

Statistics and Data Analysis

Unit 04 – Lecture 08: Cross-validation and Hyper-parameter Tuning

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<https://github.com/tali7c/Statistics-and-Data-Analysis>

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Learning Outcomes

- Explain train/validation/test split roles

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- Describe k-fold cross-validation

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- Describe k-fold cross-validation
- Explain grid search vs random search
- Avoid data leakage using pipelines

Cross-validation: Key Points

- CV estimates generalization more stably than one split

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Cross-validation: Key Points

- CV estimates generalization more stably than one split
- k-fold repeats train/validate across folds
- Average score guides selection

Hyper-parameter Tuning: Key Points

- Grid search tries all combos

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- Random search samples combos efficiently

Hyper-parameter Tuning: Key Points

- Grid search tries all combos
- Random search samples combos efficiently
- Never tune on the test set

Exercise 1: Grid size

3 parameters with 4 values each: how many combinations?

Solution 1

■ $4^3 = 64$

Exercise 2: Leakage

Is scaling on full dataset before split leakage?

Solution 2

- Yes; fit preprocessing on training only.

Exercise 3: Why CV

Why is a single train-test split misleading sometimes?

Solution 3

- Performance depends on split; CV reduces variance.

Mini Demo (Python)

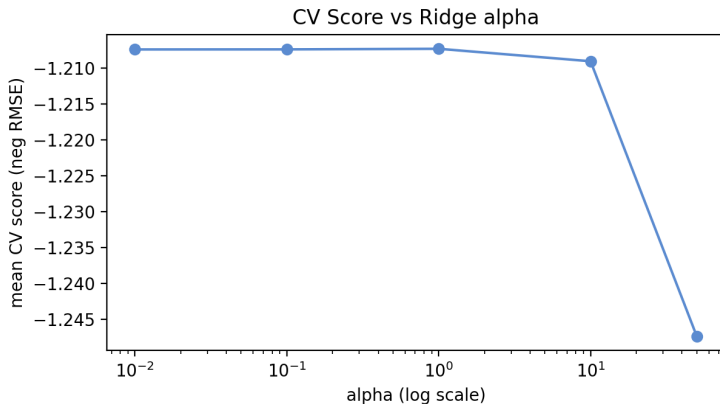
Run from the lecture folder:

```
python demo/demo.py
```

Outputs:

- images/demo.png
- data/results.txt

Demo Output (Example)



Summary

- Key definitions and the main formula.

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- How to interpret results in context.

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- Key definitions and the main formula.
- How to interpret results in context.
- How the demo connects to the theory.

Exit Question

Why must you never use the test set to choose hyperparameters?