WORKSHOP TITLE

Iterative Learning Control: Algebraic Analysis and Optimal Design

WORKSHOP ORGANIZERS AND PRESENTERS (see below for bios)

Kevin L. Moore – Colorado School of Mines
YangQuan Chen – Utah State University

CONTACT INFORMATION: For more information about the workshop, please contact:

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WORKSHOP DURATION: Half Day

WORKSHOP WEBPAGE: http://www.csois.usu.edu/ilc/ieee-icma06-tutorial/

WORKSHOP ABSTRACT AND OBJECTIVES

The purpose of this workshop is to present a unified exposition of recent advances in ILC analysis and design, providing an integrated view of the presenters' collaborative research on theoretical aspects of ILC research that has developed over several years into a systematic methodology. At the 2000 CDC in Sydney a tutorial introduction to ILC was given that concentrated on the fundamentals of ILC. The present workshop is aimed at a more advanced and systematic focus on the algebraic approach to ILC analysis and on the optimal robust design of ILC algorithms that has developed since the previous tutorial. Throughout the workshop the underlying theme will be on ILC as a mature design methodology with both significant demonstration of, and further potential for, actual implementations with clearly visible returns in terms of improved performance.

WORKSHOP AUDIENCE

The expected audience includes engineers, scientists, postgraduate students, and academics. The workshop will be self-contained so that it is suitable for systems and control researchers and practitioners who may not be familiar with the concept of ILC as well as to those with some background in the field.

ORGANIZATIONAL DETAILS

1. Attendees will be given access to electronic copies of the workshop presentation materials.

2. The organizers and presenters will use electronic projection in PowerPoint or PDF format. We will provide our own computers, but we require the use of an LCD projector. The ability to make extemporaneous comments on a chalkboard or a dry-erase board would also be helpful, though not essential.

WORKSHOP PROGRAM

The workshop begins with an introduction to the basic ideas of ILC including application domains, modeling issues and the issues faced by designers. Aspects of the current state of theoretical knowledge are then described. This includes the formulation of a unifying algebraic framework what can be applied to linear discrete-time systems as well as some classes of affine nonlinear systems. The key to this formulation is to first perform a lifting procedure to form so-called super-vectors, followed by a *z*-transform-type operator in the iteration domain. Next, it is shown how the algebraic framework can be used to analyze the convergence and performance properties of ILC systems. This framework makes it possible to understand system characteristics in terms of poles in the iteration domain and motivates qualitative understandings about design from an internal model perspective and pole placement ideas. Next we consider design. We begin with a study of design from the algebraic perspective, including design for monotonic convergence and the design of optimal ILC-PID algorithms. Examples of ILC design applications to disk drive servo control are presented, demonstrating the effectiveness of ILC algorithms in a real industrial setting. We conclude the workshop with a discussion of recent results on robust ILC for both interval and frequency uncertainties, focusing on iteration-domain-based design.

SCHEDULE

Time	**Topic**	**Presenter**
14:00-14:10	Welcome and Introduction	K. Moore
14:10-14:55	Formulation of the Algebraic Approach to ILC Motivations, generic algorithms, examples Analysis of ILC from the Algebraic Perspective Lifting, w-transform along the iteration axes Poles along the iteration axes, Internal model principle	K. Moore
14:55-15:40	Algebraic-based design of ILC Monotone convergence, Optimal PID	Y.Q. Chen
15:40-16:00	Break	
16:00-16:45	ILC Application Examples	Y.Q. Chen
16:45-17:15	Robust ILC Interval and Frequency-domain robustness Time-varying ILC design	K. Moore
17:15-17:30	Closing remarks: Future research in ILC	K. Moore

ORGANIZERS' AND PRESENTERS' BIOGRAPHIES

Kevin L. Moore received the B.S. and M.S. degrees in electrical engineering from Louisiana State University and the University of Southern California, respectively. He received the Ph.D. in electrical engineering, with an emphasis in control theory, from Texas A&M University. He is currently the G.A. Dobelman Distinguished Chair and Professor of Engineering at the Colorado School of Mines. He was previously a senior scientist at Johns Hopkins University's Applied Physics Laboratory (2004-2005), the Director of the Center for Self-Organizing and Intelligent Systems, and Professor of Electrical Engineering at Utah State University (1998 -2004), and on the faculty at Idaho State University (1989-1998). He is the author of the research monograph *Iterative Learning Control for Deterministic Systems* and co-author of the book *Modeling, Sensing, and Control of Gas Metal Arc Welding*, published by Elsevier. He is an active contributor to the literature of iterative learning control and conducts research in ILC, robotics and industrial control applications, cooperative control, and autonomous systems.

YangQuan Chen is presently an assistant professor of Electrical and Computer Engineering Department and the Acting Director for CSOIS (Center for Self-Organizing and Intelligent Systems) at Utah State University. He obtained his Ph.D. from Nanyang Tech. Univ. (NTU), Singapore. Dr Chen has 12 US patents granted and 2 US patent applications published, most related to iterative learning control and repetitive control. He published over 160 academic papers, two textbooks, one research monograph, and (co)authored over 50 industrial reports. He has been an Associate Editor in the Conference Editorial Board of IEEE Control Systems Society since 2002 and is a founding member of the ASME subcommittee of "Fractional Dynamics" in 2003. He is a senior member of IEEE, a member of ASME and a member of International Society for Information Fusion.

DETAILED WORKSHOP SYNOPSIS

This workshop presents a unified exposition of recent advances in iterative learning control (ILC) analysis and design, providing a systematic focus on algebraic analysis and optimal and robust design approaches to ILC, as well as a discussion of ILC experimental implementations. Iterative learning control is both theoretically and, increasingly, practically a mature technique for improving the transient response and tracking performance of processes, machines, equipment, or systems that execute the same trajectory, motion, or operation in a repetitive manner. The ILC paradigm is motivated by the observation that if a system's controller is fixed, and its initial operating conditions are the same each time it executes, then any errors in the output response of the system will be repeated during each operation. The situation can be improved by using errors recorded during system operation to update the input signal from repetition to repetition. In this way the controller is capable of learning, in an iterative manner, the input signal that results in greatly improved tracking performance. The ILC paradigm has been studied extensively and successfully applied to a variety of industrial control problems, such as high-precision motors and manipulators, component testing for fatigue life, road simulation in car racing, hard disk servo controllers, and food packaging plants, among many others. The workshop will be organized into three main sections: exposition of an algebraic framework for ILC analysis and design; presentation of optimal ILC design ideas, a presentation of an experimental ILC application for disk drive servo control, and discussion of recent results on robust ILC design.