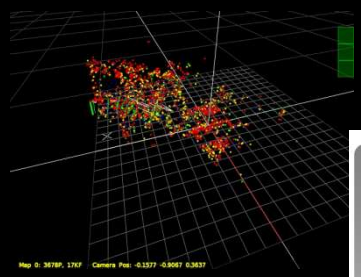
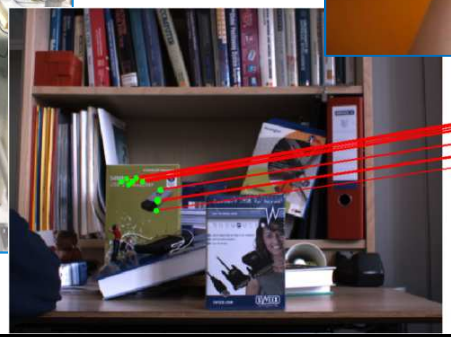
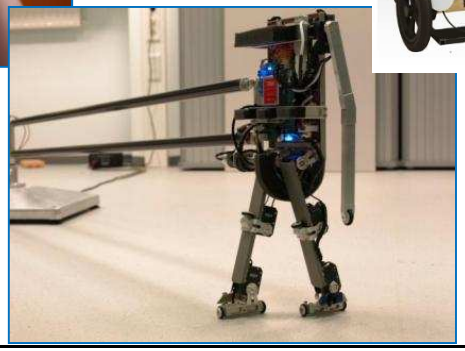
Machine Vision for Service Robots & Surveillance

Prof.dr.ir. Pieter Jonker

EMVA Conference 2015







Cognitive Robotics (text intro)

This presentation addresses the issue that machine vision and learning systems will dominate our lives and work in future, notably through surveillance systems and service robots. Pieter Jonker's specialism is robot vision; the perception and cognition of service robots, more specifically autonomous surveillance robots and butler robots. With robot vision comes the artificial intelligence; if you perceive and understand, than taking sensible actions becomes relative easy. As robots – or autonomous cars, or … - can move around in the world, they encounter various situations to which they have to adapt. Remembering in which situation you adapted to what is learning. Learning comes in three flavors: cognitive learning through Pattern Recognition (association), skills learning through Reinforcement Learning (conditioning) and the combination (visual servoing); such as a robot learning from observing a human how to poor in a glass of beer. But as always in life this learning comes with a price; bad teachers / bad examples.

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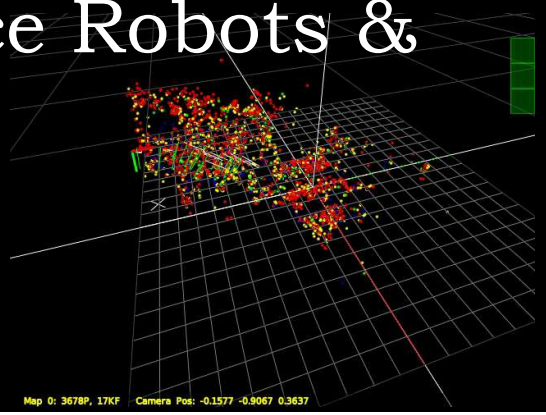

- Professor of (Bio) Mechanical Engineering
  Vision based Robotics group, TU-Delft Robotics Institute
- Chairman Foundation Living Labs for Care Innovation
- CEO LEROVIS BV, CEO QdepQ BV, CTO Robot Care Systems

Content

- What is cognitive robotics + examples
- Cognitive learning and pattern recognition
  Skills learning and reinforcement learning
  Cognitive skills learning (visual servoing)
- Impact of robots / learning systems

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Cognitive Robotics

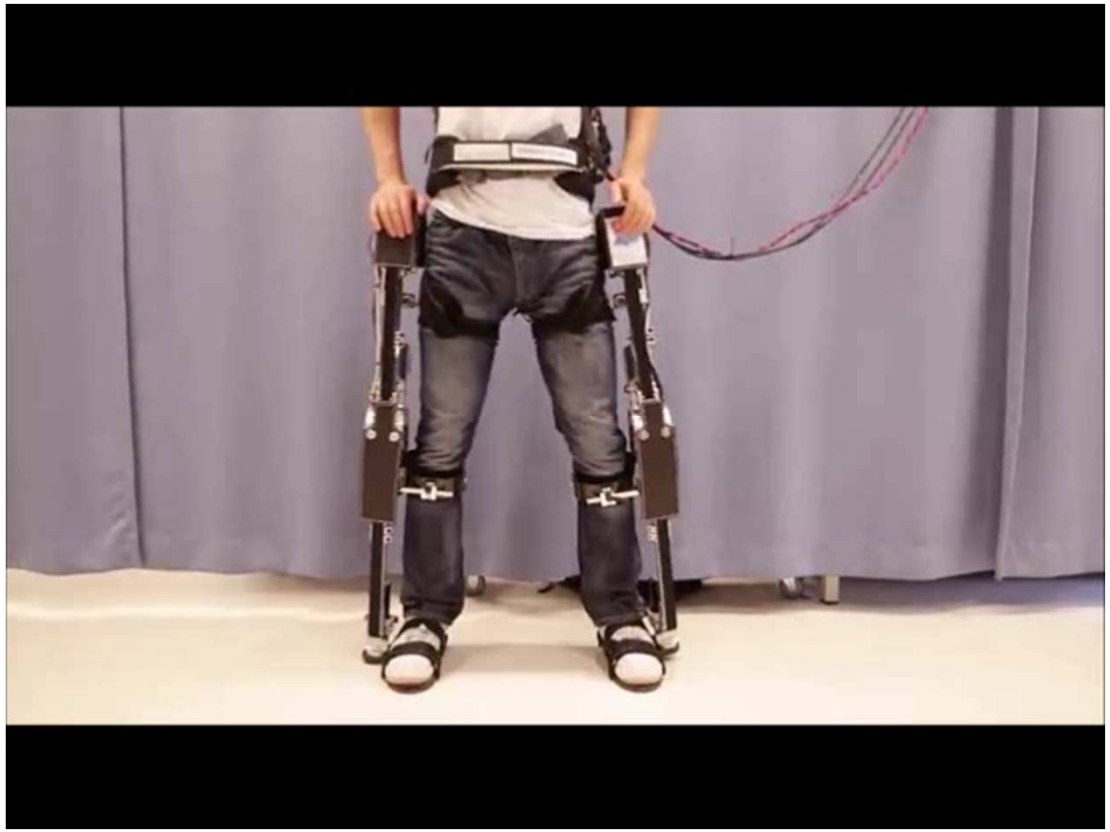
- Machine vision with machine learning
- Study the human and robot body & brain
- Robot Vision, Artificial Intelligence, Embedded Systems, Robot Platforms
- Learning to recognize: saliency, objects, persons, faces, places, affordances, actions, activities
- Learn to perform: actions, activities, …
- With robot vision in the control loop

For the purpose of (1):

- Human and machine tightly coupled cooperating on the control level with proprioceptic / haptic feedback: e.g. exo-skeleton Mindwalker

Tight human-machine control loops

- Mindwalker exoskeleton:
  - Align joints
  - Measure Forces
  - Control Forces
  - Control Stifness

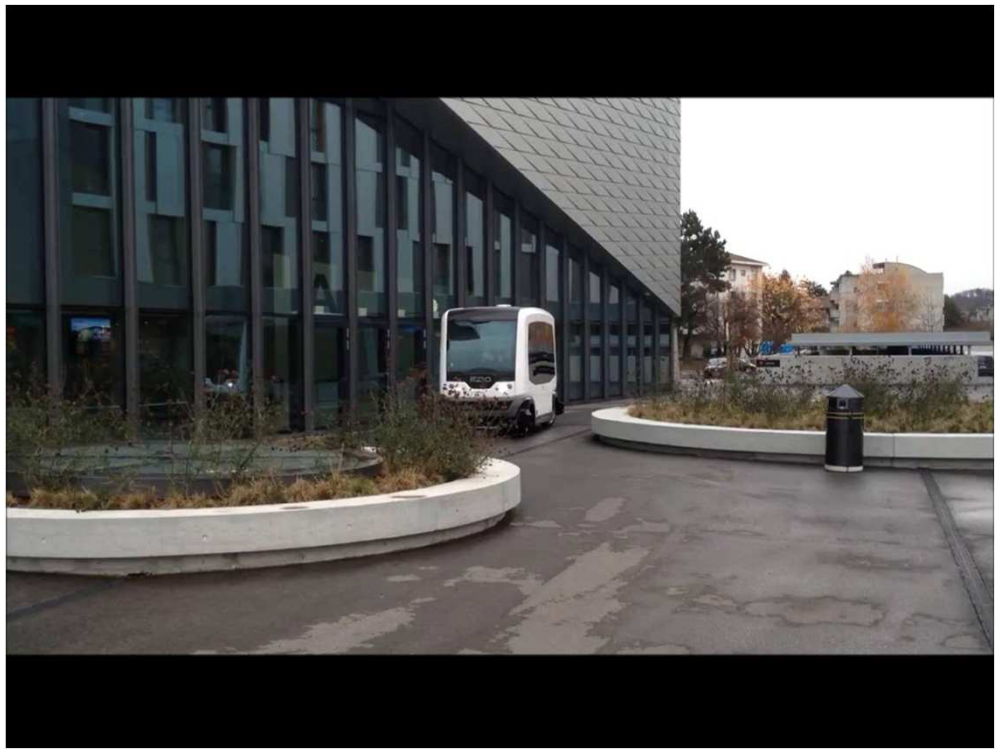


For the purpose of (2):

- Human and machine less tightly coupled cooperating on the control *and* protocol level using proprioceptic and visual feedback in the control loop: autonomous car driving, robot football, …

Less tight human machine control loop

- EZ10 people mover
  - Measure road users: road, road-signs, cars, bicycles, pedestrians; intentions, paths, possible collisions
  - Control collision free auto-motion
  - Control alternative paths while moving



- Fusion of camera, radar, gps, maps data for (auto) pose and ADAS

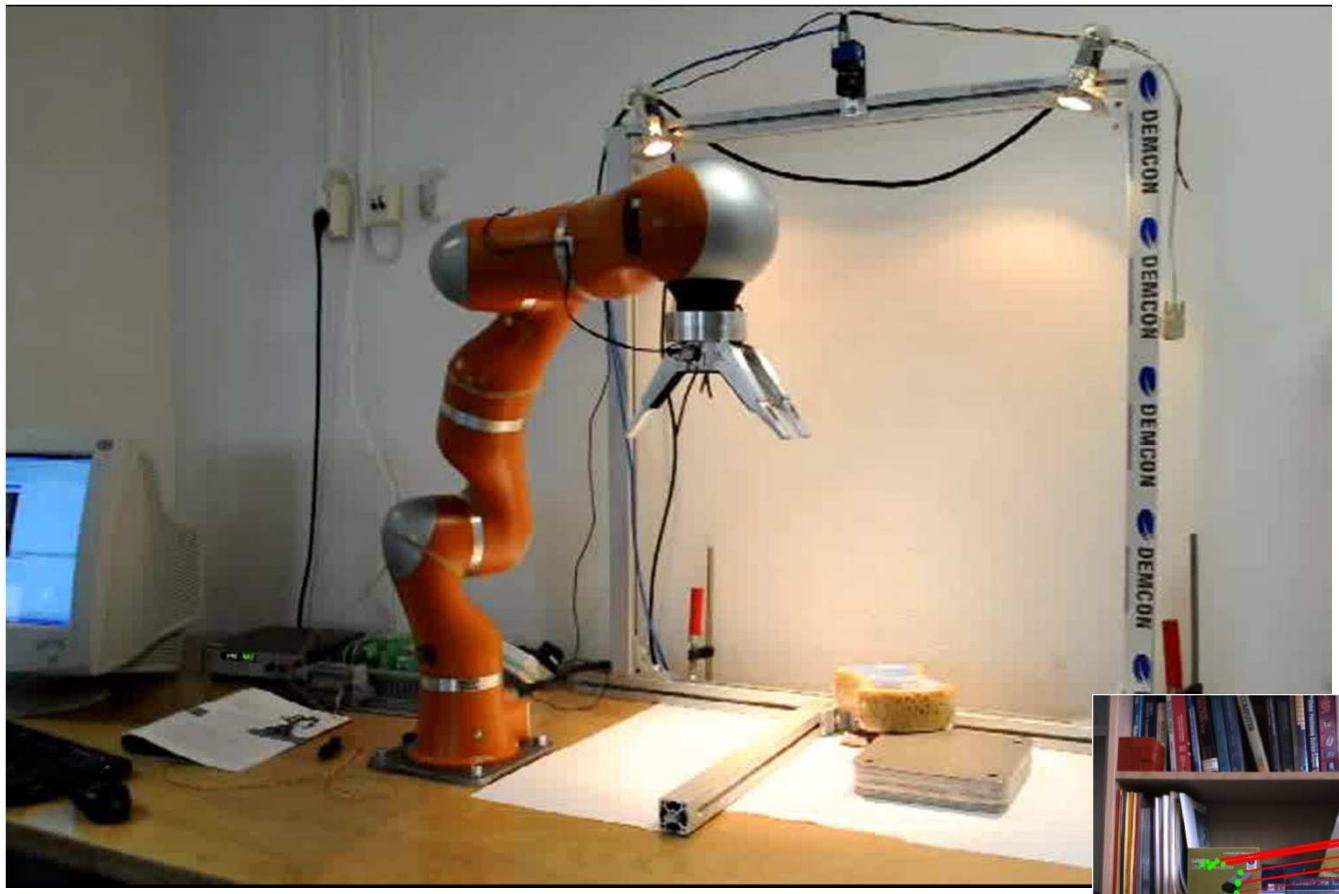
Robot Football

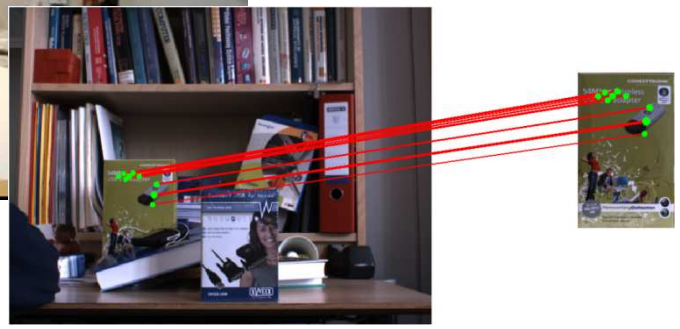
Legged robots are still too difficult

For the purpose of (3):

- Human and machine less loosely coupled cooperating on a protocol level using vision only in the loop: turn taking in cooperative assembly, automatic surveillance robots

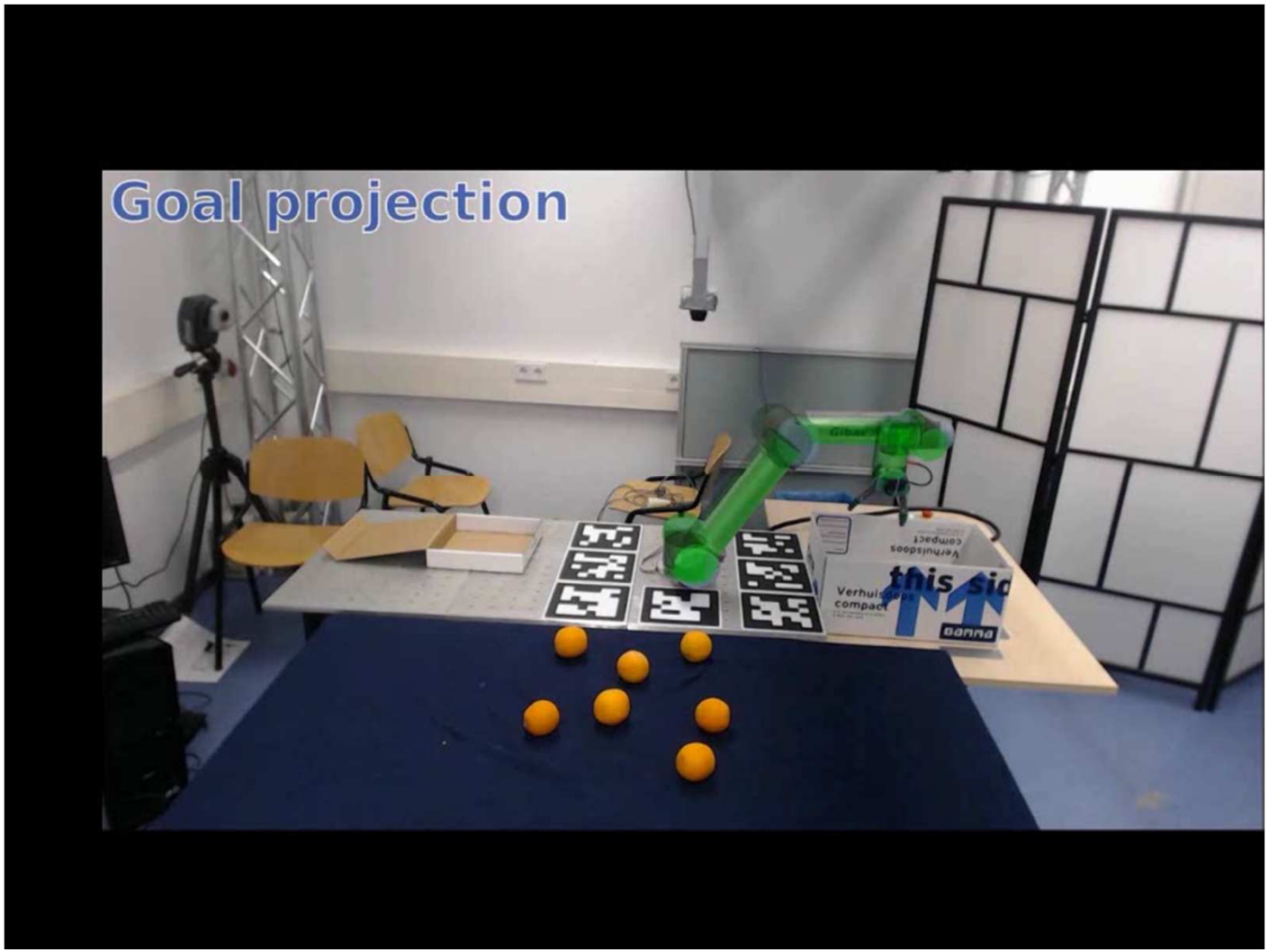
Bin picking with monocular vision





- Scale Invariant Feature tracking

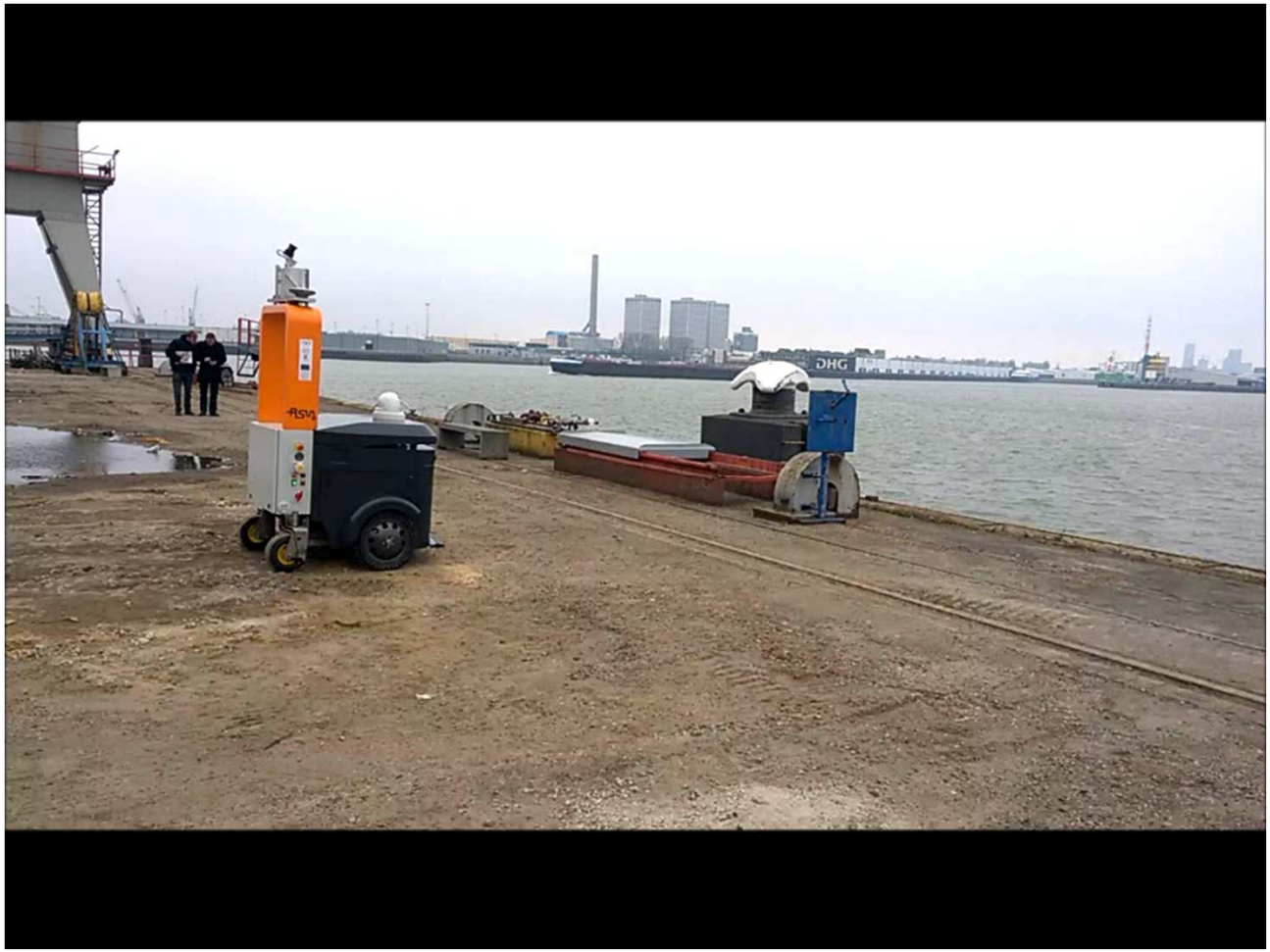
Less tight human machine control loop



SAM Warehouse Surveillance

- (Large Maps) Visual Slam, RF Beacons

SAM Outdoor Surveillance



- (Large Maps) Visual Slam, RF Beacons, Radar, GPS, IR

Less tight human machine control loop

- Factory in a day
  - Quickly set-up a production
  - Simple protocols; e.g. collaboration by turn-taking
  - Intention projection;
    - Autonomous vehicles
    - Robot arms

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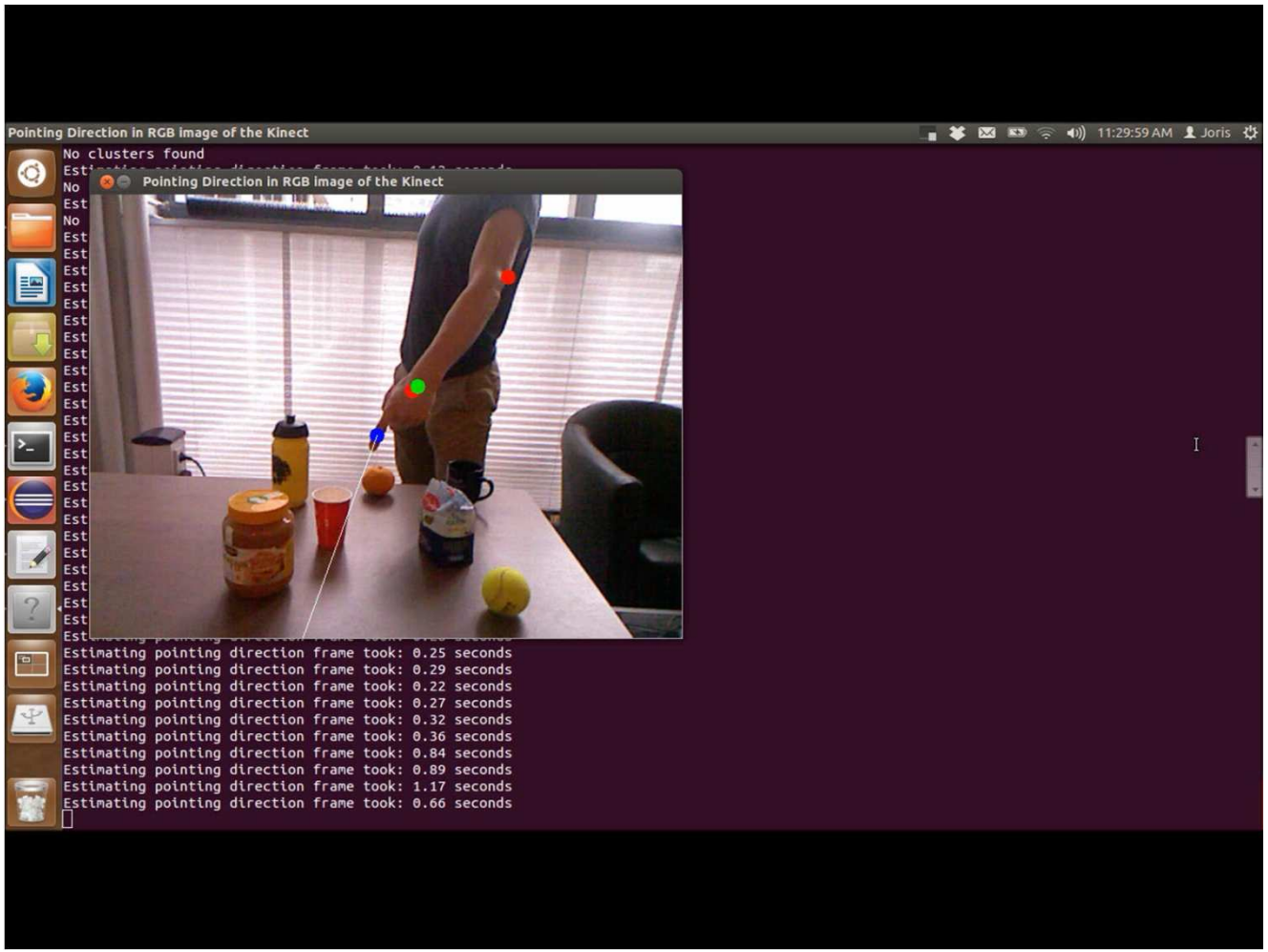
The most advanced is research on Cognitive Butler Robots

1. Perceive (pattern recognition) & understand
2. Interact with users
3. Memorize
4. Physically help with simple task (pick up objects)
5. Provide feedback and motivation
6. Signal and alarm

Butler robots; where are we now

Pointing at Objects



Cognitive Robotics (percieve and understand)

- Cognitive learning: to recognize objects, persons, faces, actions, places, …
- Skills learning: to move, walk, grasp, …
- Combining: Visual servoing for grasping, balance while acting, human / robot collaboration

- Target: a baby of 6 months

Cognitive Robotics

Robot Cognition

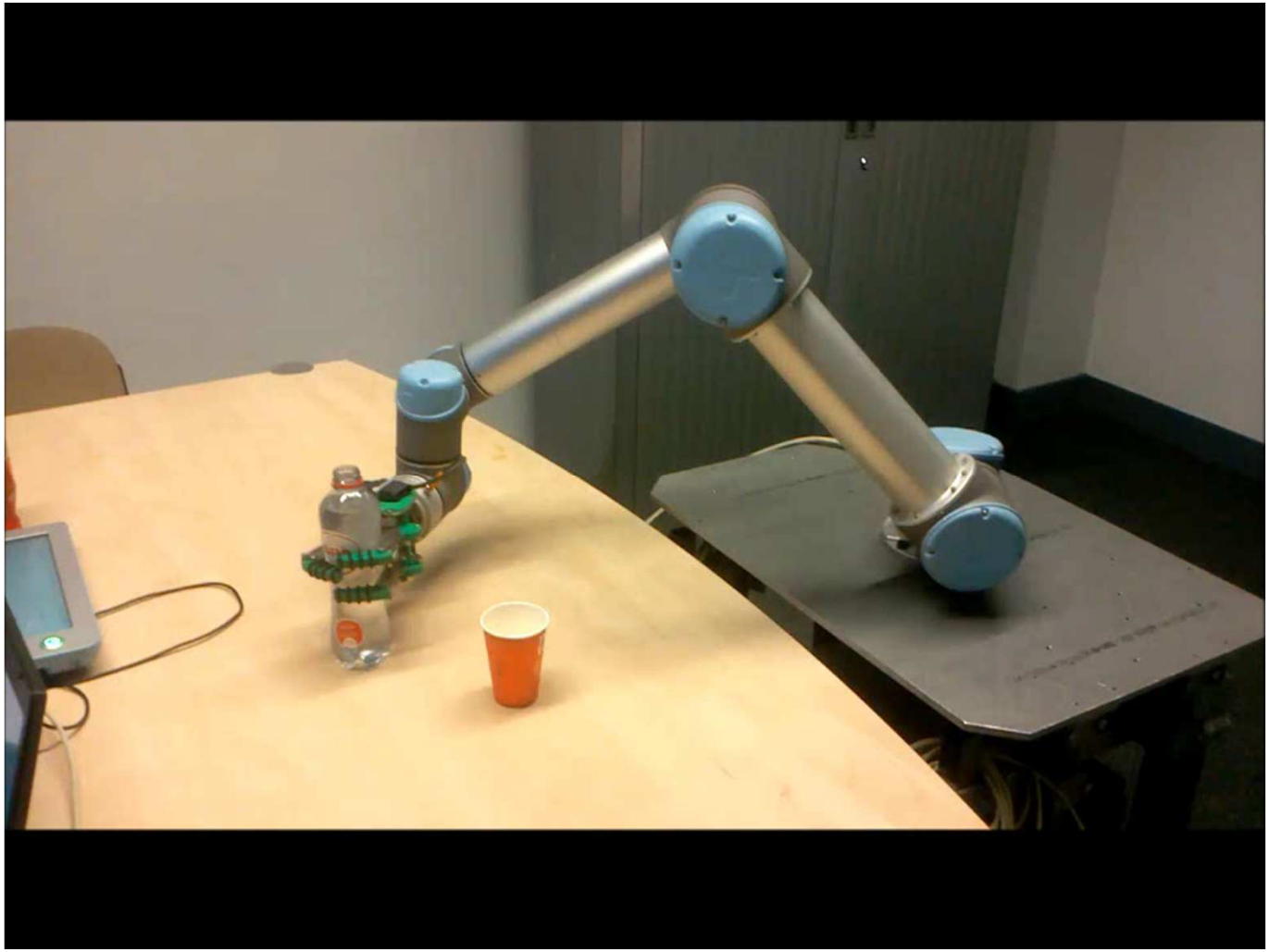
- Learn to recognize unknown objects
- Find the proper viewpoint
- Find the proper point to grasp
- Grasp this by visual servoing
- Remember this with reinforcement learning

Cognitive learning by pattern recognition

1. sensors or/and cameras with image processing
2. Measure features: x, y, …
3. Label / name the item
4. Label = ax + by + cz + …
5. Learn a, b, c by trial and error
6. Learn over groups and individuals
7. Use the system

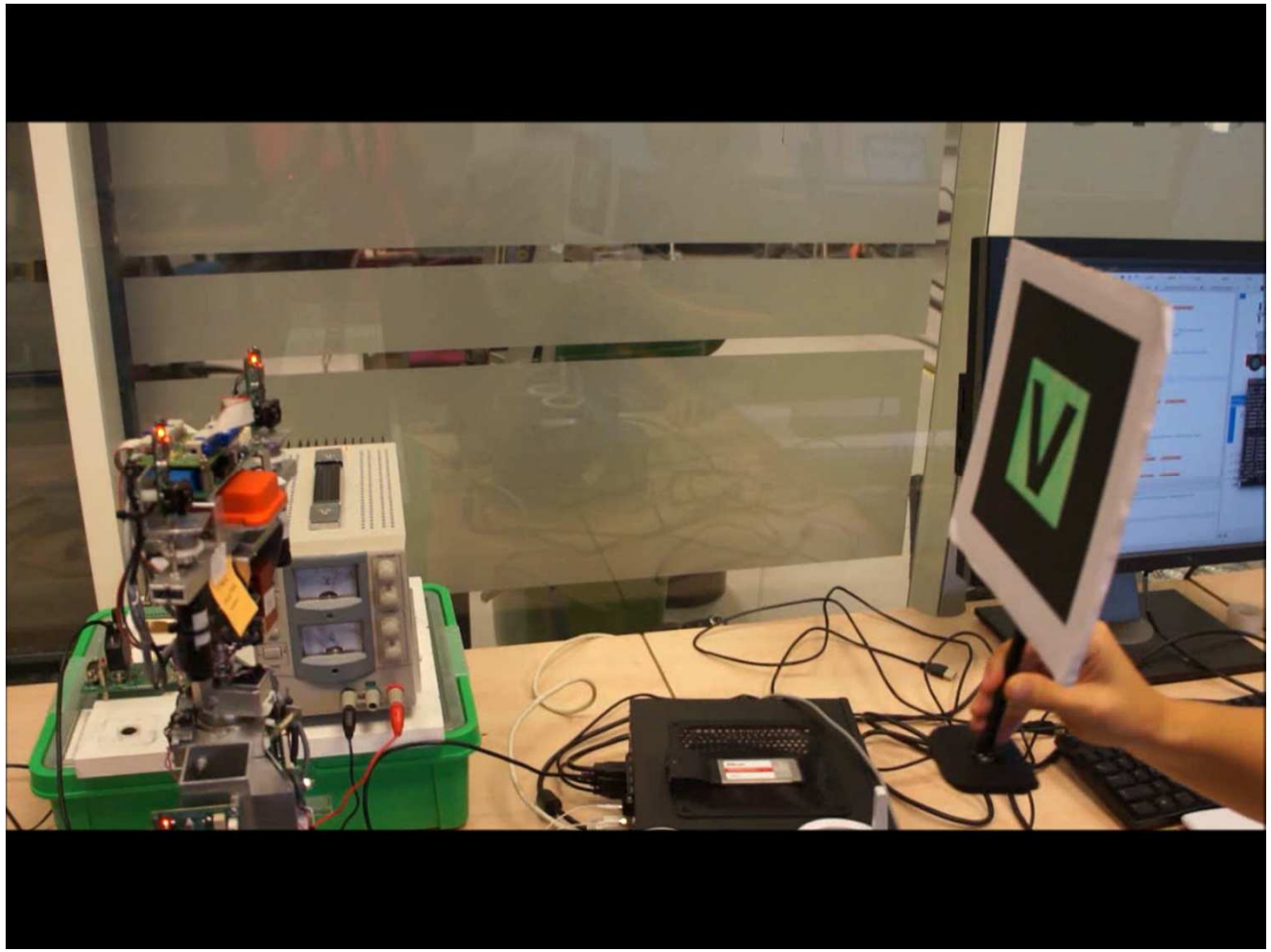
Skills learning by reinforcement learning

learning visual servoing tasks by example



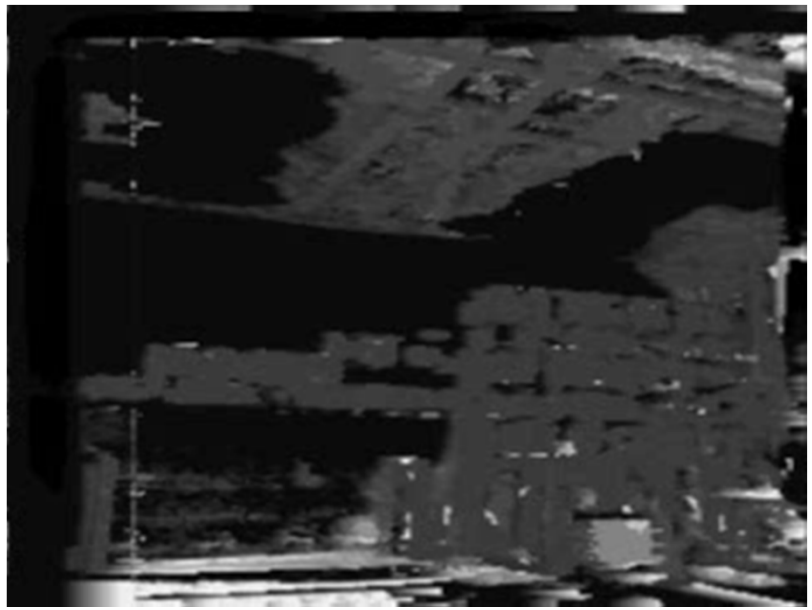
Towards learning of visual reflexes

Robot head with its visual reflexes



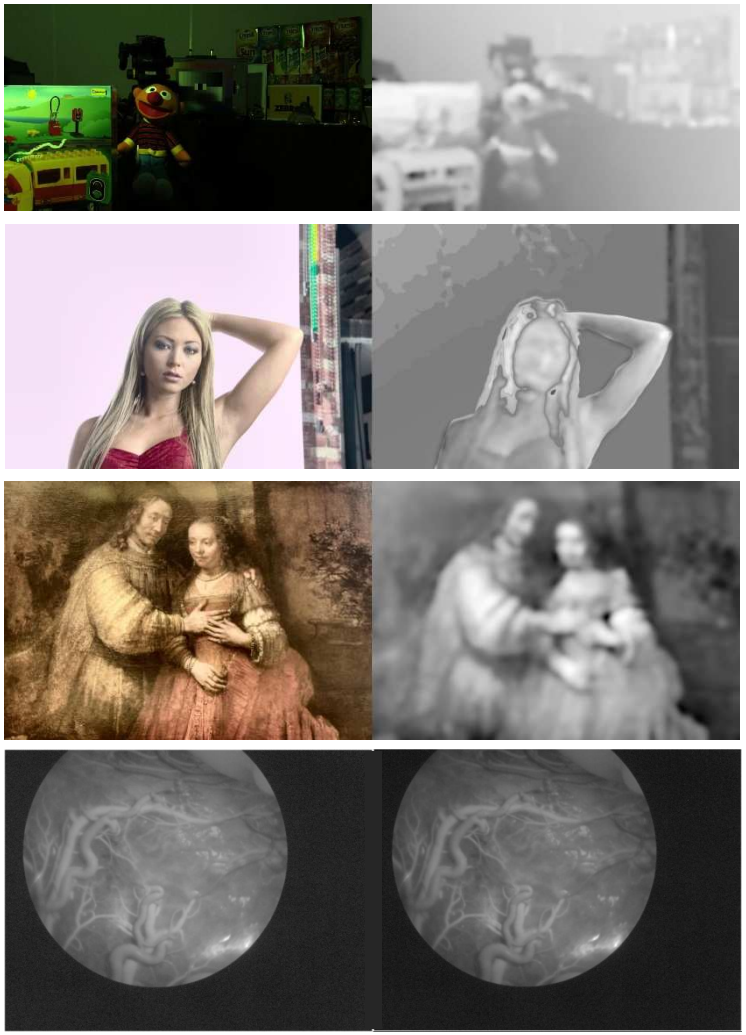
Using a fusion of depth Cues

- Depth from vergence
- Depth from stereo
- Depth from luminance
  (EMD + DFL)



ADAPTIVE MULTI-DIMENSIONAL
DATA DECOMPOSITION

PCT/EP2013/051255



Download the QdepQ 3D viewer from the Google playstore!

Conclusions

1. *Human Machine Loop:*
   - *tightly coupled control over propriocepsis / hapics*
   - *loosely coupled control over propriocepsis + vision*
   - *loosely coupled protocol over vision*

2. *The most advanced research is on cognitive butler robots*
   - *cognitive learning*
   - *skills learning*

3. *Learning visual reflexes*
   - *combined (cognitive + skills learning)*

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Propositions

1. *Cognitive Robotics will penetrate out lives*

2. *New is the cognitive skills (visual servoing) learning capability, beware!*

3. *This brings the troubles along of bad teachers, bad youth, personality disorders, …*