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13. ABSTRACT (Maximum 200 words)

Abstract: The goal of this research is to develop a computationally feasible approach to the design of compensators for nonlinear plants such as high performance aircraft and robots. The basic approach is to take parts of the current theory of nonlinear control, and extend and modify them as needed so as to develop numerical algorithms. To date the emphasis has been on a perturbational approach developed from well-established linear methodologies.

We have written a MATLAB based set of algorithms which accomplish feedback linearization, input-output injection linearization and nonlinear regulation. These are incorporated into a Nonlinear_System_Toolbox which is available via telnet. Contact ajkrener@ucdavis.edu for instructions on how to obtain them.

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Technical Report AFOSR–91–0228

Computational Nonlinear Control

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The goal of this research program is to develop a computationally feasible approach to the design of compensators for nonlinear plants such as high performance aircraft and robots. The basic approach is to take parts of the current theory of nonlinear control, and extend and modify them as needed so as to develop numerical algorithms. To date the emphasis has been on a perturbational approach developed from well–established linear methodologies.

In the last year, we have published four papers on this approach (listed below) and are distributing the Nonlinear_Systems_Toolbox. The latter is a MATLAB–based package of routines for the design of controllers and observers for systems with quadratic and cubic nonlinearities.

The feedback linearization scheme to nonlinear controller and the input–output injection linearization scheme for nonlinear observers has been solved term by term using Poincaré's approach. These are described in [1] and [2] and have been implemented in the "pc3" and "po3" algorithm of the Nonlinear_Systems_Toolbox.

We are also implementing some of the important, new theories of nonlinear control. The use of the term implementing is an understatement as very often these theories of nonlinear control are not in a form that is amenable to computer implementation. A case in point is the nonlinear regulation theory of Isidori and Byrnes which recently received the IEEE award for Best Paper appearing in the Transactions on Automatic Control.

The Isidori–Byrnes theory dealt with the construction of a tracking manifold in the combined state space of the plant and exosystem, which is invariant and on which tracking is exact. They did not discuss extensively the transverse problem of driving the combined system to this manifold, e.g. the problem of asymptotic tracking. In [3] we presented an optimal control formulation of the transverse problem and showed how to compute explicitly the solution to the transverse problem. This solution is original even for linear systems and quadratic cost functions. It is implemented in the "servo3" file of the Nonlinear_Systems_Toolbox.

In [4], we showed how the basic approach described in [3] could be generalized to the model–matching problem. This is the problem of designing a combination of feedforward and feedback control laws which make the input–output behavior of a nonlinear system mimic the input–output behavior of a given linear or nonlinear model. We are currently writing a MATLAB implementation of this algorithm.

In order to further the development of computational nonlinear control, we are distributing free of charge, via telnet, our Nonlinear_System_Toolbox and related files. Anyone interested should contact ajkrener@ucdavis.edu for instructions on how to obtain them.

Publications supported by AFOSR-91-0228:

1. 1991 Krener, A.J. and B. Maag. Controller and observer design for cubic systems. In Modeling, Estimation and Control of Systems with Uncertainty. G. B. DiMasi, A. Gombani and A. B. Kurzhansky, (eds.), Birkhauser-Boston, pp.224-239.
2. 1991 Krener, A.J., M. Hubbard, S. Karahan, A. Phelps and B. Maag. Poincare's linearization method applied to the design of nonlinear compensators. In Algebraic Computing in Control, G Jacob and F. Lamnahbi-Lagarrigue, (eds.), Springer, Berlin, pp. 76-114.
3. 1992 Krener, A.J. The construction of optimal linear and nonlinear regulators. In Systems, Models and Feedback: Theory and Applications. A. Isidori and T.J. Tarn, (eds.) Birkhauser-Boston, pp.301-322.
4. 1992 Krener, A. J. Optimal model matching controllers for linear and nonlinear systems. Proceedings of NOLCOS 92, Bordeaux.

Related Talks:

AFOSR Workshop on the Theory and Applications of Nonlinear Control, Washington University, 8/15-16/91, "Perturbation Approaches to Nonlinear Control"

Workshop on Nonlinear Control of Articulated Flexible Structues, UCSB, 10/10-12/91, "Nonlinear Servos"

Colloquium at MIT and Draper Laboratory, 2/25/92, "The Design of Nonlinear Controllers and Observers".

Regulation of Nonlinear Systems with State Constraints, Ecole de Physique, Les Houches, France, 3/9-12/92, "Computational Tools for Nonlinear Control".

Regelungstheorie, Mathematisches Forschungsinstitut, Oberwolfach, Germany, 3/15-21/92, "The Design of Nonlinear Controllers and Observers".

Colloquium at University of Stuttgart, 3/24/92, "The Design of Nonlinear Controllers and Observers".

NSF Workshop on Nonlinear Control, Washington University, 5/27-31/92, "Optimal Model Matching Controllers for Linear and Nonlinear Systems"

Workshop on Geometric Variational Problems and Optimal Control, Fields Institute, University of Waterloo, Canada, 6/6-9/92, "Chattering in Control and Estimation".

Systems, Models and Feedback: Theory and Applications, Capri, Italy, 6/15-19/92, "The Construction of Optimal Linear and Nonlinear Regulators".

IFAC Nonlinear Control Design Symposium, Bordeaux, France, 6/24-26/92, "The Construction of Optimal Nonlinear Model Reference Controllers'.

Nonlinear_System_Toolbox

Name	Size	Kind	Label	Last Modified
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Nonlinear_System_Toolbox

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blk_srv3	18K	MATLAB/S docum...	—	Thu, Jun 4, 1992, 1:27 PM
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Matlab_Data_Files

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