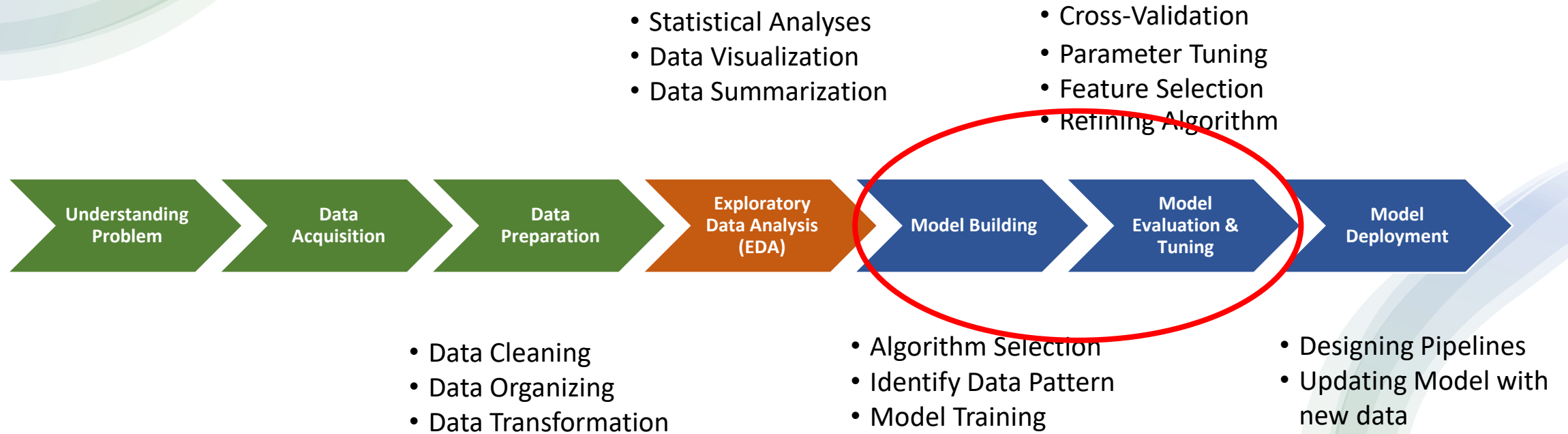


<https://tinyurl.com/DSinMed>

Core Processes in Data Science





Introduction to Supervised Learning

Machine Learning

Machine learning is a branch of artificial intelligence that enables computer programs to automatically learn and improve from experience. Machine learning algorithms learn from datasets, and then based on the patterns identified from the datasets, make predictions on unseen data.

Machine learning algorithms can be mainly categorized into two types:

- Supervised learning algorithms
- Unsupervised learning algorithms

Supervised & Unsupervised Learning

- **Supervised learning**

- Outcome variable is available
- Involves building a statistical model for predicting, or estimating, an *output* based on one or more *inputs*.

- **Unsupervised learning**

- No outcome variable (the true labels for the outputs are not known)
- There are inputs but no supervising output; nevertheless we can learn relationships and structure from such data.

Regression Versus Classification Problems

Supervised learning algorithms are divided further into two types:

- Regression
 - Quantitative outcome variable
 - Predict a continuous value, for example, the price of a house, blood pressure of a person, a student's score in a particular exam, etc.
- Classification
 - Qualitative outcome variable
 - Predict a discrete value such as whether or not a tumor is malignant, whether a student is going to pass or fail an exam, etc.

Linear Regression (cont.)

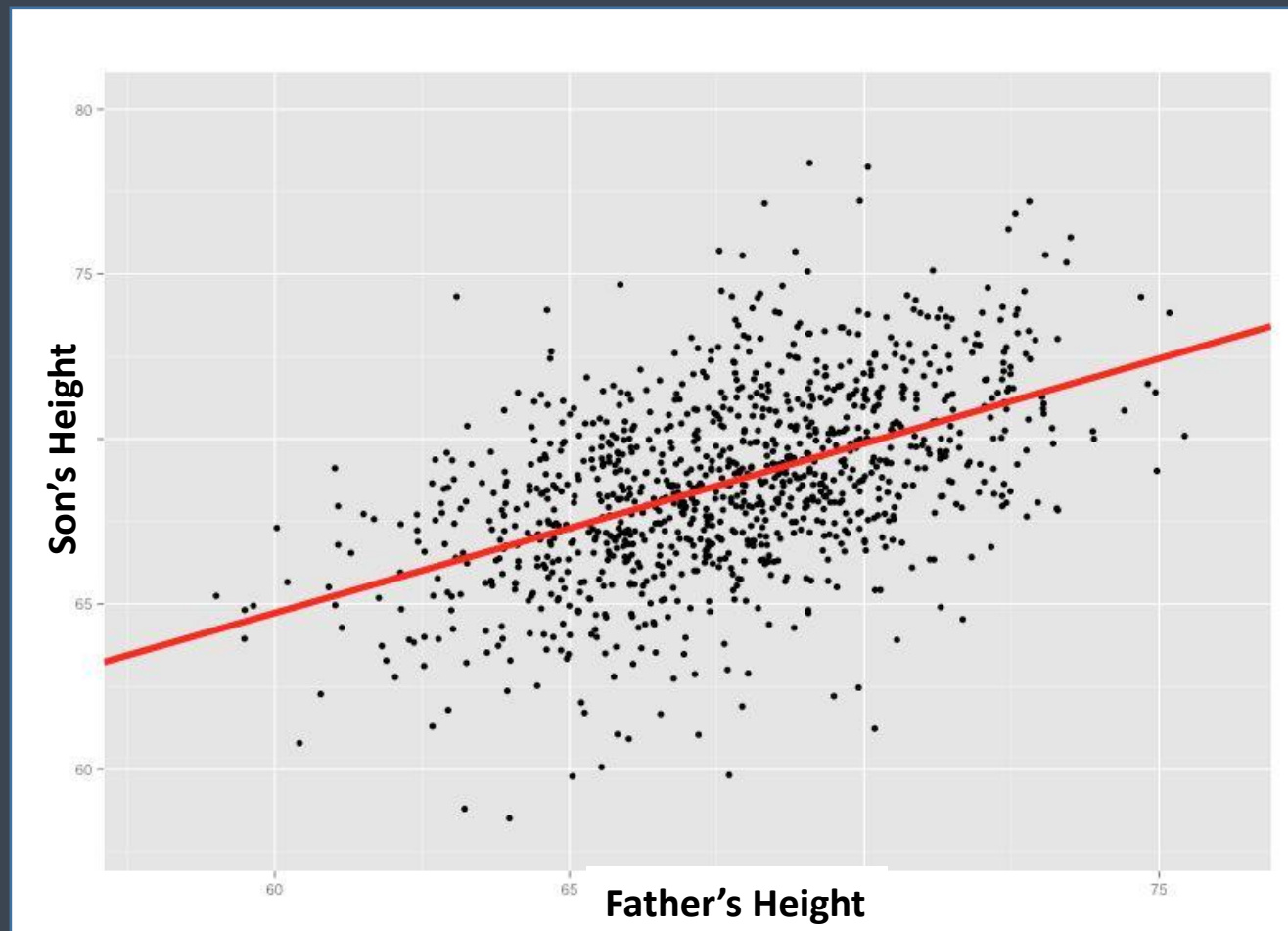
- Then we draw a line that minimize the distance between all the points and their distance to this line
- This line can be shown as:

$$\hat{y} = \overset{\text{intercept}}{\widehat{\beta}_0} + \overset{\text{slope}}{\widehat{\beta}_1}x^*$$

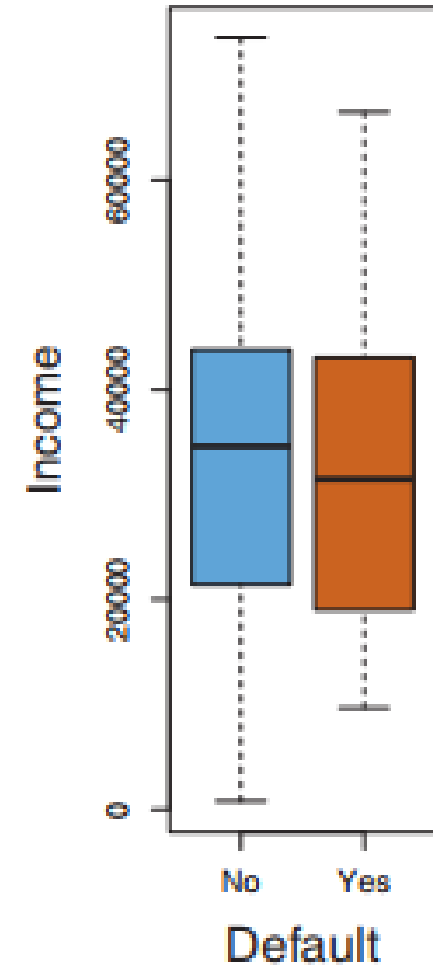
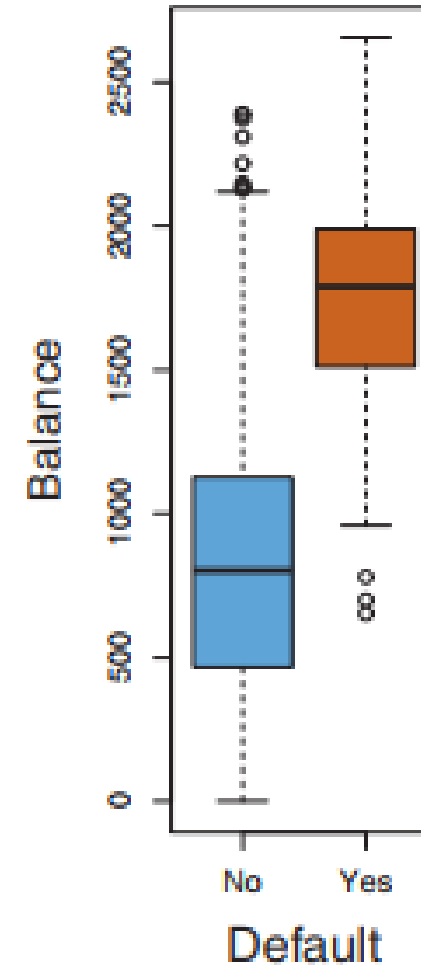
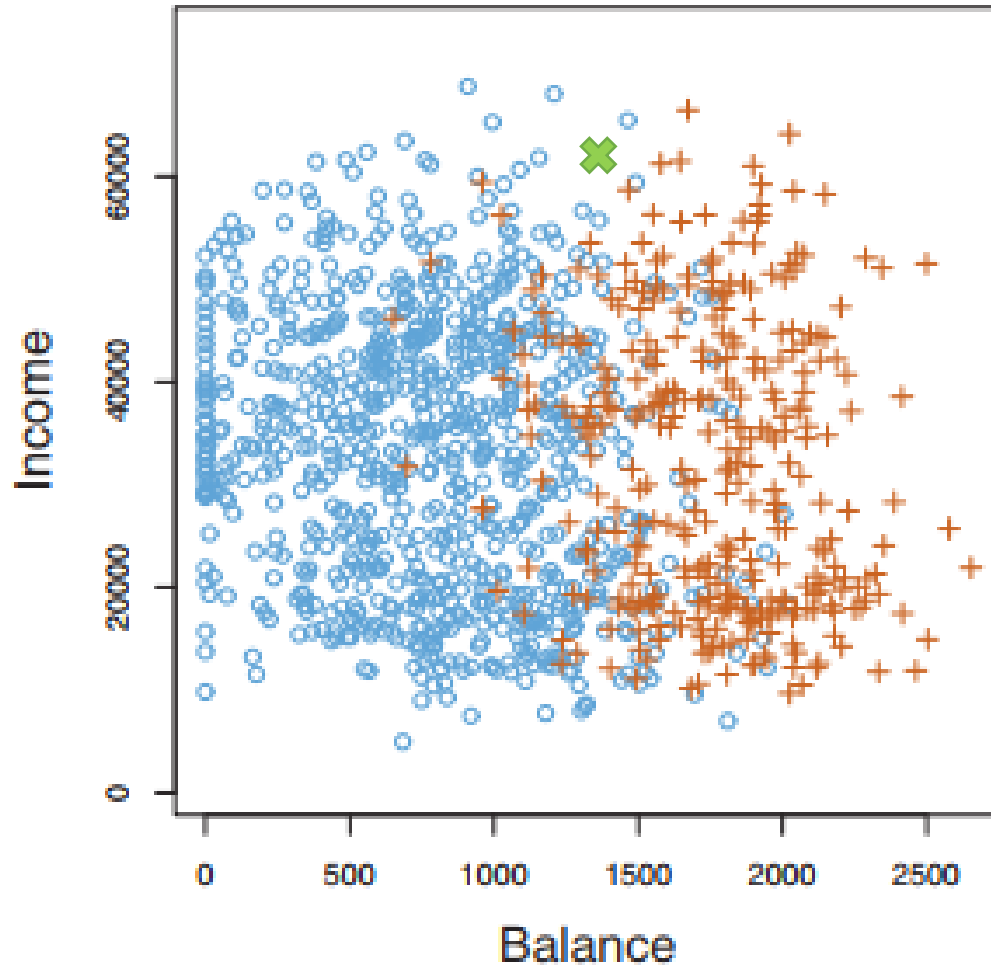
$$\widehat{\text{Son's Height}} = \widehat{\beta}_0 + \widehat{\beta}_1(\text{Father's Height})$$


$$\hat{f}(X) = \widehat{\beta}_0 + \widehat{\beta}_1x$$

* Also, $y = a+bx$, $y = ax+b$, $y = mx+c$



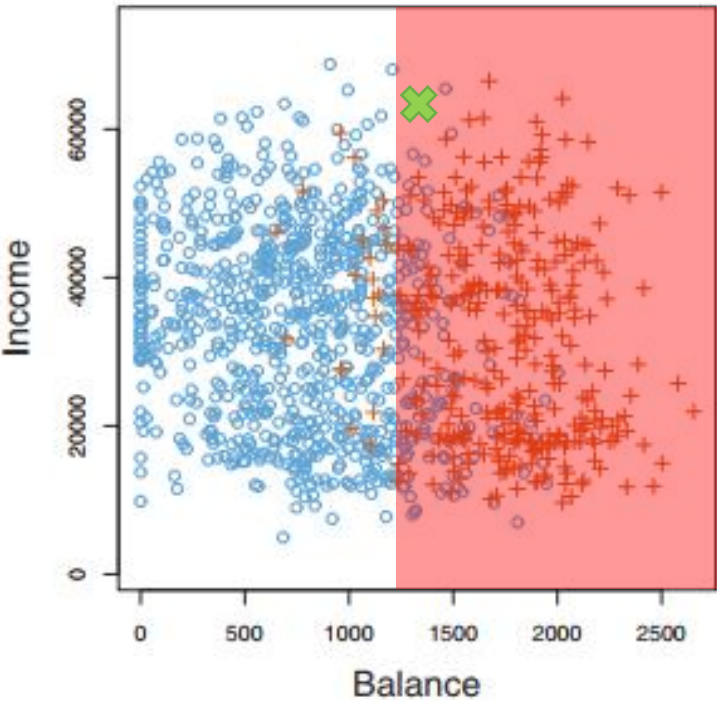
Classification Problem



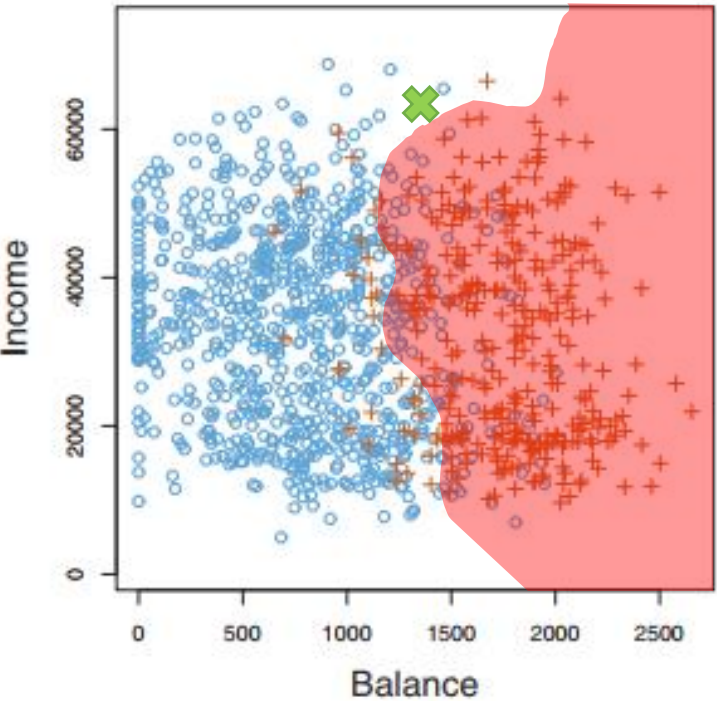
1. What will be our model to explain this data?
2. If we have a new data, can we make a prediction for that data?
()

Classification Problem

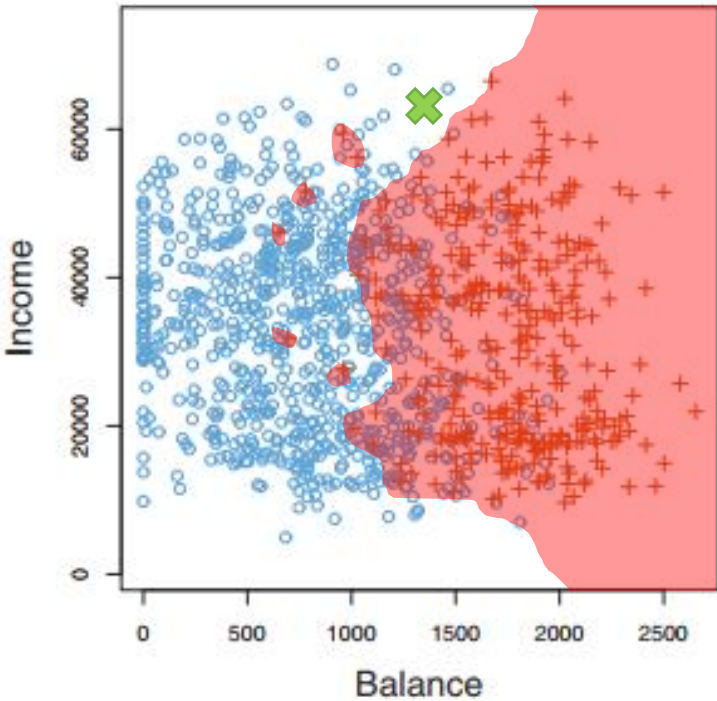
Model 1



Model 2



Model 3



Data Preparation for Machine Learning (ML)

Data preparation process:

- Cleaning
- Organizing
- Removing outliers
- Denoising
- Validation
- Standardization
- Transformation*
- etc.

Importance of data preparation:

- ML algorithms require specific data format*
- Garbage in, garbage out (GIGO)
- Modern ML models requires data normalization
- etc.

Types of Data & Transformation Process

Numerical data

- Discrete data
- Continuous data



Normalization

Scaling

Categorical data

- Nominal
- Ordinal



One-hot encoding

0, 1

Ordinal encoding

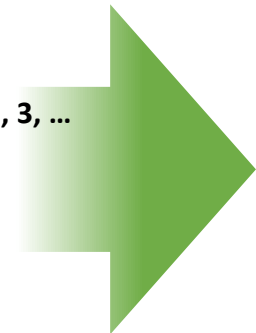
0, 1, 2, 3, ...

Textual data

Image/sound/
other data



Specific encoding



**Numeric
values**

One-Hot Encoding Example

ID	gender
1	M
2	F
3	M



ID	gender_F	gender_M
1	0	1
2	1	0
3	0	1

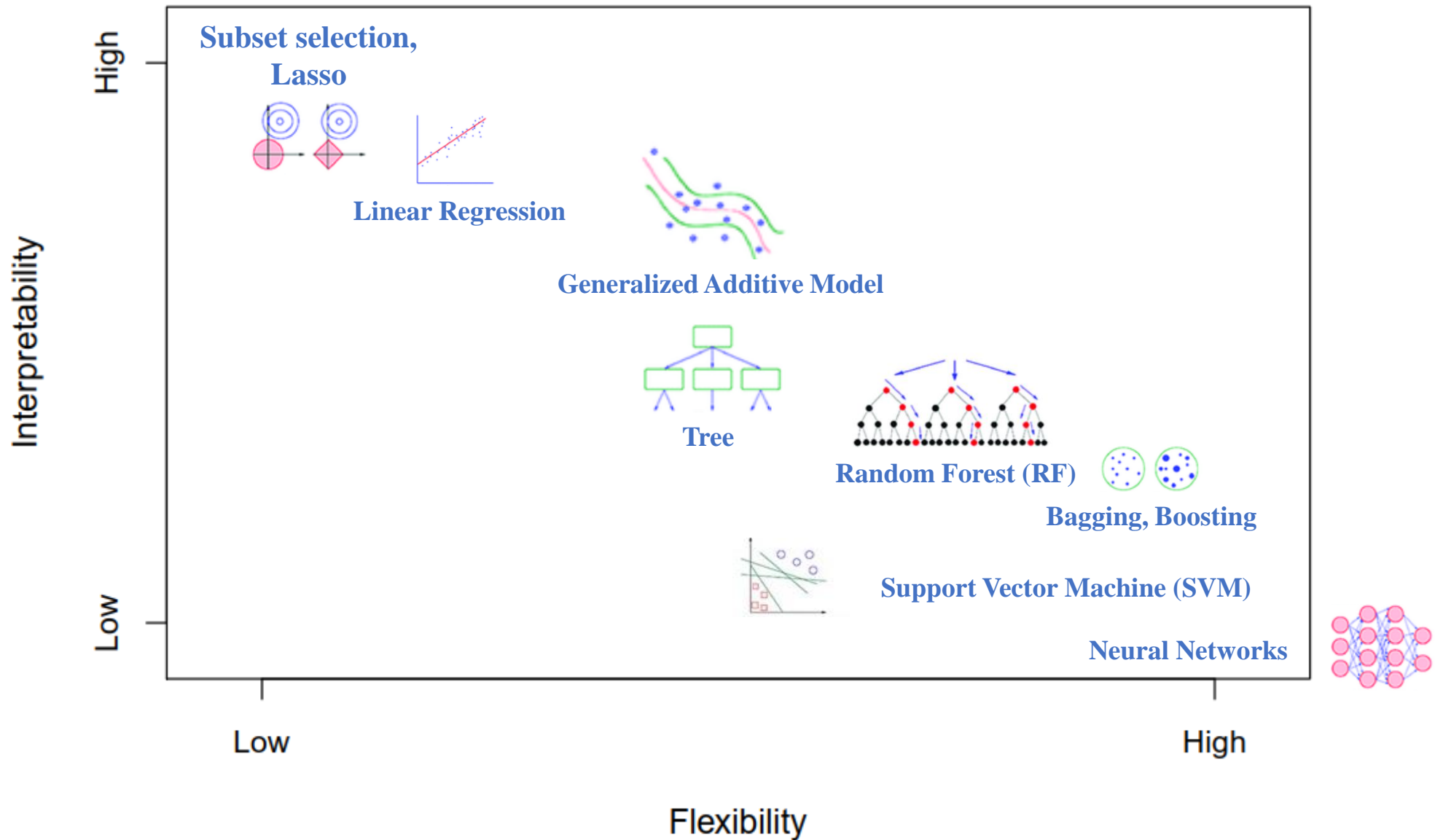
One-hot encoding

- get_dummies() in Pandas

ID	blood_gr
1	A
2	B
3	AB
4	O



ID	bg_A	bg_B	bg_AB	bg_O
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1



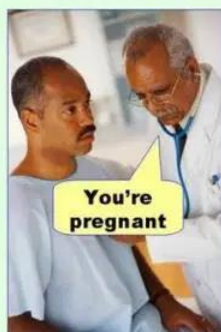
Evaluating Model Performance

- In regression problems
 - Mean squared error
 - Root mean squared error
 - R-squared
- In classification problems
 - Accuracy
 - Sensitivity
 - Specificity
 - Area under receiver operating characteristic curve

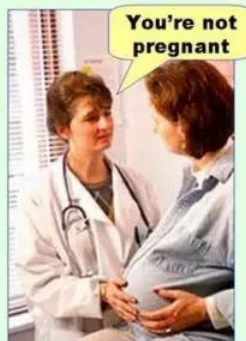
Confusion matrix

		Predicted class	
		<i>P</i>	<i>N</i>
Actual Class	<i>P</i>	True Positives (TP)	False Negatives (FN) Type 2 error
	<i>N</i>	False Positives (FP) Type 1 error	True Negatives (TN)

Type I error
(false positive)



Type II error
(false negative)



Accuracy (ACC)

$$ACC = (TP + TN) / (P + N)$$

Balanced Accuracy (BACC)

$$BACC = (TP/P + TN/N) / 2$$

F1 Score

is the harmonic mean of Precision and Sensitivity

$$F1 = 2TP / (2TP + FP + FN)$$

Matthews Correlation Coefficient (MCC)

$$\frac{TP \times TN - FP \times FN}{\sqrt{(TP + FP)(TP + FN)(TN + FP)(TN + FN)}}$$

Sensitivity or True Positive Rate (TPR)

eqv. with hit rate, recall

$$TPR = TP / P = TP / (TP + FN)$$

Specificity (SPC) or True Negative Rate (TNR)

$$SPC = TN / N = TN / (FP + TN)$$

Precision or Positive Predictive Value (PPV)

$$PPV = TP / (TP + FP)$$

Negative Predictive Value (NPV)

$$NPV = TN / (TN + FN)$$

Fall-out or False Positive Rate (FPR)

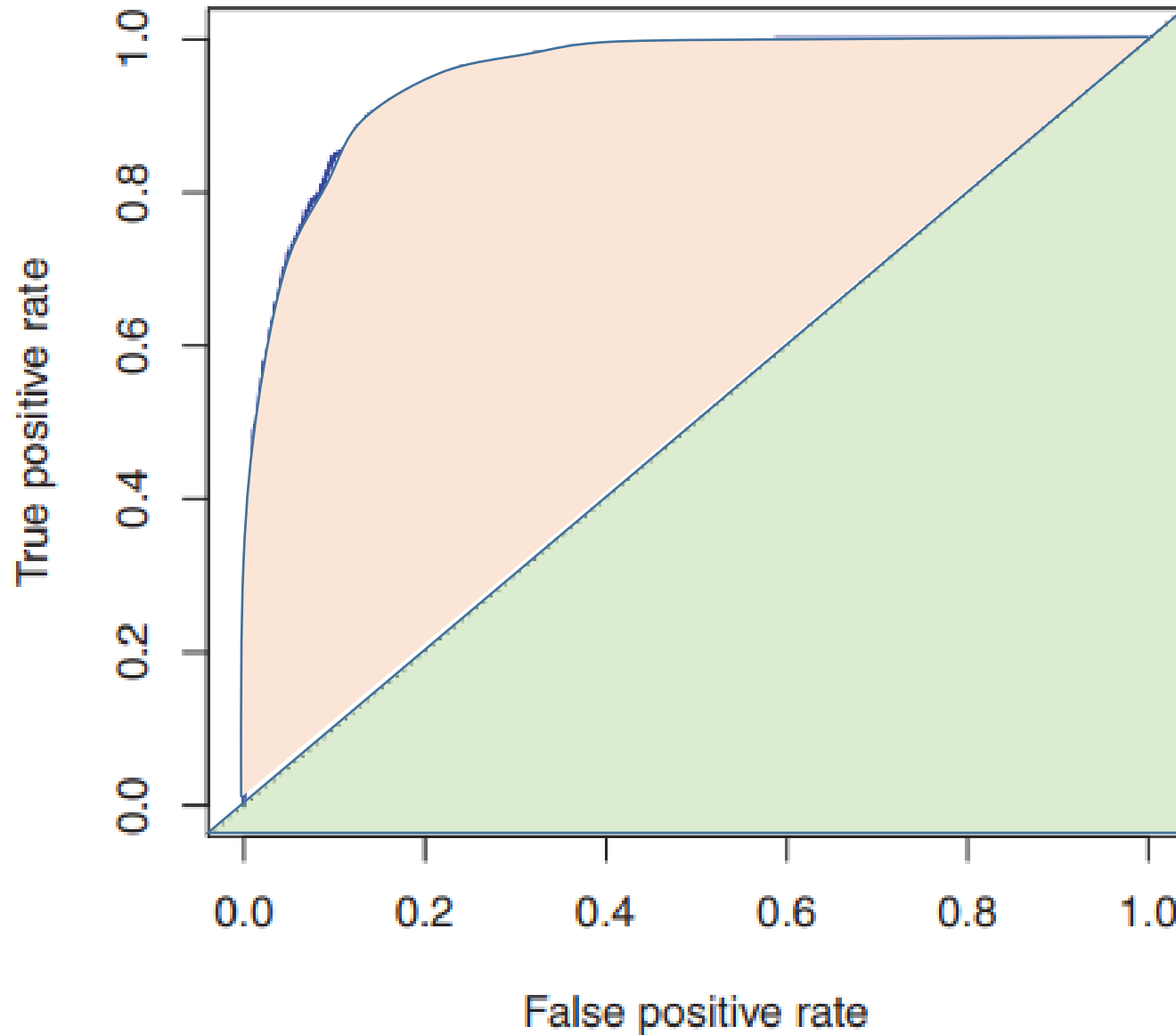
$$FPR = FP / N = FP / (FP + TN) = 1 - TNR$$



False Discovery Rate (FDR)

$$FDR = FP / (FP + TP) = 1 - PPV$$

Miss Rate or False Negative Rate (FNR)

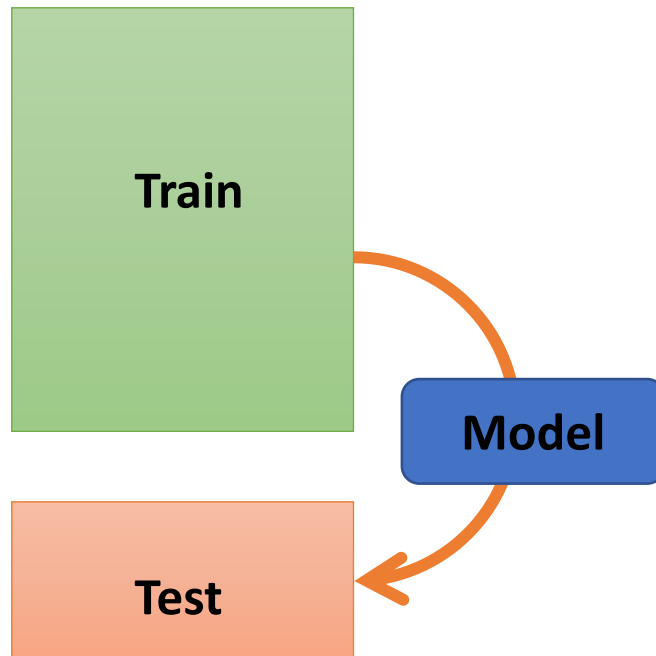
$$FNR = FN / (FN + TP) = 1 - TPR$$

ROC Curve**Area Under the roc Curve (AUC)**

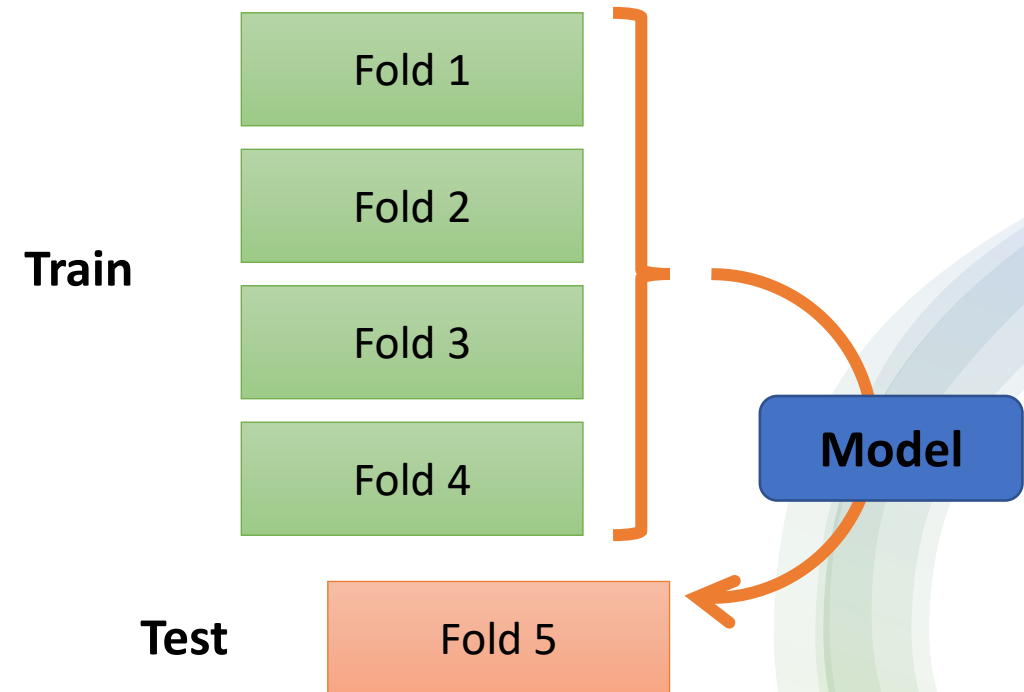
-  Random guess
-  Better than random guess

Model Evaluation Technique Using Cross-Validation

Hold-out



K-fold cross-validation (CV)



	Fold1	Fold2	Fold3	Fold4	Fold5
Iteration 1	Test	Train	Train	Train	Train
Iteration 2	Train	Test	Train	Train	Train
Iteration 3	Train	Train	Test	Train	Train
Iteration 4	Train	Train	Train	Test	Train
Iteration 5	Train	Train	Train	Train	Test