



POLITECHNIKA ŚLĄSKA
WYDZIAŁ AUTOMATYKI, ELEKTRONIKI I INFORMATYKI

Dysertacja doktorska

Zastosowanie systemów rozmytych do oceny jakości modeli na potrzeby wirtualnego rozruchu systemów automatyki przemysłowej

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Gliwice, wrzesień 2023

Abstract

The complexity of modern plants is continuously growing, which leads to the necessity of rapid testing and validation of industrial automation systems. The answer to this demand is the use of simulation techniques, such as virtual commissioning, which at an early stage of the production line reconstruction, allows for analyzing the operation of various components and identifying bottlenecks of the entire production process. In addition, virtual commissioning is increasingly used to train production line operators.

One of the crucial stages of virtual commissioning is verifying the quality of the mathematical model of the commissioned object. A plethora of measures are used to assess the quality of the model, but each of them is characterized by a different range of values and interpretations. As a result, selecting the adequate measure to assess model quality takes work, and sometimes the information carried by several measures would be needed to assess the overall quality of the model. In addition, scientific articles from 2022 on the subject of virtual commissioning indicate that there is a need to determine the quality of the model.

This work systematizes the knowledge about commonly used measures to assess the quality of the model. In addition, the Takagi-Sugeno-Kang fuzzy system was created to evaluate the quality of the model (VCMF, Virtual-Commissioning-Fuzzy coefficient), which allows for the aggregation of information carried by various measures, as well as dynamic expansion thanks to the possibility of using expert knowledge in the field of virtual commissioning of industrial automation systems. The proposed coefficient was tested on measurement data collected during the belt conveyor operation, which was subjected to the pre-processing process using various statistical data analysis methods and on two simulated datasets: two tank system and classical pendulum. The VCMF coefficient allowed the models to be assigned to a group of models well matched to the data and a group of incorrectly assigned ones. The cut-off threshold below which models are considered too low quality for the virtual commissioning was selected using Gaussian Mixture Modeling (GMM). The obtained results were analyzed and compared with the described measures commonly used to assess the quality of models.