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Full paper

Automatic tuning of pneumatic servo actuators

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Abstract—The high power-to-weight ratio and low cost of pneumatic actuators makes them attractive for robotics and automation applications; however, achieving fast, accurate position control with them is difficult. Furthermore, tuning the controller (and/or obtaining process models) requires extensive expertise and time. In this paper, a novel automatic tuning methodology for the accurate position control of pneumatic servo actuators is described. The methodology combines off-line model-based analysis with on-line iteration. Experiments performed on three actuators with distinct open-loop dynamics verified the auto-tuner's effectiveness. The auto-tuning required 1/50 of the time needed for manual tuning and only non-expert supervision. The performance of the auto-tuned actuators is comparable to that achieved by other researchers using more complex and expensive hardware.

Keywords: Actuator; adaptive control; auto-tuner; pneumatic; position control.

1. INTRODUCTION

Pneumatic actuators offer several advantages over electromechanical and hydraulic actuators for positioning applications. These include lower cost, high power-to-weight ratio, cleanliness, ease of maintenance and a readily available power source. When applied to robotic manipulators, the high power-to-weight ratio of pneumatic actuators will allow greater payloads to be carried by the same size arm. This, in combination with their low cost, makes pneumatic actuators of great interest for robotics and automation applications.

Unfortunately, pneumatic actuators are subject to high friction forces, deadband (due to stiction) and dead time (due to the compressibility of air) which make fast, accurate position control difficult to achieve. Controllers have been developed for this application by many researchers (see [1] and [2] for reviews of pneumatic position control research). Many of these systems, though successful, use expensive servo valves and pressure sensor feedback loops. Van Varseveld and Bone [1] developed a system employing inexpensive on/off solenoid valves with a novel pulse-width modulation (PWM) scheme which achieves comparable performance to these systems at a substantially lower cost (~60%).