Desbalance de Clases

Machine Learning

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Agenda

Classification

- We observe (y_i, X_i) $i = 1, \ldots, n$
- Probabilities
  - Logit
  - Random Forests
  - ...
  - Networks
- Classification

$$\hat{Y}_i = 1[\hat{p}_i > c] \tag{1}$$

Deep Learning: Recap

- Neural networks are linear combinations of inputs that are passed through nonlinear activation functions called nodes (or, in reference to the human brain, neurons).

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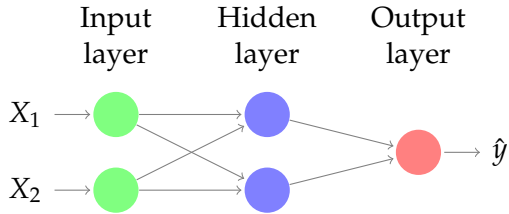


Activation Functions

- Activation functions
  - $\text{ReLU}(x) = \max\{x, 0\}$.
  - $\text{sigmoid}(x) = \frac{1}{1+\exp(-x)}$.
  - $\tanh(x) = \frac{1-\exp(-2x)}{1+\exp(-2x)}$.
  - Others like: $cos(x)$, Radial basis function (RBF), Softplus, Hard tanh, etc ...
  - Radial basis function (RBF): $exp\left(\frac{1}{\sigma^2}||W-x||^2\right)$
  - Softplus: $log(1+e^x)$
  - Hard tanh: $max(-1, min(1, x))$
- Hidden unit design remains an active area of research, and many useful hidden unit types remain to be discovered

Output Functions

- The choice of cost function is tightly coupled with the choice of output unit.
- Most of the time, we simply use the distance between the data distribution and the model distribution.
  - Linear $y = \beta_0 + \sum_{k=1}^{K} \beta_k h_k \rightarrow \mathbb{R}$
  - Sigmoid (Logistic) $\rightarrow$ classification $\{0, 1\}$
  - Softmax $\rightarrow$ classification multiple categories

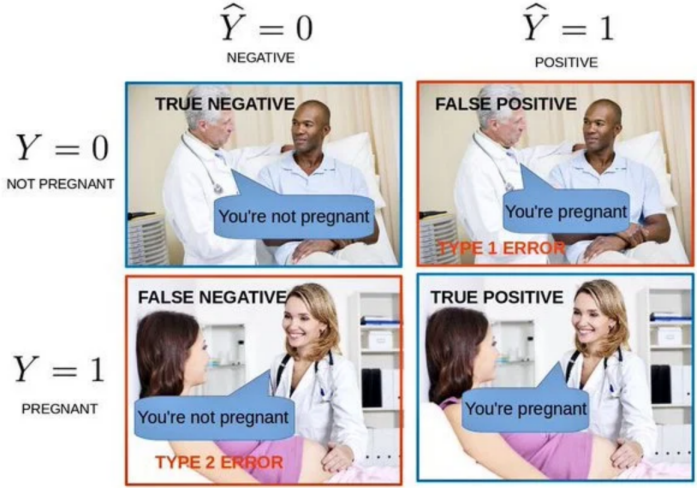
Example: Default

photo from https://www.dailydot.com/parsec/batman-1966-labels-tumblr-twitter-vine/

Agenda

1. Classification
2. Misclassification Rates
   - ROC curve
3. Desbalance de Clases

Misclassification Rates



Misclassification Rates

		$\hat{y}_i$	
		0	1
y_i	0	TN	FP
	1	FN	TP

- We have two types of error associated with this that we can use as a measure of performance

$$\begin{aligned} \textit{False Positive Rate} &= \frac{\textit{False Positives}}{\textit{Negatives}} \\ \textit{True Positive Rate} &= \frac{\textit{True Positives}}{\textit{Positives}} \end{aligned} \tag{2}$$

- Another names they receive:
  - False positive rate: Type I error, 1-Specificity
  - True positive rate: 1- Type II error, power, sensitivity.

Misclassification Rates

		$\hat{y}_i$	
		0	1
y_i	0	TN	FP
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- Another measures of performance using the predicted classes
  - Positive predicted values, also called: Precision, 1- false discovery proportion

$$Positive\ Predicted\ Values = \frac{True\ Positives}{PredictedPositives} \tag{3}$$

  - Negative predicted values

$$Negative\ Predicted\ Values = \frac{True\ Negatives}{PredictedNegatives} \tag{4}$$

Misclassification Rates

Accuracy

		$\hat{y}_i$	
		0	1
y_i	0	TN	FP
	1	FN	TP

- Accuracy: the fraction of predictions our model got right.

$$Accuracy = \frac{TP + TN}{TP + TN + FN + FP} \tag{5}$$

Misclassification Rates

F1 Score

		$\hat{y}_i$	
		0	1
y_i	0	TN	FP
	1	FN	TP

- The F1 Score is the harmonic mean of precision and recall. It is a way to combine both metrics into a single, useful metric.

$$F1 = 2\frac{Precision \times Recall}{Precision + Recall} \tag{6}$$

- The F1 score is particularly useful when you need to balance precision and recall, and there is an uneven class distribution (large number of actual negatives).

ROC

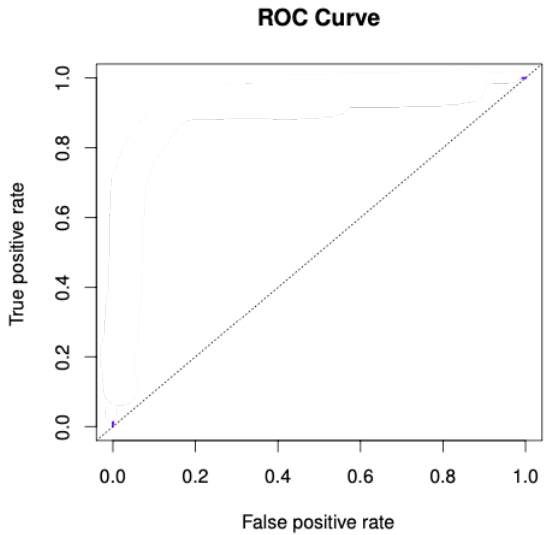
		$\hat{y}_i$ = 0	$\hat{y}_i$ = 1
y_i	0	TN	FP
	1	FN	TP

- A classification rule, or cutoff, is the probability p at which you predict
  - $\hat{y}_i = 0$ if $p_i < c$
  - $\hat{y}_i = 1$ if $p_i > c$
- Bayes classifier $c = 0.5$
- Changing c changes predictions, changes FP and FN
- There is a trade-off: reducing one error increases the other

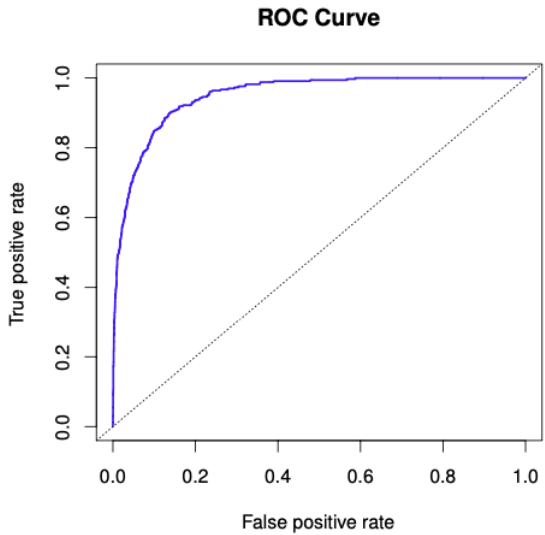
ROC

- ROC curve: Receiver operating characteristic curve
- ROC curve illustrates the trade-off of the classification rule
- Gives us the ability
  - Measure the predictive capacity of our model
  - Compare between models

ROC


ROC Curve
True positive rate
False positive rate
0.0
0.2
0.4
0.6
0.8
1.0

ROC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Example: Default

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Desbalance de Clases: Motivation

- Al modelar clases discretas, las frecuencias relativas de las clases pueden tener un impacto significativo en la efectividad del modelo.
- Se produce un desequilibrio cuando una o más clases tienen proporciones muy bajas en los datos de entrenamiento en comparación con las otras clases.
- Ejemplos: Default, Pobreza, Tasa de Positividad de Covid, etc.
- Existen varias estrategias a utilizar y vamos a explorarla en el siguiente ejemplo

Example: Fraud

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