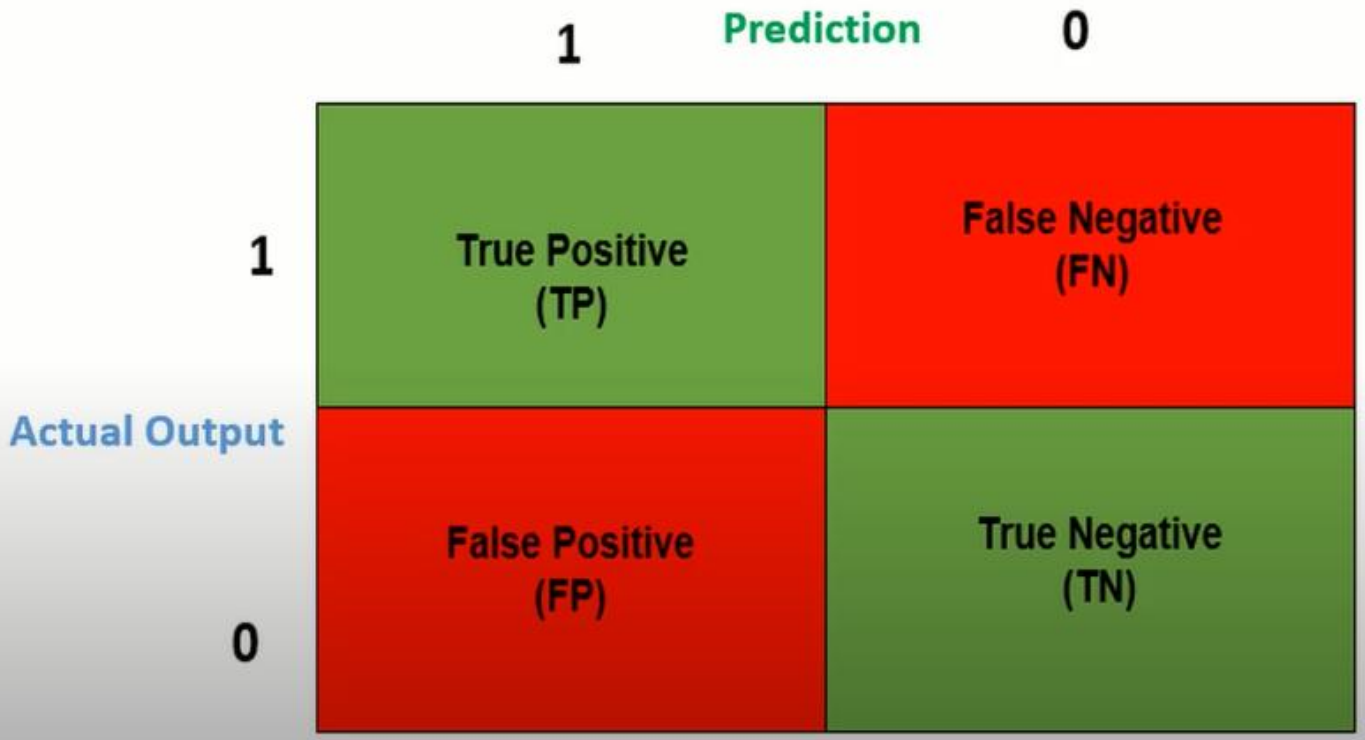
# All About Confusion Matrix

- Confusion Matrix
- Accuracy
- Precision
- Recall
- F1 Measure
- Harmonic Mean
- Specificity
- Sensitivity
- AUC Curve
- ROC Curve

# All About Confusion Matrix


Image




True positive (TP).

- Equivalent with hit.

True negative (TN).

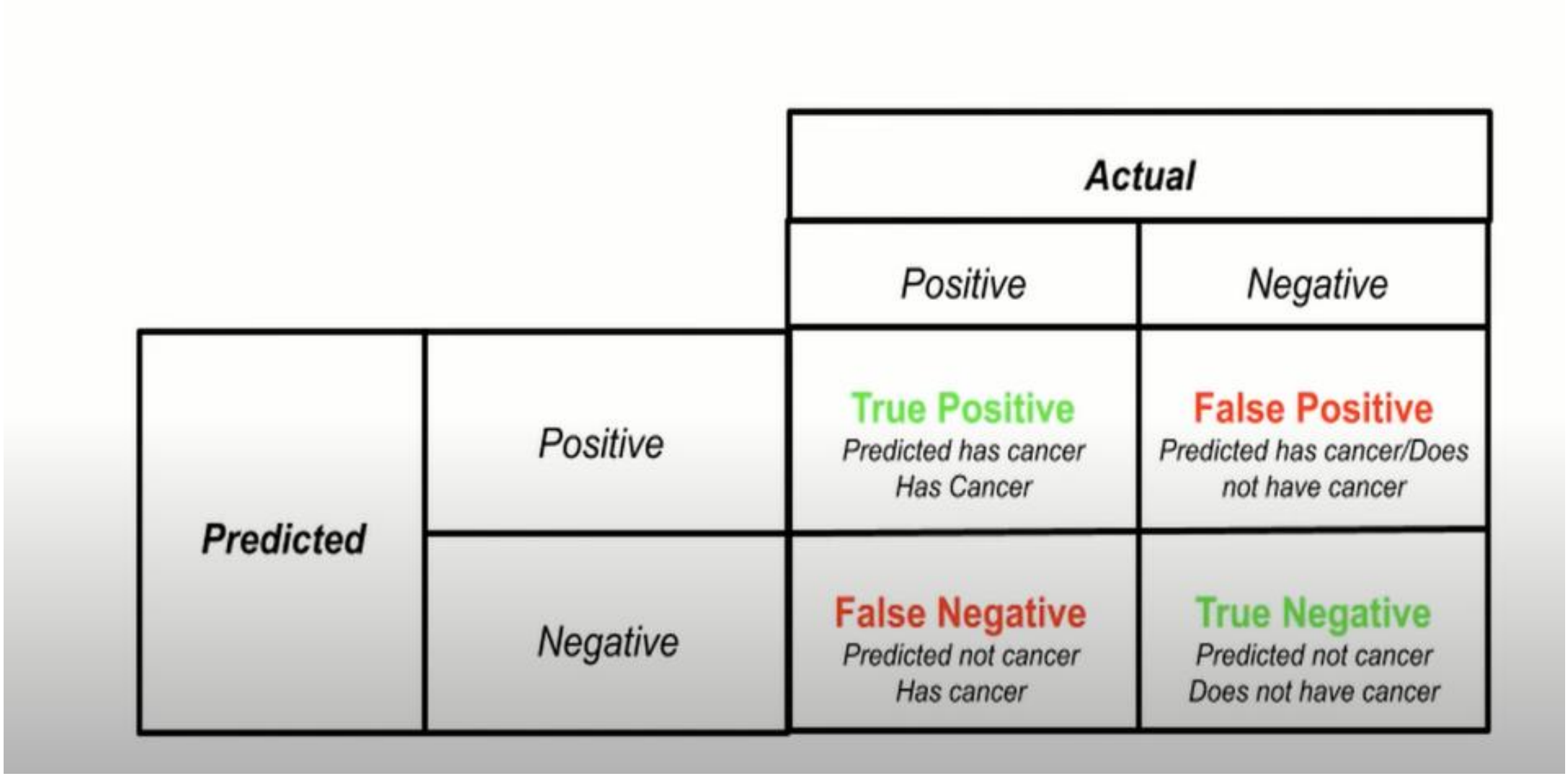
- Equivalent with correct rejection.

False positive (FP).

- Equivalent with false alarm, type I error or underestimation.

False negative (FN) .

- Equivalent with miss, type II error or overestimation.


Actual
Positive
Negative
Predicted
Positive
Negative
True Positive
Predicted has cancer
Has Cancer
False Positive
Predicted has cancer/Does not have cancer
False Negative
Predicted not cancer
Has cancer
True Negative
Predicted not cancer
Does not have cancer

# Accuracy

- Accuracy = (TP + TN ) / (TP + FP + TN + FN)

- Condition positive (P).
  - The number of real positive cases in the data.
- Condition negative (N).
  - The number of real negative cases in the data.

# Precision or Positive Predictive Value (PPV)

PPV = True Positive / (True Positive + False Positive)

# Sensitivity, Recall, Hit Rate, or True Positive Rate (TPR)

TPR = True Positive / (True Positive + False Negative)

# False Positive Rate (FPR)

$$FPR = FP / (FP + TN)$$

# F1 Measure

F1 Measure = (Precision + Recall) / 2

# Harmonic Mean, F1 Score

$$F1 = ( 2 * Precision * Recall ) / (Precision + Recall)$$

# Specificity, Selectivity or True Negative Rate (TNR)

Specificity = True Negative / (True Negative + False Positive)

# Threat Score (TS) or Critical Success Index (CSI)

$$CSI = TP / (TP + FN + FP)$$

# False Discovery Rate (FDR)

$$FDR = FP / (TP + FP)$$

**accuracy (ACC)**

$$\mathrm{ACC} = \frac{\mathrm{TP} + \mathrm{TN}}{\mathrm{P} + \mathrm{N}} = \frac{\mathrm{TP} + \mathrm{TN}}{\mathrm{TP} + \mathrm{TN} + \mathrm{FP} + \mathrm{FN}}$$

**balanced accuracy (BA)**

$$\mathrm{BA} = \frac{TPR + TNR}{2}$$

**informedness or bookmaker informedness (BM)**

$$\mathrm{BM} = \mathrm{TPR} + \mathrm{TNR} - 1$$

**markedness (MK) or deltaP (Δp)**

$$\mathrm{MK} = \mathrm{PPV} + \mathrm{NPV} - 1$$

**Matthews correlation coefficient (MCC)**

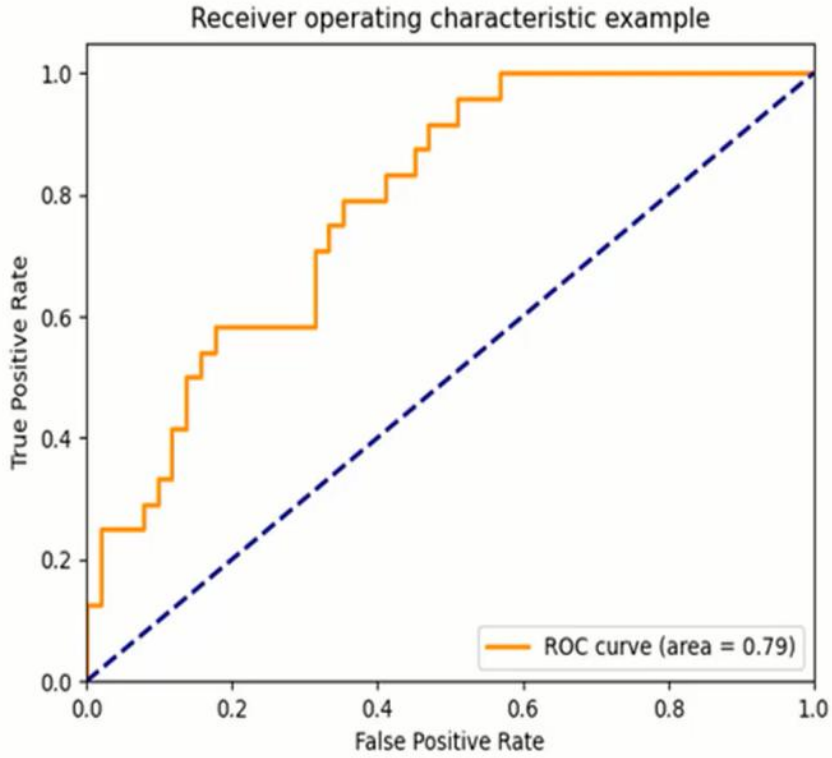
$$\mathrm{MCC} = \frac{\mathrm{TP} \times \mathrm{TN} - \mathrm{FP} \times \mathrm{FN}}{\sqrt{(\mathrm{TP} + \mathrm{FP})(\mathrm{TP} + \mathrm{FN})(\mathrm{TN} + \mathrm{FP})(\mathrm{TN} + \mathrm{FN})}}$$

**Fowlkes–Mallows index (FM)**

$$\mathrm{FM} = \sqrt{\frac{TP}{TP + FP} \times \frac{TP}{TP + FN}} = \sqrt{PPV \times TPR}$$

# ROC & AUC Curve

Receiver Operating Characteristic (ROC): Since, TPR is equivalent to Sensitivity and FPR is equal to 1 – specificity, the ROC graph is sometimes called the sensitivity vs (1 – specificity) plot.



# ROC & AUC Curve

| Actual Result | Predicted Result |
|---|---|
| Yes | 0.89 |
| Yes | 0.57 |
| No | 0.51 |
| No | 0.25 |
| Yes | 0.69 |
| Yes | 0.58 |

Sensitivity,
TPR = TP / (TP + FN), and

FPR = FP / (FP + TN)

Threshold Value = [ 0. 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70

# ROC & AUC Curve

| Actual Result | Predicted Result | Predicted (0) |
|---|---|---|
| Yes | 0.89 | 1 |
| Yes | 0.57 | 1 |
| No | 0.51 | 1 |
| No | 0.25 | 1 |
| Yes | 0.69 | 1 |
| Yes | 0.58 | 1 |

Sensitivity,
TPR = TP / (TP + FN), and

FPR = FP / (FP + TN)

Threshold Value = 0

# ROC & AUC Curve

| Actual Result | Predicted Result | Predicted (0) | Predicted (.30) | Predicted (.50) |
|---|---|---|---|---|
| Yes | 0.89 | 1 | 1 | 1 |
| Yes | 0.57 | 1 | 1 | 1 |
| No | 0.51 | 1 | 1 | 1 |
| No | 0.25 | 1 | 0 | 0 |
| Yes | 0.69 | 1 | 1 | 1 |
| Yes | 0.58 | 1 | 1 | 1 |

Sensitivity,
TPR = TP / (TP + FN), and

FPR = FP / (FP + TN)

Threshold Value = 0.50

# ROC & AUC Curve

| Actual Result | Predicted Result | Predicted (0) | Predicted (.30) | Predicted (.50) | Predicted (.60) |
|---|---|---|---|---|---|
| Yes | 0.89 | 1 | 1 | 1 | 1 |
| Yes | 0.57 | 1 | 1 | 1 | 0 |
| No | 0.51 | 1 | 1 | 1 | 0 |
| No | 0.25 | 1 | 0 | 0 | 0 |
| Yes | 0.69 | 1 | 1 | 1 | 1 |
| Yes | 0.58 | 1 | 1 | 1 | 0 |

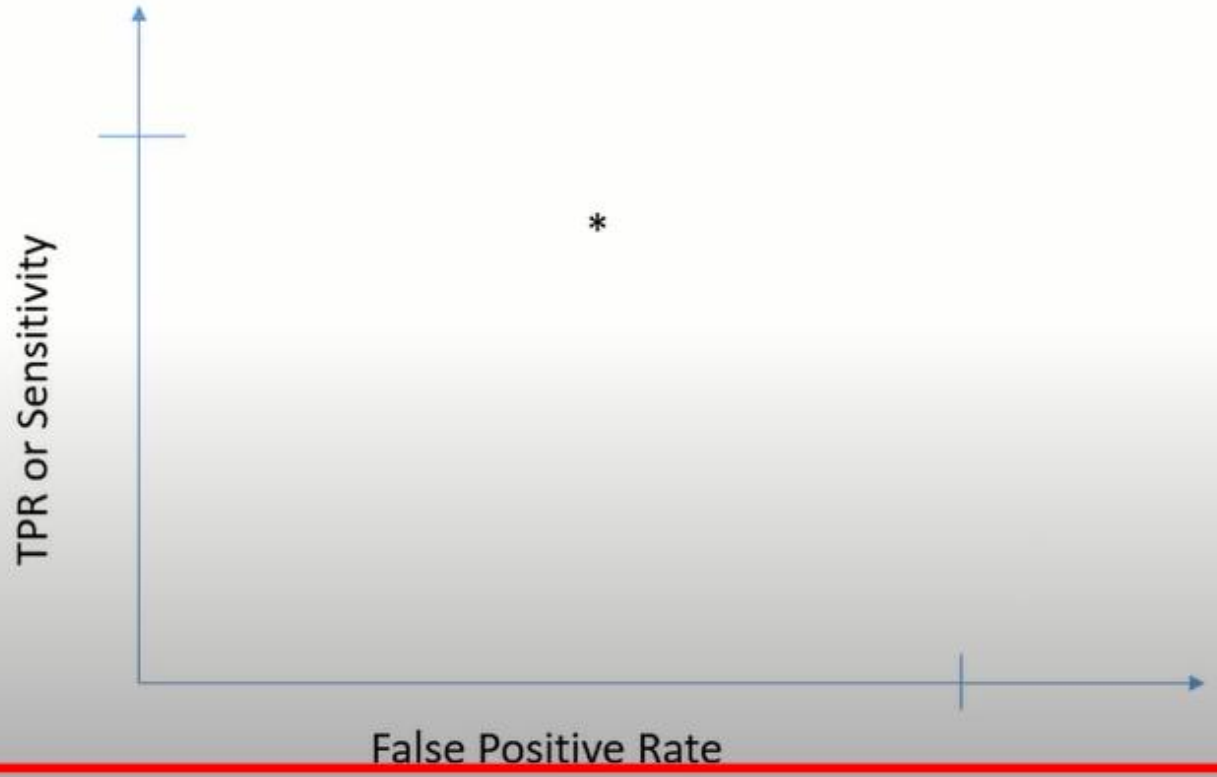
Sensitivity,
TPR = TP / (TP + FN), and

FPR = FP / (FP + TN)

Threshold Value = 0.60

# ROC & AUC Curve

| Actual Result | Predicted Result | Predicted (0) |
|---|---|---|
| Yes | 0.89 | 1 |
| Yes | 0.57 | 1 |
| No | 0.51 | 1 |
| No | 0.25 | 1 |
| Yes | 0.69 | 1 |
| Yes | 0.58 | 1 |




Sensitivity,

TPR = TP / (TP + FN)

= 4 / 4 + 1

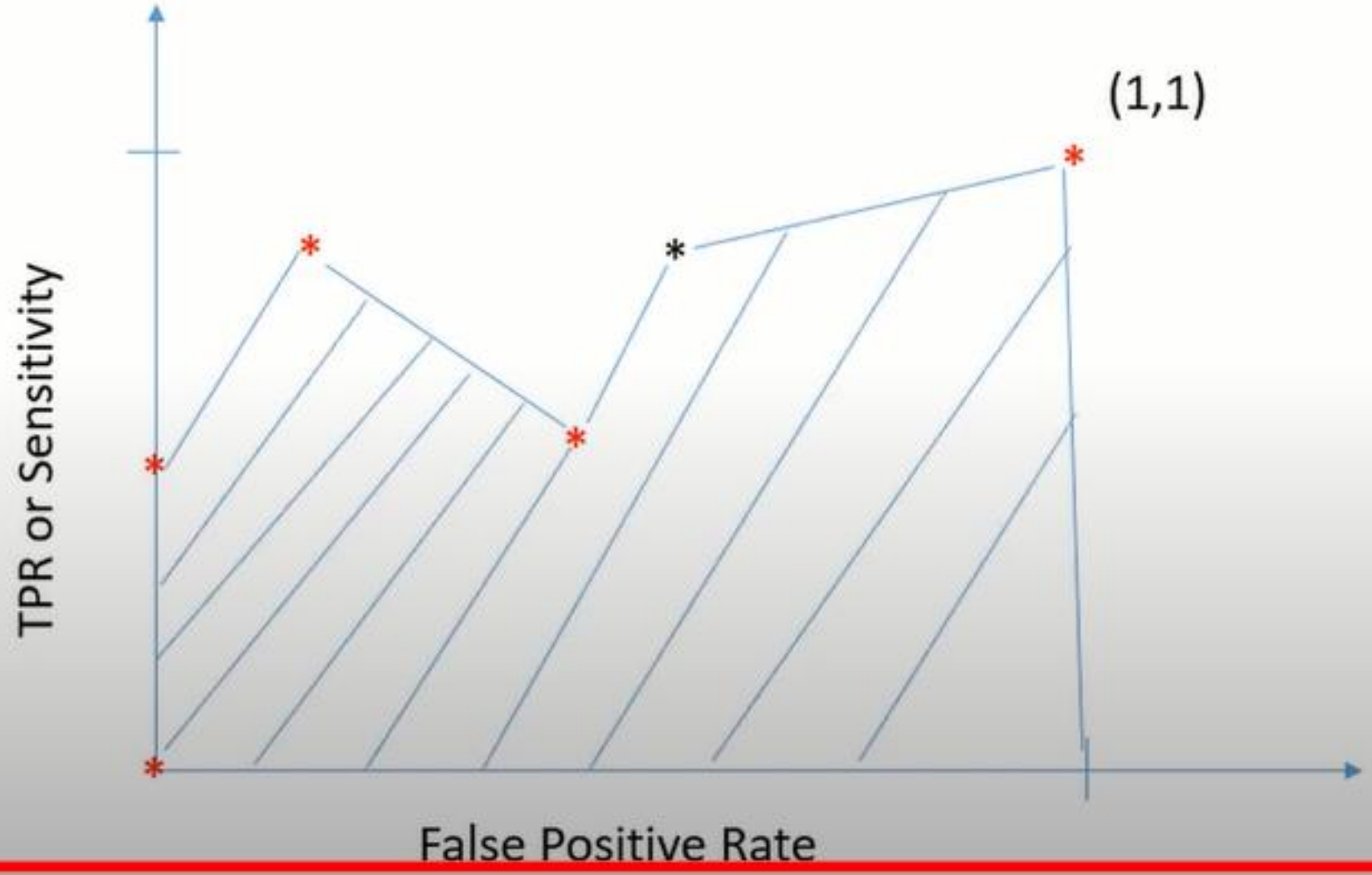
= .80

FPR = FP / (FP + TN)

= 1 / 1 + 1

= 0.5

# ROC & AUC Curve



# ROC & AUC Curve