University of Southern Queensland

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Analysis and Development of Iterative Fast Model Control Strategies for Systems with Constraints

A thesis submitted by

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Abstract

In this research, new fast model control strategies are developed and analysed. To avoid confusion with the competing directions taken by Predictive Control they have been named 'Iterative Fast Model Control (IFMC) Strategies'. It has been shown that new IFMC strategies deliver near time optimal performance and have finite settling time. IFMC strategies that include various state constraints are also developed. The system responses and the Lyapunov stability have been analysed.

The possibility of extending IFMC strategies for systems up to an n^{th} order is supported by development of IFMC strategies for 6^{th} to 11^{th} order systems. Application of IFMC in a real life situation of Aircraft Lateral Control has been studied. Successful implementation of IFMC in a third order ball and beam experiment demonstrates its effectiveness practice. A performance comparison with other contemporary strategies showed that IFMC delivers performance with almost 45% improvement.

The purpose of any real time controller is to determine the drive that should be applied to the plant at each instant. In IFMC, this is performed with the aid of a fast model of the system that can run at a speed that may be a thousand or more times that of the system. Then a decision on plant input is made, based on the fast model behaviour. The input is constrained at both extremes, full positive and full negative.

Fast Model Control strategies were developed from the mid 1950s, initially termed "Predictive control" although subsequently this term has been taken up by a different research thread. There have been hardly any publications extending the original theme since 1990. It is possible that the slow and expensive computing resources of that time may have led to the methods being regarded as purely academic. However the more recent proliferation of high speed, yet small affordable microcontrollers may have renewed the relevance of fast model control strategies.

Certification of Dissertation

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.
I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Sarang Ghude

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Notations and Definitions

T	Plant time
t	Model time
t_+	Predicted model time, to have all model variables positive with full positive drive applied
t_-	Predicted model time, to have all model variables negative with full negative drive applied
dtp	Plant steplength
dtf	Model steplength
onside	A stage where variables have the sign, same as the input
offside	A stage where variables have the sign, opposite to the input
primary variable	First variable (integral) in the cascade
subsequent variable	Remaining variables (integrals) in the cascade