Manual Guidance of the humanoid NAO without Force Measurements

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EXTENDED ABSTRACT

Physical Human-Robot interaction (pHRI) is attracting an increasing interest in robotics research with a consequent fast progress in both methodological and technological aspects. Most of the results, however, deal with robotic manipulators and their application to humanoid robots is either not direct or poorly effective because they do not exploit the specificities of these robotic systems related to their mobility system. In addition, most humanoids are not equipped, for costs reasons, with the sensors commonly used in physical interaction, like, e.g., force sensors.

In this work we propose a technique for guiding humanoids toward desired walking directions with a specified speed via physical interaction. The distinctive feature of the proposed method resides in the absence of any requirement to use force/torque sensors to measure the interaction forces. The considered physical interaction, herein referred to as manual guidance, includes both simple hand-in-hand guidance (see Fig. 1) and joint object transportation. Here we focus on hand-in-hand guidance.

Manual guidance is usually obtained using force/torque sensors located at the humanoid’s wrists [1]. These sensors are not part of the standard equipment and their inclusion increases both cost and complexity of the robotic platform. Developing minimal sensing approaches to physical interaction would at the same time overcome this problem and lay the basis for the exploration of new methodologies for pHRI especially suited to humanoid robots. The same minimal-sensing spirit is behind the interaction behavior obtained with the Acroban robot in [2] which, however, relies on the dynamic peculiarities of a specific robot.

Our method is equilibrium-based and uses the perceived perturbation of the Capture Point as a measure of the effect of interaction on the robot equilibrium. The concept of Capture Point (CP) was first introduced in [3]: the ability of a humanoid to cover a Capture Point with one of its feet is related to the possibility to come to a stop without falling.

In this work, we propose an original use of the Capture Point concept. In manually guiding a humanoid the human is supposed to push or pull it toward some intended direction of motion. The humanoid center of mass (CoM) position and velocity will change accordingly. In particular, the position of the Capture Point, computed through the Linear Inverted Pendulum Model (LIPM) [3] and depending on these two quantities, moves in the same direction of the pushing or pulling force exerted by the human. The desired manual-guidance is obtained by commanding the robot to walk toward the CP with a velocity depending on its distance from the current position of the support polygon centroid.

The proposed technique has been validated on the small humanoid Aldebaran NAO. Due to the lack of force/torque sensors (except for those under the feet, not used in our approach), NAO is a good platform to show how minimal are the requirements of our method.

To keep the method as general as possible, the desired walking velocity is commanded to NAO through its high-level Locomotion API: any humanoid platform on which similar high-level commands could be executed will be immediately able to perform manual-guidance using the proposed approach. Figure 1 shows snapshots from a companion video available at the DIAG Robotics Laboratory YouTube channel http://www.youtube.com/user/RoboticsLabSapienza, section “Humanoid Robots”.

REFERENCES

