Confusion matrix and evaluation metrics

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1. Confusion matrix

		Actuality	
		P	**N**
Prediction	**P**	TP (hit)	FP (false alarm, type I error)
	N	FN (miss, type II error)	TN (correct rejection)

Total is the sum of TP, FP, FN and FN

Sensitivity, hit rate, recall, TPR (no miss → high recall):

$$\text{Recall} = \text{TPR} = \frac{\text{TP}}{\text{P}} = \frac{\text{TP}}{\text{TP} + \text{FN}}$$

Precision (no false alarm → high precision):

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

Accuracy:

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

FPR:

$$\text{FPR} = \frac{\text{FP}}{\text{N}} = \frac{\text{FP}}{\text{FP} + \text{TN}}$$

F1 score:

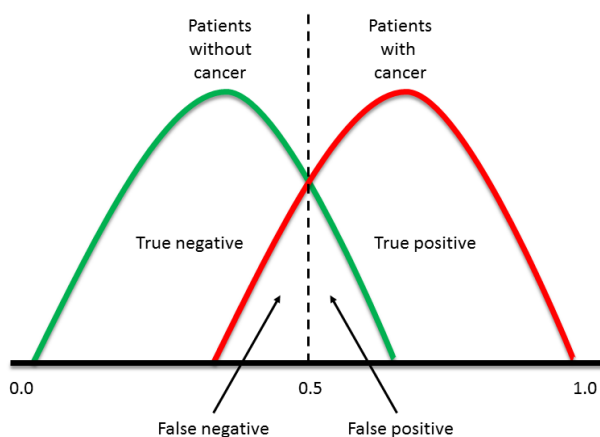$$\text{F1} = 2\frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}$$

Figure 1. Just one way to visualize the confusion matrix

2. Errors

a. Type I error (false positive, false alarm)

Type I error occurs when **rejecting the null hypothesis when it's true**. The type I error rate or significant level α is usually set to 5%, implying that it is acceptable to have a 5% probability of incorrectly rejecting the null hypothesis.

b. Type II error (miss)

Type II error occurs when **failing to reject the null hypothesis when it's false**. The type II error rate is denoted by β, and is related to the power of a test (which is $1 - \beta$).
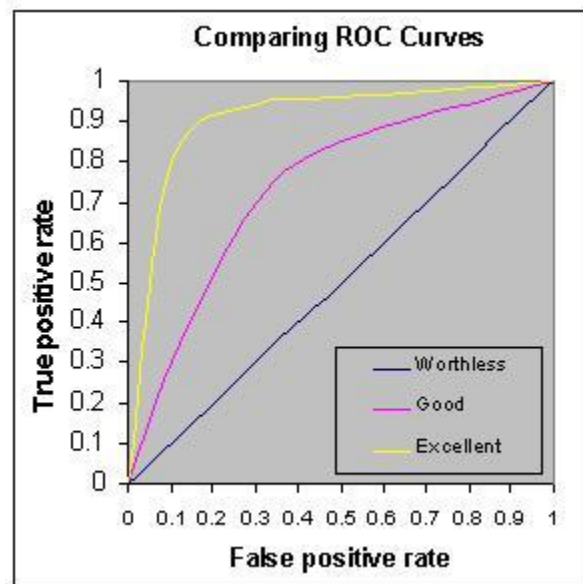
3. Receiver operating characteristic (ROC, TPR vs FPR)

Figure 2. Note when TPR == FPR, the prediction is worthless!