Motivation
Bayesian networks (BNs), which originated from the fields of machine learning and artificial intelligence, have been used as a probabilistic modelling framework in various fields. In a BN the qualitative dependence structure between the nodes, representing random variables, of the model is encoded in a (typically causal) directed acyclic graph (DAG). The quantitative side of the BN is represented by local conditional probability distributions that are assigned to each node. A main advantage of the BN framework is that through its graphical representation in a DAG the logic behind a model is understandable even by non-probability experts. While this is true for the qualitative dependence structure, BNs are still capable of representing various kinds of (also complex) probabilistic dependencies. Many authors have applied BNs for reliability and engineering risk analysis. Nevertheless to exploit the full potential of BNs for reliability analysis a number of challenges need to be overcome. Some of them are addressed in this thesis.

Derivation of the qualitative model structure
Based on a literature review different approaches for eliciting the qualitative dependence structure for a BN in the field of reliability and engineering risk analysis can be distinguished. These are (1) structure elicitation based on existing probabilistic models; (2) structure elicitation based on physical/empirical models; (3) structure learning from data and (4) structure elicitation based on domain expert knowledge. In this thesis a generic description of the approaches for eliciting BN structures in the field of reliability is provided.
Once the model structure is derived the BN is quantified typically using data, expert elicitations or a combination of both.

**Inference in BNs**

Exact inference algorithms in BNs enable straightforward and fast Bayesian updating. However exact inference is not available for general BNs containing also continuous nodes (hybrid BNs) and for some large discrete BNs.

Continuous random variables are commonly encountered in BNs representing structural reliability problems, where the performance of an engineering system is described through a physical model. A way to use exact inference algorithms for hybrid BNs is to approximate them by discretization. An efficient discretization procedure for such BNs was developed (Zwirglmaier and Straub, 2016). This procedure is based on finding the most likely failure point and discretizing around this area.

**Applications**

The developed methods are applied to two examples. As a first application an existing physical model for the required landing distance of an aircraft is considered. Based on this a prototype of a BN is developed that can be used for a landing aircraft to determine and update the probability of runway overrun based on measurements that can be obtained during the approach phase (Fig.1). This BN can support the pilot in making the decision whether it is save to land or whether she should attempt a second approach. The main focus in this application is on the efficient discretization of the continuous random variables of the network.

In a second application BNs for human reliability analysis (HRA) are considered. A main objective of HRA is to predict human error probabilities, such that they can be considered in a risk analysis for human-machine systems. A framework for eliciting BN structures based on the available qualitative information and for quantifying these BN structures based on expert-elicitation and the sparsely available data was developed (Zwirglmaier et al., 2015).

**Fig. 1:** BN structure for predicting runway overrun of a landing aircraft in near-real-time (Zwirglmaier and Straub, 2016).

**References**


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