Impact-aware humanoid robot motion generation with a quadratic optimization controller

Yuquan Wang

CNRS-UM, LIRMM, Montpellier 34090, France

June 20, 2020

Abstract

Generating on-purpose impacts with rigid robots is challenging as they may lead to severe hardware failures due to abrupt changes in the velocities and torques. Without dedicated hardware and controllers, robots typically operate at a near-zero velocity in the vicinity of contacts. We assume knowing how much of impact the hardware can absorb and focus solely on the controller aspects. Alternative to the elegant solutions provided by hybrid controllers with reset maps, we use the task-space inverse dynamics formalism that we extend by seamlessly integrating impact tasks. Our main idea lies in integrating post-impact states prediction and impact-aware inequality constraints as part of our existing general-purpose whole-body controller. To achieve such prediction, we formulate task-space impacts and its spreading along the kinematic, and potentially arborescent, structure of a floating-base robot with subsequent joint velocity and torque jumps. As a result, the feasible solution set accounts for various constraints due to expected impacts. In a multi-contact situation of under-actuated legged robots subject to multiple impacts, we also enforce the dynamic equilibrium margins. By design, our controller does not require precise knowledge of impact location and timing. We assessed our formalism with the humanoid robot HRP-4, generating maximum contact velocities, neither breaking established contacts nor damaging the hardware.