

## ML Week 0x04 Logistic Regression

### linear vs logistic ( $\times 2$ )

- $y$  is discrete: classification
- Examples:
  - spam/non-spam
  - transaction: fraud or legitimate
  - tumor: malignant or benign
- So 0 or 1
- Problems with linear regression here (picture)
- sigmoid ( $\times 2$ )

### Non-linear decision boundaries ( $\times 2$ )

- Still just use gradient descent (*algorithme du gradient*) (*de la plus forte pente*) (*de la plus profonde descente*) (*hill climbing*)
- This is why we like things to be differentiable
- Multinomial (multi-class) classification
  - one vs all (OvA, OvR) (draw picture, get three classifiers)
    - \* At decision time, try  $k - 1$  classifiers, choose the one with the most +1 votes (highest probability)
    - \* Problem: learners see more negatives than positives
    - \* Problem: different confidence for different decision boundaries
  - one vs one (OvO) (draw picture, get three classifiers)
    - \* At decision time, try  $k(k - 1)/2$  classifiers, choose the one with the most +1 votes (highest probability)

### Cost function ( $\times 7$ )

- This is not convex
- So potentially many local minima

- **Plot cost** and explain what it means for  $y \in \{0, 1\}$ .
- Note that our convex cost function
  - is differentiable
  - can be derived from statistics using the principles of maximum likelihood estimation (maximum de vraisemblance)

## Exercises

### Error types

- Null hypothesis (*hypothèse nulle*)
- True/false positive/negative
- Type I error = incorrect rejection of null hypothesis (roughly, false positives)
- Type II error = failure to reject null hypothesis (roughly, false negatives)
- 100% sensitivity = no false negatives
- 100% specificity = no false positives

### Performance metrics

- **Precision** (also: sensitivity)
- **Recall**
- Accuracy
- F1 score (F1 measure) *roughly, a weighted average*
- *skip this:*
  - ROC (receiver operating characteristics = fonction d'efficacité du récepteur, courbe ROC) AUC (area under curve = l'aire sous la courbe)
  - Inventé pendant la WWII pour montrer la séparation entre les signaux radar et le bruit de fond.
- Confusion matrix (*matrice de confusion*) or contingency table, error matrix. Rows are classes, columns are predicted classes.

### ROC

- x-axis is FPR, y-axis is TPR
- Plots cdf of TPR against cdf of FPR
- Really, plotting both against some classifier parameter
- Random guessing gives point on diagonal line. Coin flipping evolves towards  $(.5, .5)$ .
- Want: just an upper left point