

INSTITUTO
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Departamento
Engenharia
Electrotécnica
e de
Computadores

Report on the Doctoral Thesis presented by Ing. Jakub Novák

The doctoral thesis presented by **Ing. Jakub Novák** is entitled **Nonlinear System Identification and Control Using Local Model Networks**. The thesis has 98 pages and is divided in 6 chapters.

The thesis is concerned with the use of Local Model Networks for (LMN) controller design. LMN is a technique for tackling the modelling of nonlinear systems. It amounts to describe the whole nonlinearity by a set of local linear dynamic models that are then combined with weight or validity functions. When the combination is made in terms of local controllers to yield a global nonlinear controller, this is known as Local Controller Network (LCN).

The objective of the thesis is twofold:

- Development and investigation of various techniques for optimization of the local network parameters.
- Investigate various control algorithms, with an emphasis on Model Predictive Control (either linear or nonlinear) that use local model network.

Chapter 1 provides an overall state-of-the-art and states the thesis objectives and structure.

Chapter 2 describes LMNs and discusses the relation with fuzzy models.

Chapter 3 describes nonlinear system modelling using LMNs and algorithms for LMN identification. These algorithms are taken from the literature.

Chapter 4 is devoted to controller design based on LMNs, resulting in LCNs. The use of Predictive Control (linear and nonlinear) and Internal Model Control is considered.

Chapter 5 is devoted to simulation and experimental studies in pilot plant models, illustrating the application of the previously described methods.

Chapter 6 draws conclusions.

Av. Rovisco Pais
1049-001 Lisboa
Portugal
Tel. 21 841 72 92 / 21 841 84 99
Fax 21 841 71 90

Cont. N° 501 507 930
CAE 80300

Mod. 25/Eco

The thesis addresses the combination of two issues that currently receive major attention from the scientific community: Local Model Networks and Nonlinear Model Predictive Control. As such, its subject is quite appropriate for a doctoral thesis where Control Engineering is the broad area.

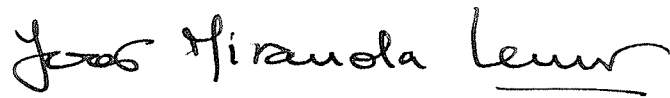
Theoretical issues such as stability or identifiability conditions are not addressed, neither is the development of completely new algorithms for identification and control. Hence, the degree of innovation is moderate. The contributions of the thesis have to be sought in the combination of the different techniques and their testing in case studies.

The list of references is adequate and fairly complete.

Concerning the style, the thesis is well written and concise.

In conclusion, I consider that the thesis fulfils the minimum standards of a Doctoral thesis and can be accepted for discussion in the exam for the degree of Doctor at Tomas Bata University in Zlin, Faculty of Applied Informatics.

Lisboa, April 27th, 2007



João M. L. de Miranda Lemos
Professor Catedrático (Full Professor) of IST
Universidade Técnica de Lisboa

Reviewer statement of the Ph.D. thesis

Name of the postgraduate student: Ing. Jakub Novák

Ph.D. thesis title: Nonlinear System Identification and Control Using Local Model Networks

Reviewer: Prof. Ing. Petr Pivoňka, CSc., Department of Control and Instrumentation, Faculty of Electrical Engineering and Communication, Brno University of Technology, Czech Republic

The theme of this thesis belongs to the control subject area. Even though the identification belongs to the discipline elaborated widely and there are thousands of publications on this topic, still there is not universal identification method that is robust successfully and applicable on wider class of processes and gives the infallible results in any cases. Every person who concerns with the process identification and after using its results can confirm that one identification method gives reliable results in the particular case while it does not in the another case.

This thesis has examined the Local Model Network structures for identification and control of nonlinear systems. The idea beyond these networks is to divide the operating range of nonlinear system into smaller part where the nonlinear system can be represented by a simple model. For this reason I consider the thesis theme as well chosen and it is current for a present state of science.

In thesis several training algorithms are described and new training algorithm that utilizes Self-Organizing Migration algorithm for validity function optimization and quadratic programming for local model parameters estimation is proposed. This method is able to find improved model.

The predictive control scheme that uses linearization of LMN for prediction future outputs and compensation for model/plant mismatch has been proposed. Results from experiments have shown that incorporation of the modelling error into the cost criterion ensures good tracking performance despite modelling errors.

Results of various simulation studies have been presented in thesis that showed the satisfactory performance of the proposed identification schemes. All the experiments and simulations within the thesis have been only on single-input single-output system executed.

Even though the ideas used in the algorithms are known, their elaboration is indisputable contribution of the student. A comparison of methods in simulation is very interesting. The conclusions formulated by student in sense of a comparison method advantages and disadvantages are correct.

Some remarks:

- The figure 13. IMC block diagram is out of drawing.
- p. 61 IMC is not generalized Smith predictor, by IMC is another kind of feedback.

The publication themes of the student covered the content of its thesis sufficiently. I consider as the most significant publications [1], [2] and [3]. However is recommended to public results of Ph.D. work in prestigious international conferences. From results of works is obviously, that the postgraduate student have all expectations for others scientific works.

After studying the thesis and the student publication activities, I reached the conclusion that the student is a fully developed scientist and is able to do a creative research.

The thesis complies with the requirements on this type of the work. I recommend the thesis to defence and I recommend awarding the candidate the title of doctor (Ph.D.) in case of a successful defence.

Brno, 12.4.2007

Prof. Ing. Petr Pivoňka, CSc.

Review of PhD Thesis

Nonlinear System Identification and Control Using Local Model Networks

Ing. J. Novák

Contents

The submitted dissertation thesis consists of 99 pages, 6 chapters, Bibliography, and curriculum vitae of the author. It is written in English. Publication activity of the author comprises 9 international and local conferences.

The first chapter presents bibliography overview and summarises aims and overview of the thesis. The aims are as follows:

- development and investigation of various techniques for optimisation of local model network parameters
- to investigate various control algorithms for models with local model networks

In my opinion, investigation of known techniques in both aims belongs rather to bibliography review part of the thesis than to its real outcomes.

The second chapter provides overview of existing approaches in local model networks. It discusses various issues in validity functions and in normalisation. The chapter concludes with relation of local model networks and fuzzy sets.

Chapter 3 summarises recent advances in modelling of nonlinear systems with local model networks and parameter estimation for models that are partially linear. Both deterministic and stochastic approaches are discussed.

Chapter 4 presents selected approaches to control of LMN - local controller networks, predictive control, and IMC.

Selected methods that have been treated in Chapters 2-4 are tested in simulation and on experimental plant in Chapter 5. Simulation deals with a nonlinear model of a pH reactor whereas experimental results are obtained with a storage tank system.

Actuality of the Work

The author studies topics in the field that is highly actual as simple linear models are known to be not very good approximators for highly nonlinear processes. The proposed methods are well chosen.

Formal Comments

- Bibliography: works [33], [35], [37], and several others are not cited in the main body of the thesis.
- Bibliography: although it seems that the citation order corresponds to the order of appearance in the text, there are several citations that are out of order ([62-64] after [62], [5] after [9], etc).