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NEURAL NETWORK-BASED DIGITAL REDESIGN APPROACH FOR PID CONTROL OF UNKNOWN NONLINEAR MULTIVARIABLE SYSTEMS

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Abstract. This paper presents a neural network-based digital redesign approach to design digital PID controllers for continuous-time noise-free nonlinear multivariable systems with known state dimension but unknown structures and parameters. Important features of the approach are: (i) it generalizes the existing optimal linearization approach to the models which are nonlinear in both the state and the input; (ii) it develops a neural network-based optimal linear state-space model for unknown nonlinear systems; (iii) it develops an inverse digital redesign approach for indirectly estimating an analog PID control law from a fast-rate optimal digital PID control law, without directly utilizing the analog models. This analog control law is then converted to a slow-rate digital PID control law via the prediction-based digital redesign method; (iv) it develops a linear time-varying piecewise-constant low-gain tracker which can be implemented using microprocessors. A nonlinear synchronous motor is utilized as a simulation example to demonstrate the effectiveness of the proposed methodology.

Keywords. digital redesign, multivariable system, neural network, nonlinear system, optimal linear model, PID control.

1 Introduction

Since its development, the proportional-integral-derivative (PID) controller and its variations constitute the control algorithms most commonly used in industrial applications. Besides their simple structures and general applicability in the majority of the control systems, when well designed they provide a good performance in both transient and steady-state responses as a consequence of the combination of the derivative and integral actions.

However, in certain cases the design of a PID controller is not an easy task. Often, the derivative action is turned off because it is difficult to design