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Process Control in a High-Noise Environment Using a Limited Number of Measurements

Leandro G. Barajas, Magnus B. Egerstedt, Edward W. Kamen, and Alex Goldstein

{LBarajas, Magnus, Ed.Kamen, Alex.Goldstein}@ece.gatech.edu
School of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, GA 30332, U.S.A.

Abstract

In this paper, we develop a hybrid control algorithm that generates adequate control values for processes where only a limited number of function evaluations are available for the control law generation. This situation arises, for example, in stencil printing processes in printed circuit board manufacturing, where the cost associated with multiple function evaluations is prohibitive. The proposed control scheme is based on a weak-search algorithm that can be used in the presence of large amounts of noise as well as when only a limited amount of information is known about the process. The control law is given by a modified version of a constrained conjugated-gradient method, transitioned into a windowed-smoothed block-form of the least-squares affine estimator.

1 Introduction

Process control has long been a highly successful branch of control theory, both in terms of industrial impact and theoretical development. (See for example the classic reference [1]). However, as new technologies have emerged, from Printed Circuit Boards (PCB) to Micro-Electro-Mechanical Systems (MEMS) devices, new challenges have presented themselves in the area of process control. In this paper we investigate one such challenge, concerning how to adjust the machine parameter settings in a stencil printing process (SPP) for PCB production, the closed-loop control that we developed compensates for discrepancies associated with different print directions, recovers from faulty initial settings, and provides robustness by maintaining an acceptable performance in the presence of environmental variations or unscheduled process interrupts. This is a novel and potentially useful result for the following two reasons:

1. To control the SPP in a closed-loop fashion has long been an evasive goal to the industry; even when some closed-loop control strategies have been proposed, their limited applicability and portability into production environments have prevented these methodologies from being widely adopted [2, 3, 4, 5].

2. The SPP poses new challenges on the control laws in terms of the use of limited number of measurements as well as high noise levels, thus rendering the control law proposed in this paper, useful in a number of similar applications.