Selecting a useful subset from all the features

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Why Feature Selection?

• Some algorithms scale (computationally) poorly with increased dimension

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- Reduces data set and resulting model size
- Note: Feature Selection is different from Feature Extraction
 - The latter transforms original features to get a small set of new features
 - More on feature extraction when we cover Dimensionality Reduction

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• Methods agnostic to the learning algorithm

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- Methods agnostic to the learning algorithm
 - Preprocessing based methods
 - E.g., remove a binary feature if it's ON in very few or most examples
 - Filter Feature Selection methods
 - Use some ranking criteria to rank features
 - Select the top ranking features

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- Wrapper Methods (keep the learning algorithm in the loop)
 - Requires repeated runs of the learning algorithm with different set of features
 - Can be computationally expensive

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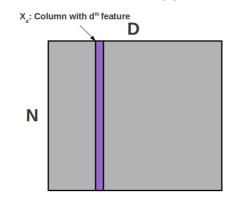
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• Uses heuristics but is much faster than wrapper methods

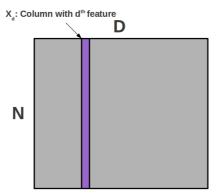


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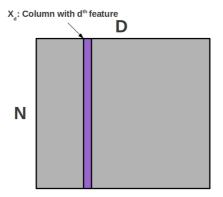
• Correlation Critera: Rank features in order of their correlation with the labels ()/)/)

$$R(X_d, Y) = rac{cov(X_d, Y)}{\sqrt{var(X_d)var(Y)}}$$

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• Mutual Information Criteria:

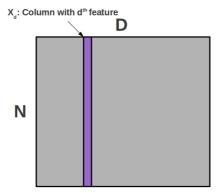
$$MI(X_d, Y) = \sum_{X_d \in \{0,1\}} \sum_{Y \in \{-1,+1\}} P(X_d, Y) \frac{\log P(X_d, Y)}{P(X_d) P(Y)}$$

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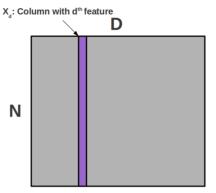
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- High mutual information mean high relevance of that feature
- Note: These probabilities can be easily estimated from the data

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• Two types: Forward Search and Backward Search

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- Two types: Forward Search and Backward Search
 - Forward Search
 - Start with no features

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• Two types: Forward Search and Backward Search

- Forward Search
 - Start with no features
 - Greedily include the most relevant feature

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• Two types: Forward Search and Backward Search

• Forward Search

- Start with no features
- Greedily include the most relevant feature
- Stop when selected the desired number of features
- Backward Search

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• Two types: Forward Search and Backward Search

• Forward Search

- Start with no features
- Greedily include the most relevant feature
- Stop when selected the desired number of features

Backward Search

• Start with all the features

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• Two types: Forward Search and Backward Search

• Forward Search

- Start with no features
- Greedily include the most relevant feature
- Stop when selected the desired number of features

Backward Search

- Start with all the features
- Greedily remove the least relevant feature

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• Two types: Forward Search and Backward Search

Forward Search

- Start with no features
- Greedily include the most relevant feature
- Stop when selected the desired number of features

Backward Search

- Start with all the features
- Greedily remove the least relevant feature
- Stop when selected the desired number of features

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• Two types: Forward Search and Backward Search

Forward Search

- Start with no features
- Greedily include the most relevant feature
- Stop when selected the desired number of features

Backward Search

- Start with all the features
- Greedily remove the least relevant feature
- Stop when selected the desired number of features
- Inclusion/Removal criteria uses cross-validation

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• Forward Search

• Let $\mathcal{F} = \{\}$

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Forward Search

- Let $\mathcal{F} = \{\}$
- While not selected desired number of features
- For each unused feature f:

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Forward Search

- Let $\mathcal{F} = \{\}$
- While not selected desired number of features
- For each unused feature *f*:
 - Estimate model's error on feature set $\mathcal{F} \bigcup f$ (using cross-validation)

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Forward Search

- Let $\mathcal{F} = \{\}$
- While not selected desired number of features
- For each unused feature *f*:
 - Estimate model's error on feature set $\mathcal{F} \bigcup f$ (using cross-validation)
- Add f with lowest error to \mathcal{F}

Backward Search

• Let $\mathcal{F} = \{ all \text{ features} \}$

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Forward Search

- Let $\mathcal{F} = \{\}$
- While not selected desired number of features
- For each unused feature *f*:
 - Estimate model's error on feature set $\mathcal{F} \bigcup f$ (using cross-validation)
- Add f with lowest error to \mathcal{F}

Backward Search

- Let $\mathcal{F} = \{ all features \}$
- While not reduced to desired number of features
- For each feature $f \in \mathcal{F}$:

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Forward Search

- Let $\mathcal{F} = \{\}$
- While not selected desired number of features
- For each unused feature *f*:
 - Estimate model's error on feature set $\mathcal{F} \bigcup f$ (using cross-validation)
- Add f with lowest error to \mathcal{F}

Backward Search

- Let $\mathcal{F} = \{ all \text{ features} \}$
- While not reduced to desired number of features
- For each feature $f \in \mathcal{F}$:
 - Estimate model's error on feature set $\mathcal{F} \setminus f$ (using cross-validation)

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Forward Search

- Let $\mathcal{F} = \{\}$
- While not selected desired number of features
- For each unused feature *f*:
 - Estimate model's error on feature set $\mathcal{F} \bigcup f$ (using cross-validation)
- Add f with lowest error to \mathcal{F}

Backward Search

- Let $\mathcal{F} = \{ all \text{ features} \}$
- While not reduced to desired number of features
- For each feature $f \in \mathcal{F}$:
 - Estimate model's error on feature set $\mathcal{F} \setminus f$ (using cross-validation)
- Remove f with lowest error from \mathcal{F}

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