Confusion matrix

- A confusion matrix for a problem involving n classes
  - is an $n \times n$ matrix with the columns labeled with actual classes and the rows labels with predicted classes

		p	**n**
Predicted	**Y**	True positives	False positives
	N	False negatives	True negatives

- Each example in a test set has an **actual class label** and the **class predicted** by the classifier
- The confusion matrix separates out the decisions made by the classifier
  - actual/true classes: **p**(ositive), **n**(egative)
  - predicted classes: **Y**(es), **N**(o)
  - The main diagonal contains the count of correct decisions

Confusion matrix

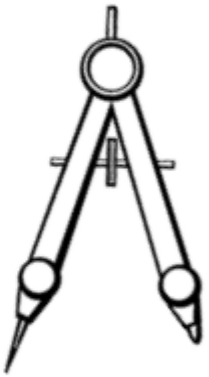
- Examples

$$CM_A = \begin{array}{c} \\ Y \\ N \end{array} \begin{array}{c} \begin{array}{cc} \textbf{churn} & \textbf{not churn} \end{array} \\ \begin{pmatrix} 500 & 200 \\ 0 & 300 \end{pmatrix} \end{array}$$

$$CM_B = \begin{array}{c} \\ Y \\ N \end{array} \begin{array}{c} \begin{array}{cc} \textbf{churn} & \textbf{not churn} \end{array} \\ \begin{pmatrix} 300 & 0 \\ 200 & 500 \end{pmatrix} \end{array}$$

Confusion matrix

- Based on the entries of the confusion matrix, we can describe various evaluation metrics
  - True positive rate (Recall): $\frac{TP}{TP+FN}$
  - False negative rate: $\frac{FN}{TP+FN}$
  - Precision (accuracy over the cases predicted to be positive): $\frac{TP}{TP+FP}$
  - F-measure (harmonic mean): $2 \cdot \frac{precision \cdot recall}{precision+recall}$
  - Sensitivity: $\frac{TN}{TN+FP}$
  - Specificity: $\frac{TP}{TP+FN}$
  - Accuracy (count of correct decisions): $\frac{TP+TN}{P+N}$



Classification weights

- Each outcome “X” (true positive, false positives, etc.) can be associated to a weight
- Objective of the classification algorithm: find the model that minimizes the total cost:
  - Sum_X weight(X) * freq(X)

$$CM_A = \begin{matrix} & \textbf{churn} & \textbf{not churn} \\ Y & 500 & 200 \\ N & 0 & 300 \end{matrix}$$

$$CM_B = \begin{matrix} & \textbf{churn} & \textbf{not churn} \\ Y & 300 & 0 \\ N & 200 & 500 \end{matrix}$$

Classification weights

- Example

Outcomes

Predicted	Actual	
	p	n
Y	56	7
N	5	42

Weights

Predicted	Actual	
	p	n
Y	99	-1
N	0	0

- Total cost: 56*99 + 7*(-1) + 5*0 + 42*0