Assignment 8,9 + Classifiers

(SNLP Tutorial 9)

Vilém Zouhar, Awantee Deshpande, Julius Steuer

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Assignment 8

- Exercise 1: Feature Selection (DF, PMI)
- Exercise 2: χ^2
- Exercise 3: Author identification
- Bonus: Features for clustering

Decision Trees

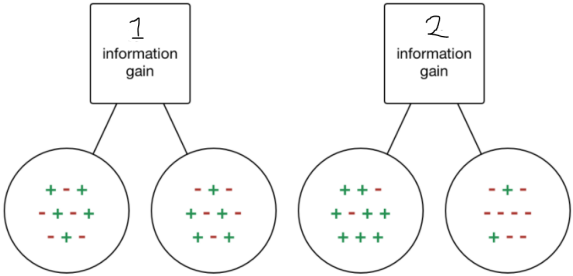
- Can be used for classification as well as regression
- Algorithm

function DECISION-TREE-LEARNING(examples, attributes, parent_examples) **returns** a tree
  if *examples* is empty **then return** PLURALITY-VALUE(*parent_examples*)
  else if all *examples* have the same classification **then return** the classification
  else if *attributes* is empty **then return** PLURALITY-VALUE(*examples*)
  else
    $A \leftarrow \underset{a \in attributes}{\textbf{argmax}}$ IMPORTANCE(*examples*)
    tree $\leftarrow$ a new decision tree with root test A
    for each value v_k of A **do**
      $exs \leftarrow \{e : e \in examples \textbf{ and } e.A = v_k\}$
      subtree $\leftarrow$ DECISION-TREE-LEARNING(*exs*, *attributes* $-A$, *examples*)
      add a branch to *tree* with label $(A = v_k)$ and subtree *subtree*
    return *tree*

What is plurality value?
What is importance?

Decision Trees - Questions

- Which of the 2 splits has a better information gain?



Decision Trees - Questions

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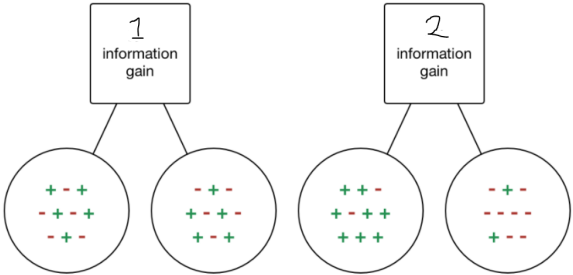
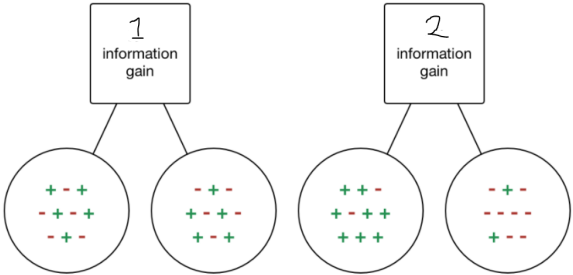


- What are the pros and cons of decision trees?

Decision Trees - Questions

- Which of the 2 splits has a better information gain?



- What are the pros and cons of decision trees?
- How to avoid overfitting?

Naïve Bayes

- Based on Bayes Theorem
- Algorithm

```
Given a set of features {x1…xn} and class label y
For each xi in x and yi in y:
      Find P (xi | yi)
For all yi in y:
      Find P(yi)
For a new sample x' = {x1'…xn'}
For every y in yi:
      P (yi | x') = Π P(yi | xi'} for xi' in {x1'…xn'}
Assign yi with maximum P(yi|x') as the class label.
```

Questions

- Why is Naive Bayes naive?
- What are the pros and cons?

kNN

- Algorithm

k-Nearest Neighbor
Classify $(\mathbf{X}, \mathbf{Y}, x)$ // $\mathbf{X}$: training data, $\mathbf{Y}$: class labels of $\mathbf{X}$, x: unknown sample
for $i = 1$ **to** m **do**
  Compute distance $d(\mathbf{X}_i, x)$
end for
Compute set I containing indices for the k smallest distances $d(\mathbf{X}_i, x)$.
return majority label for $\{\mathbf{Y}_i$ where $i \in I\}$

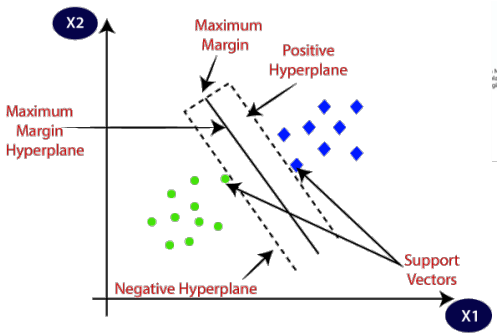
Source:https://www.researchgate.net/figure/Pseudocode-for-KNN-classification_fig7_260397165

Questions

- What are the training and test computation times for kNN?
- What are the pros and cons of kNN classifiers?
- Can kNN be used for regression?

SVM

- Find a boundary that maximizes the distance to closest vectors
- If not possible, find one that minimizes the error
- Add the kernel trick for non-linear data



Questions

- What are the pros and cons of SVMs?
- Can SVMs be used for regression?

Perceptron

- Binary classification
- Linear boundary in feature space
- $\hat{y} = \text{sign}(wx + b)$

Algorithm:

- $w_0 = \overrightarrow{0}$
- For every data point x_i
- $\hat{y}_i = \text{sign}(w_k x_i + b)$
- ▸ if $\hat{y}_i \neq y_i$:
- ▸ ★ $w_{k+1} = w_k - \hat{y}_i \cdot x$
- ▸ else:
- ▸ ★ $w_{k+1} = w_k$

Questions

- What are the pros and cons of simple perceptrons?
- Can we extend this to non-linear data?

Common Evaluation Measures

- Confusion matrix
- Precision $= \frac{TP}{TP+FP}$ (out of those marked as 1, how many are actually 1?)
- Recall $= \frac{TP}{TN+FN}$ (out of all 1s, how many are marked 1?)
- F-measure $= \frac{2*P \cdot R}{P+R}$ (weighted average of precision and recall)
- Accuracy $= \frac{TP+TN}{TP+TN+FP+FN}$

Useful Python Implementations

- https://scikit-learn.org/stable/supervised_learning.html
- Decision Trees: https://scikit-learn.org/stable/modules/tree.html
- Naive Bayes: https://scikit-learn.org/stable/modules/naive_bayes.html
- K Nearest Neighbour: https://scikit-learn.org/stable/modules/neighbors.html
- SVMs: https://scikit-learn.org/stable/modules/svm.html
- Perceptron: https://scikit-learn.org/stable/modules/generated/sklearn.linear_model.Perceptron.html
- Evaluation metrics: https://scikit-learn.org/stable/modules/model_evaluation.html

Resources

1. UdS SNLP Class, WSD: https://teaching.lsv.uni-saarland.de/snlp/
2. Decision Trees: https://www.kdnuggets.com/2020/01/decision-tree-algorithm-explained.html
3. Naive Bayes Example: https://medium.com/analytics-vidhya/naive-bayes-classifier-for-text-classification-556fabaf252b
4. kNN Example: https://iq.opengenus.org/text-classification-using-k-nearest-neighbors/
5. SVM: https://monkeylearn.com/blog/introduction-to-support-vector-machines-svm/
6. Perceptron https://machinelearningmastery.com/perceptron-algorithm-for-classification-in-python/