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Review of Dissertation Thesis

Discrete Wavelet Transform in Linear System Identification
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Contents of the Thesis

The dissertation thesis contains about 70 pages of contents plus additional material as foreground information, author's publications, and list of references. Therefore, it can be considered as a fairly small work that concentrates on one topic – usage of wavelets in system identification. The thesis is written concisely, at a very good level both from formal and scientific point of view.

The first chapter serves as introduction but also supplies a very brief state of art in the origins of wavelet analysis. The review continues in Chapters 3 (State of the art) and 4 (Wavelet transform).

Chapter 5 concentrates on foundations of system identification of linear systems. It is mainly based on monographs of Ljung and Soderstrom. Prediction methods are discussed and frequency domain aspects are explained.

The main parts of the work are treated in Chapters 6 – 8 that constitute major achievements of the thesis. Chapter 6 deals with identification of SISO systems using wavelets. The connection between the standard linear case and the proposed wavelet formulation is explained. It is shown how to construct the transformation matrix T that holds the desired frequency weightings. Next, theoretical properties of the method are examined. The author also discusses possible extensions and shortcomings. The chapter finishes with a comprehensive simulation case study that highlights main properties of the proposed solution.

Chapter 7 can be thought as an extension of the previous chapter to multivariable systems. Two possible systems representations are considered: transfer functions and state-space. These follow a fairly standard way to treat identification of multivariable systems. A case study is presented that deals with experimental identification of HVAC system in one of buildings of CTU in Prague.

Chapter 8 treats one possible extension of the proposed method to parameter estimation of continuous-time systems. Here, again, standard method of modulating functions is applied. Wavelets are then discussed as possible modulating functions.

The publications of the author are divided into two groups. The topic of dissertation is comprehensively treated in one impact journal publication (Systems and Control Letters) and in one renowned conference series (ESCAPE). Besides, his activity in group dealing with building MPC resulted in several publications in impacted journals and renowned international conferences. Therefore, publication record of the author is much over standard.

Actuality of the Thesis and Methodology

Wavelets are a relatively young topic in applied mathematics. They have started to find their way into modelling, control, and identification of systems. Therefore, the topic of the thesis and treated methodology is actual and reflects state of art in system identification and automatic control.

Main Objectives

The main aims of the thesis as stated in Chapter 2 are as follows:

1. A comprehensive survey of the methods of exploiting the wavelet transform for system identification.
2. Incorporation of wavelet transform into single-input single-output linear system identification. Analysis of the method.
3. Extension to multivariable systems.
4. Investigation of wavelets for identification of continuous-time systems.

The duties of the reviewer are greatly relieved as items 2 and 3 underwent a thorough review and were accepted for the journal Systems and Control Letters. Also other items are treated satisfactorily.

Questions and Comments

- Chapter 4.5.1: clarity of presentation would be improved if the thesis had not only discussed about different wavelet families, but also would have defined them or would have given their examples. I would also recommend to structure the information in Chapters 1,3,4 (review part) differently, to start with definitions and only afterwards to discuss properties and methods.
- Since the wavelet transform is linear, the identification can be written as the original problem with transformation matrix T. Once this matrix is calculated and fixed, it should be possible to transform the wavelet formulation into the classical LS method. Please discuss.

- Chapter 8 deals mainly with integral representation of modulating functions. Unbehauen and Rao (1987) also discuss functions that acts as filtered derivatives. Is the proposed methodology applicable in such framework?

Concluding Remarks

The author has shown a good overview in multiple domains of wavelets, frequency analysis, system identification, and model predictive control. He successfully combined properties of discrete wavelet transform and system identification and proposed methods for identification of discrete-time and continuous-time systems. The proposed algorithms were implemented and tested in simulations and also in real data. This demonstrates that the proposed methodology could be applied in industry.

Although the submitted thesis does not contain much material, it contains original scientific results, fulfils all proposed aims and complies with requirements of committee for scientific degrees. Therefore, I **recommend** it for defence for PhD degree.

Bratislava, May 7, 2014