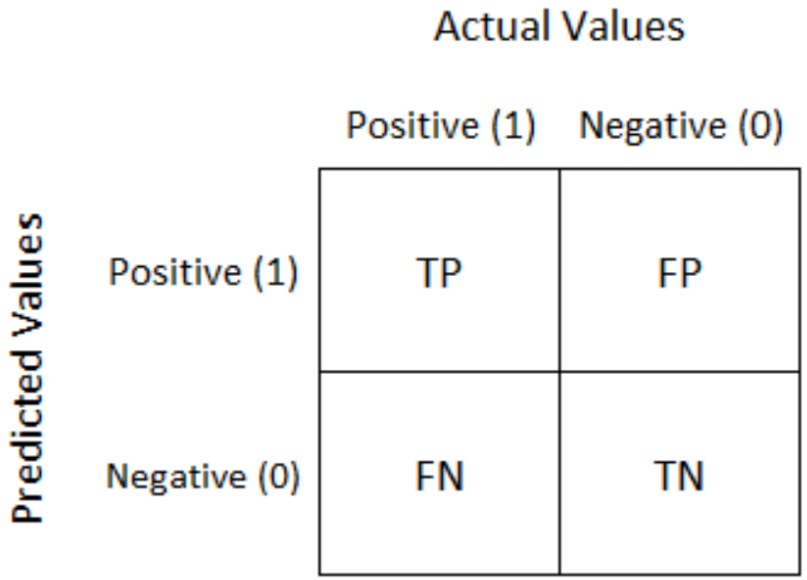
CSD3186
Machine Learning

Classification – Performance Measurement

TP FP FN TN



- True Positive
  - You predicted positive and it's true(correct)
- False Positive
  - You predicted positive and it's false(wrong)
  - Type 1 Error: false alarm
- False Negative
  - You predicted negative and it's false(wrong)
  - Type 2 Error: miss
- True Negative
  - You predicted negative and it's true(correct)

Confusion Matrix

- Binary-class classification problem

y	y pred	output for threshold 0.6
0	0.5	0
1	0.9	1
0	0.7	1
1	0.7	1
1	0.3	0
0	0.4	0
1	0.5	0

TP 2	FP 1
FN 2	TN 2

Beyond Accuracy - Recall Precision

- Binary-class classification problem

$$\text{Accuracy} = \frac{TP + TN}{Total}$$

- Imbalanced classification problem
  - Dataset: 100 samples, 1 positive, 99 negative
  - Model simply label any sample as negative
  - Accuracy is 99%, would you buy the model?
- Metrics

$$\text{Precision} = \frac{TP}{TP + FP} \qquad \text{Sensitivity/Recall} = \frac{TP}{TP + FN}$$

Imbalanced data

- Dataset: 100 samples, 1 positive, 99 negative
  - Model simply label any sample as negative
    - Accuracy is 99%
    - Precision is 0
    - Recall is 0
  - Model simply label any sample as positive
    - Accuracy is 1%
    - Precision is 1%
    - Recall is 1.0

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

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

Combining Precision and Call

- F1 score is the harmonic mean of precision and recall taking both metrics into account

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

- The use of the harmonic mean instead of a simple average because it punishes extreme values.
  - A classifier with a precision of 1.0 and a recall of 0.0 has a simple average of 0.5 but an F1 score of 0.

Confusion Matrix

- Multi-class classification problem

Assuming a sample of 27 animals — 8 cats, 6 dogs, and 13 rabbits

		Actual class		
		Cat	**Dog**	**Rabbit**
Predicted class	**Cat**	**5**	2	0
	Dog	3	**3**	2
	Rabbit	0	1	**11**

Recall Precision

- Multi-class classification problem

$$\text{Precision}(\text{cat}) = \frac{T\text{cat}}{T\text{cat} + F\text{cat}} = \frac{5}{7}$$

$$Recall(\text{cat}) = \frac{T\text{cat}}{\#\ actual\ cat} = \frac{5}{8}$$

		Actual class		
		Cat	**Dog**	**Rabbit**
Predicted class	**Cat**	**5**	2	0
	Dog	3	**3**	2
	Rabbit	0	1	**11**

TPR FPR TNR

- Ture Positive Rate/ Recall / Sensitivity

$$\mathrm{TPR} = \frac{TP}{TP + FN}$$

- False Positive Rate

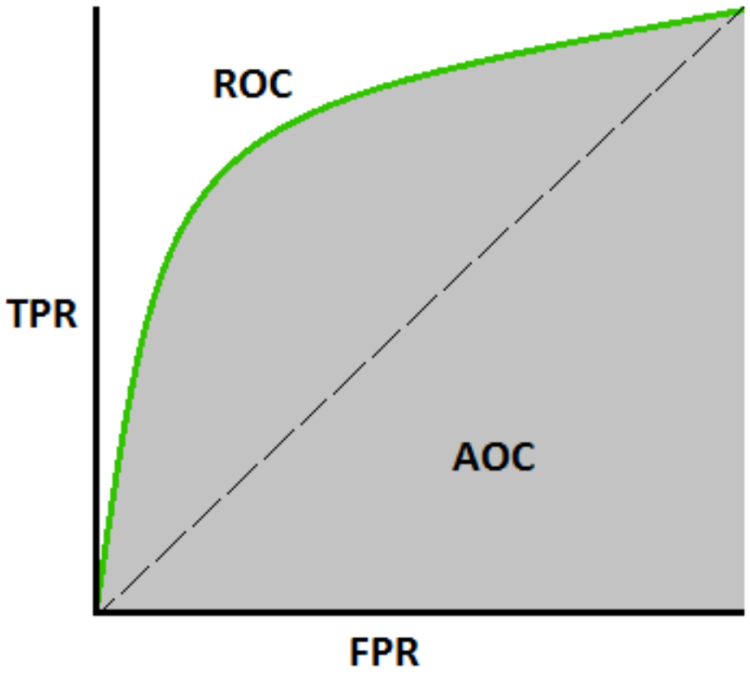
$$\mathrm{FPR} = \frac{FP}{FP + TN}$$

- True Negative Rate/ Specificity

$$\mathrm{TNR} = \frac{TN}{FP + TN}$$

AUROC

- Receiver Operating Characteristic
- Area Under The Curve
- Area Under the Receiver Operating Characteristics



ROC Curve and AUC (Area Under the Curve)

- **ROC Curve:** Plots the **True Positive Rate (Recall)** against the **False Positive Rate (FPR)** at different thresholds.
- **AUC:** Measures the model's ability to differentiate between classes.
  - **AUC = 1.0: Perfect classifier.**
  - **AUC = 0.5:** Random guessing.

Example:
If AUC = 0.85, the model has an 85% chance of distinguishing between a positive and a negative instance.