

Opponent review of dissertation

Distributed Estimation and Control

With Applications to Spatially Distributed Damping Systems

Author: Xueji ZHANG

The dissertation of Mr. Xueji Zhang is dedicated to adapting the networked or distributed control concept specifically for active vibration reduction of flexible structures fitted with a network of actuators and sensors. The thesis has 152 pages and is divided into 7 main chapters.

In the first introductory chapter, the author briefly recapitulates motivation of his work and his contributions to the problem solution. One part of applicant contribution is directed to solution of distributed estimation problem by cooperative observers combining local measurement and communication with neighbors. Four design methods for cooperative observers are proposed and formulated by directed graphs. Second part of Mr. Zhang contribution is based on three novel algorithms of distributed homogeneous sensor fusion for estimation of a constant scalar. The second chapter presents the basic overview of the graph theory and cooperative control strategy. Cooperative control problems are categorized into leaderless consensus and leader-following consensus problems and the synchronizing region method is introduced. Next, in the third chapter, the author formulates four variants of the decentralized approaches for cooperative observers. The first one assumes, that the global information is known to local agents, the second one is for locally detectable systems, the third one can be applied to both locally detectable and locally undetectable systems without local knowledge of global topology and the last one uses local observability decomposition. The fourth chapter is dedicated to the design of feedback control laws for the distributed agents. A heuristic approach with trial-and-error design of feedback matrix is proposed and numerically tested. The chapter five presents an experimental study of distributed estimation and control for a composite panel actuated by piezoactuators. Due to limited time, only the distributed estimation design with 3 agents, MFC piezo actuators and PCB accelerometers. was experimentally validated. The following sixth chapter introduces the consensus based distributed homogeneous sensor fusion for static noisy signals. The fusion scheme proposed by author differs from the known alternatives. The router nodes are allowed in the sensor networks, the variances of the measurement noise terms are taken as reliability indicators, the measuring data are continuously fed into the fusion network and the evolution dynamics of expected values and covariances throughout the whole network are analyzed explicitly. The last chapter has two parts, namely conclusions in subchapter 7.1. and recommendations for ongoing research in subchapter 7.2.

The presented dissertation is at a very good level, it has a coherent and mature impression. The interpretation is conducted in detail and in fact with obvious didactic insight. The author's procedure can be well monitored. What could be somewhat more extensive is the experimental verification part. Mr. Xueji Zhang published the content of his Ph.D. thesis within 8 research papers where he is a first author. Especially valuable are three papers in international peer-reviewed journals and two papers in international peer-reviewed conference proceedings. Each of the basic parts of the thesis is supported by the prestigious publication output.

Overall, I consider the work very positively and I have no serious reservations about it. I would like to ask the applicant to comment on two points during the defense.

1) You use the Rayleigh damping model for the testing simulation model of the piezoelectric actuated beam clamped at both ends. This model is substantially reduced with respect to the general damping model. Why you use this model ? Are the results and comparisons of simulation experiments independent of the damping model used ?

2) You mentioned limited resources as one of the reasons for reducing experimental validations only to the distributed estimation design. However, in chapter 5.1, you name a large set of components needed for the rapid prototyping control design. Could you explain the situation/problems with experiments in more detail ? Do you have some better photos of the experimental demonstrator ? Figure 5.2 is very unclear.

Conclusion

Altogether the doctoral thesis of Mr. Xueji Zhang completely fulfil the defined targets of the work and the general requirements to scientific level of the doctoral thesis. The work is a valuable contribution especially in the range of distributed estimation and control for the active damping of light structures. I recommend the work for the defense and after the successful answers of the reviewer and commission questions I recommend to award Mr. Zhang academic degree "doctor" in the relevant Ph.D. programme.

Prague, April 18, 2018

prof. Ing. Zbyněk Šika, Ph.D.

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