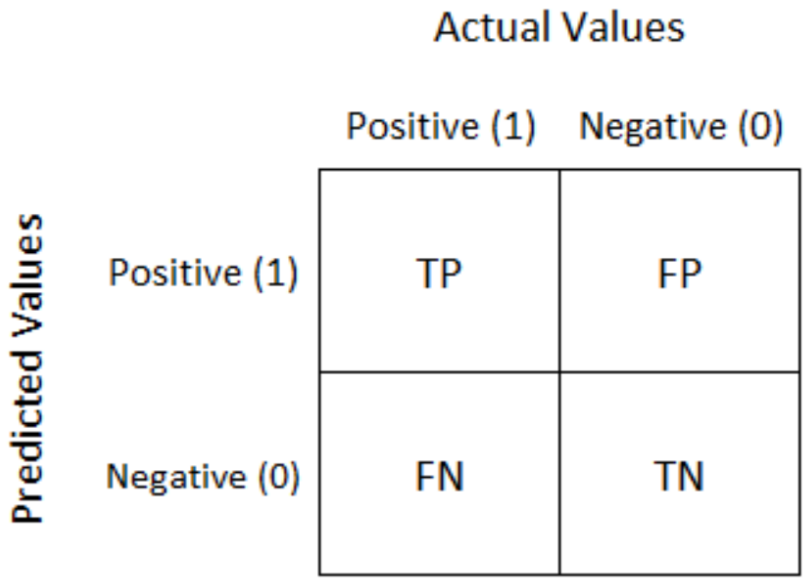
TFIP-AI - Machine Learning

Unit 4 K-Nearest Neighbor (KNN) Algorithm

Part 2 Evaluating Machine Learning Algorithms

(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

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

$$Recall(\text{cat}) = \frac{T\text{cat}}{Actual\ cat\ number} = \frac{5}{8}$$

		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

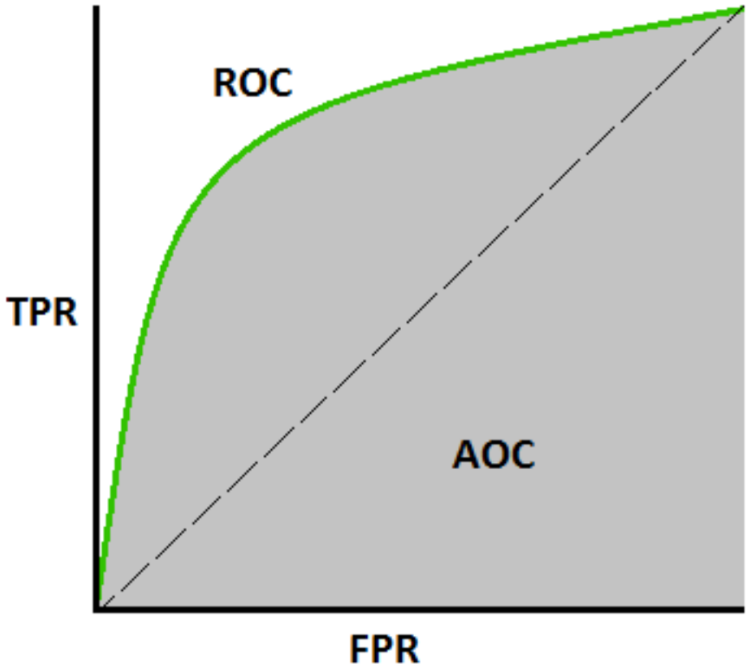
$$\mathrm{FPR} = \frac{FP}{FP + TN}$$

- True Negative Rate/ Specificity

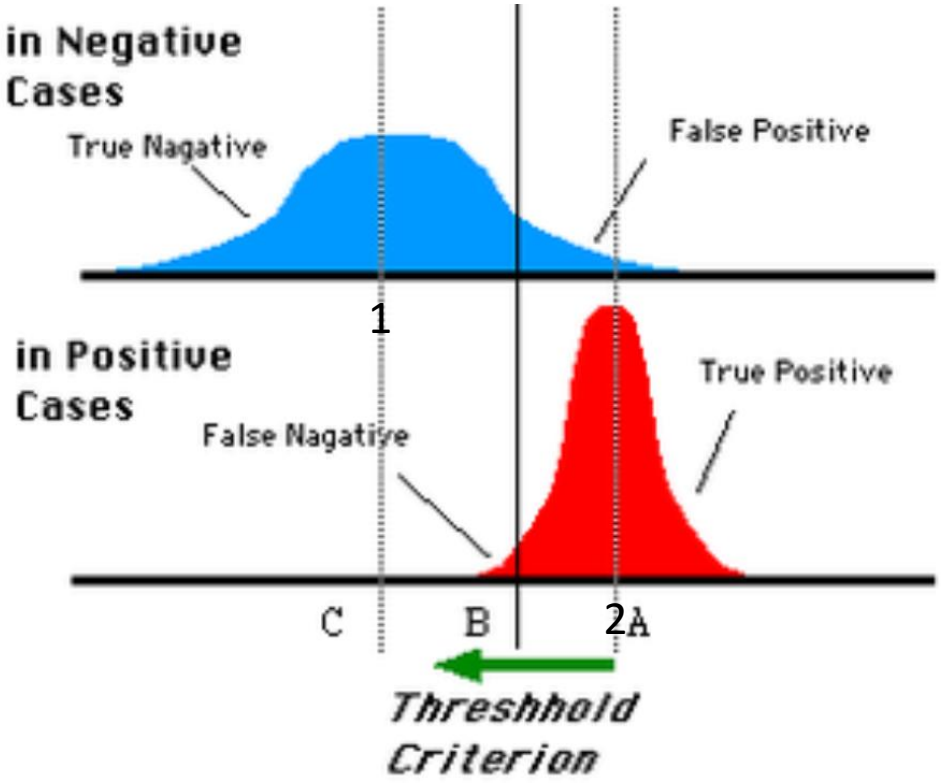
$$\mathrm{TNR} = \frac{TN}{FP + TN}$$

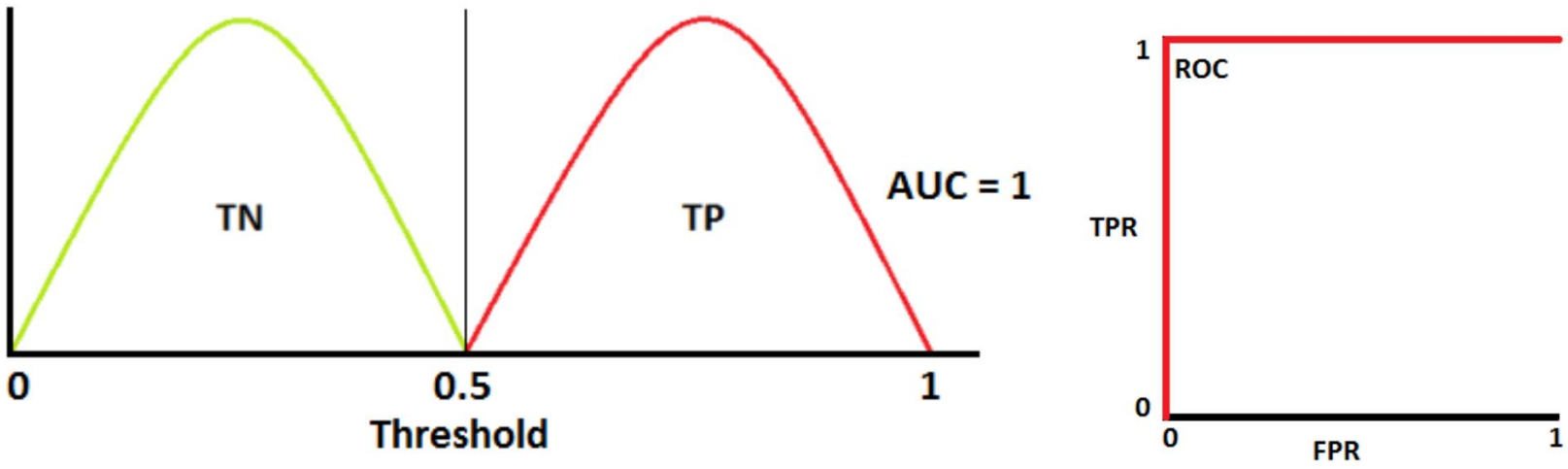
AUROC

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



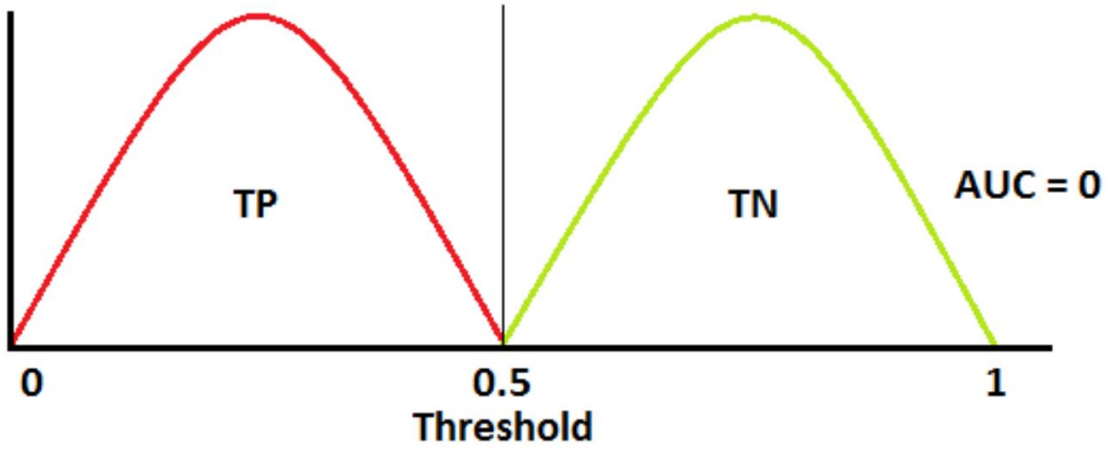
Blood Protein Level Distribution

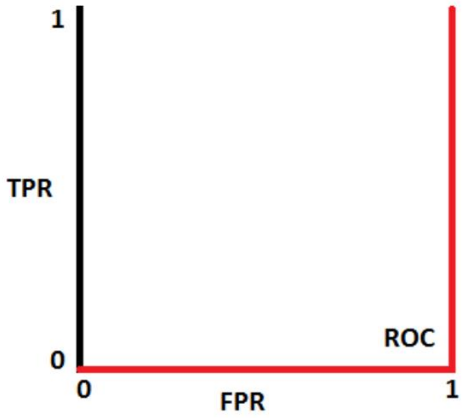




Red distribution curve is of the positive class (patients with disease)

green distribution curve is of negative class(patients with no disease)





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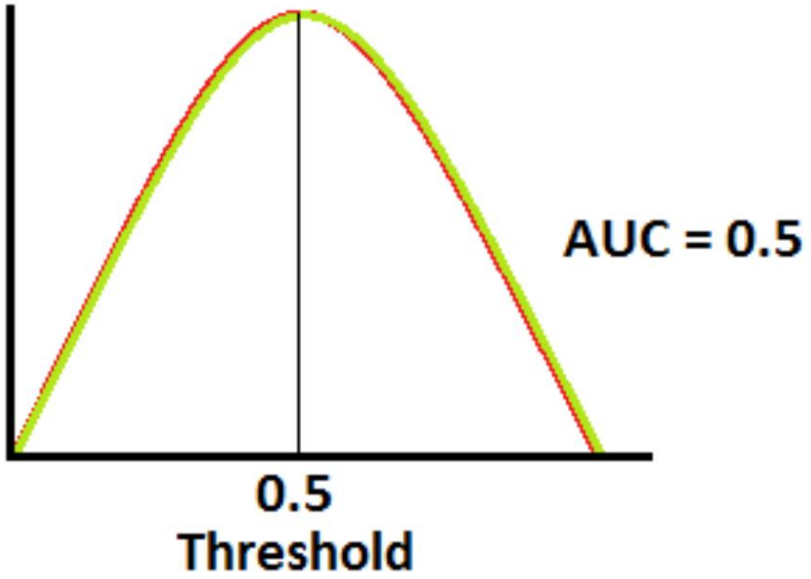
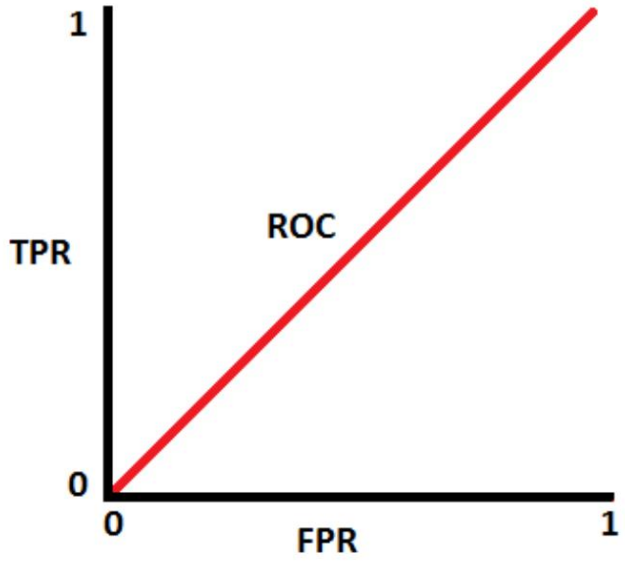
A Random classifier





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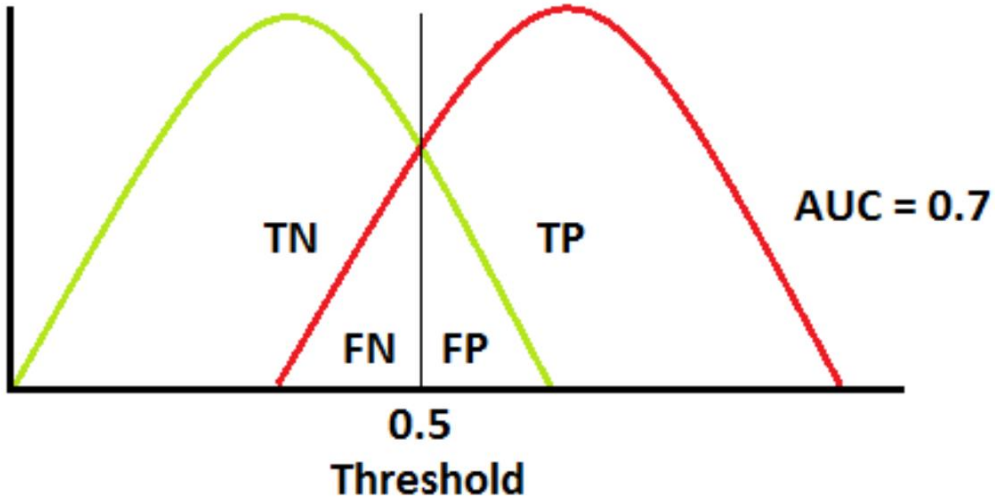

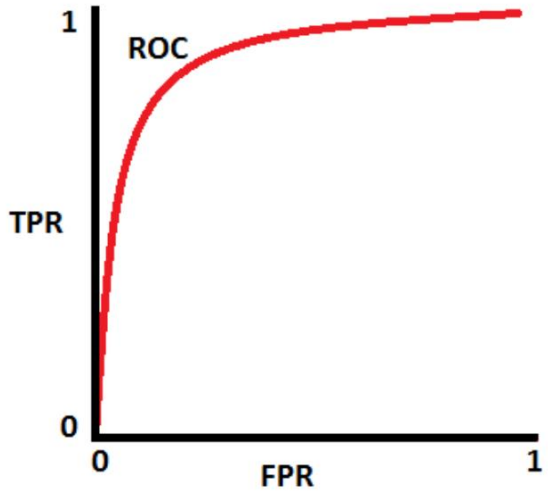

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green distribution curve is of negative class(patients with no disease)

Example – TP, FP, TN, FN

Threshold	TP	FP	TN	FN
0.0	50	50	0	0
0.1	48	47	3	2
0.2	47	40	9	4
0.3	45	31	16	8
0.4	44	23	22	11
0.5	42	16	29	13
0.6	36	12	34	18
0.7	30	11	38	21
0.8	20	4	43	33
0.9	12	3	45	40
1.0	0	0	50	50

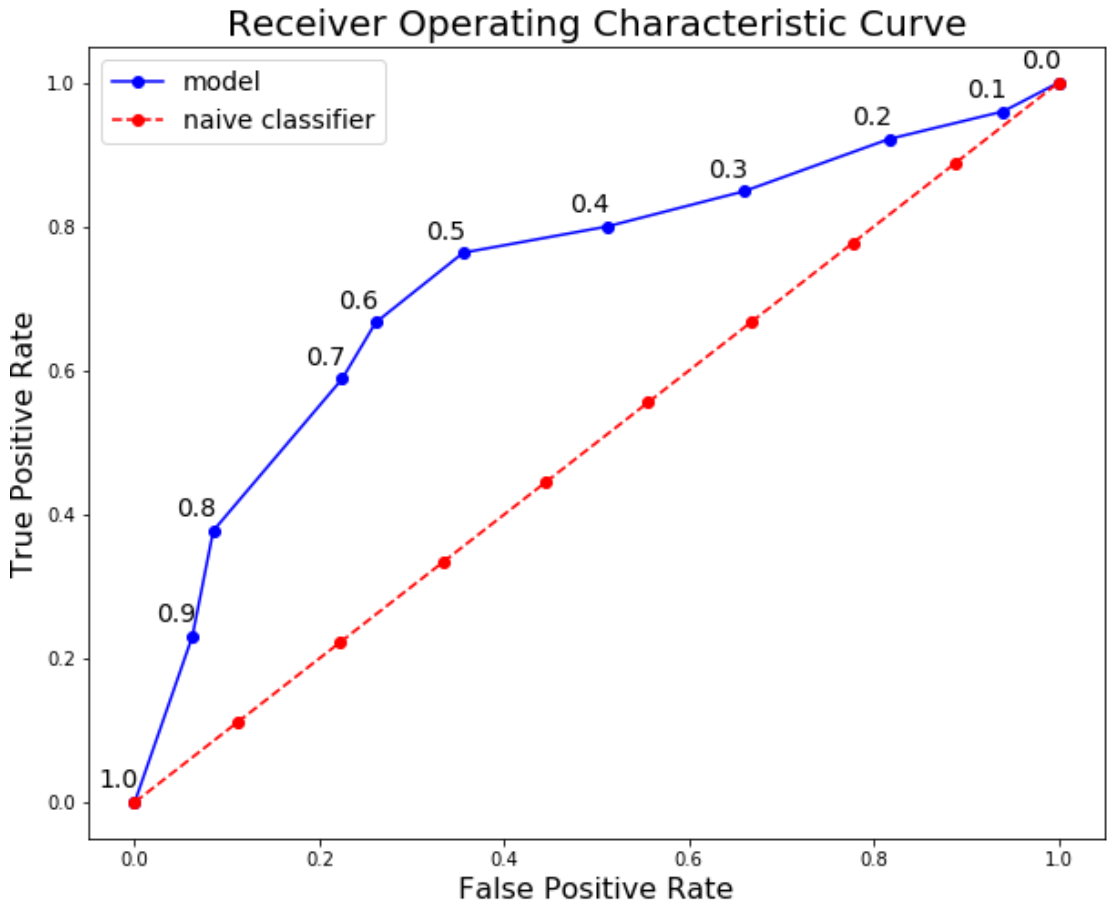
Outcome at each threshold

Example – recall, precision

threshold	recall	precision	f1	tpr	fpr
0.0	1	0.5	0.666667	1	1
0.1	0.96	0.505263	0.662069	0.96	0.94
0.2	0.921569	0.54023	0.681159	0.921569	0.816327
0.3	0.849057	0.592105	0.697674	0.849057	0.659574
0.4	0.8	0.656716	0.721311	0.8	0.511111
0.5	0.763636	0.724138	0.743363	0.763636	0.355556
0.6	0.666667	0.75	0.705882	0.666667	0.26087
0.7	0.588235	0.731707	0.652174	0.588235	0.22449
0.8	0.377358	0.833333	0.519481	0.377358	0.0851064
0.9	0.230769	0.8	0.358209	0.230769	0.0625
1.0	0	0	0	0	0

Statistics at each threshold

Example – ROC


Receiver Operating Characteristic Curve
model
naive classifier
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0