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Practical Iterative Learning Control with Frequency Domain Design and Sampled Data Implementation

Springer

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To my wife, Ming, and children:
Anmin, Andai and Anyu

Danwei Wang

To my wife, Xiaozhen, and children:
Jici and Ji'an

Yongqiang Ye

To my wife, Weiwei, and children:
Leo and Nina

Bin Zhang

Preface

When looking around our own world, we can be convinced that most engineered machines and systems are of repetitive nature and/or are used for repetitive operations. Lifts in tall buildings run up and down along the same path with the same stopping positions. Robots are used to carry out the same tasks repetitively. Machines in factory assembly lines carry out the same operations repetitively to produce large quantities of the same products. Hard-disk drives in our computers write and retrieve data in storage disks with repetitive motions. Chemical industries have many batch processes and manufacturing systems have many run-to-run processes. Trains run at fixed schedules over the same distance on a daily basis. Satellites cycle along the same orbits around the Earth a few times a day. Power generators produce periodic AC voltages and currents which are required to be matching the reference frequency and with quality waveforms for feeding into power grids. Power electronics devices, such as converters, are to ensure output voltages or currents sinusoidal with minimum distortion.

In the past 30 years, the repetitive feature of such machines/systems has been exploited to meet the ever-increasing demand for better precision and performance. Theory and designs of iterative learning controllers have been developed taking advantage of the repetitive operations to improve the tracking performance and accuracy. This improvement over iterations is not achievable using feedback controllers. A majority of the published literature on iterative learning control is on time domain analysis and design methods, including a few books on this topic. This book addresses the analysis and design of iterative learning control in frequency domain as well as digital implementation of iterative learning control for industrial systems and machines. One distinctive advantage of frequency domain approach is the clear view of bandwidth which should ensure learning of useful signal components but filtering out unwanted interferences and disturbances. This book offers a spectrum of analysis and design methodologies and techniques to tune the cut-off frequency for iterative learning controllers. Pseudo-downsampled-data schemes are developed to implement iterative learning controllers with good cut-off frequency. These developed designs and techniques ensure stable learning transient and monotonic convergence performance over iterations and at the same

time include as many as possible signal components in the given tracking tasks. This book is aimed for practitioners/engineers, senior undergraduate students as well as postgraduate students in control engineering.

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