Supervised learning of actions

Seminar on AI, summer 2017

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Task

- Learning the function from sensor data to control/action data
- Compare the results of different classification algorithms
- Results depend on data preprocessing
- Based on methods of human activity recognition using wearable sensors

Input and output

- Sensor data corresponding to a single action:
  - Vector of preprocessed sensor data
  - Multivariate time series of sensor data
- Categorical or numeric variables
- Dimensionality, amount of data
- Set of target actions:
  - Control commands
  - Manually annotated activities
- Can also learn to predict the next state (expected sensor readings at time t+1)
- Input: table of preprocessed sensor data + action corresponding to each row or several time-annotated rows

Supervised learning process

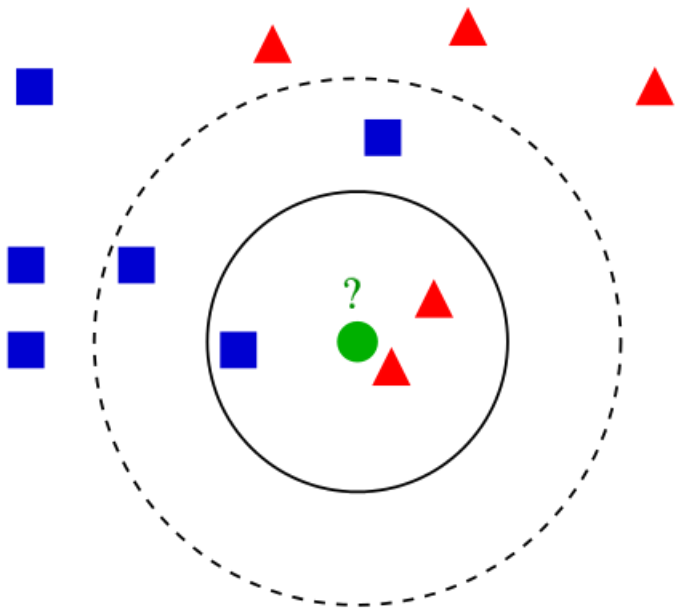
- Multiclass classification
- Hyperparameter optimization using cross-validation
- Measuring accuracy on the test dataset, selecting the best model

Classification algorithms

- Some of the following:
  - K-nearest neighbors
  - Naive Bayes
  - Decision trees
  - Random forest
  - Logistic regression
  - Neural networks
  - …
- Library: scikit-learn in Python

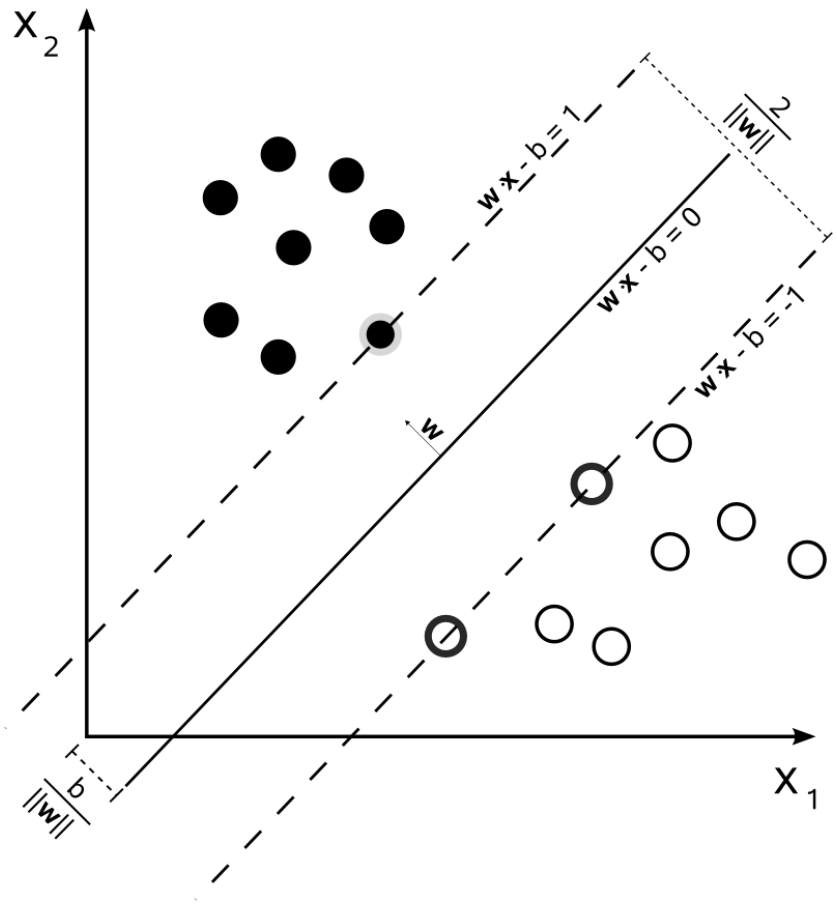
K-nearest neighbors

- Training: store the data points
- Classification: majority vote among *k* nearest neighbors in the feature space
- Choice of parameter *k*



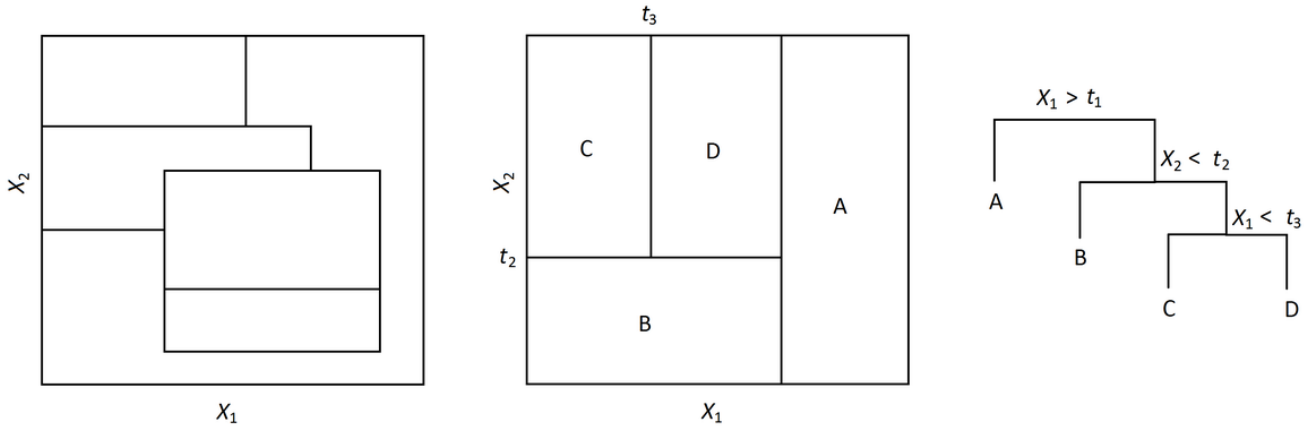
Support vector machines

- Finding a separating hyperplane with the largest margin
- Soft-margin version for non-linearly separable data
- Non-linear classification by using kernel methods – projecting to a higher dimensional space
- Multiclass: one vs. rest or one vs. one



Decision trees

- Each leaf represents the target class obtained by following the path from the root
- Training: top-down splitting of the data set based on value of a feature
- Various heuristics for selecting the best feature for the split, e.g. based on information gain
- Pruning to avoid overfitting



Random forest

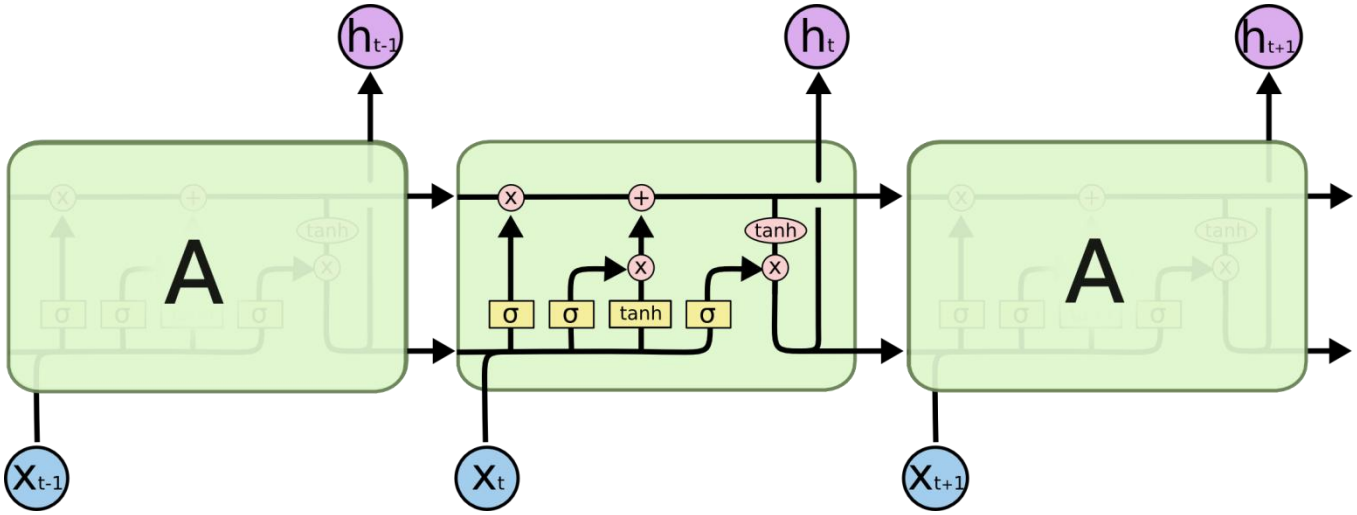
- Ensemble of decision trees
- Each tree constructed using random sampling of the data, as well as random subset of features
- Majority vote of the class
- Corrects overfitting of a single decision tree

Time series classification

- Sequence of sensor data corresponding to a target action – multivariate time series
- Methods of classification include:
  - Hidden Markov models
  - Recurrent neural networks
  - Dynamic time warping + nearest neighbor classification

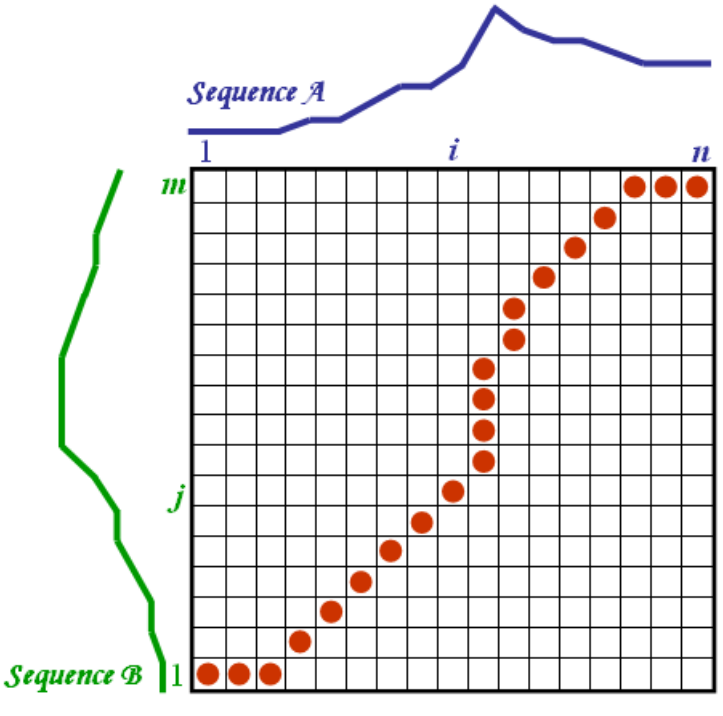
Recurrent neural networks

- **LSTM** (Long short-term memory)
  - Type of RNN capable of learning long-term dependencies, easier to train
  - Contain three or four "gates" to control the flow of information into or out of their memory
  - Trained using backpropagation through time
  - Library: [Tensorflow]



Dynamic time warping

- Algorithm for computing the distance and alignment between two time series which may vary in speed
- Can be used as a distance metric with a 1-nearest neighbor classification



Literature

- Barták, R.; Vomlelová, M. **Using Machine Learning to Identify Activities of a Flying Drone from Sensor Readings**

Human activity recognition:

- Attal, F.; Mohammed, S.; Dedabrishvili, M.; Chamroukhi, F.; Oukhellou, L.; Amirat, Y. **Physical Human Activity Recognition Using Wearable Sensors.**
- Bulling, A.; Blanke, U.; Schiele, B. **A Tutorial on Human Activity Recognition Using Body-Worn Inertial Sensors**
- Lara, O.; Labrador, M. **A Survey on Human Activity Recognition using Wearable Sensors**
- **LSTM for Human Activity Recognition,** https://github.com/guillaume-chevalier/LSTM-Human-Activity-Recognition