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GUEST EDITORIAL OF THE SPECIAL ISSUE ON WHOLE-BODY CONTROL FOR ROBOTS IN THE REAL WORLD

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GUEST EDITORIAL OF THE SPECIAL ISSUE ON WHOLE-BODY CONTROL FOR ROBOTS IN THE REAL WORLD

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Research in whole-body control (WBC) aims to contribute to provide robots with those capabilities that are necessary to move and perform in real world scenarios. Until recent years, limitations on hardware relegated whole-body control to almost purely theoretical research. Recently a growing number of experimental platforms have become available (in particular torque-controlled humanoids). This new opportunity has triggered the deployment on real robots of the theoretical outcomes of research in the field. This is backed up by a number of new research projects and initiatives addressing issues in this domain, including the Darpa Robotic Challenge (DRC). The goal of this special issue is to provide a clear representation of what is the state-of-the-art in whole-body control, and to help identifying what steps still need to be taken to have humanoid robots moving out of research laboratories to real world applications.

Keywords: Whole-Body Control; Floating-Base Robot Dynamics; Real World Scenarios.

1. INTRODUCTION

In recent years research in humanoid robotics has witnessed a growing interest among the broad robotics community. Several humanoid platforms have become available, and the next big target is to make these robots capable to perform in real world applications. Whole-body control (WBC) aims to bridge the gap between robots and humans in terms of mobility skills, providing robots with the flexibility that is necessary to adapt to the uncertainties of real world scenarios.

The class of WBC systems, in fact, represent a wide range of complex movement skills in the form of low dimensional task descriptors which are projected on to the robot's actuators, thereby exploiting the full capabilities of the entire body of redundant, floating-base robots in compliant multi-contact interaction with the environment, to execute any single task, when feasible, and simultaneous multiple tasks.

This special issue provides a clear representation of the state-of-the-art in whole-body control, addressing theoretical open problems, presenting implementations of WBC systems on real hardware platforms, and showing the potential of this approach and the limitations that still need to be overcome.

2. CONTRIBUTED PAPERS

The works of Wensing and Orin[1], and of Moro[2] mainly focus on theoretical aspects of whole-body control that are fundamental to develop effective general purpose whole-body control systems.

Wensing and Orin[1] show how to compute efficiently the Centroidal Momentum Matrix (CMM) and terms involving its derivative. The new computation method is then applied to perform whole-body control of a dynamic kicking motion.

Moro[2] proposes to maximize the gravitational stiffness of a robot in order to minimize its effort indirectly. In the paper it is shown that controlling the gravitational stiffness and the centroidal momentum at the same time allows to guarantee balance, and to execute multiple, possibly conflicting tasks simultaneously.

Fok et al.[3] present ControlIt!, a new open-source middleware that enable the Whole Body Operational Space Control (WBOSC) algorithm to perform and be integrated into larger control system. ControlIt! is successfully tested with the robot Dreamer.

Whole-body control formulations are used to control real hardware robots also by Koolen et al.[4], Hopkins et al.[5], and Del Prete et al.[6].

Koolen et al.[4], present the momentum-based control framework that was developed by IHMC team to control the Atlas robot at the Darpa Robotics Challenge (DRC). The IHMC team took second place in the DRC finals.

Hopkins et al.[5] propose a low-impedance whole-body control formulation that was tested with THOR, a full-body humanoid robot equipped with Series Elastic Actuators (SEAs), in a firefighting demonstration onboard a US Navy ship.

Del Prete et al.[6] present a complete framework for the implementation of joint-

torque control on the humanoid robot HRP-2, which was originally designed to provide only position control capabilities.

Whole-body control approaches to more specific applications are presented by Wang et al.[7], Yi et al.[8], and Minami Shiguematsu et al.[9].

Wang et al.[7] propose to use a Virtual Kinematic Chain (VKC) to control a dual-arm mobile robot performing manipulation tasks. The proposed approach is validated with a PR2 robot.

Yi et al.[8] developed a hierarchical control architecture for reactive push recovery. The method is evaluated in physically realistic simulations and with a DARwIn-OP robot.

Minami Shiguematsu et al.[9] propose a novel heel-contact toe-off walking pattern generator for a biped humanoid robot. The generated patterns are implemented and evaluated with the robotic platform WABIAN-2R.

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