Komplexpraktikum Mobile Roboter
Mobile Robotics Lab
Winter 2003/04

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Knowledge Representation and Reasoning Group
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Syllabus Winter 2003/04

Student’s record

- 0/0/4 SWS
- 6 credit points

Outline

- Introduction to AI-based mobile robotics
- Probabilistic methods for robot localisation and mapping
- Project or team project, e.g., on learning 2D-maps using a laser range finder

Equipment

- Pioneer 2 mobile robot equipped with colour camera, laser range finder, compass, and gripper
- Development environment with simulator for the Pioneer 2 robot

Examination method

- Course assessed to 60% for the demonstration and to 40% for the writeup of the project
Recommended Books

- Ulrich Nehmzow,
  *Mobile Robotics: A Practical Introduction*,
  Springer, 2000

- Ronald C. Arkin,
  *Behaviour-Based Robotics*,
  MIT Press, 1998

- Robin R. Murphy,
  *Introduction to AI Robotics*,
  MIT Press, 2000

- Gregory Dudek and Michael Jenkin,
  *Computational Principles of Mobile Robotics*,
  Cambridge University Press, 2000
Contact and Communication

Course Web page

- Updated by 12noon the same day

Email list

- robotics@janeway.inf.tu-dresden.de

Personal email

- axg@inf.tu-dresden.de

Office

- GRU 421 (request an appointment by email)
Scientific Issues in Mobile Robotics

Robotics as fascinating research topic - why?

- Mobile robotics reverses the trend in science toward specialisation, and demands lateral thinking and the combination of many disciplines.
- Elements: engineering, computer science, artificial intelligence, cognitive science, and psychology.
- Autonomous mobile robots are the closest approximation yet of intelligent agents.
- Commercial applications of mobile robots: transportation, surveillance, inspection, cleaning or household robots, intelligent toys.

Have a look at recent examples of mobile robotics research.
Humanoid Robots *Asimo* and *P3* by Honda
Video clip

- Amateur video shot at Robodex-2002
Humanoid Robot \textit{SDR-4X} by Sony
Robot \textit{SDR-4X} in Action

Specification

- A total of 38 joints in the robot’s body
- Two CCD colour cameras for image recognition
- Seven microphones located inside its head
- Wireless LAN communication
- Weight 6.5 kg with battery and memory
- Dimensions 580 x 260 x 190 mm

Video clip

- Amateur video shot at Robodex-2002
Robot Dog *Aibo* by Sony

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Robots $SDR-4X$ and $Aibo$ in Action

Video clip

- Amateur video shot at Robodex-2002
Humanoid Robot *Kismet* (MIT AI Lab)
Museum Tour-Guide *Minerva* (CMU Robotics Institute)
Pioneer 2 Robot  *Bender*
Pioneer 2 Robot *Astra*
Robots *Astra* in Action

Video clip: *Astra* collecting cups and soda cans

- Video shot by a group of students

Video clip: *Astra* navigating obstacles and people

- Video shot by Matthias Fichtner and Markus Krötzsch
Application Scenario: Office Delivery

Video clip

- Karen Zita Heigh,
  *Xavier: An Office Delivery Robot*,
  Video Proceedings of the AAAI-98 Mobile Robot Exhibition

Try to remember some ‘buzz words’
The ‘Cognitive Robotics’ Point of View

Designing robots capable of task planning on a high level

Maximum level of abstraction from

- physical platforms
- the specifics of real environments

Planning, reasoning

- Fluent Calculus
  - Basic notions: fluents, actions, states, and situations

Execution

- Fluent Calculus Executor (FLUX)

Issues

- Groundedness?
- Implementation?
The ‘AI Robotics’ Point of View

Look at the full picture
- from hardware sensors to high-level planning

Dealing with uncertainty in sensing and execution

Probabilistic representations

Probabilistic methods
- localisation
- map learning
- object detection
Robot Control Architecture

- **Robot hardware**
  - Hardware-level controller (P2OS)
- **Vision system**
  - Cognitive-level controller (FLUX)
  - Reactive-level controller (Saphira)
  - Position-tracking system
- **Map module**
  - Path planner
  - Map symbol
  - Target coordinates
- **Behavior**
  - Status information
  - Behaviour parameter
  - Corrected position
- **Sensor data**
  - Sonar and odometry sensor readings
  - Actuator settings
- **Position of detected objects**
- **Camera image**
- **Symbol coordinates**
- **Map target**
- **Corrected position**
- **Axel Großmann, MRL 2003/04**
System Architecture

Reactive-level controller

- Maintaining a model of the robot’s environment using the readings of the robot’s distance and odometry sensors
- Computing target values of the robot’s actuators based on the output of a set of reactive behaviours
- Execution monitoring at the level of reactive behaviours

Vision system

- Model-based object detection using colour segmentation

Position tracking system

- Implementation of Monte-Carlo localisation
- Computing a probability distribution (belief) about the robot’s position with respect to a map of the environment using laser range data
System Architecture (contd.)

Map module and path planner

- Computing a topological graph for global navigation using Voronoi segmentation
- Translating symbols for locations into target coordinates

Cognitive-level controller

- Planning and reasoning system
- Implementation of the Fluent Calculus
- Execution monitoring at the cognitive level
Upcoming Practical Exercises

Saphira

- Run Saphira demo
- Direct motion commands
- Make turns around two pillars

Robot sensors

- Compute a model of sonar sensors in simulation
- Laser tracking experiments
Homework

Read *Saphira* manual: Chapters 1 to 6

Read Diplomarbeite by Daniel Hennig: Kapitel 2 bis 4

Next lecture on Monday, 10th November 2003