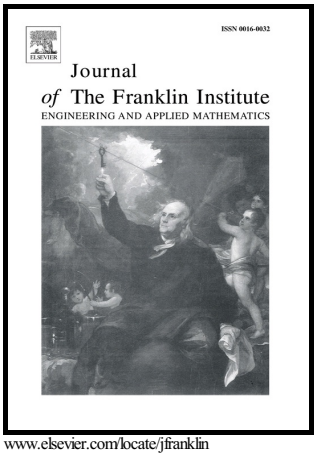

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Bio-inspired Robust Control of A Robot Arm-and-Hand System based on Human Viscoelastic Properties

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Abstract

A bio-inspired scheme based on the human multi-joint arm (HMJA) viscoelastic properties is proposed to design a robust controller for the complex robot arm-and-hand system (RAHS) using the operator-based robust right coprime factorization (RRCF) approach. The RAHS mainly consists of two components, a robot arm and a micro-hand with three fingers. The fingers are made up of miniature pneumatic curling soft (MPCS) actuators, and are located in the endpoint of the robot arm. The aim is for a human to intuitively control the robot arm to perform a task under unknown environments from a remote location. We identify the main limitations of standard interaction control schemes in obtaining the learned information pairs, then proposes a new control approach that is inspired by the biological model of HMJA viscoelasticity in voluntary movements. To achieve the precise position of the robot arm and obtain the desired force using the micro-hand for coping with the external environment or task involved, we propose a two-loop feedback control architecture using the operator-based RRCF approach. The bio-inspired inner-loop controller is designed based on HMJA viscoelastic properties to control the angular position of the robot arm. The outer-loop controller is designed to control the fingers force by considering the stable inner-loop as a right factorization. The robust tracking conditions and the realization of the proposed control system are also discussed. Finally, the effectiveness of the proposed control system is also verified by simulation results based on experimental data.

Keywords: RAHS; robust control; HMJA viscoelasticity; operator-based RRCF approach; pneumatic soft actuator.

1. Introduction

Robot arm-and-hand systems (RAHS) are standard components in various application fields, for instance, industries, spaces, and sports. The dynamics of these systems are intuitively inspired by the human multi-joint arm (HMJA)-and-hand, and have been introduced to numerous applications, for example, biomedical surgery, physical rehabilitation of the disabled and the elderly, motor therapy [1, 2]. Due to the potential applications, the robot arms with human-inspired motion mechanism which move smoothly and dexterous like the HMJAs have attracted a lot of attentions from both academic research and industrial communities [3]. Over the past decades, the robot arms have become more and more compact, light and stable, and are often designed to operate in the environments interacting

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