Module 10.3: Regression Evaluation Metrics

R^2, MAE, RMSE made simple

Why Do We Need Metrics?

When you build a regression model, you need to know:
How good is it?

Metrics help us measure how close our predictions are to reality. They give us a simple number that tells us if our model is working well or needs improvement.

Think of metrics like a report card for your model — they show where it excels and where it struggles.

MAE

Mean Absolute Error

RMSE

Root Mean Squared Error

R^2

Coefficient of Determination

Our Example Dataset

Let's use a simple scenario to understand each metric. Imagine we're predicting test scores based on hours studied.

Hours Studied	Actual Score	Predicted Score
2	65	68
4	75	73
6	82	78
8	88	83
10	95	88

We'll use this data throughout the module to show how each metric works in practice.

MAE: Mean Absolute Error

What is MAE?

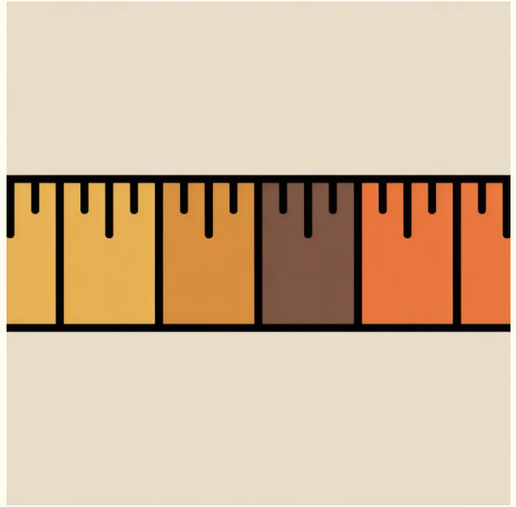
MAE measures the average size of errors in your predictions, ignoring whether they're too high or too low.

How it works: Take each prediction error, ignore the + or - sign, then average them all together.

Example Calculation:

- Error 1: |65 - 68| = 3
- Error 2: |75 - 73| = 2
- Error 3: |82 - 78| = 4
- Error 4: |88 - 83| = 5
- Error 5: |95 - 88| = 7

MAE = (3 + 2 + 4 + 5 + 7) ÷ 5 = 4.2 points



Interpretation

On average, our predictions are off by about 4 points. Lower MAE means better predictions!

RMSE: Root Mean Squared Error

What is RMSE?

RMSE is similar to MAE, but it penalizes big errors more heavily by squaring them first.

Why square the errors?

Squaring makes large errors stand out. An error of 10 becomes 100, while an error of 2 becomes just 4. This helps identify models that occasionally make terrible predictions.

The Process:

01

Square each error

$3^2 = 9$, $2^2 = 4$, $4^2 = 16$, $5^2 = 25$, $7^2 = 49$

02

Find the mean

$(9 + 4 + 16 + 25 + 49) \div 5 = 20.6$

03

Take the square root

$\sqrt{20.6} \approx 4.5$ points

Our RMSE of 4.5 is slightly higher than our MAE of 4.2, showing we have some larger errors in the mix.

R^2: How Much Did We Explain?

R^2 (R-squared) tells you what percentage of variation in the data your model explains. Think of it as a score from 0 to 1.

$R^2 = 1.0$

Perfect! Every point lands exactly on the line.

$R^2 = 0.75$

Good. The model explains 75% of the variation.

$R^2 = 0.0$

The model doesn't explain anything useful.

What is R^2?

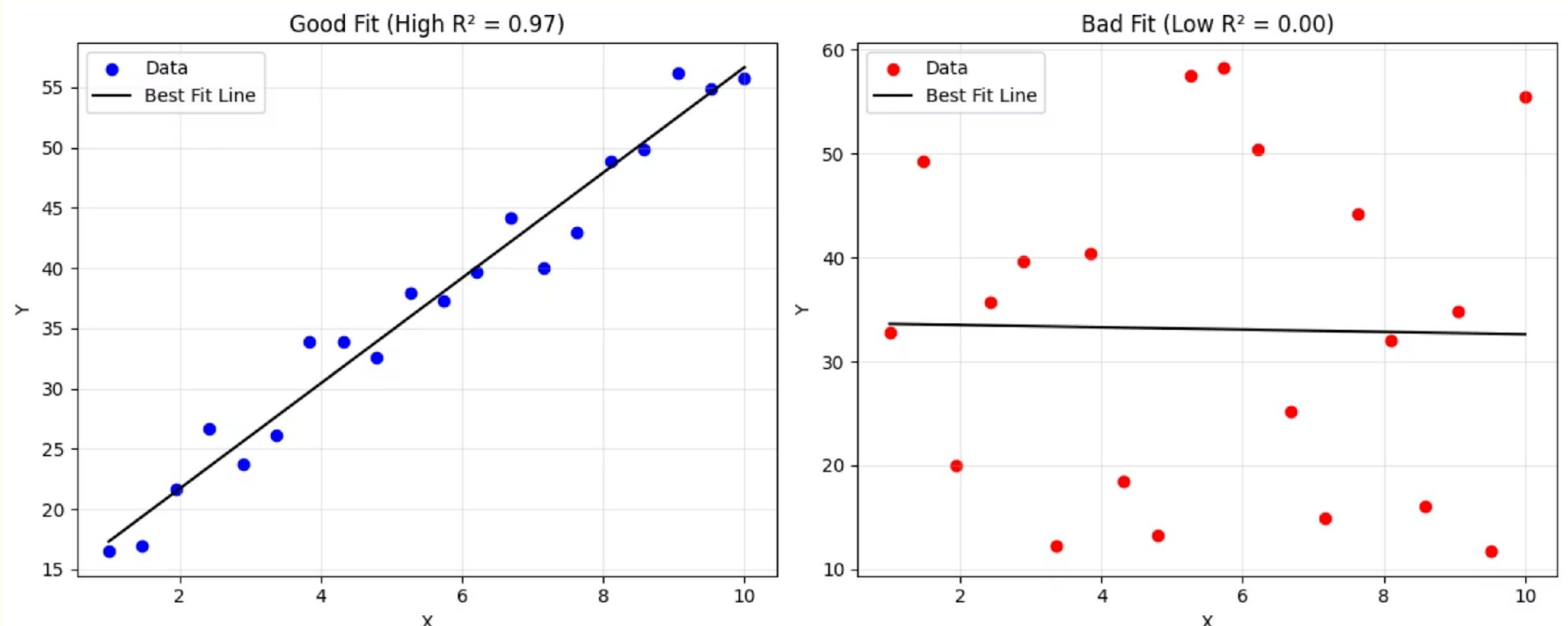
R^2 (R-squared) tells you what percentage of variation in the data your model explains. Think of it as a score from 0 to 1.

Visual Comparison

Bad fit (Low R^2): Points scattered everywhere, the line doesn't capture the pattern well.

Good fit (High R^2): Points cluster close to the line, showing a strong relationship.

Higher R^2 values mean your model captures more of the story in your data!



Which Metric Should You Use?

Each metric has its strengths. Here's a quick guide to help you choose:

Metric	Best Used When...	Key Strength
MAE	You want to understand typical error size in the same units as your data	Easy to interpret and explain
RMSE	Large errors are especially problematic and should be avoided	Penalizes big mistakes heavily
R^2	You want to know how well your model captures overall patterns	Shows explanatory power (0 to 1 scale)

Pro tip: Don't rely on just one metric! Using all three gives you a complete picture of your model's performance.

Visual Intuition: What Are We Measuring?

Every metric we've discussed boils down to one thing: measuring the distance between predictions and reality.

Those vertical lines from each point to the regression line? Those are your errors (also called residuals). Our metrics simply summarize these distances in different ways:

MAE

Average distance

RMSE

Distance with big gaps emphasized

R^2

How tight the fit is overall

Key Takeaways

MAE: Your Average Error

Tells you the typical mistake size in simple, understandable units. Great for explaining model performance to non-technical audiences.

RMSE: Watch Out for Big Errors

Highlights when your model makes occasional large mistakes. Use this when accuracy consistency matters most.

R^2: The Big Picture

Shows how much of the story your model captures. Values closer to 1 mean you're explaining more of what's happening in the data.

Remember: A good data scientist uses multiple metrics together to get a complete view of model performance. No single number tells the whole story!