

Improvements of the Adaptive Slotine & Li Controller – Comparative Analysis with Solutions Using Local Robust Fixed Point Transformations

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Abstract: One of the most sophisticated classical robot controller, the "*Slotine-Li Adaptive Controller*" is constructed on the basis of exact knowledge on the form of the equations of motion of the system under control, and on the application of "*Lyapunov's 2nd Method*". This generic technique makes it possible to guarantee the stability of the controlled system using only simple estimations without having any detailed knowledge on its motion that is a great advantage. However, in the application of this elegant technique the main problem is the proper construction of the Lyapunov function. Formal elegance usually has the price of limitations in the applicable trajectory tracking policy and in the presence of a huge number of the constant control parameters to be determined in the commencement of the controller's operation. In the here presented approach the controller invented by Slotine and Li is modified in two steps: the first step modifies the original Lyapunov function, the second one—as an addition—modifies the parameter tuning by utilizing the information encoded in the equations of motion for which no any Lyapunov function is needed. The advantage is the limitation in the number of the fixed control parameters, and possibility for faster parameter tuning. The modified controller's operation is compared with that of a simple adaptive technique using locally convergent Cauchy sequences in iterative learning via simulation for a simple Classical Mechanical System as a paradigm.

Key-Words: Adaptive Control, Slotine-Li Adaptive Controller, Parameter Tuning, Iterative Learning, Cauchy Sequences

1 Introduction

In this paper possible improvements of the most sophisticated classical controller, the "*Slotine-Li Adaptive Controller*" [1] based on the use of *formally exact, permanent, and complete* model with *parameter uncertainties* is considered in comparison with a novel adaptive approach applying only *partial, incomplete, temporal, and situation-dependent* model that requires continuous refreshment via observing the behavior of the controlled system in the actual situation. It will be shown how simple geometric considerations can be used for developing iterative learning control. It will also be shown that in the case of the novel approach the conditions of convergence normally can be satisfied by choosing very primitive initial system models and roughly chosen control parameters on the basis of simple geometric considerations.

It will be pointed out that while even the improved Slotine-Li controller is applicable only for learning linearly separable dynamical system parameters and normally it fails for the permanent presence of unknown external disturbances and linearly non-separable (e.g. friction) parameters, the novel approach can well compensate the simultaneous effects of these factors. In contrast to the traditional solutions that normally guarantee global (asymptotic) stability by using Lyapunov functions, the novel approach can assure only local region of stability that in principle can be left by the system's state. To cope with this problem a *real time simulation tool* has been developed to study the robustness of the various controllers against the variation of the adaptive control parameters. The already achieved results will be exemplified by simulation studies using the same paradigm.

Slotine Li Solutions Manual

L Reisser



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