

# Classification error metric

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# Choosing the right error measurement

- You are asked to build a classifier for leukemia
- **Training data:** 1% patients with leukemia, 99% healthy
- **Measure accuracy:** total % of predictions that are correct

# Choosing the right error measurement

- You are asked to build a classifier for leukemia
- **Training data:** 1% patients with leukemia, 99% healthy
- **Measure accuracy:** total % of predictions that are correct
- Build a simple model that always predicts "healthy"
- Accuracy will be still 99%...

# Confusion matrix

- Confusion matrix

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

# Confusion matrix

- Confusion matrix

	Predicted Positive	Predicted Negative	
Actual Positive	True Positive (TP)	False Negative (FN)	← Type II Error
Actual Negative	False Positive (FP)	True Negative (TN)	

↑  
Type I Error

The diagram shows a 2x2 confusion matrix. The columns are labeled 'Predicted Positive' and 'Predicted Negative'. The rows are labeled 'Actual Positive' and 'Actual Negative'. The cells contain: True Positive (TP) in blue, False Negative (FN) in red, False Positive (FP) in red, and True Negative (TN) in blue. An arrow points from the text 'Type II Error' to the False Negative (FN) cell. Another arrow points from the text 'Type I Error' to the False Positive (FP) cell.

# Confusion matrix (continued)

- Confusion matrix - accuracy

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

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

# Confusion matrix (continued)

- Confusion matrix – recall or sensitivity

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

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

A negative result in a test with high sensitivity is useful for ruling out disease. A high sensitivity test is reliable when its result is negative, since it rarely misdiagnoses those who have the disease

# Confusion matrix (continued)

- Confusion matrix - specificity

$$\text{Specificity} = \frac{\text{TN}}{\text{FP} + \text{TN}}$$

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

A positive result in a test with high specificity is useful for ruling in disease. The test rarely gives positive results in healthy patients. A positive result signifies a high probability of the presence of disease.



# Confusion matrix (continued)

- Confusion matrix - precision

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

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

# Confusion matrix (continued)

- Confusion matrix – precision
  - a computer program for recognizing dogs
    - 10 cat images and 12 dog images
    - The program identifies 8 dogs -- actually, 5 dogs (true positive) and 3 cats (false positive)
    - Precision  $5/8$  (true positive / selected items)
    - Recall  $5/12$  (true positive / all relevant items)
  - Search engine
    - Return 30 pages
    - Only 20 are relevant (true positive) / fail to return 40 additional pages
    - Precision  $20/30$
    - Recall  $20/60$

# Confusion matrix (continued)

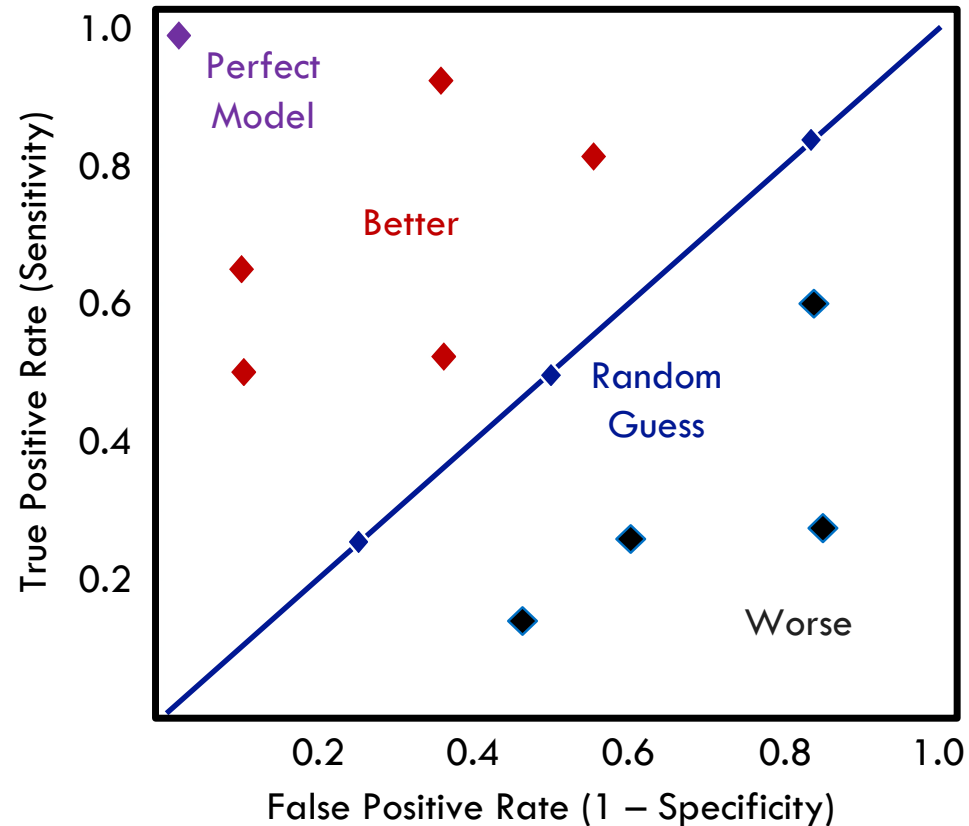
- Confusion matrix – F1 score

$$F1 = 2 \frac{\text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

# Receiver operating curve (ROC)

- Evaluation of model at all possible thresholds



# Area under the curve

- Measures total area under ROC curve

