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Bayesian network learning for natural hazard assessments

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Even though quite different in occurrence and consequences, from a modelling perspective many natural hazards share similar properties and challenges. Their complex nature as well as lacking knowledge about their driving forces and potential effects make their analysis demanding. On top of the uncertainty about the modelling framework, inaccurate or incomplete event observations and the intrinsic randomness of the natural phenomenon add up to different interacting layers of uncertainty, which require a careful handling. Thus, for reliable natural hazard assessments it is crucial not only to capture and quantify involved uncertainties, but also to express and communicate uncertainties in an intuitive way. Decision-makers, who often find it difficult to deal with uncertainties, might otherwise return to familiar (mostly deterministic) proceedings.

In the scope of the DFG research training group „NatRiskChange" we apply the probabilistic framework of Bayesian networks for diverse natural hazard and vulnerability studies. The
great potential of Bayesian networks was already shown in previous natural hazard assessments.
Treating each model component as random variable, Bayesian networks aim at capturing the joint distribution of all considered variables. Hence, each conditional distribution of interest (e.g. the effect of precautionary measures on damage reduction) can be inferred.
The (in-)dependencies between the considered variables can be learned purely data driven or be given by experts. Even a combination of both is possible. By translating the (in-)dependences into a graph structure, Bayesian networks provide direct insights into the workings of the system and allow to learn about the underlying processes.

Besides numerous studies on the topic, learning Bayesian networks from real-world data remains challenging. In previous studies, e.g. on earthquake induced ground motion and flood damage assessments, we tackled the problems arising with continuous variables and incomplete observations. Further studies rise the challenge of relying on very small data sets. Since parameter estimates for complex models based on few observations are unreliable, it is necessary to focus on simplified, yet still meaningful models. A so called Markov Blanket approach is developed to identify the most relevant model components and to construct a simple Bayesian network based on those findings.
Since the proceeding is completely data driven, it can easily be transferred to various applications in natural hazard domains.

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