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Review on the Doctoral Thesis of Ing. Jana Nováková titled

„Dynamic system identification methods for fMRI data processing"

Content of the Dissertation

The dissertation is focused on the identification of complex dynamic systems modeling the activity in the human brain. The contents of the thesis were partly developed within a cooperation with the Department of Neurology, Charles University, Prague:

1. Review of methods for system identification, specifically tailored to fMRI measurements with a focus on alternative system identification concepts.
2. Understanding the concept of DCM (Dynamic causal modeling), the standard technique for identification from fMRI data. Acquisition of competence for applying such tool to real patient data. Ability to pinpoint the strengths and weaknesses of the approach.
3. Selecting a suitable alternative identification method (subspace identification- SSI - in state space) and development of a methodology to identify structures given by the standard DCM method, preferably with less parameters and less computational burden.

Appraisal and Discussion of the Dissertation

The topic of the thesis of Mrs. Nováková is of high interest for the scientific community. The development of new methods and the adaptation of existing algorithms for identification of complex nonlinear systems is quite challenging, especially when considering the given biomedical application with three-dimensional spatial plus temporal data.

The main objectives of the work have been clearly stated in the thesis (Chapter 2); correspondingly, in the Conclusion (Chapter 9) the obtained results for each goal are summarized. Throughout the main body of the thesis and even more explicitly in the Conclusion it becomes quite obvious that all objectives have been fulfilled almost completely. For the last goal it would have been interesting to present a direct comparison between DCM and the proposed SSI method.

The work has been conducted in a methodically correct and adequate way; citations of references are sufficiently extensive and up to date. Although some concepts and notions are introduced in the thesis in a quite curt way, the publications in peer reviewed quality journals prove that the scientific quality of the work meets international standards.

I want to emphasize that Mrs. Nováková has clearly proven that she is capable of applying existing methods to new and challenging biomedical system identification problems, and that she can adapt and extend state-of-the-art algorithms where necessary (e.g. state transformation for structure recovery, Section 6.3).

The problem posed in the thesis is definitely a very challenging task due to the nonlinear and high-dimensional problem and the usually small data size available. The thesis of Mrs. Nováková is definitely a first step in the right direction to tackle that problem in more efficient and structured way. It is therefore out of doubt that the thesis and the related scientific publications constitute a significant contribution to the further development of science.

All elements of creative scientific work are contained within the thesis. Additionally, Mrs. Nováková has proved that she is able to produce sound results with complex methods and tools with real-world data from a patient study, despite of the inevitable organizational and technical problems such a project brings about.

Due to the concise style of the thesis some specific questions related to the contents could be addressed more specifically:

- DCM approach is based on testing different models in the second level analysis (all based on the same data sample), see Section 5.3. Since this constitutes repeated testing based on the same sample, is there some form of adjustment included for the significance-level (e.g. Bonferroni, Tukey,etc.)?
- In Section 6.2 the model output is compared to "measured data" (noisy data from simulation). Why not compare to the ideal, noise-free simulation output?
- In Section 6.3.2 only two brain areas are included in the study. How does the structure look like for more areas? How does the number of areas affect the number of identified parameters in the SSI method? How does this affect computation time?
- In Section 7.2.1 it is mentioned that the bilinear structure has been neglected. Would it be possible to utilize Local Linear Models with the input variable u_j as single partitioning variable to overcome that problem and still use SSI methods?

The author of the thesis proved to have an ability to perform research and to achieve scientific results.
I do recommend the thesis for presentation with the aim of receiving the Degree of Ph.D.

Best regards,

Ao.Univ.Prof. DI Dr. Martin Kozek

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