Engineering Risk Analysis Group
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MSc thesis

Sequential decision problems with uncertain observations: Value of Information with erroneous assumptions

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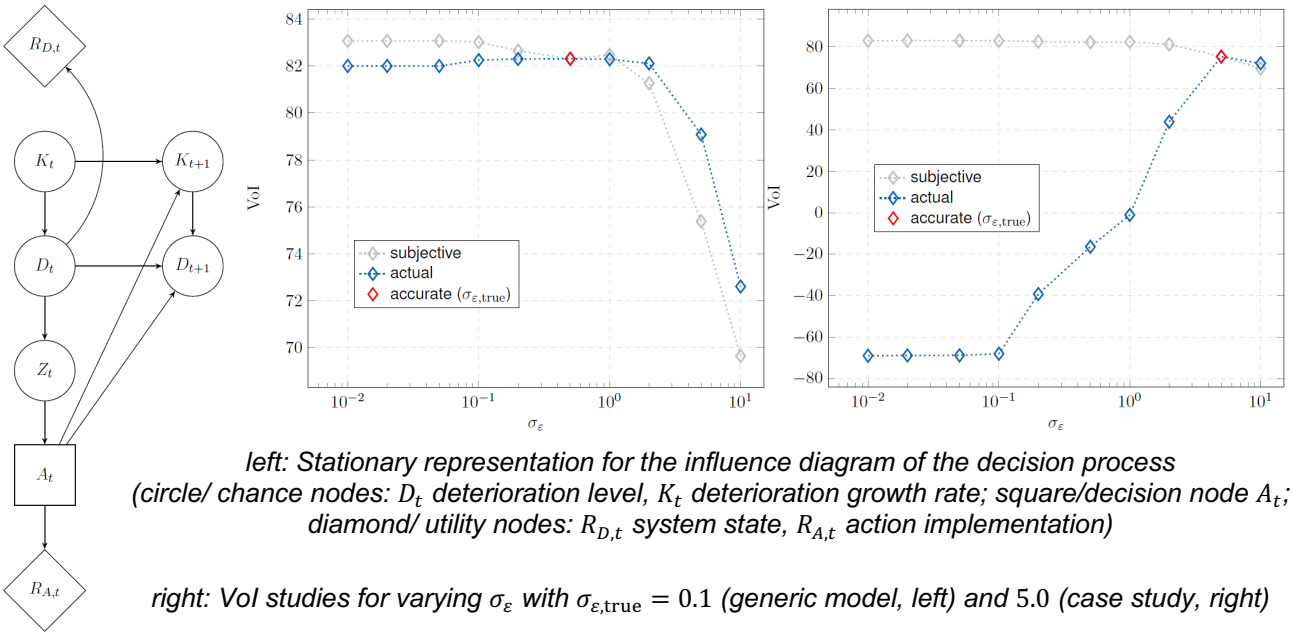
Background

Maintaining infrastructure to perform at a high level of reliability is a challenge with great socio-economic impact. To reduce the size of investments and risk of failure, maintenance strategies are subject to optimization but must be treated with all due caution, especially when significant uncertainty is involved in modelling. This thesis project is aimed at investigating negative effects of erroneous assumptions about parameters in the modelling process on the optimized outcome.



left: Stationary representation for the influence diagram of the decision process (circle/ chance nodes: D_t deterioration level, K_t deterioration growth rate; square/decision node A_t; diamond/ utility nodes: $R_{D,t}$ system state, $R_{A,t}$ action implementation)

right: VoI studies for varying σ_ε with $\sigma_{\varepsilon,\text{true}} = 0.1$ (generic model, left) and 5.0 (case study, right)

Methodology

The generic 1-component structural system is modelled and to obtain an optimized strategy, a partially observable Markov decision process (POMDP) is solved. The generated results are evaluated regarding their expected lifecycle costs (LCC) and Value of Information (VoI) for a range of values for the observation uncertainty σ_ε. The research question is then approached by varying the underlying, assumed true value of $\sigma_{\varepsilon,\text{true}}$, simulating an over- and underestimation of the monitoring data precision by the decision maker.

Conclusion

In the project it could be shown that, for an over-estimation of σ_ε, the actual VoI can become negative, making implementation unfavorable (see figure above, right side).
Decision makers in maintenance planning should be aware of this potential threat arising from overconfidence in their monitoring data, because in a select range of cases implementing such a strategy can lead to an outcome inferior to a strategy optimized for the non-observed case- let alone the cost for the monitoring system generating the underlying data.

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