Compboost

Modular framework for component-wise boosting

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What is Component-Wise Boosting

Component-Wise Boosting: Terminology

- Loss Function:

$$L : \mathcal{Y} \times \mathcal{X} \to \mathbb{R}$$

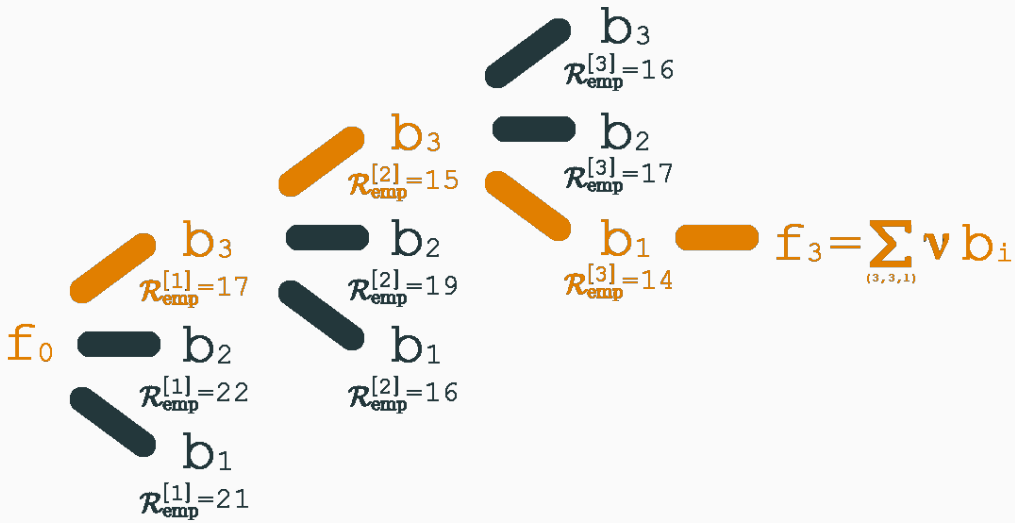
- Empirical Risk:

$$\mathcal{R}_{\text{emp}}(\theta) = \frac{1}{n} \sum_{i=1}^{n} L\left(y^{(i)}, f(x^{(i)})\right)$$

- Estimated model/parameter at iteration m:

$$\hat{f}^{[m]}, \theta^{[m]}$$

Component-Wise Boosting: The Idea



Iteration 1: $\hat{f}^{[1]}(x) = \beta b_3(x_3, \theta^{[1]})$

Iteration 2: $\hat{f}^{[2]}(x) = \beta b_3(x_3, \theta^{[1]}) + \beta b_3(x_3, \theta^{[2]})$

Iteration 2: $\hat{f}^{[3]}(x) = \beta b_3(x_3, \theta^{[1]}) + \beta b_3(x_3, \theta^{[2]}) + \beta b_1(x_1, \theta^{[3]})$

$$\Rightarrow \hat{f}^{[3]}(x) = \beta \left(b_3(x_3, \theta^{[1]} + \theta^{[2]}) + b_1(x_1, \theta^{[3]}) \right)$$

Component-Wise Boosting: The Algorithm

Result: Component-wise boosting model $\hat{f}(x)$
Initialize $\hat{f}^{[0]}(x) = \arg\min_{c \in \mathbb{R}} \mathcal{R}_{\text{emp}}(c)$;
for $m \in \{1, \ldots, M\}$ **do**

// Update pseudo residuals:

$$r^{[m](i)} = - \left[\frac{\delta}{\delta f(x^{(i)})} L\left(y^{(i)}, f(x^{(i)})\right) \right]_{f=f^{[m-1]}}, \ \forall i \in \{1, \ldots, n\} ;$$

// Get index j^* of m-th base-learner from optimizer:

for $j \in \{1, \ldots, J\}$ **do**

// Fit each base-learner $b_j^{[m]}$ to the pseudo residuals:

$$\hat{\theta}_j^{[m]} = \arg\min_{\theta_j} \sum_{i=1}^{n} \left(r^{[m](i)} - b_j^{[m]}(x^{(i)}, \theta_j)\right)^2 ;$$

// Calculate the SSE of the fitted base-learner:

$$\text{SSE}_j = \sum_{i=1}^{n} \left(r^{[m](i)} - b_j^{[m]}(x^{(i)}, \hat{\theta}_j)\right)^2 ;$$

end

// Add selected component to model:

$$\hat{f}^{[m]}(x) = \hat{f}^{[m-1]}(x) + \beta b_{j^*}^{[m]}\left(x, \theta_{j^*}^{[m]}\right)$$

end

Returns: $\hat{f}(x) = \hat{f}^{[m]}(x)$;

Available R Packages

- Tree-based implementations:
  - `xgboost`
  - `catboost`
  - `gbm`
- Model-based implementations:
  - `mboost`

So, why another boosting implementation?

About Compboost

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Small Usecase

Next Steps

Questions?