Follow the trace

Evaluating physical and digital forensic findings given activity level propositions using Bayesian networks

Vink, M.

Publication date
2025

Part III

BAYESIAN NETWORKS AND INTERDISCIPLINARY CASEWORK

All chapters in Part III are based on[1] Vink, M., de Koeijer, J. A., Sjerps, M. J. 2024. A template Bayesian network for combining forensic evidence on an item with an uncertain relation to the disputed activities. *Forensic Science International: Synergy* **9**, 100546.

Introduction to Part III

Evaluating *transfer evidence* (Evett, 1984) given *activity level propositions* (Cook *et al.*, 1998) can be challenging due to various factors, such as the number of variables involved and their possible dependencies. Bayesian networks (BNs) have proven to be useful for modeling an expert's reasoning about complex events and for facilitating the derivation of likelihood ratios (LRs). In fact, many studies (e.g., Aitken *et al.* (2003); Fonneløp *et al.* (2022); Garbolino & Taroni (2002); Gittelson *et al.* (2012); Johannessen *et al.* (2022); Kokshoorn *et al.* (2017); Mayuoni-Kirshenbaum *et al.* (2020); Onofri *et al.* (2023); Szkuta *et al.* (2018); Taroni *et al.* (2004, 2021); Taylor *et al.* (2018, 2019); Taylor & Kokshoorn (2023); Uitdehaag *et al.* (2022); Vink & Sjerps (2023); Volgin (2019)) have published BNs as useful tools to support the evaluation of evidence considering activity level propositions.

Recently in 2023, Vink & Sjerps presented a template model that originated from using the idiom-based approach to modeling BNs (see for example Lagnado *et al.* (2013); Neil *et al.* (2000)). The template model is a generalization of the template model presented by Taylor *et al.* (2018) for constructing BNs in forensic biology cases when considering activity level propositions. It also incorporates the ideas of Kokshoorn *et al.* (2017) on propositions disputing the actor or activity in DNA evidence evaluation. In essence, the template model from Vink & Sjerps (2023) is a tool meant to be used by forensic experts for evaluations when the actor, the activity, or both are in dispute.

In the template model from Vink & Sjerps (2023), the item of interest (hereafter: item) is assumed to be used by the offender during an activity. But the latter might as well be an additional uncertainty. The uncertainty surrounding the connection between a crime stain or trace material and the offender (also referred to as the *relevance* of trace material), has been studied by various authors (Evett, 1984, 1993; Garbolino & Taroni, 2002; Stoney, 1994). In 2012, Taroni *et al.* applied this foundational work to evidence evaluations with BNs under activity level propositions. They state that "uncertainty about the item actually worn by the suspect thus represents an issue that current evaluative procedures at activity level do not account for" (p. 178). The authors present a case example in which fibers found at the crime scene match those from a pullover owned by the suspect. However, it is uncertain whether the suspect actually wore the pullover during the offense or not. In most recent work by Kokshoorn & Luijsterburg (2023) and Taylor & Kokshoorn (2023) case examples are mentioned where disputes over the relation between item and activity are currently taking place. In all case examples, the link between an item of clothing and the incident was uncertain and questions arose whether the item of clothing was worn during the offense or not.

The vast majority of the earlier research focuses on monodisciplinair evaluations. There is a growing demand to evaluate evidence given activity level propositions, including DNA and other types of evidence. Consequently, there is an increasing interest to evaluate a combination of different types of evidence given a single set of activity level propositions. This increasing wish is confirmed by Kokshoorn & Luijsterburg (2023) who report an increasing number of interdisciplinary collaborations in casework at the Netherlands Forensic Institute.

In 2020, De Koeijer *et al.* published a study on combining evidential strength in interdisciplinary casework, with a specific focus on the uncertainty surrounding the relation between an item and an activity. The research states that assessing the value of evidence, given the connection between a suspect and an alleged activity, often requires multiple evaluations from one or several disciplines. These evaluations may concern a dispute over the relation between a person and an activity and/or a dispute over the relation between the item and a person or activity. Although the authors provide a framework for combining LRs from various disciplines, they do not present a model that includes the underlying evaluations of the different disciplines. To the best our knowledge, no template BN has been published that is sufficiently flexible to evaluate a combination of forensic evidence from different disciplines in cases with disputes about the actor and/or activity and/or the relation between an item of interest and an activity.

This research developed such a template model for evidence evaluations given activity level propositions. Since our focus is on reasoning and the qualitative structure of the BN, we do not aim to model every aspect of a case or provide probabilities for a specific case. Instead, our goal is to offer a flexible template model that can be adapted to various cases, promoting the uptake of BNs by forensic experts in casework. Therefore, our case examples will highlight certain parts of the case but will omit others. Chapter 4 will elaborate on the work of De Koeijer *et al.* (2020) and Taroni *et al.* (2012, 2021). They previously modeled the uncertain relationship between an alleged item and an activity using a BN, which forms the basis of our work. Moreover, we present a basic scenario involving a strangling incident. We start by modeling the evaluation of DNA traces found on a sweater, believed to have been worn by the offender during the incident, using the template model from Vink & Sjerps (2023). We will extend the fictitious case scenario with fiber evidence, proposing a case model that includes a dispute about the connection between the sweater and the alleged activity.

In Chapter 5, we will generalize the case model from Chapter 4 and present an extended version of the template model that can be applied to a range of cases. We will end Chapter 5 with demonstrating the flexibility of our template model by applying it to two more case variations. The BNs illustrated in Chapter 4 and Chapter 5 are provided as Supplementary material in Vink *et al.* (2024) and can also be accessed directly through the QR code in Appendix A of this thesis.