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Katja Mombaur, Khai-Long Ho Hoang

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How to best support sit to stand transfers of geriatric patients: Motion optimization under external forces for the design of physical assistive devices

Katja Mombaur and Khai-Long Ho Hoang

Optimization, Robotics & Biomechanics (ORB), Institute of Computer Science (ZITI), IWR, Heidelberg University, Berliner Str. 45, 69120 Heidelberg, Germany

Abstract

Sit to stand (STS) transfers form a challenging type of motion, in particular for geriatric patients. Physical assistive devices that are built to enhance the mobility of this class of patients therefore must especially be able to support STS transfers. This paper presents a method to predict geriatric STS movements and compute the best possible actions by external devices to support these movements. We treat three types of active devices that act on different parts of the patient's body and provide different levels of support. Our approach is based on the solution of optimal control problems for a whole-body multi-phase model of humans standing up from sitting to upright position. Computations are performed for percentiles 20/50/80 of male and female geriatric population. The actions of the external devices are simulated by external forces at moving contact points, which are all determined by the optimization, simultaneously with the expected movements and joint torques of the patients. The results serve as inputs for design optimizations of the different device types.

Keywords: STS transfer, geriatric patients, multi-body human modeling, optimal control, movement prediction, physical assistive devices

1. Introduction

Maintaining physical mobility up to a very high age is an important goal in today's aging society [23, 34]. This goal can be achieved by the development