

# AUC and ROC

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# Probability of Predictions

- A machine learning classification model can be used to predict the actual class of the data point directly or predict its probability of belonging to different classes.
- The latter gives us more control over the result. We can determine our own threshold to interpret the result of the classifier.
- This is sometimes more prudent than just building a completely new model!

# Probability of Predictions

- Setting different thresholds for classifying positive class for data points will inadvertently change the Sensitivity and Specificity of the model.
- And one of these thresholds will probably give a better result than the others, depending on whether we are aiming to lower the number of False Negatives or False Positives.

# Probability of Predictions

ID	Actual	Prediction Probability	>0.6	>0.7	> 0.8	Metric
1	0	0.98	1	1	1	
2	1	0.67	1	0	0	
3	1	0.58	0	0	0	
4	0	0.78	1	1	0	
5	1	0.85	1	1	1	
6	0	0.86	1	1	1	
7	0	0.79	1	1	0	
8	0	0.89	1	1	1	
9	1	0.82	1	1	1	
10	0	0.86	1	1	1	
			0.75	0.5	0.5	TPR
			1	1	0.66	FPR
			0	0	0.33	TNR
			0.25	0.5	0.5	FNR

# Probability of Predictions

- **True Positive Rate (TPR)**, also known as Sensitivity or Recall: It is the ratio of correctly predicted positive observations to all actual positives.

$$\text{TPR} = \frac{\text{True Positives (TP)}}{\text{True Positives (TP)} + \text{False Negatives (FN)}}$$

- **False Positive Rate (FPR)**: It is the ratio of incorrectly predicted positive observations to all actual negatives.

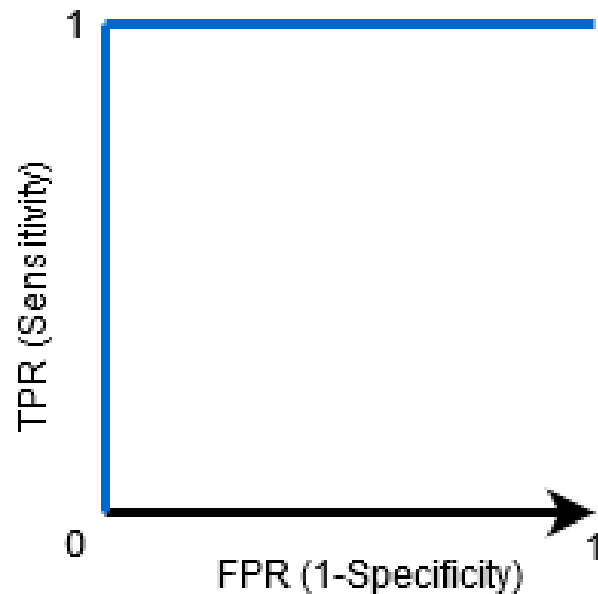
$$\text{FPR} = \frac{\text{False Positives (FP)}}{\text{False Positives (FP)} + \text{True Negatives (TN)}}$$

# AUC-ROC

- The Receiver Operator Characteristic (ROC) curve is an evaluation metric for binary classification problems.
- It is a probability curve that plots the TPR against FPR at various threshold values and essentially separates the 'signal' from the 'noise'.
- The Area Under the Curve (AUC) is the measure of the ability of a classifier to distinguish between classes and is used as a summary of the ROC curve.

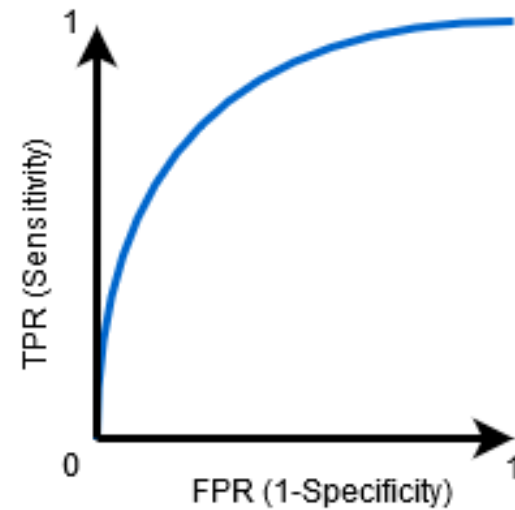
# AUC-ROC

- The higher the AUC, the better the performance of the model at distinguishing between the positive and negative classes.



# AUC-ROC

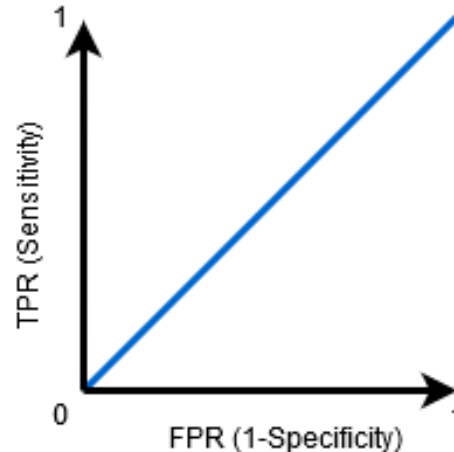
- When  $AUC = 1$ , then the classifier is able to perfectly distinguish between all the Positive and the Negative class points correctly.
- If, however, the AUC had been 0, then the classifier would be predicting all Negatives as Positives, and all Positives as Negatives.





# AUC-ROC

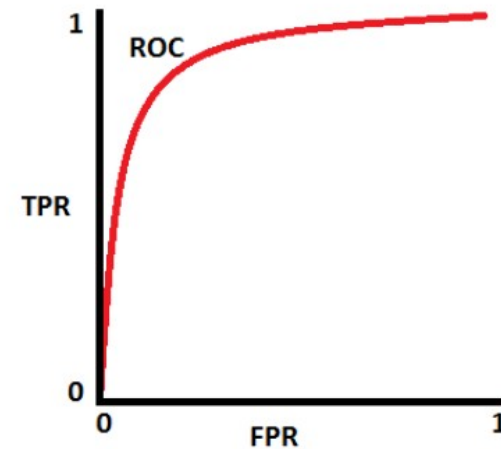
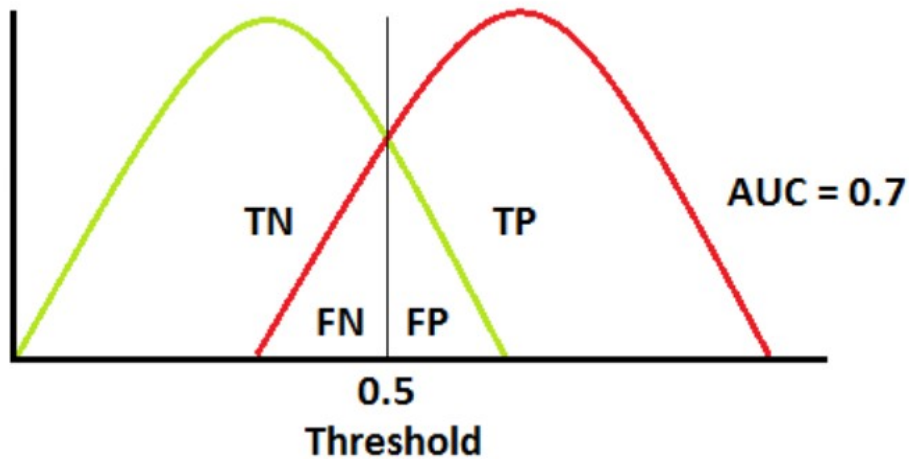
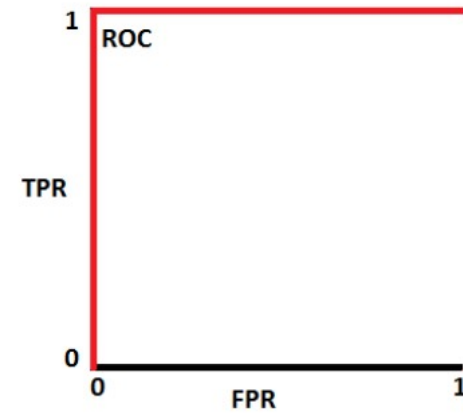
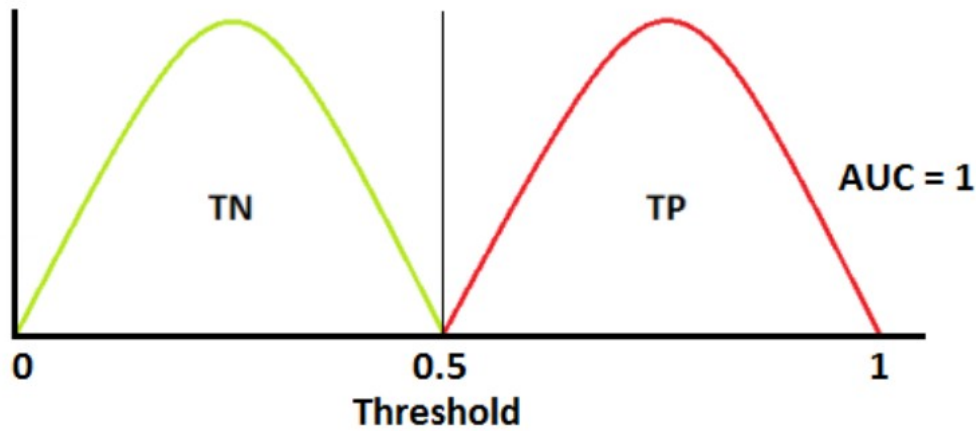
- When  $0.5 < \text{AUC} < 1$ , there is a high chance that the classifier will be able to distinguish the positive class values from the negative class values.
- This is so because the classifier is able to detect more numbers of True positives and True negatives than False negatives and False positives.



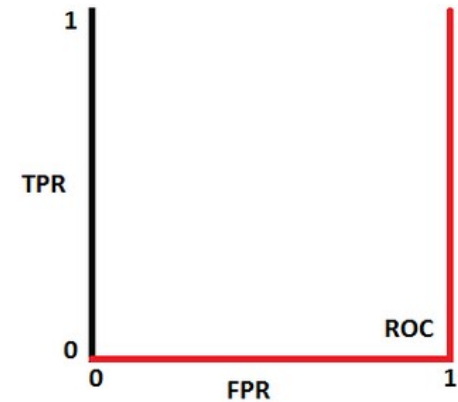
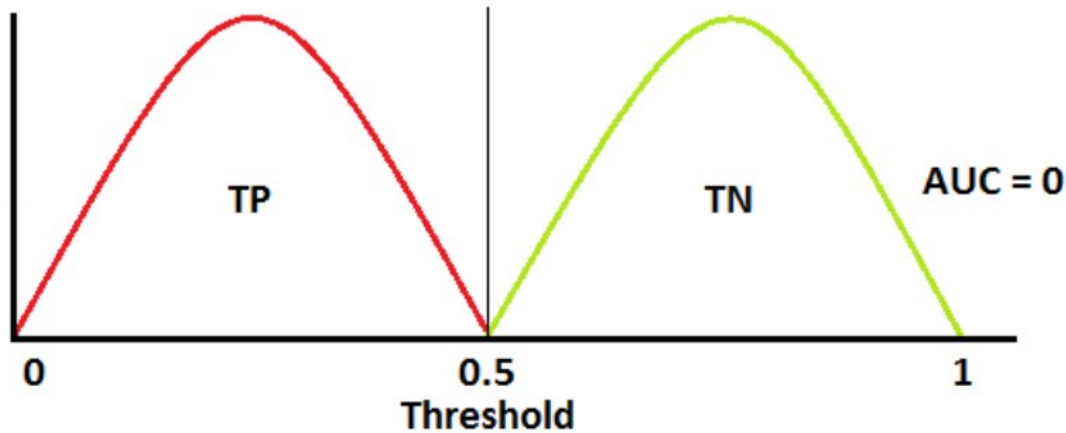
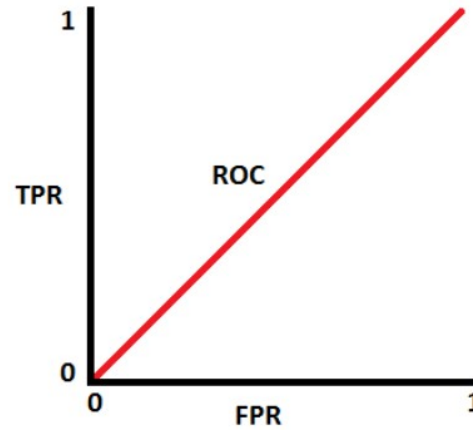
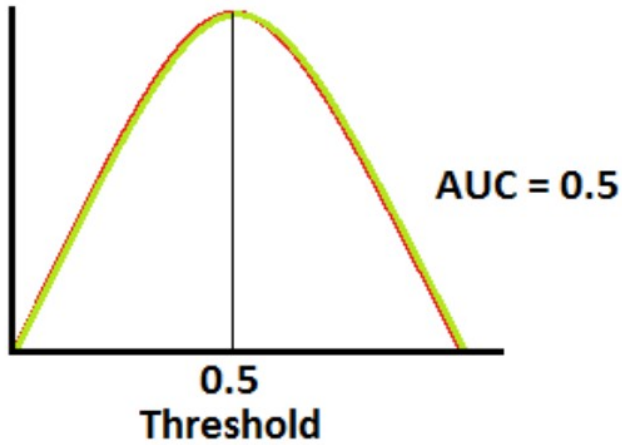
# AUC-ROC

- The AUC is a single scalar value that summarizes the performance of the classifier across all possible thresholds. The value of AUC ranges from 0 to 1, where:
  - AUC = 1: Perfect model, with perfect separation between the classes.
  - AUC = 0.5: Model with no discrimination ability, equivalent to random guessing.
  - AUC < 0.5: Model that performs worse than random guessing (often indicative of a model that has learned the inverse relationship).
- Interpretation
  - A high AUC value (close to 1) indicates a good performing model.
  - A low AUC value (close to 0.5) indicates a poor performing model.

# Summary: Relations



# Summary: Relations



# Thank you

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