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Neural-tuned PID Control for Point-to-point (PTP) Positioning System

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ABSTRACT

Motion control systems play an important role in industrial engineering applications such as advanced manufacturing systems, semiconductor manufacturing systems and robot systems. Until know, PID (proportional-integral-derivative) controllers are still the most popular controller used in industrial control systems including motion control systems due to their simplicity and also satisfactory performances. However, since the PID controller is developed based on the linear control theory, the controller gives inconsistent performance for different condition due to system nonlinearities. In order to overcome this problem, Neural-tuned PID control is proposed. By using EMRAN (Extended Minimal Resource Allocation Algorithm) to train the Radial Basis Funciton (RBF) Network, the PID controller can learn, adapt and change its parameters based on the condition of the controlled-objectin real-time. The effectiveness of the proposed method is evaluated experimentally in real time using an experimental rotary positioning system. The experimental results show that the proposed system is better than classical PID controller in terms of not only positioning performance but also robustness to inertia variations.

1. INTRODUCTION

Applications of Motion control can be seen in various engineering files such as automation, robotics, manufacturing, production, precision control, bioengineering, and semi-conductor industries. Basically there two kinds of motion control systems namely point-to-point (PTP) positioning systems and continuous path (CP) control system [1]. Both motion control systems generally need a good controller to realize high speed and high precision motion system. However, it is not easy to achieve high precision system because of non-linearities such as friction and saturation exist in the motion control systems. However, since both friction and saturation are non-linear function, friction and saturation can not be compensated effectively by controller designed based on the linear control theory.

The motion control systems are also characterized by parameter uncertainties. The parameter uncertainties are caused by estimation errors and/or parameter variations. Two major sources of the parameter variations in positioning systems are inertia and friction variations. Inertia of the positioning systems may vary due to payload variation. Friction variation may occur due to variations of the lubrication condition and/or inertia. Inertia variation can cause variation of the Coulomb friction as well [2]. Therefore, the robustness of the control system is also an important requirement of the motion control systems.

Until know, Proportional-Integral-Derivative (PID) controllers are still the most popular controller used in industrial control systems including motion control systems due to their simplicity and also satisfactory performances [3]. The use of PID controller for motion control systems was proposed by many researchers, for example discussed in [4-5]. However, since the PID controller is developed based on the linear control theory, the controller gives inconsistent performances for different condition as discussed in [6]. Improvement of the PID controller for achieving high performance (especially high speed and high precision) of motion control system is required.

To overcome the above-mentioned problem, in this paper, intelligent PID controller based on the artificial neural network is introduced so that the PID controller can learn, adapt and change its