Engineering Risk Analysis Group
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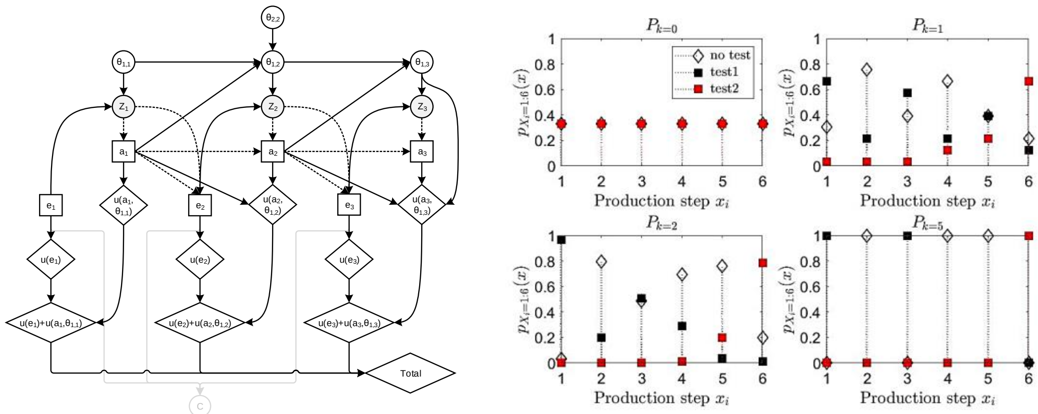
MSc thesis

Optimizing Quality Assurance Measures with the Cross-Entropy Method For Flexible Manufacturing Scenarios

Tobias Zeh, November 2018

Background

In the context of Industry 4.0, the flexible factory constitutes a scenario where software and hardware configurations can be adapted according to customer demands. One approach is to design interconnected modules. To ensure a predefined product quality in a flexible manufacturing scenario, where modules can be reallocated on the fly, test modules can be plugged in after production steps. Each quality assurance measure costs time and money. The aim of this thesis is to find an optimal test strategy based on Bayesian decision analysis including constraints.



Left: Excerpt from the decision network. Random variables (oval), actions (squares), utilities (diamonds).
Right: Dynamics of the CE method for discrete optimization. Optimal test strategy: $\boldsymbol{x} = [1,0,1,0,0,2]$.

Methodology

To this end, a Bayesian network was elicited and extended to a decision network. The Cross-Entropy (CE) method for simulation-based optimization is the selected approach in this thesis. It is a technique for solving discrete and continuous optimization tasks. The CE method allows to find an optimal test strategy based on heuristic search. Furthermore, a simple learning mechanism based on Bayesian inference was implemented. This enables to process new information from test modules. The random variables in the decision network are sequentially updated after manufacturing a product. The CE algorithm can be executed again. Thereby, a new optimal solution may be found, and the test modules can be reallocated dynamically.

Conclusion

As shown in the results of this thesis, the CE algorithm is fast to evaluate and converges to an optimum. Based on the examples discussed in this thesis, the best test strategy is to perform three tests in a serial manufacturing line with six steps. To further improve the model, it is crucial to include information from domain experts. The possibility to integrate the algorithm into a real production process model requires further investigation.

In cooperation with Siemens AG[b]

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