Human-Oriented Robotics

Bs/Ms-course

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Robots and Humans

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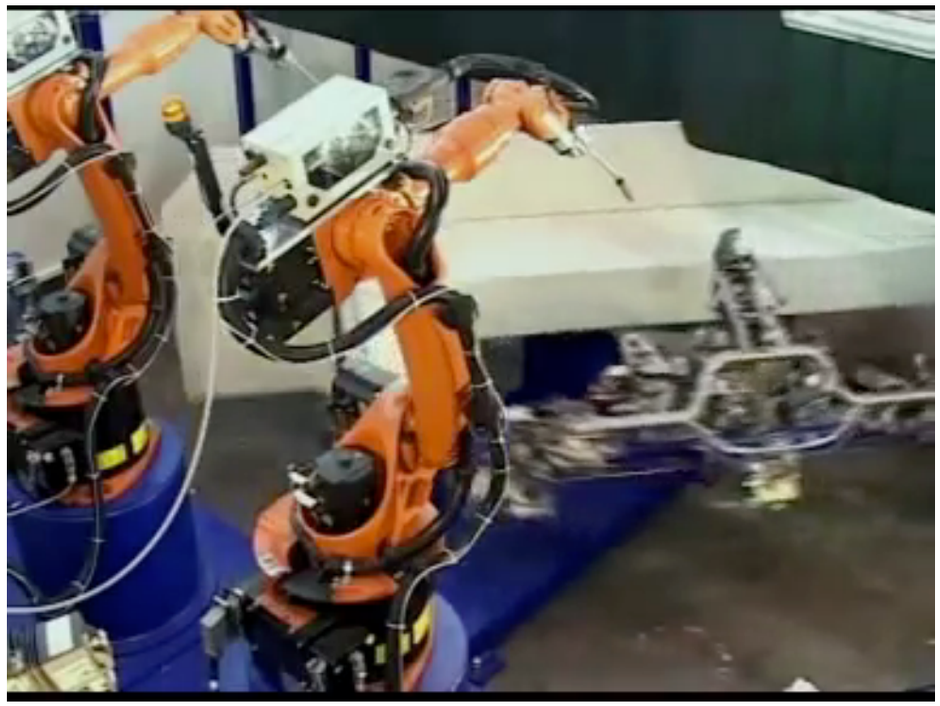
Classical image of robots as factory workers



Introduction

A new generation of robots

- These robots are impressive but also very **limited**

- With significant progress in **theories** (in robotics, artificial intelligence, machine learning, computer vision) and **hardware** (embedded computing, sensing technologies), **new applications** come into reach
- **Examples:** medical, health-care, elderly-care robots, domestic robots (mainly floor-care), entertainment robots, robots in service, defense, agriculture, logistics, telepresence robots, autonomous cars and many more
- Industry is not the only application area anymore
- In all these applications, **robots and human** are **sharing physical** and **emotional spaces**

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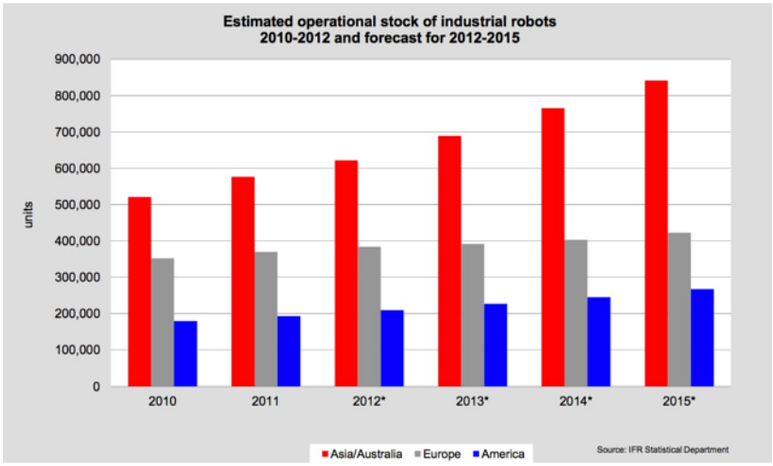
Scientific challenges

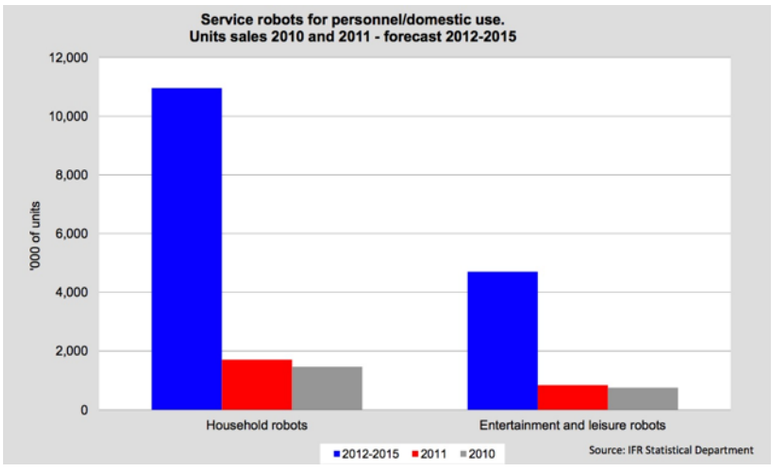
- Overall: make robots **ready** for this change
- Further improve the **robotics key technologies** towards successful operation in human environments
  - perception from sensory data
  - modeling, cognition, and learning
  - task and motion planning
  - control and system integration
- **Example problems**: detecting and recognizing humans and human activities, learning and modeling human behavior, planning among humans, designing human-robot interaction and interfaces, etc.
- **Short-term goal**: build safer, more efficient and more acceptable systems
- **Long-term goal**: believable and sustainable human-robot relationships

Introduction

This is not science fiction

- **World population** of robots is **growing quickly**
- **Industrial** robots:
  - ~1.4 Mio worldwide
  - Yearly sales of 160,000 units (2011)
  - Expected yearly growth 9% (IFR 2012)
- **Service** robots:
  - ~7 Mio worldwide (2010: iRobot announces sales of 5 Mio Roombas)
  - Yearly sales of 2.5 million units (2011)
  - Expected yearly growth: 50% (IFR 2012)
- **Germany** has **third largest** robot density (after Japan and South Korea)

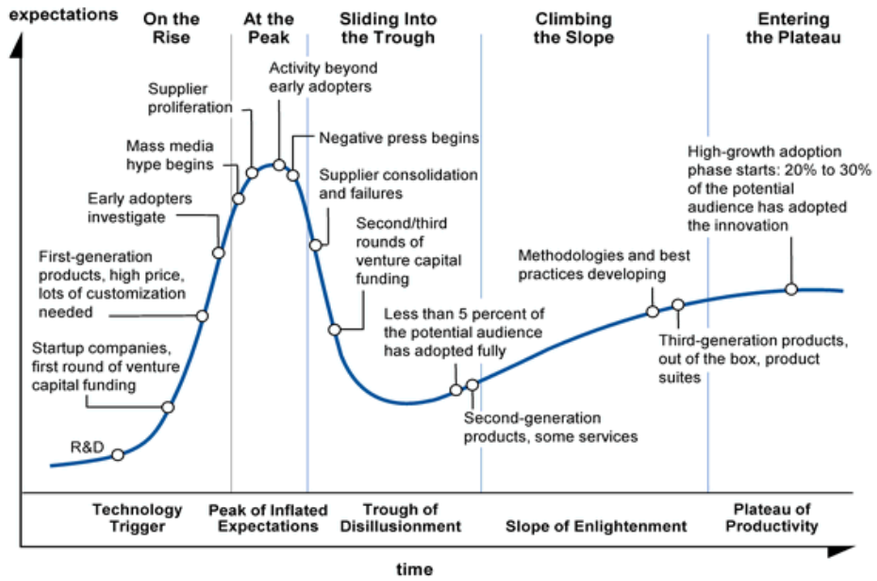




This is not science fiction

- Isn't this another **hype**?
- **AI** made audacious promises in the 1960s
- Failure to meet the expectations resulted in **AI winter** (70s and 80s)
- **Today:** AI-based technologies such as speech, face, gesture, pedestrian recognition are reaching productive plateau

Gartner Hype Cycle



- "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run" (a.k.a. Amara's law)
- **On the rise:** autonomous cars, mobile robots, health- and elderly-care robots
- **Alternative model**: market takes off like a **sputtering engine**

Introduction

Paro

- Assistive robot, elderly/health-care
- Baby seal design
- Developed by AIST, Japan
- Studies showed that Paro has a calming effect and elicits emotional responses in patients of hospitals and nursing homes, similar to animal-assisted therapy
- Paro has tactile sensors and responds to petting by moving its tail and opening and closing its eyes. It also responds to sounds, can show emotions and can learn a name
- Price: 3000 Euro or 170 Euro/month
- In use worldwide since 2004

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Care-O-Bot III

- Assistive robot, elderly care
- Developed by Fraunhofer IPA, Stuttgart
- Tasks: fetch-and-carry tasks, multimedia console, health state supervision, transport tasks in nursing homes and hospitals, support care personnel, etc.
- Research prototype
- Price: ~250 kEUR
- Goal: increase independence and living quality
- Does this technology socially isolate elderly people? Or does it allow care personnel to focus more on their social tasks?

Introduction

Ava / Beam

- Social telepresence
- Developed by iRobot (Ava), Willow Garage (Beam), many others (currently a hot topic)
- Main idea: participate in remote meetings, save traveling cost and time, getting (medical) experts on-line, etc.
- Price: several 100 to 1000 EUR
- Sales are starting now (2014)
- Is this the **new killer application** for mobile robots after floor care?

Introduction

Baxter and Co.

- Manufacturing
- Developed by Rethink Robotics, US
- Very similar: Nextage (Kawada), Justin (DLR)
- Work **side-by-side with people**, no barriers
- Promises: performs a variety of repetitive production tasks while safely and intelligently working next to people. It requires no complex programming or costly integration
- Rather new research area: human-robot collaboration a.k.a. human-robot teaming
- Price: ~22,000 $ (Baxter)

From top: Baxter (Rethink Robotics), Nextage (Kawada), Justin Rollin (DLR)

Kiva Systems

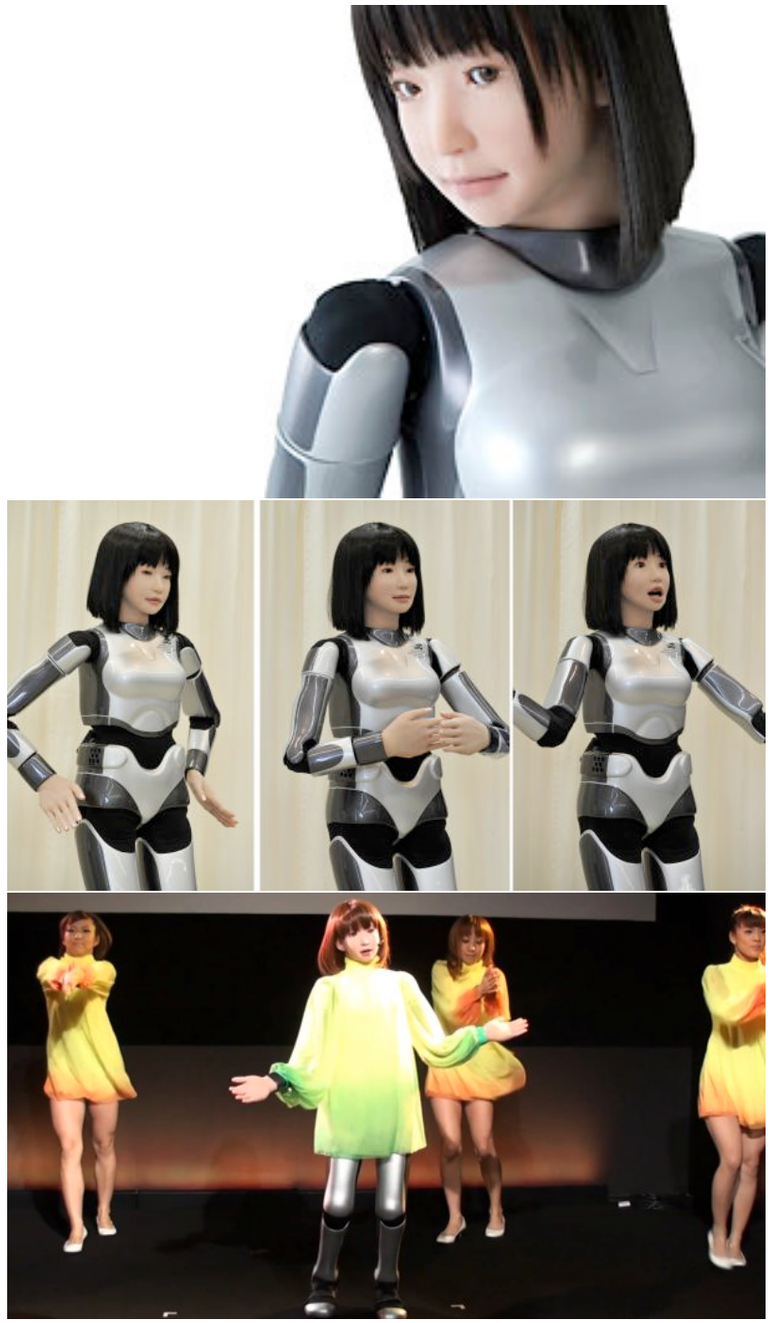
- Logistics and warehouse automation
- Developed by Kiva Systems, US
- This is what happens when you click *Buy* at amazon.com
- Tasks: picking, sortation, replenishment
- A lot of "cheating" from a robotics perspective: no localization and SLAM, no path planning but a lot of low-level adaptive control and environment modifications
- Robots operate in the same space with people, no barriers
- 2012: Amazon acquires Kiva Systems for $775 Million

Google Driverless Car

- Developed by Google Research
- Expected to make driving safer, more enjoyable, and more efficient
- 2011: Nevada passes two bills that make it legal for autonomous vehicles to operate on public roads
- 2012: completed over 300,000 autonomous-driving miles (500 000 km), accident-free
- Might enter market in 2017
- Price of prototype: 30 k$ (car) + 150 k$ (equipment) + 70 k$ (3D laser scanner)
- Other car manufacturers are actively introducing sophisticated driver assistance systems, e.g. with pedestrian detection (Volvo, Mercedes, etc.)

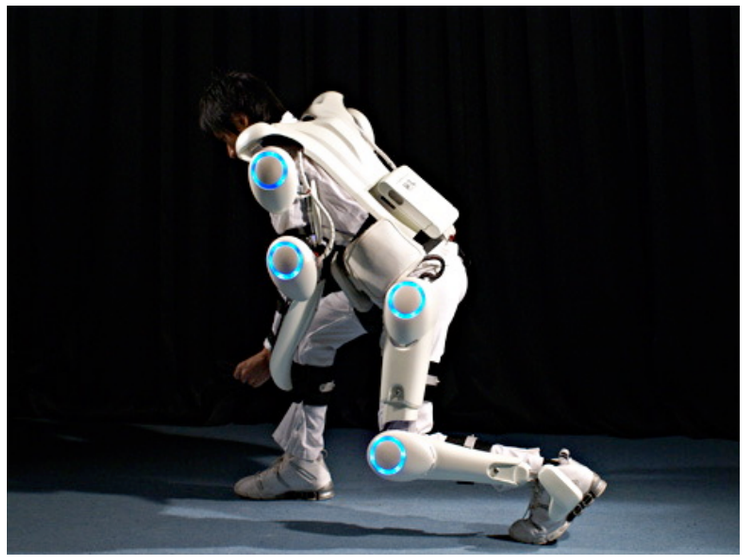
HRP-4C (Miim)

- Entertainment
- Developed by AIST, Japan
- Miim can move like a human (30 dofs, 8 dofs for facial expressions), respond using speech recognition, recognize ambient sounds, sing, etc.
- Additional applications: fashion shows, human simulator for evaluation of devices
- Background: Japan promotes humanoid robotics to improve the productivity and quality of life, in particular for "3D job" (dirty, dangerous, demanding)
- Price: ~250,000 $



Robot Suit HAL

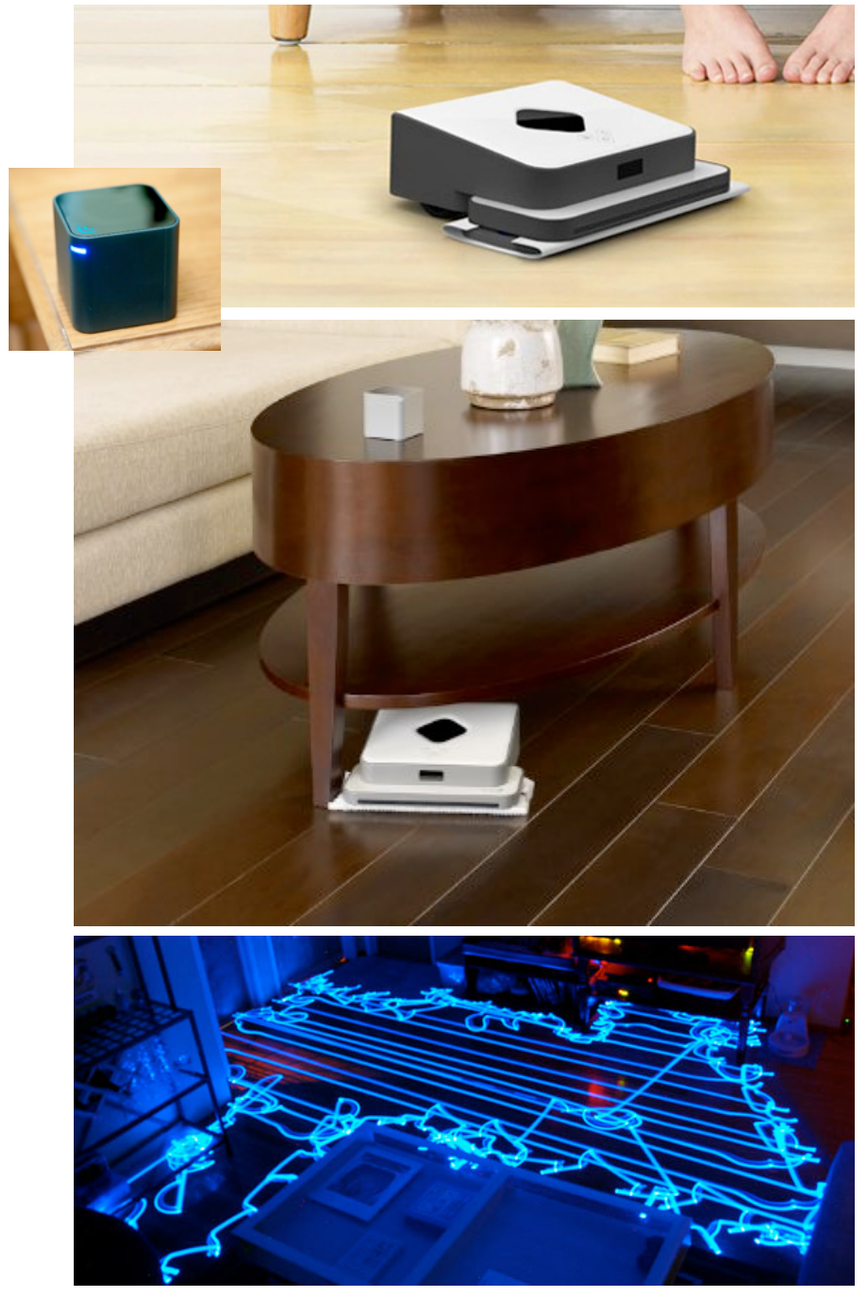
- Health, rehabilitation
- Developed by Cyberdyne, Japan
- Powered exoskeleton for rehabilitation, rescuers in disaster sites or heavy labor workers in factories or construction



- Sensors on the skin capture nerve signals from the brain to the muscles. HAL moves the joint simultaneously to the wearer's muscle movement
- 2012: HAL suits used by 130 different medical institutions across Japan
- 2013, HAL is powered exoskeleton to receive global safety certification
- Price: 2,000 $ per month

Mint Cleaner (Braava)

- Floor care
- Developed by Evolution Robotics, US
- Dusts and wet-mops hard surface floors (no vacuum cleaner)
- Systematic coverage thanks to NorthStar navigation system, projects IR spot on ceiling
- Multi-room navigation, learns a map
- Sales >200,000 units (2012)
- Price: ~200 € (amazon.de)
- 2012: Evolution Robotics has been acquired by iRobot for 74 Mio $. Now sold as iRobot Braava



Introduction

Summary

- It's not science fiction, it's **really happening**
- Research in the discussed areas that can be subsumed as **human-oriented** or **human-centered robotics** is currently very active

This course

- This course will introduce basic and advanced concepts from **robotics**, **machine learning**, **artificial intelligence** and **human-robot interaction** that consider the "**human in the loop**"
- **General-purpose course in advanced robotics** even if you are not interested in the "human" aspect
- The course will cover **6 of 10 methods** that the highly cited article "Top 10 algorithms in data mining" by Wu et al., 2008, has identified as most influential algorithms in the research community

Introduction

- **Introduction**
- **Basics**
  - Matlab/Octave introduction
  - Probability refresher, common distributions
  - Probabilistic reasoning, Bayes networks and Markov chains
- **Perception of Humans**
  - Supervised learning: logistic regression, naive Bayes, k-NN, SVM, AdaBoost, cross-validation
  - Unsupervised learning: EM and clustering: GMM, k-means, hierarchical clustering
  - Hidden Markov Models (HMM), representation, inference and learning
  - Kalman Filter and Particle Filter, filtering and smoothing
  - Tracking and data association: NN, GNN, PDAF, MHT
- **Planning among Humans**
  - Robot motion planning: A*, Theta*, potential fields, obstacle avoidance, PRM, RRT
  - From plans to policies: Markov Decision Processes (MDP)
- **Interaction with Humans**
  - Introduction to Human-Robot Interaction

Organization

Lectures

- **Hours:** Tuesday 10-12, Room SR 01-**018**, Building 101
- **Language:** English
- **Recordings:** I want you to participate :-) so no recordings
- **Requirements:** no formal requirements. The course "Introduction to Mobile Robotics" is recommended.
- **www:** http://srl.informatik.uni-freiburg.de/humanorientrobotics

Exercises

- **Hours:** Thursday 12-14, Room SR 01-**018**, Building 101
- Solving and submitting the exercise sheets **does** influence the exam grade
- No exam admission requirements
- In general, assignments will be published on Tuesday and have to be submitted the following Tuesday before class

Exam: oral

Introduction

Finally...

- This is a **new course**
- Content may slightly change, for example as a function of progress
- Your **feedback is welcome**
- This is a specialized course with relatively few students, let's make this **interactive**

Note:

- **No exercise** in week 44**: Thursday, October 30**
- **This week's exercise: install Matlab** (1h), **Matlab/Octave tutorial** (1h)
  - Get a Rechenzentrum account
  - Install Matlab (see course homepage for instructions)