

Model Evaluation & Hyperparameter Tuning

Module 5: Optimizing Machine Learning Accuracy

Advanced diagnostics and automated search strategies for high-performance modeling.

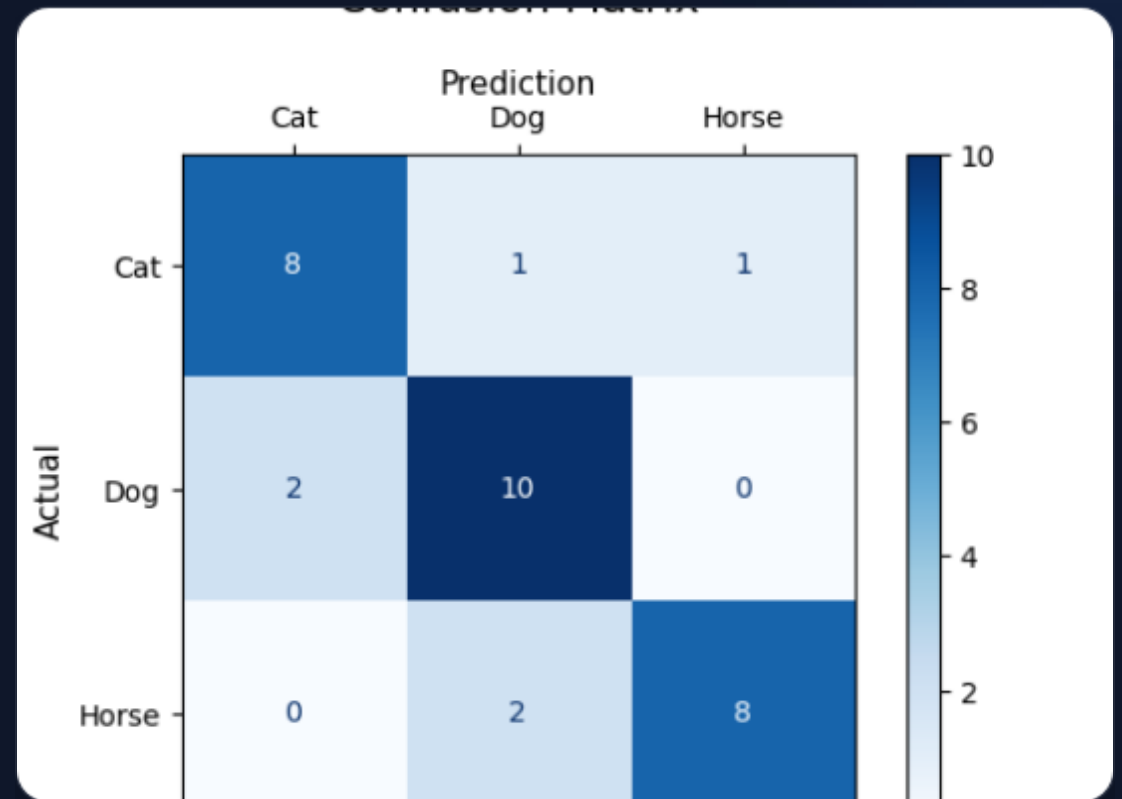
01. Performance Metrics

Interpreting matrices and error functions to measure success.

DECOUPLING CONFUSION MATRICES

A confusion matrix is more than a table; it is a **diagnostic blueprint** for classification errors.

- ✓ **True Positives (TP):** Correct identified hits.
- ✗ **False Positives (FP):** Type I errors (False Alarms).
- ⚠ **False Negatives (FN):** Type II errors (Misses).
- 🛡 **True Negatives (TN):** Correct identified rejections.



CLASSIFICATION DIAGNOSTICS



Precision: Quantifies the quality of positive predictions.

$$\text{Precision} = \frac{TP}{TP + FP}$$



Recall (Sensitivity): Measures ability to find all positive instances.

$$\text{Recall} = \frac{TP}{TP + FN}$$



F1-Score: Harmonic mean of precision and recall for balanced evaluation.

REGRESSION: ERROR MINIMIZATION



$$\text{MSE} = \frac{1}{n} \sum_{i=1}^n y_i - \hat{y}_i^2$$

The goal of hyperparameter tuning is to find the configuration that minimizes Mean Squared Error (MSE).

| OPTIMIZATION IMPACT

+14

ACCURACY GAIN

%

Moving Beyond Defaults

Default hyperparameters rarely yield the optimal model. Through systematic tuning, we can significantly shift the accuracy curve, transforming a baseline model into a high-performance production asset.



Refined decision boundaries.



Reduced variance and overfitting.

02. Hyperparameter Tuning

Harnessing GridSearchCV for automated parameter optimization.

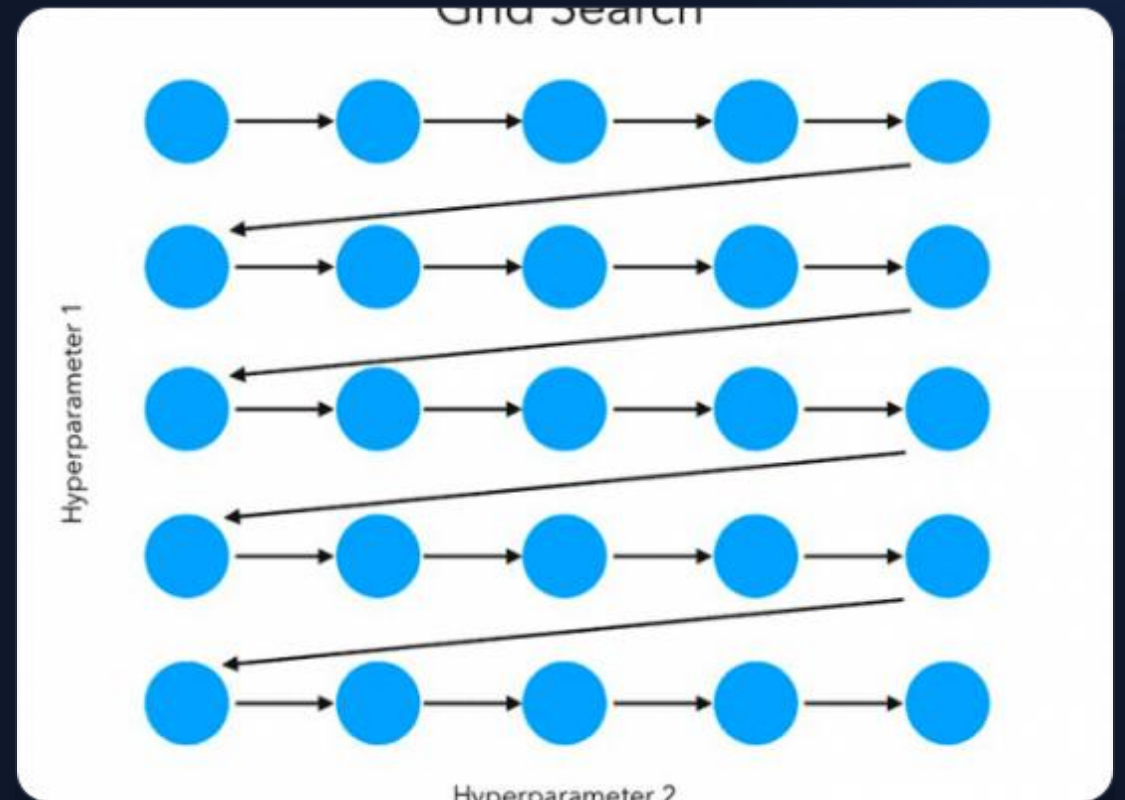
GRIDSEARCHCV MECHANICS

GridSearchCV performs an exhaustive search over a specified parameter values for an estimator.

 **Parameter Grid:** Define a dictionary of settings.

 **Cross-Validation:** K-Fold splits ensure robust scoring.

 **Best Estimator:** Automatically selects the top-performing model.



TUNING STRATEGIES



Parameters

Learned from data during training (e.g., weights in a linear regression model).



Hyperparameters

Set before training. Controls the learning process (e.g., learning rate, tree depth).



Grid Search

Automated method to test every combination of hyperparameters defined.

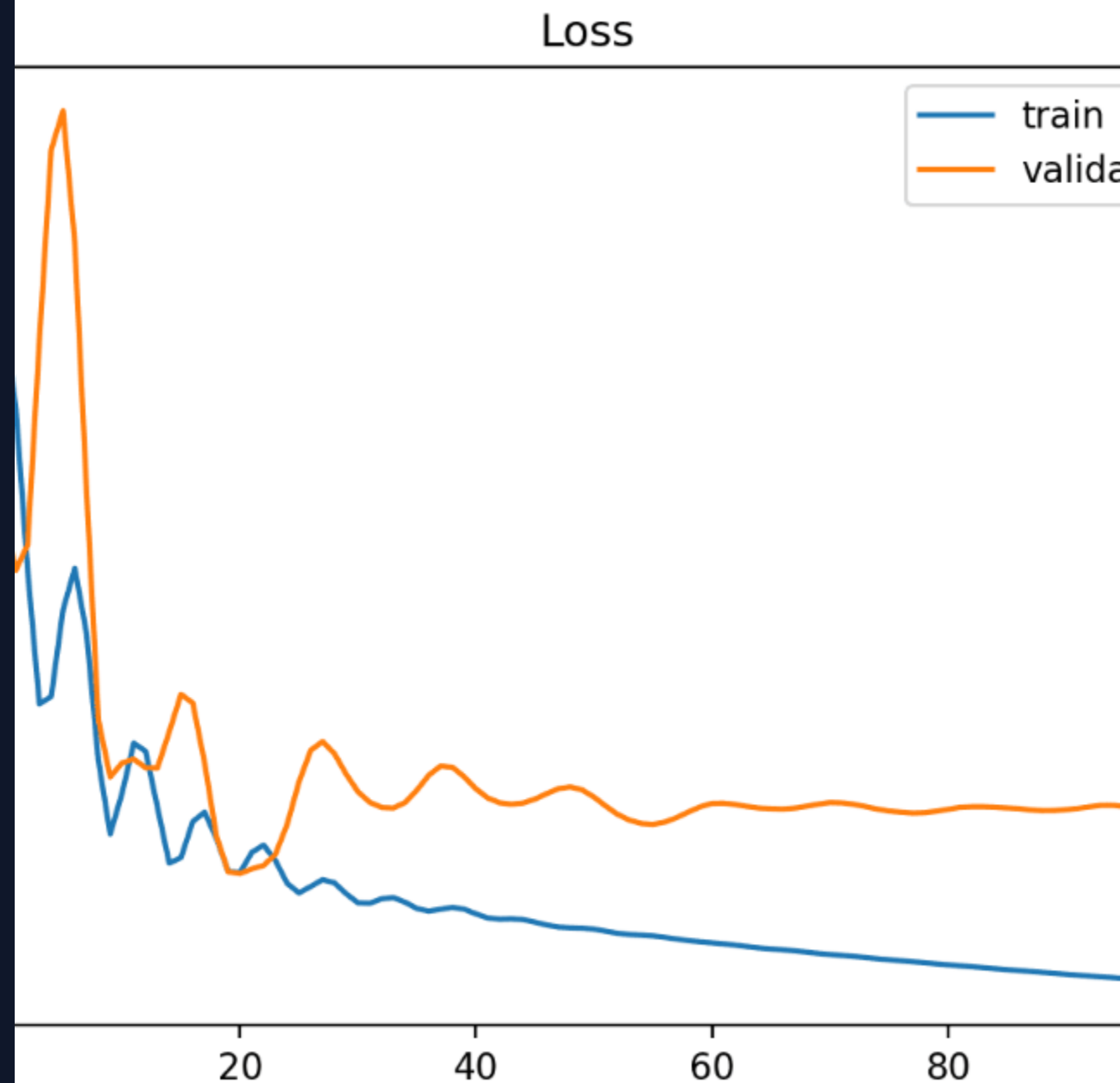
THE OPTIMAL CURVE

By plotting **Validation Curves**, we identify the peak accuracy point before overfitting occurs.

📈 Training accuracy increases with complexity.

🔗 Validation accuracy peaks then plateaus or drops.

🎯 The "Highest Accuracy Curve" represents the optimal bias-variance tradeoff.



VERIFICATION REPORTS

Functionality	Code Implementation	Output Deliverable
Global Diagnostics	<code>classification_report()</code>	Precision, Recall, F1 per class
Error Magnitude	<code>mean_squared_error()</code>	Scalar variance value (Loss)
Auto-Optimization	<code>GridSearchCV()</code>	Best Hyperparameter Set

Deliverable Ready

Optimized High-Accuracy Model

Your model is now backed by empirical verification and systematic tuning. Any questions on interpreting the reports or tuning strategies?

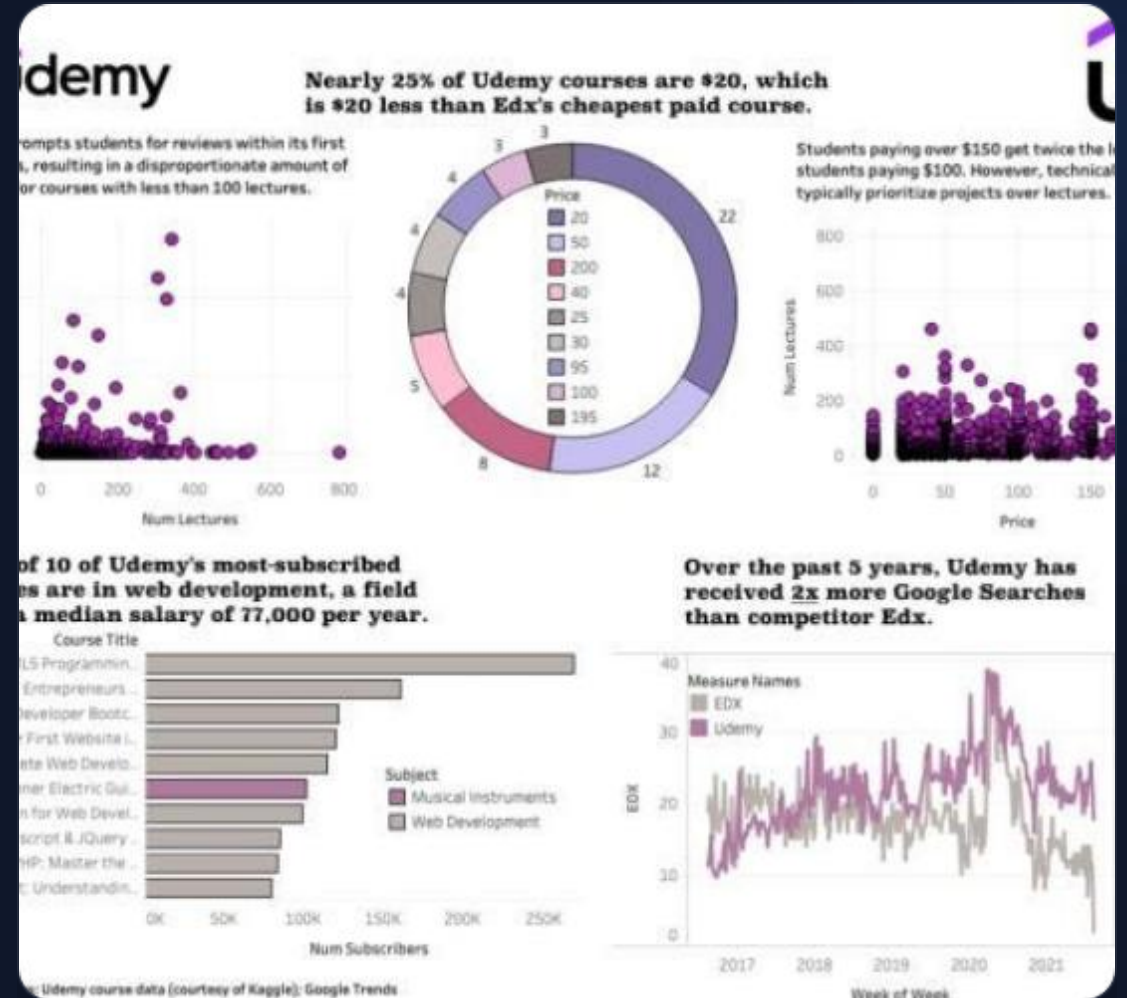
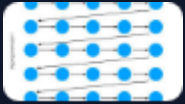


IMAGE SOURCES



<https://media.geeksforgeeks.org/wp-content/uploads/20240708132251/confusion-Matrix.PNG>

Source: www.geeksforgeeks.org



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Source: pyimagesearch.com



<https://machinelearningmastery.com/wp-content/uploads/2018/12/Example-of-Train-and-Validation-Learning-Curves-Showing-a-Training-Dataset-the-May-be-too-Small-Relative-to-the-Validation-Dataset.png>

Source: machinelearningmastery.com



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