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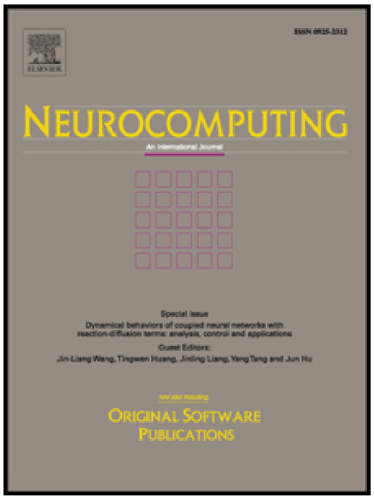

Optimized linear active disturbance rejection control for pneumatic servo systems via least squares support vector machine

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Optimized linear active disturbance rejection control for pneumatic servo systems via least squares support vector machine

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Abstract. This paper presents an optimized linear active disturbance rejection controller to improve the response rapidity and anti-interference ability of a pneumatic servo system. Both a linear extended state observer and a least squares support vector machine are established to estimate and compensate total nonlinearity of the system. Moreover, a linear state error feedback controller is designed to ensure good performances of the closed-loop system. In addition, estimation error and tracking error are bounded and decrease with the increase of their respective eigenvalues. Lastly, simulation results show that the optimized controller has the better response rapidity and anti-interference ability than the traditional controller.

Keywords: Active disturbance rejection control, pneumatic servo system, positioning control, least squares support vector machine (LSSVM).

1. Introduction

In recent years, pneumatic servo systems have been increasingly popular due to their advantages of rapidness response, safety operation, low cost, cleanliness and high power-weight ratio [1]. Pneumatic servo systems are traditional systems and have a wide variety of applications, such as food packing, medical areas, robots, mechanical operations and automotive industry [2]. However, it is difficult to acquire a precise positioning control for pneumatic servo systems because of strong nonlinearity which is caused by air compressibility, large friction forces and nonlinear properties of servo valves [3]. Therefore, it is worth to study on positioning control of pneumatic servo systems. Many researchers have designed a series of control strategies to improve the performances of pneumatic servo systems, please refer to [4]. Various modified PID controllers have been designed to improve self adaptability and robustness of pneumatic servo systems, such as in [5]. Sliding model control has also been widely used in pneumatic servo systems due to robustness and tolerance for uncertainties [6]. In [7], back-stepping control has been introduced to achieve good control performances of pneumatic servo systems. However, it is very difficult to achieve a high control precision in PID controllers [8]. Moreover, sliding model control and back-stepping control require highly complete mathematical models which are hardly obtained for pneumatic servo systems [9, 10]. Therefore, it is a key task to design an optimized controller for pneumatic servo systems satisfying a high control precision and doing not rely on an accuracy mathematical model in this topic.

Active disturbance rejection control, which was proposed by Han Jingqing in 1990s, does not rely on an accuracy mathematical model but has a high control precision [11]. The control method has been widely used in many fields, such as drag tracking in MARS entry guidance [12], diving control of autonomous underwater vehicle [13], airship horizontal trajectory tracking control [14] and permanent-magnet synchronous motors [15]. The active disturbance rejection control consists of a tracking differentiator, an extended state observer and a state error feedback controller [16]. The tracking differentiator, which is usually used to get a differential signal of input signal, can reduce overshoot effectively [17].

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