Making Robust Classification Decisions: Constructing and Evaluating Fast and Frugal Trees (FFTs)

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Abstract

Fast and Frugal Trees (FFTs) are a quintessential family of simple heuristics that allow effective and efficient binary classification decisions and often perform remarkably well when compared to more complex methods. This half-day tutorial will familiarize participants with examples of FFTs and elucidate the theoretical link between FFTs and signal detection theory (SDT). A range of presentations, practical exercises and interactive tools will enable participants to construct and evaluate FFTs for different data sets.

Keywords: Fast and frugal trees; binary classifications; simple heuristics; signal detection theory; validity; robustness

Motivation

Many real-world problems call for binary classification decisions. We may want to predict whether a partnership is promising, whether an investment is profitable, or whether a patient is in peril. Such classifications have important consequences, yet are typically made under time-pressure and uncertainty. Predictions of experts and laypeople in the real world require robust decision strategies that work swiftly and reliably on the basis of limited information.

Fast and Frugal Trees (FFTs) allow efficient and effective binary classification decisions by sequentially attending to a list of diagnostic cues (Martignon, Vitouch, Takezawa, & Forster, 2003; Martignon, Katsikopoulos, & Woike, 2008). FFTs are a special case of simple heuristics — simple decision processes that often perform remarkably well in comparison to more complex methods (Gigerenzer, Todd, & the ABC research group, 1999; Gigerenzer, Hertwig, & Pachur, 2011) — and have been linked with the theoretical framework for diagnostic classification decisions provided by *signal detection theory* (SDT, Luan, Schooler, & Gigerenzer, 2011).

Figure 1 illustrates an example of a FFT that predicts whether an antibiotic prescription is indicated for some patients, particularly children. By checking only one or two cues physicians can identify patients at risk of being infected with a specific type of bacteria and prescribe an appropriate antibiotic treatment (Fischer et al., 2002). Beyond being both effective and efficient FFTs are useful by virtue of being robust (by being insensitive to perturbations due to noisy data and by providing reliable out-of-sample predictions) and communicable (e.g., they can easily be understood, learned and taught). FFTs have successfully been developed in a variety of applied domains, including medical, legal, and financial decision making (see Luan et al., 2011, for examples).

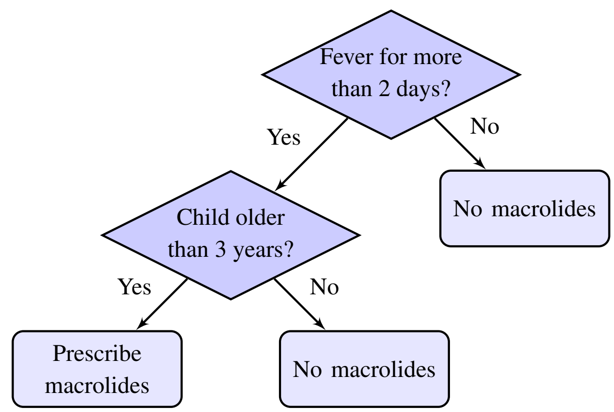

Figure 1: Example of a FFT that allows clinicians to prescribe treatment with macrolides (see Fischer et al., 2002).

Content, Structure, and Activities

This half-day tutorial builds upon the lectures and materials used in previous tutorials (e.g., at the *International Conference on Cognitive Modeling*, ICCM 2012) and workshops (e.g., at the *Max Planck Research School on Adapting Behavior in a Fundamentally Uncertain World*, 2012, and the *ABC Summer Institute on Bounded Rationality*, 2013). Through a combination of presentations and practical exercises participants will become familiar with the theoretical framework behind FFTs, contrast them with alternative classification algorithms, and learn to construct and evaluate FFTs for real-world data sets.

The half-day tutorial interleaves lecture-style presentations with practical exercises and will be structured as follows:

Theoretical background [45 min]: We briefly introduce the basic ideas behind the simple heuristics framework to explain when and why biased minds can make successful inferences. This illustrates how strategies with limited information search can yield robust classification decisions relative to computationally more complex models (Katsikopoulos, Schooler, & Hertwig, 2010). Theoretical notions reviewed in this part include the predictive validity of cues, speed-accuracy tradeoffs, the bias-variance dilemma, assessing classification outcomes via contingency tables (hits and correct rejections vs. false alarms and misses), as well as fundamental concepts of SDT (e.g., criterion shifts, bias c, the sensitivity index d', and the interpretation of ROC curves, Luan et al., 2011). The question *How can we make effective and efficient classification decisions on the basis of limited and noisy data?* will set the stage for the practical exercises.

Hands-on sessions [2×45 min]: Two practical parts will explore the consequences of specific cue and criterion choices. By using interactive software tools participants will acquire hands-on experience in constructing FFTs.

1. Spreadsheet-based FFTs: In a first practical part, participants will be guided through a series of exercises using a pre-designed MS Excel^{TM} sheet. To facilitate the transfer from theoretical notions to applicable expertise we will examine the consequences of different cue choices, bias values, and criterion shifts on various measures of classification performance. After assessing a selection of minimal FFTs (with only one predictive cue) participants will re-construct a FFT that has been designed to help emergency-room doctors to rapidly decide whether to send a patient with severe chest pain to the coronary care unit (Green & Mehr, 1997). Finally, particpants will explore alternative multi-cue FFTs and evaluate their performance on a variety of outcome measures.

2. Interactive software tool (FFT-builder): A second practical session will introduce a new version of *FFT-builder* — an interactive software tool that allows rapid-prototyping, explorative learning and the visual inspection of outcome measures in the context of FFTs (see Figure 2). *FFT-builder* provides a range of features to create and manage environments, data sets, and corresponding FFTs. Numeric and visual analysis tools allow to quantify and compare the performance of different solutions to the same data or explore and inspect the consequences of applying FFTs to different data sets.

Validity and robustness [45 min]: In a final session we will cover two topics central to the theory and practical application of FFTs: their validity and their robustness. The point here is not to merely declare FFTs to be valid and robust, but rather to examine the evidence base and methodological options for addressing these important concerns. Results from cross-validation analyses and a formal quantification and methodological operationalization of robustness will supplement the conceptual discussion.

Objectives

The goal of this tutorial is to provide participants with intellectual and software tools to tackle real-world classification problems. Upon completing the tutorial, participants will be familiar with theoretical criteria and practical skills for designing efficient, effective, and robust classification algorithms. By building and evaluating a variety of FFTs in an interactive fashion, participants will be enabled and encouraged to apply FFTs to data sets in their own domain of expertise.

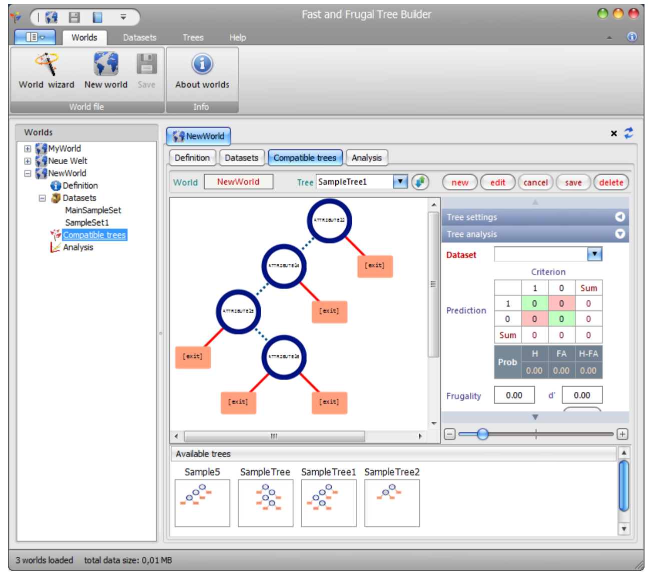

Figure 2: Screenshot of the *FFT-builder* software tool.

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