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Characteristics-Based Lq-Control of Cracking Reactor by Integral Reinforcement

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Abstract : The linear quadratic control system of hyperbolic first order partial differential equations (PDEs) are presented. The aim of this research is to control chemical reactions. This is achieved by converting the PDEs system to ordinary differential equations (ODEs) using the method of characteristics to reduce the system to control it by using the integral reinforcement learning. The designed controller is applied to a catalytic cracking reactor. Background—Transport-Reaction systems cover a large chemical and bio-chemical processes. They are best described by nonlinear PDEs derived from mass and energy balances. As a main application to be considered in this work is the catalytic cracking reactor. Indeed, the cracking reactor is widely used to convert high-boiling, high-molecular weight hydrocarbon fractions of petroleum crude oils into more valuable gasoline, olefinic gases, and others. On the other hand, control of PDEs systems is an important and rich area of research. One of the main control techniques is feedback control. This type of control utilizes information coming from the system to correct its trajectories and drive it to a desired state. Moreover, feedback control rejects disturbances and reduces the variation effects on the plant parameters. Linear-quadratic control is a feedback control since the developed optimal input is expressed as feedback on the system state to exponentially stabilize and drive a linear plant to the steady-state while minimizing a cost criterion. The integral reinforcement learning policy iteration technique is a strong method that solves the linear quadratic regulator problem for continuous-time systems online in real time, using only partial information about the system dynamics (i.e. the drift dynamics A of the system need not be known), and without requiring measurements of the state derivative. This is, in effect, a direct (i.e. no system identification procedure is employed) adaptive control scheme for partially unknown linear systems that converges to the optimal control solution. Contribution—The goal of this research is to Develop a characteristics-based optimal controller for a class of hyperbolic PDEs and apply the developed controller to a catalytic cracking reactor model. In the first part, developing an algorithm to control a class of hyperbolic PDEs system will be investigated. The method of characteristics will be employed to convert the PDEs system into a system of ODEs. Then, the control problem will be solved along the characteristic curves. The reinforcement technique is implemented to find the state-feedback matrix. In the other half, applying the developed algorithm to the important application of a catalytic cracking reactor. The main objective is to use the inlet fraction of gas oil as a manipulated variable to drive the process state towards desired trajectories. The outcome of this challenging research would yield the potential to provide a significant technological innovation for the gas industries since the catalytic cracking reactor is one of the most important conversion processes in petroleum refineries.

Keywords : PDEs, reinforcement iteration, method of characteristics, riccati equation, cracking reactor
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