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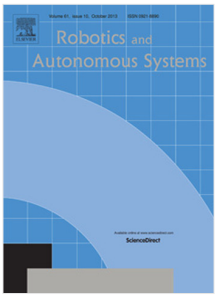

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Iman Kardan, Alireza Akbarzadeh

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Robust Output Feedback Assistive Control of a Compliantly Actuated Knee Exoskeleton

Iman Kardan[a], Alireza Akbarzadeh[b*]

[a,b]*Center of Excellence on Soft Computing and Intelligent Information Processing, Mechanical Engineering Department, Ferdowsi University of Mashhad, Mashhad, Iran.*
[a]*Iman.Kardan@stu.um.ac.ir;* [b]*Ali_Akbarzadeh@um.ac.ir;*

Abstract

The use of compliant actuators in assistive exoskeletons offers an increased level of comfort for their users. Various control algorithms are presented for assistive exoskeletons, seeking to facilitate wearer's motions. This paper complements a newly proposed output feedback assistive control (OFAC) algorithm for compliantly actuated exoskeletons. H_∞ analysis is used to define robust stability and robust performance constraints for the OFAC method. The robust OFAC method is then implemented on a custom made knee exoskeleton. Effectiveness of the proposed method is demonstrated through some simulations and experiments. Robustness of the OFAC method is further verified by successful reduction of the required knee torques in the non-linear model of the human-exoskeleton system as well as decreasing the muscles activities in a healthy subject wearing the FUM-KneeExo. The OFAC method is independent from user intent, has a simple model free structure, requires a very low number of sensors and simplifies the assistive control objective into position control of the compliant actuator. Moreover, the OFAC method has a very low number of adjustable control parameters which simplifies the adaptation of the OFAC method to different users in real-world applications. The proposed OFAC method can be used as a building block in assistive control of compliantly actuated exoskeletons. This, along with the superior advantages of the proposed OFAC method, should potentially boost the increasing applications of compliant actuators in assistive exoskeletons.

Keywords: Exoskeleton; H_∞ robustness analysis; Output feedback assistive control method; Compliant actuation; Integral admittance.

* Corresponding author at Ferdowsi University of Mashhad, Azadi Sq., Mashhad, Iran, P.O. Box: 9177948974, Tel: +98 513-8802000, Email: Ali_Akbarzadeh@um.ac.ir.