Boosting Legal Probabilism

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1 The Book

1.1 Brief Description

In one or two paragraphs, describe the work, including its rationale, approach, and pedagogy. (This book is... It does... Its distinguishing features are...)

Can the evidence presented at trial be examined, weighed and assessed using probability theory? Can legal decision-making and standards of proof such as 'preponderance of the evidence' or 'proof beyond a reasonable doubt' be defined using the language of probability and expected utility? Does the deployment of probability theory in assessing evidence and making decisions improve the accuracy and fairness of legal decision-making? Over the last fifty years, these questions have been extensively debated in the literature in philosophy, law, forensic science and artificial intelligence. Legal probabilism is a research program whose supporters believe that the answer to these questions is, by and large, affirmative. Others, however, hold a less optimistic view. 'Boosting Legal Probabilism' examines the most important objections to this research program and articulates a version of legal probabilism that is able to address many, if not all, of these objections.

We first articulate the simple version of legal probabilism. This version has much to be reccomeded for, but also falls prey to several difficulties, including the problem of conjunction, puzzles of naked statistical evidence, the problem of priors. Some legal probabilists have attempted to dismiss these difficulties or downplay their significance. We confront them upront and show they cannot be easily addressed within the confines of simple legal probabilism. We then develop a more sophisticated version of the theory, what we call legal probabilism 1.02, which deploys Bayesian networks and takes advantage of seminal ideas in the literature in forensic science and artificial intelligence. 'Boosting Legal Probabilism' articulates the first comprehensive philosophical analysis of whether—and if so, to what extent—legal probabilism 1.02 can overcome the limitations of simple legal probabilism. We show that the more sophisticated version significantly improves on the simple version and rivals in explanatory power two competing accounts of judicial fact-finding: argumentation theory and relative plausibility. To add precision to the claims made in the book, the analytical argument is supplemented with an **R** code implementation.

'Boosting Legal Probabilism' is aimed at philosophers with an interest in legal epistemology and epistemology more generally. Many of the difficulties of legal probabilism resemble difficulties faced by Bayesianism in epistemology. The book will also draw attention outside philosophy from legal scholars who have championed applications of probability theory to evidence law as well as scholars who have resisted this trend. Another target audience includes computer scientists and psychologists interested in studying evidential reasoning and decision-making under uncertainty. Besides contributing to the literature about legal probabilism, the book aims to introduce unfamiliar readers to the rich interdisciplinary debate on the topic, often scattered throughout journals and books in philosophy, law, computer science, forensic science and psychology. So the book is aimed at scholars, advanced undergraduates and curios readers more generally. Some chapters present original research and require technical background in probability theory. Others are introductory, suitable for an advanced undergraduate course.

1.2 Outline

Part I

The first part of the book outlines simple legal probabilism (Chapter 1) and its foes (Chapter 2). The simple version comprises a familiar repertoire: Bayes' theorem, likelihood ratios, probability thresholds, expected utility maximization. This repertoire has proven useful in several ways, especially in the assessment of explicitly quantitative evidence such as DNA matches and other expert evidence. At the same time, simple legal probabilism is liable to a host of conceptual difficulties: the conjunction problem, the problem of priors, paradoxes of naked statistical evidence. These difficulties are well-known. Others are less familiar: the problem of complexity, soft variables, the difficulty with corroboration.

Part I is meant to instill interest in the topic among unfamiliar readers and refresh seasoned readers about the main points of contention. Part I provides the essential background for a deeper examination of legal probabilism and the development of its more sophisticated version. The remaining two parts of the book covers two separate topics: evidence assessment (Part II) and decision-making (Part III). This distinction reflects the fact that legal probabilism is both a theory of evidence assessment (evidence evaluation, evidence weighing) as well as a theory of decision-making at trial. These two topics are obviously intertwined in important ways, but are best kept separate for analytical clarity.

Part II

The second part of the book discusses in great detail three formal tools used for the assessment of evidence from a probabilistic perspective: Bayes' theorem, likelihood ratios and Bayesian networks. This part discusses how these formal tools can help to assess, weigh and evaluate evidence at trial as well as what their limitations are. The objective of this part of the book is to articulate a more sophisticated version of legal probabilism for evidence assessment which overcomes the difficulties of the simpler version.

Chapter 3 presents Bayes' theorem and how it can be used for weighing one or two pieces of evidence. Bayes' theorem is useful in many ways, for example, to avoid reasoning fallacies such as the prosecutor's fallacy and the base rate fallacy. At the same time, the applications of this formal tool are also quite limited. As discussed in Chapter 4, court cases often require fact-finders to weigh several pieces of evidence, sometimes conficting and susceptible to different interpretations. The hypotheses that the fact-finders are asked to evaluate in light of the evidence presented are structured stories or explanations of the evidence constituted by several sub-propositions. This level of complexity can hardly be modeled by a simple application of Bayes' theorem. A more sophisticated machinery for evidence assessment is nedded.

Before discussing this more sophisticated machinery, the book describes a formal tool that is, in some important way, an alternative to Bayes' theorem and that many legal probabilists have found useful: likelihood ratios. Bayes' theorem requires one to assess the prior probabilities of the hypothesis of interest. The problem is that assessing prior probabilities is notoriously difficult. Likelihood ratios offer a way to evaluate the evidence presented at trial without the need of assessing prior probabilities. While likelihood ratios are still unable to model complex bodies of evidence, they have proven useful in many ways. Chapter 5 describes how likelihood ratios can be deployed in assessing evidence at trial. Cold-hit DNA matches serve as an illustration. The chapter also examines the weaknesses of the likelihood ratio approach, in particular, the chapter details how the choice of the competing hypotheses to be compared in the likelihood ratio is often a source of confusion, manipulation and subjective judgment.

Chapters 3, 4 and 5 – combined – show that we need to move past simple legal probabilism. The journey toward legal probabilism 1.02 is accomplished in Chapters 6 through 10. We focus on two theoretical shortcomings of simple legal probabilism: first, its inability to capture the fact that judges and jurors often think holistically about the evidece, say in terms of coherent stories or explanations, without assessing the evidence by discrete applications of Bayes' theorem; second, its inability to represent complex relationships between pieces of evidence, such as undercutting, rebutting, converging, corroborating evidence. Bayesian networks constitute the formal machinery that is essential for developing a more sophisticated legal probabilism.

Chapter 6 offers a crash course on Bayesian networks with a focus on the assessment of legal evidence. A Bayesian network comprises a directed acyclic graph (called a DAG) that represents relations of dependence between variables, along with conditional probability tables corresponding to these relations. Simple graphical patterns called 'idioms' often appear while modeling the relationships between evidence and hypotheses. In the last decade, the literature in artificial intelligence and forensic science has made significant progress in modeling holistic notions such as the coherence of a story and argument-based notions such as conflicts between pieces of evidence. Chapter 6 surveys this literature focusing on the work of Charlotte Vlek and Norman Fenton. Vlek, together with Bart Verheij and Henry Prakken, proposed to model the coherence of a story by adding a node in the Bayesian network, call it a 'story node'. The story node has other nodes as its children. These correspond to the events that make up the story. In turn, these events are linked to their supporting evidence. An example of a Bayesian network with a story node (or scenario node to use Vlek's terminology) is depicted below:
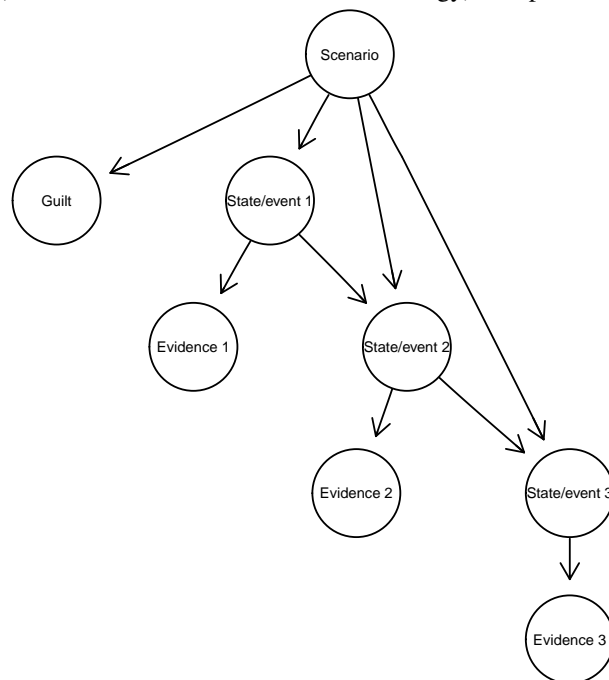
Since the story node unifies the different parts of a story, changes in the probabilities of these parts can be used to model the notion of coherence. The stronger the (positive) probabilistic dependency between the different parts, the more coherent the story. There may also be competing stories about what happened, say, one story was put forward by the prosecution and another by the defense. A Bayesian network can be built that comprises two competing stories and specifies that the stories are incompatible and cannot be true concurrently. Another approach to model competing stories was developed by Norman Fenton and his research group. Separate stories are represented by separate Bayesian networks, and Bayesian model comparison is then used for assessing the relative strenght of the competing stories.

The following chapters articulate different lines of criticism of Vlek's and Fenton's formalizations. The criticism are followed by our positive proposal which still relies on Bayesian networks. Chapter 7 focuses on weakenessses of the story node approach as an account of coherence. We show that adding a story node by fiat – without any good reason for supposing that the different parts of the story are connected other than being part of one story – introduces unnecessary probabilistic dependencies between the elements of a story. Since these dependencies may or may not exist, they should be assessed on a case-by-case basis and modeled accordingly. In addition, the story node approach is overly simplistic as an account of coherence and fails to engage with the rich philosophical literature on the topic. After the critical part, Chapter 7 articulates a more adequate probabilistic account of the coherence of a story. Instead of adding a story node, we show that it is more appropriate to assess the dependency between the different parts of a story

on a case-by-case basis and build the Bayesian network accordingly. [THIS FEELS A BIT THIN. ANYTHING ELSE HERE TO DESCRIBE THE POSITIVE ACCOUNT OF COHERENCE? ANYTHING TO ADD?]

Chapter 8 and 9 focus on complex relantionships between pieces of evidence, such as conflicting evidence and corroborating evidence. A criticism we level against Vlek's story node approch and Fenton's model comparison approach is that they both fail to capture crucial aspects of how pieces of evidence and competing stories conflict with one another at trial. It is too simplistic to posit that the complex adversarial dialectic that takes place in a trial could be modeled by averaging different Bayesian networks (Fenton) or postulating relationships of incompatibility between different story nodes (Vlek). We need an account of more fine-grained notions, such as undercutting and rebutting evidence and more generally we need an accounf of how cross-examination operates at trial. What cross-examination often accomplishes is not so much the creation of an alternative story, but rather the reinterpretation of an existign story by supplying additional information As chapter 8 illustrates, this process of reintepretation can be represented formally as the refinement of an existing Bayesian network. Additional arrows can be drawn between evidence nodes and hypothesis nodes and these additional arrows can model relationships such as undercutting and rebutting.

The reverse of the phenomenon of conflict between evidence is that of convergence between pieces of evidence, in particular the fact that one piece of evidence corroborates another. Corroboration has been the the focus of extensive scholarly debate. Chapter 9 surveys the probabilistic literature on corroboration and the main difficulties that have been lavelled against the proposed accounts. The chapter then formalizes a notion of corroboration based on Bayesian networks that overcomes most of the difficulties of exisiting accounts. [ANYTHING ELSE HERE TO DESCRIBE THE POSITIVE ACCOUNT OF CORROBORATION?]

Chapter 10 summarizes our proposal for legal probabilism 1.02, limited to the realm of evidence asessment at trial. The chapter also compares our proposal with competing accounts. In earlier chapter, we have shown that legal probabilism 1.02 – roughly, simple legal probabilism supplemented by Bayesian networks – can represent complex relationships between pieces of evidence such as undercutting and corroboration (Chapters 8 and 9), as well as holistic notions such as coherence (Chapter 7). As a consequence, legal probabilism 1.02 rivals two competing accounts of judicial fact-finding: argumentation theory and relative plausibility. The key idea is that the coherence of a story as well as conflicts between pieces of evidence can be modeled formally in terms of corresponding properties of, operations on, and relations between Bayesian networks. We venture to say that our account outperformes competing accounts for the following reason. First, argumentation theory does not offer a clear account of degrees of evidential strenght. Evidence may supports a hypothesis more or less strongly, or two pieces of evodence may cinflcts with one another more less strongly. Not only does legal probabilism 1.02 offer an account of evidenetila support, coinflict ad converegence, but this account is nuanced enough to capture degree of support, conflict and converegence. Second, relative plausibility is often critizzed because the defense need not always present a full-fledge alternatuve story or epxlaination of the evidence. It is enought for the defense to challange the story proposed by the party, say the prosecution in a criminal case. We do not take a strong stance on this controversial pint, but we simply note that legal probabilism 1.02 is flexible enough to be able to model competing stories or explanation of the evidence (in agreemwnt with relative plausibility) or alternatively model conflicts between pieces of evidence without the need to construct a full-fledged alternative story (as critics of relative plausibility bliev eis more appropriate). There remains, howvere, a fundamental difficultiy with legal probabilism 1.02, namely its cognitive plausibility. It is not at all clear that the process of evidence asessment can follow the probabilistic machinery, even one guided by Bayesian network. This difficulty does not undermine legal probabilism 1.02 as a tehory of evidence asessment but is certainly quesion its practical applicability to trial proceedings.

MAYBE ADD OUR ACCOUNT CAN CAPTURE THINGS LIKE COMPLETENESS OF EVIDEMCE, SPECIFICITY OF A NARRATIVE, WHETHER A PIECE OF EVIDENCE IS INDEPENDENTLY SECURED, CROSSWORD PUZZLE ANALOGY AND SUSAN HAACK.

Part III

The final part of the book examines trial-decision making, specifically, to what extent standards of proof such as 'preponderance of the evidence' and 'proof beyond a reasonable doubt' can be understood through the lenses of probability theory.

Table of contents

1.3 Outstanding Features of the Book

- (First) comprehensive sustained philosophical discussion of legal probabilism.
- Multi-faceted in its incorporation of insights from various discussions present in legal, philosophical, and forensic research.
- With a practical accent, due to the implementation of the conceptual points by means of bayesian networks and **R** programming language.

> what else?

1.4 Apparatus

a. Will the book include photographs, line drawings, cases, questions, problems, glossaries, bibliography, references, appendices, etc.?

Yes, the book will contain various plots, either of Bayesian networks, or some other data visualisations generated by ggplot2. The book also will contain bibliography.

b. If the book is a text, do you plan to provide supplementary material to accompany it? (Teacher's manual, study guide, solutions, answers, workbook, anthology, or other material.)

The book will be accompanied by an online-only appendix detailing the use of the R code in the book and the source code we used.

1.5 Competition

a. Consider the existing books in this field and discuss specifically their strengths and weaknesses. Spell out how your book will be similar to, as well as different from, competing works.

> For now, let's list competition, and discuss key differences

Three types: BNs in the law, Philosophy & law, Statistics in law and forensics

- "Bayesian Networks and Probabilistic Inference in Forensic Science" by Taroni, Aitken, Garbolino and Biedermann.
- "Risk Assessment and Decision Analysis with Bayesian Networks" by Fenton and Neil.
- "Bayesian Networks With Examples in R" by Marco Scutari and Jean-Baptiste Denis.
- Alex Stein, foundations of evidence law
- Nance, Burdens of proof
- Schauer, Profiles, . . .
- Ho, Philosophy of evidence law
- Robertson, Vignaux
- Lucy Dawid,
- Statistics for Lawyers etc.

b. Consider what aspects of topical coverage are similar to or different from the competition. What topics have been left out of competing books and what topics have been left out of yours?

c. Please discuss each competing book in a separate paragraph. (If possible, please provide us with the publisher and date of publication as well.) This information will provide the reviewers and the publisher a frame of reference for evaluating your material. Remember, you are writing for reviewers and not for publication, so be as frank as possible regarding your competition. Give credit where credit is due, and show how you can do it better.

2 Market Considerations

2.1 The Primary Market

1. What is the major market for the book? (Scholarly/professional, text, reference, trade?)
2. If this is a text, for what course is the book intended? Is the book a core text or a supplement? What type of student takes this course? What is the level? (Major or non-major; freshman, senior, graduate?) Do you offer this course yourself? If so, how many times have you given it? Is your text class-tested?
3. If the market is scholarly/professional, reference, or trade, how may it best be reached? (Direct mail, relevant journals, professional associations, libraries, book or music stores?) For what type of reader is your book intended?

3 Status of the Work

1. Do you have a timetable for completing the book?
a. What portion or percentage of the material is now complete?
b. When do you expect to have a complete manuscript?
2. What do you estimate to be the size of the completed book?
a. Double spaced typewritten pages normally reduce about one-third when set in type; e.g., 300 typewritten pages make about 200 printed pages. There are about 450 words on a printed page.
b. Approximately how many photographs do you plan to include?
c. Approximately how many line drawings (charts, graphs, diagrams, etc.) will you need?
d. Do you plan to include material requiring permission (text, music, lyrics, illustrations)? To what extent? Have you started the permissions request process?
3. Do you plan to class-test the material in your own or other sections of the course? (Any material distributed to students should be protected by copyright notice on the material.)

4 Sample Chapters

Select one or two chapters of the manuscript that are an integral part of the book. They should be those you consider the best-written ones, and do not have to be in sequence. For example, you might submit chapters 3, 7, and 14 of a 20-chapter book, so long as these chapters represent the content and reflect your writing style and pedagogy in the best possible light. It is also advisable to submit any chapter that is particularly innovative or unique. Sample chapters should contain rough sketches, charts, hand-written musical examples or xerox reproductions, and description of photographs to be included. The material need not be in final form, although it should be carefully prepared and represent your best work. In your preparation, emphasis should be on readability. Please do not bind your manuscript, as we will have to unbind it in order to make photocopies for reviewers. Also be sure all pages are numbered either consecutively or double-numbered by chapter.

5 Reviews

If we are interested in your project, we will commission outside reviewers to read and evaluate your proposal. We will, of course, obtain the best available reviewers to consider your work. If you wish to suggest the names of experts in your field whom you believe to be ideally suited to evaluate your proposal, you may provide their names, titles, and email addresses. While we are unlikely to approach these scholars to act as reviewers themselves, we may ask them for their suggestions for peer readers. Naturally, we do not reveal the names of reviewers without their permission.

6 Author Background

Please include a current CV or brief biography of your writing, teaching, and/or educational background and experience. Be sure to list any books that you have previously published, and any other information about yourself on why you are qualified to write this book.

7 Response Time

Please allow at least 6-10 weeks for the manuscript proposal evaluation and review process. We will contact you as soon as we have had a chance to thoroughly examine your manuscript proposal. Thank you for your interest in Oxford University Press. We look forward to reading your materials.