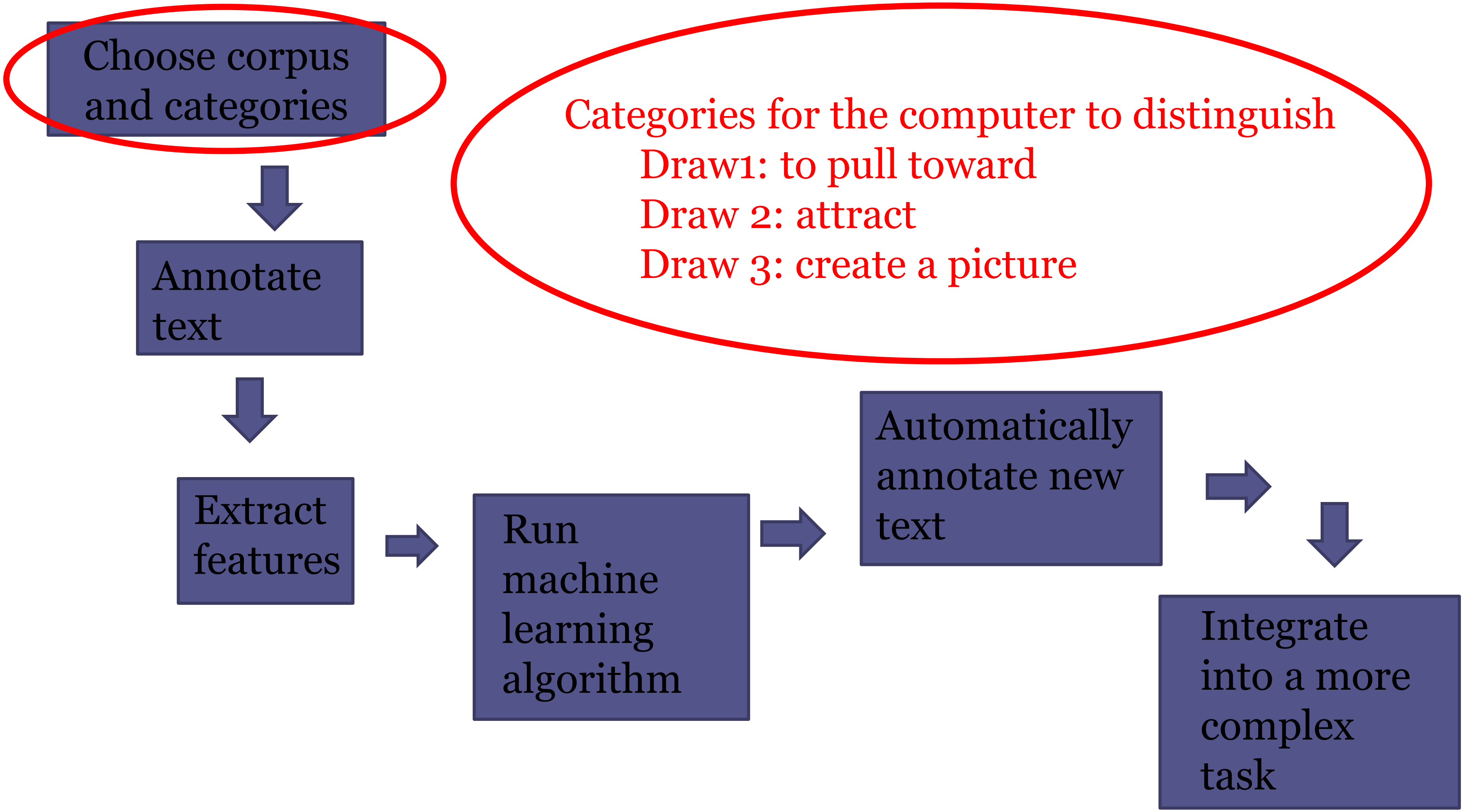
Machine Learning for Semantics in NLP

Supervised machine learning for NLP



Supervised machine learning for NLP

Choose corpus and categories

Annotate text

Label each instance of *draw* in the corpus as draw1, draw2 or draw3

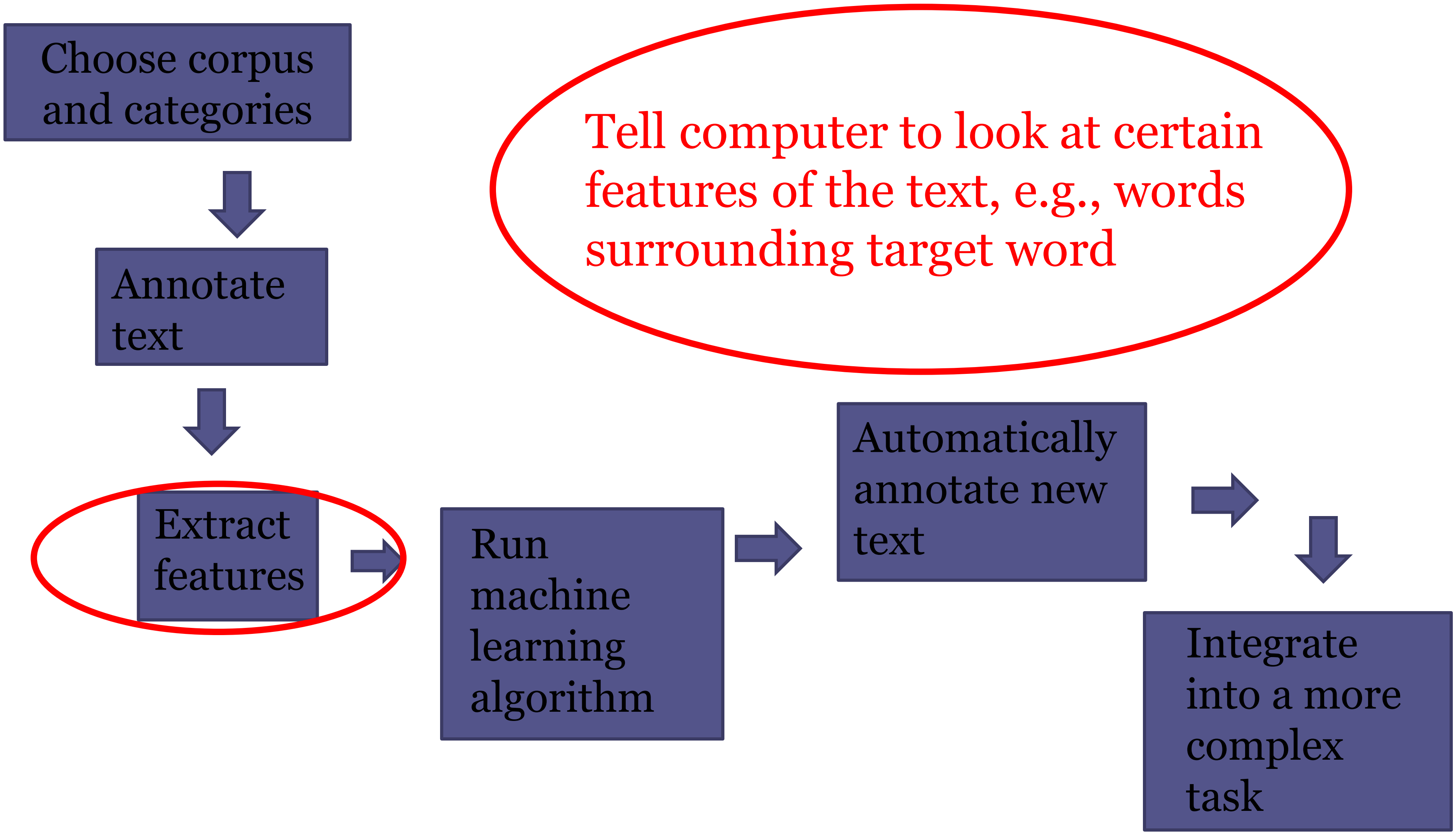
Extract features

Run machine learning algorithm

Automatically annotate new text

Integrate into a more complex task

Supervised machine learning for NLP



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Computer correlates features with different senses of *draw*

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When given new text, the system looks at those features to label instances of *draw* with draw1, draw2, or draw3

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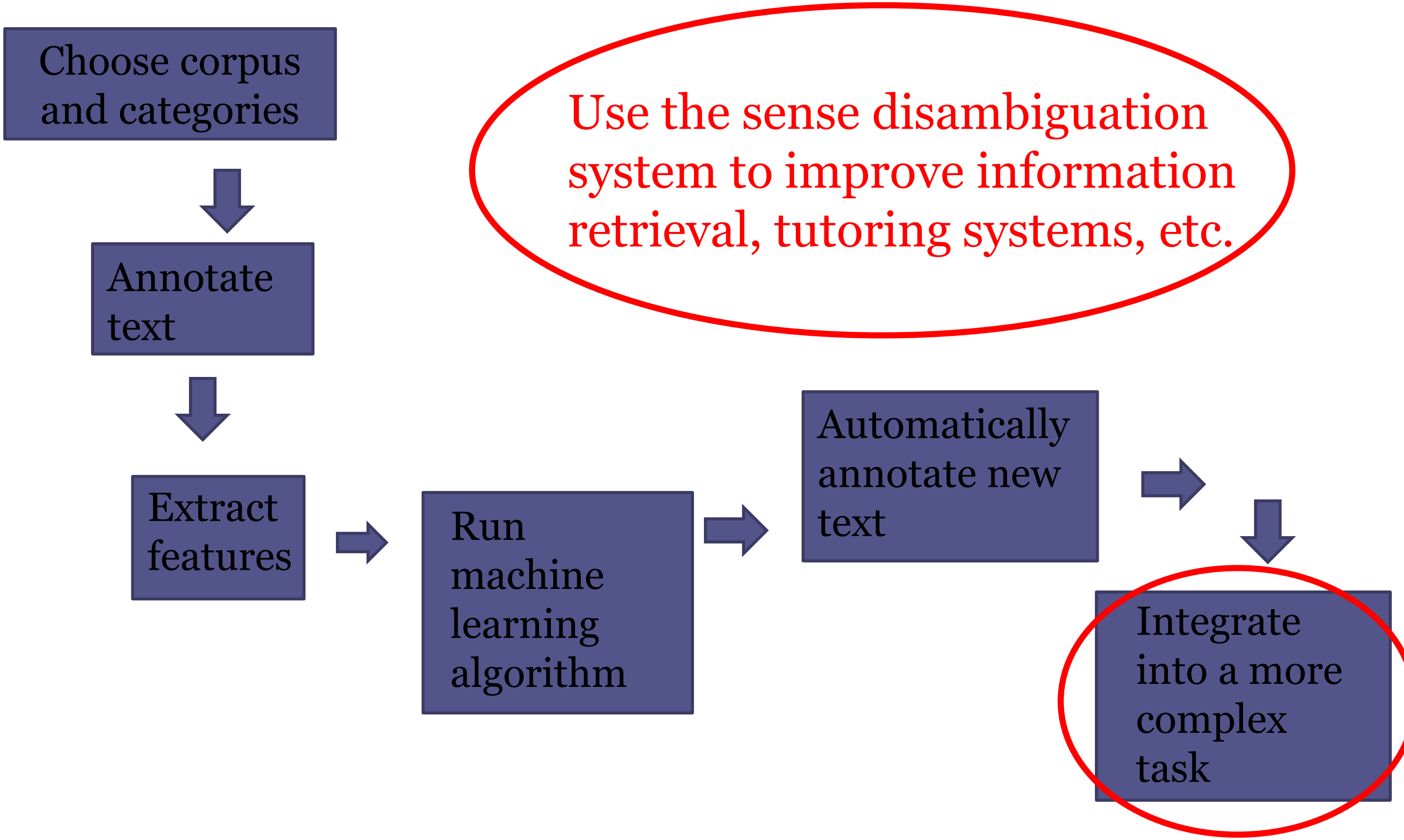

Features for WSD

- Lexical
- Syntactic
- Semantic

Lexical

- Words surrounding the target word
  - Choose the window size (2-3 is common)
- All the words in the sentence (and the sentence before and after)
- POS tag for words in the window
- 10,000s of features
- Binary choice for all the words in the corpus
- Most powerful features

Syntactic

- Parse tree labels of the phrase's and its siblings' head words
- For verb sense disambiguation
    - Whether a sentence is passive or active
    - Whether target has subordinate clause
    - Whether target has a PP adjunct
    - Parse tree label of the verb's parent

Semantic

- Named entity type of the word
- Document topic
- For verbs:
  - Synonyms and hypernyms of the arguments (WN)
  - Named entity type of the arguments
  - Dynamic dependency neighbors (object classes)

Features for SRL: Parse-free

- Argument phrase type
  - FN Speaker likely to be a noun phrase
  - FN Topic likely to be a PP or NP
  - FN Medium likely to be a PP
  - [We] talked [about the party] [over the phone.]
- Argument position relative to the target predicate
- Argument order
  - First step is to ID arguments of a sentence
  - Number the arguments

SRL features: Using a parse

- Governing category: Subject or in the VP
- Path through the parse tree from the target predicate to the argument
- Active or passive voice
- Head word of the phrase
  - Lexical feature that needs a parse
- Head word of objects of PPs
  - On Monday
  - On the table

SRL features: to parse or not

- Some languages do not have high-accuracy automatic parsers
- Parsing takes a long time
- Chunking is almost as good (Carreras and Marquez, 2005)
  - NP V NP PP
- Use both to compensate for parser errors

How do you get the features?

- For most realistic assessment of a system, should be done automatically
- The system should be usable on new data
- For example, for syntactic features, use an automatic parser
- Automatic parsers produce errors
  - Lowers a SRL system's F score by 10 points
  - Less impact on WSD

What type of parse to use

- Phrase structure parser (Penn Treebank)
- Combinatorial Categorical Grammar (CCG)
- Lexical Tree Adjoining Grammar (LTAG)
- Dependency parses
- Last 3 more compatible with SRL (Palmer et al., 2010)

Which classifier to use?

- SVM is fast
  - Good for data with a lot of features
  - Good for creating many classifiers (wsd)
- Try different ones out
- SRL
- 2-stage process
  - ID and label individual arguments
  - Finding the best set of roles for an entire sentence
    - Reranking
    - Viterbi search
    - Integer linear programming

Evaluation of WSD systems

- Accuracy
- Percentage correct, as judged against "gold standard" annotation
- Compared to a lower bound, usually the accuracy of a most-frequent-sense method
  - Can be quite high for words with one dominant sense
- Compared to an upper bound: inter-annotator agreement

Evaluation of SRL systems

- System must find the constituents to annotate
- Precision: Percentage of labels output by the system that are correct
- Recall: Percentage of true labels the system identifies

True: [Agent He] ate [Patient the peaches] [Instrument with a spoon.]

System: [Agent He] ate [Patient the peaches] with a spoon.

Precision: 100%; Recall: 66%

F-score

- A way to combine precision and recall into one score
- Harmonic mean of precision (P) and recall (R)

$$F = \frac{2PR}{P + R}$$

Feature evaluation

- Difficult to see which features contributed the most to defining the categories, especially when using SVM
- Run the system (train and test) using only one feature or one type of feature
- Add in another feature and run again
- Compare the results. Did the new feature help?
  - Simple comparison: Is one score higher?
  - Significance tests: Is one score significantly different from the other?

VerbNet classifier

- Treated as a verb sense disambiguation task
- One classifier per verb
- Semlink corpus used for training and test data
- 344 multiclass verbs
  - average 2.7 classes
  - average of 133 instances
  - Includes verbs labeled in the corpus with one VerbNet class and “No appropriate class”

Features

- Lexical
  - Neighbor words and their POS
- Syntactic
  - Passive/active
  - Types of phrases and clauses
  - Heads of phrases
- Semantic
  - Synonyms and hypernyms of arguments
  - Named entity features
  - Dynamic dependency neighbors

Overall Results

- Accuracy, using 5-fold cross validation: 88.67%
- Baseline (most frequent class): 77.78%
- Error reduction: 49%

Feature Experiments

- Developed several different models, each with a different combination of features
- Created a dedicated test set using 30% of the Semlink corpus

Model
Lexical features only
Lexical + syntactic
Lexical + semantic
All but DDN
Lexical + syntactic + DDN
All features

Feature Results

Model	Baseline (%)	Accuracy (%)	Error Reduction (%)
Lexical features only	77.78	83.07	23.81
Lexical + syntactic	77.78	84.44	29.97
Lexical + semantic	77.78	83.75	26.87
All but DDN	77.78	84.12	28.53
Lexical + syntactic + DDN	**77.78**	**84.89**	**32.00**
All features	77.78	84.65	30.92

- DDNs added significantly more than the other semantic features, resulting in the best-performing model

Tools you can use: WEKA Explorer

- Open source
- Implemented in Java
- Graphical user interface
- Preprocessing tools
- Multiple algorithms
  - K-nearest neighbor
  - Naïve Bayes
  - Perceptrons, including SVM
- Visualization tools
- Hands-on tutorial next week
- http://www.cs.waikato.ac.nz/ml/weka/

Tools you can use: RapidMiner

- Open source
- Implemented in Java
- Graphical user interface
- Preprocessing tools
- Multiple algorithms
  - K-nearest neighbor
  - Naïve Bayes
  - Perceptrons, including SVM
- Visualization tools
- http://rapid-i.com/content/view/181/190/