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Introduction to Robotics

WS 2015 / 16

Prof. Dr. Daniel Göhring
Intelligent Systems and Robotics
Department of Computer Science
Freie Universität Berlin

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Organization

- Instructor: Prof. Daniel Göhring *(daniel.goehring@fu-berlin.de)*
  - Mon: 8-10 a.m.
  - Office hours: Mo: 2-3 p.m., Arnimallee 7, E029
- TFs: Fritz Ulbrich *(fritz.ulbrich@fu-berlin.de)*
  - Tue: 12-2 p.m.
  - 60% of points necessary
- Secretariat: Susanne Schöttker-Söhl *(susanne.schoettker-soehl@fu-berlin.de),*
  - Arnimallee 7, E019

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Organization contd.

- Weekly or biweekly assignments
  - paper
  - programming
  - humanoid simulator, autonomous-car simulator
  - Linux/Ubuntu, C++
- Slides and assignments online in KVV
- Written exams by mid of February 2016
  - XX. February 2016, 8-10 Uhr, Takustr. 9, room t.b.a.

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Literature

- Oussama Khatib (Stanford University): *Advanced Robotic Manipulation*

- Siegwart, Nourbakhsh: *Introduction to Autonomous Mobile Robots*
- Robin R. Murphy: *Introduction to AI Robotics*

- Jorge Angeles: *Fundamentals of Robotic Mechanical Systems: Theory, Methods, and Algorithms, Second Edition*

- S. Thrun, W. Burgard, D. Fox: *Probabilistic Robotics*

- S.M. LaValle: *Planning Algorithms* (online available)
- J.J. Craig: *Introduction to Robotics: Mechanics and Control* (online)

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Online Ressources

- Video Lecture, Introduction to Robotics, Oussama Khatib, Stanford (2008), focus on kinematics, dynamics, control:
  http://see.stanford.edu/see/courseinfo.aspx?coll=86cc8662-f6e4-43c3-a1be-b30d1d179743
- Slides, Introduction to Robotics, Robert Wood, Harvard (2007)
- Course Material, Howie Choset, CMU
  http://www.cs.cmu.edu/afs/cs.cmu.edu/academic/class/16311/www/current/syllabus.html
- Course Material, Robert F. Stengel, Princeton (2007), focus on dynamics, control and optimization / learning
  https://www.princeton.edu/~stengel/RISVirText.html
- Robotee – Website: *http://www.robotee.com/*

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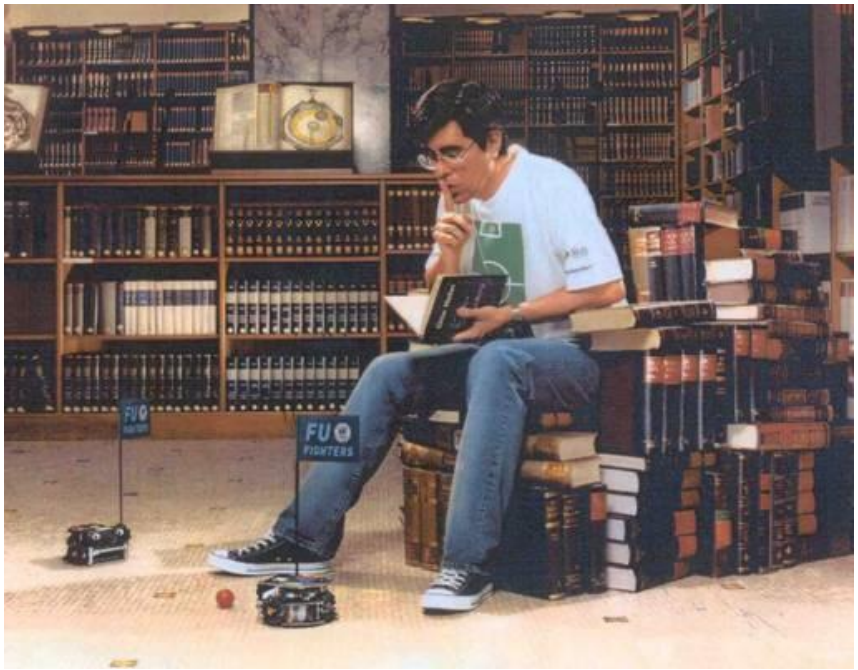
Research Group

Head of Research Group Artificial Intelligence and Robotics:

- Prof. Dr. Raúl Rojas
- Projects:
  - Autonomous Cars/ Innolab
  - CaroloCup / AudiCup
  - Fumanoids
  - Electric wheelchair



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Robots in our Research Lab

- Autonomous Car

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Robots in our Research Lab

- AudiCup

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Robots in our Research Lab

- Electric Wheelchair

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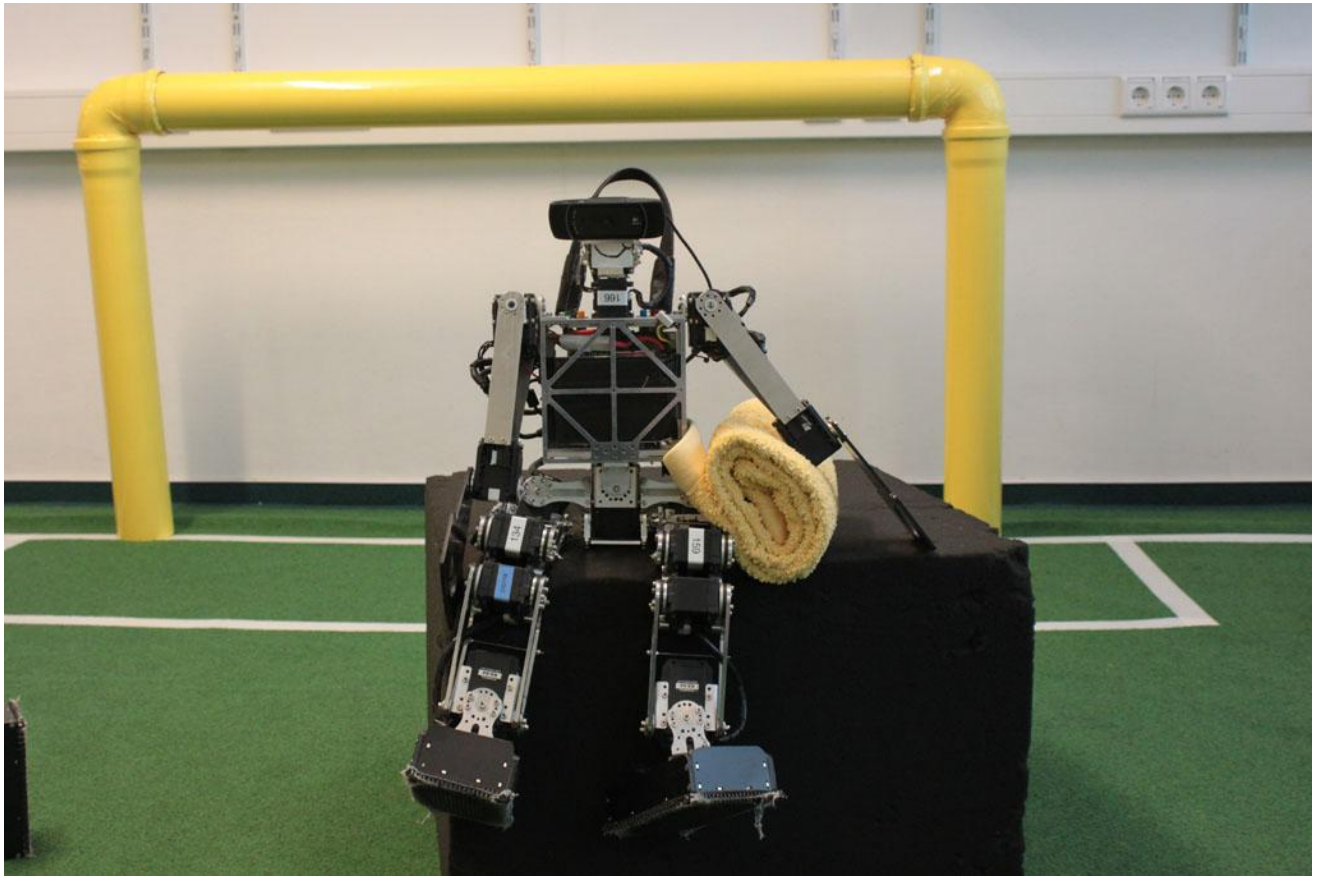
Robots in our Research Lab

- FUmanoids



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History of Robots

- Aristotle, 4th c. BC:
  - if every instrument could accomplish its own work, obeying or anticipating the will of others … chief workmen would not need servants.
- Robot = worker in slavic
  - Karel Capek's 1921 play, RUR (Rossum's Universal Robots), in which machines took over the world
- Little lost robot, Short story in collection, *I, Robot,* Isaac Asimov, 1942

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Robotic Antecedents

- Water powered clock tower

- Puppets
  - Tea-serving karakuri
  - da Vinci‘s Lion

- Chess automaton
  „The Turk“ (fake)

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Robotic Antecedents (Industry)

(R. Stengel)

- Jacquard loom, worked with punched cards

- Watt‘s steam enginge, used a regulator for constant rotational velocity
- Elektro, 1937, 700 words, smoked cig.

- 1930s: enabling technologies:
  - Electric motos
  - Hydraulic, pneumatic actuators
  - Sensors
  - Analog computation
  - Control theory

Toward Autonomous Robots

(R. Stengel)

- 1940s: World War II
  - Teleoperators
  - Fire control systems
  - Aerial drones (TDN1)
  - Numerically controlled machines
  - Chemical process control
- 1950s: Cold War
  - Guided multi-stage missiles
- 1960s: Space Age
  - Uninhabited spacecraft
  - Industrial robots
  - Boston Arm (Mann, MIT)
  - Toward Autonomous Robots
- 1970s: Energy and the Environment
  - Computer-machine integration

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Elements of Robotic Devices

(R. Stengel)

- Structure
- Power source
- Actuation
- Sensing
- Locomotion
- Environmental Interaction
- Human-machine interaction
- Guidance
- Navigation
- Control

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Autonomous Robots

(R. Stengel)

- Self control
- Self maintenance
- Awareness of environment
- Task orientation
- Mission specificity
- Power source
- Cooperation and collaboration
- = Intelligence?
- Self replication?
- Ethical issues

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Robots Today

- Nowadays robots are found in human environments as:
  - hospitals – surgery by teleoperated robots
  - human interaction
  - households
  - agriculture
  - nanotechnology / simulation

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Robots in Human Environment

- As robots get closer to human environments
  - there is more uncertainty
  - safety is an issue
  - perception, foremost vision is key
  - tactile sensing and
  - learning important

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Topics

Generating motion and dynamic control:

- Spatial Descriptions, Coordinates and Transformations, Link Description, Forward Kinematics, Kinematic Chain, Denavit-Hartenberg-Notation, Jacobian – Velocities and Forces (linear and angular), Inverse Kinematics, Joint Space, Cartesian Space

- PID control, Joint Space dynamic control, cartesian space dynamic control

Planning:

- Trajectory Generation, Path Description
- RRTs, A*
- Numerical Optimization

Localization and Mapping:

- Probability and Statistics, Probabilistic state and Parameter Estimation, Bayesian filtering, Kalman filters, SLAM

Vision:

- SIFT, HOG, DPM, 3D-Point Clouds, RANSAC