Preview Control of Dual-Stage Actuators

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying subject to the provisions of the Copyright Act 1968.

I hereby certify that the work embodied in this thesis is the result of original research, completed subsequent to admission to candidature for the degree. During the course of the candidature several papers have been coauthored with my academic supervisors based on a normal candidate-supervisor practice. Chapter 2 is based on collaborative work with Dr. Jinchuan Zheng. However, I took an active role in every stage of the development of such work.

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Rarely a researcher that climbs to the very summit of a scientific area retains the ability to engage students at the lowest levels. For this, I am grateful to my supervisor, Prof. Minyue Fu. Without his guidance and foresight this work would not have been accomplished. I feel compelled to thank him for illuminating the path while providing me liberty and support in the direction I chose to take.

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Contents

Abstract

The vast majority of control theory has focused on the stability of dynamical systems as opposed to their performance, a consequence of the fact that an unstable system may be considered an engineering disaster. However, it is according to how well a system performs that it is defined as good or bad, making stability a necessary, but not sufficient condition for a successful design. Any closed loop system should simultaneously achieve the *necessary* stability property along with the *desirable* performance criteria.

In motion control, performance criteria commonly concerns the system's ability to accurately and promptly track a desired reference. Of paramount importance towards the improvement of both these goals was the development of the Dual-Stage Actuators (DSA) concept. This thesis exposes the author's and collaborators work on the development of new control methods that improve the DSA ability to promptly transition its output from one reference level to another.

The main achievements of this work include the design and control of a novel DSA prototype, the development of new fast tracking servomechanisms focused on improving the performance of the slow actuator, and a novel integrated design that fully explores the redundancy of actuators. The integrated DSA control design makes use of future information in order to compute a pair of inputs to be applied before the output transition time, hence, it came to be known as Preview Control. The author hopes the material presented in this thesis will show that the integration of the novel fast tracking servomechanisms with the Preview Control strategy provides remarkable performance improvements to dual-stage systems.

Experimental results are presented throughout the thesis in order to clarify and validate the proposed designs.