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Capturing changes in flood risk with Bayesian approaches for flood damage assessment

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Flood risk is a function of hazard as well as of exposure and vulnerability. All three components are under change over space and time and have to be considered for reliable damage estimations and risk analyses, since this is the basis for an efficient, adaptable risk management. Hitherto, models for estimating flood damage are comparatively simple and cannot sufficiently account for changing conditions.

The Bayesian network approach allows for a multivariate modeling of complex systems without relying on expert knowledge about physical constraints. In a Bayesian network each model component is considered to be a random variable. The way of interactions between those variables can be learned from observations or be defined by expert knowledge. Even a combination of both is possible. Moreover, the probabilistic framework captures uncertainties related to the prediction and provides a probability distribution for the damage instead of a point estimate. The graphical representation of Bayesian networks helps to study the change of probabilities for changing circumstances and may thus simplify the communication between scientists and public authorities.

In the framework of the DFG-Research Training Group “NatRiskChange” we aim to develop Bayesian networks for flood damage and vulnerability assessments of residential buildings and companies under changing conditions. A Bayesian network learned from data, collected over the last 15 years in flooded regions in the Elbe and Danube catchments (Germany), reveals the impact of many variables like building characteristics, precaution and warning situation on flood damage to residential buildings.
While the handling of incomplete and hybrid (discrete mixed with continuous) data are the most challenging issues in the study on residential buildings, a similar study, that focuses on the vulnerability of small to medium sized companies, bears new challenges. Relying on a much smaller data set for the determination of the model parameters, overly complex models should be avoided. A so called Markov Blanket approach aims at the identification of the most relevant factors and constructs a Bayesian network based on those findings.

With our approach we want to exploit a major advantage of Bayesian networks which is their ability to consider dependencies not only pairwise, but to capture the joint effects and interactions of driving forces. Hence, the flood damage network does not only show the impact of precaution on the building damage separately, but also reveals the mutual effects of precaution and the quality of warning for a variety of flood settings. Thus, it allows for a consideration of changing conditions and different courses of action and forms a novel and valuable tool for decision support.

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