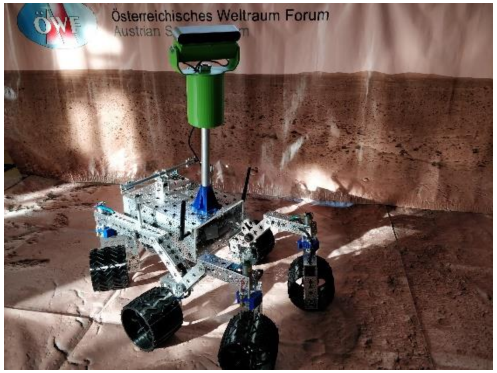
Construction of Mobile Robots 716.091

Richard Halatschek, Marco de Bortoli, Martin Kandlhofer, Gerald Steinbauer

Institute for Software Technology

Previous Years

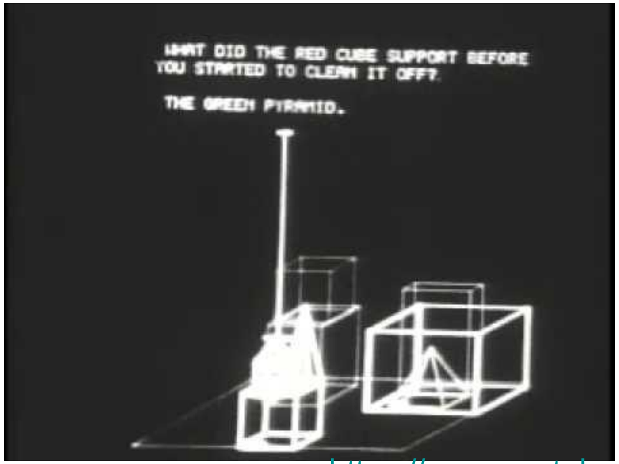
- Breakfast Robot
  https://youtu.be/dtoQIKlQcug
- RoboCup Logistics League
  https://youtu.be/jdQexkXq2Qs
- Mini Mars Rover
  https://youtu.be/ew_Mrk4u0mA

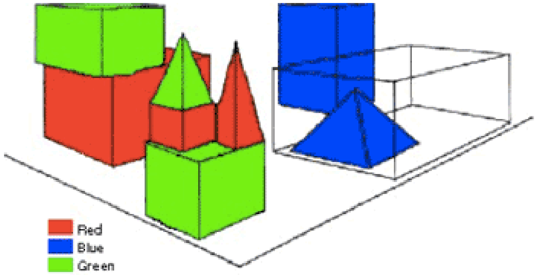


This year …..

The Graz HRI Challenge (1)

- inspired by Terry Winograd‘s SHRDLU
- the robot is able to understand a scene
- the robot is able to communicate with a user
- the robot is able to answer queries and manipulate the scene based on user commands



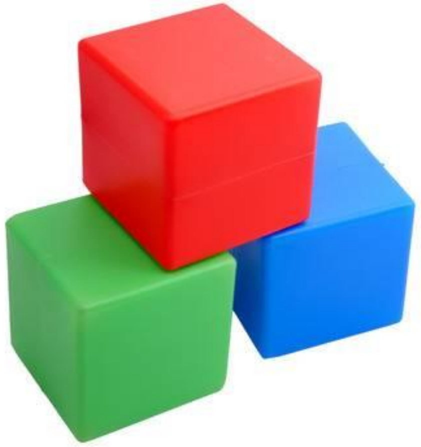


Person: Pick up a big red block.
Computer: OK.
Person: Grasp the pyramid.
Computer: I don't understand which pyramid you mean.

https://www.youtube.com/watch?v=bo4RvYJYOzI
https://www.youtube.com/watch?v=TwWTtv3tb0Q

The Graz HRI Challenge (2)

- we will do it in the real world!
- we will use the Baxter robot
- we communicate via speech
- we simplify the setup to a table top with cubes of different size and color (to ease perception)



The Graz HRI Challenge (3)

the robots should be able

- to understand the scene using sensors and to build up an internal representation of the world (e.g. small red cube 1 is on top of large blue cube 3, medium green cube 2 is free)
- to understand spoken commands and queries from the user: “Baxter please stack all blue cubes!”
- to resolve ambiguities and missing information in the commands and queries in a dialogue: “There are two green cubes. Which one do you mean?”
- to be able to update the internal representation using spoken commands and to derive a plan to perform a command
- to execute the commanded manipulation task in the real environment

Major Challenges

- students form one team working on all major challenges

1. perception
   - detect the type and position of objects in the environment
   - update the internal representation of the environment
2. interaction by speech
   - understand and parse spoken natural sentences
   - generation of speech
3. reasoning and planning
   - answer queries based on the internal representation of the world
   - plan a sequence of basic skills for a given command
4. manipulation
   - grasping, moving, and releasing objects (basic skills)

Engineered Environment

- the basic setup – robot + table + cubes – is fixed
- but the actual configuration of the setup can be changed in favor of a simpler solution
- the actual objects can be changed to make perception simpler – as long as enough different objects remain allowing for an interesting conversation and manipulation challenge
- place any number of sensor in any position that is helpful

Audience/Prerequisites

- Master Information and Computer Engineering/Computer Science/Software Development and Business Management
  - compulsory for major in mobile robots
- interested students
  - specialization for mobile robots
- expected skills
  - teamwork
  - independent work
  - experience with Linux
  - experience with ROS
  - programming skills (e.g. C++)
  - courses: mobile robots/advanced robotics

Resources

- Baxter will be extended and adapted and remain the same for the rest of the course – so the entire setup
- Baxter will be exclusively used for the course
- access to the lab during late hours or holidays with the TUG Card

Available Software/Hardware

- Robots
  - Baxter Research Robot
- Software
  - ROS
  - Baxter SDK
  - MoveIt!
  - Point Cloud Library (PCL)
  - DexNet
  - Google Cloud Speech API
  - Stanford NLP Core
  - tmkit
  - object table detector
  - various 3rd Party Libraries
- Additional Equipment & Small Parts
  - can be purchased or built during the course
- Additional Sensors
  - 2D Cameras
  - 3D Cameras
  - 2D Lidars
  - 3D Lidars
- Grippers
  - Parallel Gripper
  - Vacuum Gripper

World Representation

As a first task, you are required to obtain an abstract representation of the world (the working space + the cubes (position, color, size)) from the camera, which will be used by the planner as the input scenario.

Below are some tutorials/projects to get an idea on how to realize it:

- Objects recognition and position calculation (C++):
  http://robotica.unileon.es/index.php/Objects_recognition_and_position_calculation_(webcam)
- Color detection (C++):
  https://www.opencv-srf.com/2010/09/object-detection-using-color-seperation.html
- Color detection (Python):
  https://www.pyimagesearch.com/2016/02/15/determining-object-color-with-opencv/
- Project for recognition of type and position of an object with baxter:
  http://jessicamullins.com/pdf/mullins-boyce.pdf

Goal/Procedure

- students are able to select, build and apply a robot for a task
- experience with robots, robotics software, actuators and sensors
- solve a task with a robot
- working as a team (sub-teams are ok)
- as much as possible freedom und creativity, no usual static lab setup
- independent working in the lab
- FUN

Roadmap

- 02.10.2019, 10:00-12:00, robot lab: introduction
- 09.10.2019, 09:00-12:00, robot lab: practical introduction - robot, ROS, manipulation, speech recognition
- 21.10.2019, 23:59: submission design document - email
- 23.10.2019, 10:00-12:00, robot lab: discussion design document
- 20.11.2019, 10:00-12:00, robot lab: 1. progress meeting
- 11.12.2019, 10:00-12:00, robot lab: 2. progress meeting
- 08.01.2019, 10:00-12:00, robot lab: 3. progress meeting
- 29.01.2020, 10:00-12:00, robot lab: presentation and demo

Design Document

- one comprehensive for the entire group
- short description of the planned solution
- content
  - solution idea
  - software modules including 3rd party libraries
  - robot adaptions including sensors and small parts
  - interfaces to other hardware/software modules
  - brief project plan (in keywords, milestones, risks)
  - organizational structure of the team (sub-teams, responsibilities)
- document
  - PDF – 2-4 pages
  - via email to steinbauer@ist.tugraz.at, subject „KMR 2019 Design“

Developed Software

- have to be based on ROS xy (tba)
- all freely available ROS packages can be used
- additional Packages of TUG will be available in the robot lab git repository
- developed software has to be organized as independent ROS catkin packages including launch and parameter files
- the software has to be stored in the robot lab git repository
- access data to the git repository will be provided during the practical introduction

Grading

Task	Content	Available Points
Design Document	Solution Proposal	20
Progress Meetings	Presentation of the Project Progress	20
Final Demo	Presentation of the developed solution Live Demo	40
Final Report	Documentation of the development and the realized system	20
Sum		**100**

Grading

Points	Grade
-100 %	1
-87,5 %	2
-75 %	3
50-62,5 %	4
< 50 %	5

Information

Webpage of the Course:

- http://www.ist.tugraz.at/steinbauer/Kmr19

Literature:

- Papers, Documentation, recommended Books

Contact:

- email: steinbauer@ist.tugraz.at
- personal: Inst. for Software Technology, Inffeldgasse 16b/II

Questions ?