

Válaszok dr. Szilágyi Botond opponensi véleményére

Tarcsay Bálint Levente okleveles vegyészmérnök

*„System supervision and abnormality detection
through multivariate statistical methods”*

című doktori értekezéséről

Ezúton is szeretném megköszönni, hogy vállalta a dolgozatom bírálatát, a sok munkát és a részletes bírálatot. Szeretném megköszönni az elő bírálat során felsorolt hasznos tanácsait is, melyek hozzájárultak ahhoz, hogy a dolgozatomat még színvonalasabban elkészíthessem.

Question: The Bayesian networks were applied, and outstanding results were obtained in the investigated case studies. I was wondering if the Candidate could comment on the practical aspects of building such Bayesian networks, including identifying the failure modes and getting the corresponding scores for a technically much more complex, integrated system with a significantly higher number of failure modes.

Reply: *The development of Bayesian networks consists of two main steps, the first is the structure learning procedure, the second is the learning of the weights connecting the nodes of the established network. In general, if expert knowledge is available, it is useful to integrate it into the structure definition step of the procedure as identifying the Bayesian network structure from data is a complex NP-hard problem with super-exponential complexity. It should be noted that when many fault possibilities are present and sufficient historical data about system behavior is available then attempting to identify the network structure from data might be the optimal way to quickly and efficiently establish a network structure that can characterize system behavior. While suffering from the curse of high computational requirements two main methods known as score-based and constraint-based structure learning are available to automatically generate Bayesian-network structures from raw data and are thus expected to cope with the task of accounting for high numbers of failure modes which expert knowledge would struggle to identify accurately.*

Question: Suppose we accept that the number of patents correlates with the number of technical realizations. In that case, one can assume that the practical implementations in the field are lagging behind the research and development – which, in general, is not outstanding. What are the main obstacles that prevent the widespread implementation in the field? How does the research conducted by the Candidate contribute to the practical realizations?

Reply: *In general, the application of more complex model and data-based mathematical techniques such as the ones used in fault detection and isolation is scarce for industrial practice due to a multitude of causes. The first and foremost is the general complexity and nonlinearity of industrial systems, especially in the chemical industry. Implementing the techniques is therefore limited by a lack of sufficient knowledge to properly train and utilize mathematical models that could be used for fault detection and isolation. Secondly there is often a significant lack of real-world historical data to train data-based techniques for various fault scenarios making the use of such methods limited.*

While the methods introduced in this dissertation do not fundamentally solve these problems, they are following a trend which facilitates the use of such techniques in industrial practice. Firstly, with the advent of the Internet of Things data acquisition and recording in chemical industrial systems has been greatly facilitated. The data to train multivariate statistical process abnormality detection methods such as the ones proposed in the dissertation become much easier with the abundance of process data existing becoming the norm. Secondly as most of the techniques proposed in the work rely on data-based procedures they do not require the same level of mathematical knowledge for their implementation as more complex analytical solutions to the fault detection problem such as the use of modulating functions or the use of nonlinear parity relation methods.

Question: Finally, I would like to ask the Candidate to briefly present the most challenging technical problem he encountered during his research and the key element in solving that problem.

Reply: *On a personal note, I felt that the greatest challenge I was faced with during my work was the proper definition of the scope and limits of my research as I had to deal with the burden of abundance. As shown in the thesis the techniques of fault detection and isolation cover an incredibly broad range of methods extending from analytical solutions of system models to purely machine learning based approaches. It was extremely challenging to decide how to narrow down the approaches and choose the family of methods I wish to research and even then, multivariate statistical process monitoring techniques still represent a broad category with methods besides PCA such as ICA, PLS, CCA, etc. being viable alternatives.*

In this problem I was actively supported by my supervisors and by performing proper literature reviews to locate the area which held both research interest, practical applicability and was within the scope of my abilities at the time.

Még egyszer köszönöm dr. Szilágyi Botondnak opponensi munkáját, és tisztelettel kérem válaszaim elfogadását.

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doktorjelölt