HACKERMATH FOR ML

Intro to Stats & Maths for Machine Learning

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“WHAT I CANNOT CREATE, I DO NOT UNDERSTAND ”

Richard Feynman

PHILOSOPHY OF HACKERMATH

“Hacker literally means developing mastery over something.”
Paul Graham

Here we will aim to learn Math essential for Data Science in this hacker way.

Three key questions

- Why do you need to understand the math?
- What math knowledge do you need?
- Why approach it the hacker's way?

Approach

- Understand the Math.
- Code it to learn it.
- Play with code.

Module 1: Linear Algebra
Supervised ML - Regression, Classification

- Solve $Ax = b$ for $n \times n$
- Solve $Ax = b$ for $n \times p + 1$
- Linear Regression
- Ridge Regularization (L2)
- Bootstrapping
- Logistic Regression (Classification)

Module 2: Statistics

Hypothesis Testing: A/B Testing

- Basic Statistics
- Distributions
- Shuffling
- Bootstrapping & Simulation
- A/B Testing

Module 3: Linear Algebra Contd.

Unsupervised ML: Dimensionality Reduction

- Solve $Ax = \lambda x$ for $n \times n$
- Eigenvectors & Eigenvalues
- Principle Component Analysis
- Cluster Analysis (K-Means)

SCHEDULE

0900 - 1000: Breakfast
1000 - 1130: Session 1
1130 - 1145: Tea Break
1145 - 1315: Session 2
1315 - 1400: Lunch
1400 - 1530: Session 3
1530 - 1545: Tea Break
1545 - 1700: Session 4

> “IT’S TOUGH TO MAKE PREDICTIONS, ESPECIALLY ABOUT THE FUTURE.”

Yogi Berra

WHAT IS MACHINE LEARNING (ML)?

“[Machine learning is the] field of study that gives computers the ability to learn without being explicitly programmed.”
Arthur Samuel

“Machine learning is the study of computer algorithm that improve automatically through experience”
Tom Mitchell

ML Problems

- “Is this cancer?”
- “What is the market value of this house?”
- “Which of these people are friends?”
- “Will this person like this movie?”
- “Who is this?”
- “What did you say?”
- “How do you fly this thing?”.

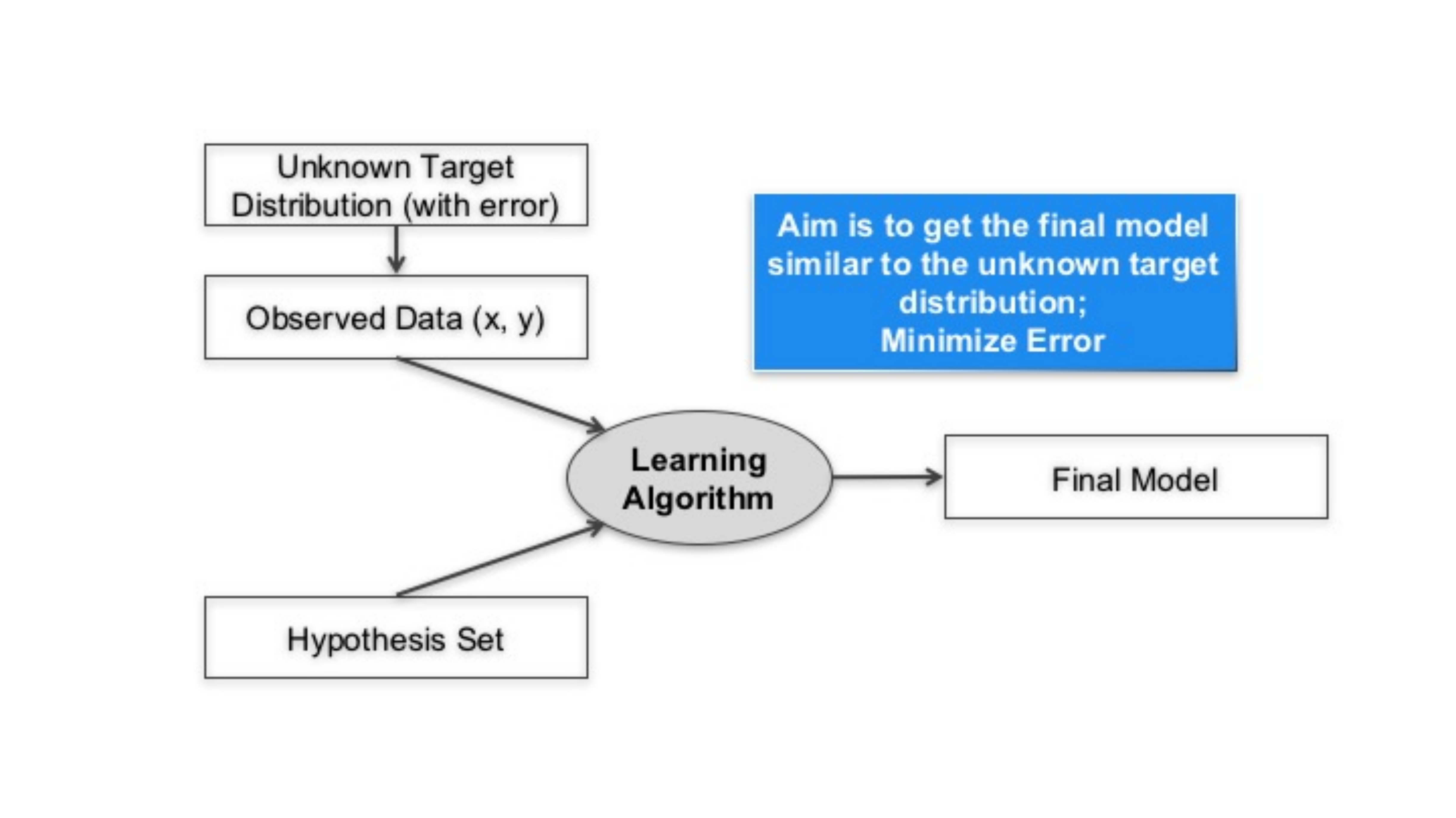
ML in use everyday

- Search
- Photo Tagging
- Spam Filtering
- Recommendation
- ...

BROAD ML APPLICATION

- Database Mining e.g. Clickstream data, Business data
- Automating e.g. Handwriting, Natural Language Processing, Computer Vision
- Self Customising Program e.g. Recommendations

ML THOUGHT PROCESS



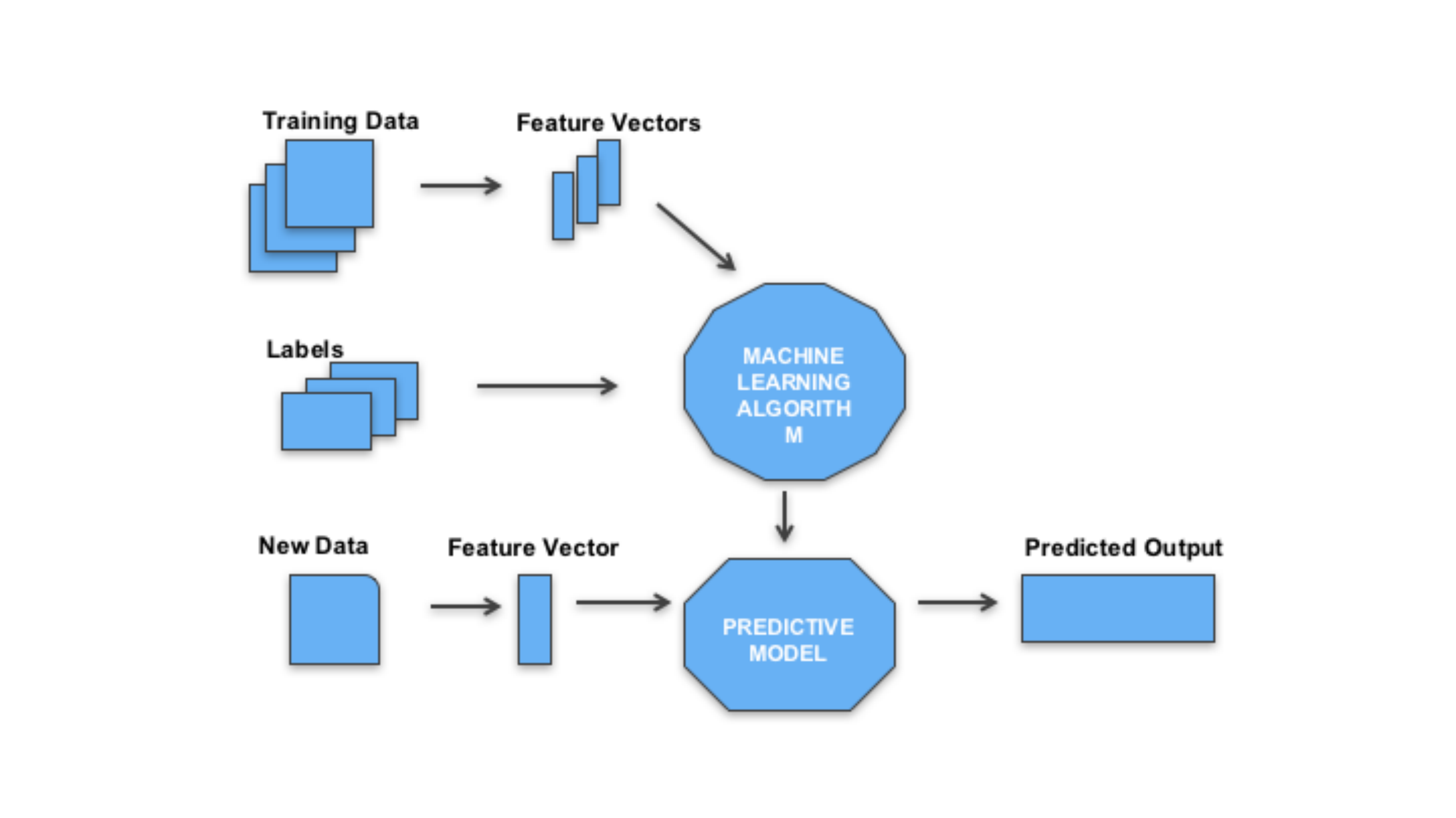
Aim is to get the final model similar to the unknown target distribution;
Minimize Error

Learning Paradigm

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning
- Online Learning

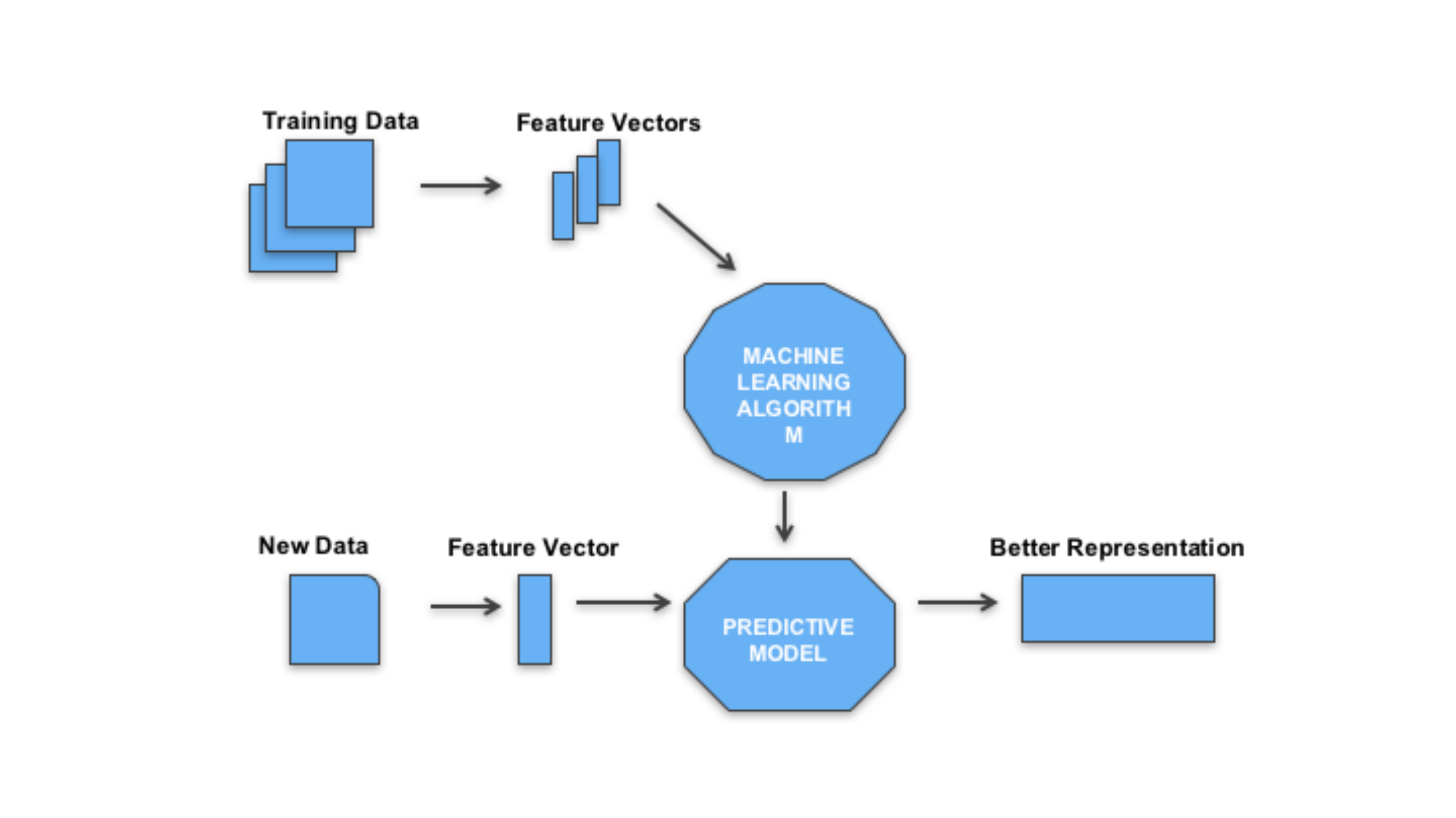
Supervised Learning

- Regression
- Classification



UNSUPERVISED LEARNING

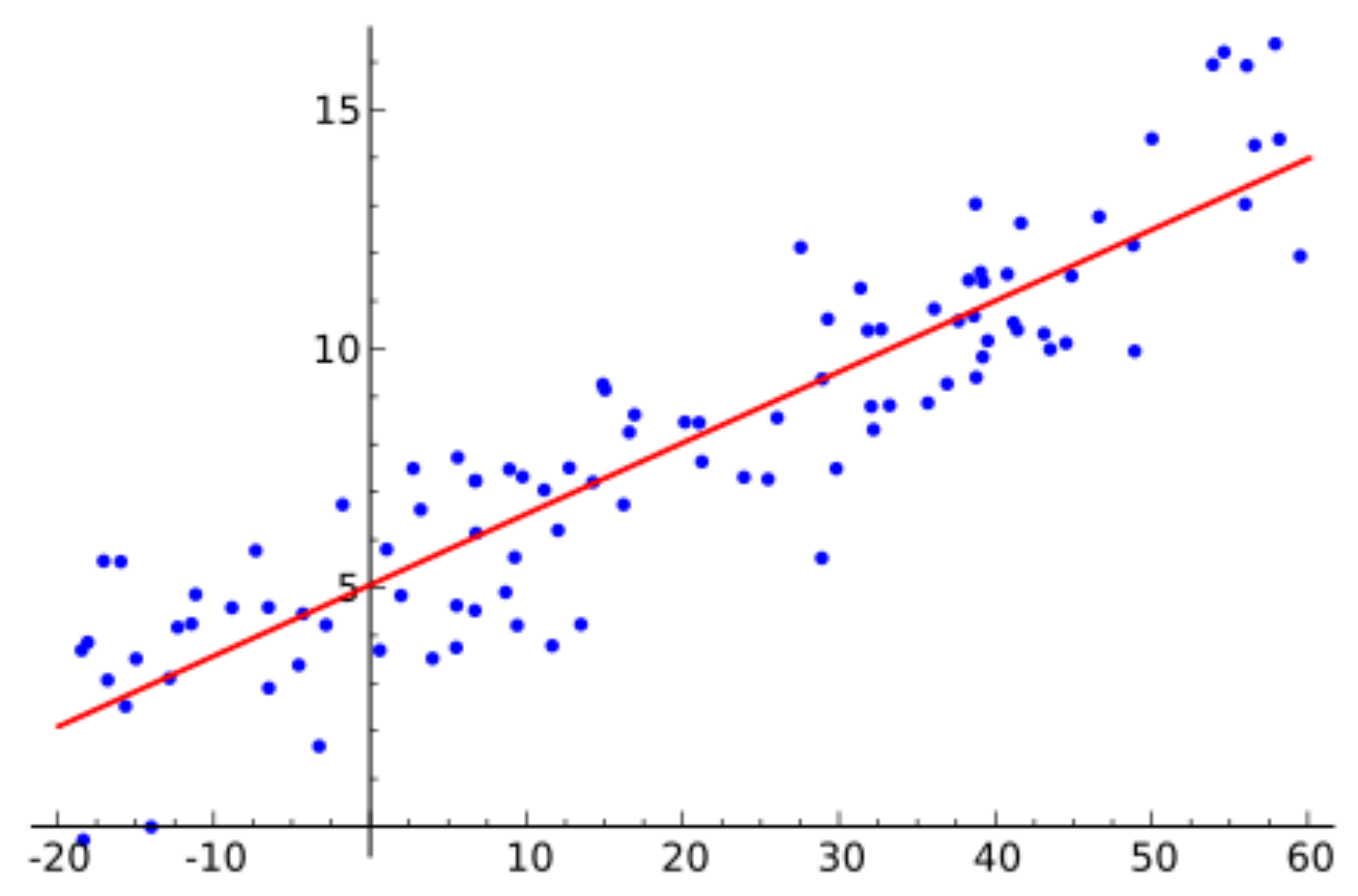
- » Clustering
- » Dimensionality Reduction



ML Pipeline

- Frame: Problem definition
- Acquire: Data ingestion
- Refine: Data wrangline
- Transform: Feature creation
- Explore: Feature selection
- Model: Model creation & assessment
- Insight: Communication

LINEAR REGRESSION



Linear Relationship

$$y_i = \alpha + \beta_1 x_1 + \beta_2 x_2 + ..$$

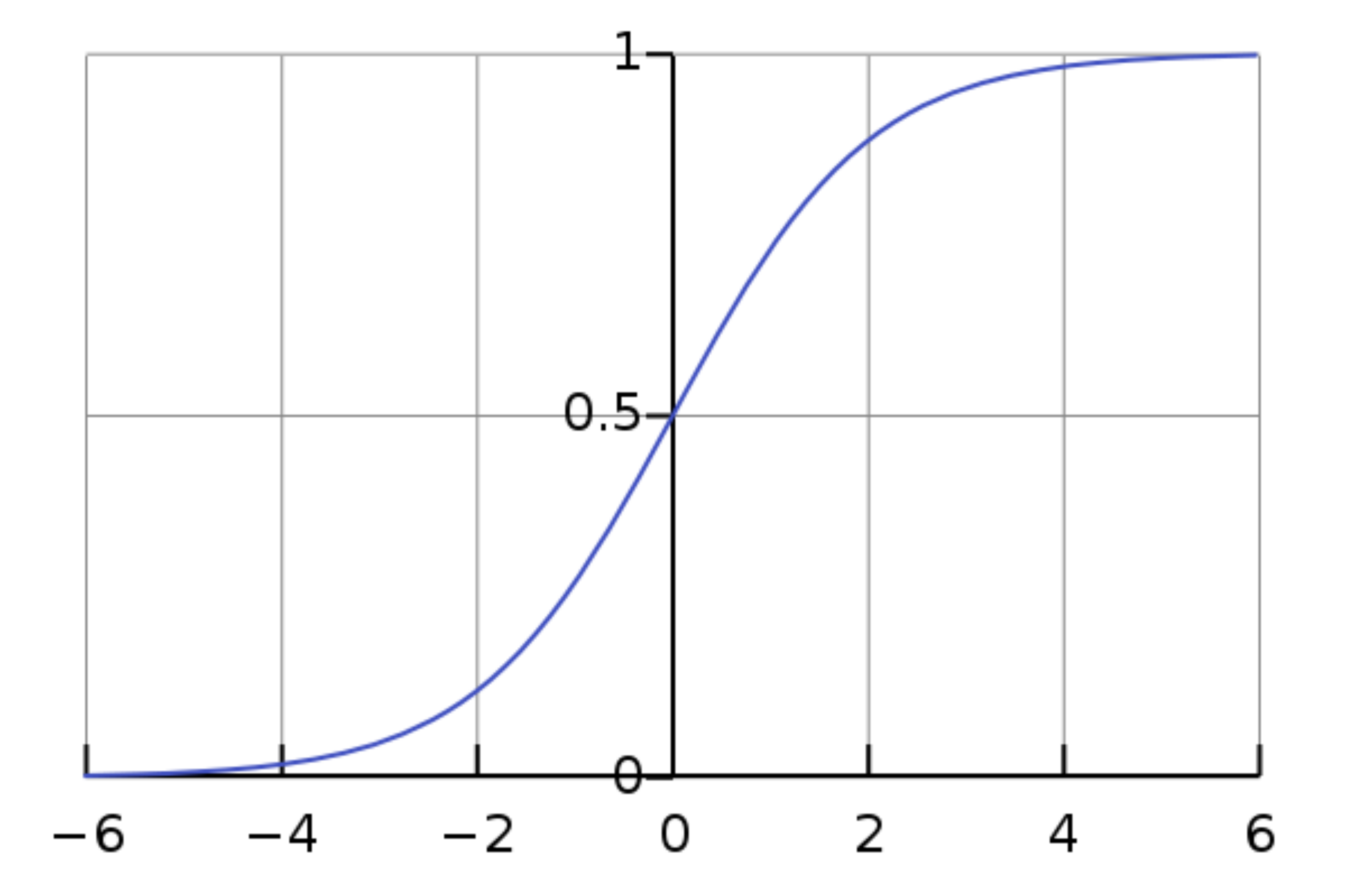
Objective Function

$$\epsilon = \sum_{k=1}^{n} (y_i - \hat{y}_i)^2$$

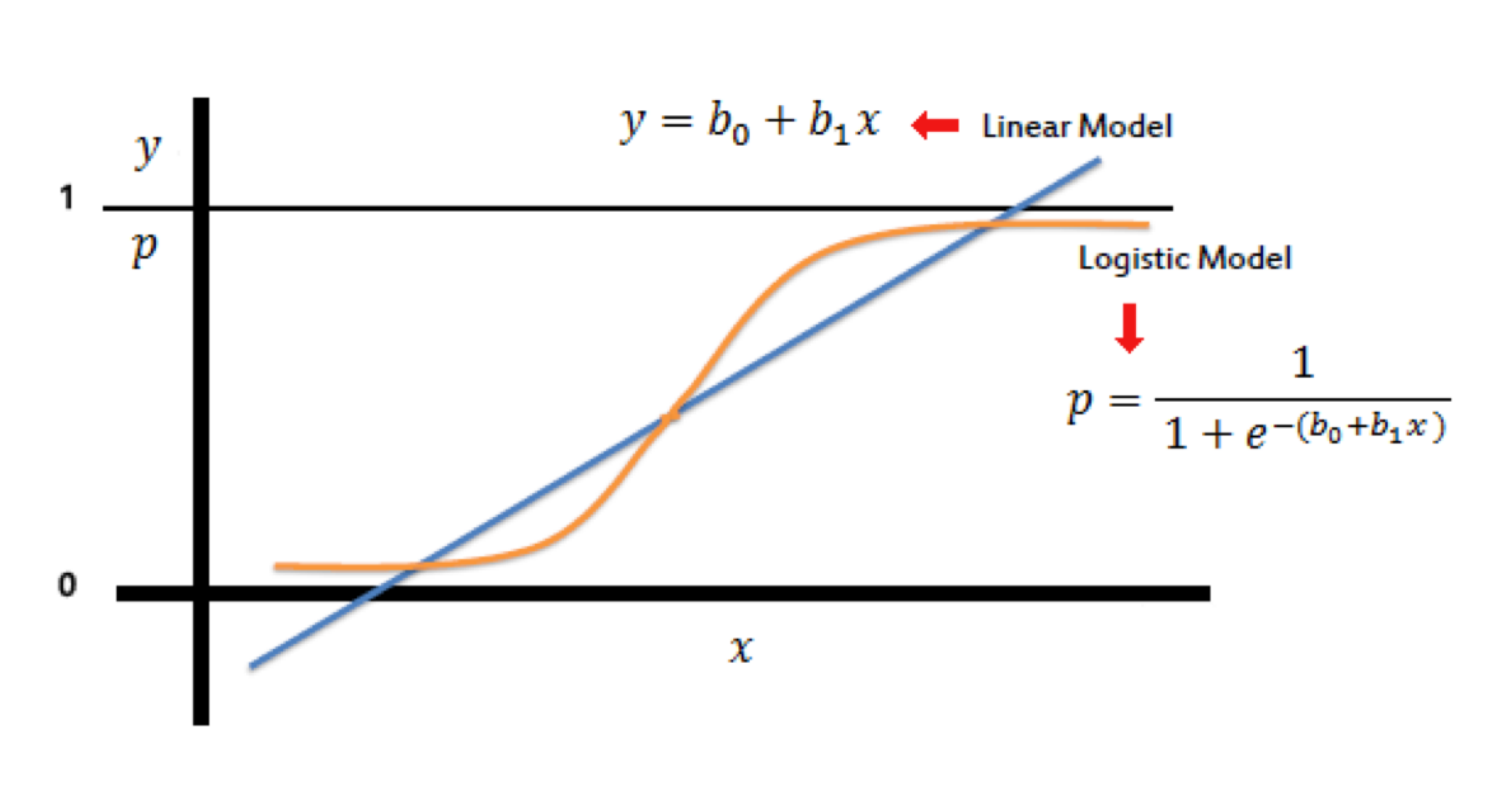
Interactive Example: http://setosa.io/ev/

LOGIT FUNCTION

$$\sigma(t) = \frac{e^t}{e^t + 1} = \frac{1}{1 + e^{-t}}$$



LOGISTIC REGRESSION



Logistic Relationship

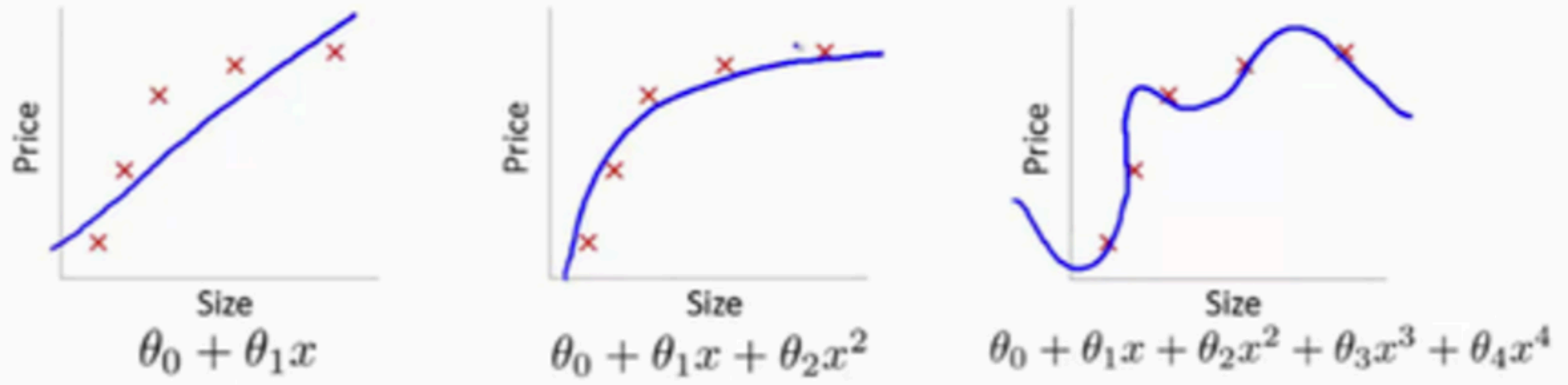
Find the β parameters that best fit:

$y = 1$ if $\beta_0 + \beta_1 x + \epsilon > 0$
$y = 0$, otherwise

Follows:

$$P(x) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x)}}$$

FITTING A MODEL



$\theta_0 + \theta_1 x$

$\theta_0 + \theta_1 x + \theta_2 x^2$

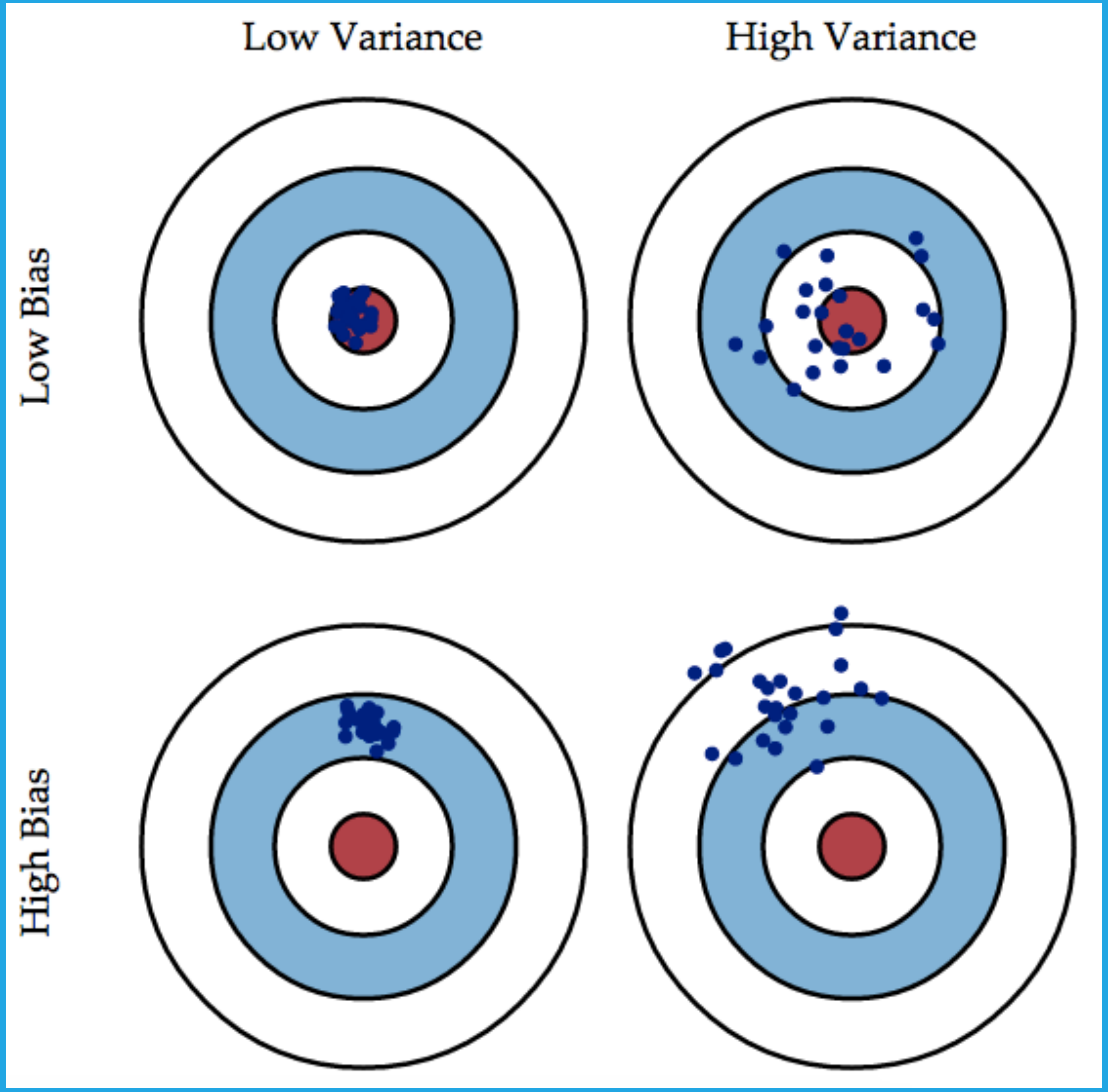
$\theta_0 + \theta_1 x + \theta_2 x^2 + \theta_3 x^3 + \theta_4 x^4$

High bias (underfit)

"Just right"

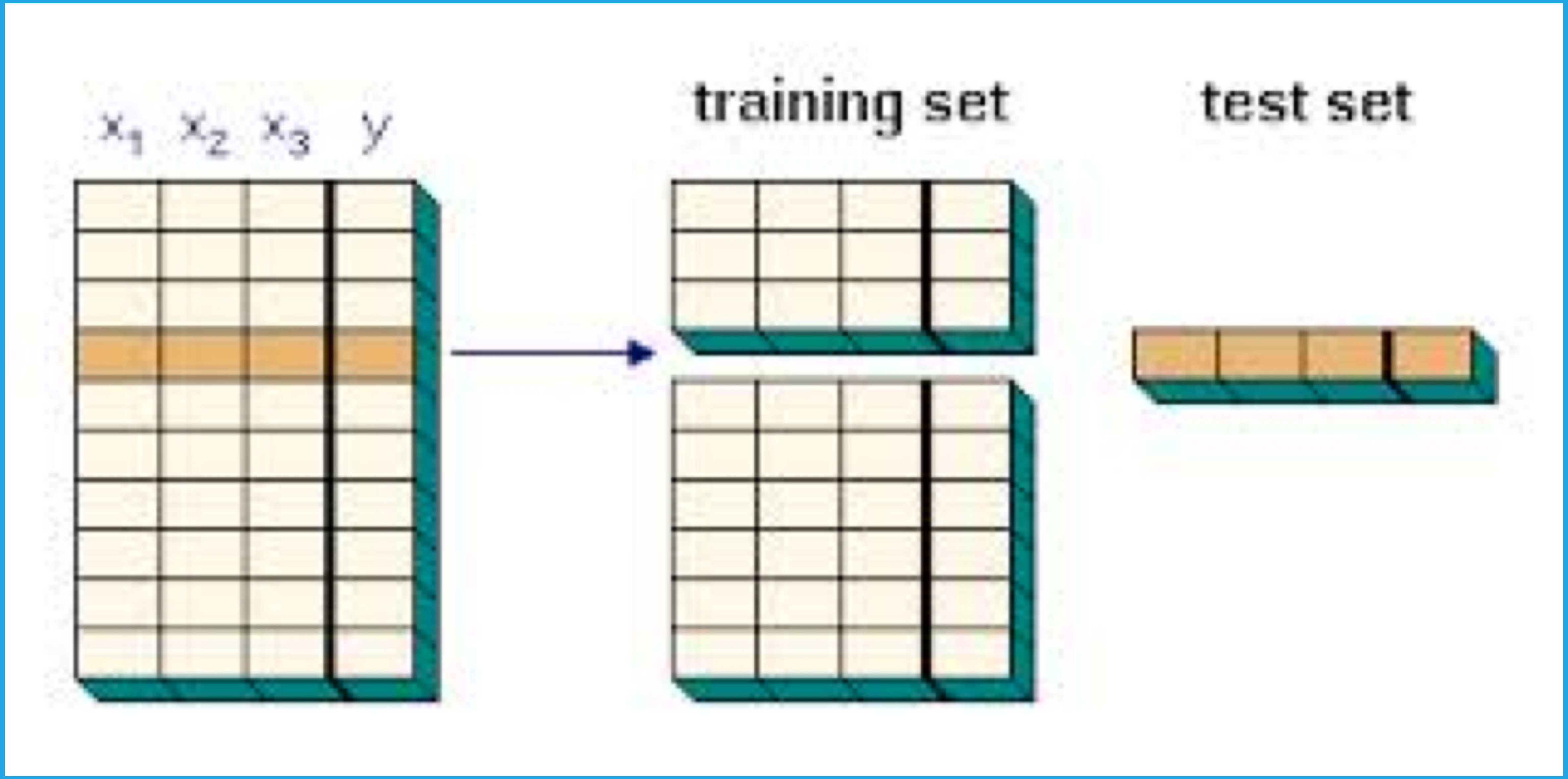
High variance (overfit)

BIAS-VARIANCE TRADEOFF



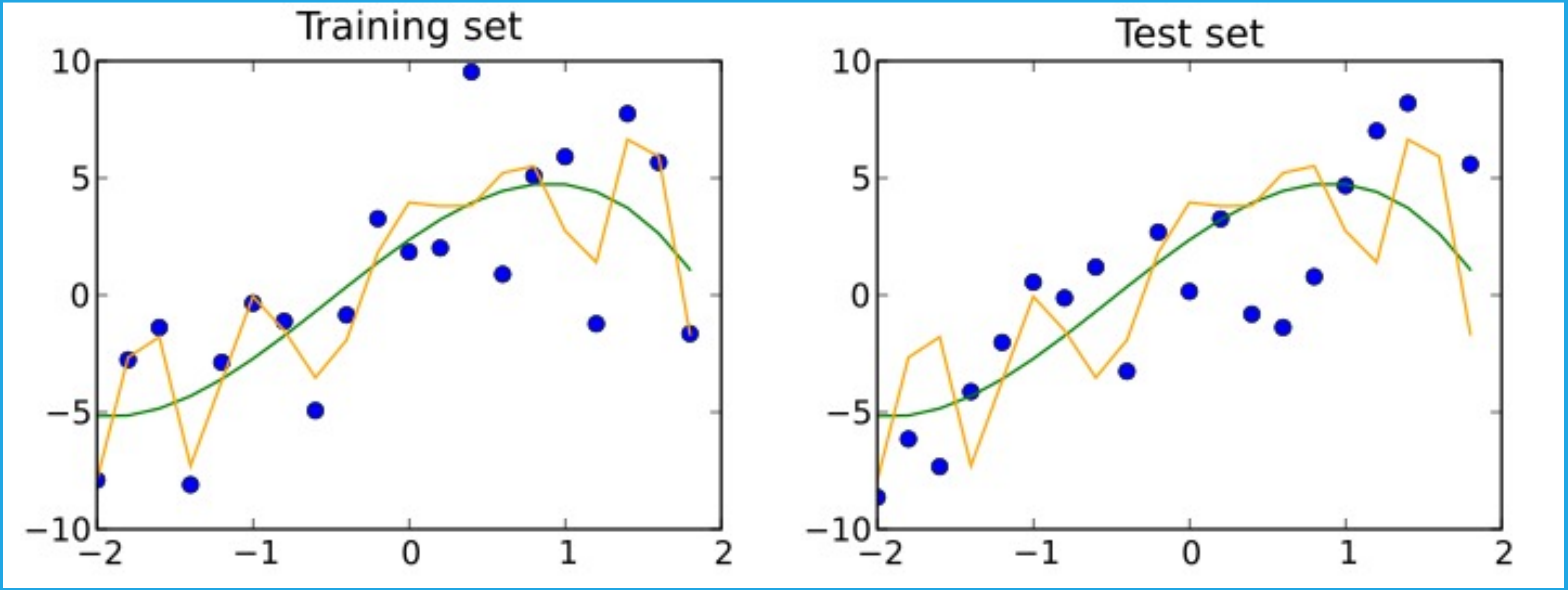
TRAIN AND TEST DATASETS

Split the Data - 80% / 20%

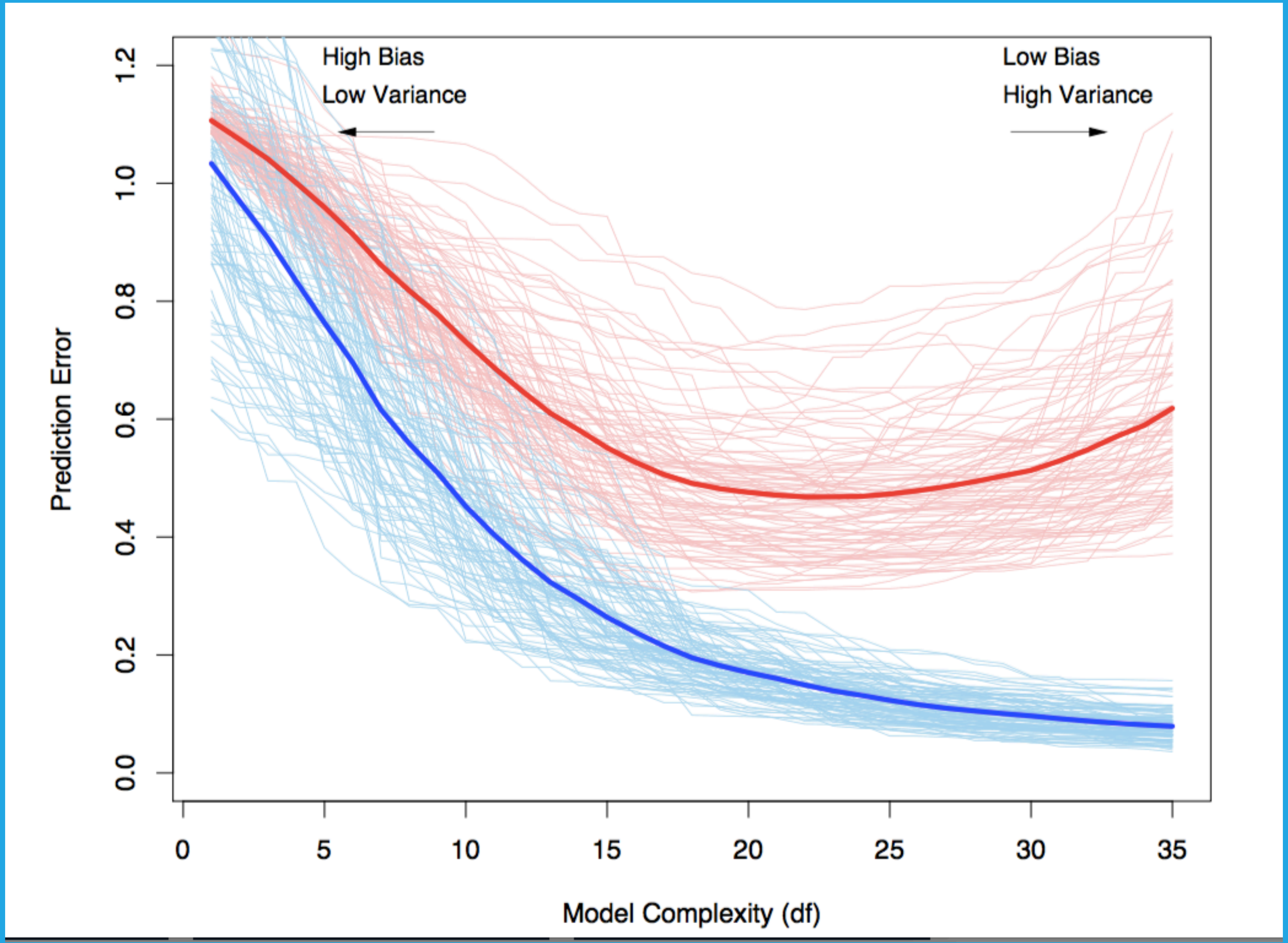


TRAIN AND TEST DATASETS

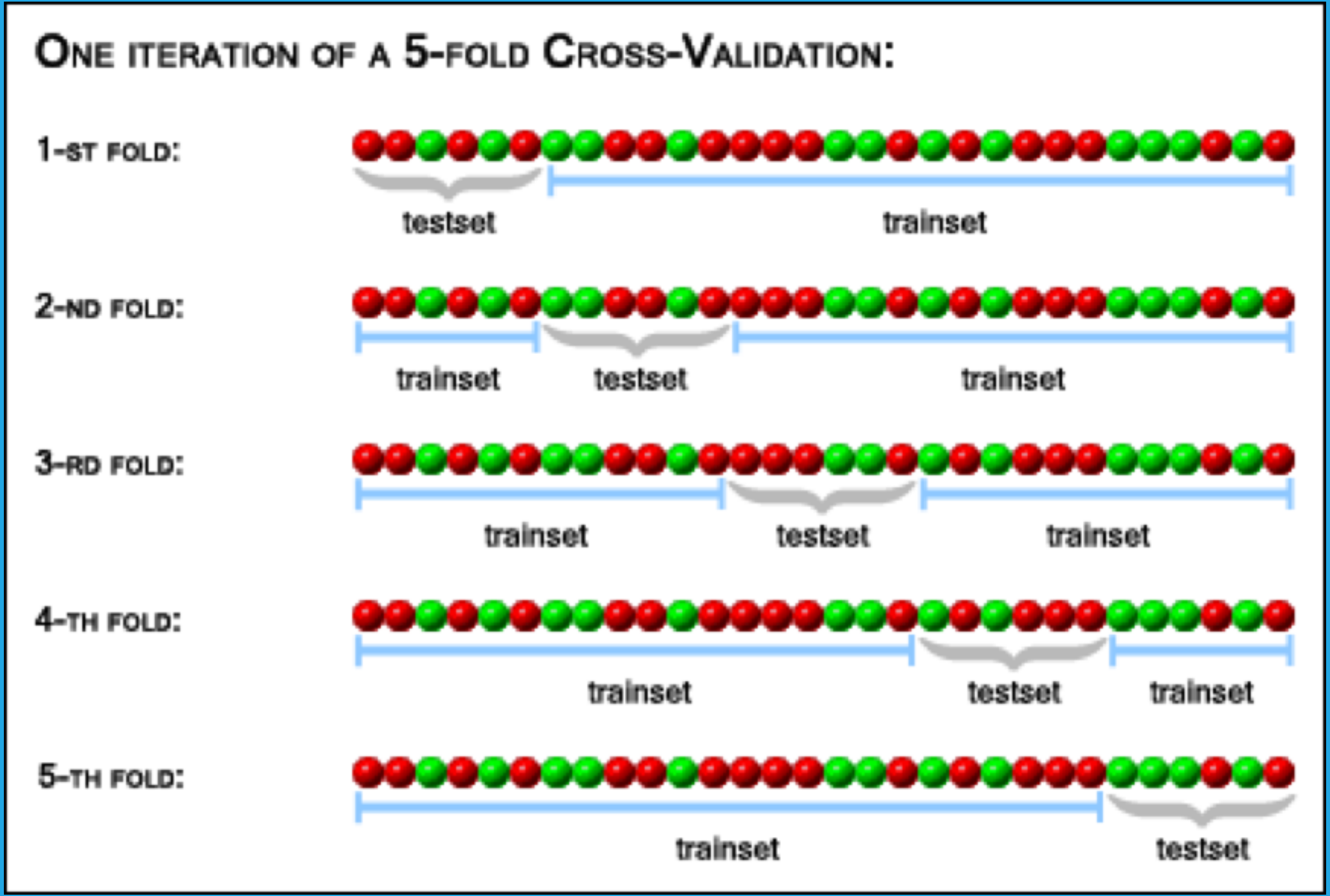
Measure the error on Test data



MODEL COMPLEXITY



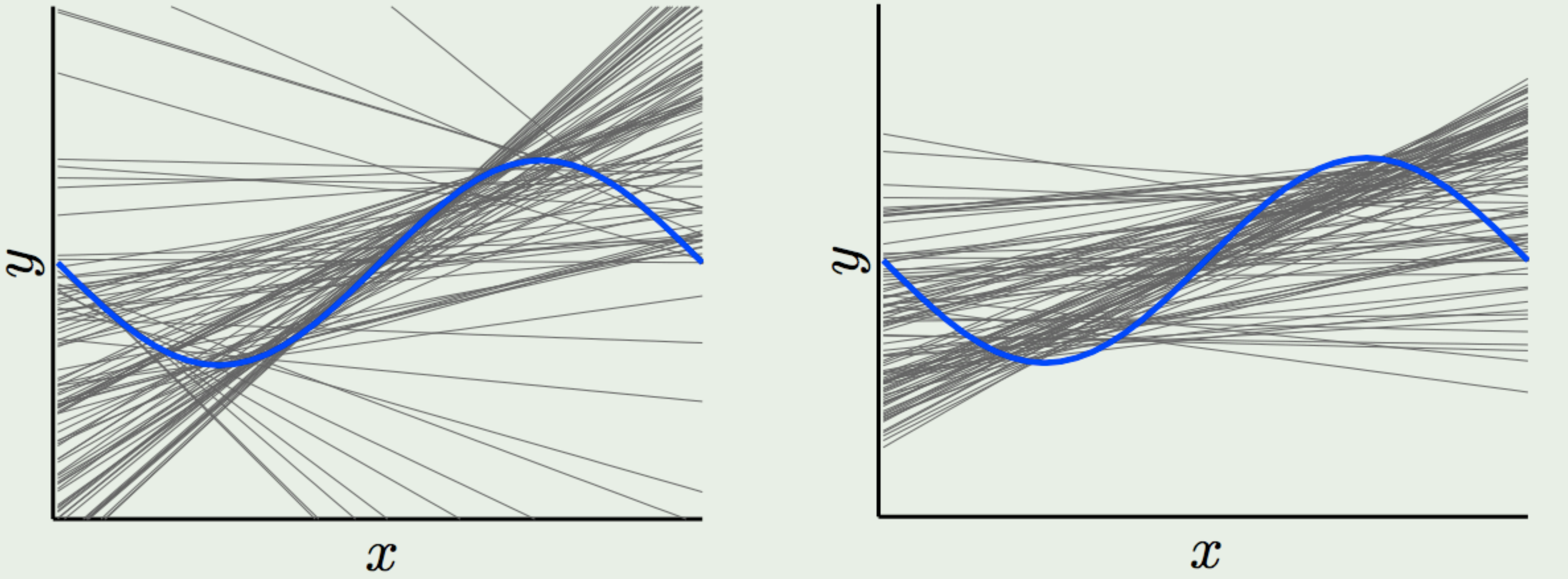
CROSS VALIDATION



ONE ITERATION OF A 5-FOLD CROSS-VALIDATION:

REGULARIZATION

Attempts to impose Occam's razor on the solution



without regularization

with regularization

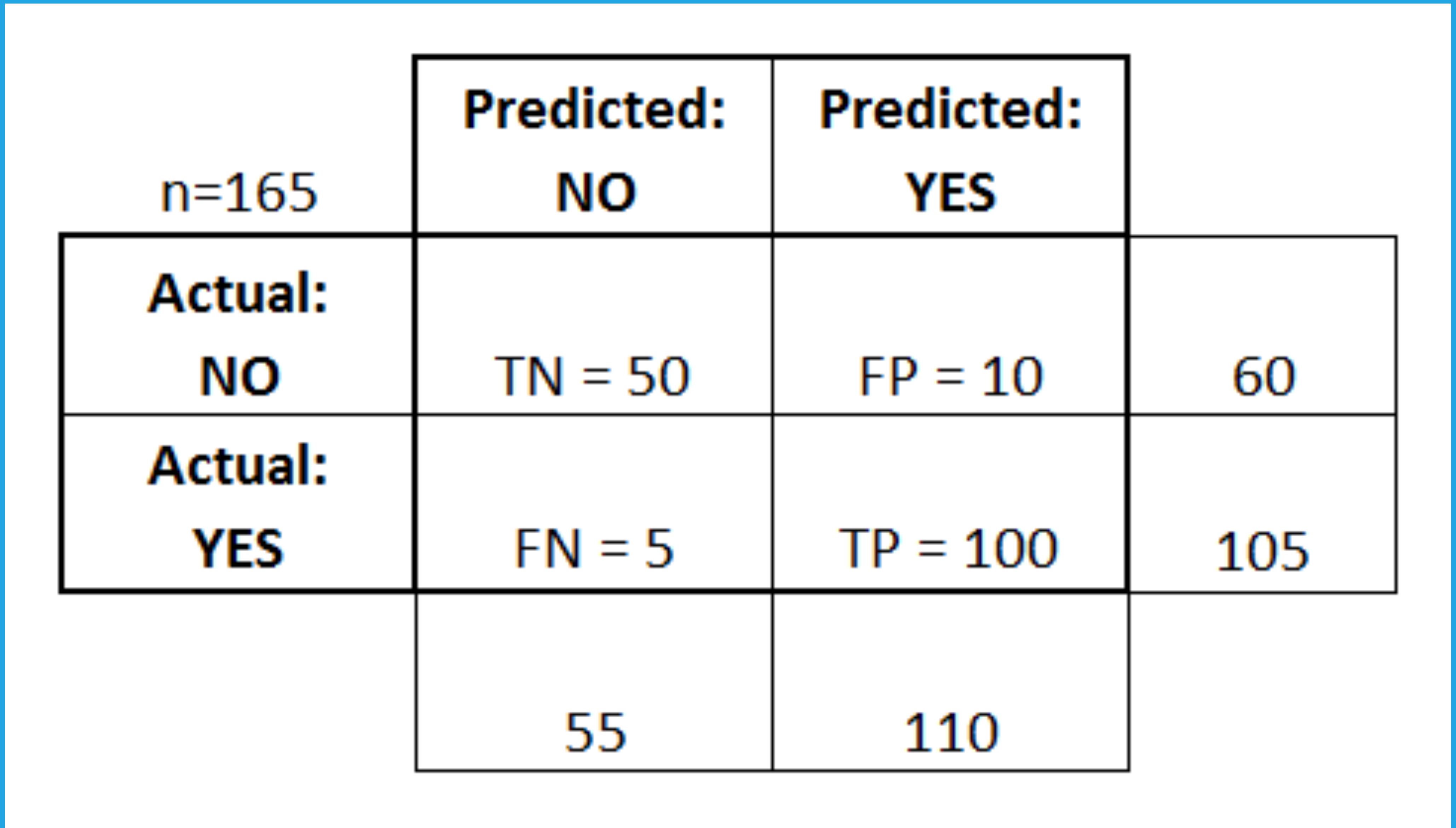
Model Evaluation

Mean Squared Error

$$MSE = 1/n \sum_{k=1}^{n} (y_i - \hat{y_i})^2$$

MODEL EVALUATION

Confusion Matrix



n=165	Predicted: NO	Predicted: YES	
Actual: NO	TN = 50	FP = 10	60
Actual: YES	FN = 5	TP = 100	105
	55	110	

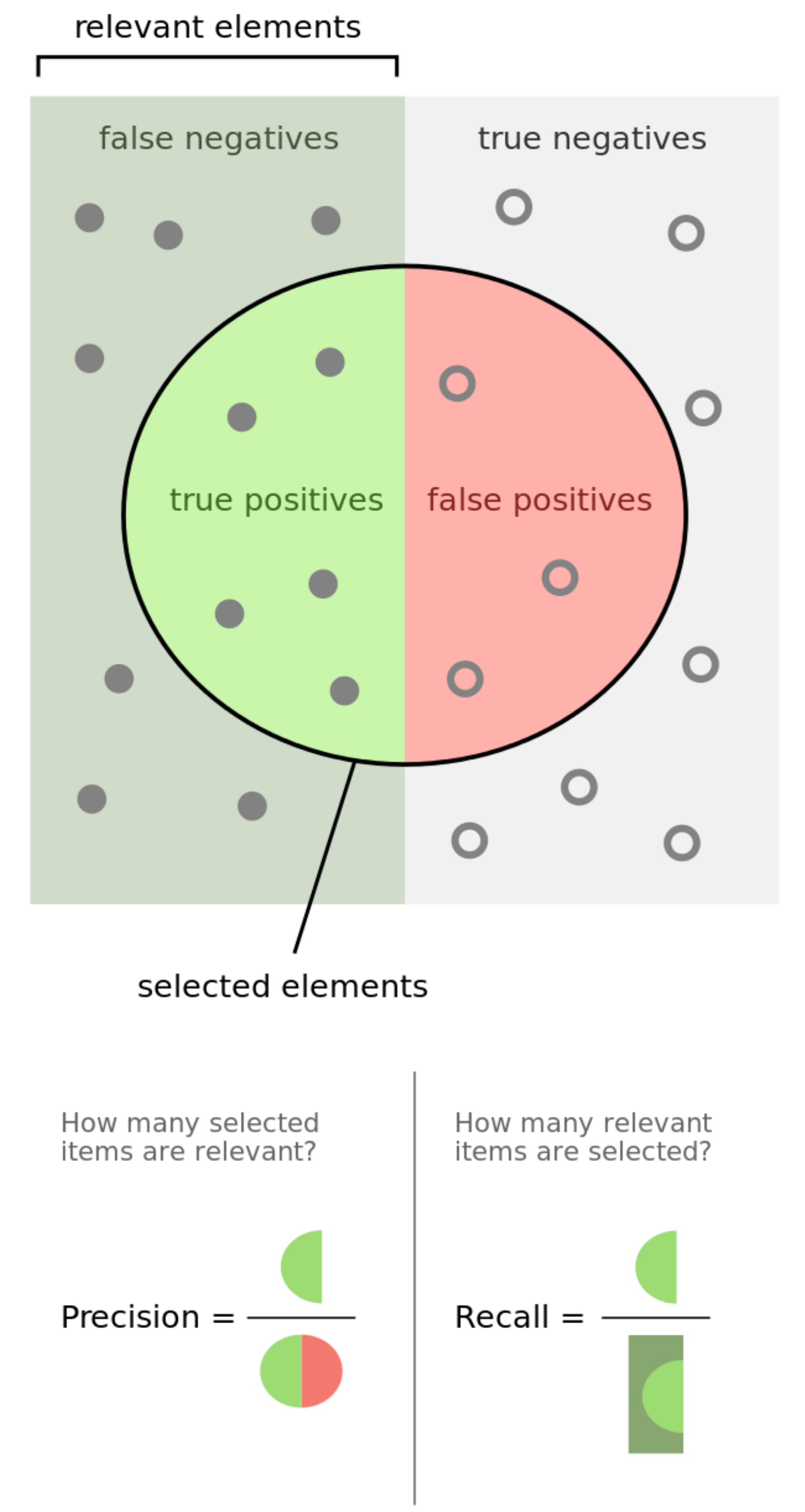
MODEL EVALUATION

Classification Metrics

Recall (TPR) = TP / (TP + FN)

Precision = TP / (TP + FP)

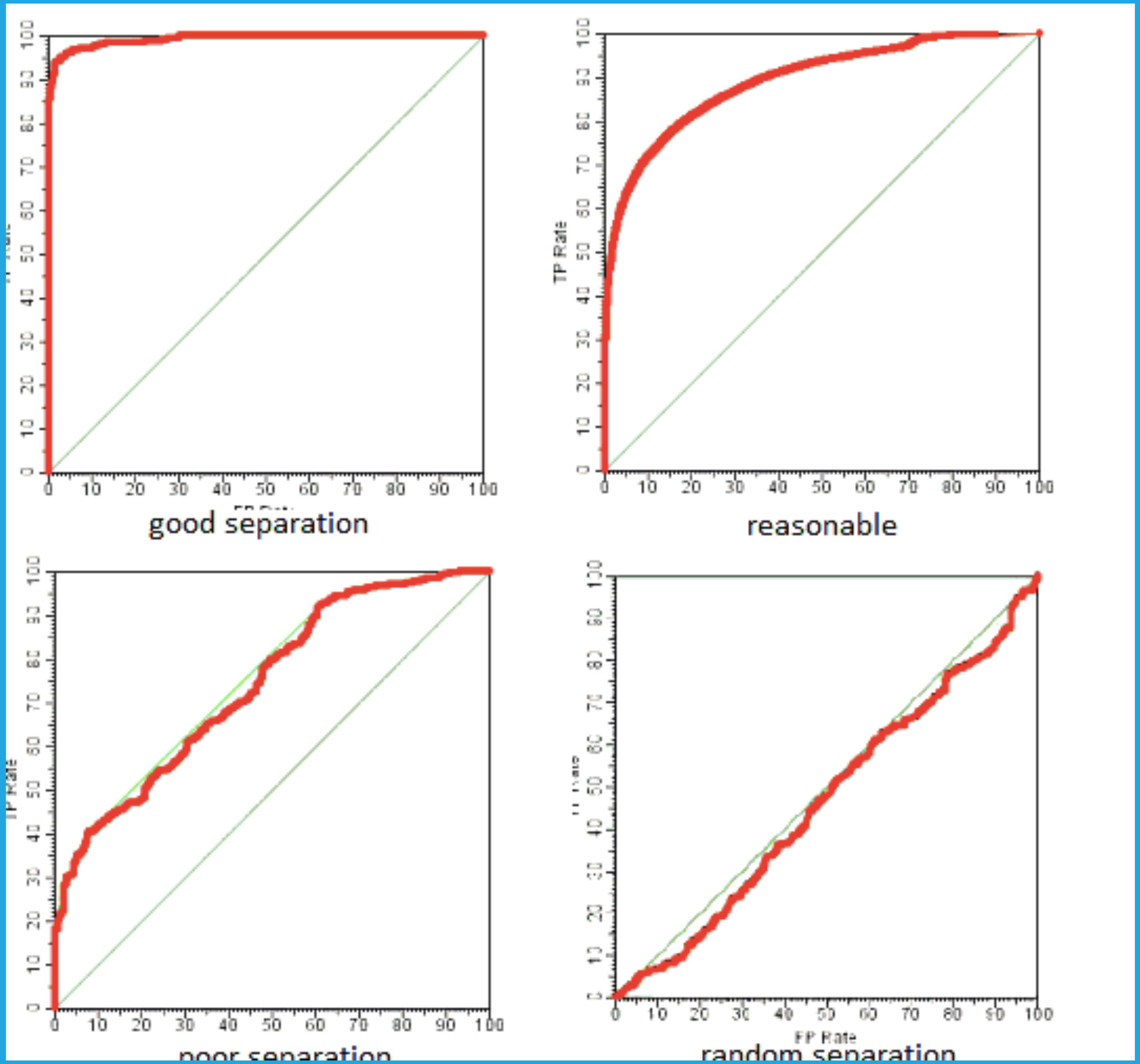
Specificity (TNR) = TN / (TN + FP)



MODEL EVALUATION

Receiver Operating Characteristic Curve

Plot of TPR vs FPR at different discrimination threshold



good separation

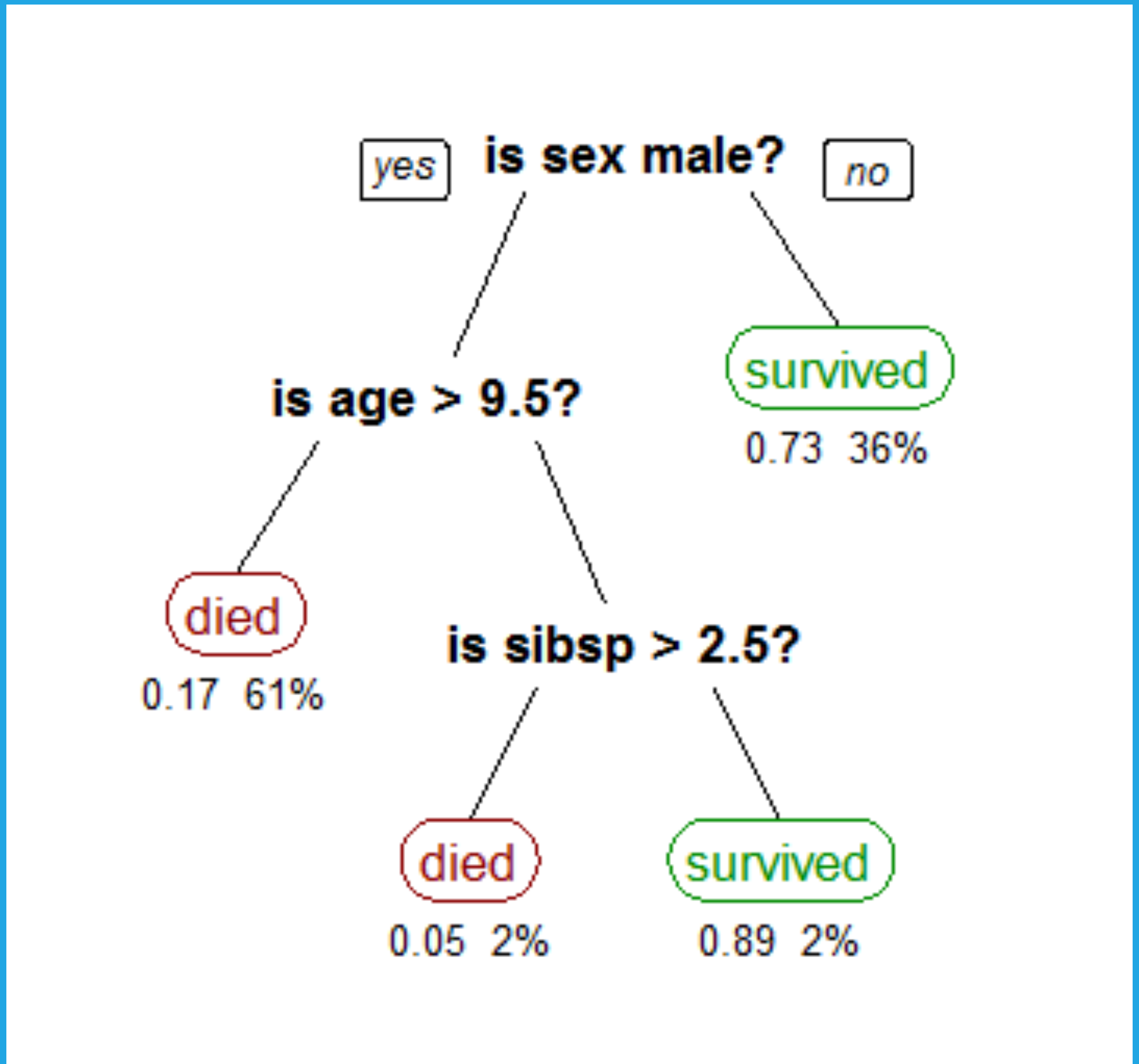
reasonable

poor separation

random separation

DECISION TREE

Example: Survivor on Titanic



Decision Tree

- Easy to interpret
- Little data preparation
- Scales well with data
- White-box model
- Instability – changing variables, altering sequence
- Overfitting

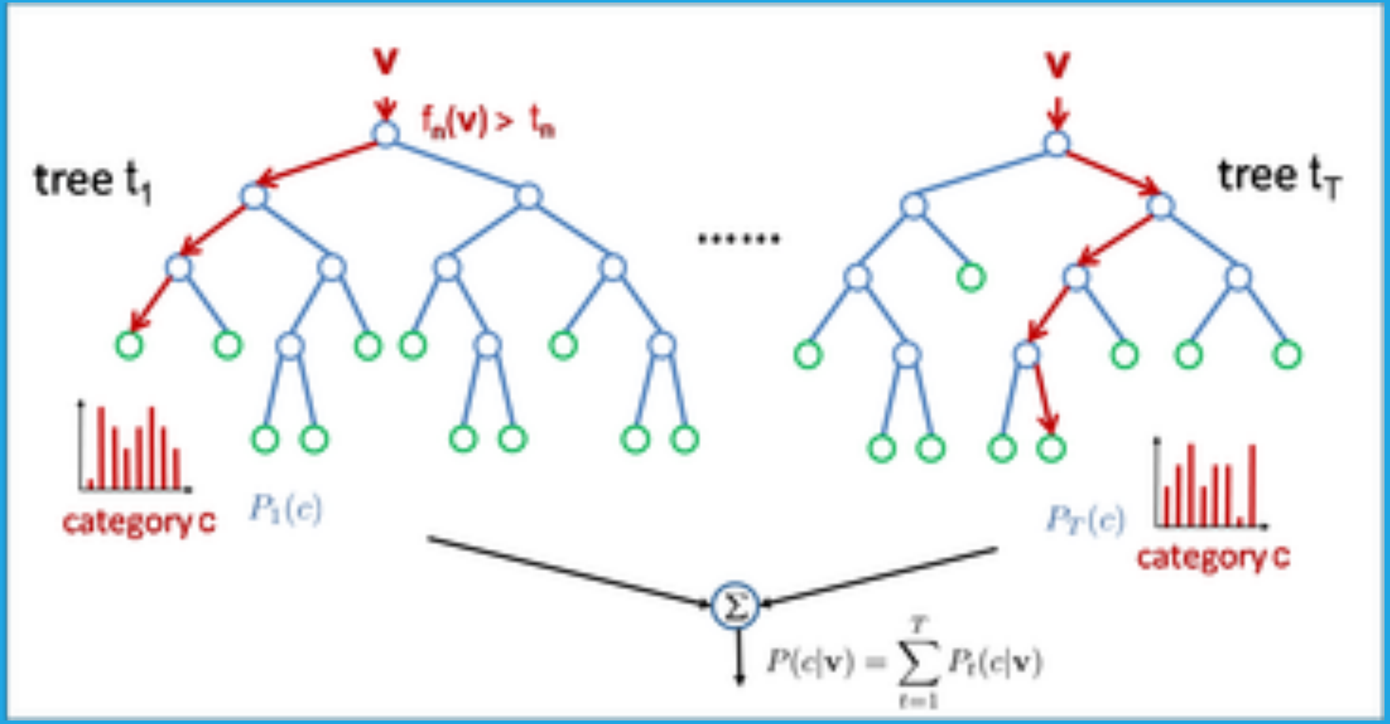
Bagging

- Also called bootstrap aggregation, reduces variance

- Uses decision trees and uses a model averaging approach

Random Forest

- Combines bagging idea and random selection of features.
- Similar to decision trees are constructed – but at each split, a random subset of features is used.



> “IF YOU TORTURE THE DATA ENOUGH, IT WILL CONFESS.”

Ronald Case

Challenges

- Data Snooping
- Selection Bias
- Survivor Bias
- Omitted Variable Bias
- Black-box model Vs White-Box model
- Adherence to regulations