MMT Symposium
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June 26-28, 2024 | Guimarães, Portugal

DEVELOPMENT OF A MULTIBODY SIMULATOR TO STUDY THE CHARMIE ROBOT

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1. INTRODUCTION

The Laboratory of Automation and Robotics of the University of Minho has developed CHARMIE, a human-inspired robot designed to assist humans in domestic tasks [1] (See Figure 1). One of the challenges in developing a complex mobile manipulator robot is testing and optimizing its control. Damages to the physical prototype, or possible hazardous situations, can be avoided by testing control solutions in a virtual environment. This is even more relevant when using Reinforcement Learning as a control strategy, where the neural network requires testing a set of inaccurate and inadequate solutions before the reward function allows the system to converge into more optimal strategies. This work deals with the development of a multibody simulator that represents the key kinematics and dynamics of CHARMIE's bodies and joints.

Figure 1. A physical prototype of the CHARMIE mobile manipulator robot

2. CHARMIE'S MULTIBODY MODEL

The multibody model of CHARMIE consists of 45 bodies and 54 joints, arranged into a configuration that results in 36 degrees of freedom (including the six degrees of freedom that allow the robot to navigate through space). These bodies are integrated into the eight following subsystems: i) locomotion wheels, ii) suspension and motor system, iii) base, iv) hip, v) torso, vi) left arm, vii) right arm, and viii) head.

The robot's four omnidirectional wheels are placed with a 90º angular displacement, and each is supported by a linear independent suspension system. The lower body and the torso have one degree of freedom each, one linear and one rotational, each supported by a static balancing mechanism. The robot's head has two additional degrees of freedom. Finally, the current prototype of the robot only has a single arm (see Figure 1), but the current multibody model assumes a future version of the robot, where two 7-DOF arms will be used.

3. MULTIBODY SIMULATION

The multibody simulator of CHARMIE was obtained by computing the robot's Equations of Motion in Python [2]. The forward kinematics of the robot are solved using a recursive algorithm centred around describing positions with cartesian, and rotations using Euler angles [3]. The inverse dynamics of the robot are then solved using a recursive Newton-Euler algorithm [4].

The two recursive algorithms used were grouped and interconnected into a seven-step methodology [2]: i) describing and characterizing the model, ii) converting the model properties into software input, iii) analyzing the kinematics of the indirectly actuated joints, iv) executing the forward kinematic analysis of the bodies of the main kinematic chains using the recursive algorithm, v) performing the forward kinematic analysis of bodies that are a part of closed and overconstrained loops, vi) executing the inverse dynamic analysis of the bodies of the main kinematic chains using the Newton-Euler recursive algorithm, and vii) solving the dynamics of the closed and overconstrained loops.

These seven steps were computed into PyCharm with support from the NumPy library. By using the Matplotlib library, a visual interface was implemented which allows observation of the robot's behaviour along the different timesteps of the computer simulation (see Figure 2).

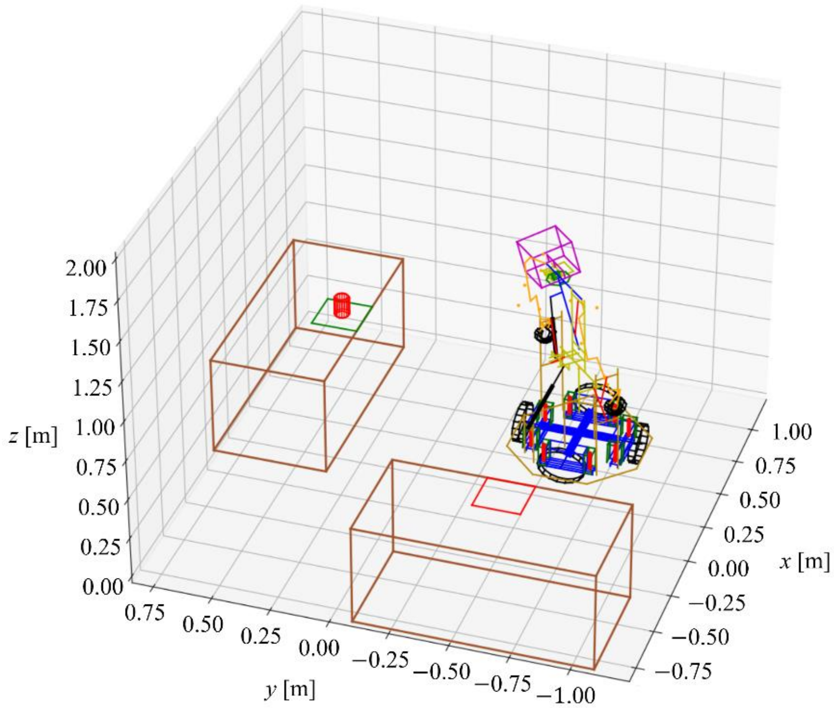

Figure 2. Multibody simulation environment developed for testing the CHARMIE Robot

ACKNOWLEDGMENTS

This work has been supported by the Laboratory of Automation and Robotics (LAR) of University of Minho, and the ALGORITMI and CMEMS research centers. The first and second authors received funding through a doctoral scholarship from the Portuguese Foundation for Science and Technology [grant numbers SFRH/BD/145993/2019 and SFRH/BD/06944/2020], with funds from the Portuguese Ministry of Science, Technology and Higher Education and the European Social Fund through the Programa Operacional do Capital Humano (POCH). This work has been supported by FCT—Fundação para a Ciência e a Tecnologia within the R&D Units Project Scope: UIDB/00319/2020. This work has also been supported by the Portuguese Foundation for Science and Technology under the national support to R&D units grant, with the reference projects UIDB/04436/2020 and UIDP/04436/2020.

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