

PRECISION, RECALL, ACCURACY, ERROR RATE

		True Class		
		T	F	
Acquired Class	Y	True Positives (TP)	False Positives (FP)	$\text{True Positive Rate (TPR)} = \frac{TP}{TP + FN}$ $\text{False Positive Rate (FPR)} = \frac{FP}{FP + TN}$
	N	False Negatives (FN)	True Negatives (TN)	$\text{Accuracy (ACC)} = \frac{TP + TN}{TP + FP + TN + FN}$

$$TPR = \frac{TP}{\text{Actual Positive}} = \frac{TP}{TP + FN}$$

$$FNR = \frac{FN}{\text{Actual Positive}} = \frac{FN}{TP + FN}$$

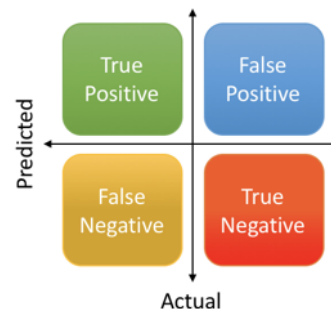
$$TNR = \frac{TN}{\text{Actual Negative}} = \frac{TN}{TN + FP}$$

$$FPR = \frac{FP}{\text{Actual Negative}} = \frac{FP}{TN + FP}$$

$$\text{Precision} = \frac{\text{True Positive}}{\text{Actual Results}} \quad \text{or} \quad \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}}$$

$$\text{Recall} = \frac{\text{True Positive}}{\text{Predicted Results}} \quad \text{or} \quad \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}}$$

$$\text{Accuracy} = \frac{\text{True Positive} + \text{True Negative}}{\text{Total}}$$



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	Prediction	Actual value	Type	Explanation
1				
2	1	1	True Positive	Predicted Positive and was Positive
3	0	0	True Negative	Predicted Negative and was Negative
4	1	0	False Positive	Predicted Positive but was Negative
5	0	1	False Negative	Predicted Negative but was Positive







		Predicted Class		
		Positive	Negative	
Actual Class	Positive	True Positive (TP)	False Negative (FN) Type II Error	Sensitivity $\frac{TP}{(TP + FN)}$
	Negative	False Positive (FP) Type I Error	True Negative (TN)	Specificity $\frac{TN}{(TN + FP)}$
		Precision $\frac{TP}{(TP + FP)}$	Negative Predictive Value $\frac{TN}{(TN + FN)}$	Accuracy $\frac{TP + TN}{(TP + TN + FP + FN)}$

- True Positive: the truth is positive, and the test predicts a positive. The person is sick, and the test accurately reports this.
- True Negative: the truth is negative, and the test predicts a negative. The person is not sick, and the test accurately reports this.
- False Negative: the truth is positive, but the test predicts a negative. The person is sick, but the test inaccurately reports that they are not. Also called a Type II error in statistics.
- False Positive: the truth is negative, but the test predicts a positive. The person is not sick, but the test inaccurately reports that they are. Also called a Type I error in statistics.

Truth										
Prediction	Dog	Dog	Dog	No Dog	Dog	No Dog	Dog	No Dog	Dog	Dog
	✓	✗	✓		✓		✗		✓	✗

True Positive = 4

False Positive = 3

Truth										
Prediction	Dog	Dog	Dog	No Dog	Dog	No Dog	Dog	No Dog	Dog	Dog
				✗		✓		✗		

True Negative = 1

False Negative = 2

		Actual	
		Fraud	Not Fraud
Predicted	Fraud	3	97
	Not Fraud	0	0

$$\text{Precision} = \frac{3}{100} = 3\%$$

$$\text{Recall} = \frac{3}{3} = 100\%$$

		Actual	
		Positives(1)	Negatives(0)
Predicted	Positives(1)	TP	FP
	Negatives(0)	FN	TN

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

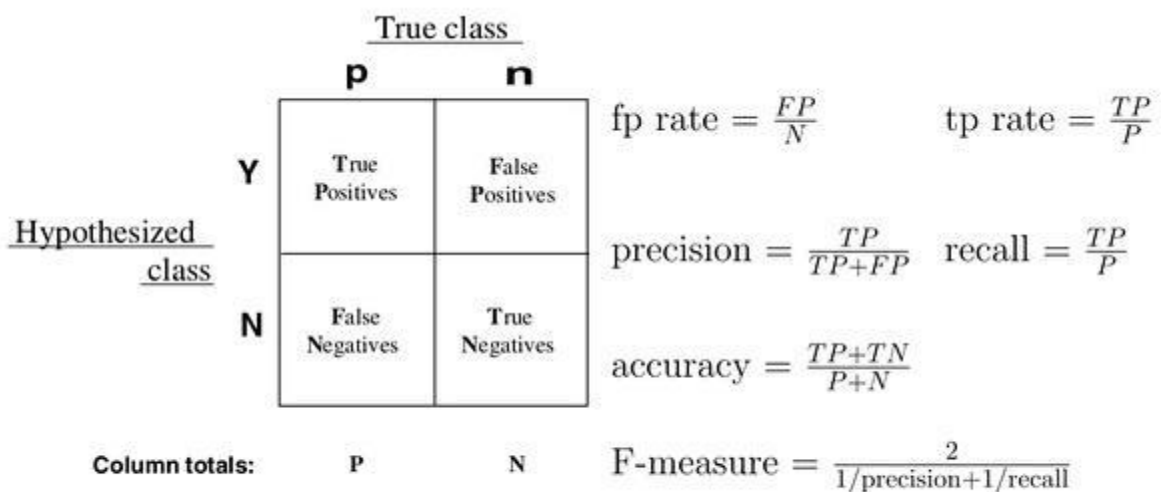
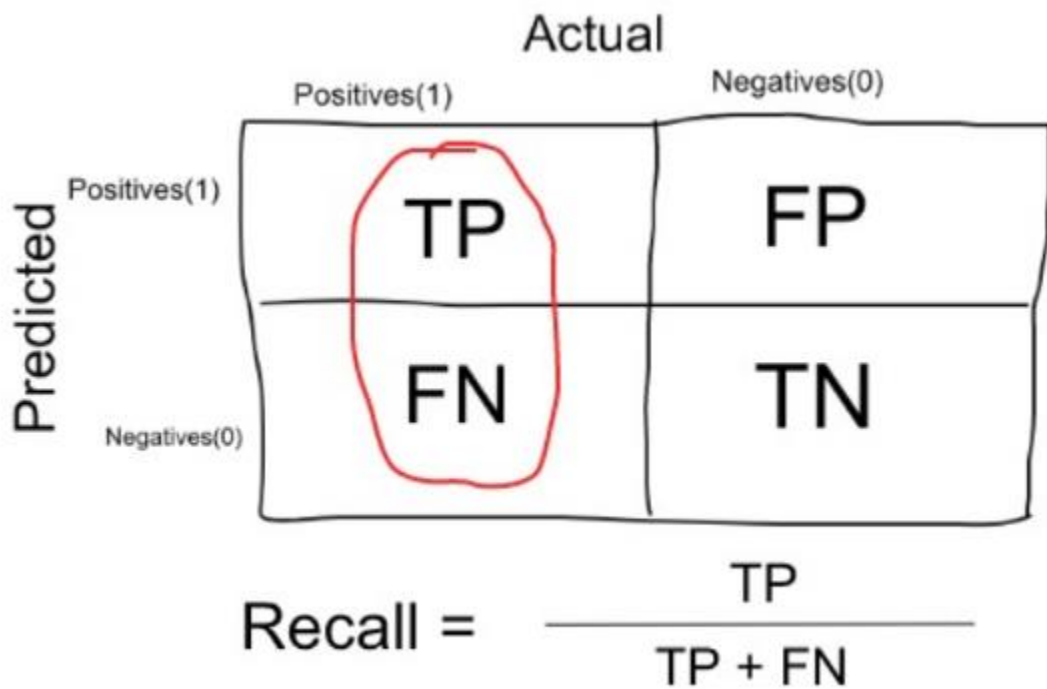


Fig. 1. Confusion matrix and common performance metrics calculated from it.

Main metrics — The following metrics are commonly used to assess the performance of classification models:

Metric	Formula	Interpretation
Accuracy	$\frac{TP + TN}{TP + TN + FP + FN}$	Overall performance of model
Precision	$\frac{TP}{TP + FP}$	How accurate the positive predictions are
Recall Sensitivity	$\frac{TP}{TP + FN}$	Coverage of actual positive sample
Specificity	$\frac{TN}{TN + FP}$	Coverage of actual negative sample
F1 score	$\frac{2TP}{2TP + FP + FN}$	Hybrid metric useful for unbalanced classes

Training set

Age	Heart rate	Blood pressure	Heart problem
65	78	150/70	Yes
37	83	112/76	No
71	67	108/65	No

Prediction set

Age	Heart rate	Blood pressure	Heart problem
43	98	147/89	?
65	58	106/63	?
84	77	150/65	?

TABLE 1 – TRAINING AND PREDICTION SETS FOR MEDICAL DATABASE

		Predicted class		
		+	-	
Actual class	+	TP 15 True Positives	FN 47 False Negatives Type II error	$\text{Recall} = \frac{15}{(15+47)} = 24.19\%$
	-	FP 12 False Positives Type I error	TN 118 True Negatives	$\text{Specificity} = \frac{118}{(118+12)} = 90.77\%$
		$\text{Precision} = \frac{15}{(15+12)} = 55.55\%$		$\text{Accuracy} = \frac{(15+118)}{192} = 69.27\%$
				$\text{F1 Score} = \frac{2 \cdot (15)}{(2 \cdot 15) + 12 + 47} = 33.70\%$
		$N = 15 + 47 + 12 + 118 = 192$		

<https://towardsdatascience.com/a-look-at-precision-recall-and-f1-score-36b5fd0dd3ec>