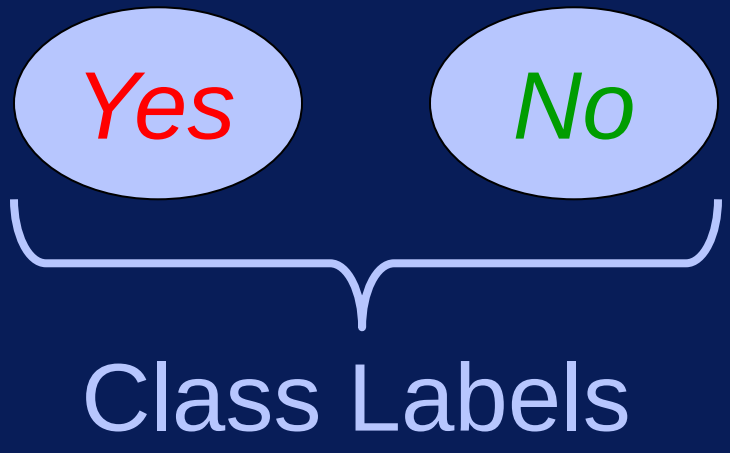
Metrics to Evaluate Model Performance

After this video you will be able to..

- Discuss how performance metrics can be used to evaluate models
- Name three model evaluation metrics
- Explain why accuracy may be misleading

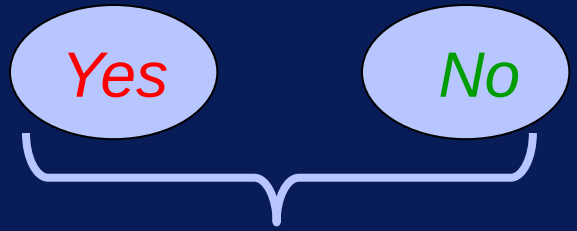
Classification

Is this animal a mammal?



Types of Classification Errors

Is this animal a mammal?



True Label	Predicted Label	Error Type
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

Accuracy Rate

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

$$\text{Accuracy Rate} = \frac{\text{\# correct predictions}}{\text{\# total predictions}}$$

$$= \frac{TP + TN}{TP + TN + FP + FN}$$

Error Rate

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

$$\text{Error Rate} = \frac{\text{\# incorrect predictions}}{\text{\# total predictions}}$$

$$= \frac{FN + FP}{TP + TN + FP + FN}$$

$$= 1 - \text{Accurate Rate}$$

True Label	Predicted Label
Yes	No
No	No
No	No
Yes	Yes
Yes	Yes
No	No
Yes	No
Yes	Yes
No	No
No	Yes

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

Classification Example

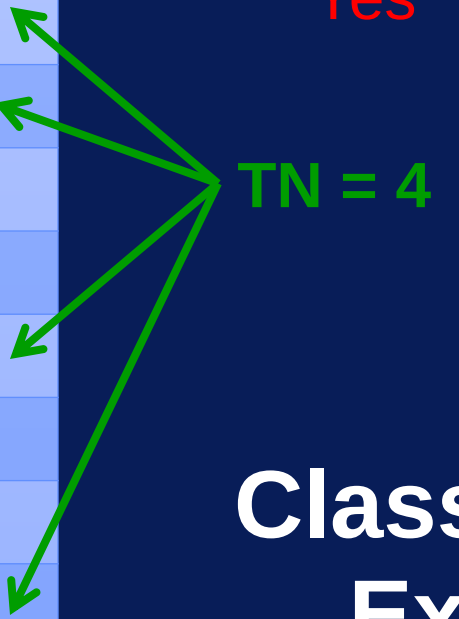
True Label	Predicted Label
Yes	No
No	No
No	No
Yes	Yes
Yes	Yes
No	No
Yes	No
Yes	Yes
No	No
No	Yes

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

Classification Example

True Label	Predicted Label
Yes	No
No	No
No	No
Yes	Yes
Yes	Yes
No	No
Yes	No
Yes	Yes
No	No
No	Yes

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)



Classification Example

Accuracy Rate

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

$$\text{Accuracy Rate} = \frac{\#\text{ correct predictions}}{\#\text{ total predictions}}$$

$$= \frac{TP + TN}{TP + TN + FP + FN}$$

$$= (3 + 4) / 10 = 7 / 10 = 0.7$$

Error Rate

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

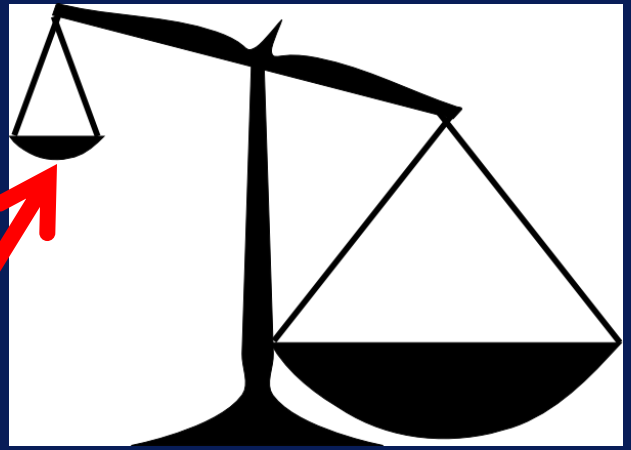
$$\text{Error Rate} = \frac{\#\text{ incorrect predictions}}{\#\text{ total predictions}}$$

$$= 1 - \text{Accuracy Rate}$$

$$= 1 - 0.7 = 0.3$$

Limitation with Accuracy

Is this tumor cancerous?



most are negative examples

very few positive examples

Class Imbalance Problem

Limitation with Accuracy

Is this tumor cancerous?

- Say 3% of samples are cancer
- If model always predicts non-cancer
  - Accuracy = 97%
  - But no cancer cases detected!

Precision & Recall

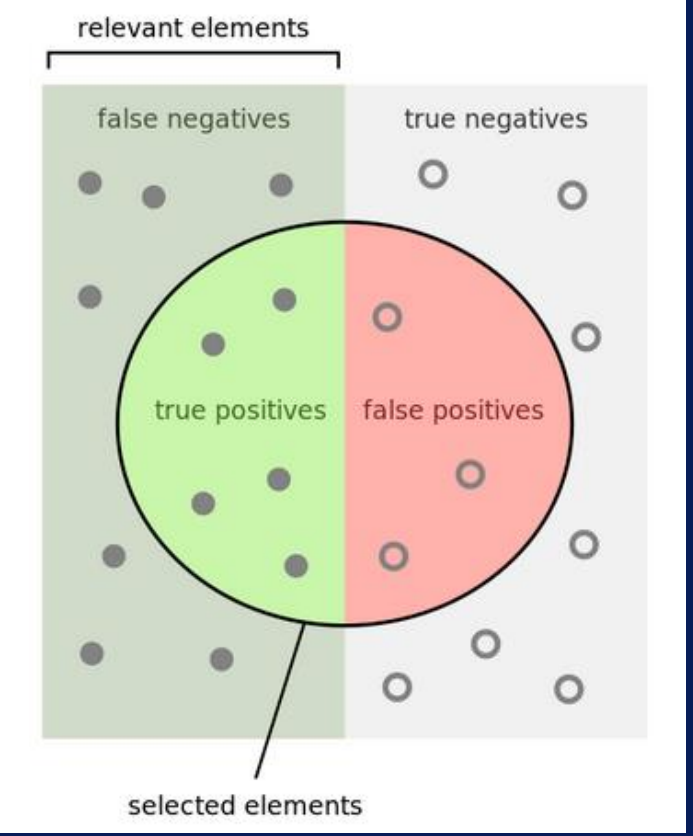
True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

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

← All samples with Predicted = Yes

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

← All samples with True = Yes



How many selected items are relevant?

$$\text{Precision} = \frac{\text{true positives}}{\text{selected elements}}$$

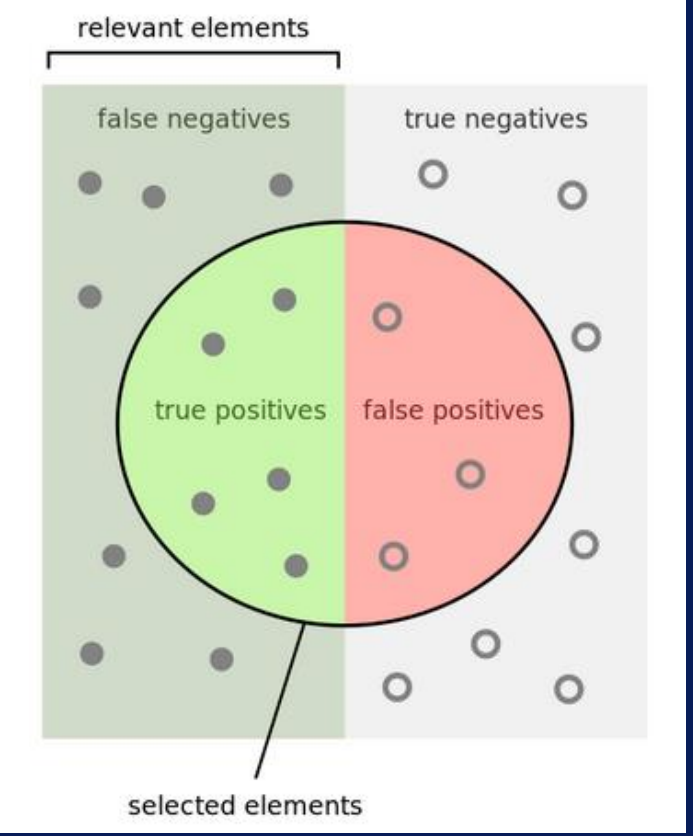
How many relevant items are selected?

$$\text{Recall} = \frac{\text{true positives}}{\text{relevant elements}}$$

Samples correctly predicted as Positive

Recall

Source: https://en.wikipedia.org/wiki/Precision_and_recall



How many selected items are relevant?

Precision =

How many relevant items are selected?

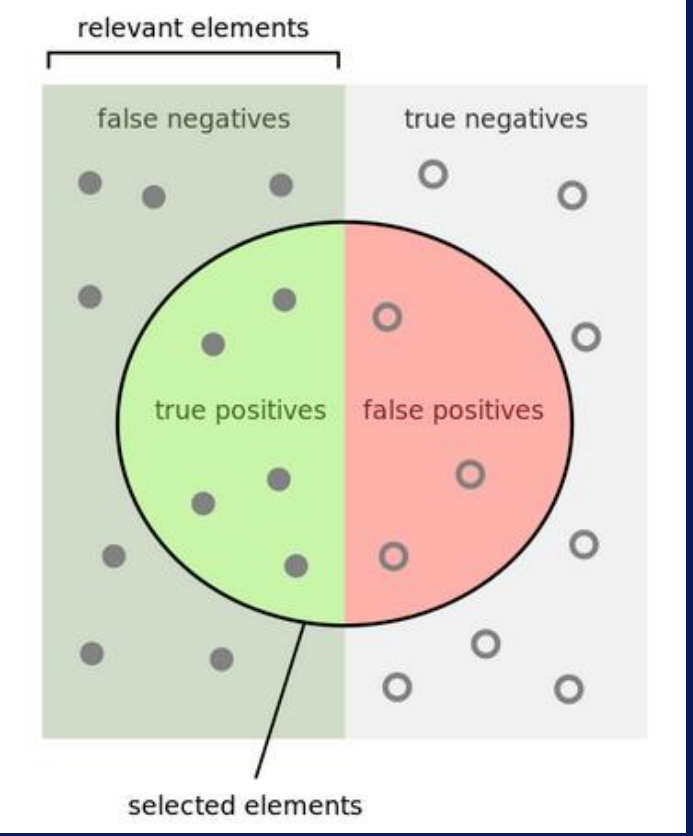
Recall =

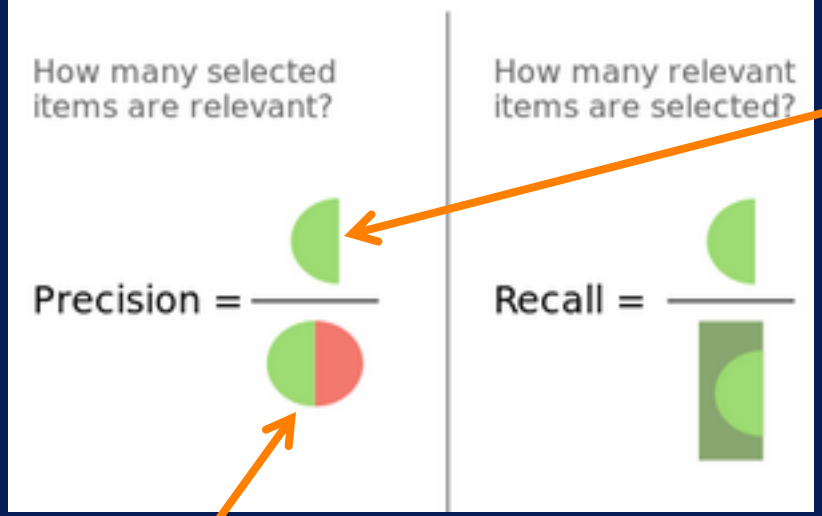
Samples correctly predicted as Positive

Samples actually Positive

Recall

Source: https://en.wikipedia.org/wiki/Precision_and_recall





Samples correctly predicted as Positive

Samples predicted as Positive

Recall

Source: https://en.wikipedia.org/wiki/Precision_and_recall

Precision & Recall

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

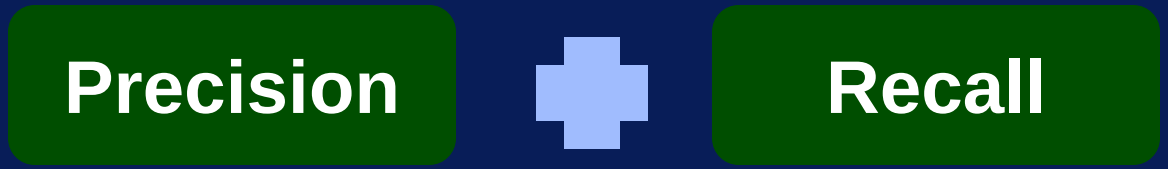
$$\text{Precision} = \frac{TP}{TP + FP} = \frac{\text{Positive samples correctly predicted}}{\text{All samples predicted as Positive}}$$

Measure of exactness

$$\text{Recall} = \frac{TP}{TP + FN} = \frac{\text{Positive samples correctly predicted}}{\text{All samples with true label Positive}}$$

Measure of completeness

Precision & Recall



- Use together
- Goal: Maximize both

F-Measure

Precision + **Recall**

$$F_1 = 2 * \frac{\text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

- F_1 : evenly weighted
- F_2 : weights Recall more
- $F_{0.5}$: weights Precision more

Evaluation Metrics

True	Predicted	Error
Yes	Yes	True Positive (TP)
No	No	True Negative (TN)
No	Yes	False Positive (FP)
Yes	No	False Negative (FN)

Accuracy Rate

Error Rate

Precision & Recall

F_1-Measure