Random Planted Forest
A Directly Interpretable Tree Ensemble

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Motivation

- Tree-based methods like Random Forest (RF):

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→ **Random Planted Forest** (RPF): Additive Random Forest

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& \underbrace{\hat{m}_{1,2,3}(x_1, x_2, x_3)}_{\text{3rd order interaction}}
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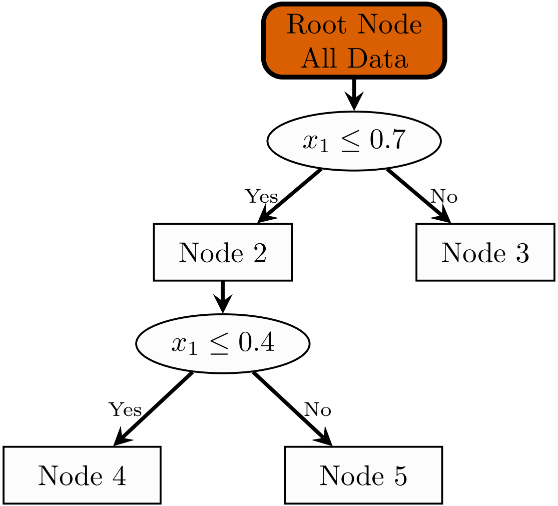
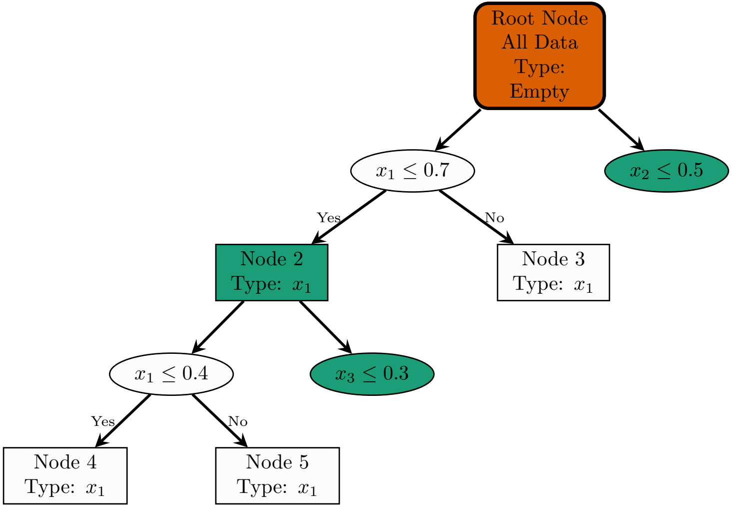
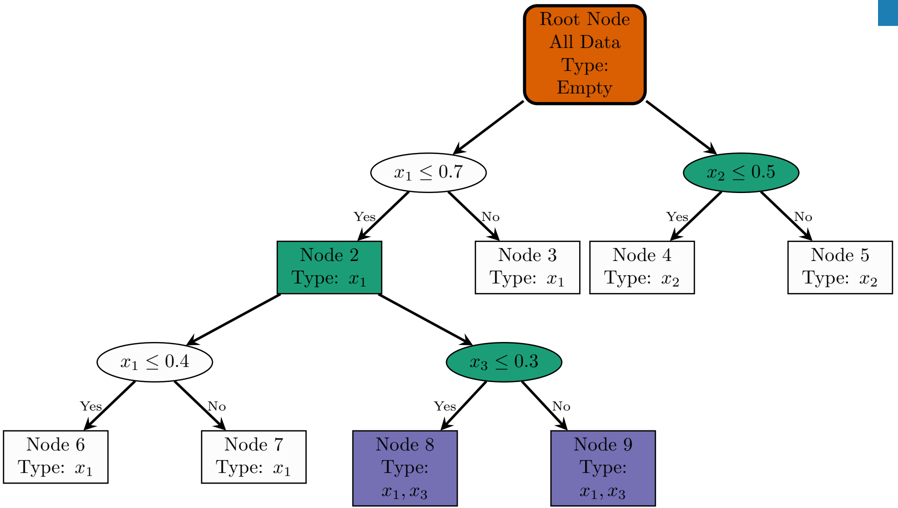
Trees in Random Forest



Planted Trees (I)



Planted Trees (II)



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- Degree of interaction can be constrained
- Prediction built up incrementally using residuals (cf. Gradient Boosting)
- Tree stops after adjustable number of splits

Application Example

- `Bikeshare` regression dataset [1]

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  - `temp` normalized temperature $\in [0, 1]$
  - `workingday` binary → {`workingday`, `no workingday`}
- Average prediction: $\hat{m}_0 \approx 144$

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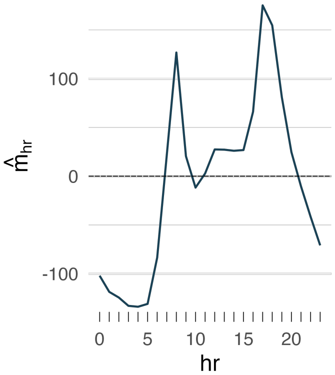
Main Effects



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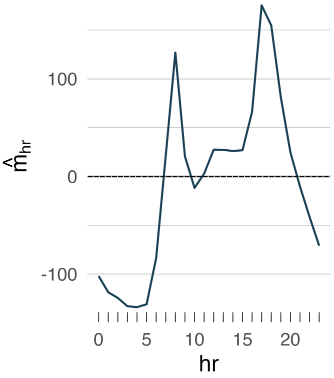

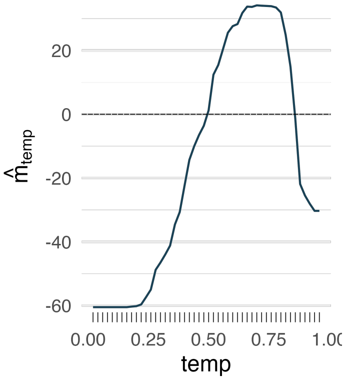

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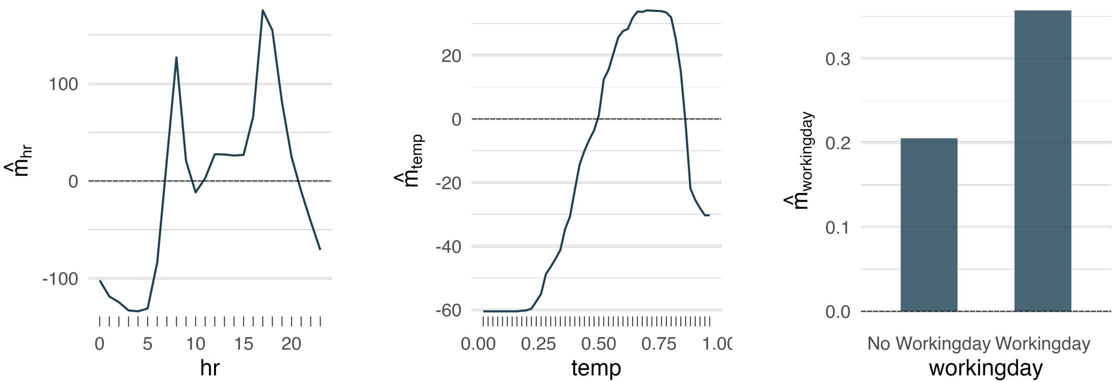
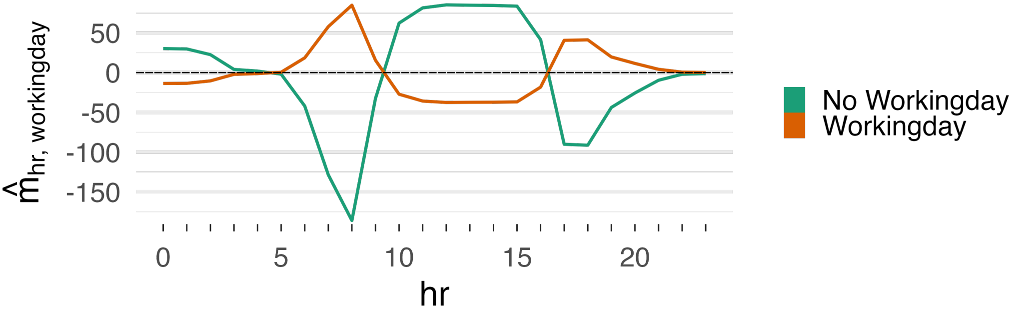


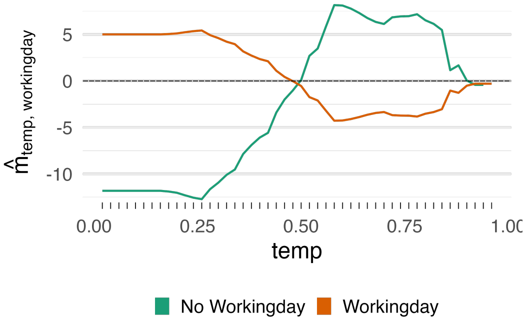
$$\hat{m} = \hat{m}_0 + \hat{m}_{\texttt{hr}}(\texttt{hr}) + \hat{m}_{\texttt{temp}}(\texttt{temp}) + \hat{m}_{\texttt{workingday}}(\texttt{workingday}) + \ldots$$

Hour × Working Day: "Rush Hour Effect"



$$\ldots + \hat{m}_{\texttt{hr,workingday}}(\texttt{hr}, \texttt{workingday}) + \ldots$$

More 2nd Order Interactions



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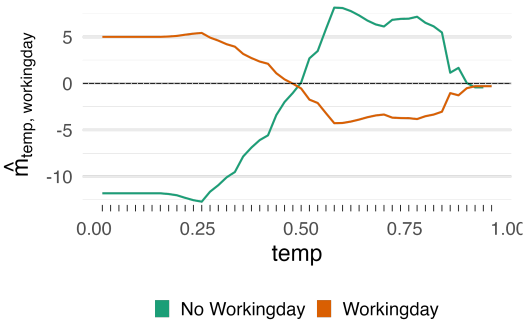
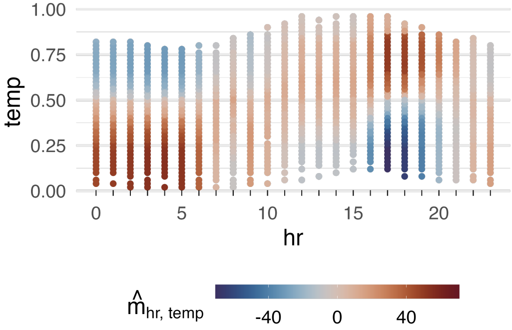
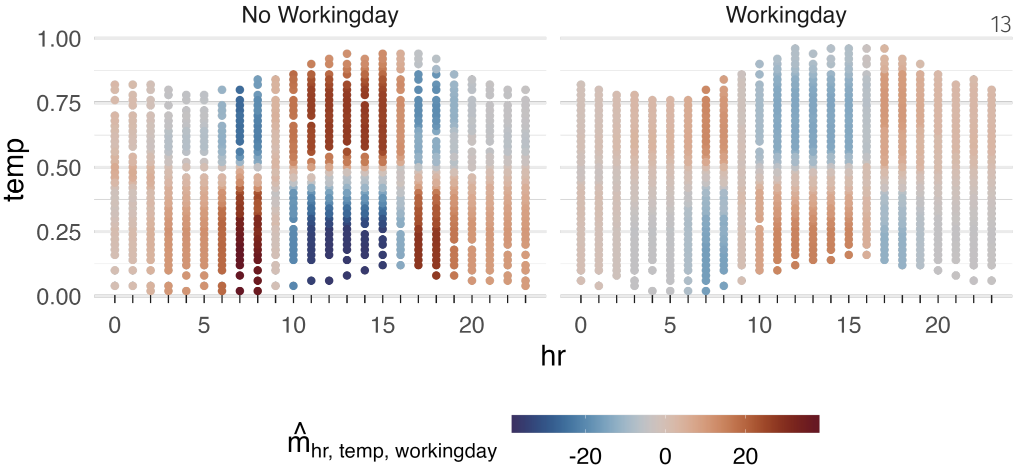




$$+\hat{m}_{\texttt{temp,workingday}}(\texttt{temp},\texttt{workingday}) \qquad +\hat{m}_{\texttt{hr,temp}}(\texttt{hr},\texttt{temp}) + \ldots$$

3rd Order Interaction



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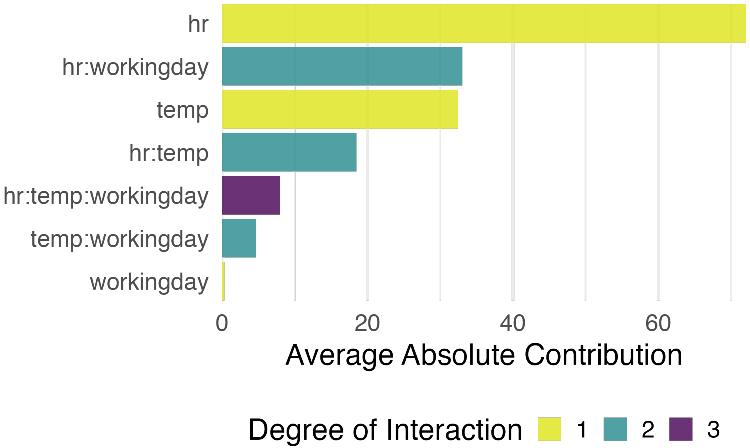
- Importance scores on same scale as prediction

Feature Importance: All Terms



No Free Lunch

$(\uparrow)$ Gains in interpretibility $\Rightarrow$ $(\downarrow)$ sacrifices in predictive performance?

[2] OpenML-CTR23 regression benchmark suite: Fischer et al. (2023)

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Benchmark on **28** datasets [2] comparing RPF with XGBoost & RF

→ RPF never best, rarely bad, usually close to XGBoost

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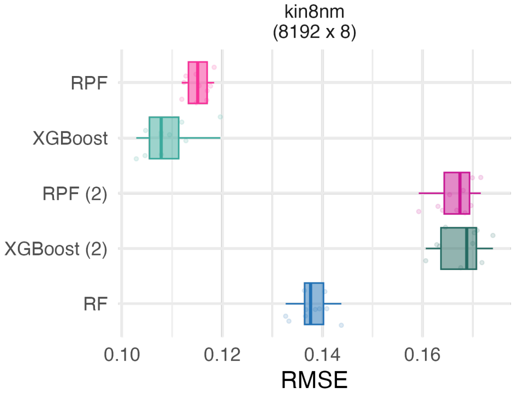
Benchmark Results (Selected Tasks)



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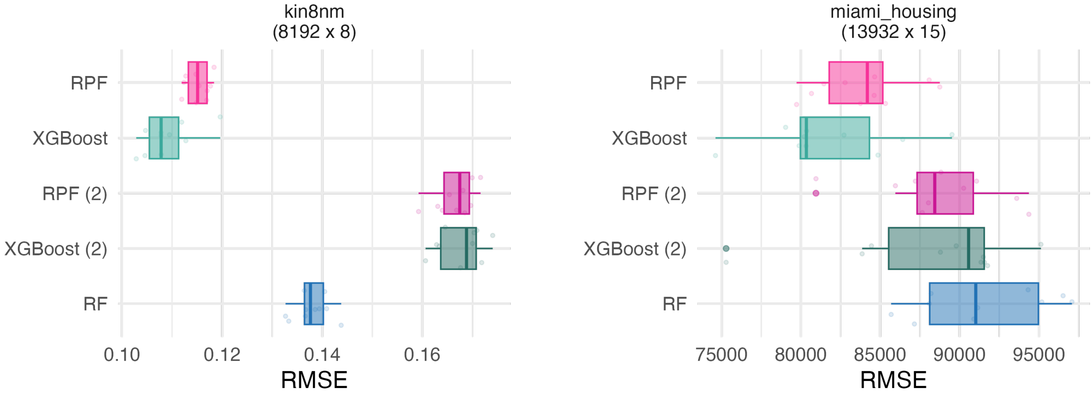

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- (↑) R package available [3]
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- (↑) R package available [3]
- (→) Competetive predictive performance (mostly)
- (↓) Slower for large data (Optimization WIP!)

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Thank you for your attention!

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References I

Fischer, Sebastian Felix et al. (2023). “OpenML-CTR23 – A Curated Tabular Regression Benchmarking Suite”. In: AutoML Conference 2023 (Workshop).