Workshop: Bayesian Networks – From Problem Structuring to Probabilistic Decision Support

ABSTRACT

Effective decision making for Emergency Response preparedness generally involves a large number of uncertain factors, which may be addressed through Bayesian Network modelling. Bayesian networks (BNs) provide a powerful framework for modeling uncertainty, making probabilistic inferences, and supporting decision-making in complex domains. This tutorial introduces participants to the foundational theory of Bayesian networks and guides them through a structured approach to problem representation and decision support.

The session will begin with an overview of the theoretical underpinnings of Bayesian networks, including their graphical structure, conditional dependencies, and methods for probabilistic inference. Participants will engage in hands-on exercises designed to translate unstructured problems into structured Bayesian networks, allowing them to visualise relationships between variables and reason about uncertainty in a systematic way.

A key challenge in building Bayesian networks is quantifying them effectively. This tutorial will cover practical approaches for eliciting expert subjective probabilities, providing a framework for integrating expert knowledge into Bayesian models. Additionally, we will explore methods for using empirical data to populate Bayesian networks, highlighting techniques for parameter learning and model refinement.

Beyond technical modeling, Bayesian networks are particularly useful in multi-stakeholder decision-making contexts. This tutorial will demonstrate how BNs can facilitate structured discussions, incorporate diverse perspectives, and support negotiation by explicitly representing different stakeholders' incentives and alternatives.

To ground the tutorial in real-world applications, we will examine case studies from Arctic Search and Rescue operations and climate adaptation in aquaculture. These examples will illustrate the practical value of Bayesian networks in high-stakes decision environments, where uncertainty and competing priorities must be managed effectively.

By the end of this tutorial, participants will have a solid foundation in Bayesian network theory, practical experience in building and quantifying models, and insights into applying BNs for collaborative decision-making. No prior experience with Bayesian networks is required, though familiarity with probabilistic reasoning will be beneficial.

PRESENTER/DEMONSTRATOR

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John has been developing Bayesian networks in practice for 25 years, with his first publication in 2001. His expertise spans a range of application areas, including UK Coastguard Search and Rescue, offshore wind farms, supply chain risk analysis, and the design and development of radar systems.

Currently, John serves as the Principal Investigator on a CINUK-funded project, where he and his team are collaborating with Inuit communities to develop a Bayesian network to support Search and Rescue operations in the Arctic. In addition, he has worked extensively with the European Food Safety Agency (EFSA), training staff in the elicitation and quantification of expert uncertainty. He has also led the COST Working Group on Processes and Procedures for eliciting expert judgment. John is the editor of the book "Elicitation: The Science and Art of Structuring Judgement," which explores methodologies for capturing expert knowledge and uncertainty in structured decision-making processes.

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Ian is currently a co-investigator on the Nunavut-Nunavik Search and Rescue (NSAR) project, assisting in the development of the Bayesian network with a particular focus on the elicitation of expert judgment from search and rescue responders. Ian's previous research includes working on a US-government-funded project aimed at developing an online tool and training materials to help intelligence analysts use Bayesian networks effectively.

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Archie is a risk modeller with a background in earthquake engineering. As an investigator on the CINUK-funded NSAR project, Archie has translated his expertise in probabilistic modelling and uncertainty evaluation to an emergency management context, quantifying a Bayesian network to act as a decision support tool that strengthens Arctic SAR.

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Josh has experience with Bayesian Networks (BNs) from both his PhD research and professional work. His expertise includes applying BNs in collaboration with industries and governing bodies such as Scottish Environmental Protection Agency (SEPA). During his PhD, he developed SEAD (Stakeholder Identification, Elicitation, Analysis, and Dialogue), an advanced decision support tool that extends Bayesian Networks by incorporating multiple stakeholders, utilities, and decisions. SEAD provides a structured framework for stakeholder dialogue, enabling collaborative exploration of optimal solutions.

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