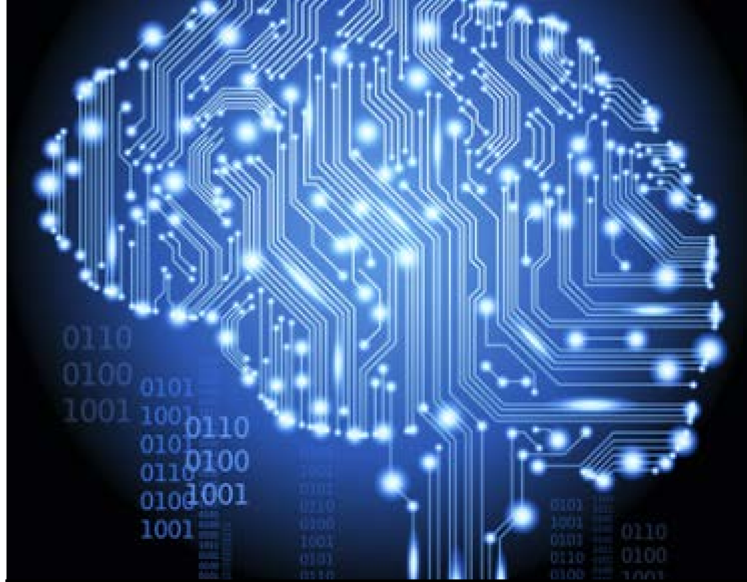
Introduction to

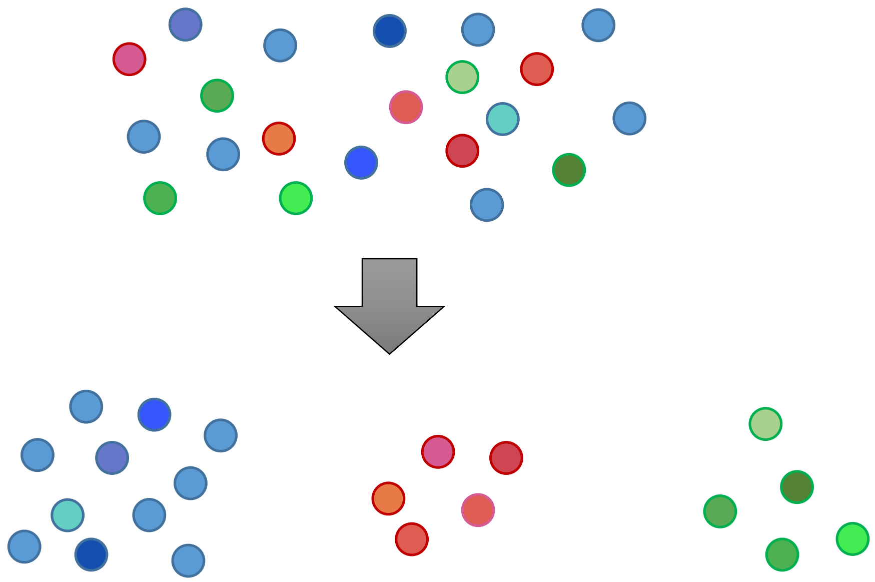
Machine Learning



Topics

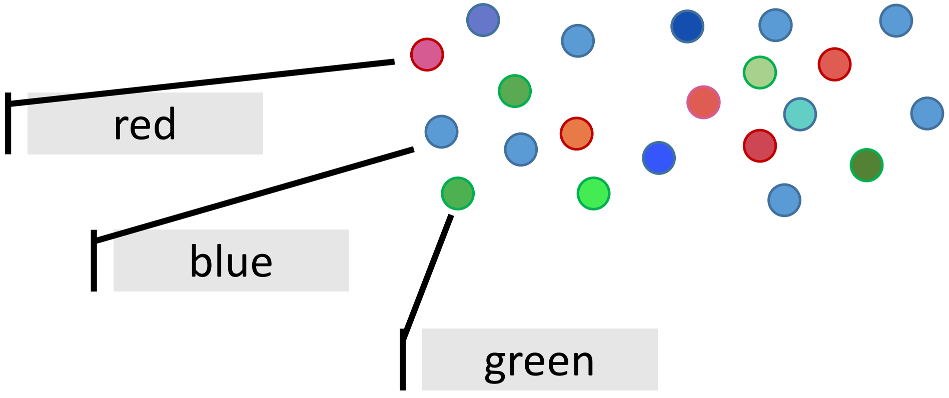
- Basic concepts and process
- Algorithms
- Example (WEKA)

Unsupervised Learning



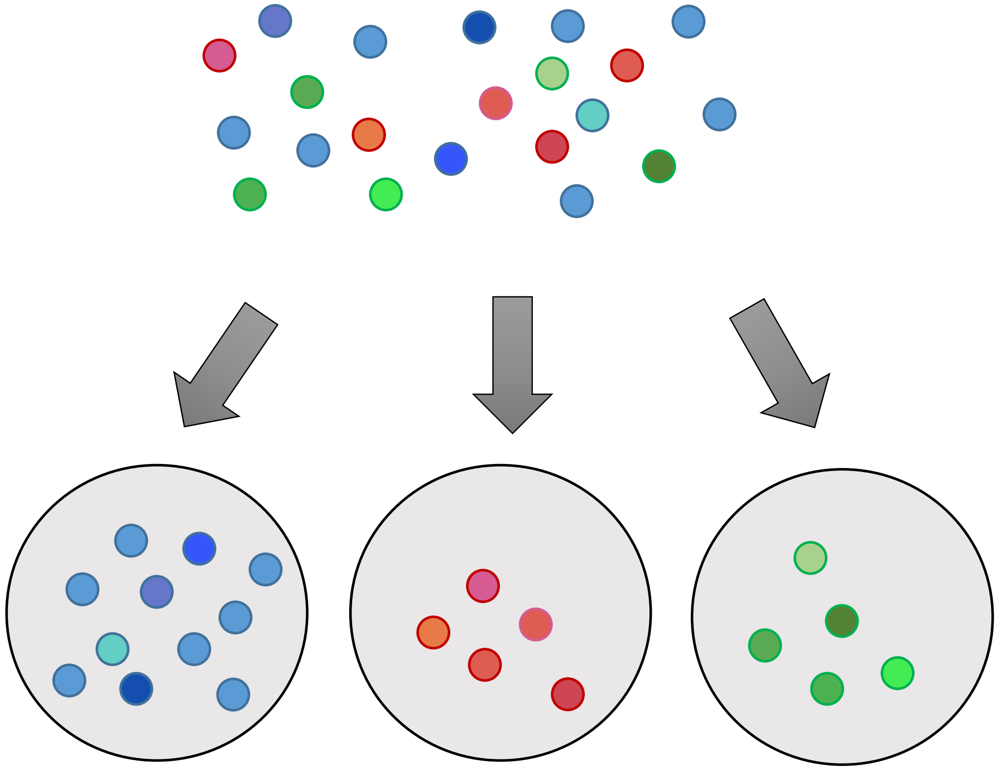
- Find patterns / clusters
- Evaluation: similarity value, classes to clusters, …

Supervised Learning



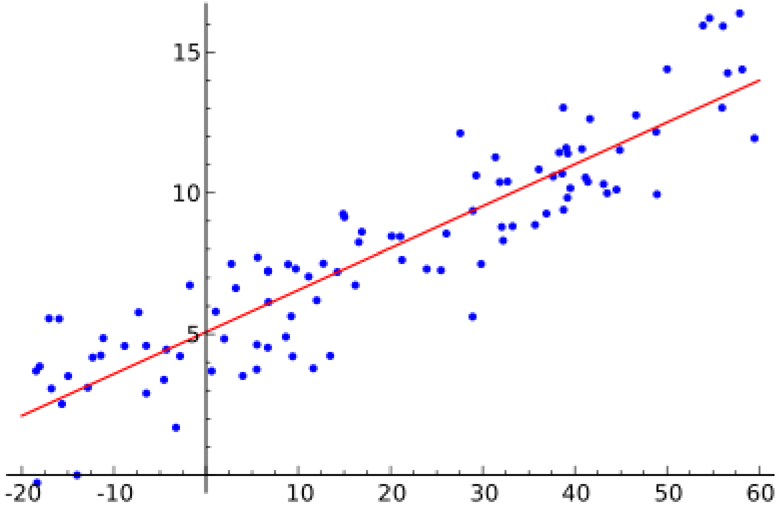
- Predict the correct label
- Evaluation: correctly classified instances, false positive rate, …

Classification



blue red green

Regression



no distinct categories, but a real value

Features / Attributes, Instances

Label / Class attribute

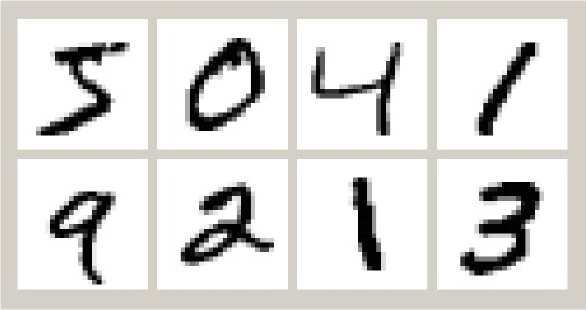
	R	G	B	Color
1	227	25	59	Red
2	17	184	56	Green
3	113	125	222	Blue
4	230	67	175	Red

Features / Attributes

Instance

Training Set – Test Set

Dataset



Labels

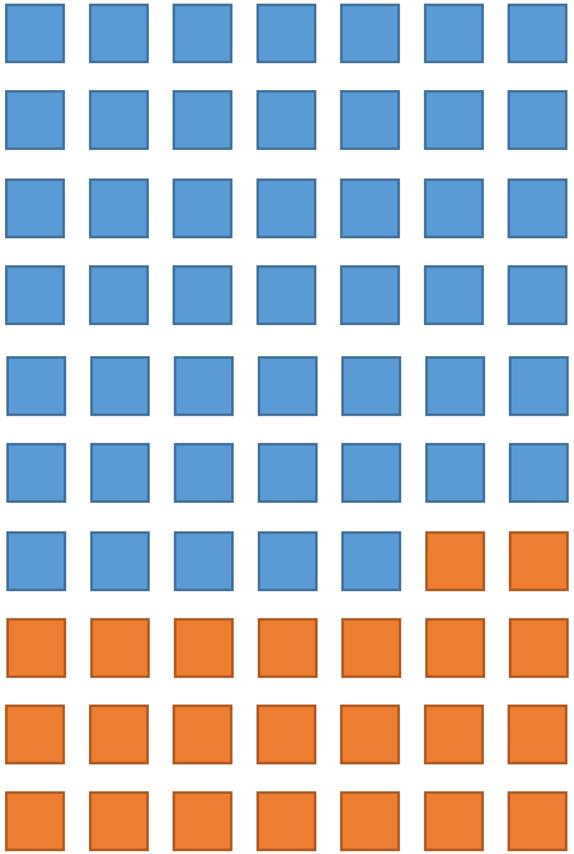
5	0	4	1
4	2	1	3

Training Set

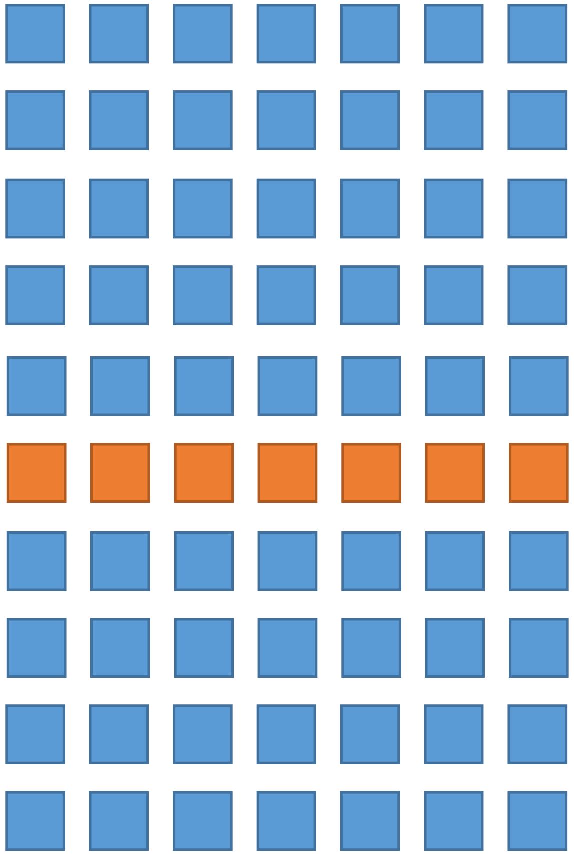
Test Set

Validation Methods

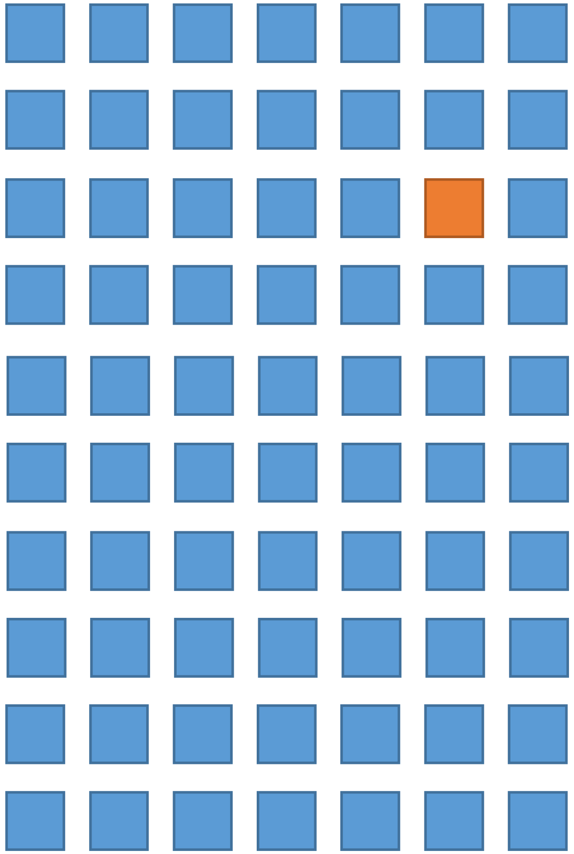
2/3 Training Set
1/3 Test Set



10-fold
Cross-validation



Leave-one-out
cross-validation



Validation Metrics

Confusion Matrix

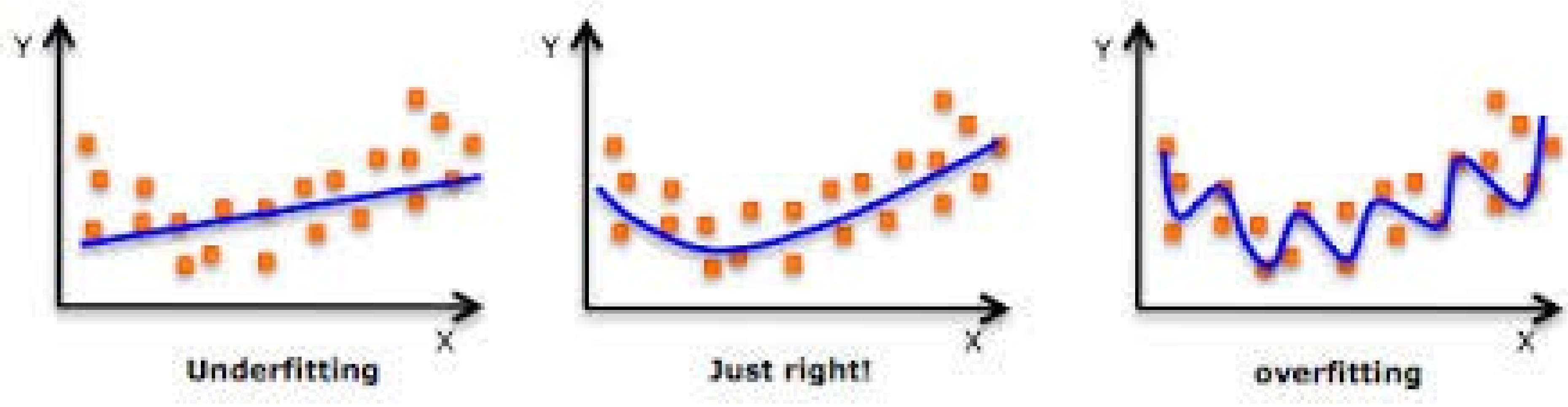
	Classifier outcome: Positive	Classifier outcome: Negative
Condition (label): Positive	**True positive**	**False negative**
Condition (label): Negative	**False positive**	**True negative**

Accuracy: (Σ True positive + Σ True negative) / total
Compare to: base accuracy = percentage share of most likely category

True positive rate = **Recall**: Σ True positive / Σ condition positive
True negative rate: Σ True negative / Σ condition negative
Precision: Σ True positive / Σ Classifier outcome positive

Source and more information: http://en.wikipedia.org/wiki/Confusion_matrix

Underfitting - Overfitting



Basic Process

1. Data collection
2. Feature calculation
3. Feature selection
4. Classification

Algorithms

- Naive Bayes
- Support Vector Machine
- Decision Trees

(There are many more: Neural networks, k-nearest neighbour, …)

Naïve Bayes

- Fast and high performance
- Based on Bayes Theorem
- Assumes independence of features

Example: e-mail classification into *spam* and *no spam.* Features: words

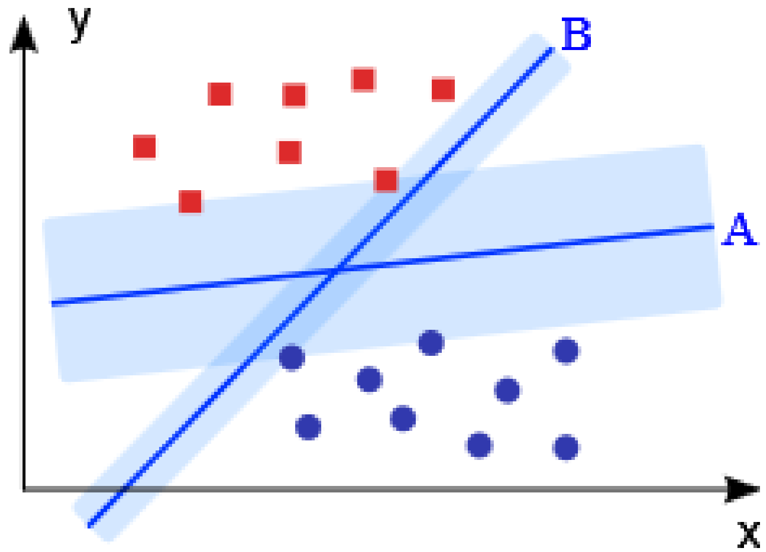
Bayes Theorem: $$P(Spam|W) = \frac{P(Spam \cap W)}{P(W)} = \frac{P(W|Spam)P(Spam)}{P(W)}$$

$$Q = \frac{P(Spam|W)}{P(\overline{Spam}|W)} = \frac{P(W|Spam)P(Spam)}{P(W)} \frac{P(W)}{P(W|\overline{Spam})P(\overline{Spam})} = \frac{P(W|Spam)P(Spam)}{P(W|\overline{Spam})P(\overline{Spam})}$$

Source: http://de.wikipedia.org/wiki/Bayes-Klassifikator

Support Vector Machine

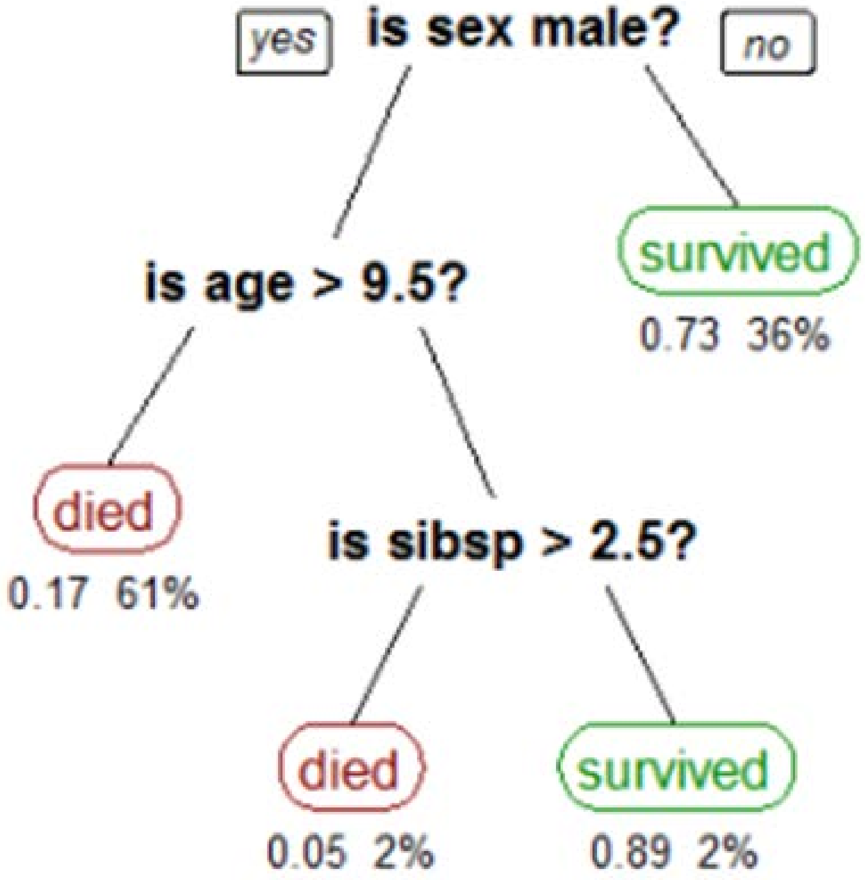
- Divides objects in classes by maintaining a maximally large margin between the objects → *Large Margin Classifier*
- can be used for classification and regression



Source: http://de.wikipedia.org/wiki/Support_Vector_Machine

Decision Tree

- Builds a tree to classify objects
- leaves = class labels
  branches = conjunctions of features that lead to those class labels
- can be used for classification and regression

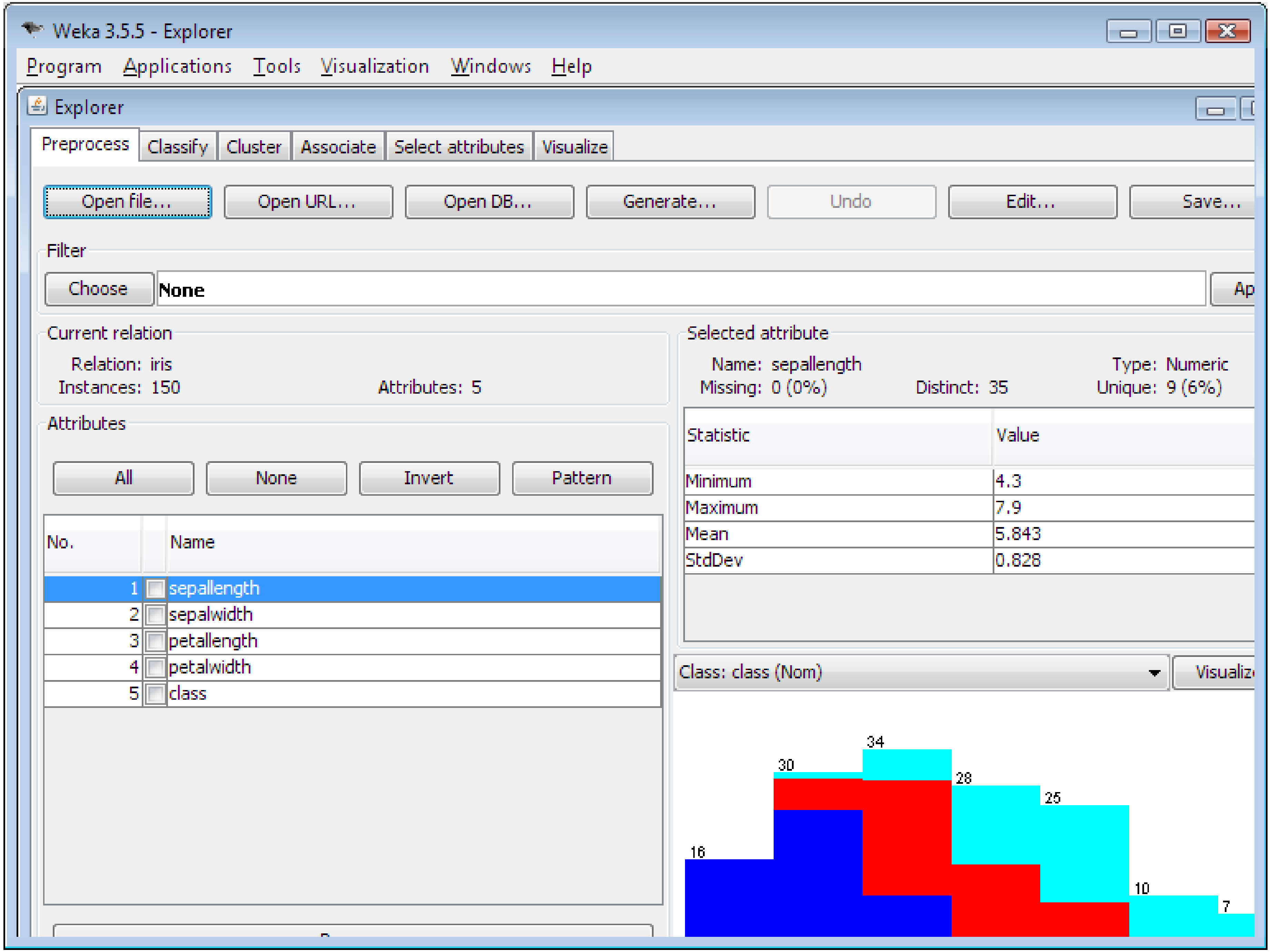


Source: http://en.wikipedia.org/wiki/Decision_tree_learning

WEKA

- Java machine learning framework
- Provides a Java library and a graphical user interface
- Implements many preprocessing algorithms (filters) and classifiers
- Filters: attribute selection, transforming and combining attributes, discretization, normalization, …
- Classifiers: Support Vector Machine (SMO), Decision Tree (J48), Naive Bayes, …

Source: http://www.cs.waikato.ac.nz/ml/weka/



Filter

None

Current relation

Relation: iris
Instances: 150 Attributes: 5

Attributes

No.		Name
1	□	sepallength
2	□	sepalwidth
3	□	petallength
4	□	petalwidth
5	□	class

Selected attribute

Name: sepallength Type: Numeric
Missing: 0 (0%) Distinct: 35 Unique: 9 (6%)

Statistic	Value
Minimum	4.3
Maximum	7.9
Mean	5.843
StdDev	0.828

Class: class (Nom)

Example Dataset: diabetes.arff

General Info:

- Number of Instances: 768
- Number of Attributes: 8 plus class
- Number of instances with label *tested_negative*: 500
- Number of instances with label *tested_positve*: 268

```
6,148,72,35,0,33.6,0.627,50,tested_positive
1,85,66,29,0,26.6,0.351,31,tested_negative
8,183,64,0,0,23.3,0.672,32,tested_positive
1,89,66,23,94,28.1,0.167,21,tested_negative
0,137,40,35,168,43.1,2.288,33,tested_positive
```

Attributes:

1. Number of times pregnant
2. Plasma glucose concentration a 2 hours in an oral glucose tolerance test
3. Diastolic blood pressure (mm Hg)
4. Triceps skin fold thickness (mm)
5. 2-Hour serum insulin (mu U/ml)
6. Body mass index (weight in kg/(height in m)^2)
7. Diabetes pedigree function
8. Age (years)
9. Class variable (0 or 1)

This and more datasets here: http://storm.cis.fordham.edu/~gweiss/data-mining/datasets.html

Example Weka Code Part 1

```
//read data file
DataSource source = new DataSource("C:/Users/Manuela/OneDrive/Work/Teaching/HASE/diabetes.arff");
Instances data = source.getDataSet();

//set class variable
if (data.classIndex() == -1) {
    data.setClassIndex(data.attribute("class").index());
}

//Attribute selection
AttributeSelection filter = new AttributeSelection();
CfsSubsetEval eval = new CfsSubsetEval();
GreedyStepwise search = new GreedyStepwise();
search.setSearchBackwards(true);
filter.setEvaluator(eval);
filter.setSearch(search);
filter.setInputFormat(data);

// Attribute reduction
Instances filteredData = Filter.useFilter(data, filter);
```

Example Weka Code Part 2

```
for (int i = 0; i < 10; i++) {
    int seed = i + 1;
    Random rand = new Random(seed);
    Instances randData = new Instances(data);
    randData.randomize(rand);
    if (randData.classAttribute().isNominal())
        randData.stratify(10);

    Evaluation evalJ48 = new Evaluation(randData);
    for (int n = 0; n < 10; n++) {
        Instances train = randData.trainCV(10, n);
        Instances test = randData.testCV(10, n);

        J48 newTree = (J48) J48.makeCopy(tree);
        newTree.buildClassifier(train);
        evalJ48.evaluateModel(newTree, test);
    }
}
```

We do a **10 times** 10-fold cross-validation

Randomize the data

We do a 10 times **10-fold** cross-validation

Set training set and test set

build and evaluate the classifier

Interpretation of Results

Base accuracy: 65.1 %

Classifier	**Features**	**Accuracy (%)**
J48	All	74.49
J48	Selected	74.38
SMO	All	76.81
SMO	Selected	76.95
Naïve Bayes	All	75.76
Naïve Bayes	Selected	77.06

Selected Features:

- Plasma glucose concentration a 2 hours in an oral glucose tolerance test
- Body mass index
- Diabetes pedigree function (synthesis of family history concerning diabetes)
- Age

Interpretation of Results

Confusion Matrix: Naïve Bayes, selected features

	Classifier outcome: Positive	Classifier outcome: Negative
Condition (label): Positive	436.3	63.7
Condition (label): Negative	112.5	155.5

Summary

Basic concepts of Machine Learning

Classification

Cross-Validation

Confusion Matrix

Test Set

Overfitting

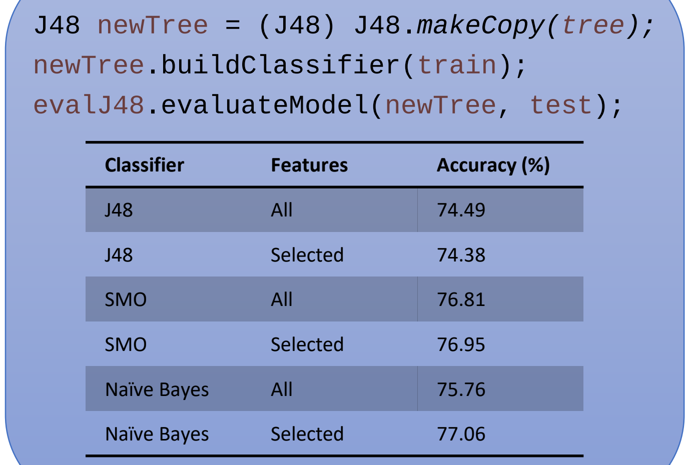
Machine Learning algorithms

Naïve Bayes

Decision Tree

Support Vector Machine

Example



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Further Readings / Links to Machine Learning

- Weka Download: http://www.cs.waikato.ac.nz/ml/weka/downloading.html
- Weka Wiki: http://weka.wikispaces.com/
- Sample Datasets: http://storm.cis.fordham.edu/~gweiss/data-mining/datasets.html
- Book about Machine Learning and Weka: http://www.cs.waikato.ac.nz/ml/weka/book.html
- Book about Artificial Intelligence: http://aima.cs.berkeley.edu/

Image Sources

Title Page: http://www.enterprisetech.com/2014/02/11/netflix-speeds-machine-learning-amazon-gpus/

Regression: http://www.digplanet.com/wiki/Linear_regression

Handwritten Letters: http://yann.lecun.com/exdb/mnist/

Overfitting: http://pingax.com/regularization-implementation-r/

Naïve Bayes Formulas: http://de.wikipedia.org/wiki/Bayes-Klassifikator

Support Vector Machine: http://de.wikipedia.org/wiki/Support_Vector_Machine

Decision Tree: http://en.wikipedia.org/wiki/Decision_tree_learning

Weka Logo: http://www.cs.waikato.ac.nz/ml/weka/

Weka Screenshot: http://commons.wikimedia.org/wiki/File:Weka-3.5.5.png

Empatica: https://www.empatica.com/products.php

Sensecore: https://www.senseyourcore.com

Conversation: http://www.ravishly.com/sites/default/files/field/image/ThinkstockPhotos-122554224.jpg

Blink Light: http://cdn.shopify.com/s/files/1/0543/2969/products/HAD000031_-_blink_Product_4_c8a69a5a-131c-4ce3-be1e-d84b2c3b2d0c.jpg?v=1448393350

Open Windows: https://u.osu.edu/5226sp15/files/2015/02/27a76377-ce9b-4837-8e4a-dd283f1ecaf1_0-1pfyu10.jpg

Meetings: http://www.toronto.ca/legdocs/news/assets/images/2012-calendar.jpg

Github History: http://4.bp.blogspot.com/_jUrEaqvFttU/TKcCHi-QXHI/AAAAAAAAA8M/OY8Shjfl23s/s1600/bikesoup-history.png