# Proseminar Robot Learning WS14/15

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UNI FREIBURG

AiS Autonomous Intelligent Systems

# Organization

- One presentation per topic:
  45 min (30+10+5)
- One seminar report per topic:
  7 pages text (+ figures & literature)
- Collaborative (if necessary): team of 2 students per topic

# Schedule

- Assignment of topics: this week please contact your supervisor for literature

- Discussion of slides with your supervisor: 2 weeks before presentation

- Presentations during 1 or 2 full days Jan/Feb 2015

- Reports due: 1 week after presentation

# Grading

- 60 % presentation
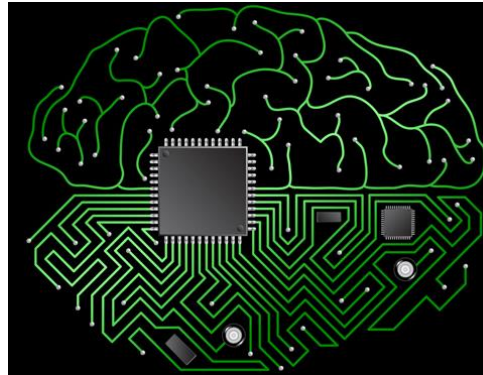- 30 % report
- 10 % contribution in discussions

- Giving and receiving feedback after presentations will be practiced

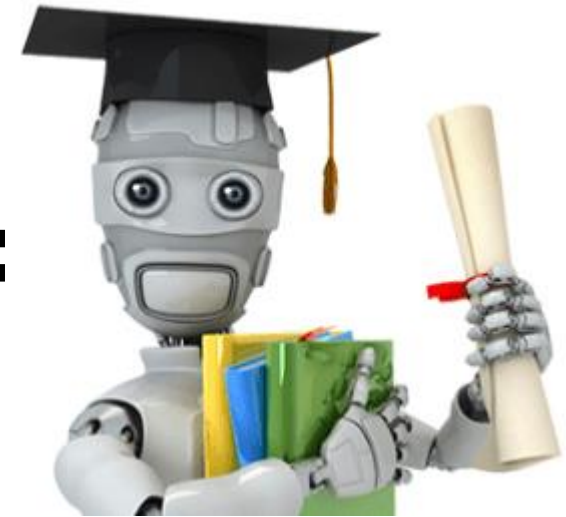# What is robot learning?



Robotics

+

Machine learning

=

Robot learning

# More seriously...

- Applications of machine learning techniques in real-world autonomous systems

- Machine learning methods automatically detect patterns in data

- These patterns are used for prediction of future data

# What is machine learning? (by examples)

- Classification – from data to discrete classes
    - Image Classification
    - Object Detection and Recognition
- Regression – predicting a numerical value
- Clustering – discover structure in data
    - Group similar things together

# What is robot learning? (by examples)

- Learning for object manipulation
- Learning for autonomous navigation
- Motion behavior learning
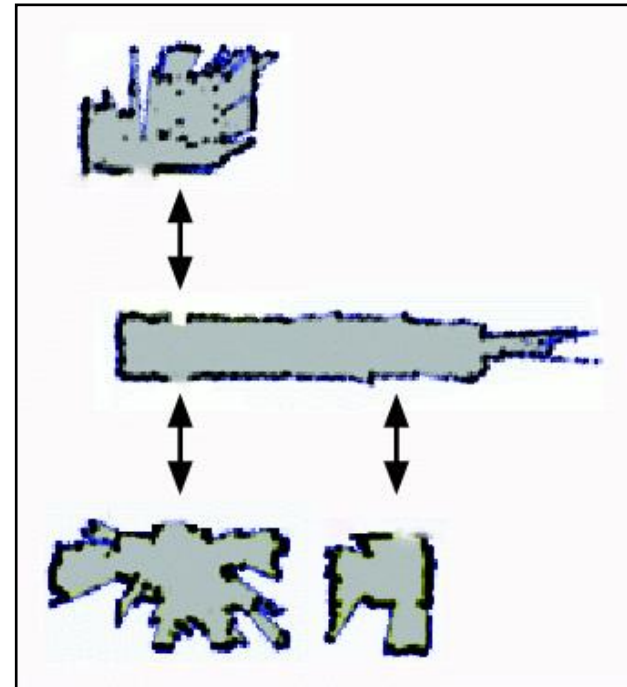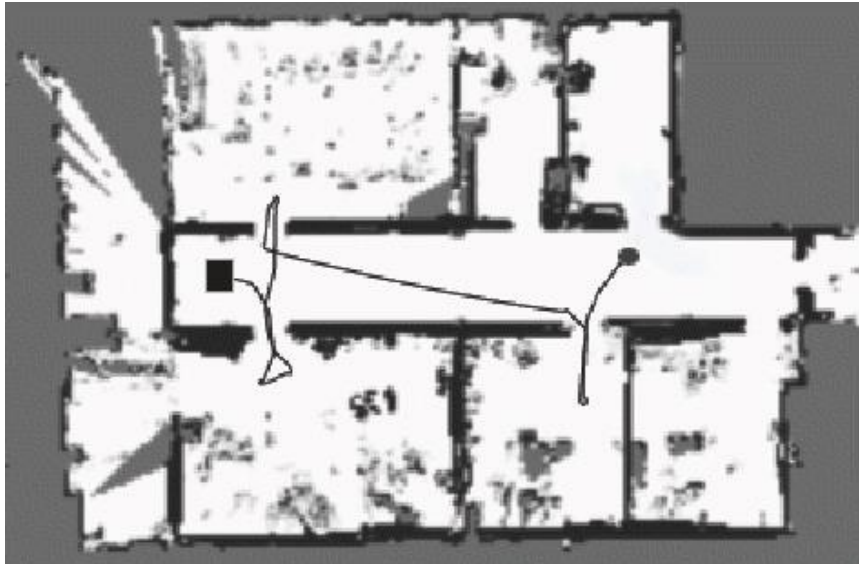- Learning from demonstration
- Object recognition and detection
- …

# Papers

# Learning for autonomous navigation
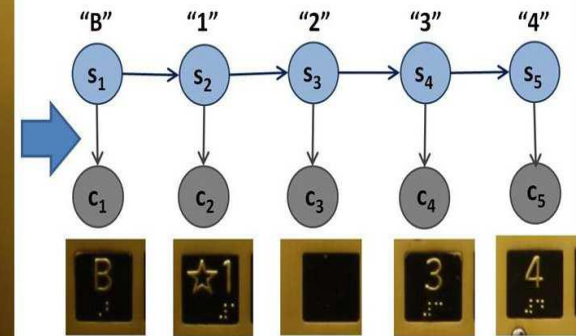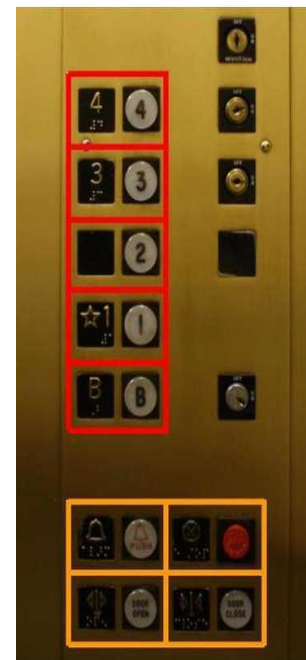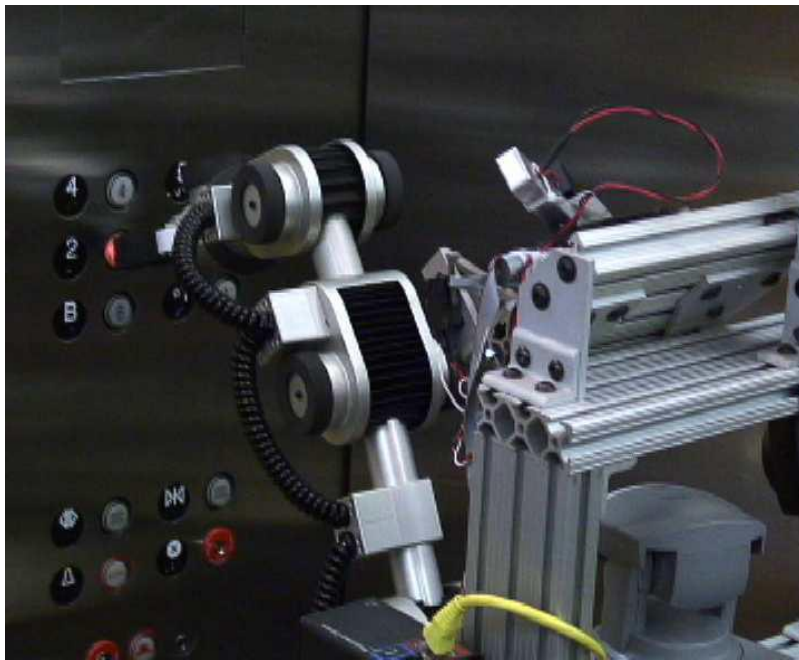


- "Autonomous Operation of Novel Elevators for Robot Navigation" Klingbeil, Carpenter, Russakovsky, Ng - ICRA10
- **Techniques**: hidden Markov models and EM

# Learning for autonomous navigation



- "Topological Mapping Using Spectral Clustering and Classification" Brunskill, Kollar, Roy – IROS07
- **Techniques**: spectral clustering and AdaBoost
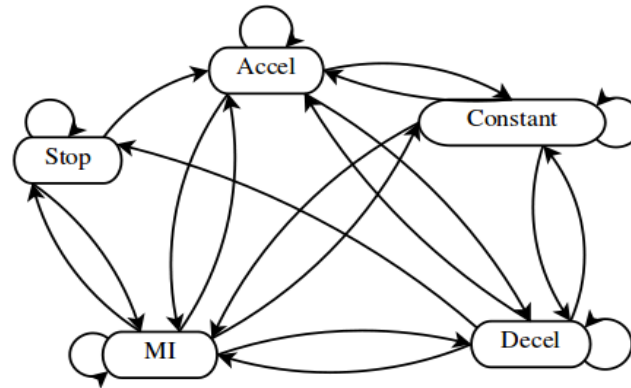
# Motion behavior learning
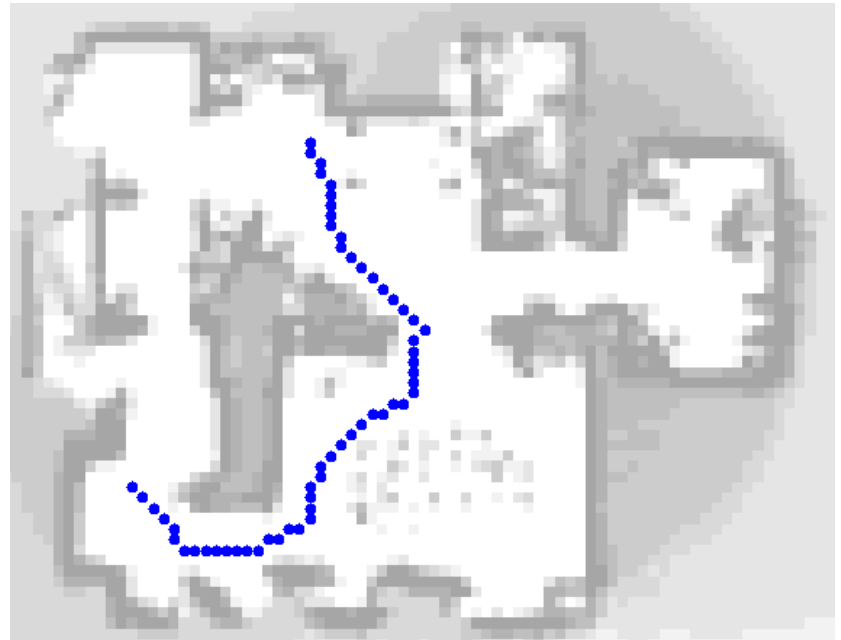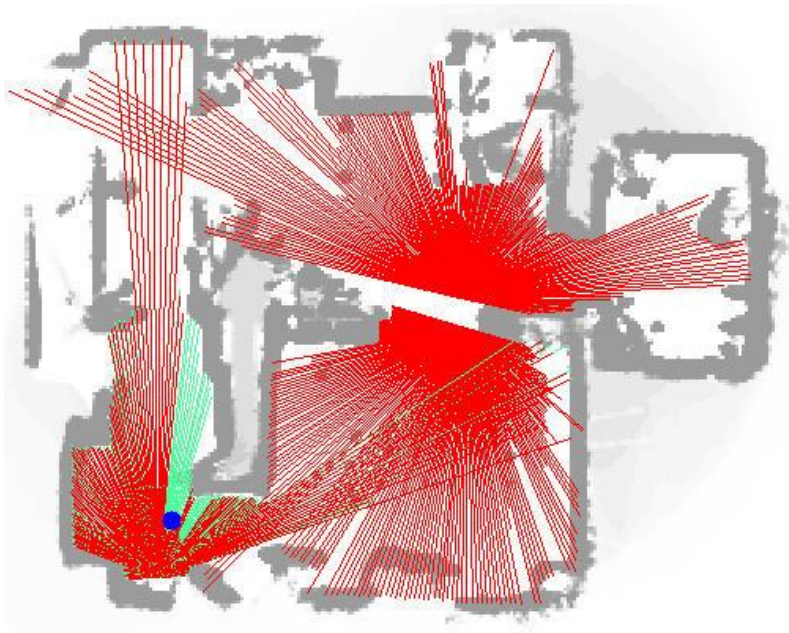


- "Using EM to Learn Motion Behaviors of Persons with Mobile Robots" Bennewitz, Burgard, Thrun - IROS02
- **Techniques**: fuzzy k-means clustering
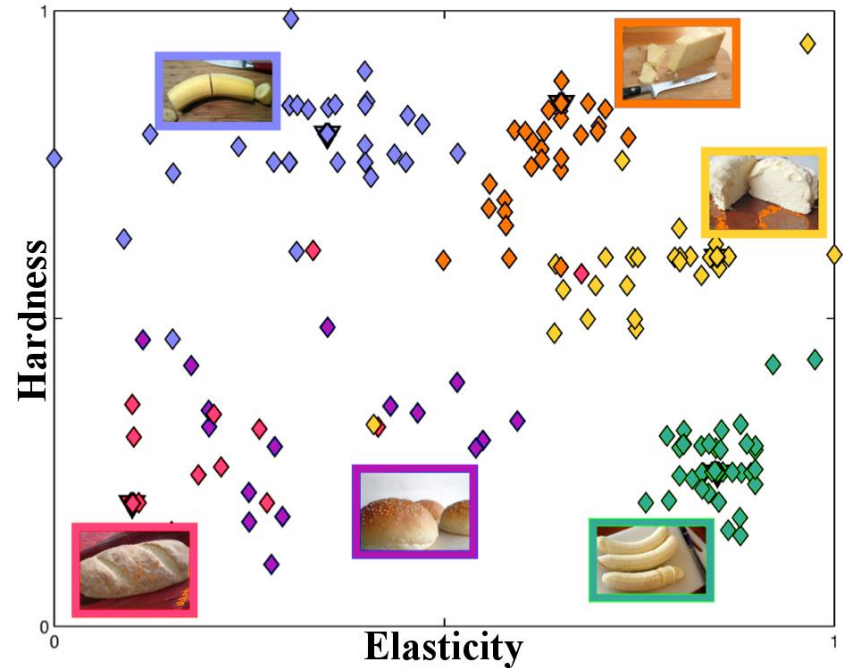
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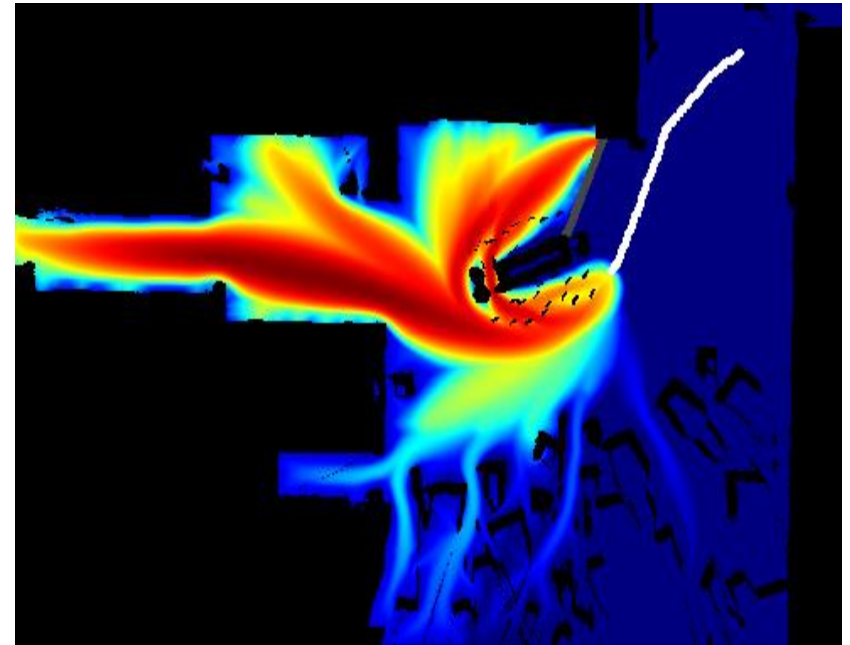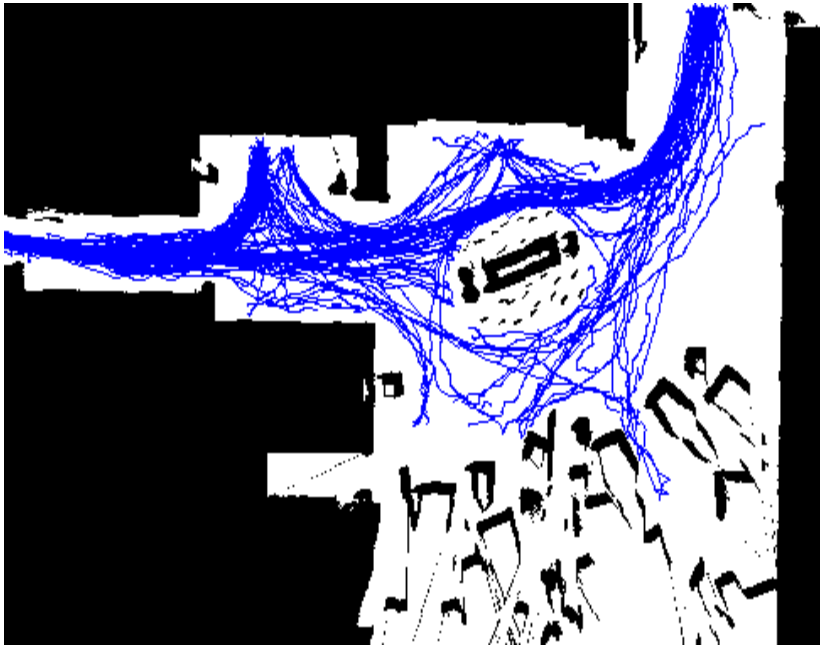


- "Planning-based Prediction for Pedestrians"  Ziebart et al. - IROS09
- **Techniques**: maximum entropy inverse reinforcement learning

# Motion behavior learning



- "Motion Interference Detection in Mobile Robots" Mendoza, Veloso, Simmons - IROS12
- **Techniques**: hidden Markov models
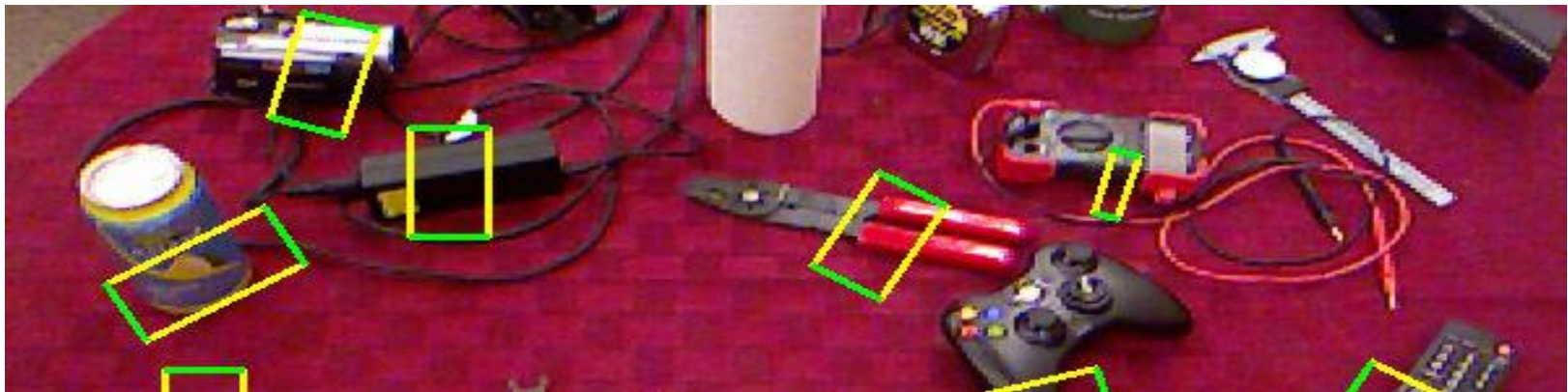
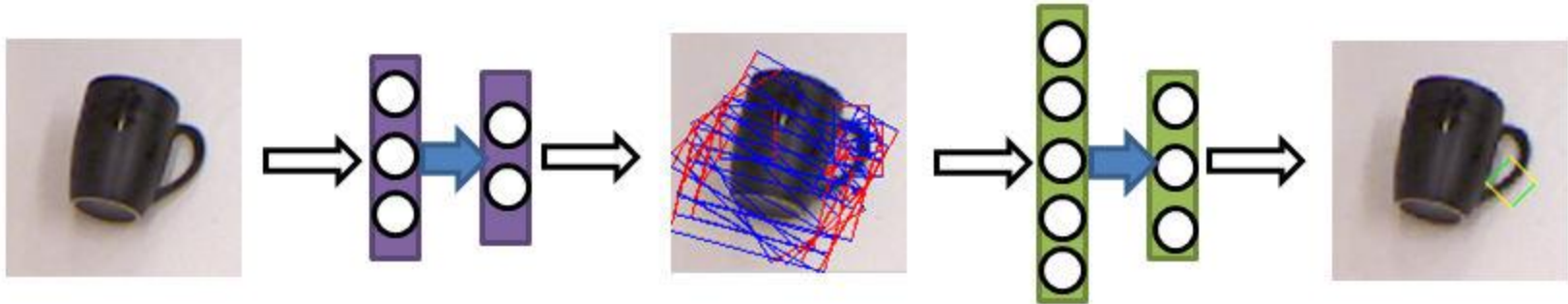# Learning for object manipulation



- "Learning Haptic Representation for Manipulating Deformable Food Objects"  Gemici, Saxena - IROS14

- **Techniques**: support vector regression and clustering using Diritchlet processes

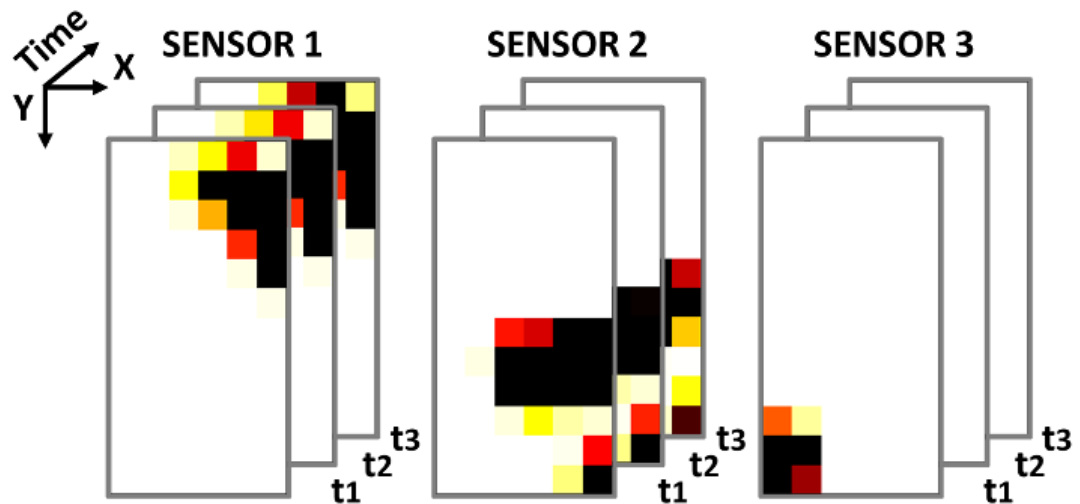# Learning for object manipulation
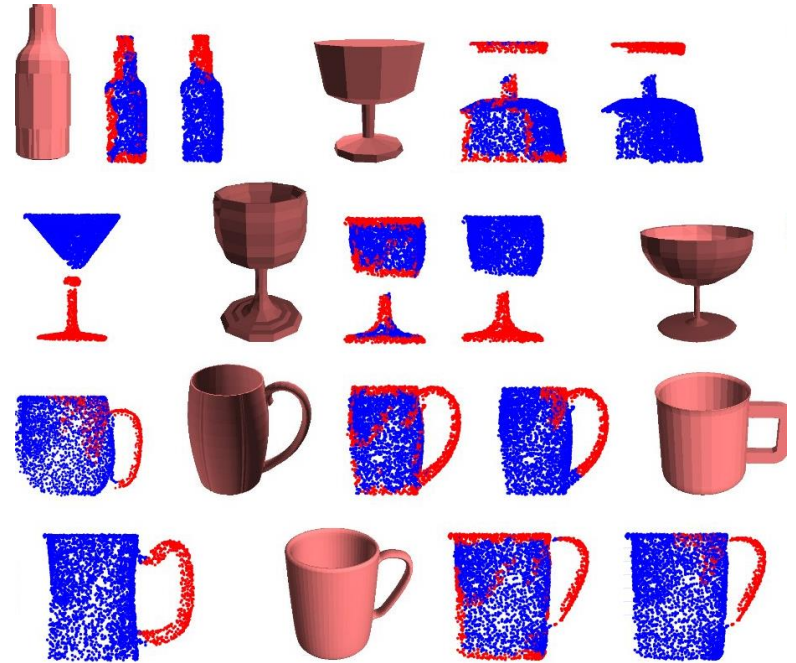


- "Learning Robot Grasping from 3-D Images with Markov Random Fields" Boularias, Kroemer, Peters – IROS11
- **Techniques**: Markov random fields (MRF)

# Learning for object manipulation



- "Deep Learning for Detecting Robotic Grasps" Lenz, Lee, Saxena – RSS13
- **Techniques**: deep learning, sparse autoencoder

# Learning for object manipulation



- "ST-HMP: Unsupervised Spatio-Temporal Feature Learning for Tactile Data" Madry, Bo, Kragic, Fox - ICRA14
- **Techniques**: sparse coding, hierarchical matching pursuit

# Learning from demonstration
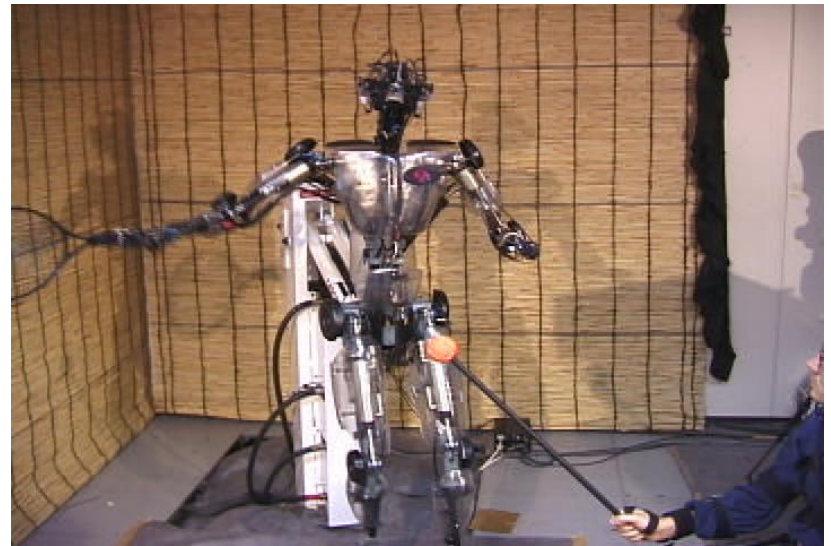


- "Movement Imitation with Nonlinear Dynamical Systems in Humanoid Robots" Ijspeert, Nakanishi, Schaal – ICRA02
- **Technique**: locally-weighted regression

# Learning from demonstration
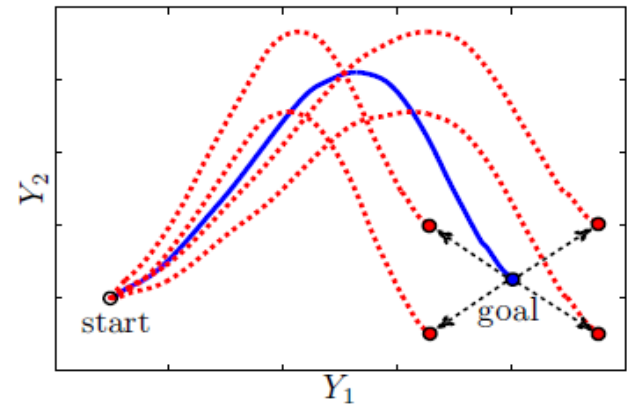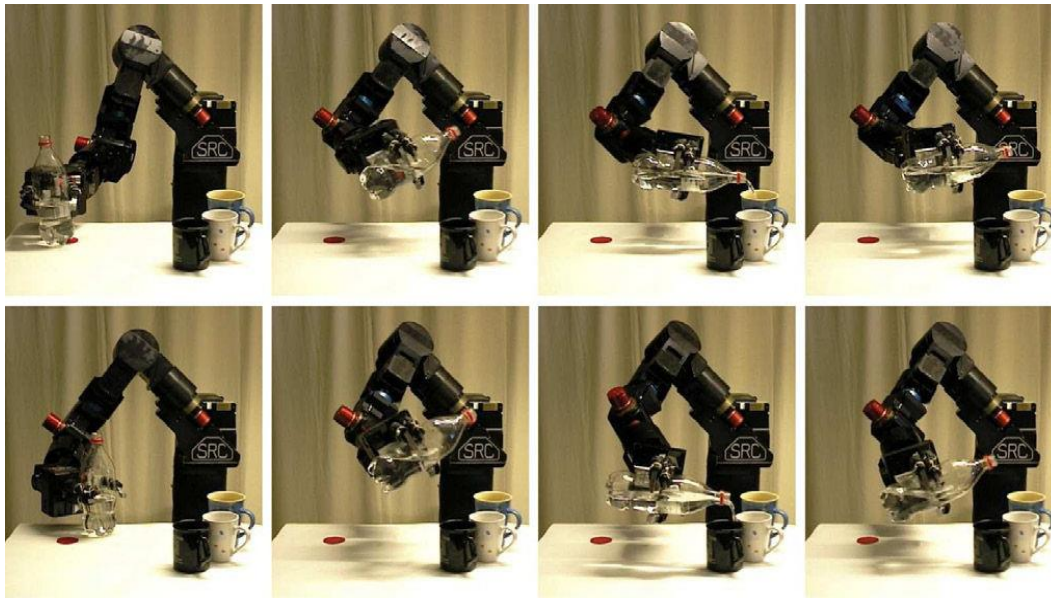


- "Learning and Generalization of Motor Skills by Learning from Demonstration" Pastor, Hoffmann, Asfour, Schaal - ICRA09
- **Techniques**: dynamical systems, linear regression
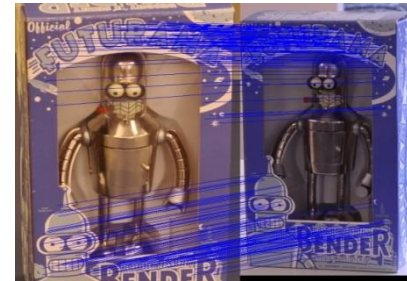
# Learning from demonstration
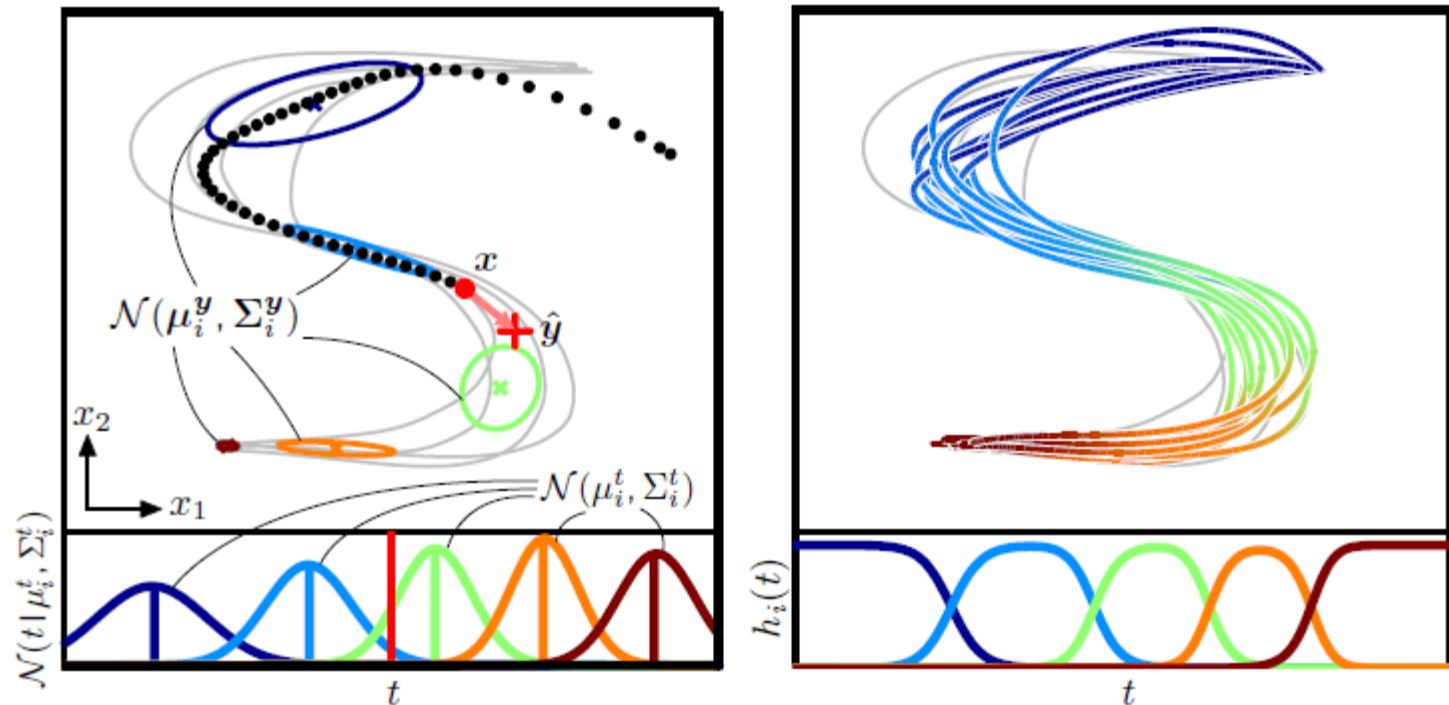


- "Statistical dynamical systems for skills acquisition in humanoids"  Calinon, Li, Alizadeh, Tsagarakis, Caldwell – Humanoids 2012
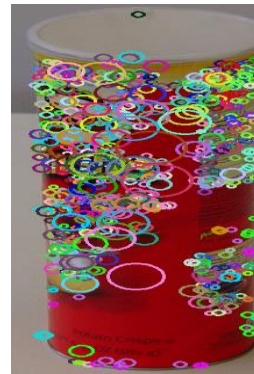- **Techniques**: Gaussian mixture models and EM
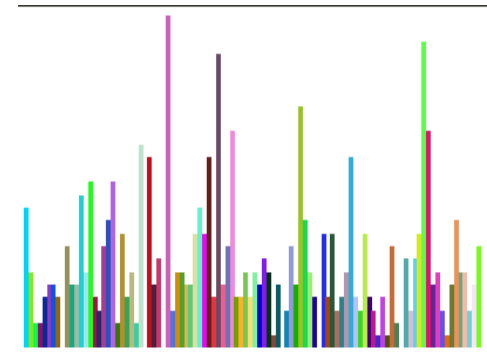
# Object recognition and detection



Experimental environment



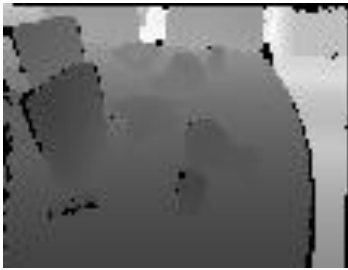Feature matching for object recognition



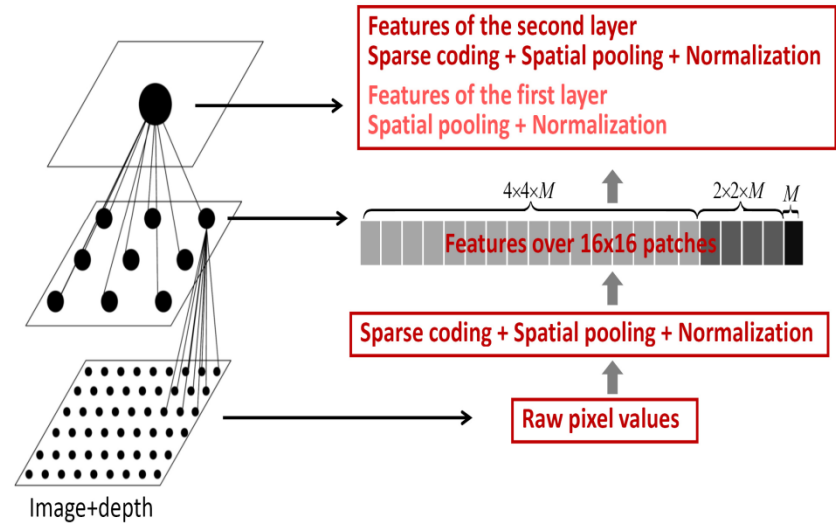Visual words extracted from the image and the corresponding histogram.

- "A Conditional Random Field Model for Place and Object Classification" Rogers , Christensen – ICRA12
- **Techniques**: conditional random field (CRF), bag of words (BoW), relevance vector machines (RVM)

# Object recognition and detection



Reconstruction of left images using dictionary learning



Features of the second layer
Sparse coding + Spatial pooling + Normalization
Features of the first layer
Spatial pooling + Normalization

$4 \times 4 \times M$    $2 \times 2 \times M$   $M$

Features over 16x16 patches

Sparse coding + Spatial pooling + Normalization

Raw pixel values

Image+depth

HMP involving two layers

- "Unsupervised Feature Learning for RGB-D Based Object Recognition" Bo, Ren, Fox – ISER12
- **Techniques**: dictionary learning and sparse coding using K-SVD, hierarchical matching pursuit (HMP) for learning image level features

# Decision time

- Score 1 to 4 each paper
- Provide email address
- Wait for optimal assignment ☺