7: Catchup Session & very short intro to other classifiers

Machine Learning and Real-world Data (MLRD)

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Lent 2019
What happens in a catchup session?

- Lecture and practical session as normal.
- New material is non-examinable.
- Time for you to catch-up or attempt some starred ticks.
- Demonstrators help as per usual.
Naive Bayes is a probabilistic classifier

- Given a set of input features a probabilistic classifier provide a distribution over classes.
- That is, for a set of observed features $O$ and classes $c_1...c_n \in C$ gives $P(c_i|O)$ for all $c_i \in C$.
- For us $O$ was the set all the words in a review $\{w_1, w_2, ..., w_n\}$ where $w_i$ is the $i$th word in a review, $C = \{\text{POS, NEG}\}$.
- We decided on a single class by choosing the one with the highest probability given the features:

$$\hat{c} = \arg\max_{c \in C} P(c|O)$$
An SVM is a popular non-probabilistic classifier

- A Support Vector Machine (SVM) is a non-probabilistic binary linear classifier
- SVMs assign new examples to one category or the other
- SVMs can reduce the amount of labeled data required to gain good accuracy
- A linear-SVM can be considered to be a base-line for non-probabilistic approaches
- SVMs can be efficiently adapted to perform a non-linear classification
SVMs find hyper-planes that separate classes

- Our classes exist in a multidimensional feature space
- A linear classifier will separate the points with a hyper-plane
SVMs find a maximum-margin hyperplane in noisy data

- There are many possible hyperplanes
- SVMs find the best hyperplane such that the distance from it to the nearest data point from each class is maximised
- i.e. the hyperplane that passes through the widest possible gap (hopefully helps to avoid over-fitting)
SVMs can be very efficient and effective

- Efficient when learning from a large number of features (good for text)
- Effective even with relatively small amounts of labelled data (we only need points close to the plane to calculate it)
- We can choose how many points to involve (size of margin) when calculating the plane (tuning vs. over-fitting)
- Can separate non-linear boundaries by increasing the feature space (using a kernel function)
Choice of classifier will depend on the task

Comparison of a SVM and Naive Bayes on the same task:

- 2000 imdb movie reviews, 400 kept for testing
- preprocess with improved tokeniser (lowercased, removed uninformative words, dealt with punctuation, lemmatised words)

<table>
<thead>
<tr>
<th></th>
<th>SVM</th>
<th>Naive Bayes</th>
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</thead>
<tbody>
<tr>
<td>Accuracy on train</td>
<td>0.98</td>
<td>0.96</td>
</tr>
<tr>
<td>Accuracy on test</td>
<td>0.84</td>
<td>0.80</td>
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</tbody>
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- But from Naive Bayes I know that character, good, story, great, ... are informative features
- SVMs are more difficult to interpret
Decision tree can be used to visually represent classifications

- Simple to interpret
- Can mix numerical and categorical data
- You specify the parameters of the tree (maximum depth, number of items at leaf nodes—both change accuracy)
- But finding the optimal decision tree can be np-complete
Information gain can be used to decide how to split

- Information gain is defined in terms of entropy $H$

Entropy of tree node:

$$H(n) = -\sum_{p} p_i \log_2 p_i$$

where $p$’s are the fraction of each class at node $n$

- Information gain $I$ is used to decide which feature to split on at each step in building the tree

Information gain:

$$I(n, D) = H(n) - H(n|D)$$

where $H(n|D)$ is the weighted entropy of the daughter nodes.
Information gain can be used to decide how to split
Results on the 2000 movie reviews:

<table>
<thead>
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<th>DTREE (max depth 7)</th>
</tr>
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<td>0.69</td>
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Classifier comparison on sample data

Modified from SciKit Learn Classifier Comparison
Today

- Come to see lecturers if you are behind
- New topic starts on Monday—try to have ticks 1–6 by end of today