

Introduction to Robotics

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Hochschule Bonn Rhein Sieg

Videos!

- b-it-bots@Work Precision Placement Test

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- Tech United Mid-sized League soccer

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- b-it-bots@Home weighing a bottle

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- Nimbro at MBZIRC 2017

Domains

- Navigation
- Sensing
- Manipulation
- Task Planning

Navigation

- World model

Navigation

- World model
- SLAM

Videos:

- [06-Mapping]

Navigation

- World model
- SLAM
- Path planning

Videos:

- [06-Mapping]

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- World model
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- Motion planning - how do robots move?

Videos:

- [06-Mapping]

Navigation

- World model
- SLAM
- Path planning
- Motion planning - how do robots move?
- Obstacle avoidance

Videos:

- [06-Mapping]

Navigation

- World model
- SLAM
- Path planning
- Motion planning - how do robots move?
- Obstacle avoidance
- What about aerial, underwater and legged robots?

Videos:

- [06-Mapping]

Sensing

- Laser scanner
- 2D camera
- 3D camera
- Sonar
- IMU
- Microphone
- Tactile
- Force and torque

Vision

Sensing

Vision

- Object detection and recognition

Videos:

- [07-3D-Detection]

Sensing

Vision

- Object detection and recognition
- Person / face detection and recognition

Videos:

- [07-3D-Detection]

Sensing

Vision

- Object detection and recognition
- Person / face detection and recognition
- Visual servoing

Videos:

- [07-3D-Detection]
- [08-Visual-Servoing]

Sensing

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- Motion detection

Videos:

- [07-3D-Detection]
- [08-Visual-Servoing]

Sensing

Vision

- Object detection and recognition
- Person / face detection and recognition
- Visual servoing
- Motion detection
- Tracking

Videos:

- [07-3D-Detection]
- [08-Visual-Servoing]

Sensing

Vision

- Object detection and recognition
- Person / face detection and recognition
- Visual servoing
- Motion detection
- Tracking
- Action recognition

Videos:

- [07-3D-Detection]
- [08-Visual-Servoing]

Sound

Sensing

Sound

- Speech recognition

Sensing

Sound

- Speech recognition
- Speaker identification

Sensing

Sound

- Speech recognition
- Speaker identification
- Sound localization

Sensing

Sound

- Speech recognition
- Speaker identification
- Sound localization
- Anomalous sound classification

- Force / load sensing

- Force / load sensing
- Tactile
 - Compliant motion
 - Grasp verification

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- Inertial

- Force / load sensing
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 - Grasp verification
- Inertial
- Range

Manipulation

- Model identification

- Model identification
- Motion planning

Videos:

- [09-Motion-Planning]

- Model identification
- Motion planning
- Motion control

Videos:

- [09-Motion-Planning]

Manipulation

- Model identification
- Motion planning
- Motion control
- Force control

Videos:

- [09-Motion-Planning]
- [10-Force-Control]

- Model identification
- Motion planning
- Motion control
- Force control
- Grasping

Videos:

- [09-Motion-Planning]
- [10-Force-Control]

Planning

Task Planning

Hardcoded state machine for Basic Transportation Task

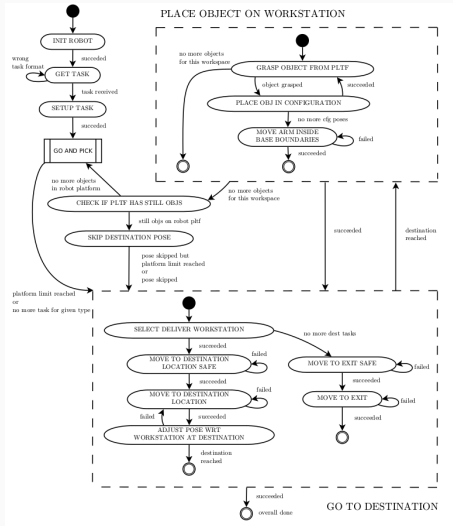


Figure 1: Basic Transportation Task [1]

Hardcoded state machine for pick object

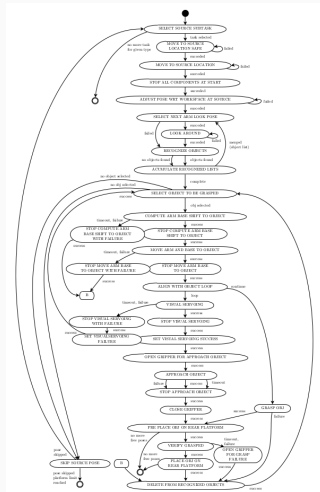


Figure 2: Pick object [1]

Task Planning

Sample plan for Basic Transportation Task

```
(move_base youbot-brsu start ws02)
(perceive youbot-brsu ws02)
(pick youbot-brsu ws02 bearing-00)
(stage youbot-brsu platform_left bearing-00)
(move_base youbot-brsu ws02 ws04)
(unstage youbot-brsu platform_left bearing-00)
(place youbot-brsu ws04 bearing-00)
```

Task Planning

Sample plan for making peppermint tea

Listing 1 A successfully generated plan for making peppermint tea

```
[1] (!goto kettle1 ForGrasping)
[2] (!access kettle1)
[3] (!open kettle1)
[4] (!grasp kettle1 ForTransport)
[5] (!goto kitchenSink ForFilling)
[6] (!position kettle1 ForFilling)
[7] (!opentap coldtap ForFilling)
[8] (!closetap coldtap)
[9] (!grasp kettle1 ForTransport)
[10] (!goto kettleBase ForReplacing)
[11] (!access kettleBase1)
[12] (!replace kettle1 kettleBase)
[13] (!close kettle1)
[14] (!boilWaterInKettle kettle1)
[15] (!goto teacup2 ForGrasping)
[16] (!access teacup2)
[17] (!grasp teacup2 ForTransport)
[18] (!placeNextTo teacup2 kettle1)
[19] (!goto peppermintTeabag ForGrasping)
[20] (!access peppermintTeabag)
[21] (!grasp peppermintTeabag ForMakingTea)
[22] (!placeIn peppermintTeabag teacup2)
[23] (!pourhot kettle1 teacup2)
[24] (!goto kettleBase1 ForReplacing)
[25] (!access kettleBase1)
[26] (!replace kettle1 kettleBase)
```

Figure 3: Plan for making peppermint tea [2]

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- Frameworks: ROS, Orocos, Fawkes

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- Simulators: Gazebo, Stage, V-Rep, OpenRAVE

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- Frameworks: ROS, Orocos, Fawkes
- Simulators: Gazebo, Stage, V-Rep, OpenRAVE
- Useful libraries: KDL, OpenCV, PCL, ZeroMQ, etc.

Some other topics

- Natural language processing

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- Natural language processing
- Fault detection and error recovery

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- Learning

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- Sensor fusion
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- Active perception
- Multi-robot systems
- Logging and databases
- Communication
- Human-robot interaction
- User interfaces

References I

- [1] O. L. Carrion, “Task planning, execution and monitoring for mobile manipulators in industrial domains,” Master’s thesis, Bonn-Rhein-Sieg University of Applied Sciences, Grantham-Allee 20, 53757 St. Augustin, Germany, April 2016.
- [2] I. Awaad, G. K. Kraetzschmar, and J. Hertzberg, “The role of functional affordances in socializing robots,” *International Journal of Social Robotics*, vol. 7, pp. 421–438, March 2015.

The End!