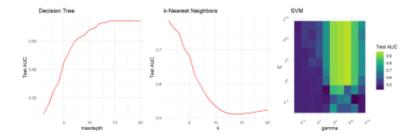
WHY TUNING MATTERS

- Just like a guitar won't perform well when out-of-tune, properly tuning a learner can drastically improve the resulting model performance.
- Tuning helps find a balance between underfitting and overfitting.



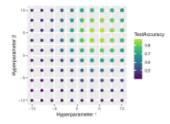
Comparing AUCs of different values for hyperparameters maxdepth, k, gamma, and C



HOW HARD COULD IT BE?

- Very difficult: There are lots of different configurations to choose from, known as the hyperparameter space, denoted by Λ (analogous to Θ).
- Black box: If one opts for a configuration λ ∈ Λ, how can its performance berfneasured (and compared)? compared)?
- ⇒ Well-thought-out Black-Box Optimization Techniques are needed.





Exponential growth of Λ : For two discrete hyperparameters with each 10 possible values, $10 \cdot 10 = 100$ configurations can be evaluated

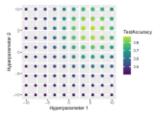
NAÏVE APPROACHES

Goal: Find a best configuration $\lambda^* \in \arg\min_{\lambda \in \Lambda} \widehat{\mathrm{GE}}(\mathcal{I}, \rho, \lambda)$

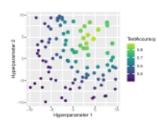
 \Rightarrow Tuners au, e.g., **Grid Search** and **Random Search**, output a $oldsymbol{\lambda}^*$







Random Search

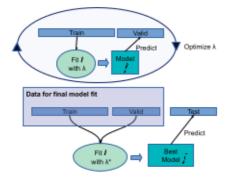


Sophisticated techniques, based on assumptions about the objective function, search for optimal solutions more efficiently.

UNTOUCHED-TEST-SET PRINCIPLE

We've found a $\lambda^* \in \Lambda$. How well does it perform?

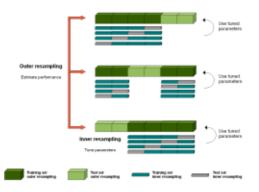
- Careful: We cannot use the same data for both tuning and performance estimation, as this would lead to (optimistically) biased performance estimates!
- ullet To obtain an unbiased \widehat{GE} , we need an **untouched** test set:





NESTED RESAMPLING

- To decrease variance of the $\widehat{\mathrm{GE}}$, **Nested Resampling** is used:
 - Just as we generalized holdout splitting to resampling, we generalize the three-way split to nested resampling (as we first have to find λ*):





PIPELINES IN MACHINE LEARNING

Pipelines are like the assembly lines in machine learning. They automate the sequence of data processing and model building tasks.

Why Pipelines Matter:

- Streamlined Workflow: Automates the flow from data preprocessing to model training.
- Reproducibility: Ensures that results can be reproduced consistently.
- Error Reduction: Minimizes the chance of human errors in the model building process.



