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STABILITY IN ROBOTS WITH DELAYED FEEDBACK: ANALYSIS AND PRACTICAL OBSERVATIONS

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Abstract: In this study we consider the stability problem of a rigid robot with time-delay in feedback. We consider delayed signals in state and output feedbacks. As demonstrated, the appearance of time-delays in the feedback loop is critical. In fact, even a relatively small time-delay may generate the destructive phenomenon of a finite escape time. In this regard some useful structural properties of the system are studied for synthesizing state and output stabilizing feedbacks in the presence of time-delays, and related features like the estimated region of attraction and the system rate of convergence, are considered.

Keywords: Robot manipulator, time-delay, state and output controllers, finite escape time, stability, region of attraction.

1 Introduction

In real situations time delays may be encountered in systems with hydraulic, pneumatic, or mechanical transmissions [7]. The time required for executing a numerical operation in a computer-based controllers can also be amounted to a time-delay in the control loop. In internet-based robotic systems time-delays are inherent part of the control process. This emerging research field has received much attention in recent years [12], and the topic of data traffic management task and the way it affects the system stability, becomes the subject of recent studies [6]. Teleoperation supports the use of robot in space, underwater or nuclear applications. Whenever a remote system is driven via a computer network, and communication links play a key role in real-time data transmission, the robustness of the control process is highly dependent on the time delays existing in the control feedback.

Instability due to time delay was a long standing critical problem in control systems. The effects of time-delays in teleoperation, which is a dual robot system in which a remote slave robot follows a master robot system, might be critical [13]. It may hamper the system's controller performances, destabilizes the system, and furthermore, it may exhibit complex behavior including chaos [10]. As reported in published papers small delays can lead to instability of current teleoperation systems, in particular internet-based