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Control Applications of TORO - a Torque Controlled Humanoid Robot

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This video presents an overview of the hardware and control applications of the TOrque-controlled humanoid RObot TORO developed at DLR. The self-contained robot was developed as a research platform for walking and whole-body control. It is based on the drive units of the DLR-KUKA Lightweight Robot Arm (LBR) III, has a total of 39 DoF, and it can be operated both in position and torque control modes. The internal state of the robot can be measured by the motor position and torque sensors, plus two IMUs in the trunk and head. Force/torque sensors at the ankles provide measurements to evaluate the stability of the robot, and stereo cameras plus one RGB-D sensor are integrated in the head for research on autonomous navigation and manipulation.

The integrated joint torque sensors allow a highly sensitive inner loop joint torque control. Based on torque control different impedance behaviors can be easily realized, which is demonstrated by an energy-based limit cycle controller used in a simple hand-shaking demonstration. The walking controller is based on the Divergent Component of Motion (DCM), also known as Capture Point. Reference trajectories for the DCM, which correspond to ZMP trajectories on the robot feet, are generated and tracked by a feedback control. The high level walking commands for the robot can be autonomously generated or can be introduced via a proportional velocity input from a gaming console remote control. A multi-contact whole-body controller for balancing and posture stabilization is implemented using optimization of contact wrenches and is tested in different contact situations.

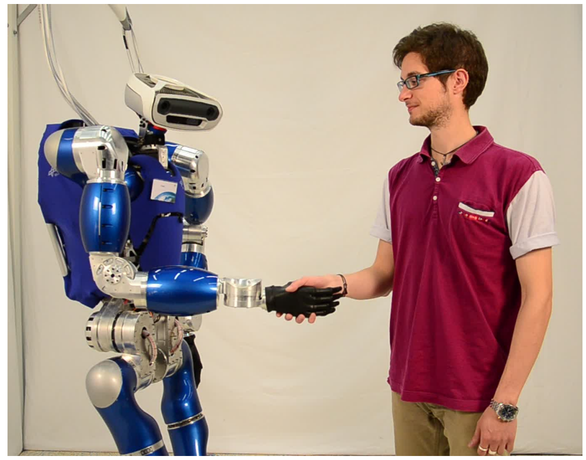

Fig. 1. Generating limit cycles with a constant energy level

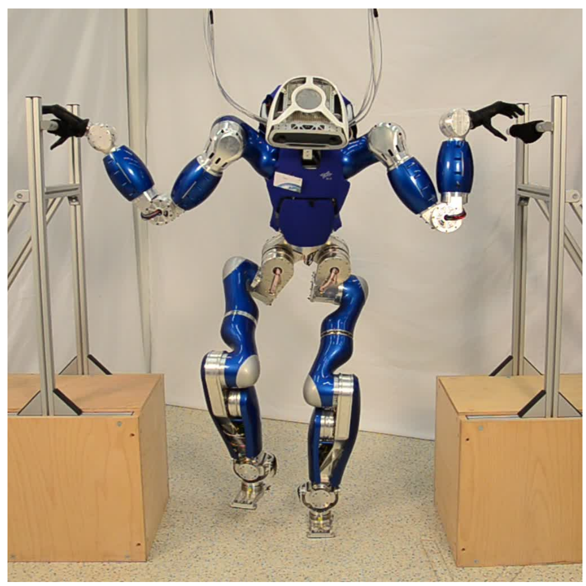

Fig. 2. Balancing with multiple contact points

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