) is that the robot cannot escape a fall if its capture point leaves the polygon containing its feet.

This methodology does not extend trivially in case of nonflat contact. In [1] we have proposed a generic methods and several algorithm to characterize the static balance with nonflat contact. The goal of this project is to extend the method to characterize dynamic (non-static) balance. The study will rely on linear algebra, linear optimization (LP) and computational geometry (polytope description). At this end of the project, we should have a direct method to decide what should be the immediate action of the robot to prevent a fall, despite any kind of contact and any on-going movement.

Reference:

[1] Andrea Del Prete, Steve Tonneau, Nicolas Mansard, "*Fast algorithms to test robust static equilibrium for legged robots*", submitted to IEEE Int. Conf. Robotics and Automation 2016 (http://projects.laas.fr/gepetto/index.php/Publications/2016DelPreteIcra)

Requirements:

- A strong mathematical or control background is desirable
- Good programming skills in C/C++
- If possible, any knowledge or practical interest in robotics would be relevant

Environment:

Located in the University town of Toulouse, in the south-west of France, the Gepetto group belongs to the CNRS-LAAS, laboratory for the analysis and architecture of systems, a 640 man-strong research center with about 90 people working in robotics. Among our robot fleet, we have access to HRP-2, the only full-size walking humanoid robot in France, while two other humanoid robots are expected within the year. The laboratory benefits from strong connections to the adjoining universities and the space and aeronautics industry.