Real-time Optimization of Nonlinear Dynamical Systems

M. Guay

1 Introduction

Increased demands imposed by global market pressures, environmental constraints and energy costs have had a dramatic impact on the management and operation of processing systems in many sectors including chemical and petrochemical production plants. There is a significant thrust in North American companies to integrate science and technology into strategies for producing services and products for a dynamic world market. These changes in operating culture have led to an emphasis on the development of integrated strategies that offer the flexibility required to respond to economic pressures while satisfying emission restrictions and reducing energy costs.

In this workshop, we provide an introduction to the problem of real-time optimization (RTO) and control of nonlinear dynamical systems. Real-time optimization (RTO) has become a leading technology for steady-state process optimization in the process industry. RTO is used as a supervisory control technique to compute, in real-time, optimal setpoints (with respect to e.g. cost, profit, quality, etc...) to be tracked by the process operation. Unfortunately, the objective of RTO, which seeks to explore new operating regimes, cannot be done effectively without an appropriate design of the enabling process control system. In this workshop, we formalize the integrated design of RTO and control systems as a model-based adaptive extremum-seeking control (AESC) task. The main idea advocated is to integrate the competing tasks by using the objective function of the AESC system to formulate a suitable Lyapunov function for the control system. The resulting integrated control system achieves the steady-state optimization objectives with guaranteed transient performance. AESC has proven to be an effective

technology in a number of areas including bioprocess control, chemical reactor control, building systems control and fuel-cell control. We will provide a comprehensive introduction to leading solutions of the AESC problem. In doing so, we establish a number of new results in the area of nonlinear adaptive control, constrained system control, periodic system control, nonlinear model predictive control and dynamic real-time optimization.

2 Workshop Organization

The workshop is organized as follows:

1. Real-time optimization problem description with examples (M. Perrier, École Polytechnique de Montréal)
2. Model-free adaptive extremum-seeking control (B. Srinivasan, École Polytechnique de Montréal)
    - Model-free Steady-state optimization: Methods
    - Extremum-seeking control: Performance enhancement and limitations
3. Model-based adaptive extremum-seeking control (M. Guay, Queen's University)
    - Real-time optimization of nonlinear systems
    - Constrained RTO of nonlinear systems
    - Input signal design for guaranteed convergence
    - Improved performance in adaptive nonlinear systems

3 Participants

- B. Srinivasan and M. Perrier, École Polytechnique de Montréal, Montréal, Québec, Canada
- M. Guay, Queen's University, Kingston, Ontario Canada