

## Context

- Machine learning now permeates daily life and high-stakes decisions, making **trustworthiness** more critical than ever.
- Trust spans multiple dimensions: **philosophy**, **bias mitigation**, and **technical safety**.
- Advances in **combinatorial optimization** and **operations research** open new paths to address trust-related challenges.



Figure 1: Four Facets of Trust Explored in This Work

## Contributions

- Fair rule lists using backtracking search and mixed-integer linear programming [1, 2]
- Optimal decision trees and diagrams using Boolean satisfiability, backtracking search, and dynamic programming [3, 4]
- Dataset reconstruction from interpretable models [5]
- Trustworthy explanations using Boolean satisfiability [6]
- Generalizing statistical fairness to unseen data using sample-robust optimization [1]
- Sensitive attribute reconstruction using constraint programming [7]

## Example of Interpretable Models

- A *rule list* model provides interpretable predictions by applying an ordered sequence of if-then rules to the input data.
- Default of Credit Card Clients* dataset: each individual is represented by demographic information, credit data, and payment history. The goal is to predict whether a person will default on their credit card payment.

- If Delay = 2 months and Age > 60, then **predict Default**.
- Else if Education = University and Sex = Male, then **predict No Default**.
- Else if Marriage = Single and Bill > 50k, then **predict Default**.
- Else **predict No Default**.

Figure 4: Example of a rule list for the *Default of Credit Card Clients* dataset.

- The model above might exhibit a gender bias. Without algorithmic considerations for fairness, unbiased outcomes cannot be guaranteed.

## Example: Learning Fair Rule Lists

- There exist multiple fairness measures. For a statistical measure  $\mathcal{M}$ , we aim to ensure that for two protected groups  $\mathcal{A}, \mathcal{B}$  (e.g., male and female),

$$|\mathcal{M}(\mathcal{A}) - \mathcal{M}(\mathcal{B})| < \epsilon.$$

- Let  $X$  be the training data and  $Y$  their true labels. For a given fairness measure  $\mathcal{M}$ , the fair rule list problem seeks a rule list that minimises prediction error subject to fairness constraints. Let  $\mathcal{R}$  be the set of all possible rules:

$$r^* = \arg \min_{r \in \mathcal{R}} \text{error}(r, X, Y)$$

$$\text{s.t. } \text{fairness}(r, X, Y) \leq \epsilon.$$

- We solve this problem using a backtracking search. At each node, an integer linear program (ILP) ensures that the joint misclassification-fairness constraint remains feasible.

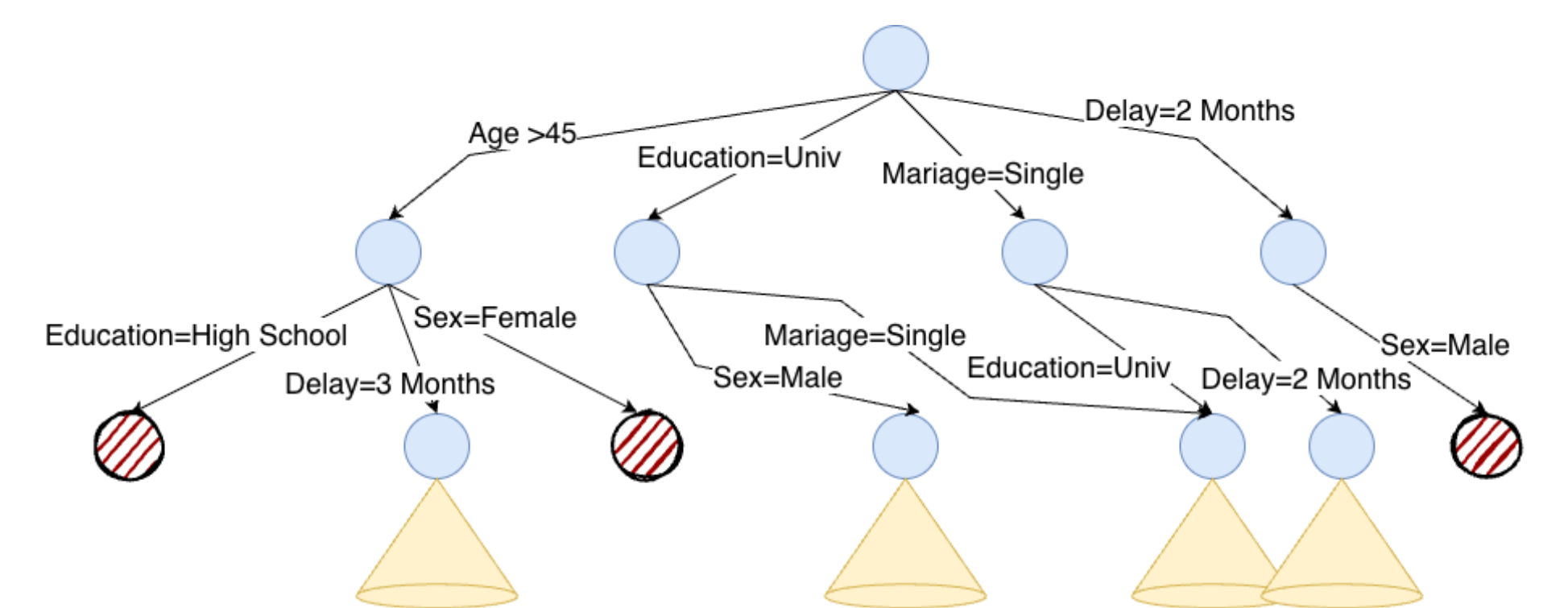


Figure 2: Pruning the search space with ILP. Each node represents a set of candidate models; dashed nodes are pruned by the ILP model.

- We also address the challenging problem of *generalizing fairness*, using mixed-integer programming within a sample-robust optimization framework to guarantee fairness under uncertainty.
- FairCORELS is a **multi-objective tool** designed to learn fair rule lists.

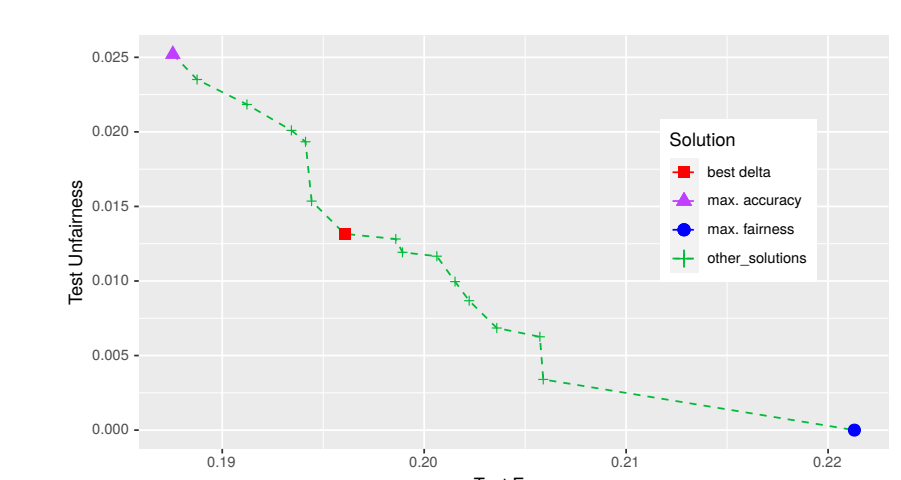
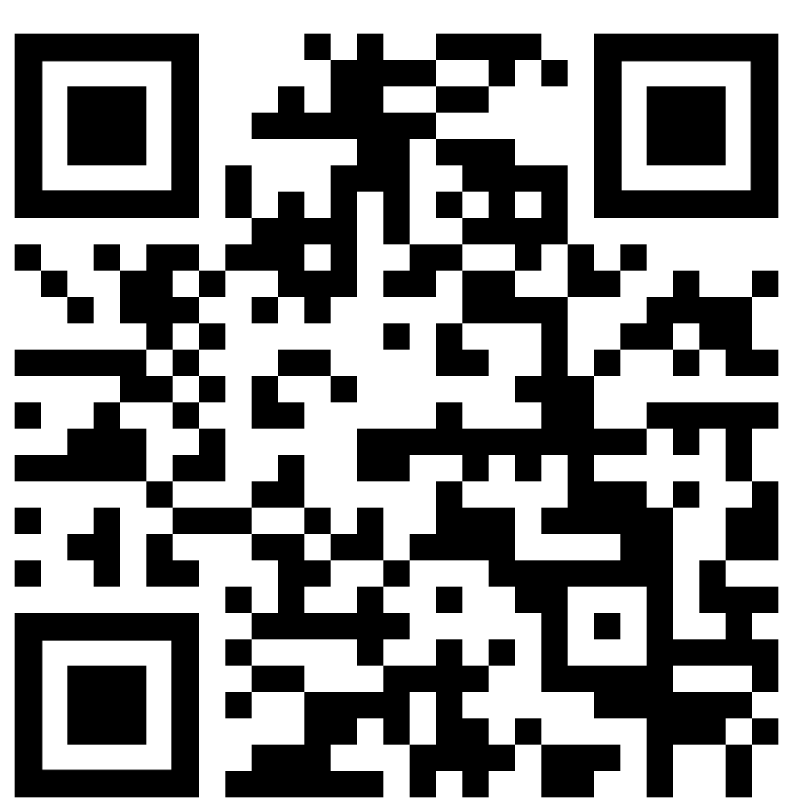


Figure 3: Example trade-offs produced by FairCORELS for the Statistical Parity fairness metric on the *Default of Credit Card* dataset.



## References

- [1] Julien Ferry, Ulrich Aïvodji, Sébastien Gambs, Marie-José Huguet, and Mohamed Siala. Improving fairness generalization through a sample-robust optimization method. *Mach. Learn.*, 2023.
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- [4] Hao Hu, Marie-José Huguet, and Mohamed Siala. Optimizing binary decision diagrams with maxsat for classification. In *AAAI*, 2022.
- [5] Julien Ferry, Ulrich Aïvodji, Sébastien Gambs, Marie-José Huguet, and Mohamed Siala. Probabilistic dataset reconstruction from interpretable models. In *IEEE SaTML*, 2024.
- [6] Mohamed Siala, Jordi Planes, and João Marques-Silva. On trustworthy rule-based models and explanations. In *ECML PKDD*, 2025.
- [7] Julien Ferry, Ulrich Aïvodji, Sébastien Gambs, Marie-José Huguet, and Mohamed Siala. Exploiting fairness to enhance sensitive attributes reconstruction. In *IEEE SaTML*. IEEE, 2023.