Modular OpenRobot Simulation Engine

The ROS-middleware for MORSE

Michael Karg

Intelligent Autonomous Systems Group
Department of Computer Science
Technische Universität München

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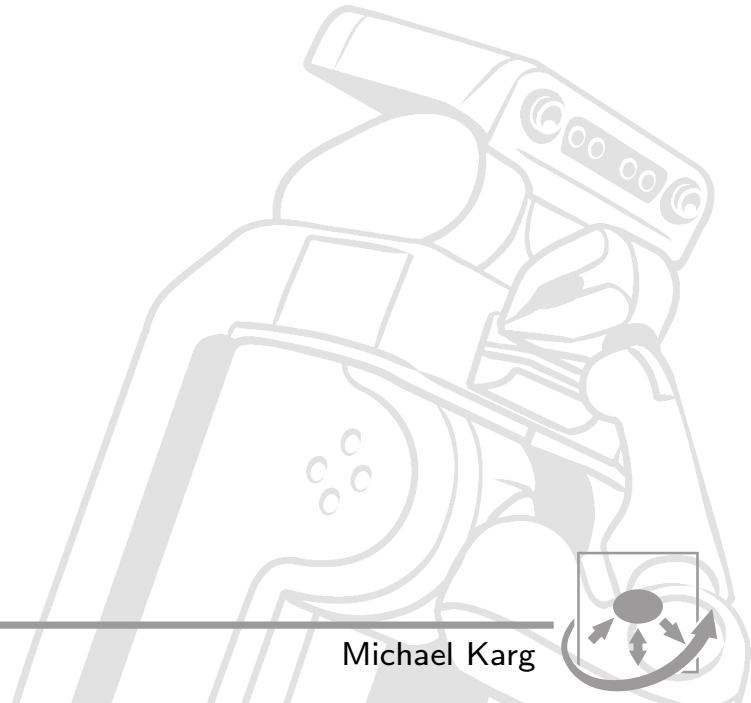
Intelligent Autonomous Systems

IAS TUM Institute for Advanced Study

Outline

1. The IAS TUM group and the Adapto project
2. The MORSE simulator
3. MORSE and ROS
4. Application scenarios



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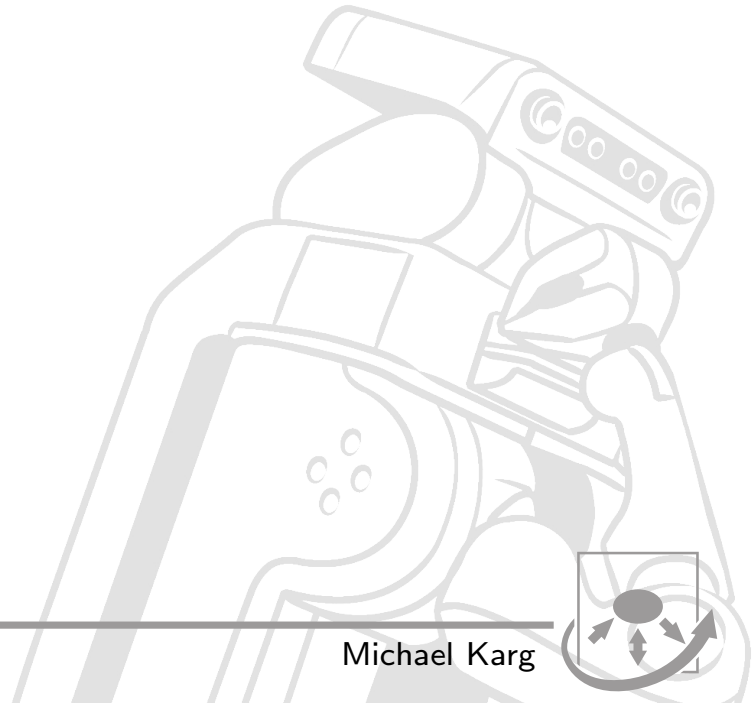
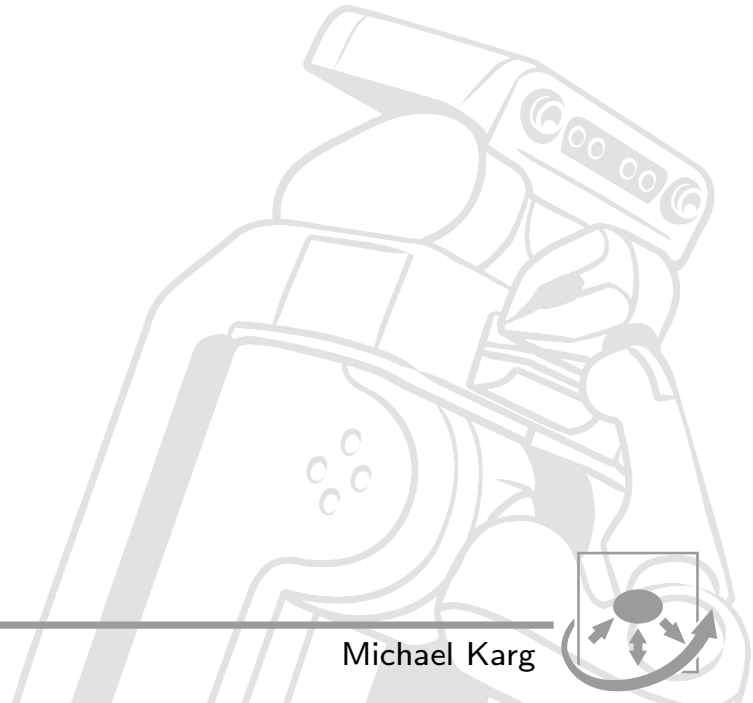


Who we are

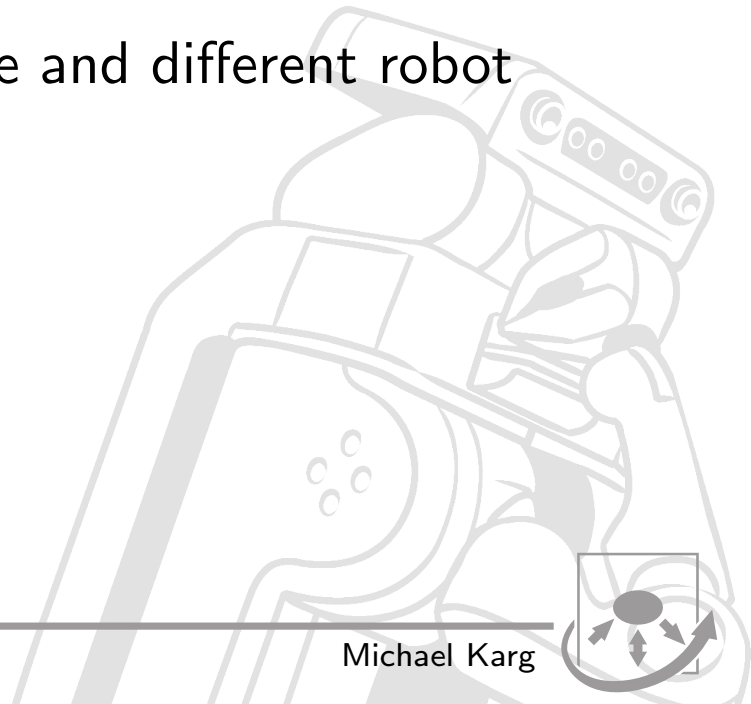
- Part of the TUM - Intelligent Autonomous Systems group of Prof. Beetz
- Adapto project under the supervision of Dr. Alexandra Kirsch
- Plan based control mechanisms for human-robot interaction in domestic enviroments
- Reactive, opportunistic and adaptive planning
- Failure recognition and avoidance using expectation models
- Continual adaptation by learning prediction models
- Human aware navigation

Outline



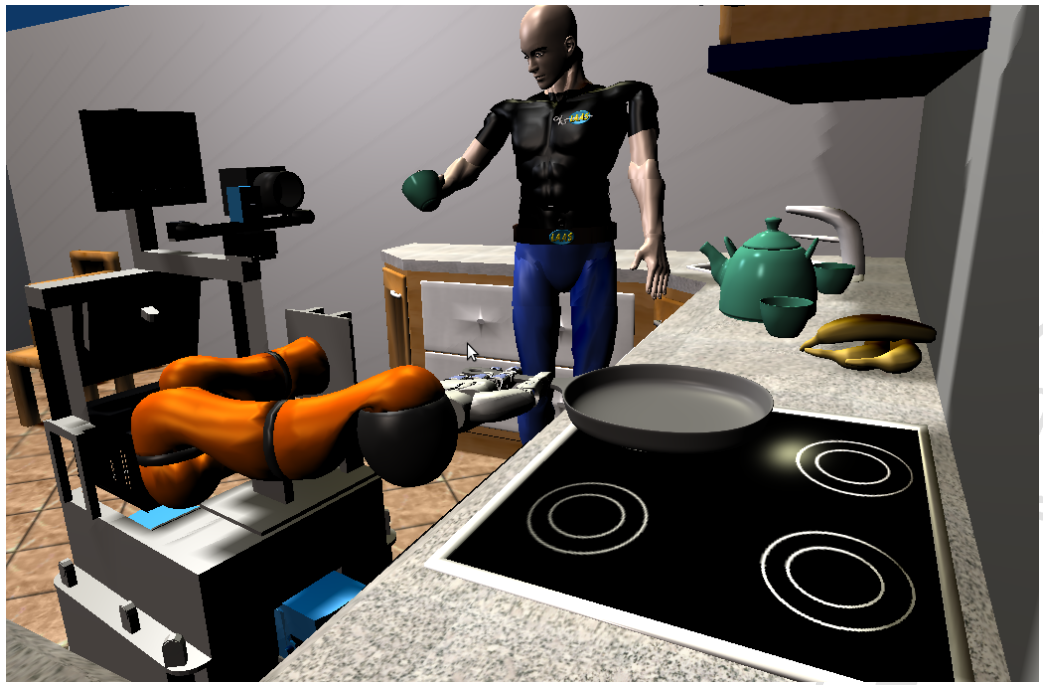
Why simulation?

- Simulation allows experiments on specific parts of a robotic system, (e.g. task planning)
- Real robot behavior is often hard to repeat (due to sensing, battery charge, ...)
- Many diverse enviroments are possible and different robot platforms are available at low cost



Why MORSE for our simulation?

- Modularity allows to regulate level of detail according to our needs (e.g. task planning)
- Human model is already available
- Human robot interaction scenarios can easily be generated in a computer-game like way



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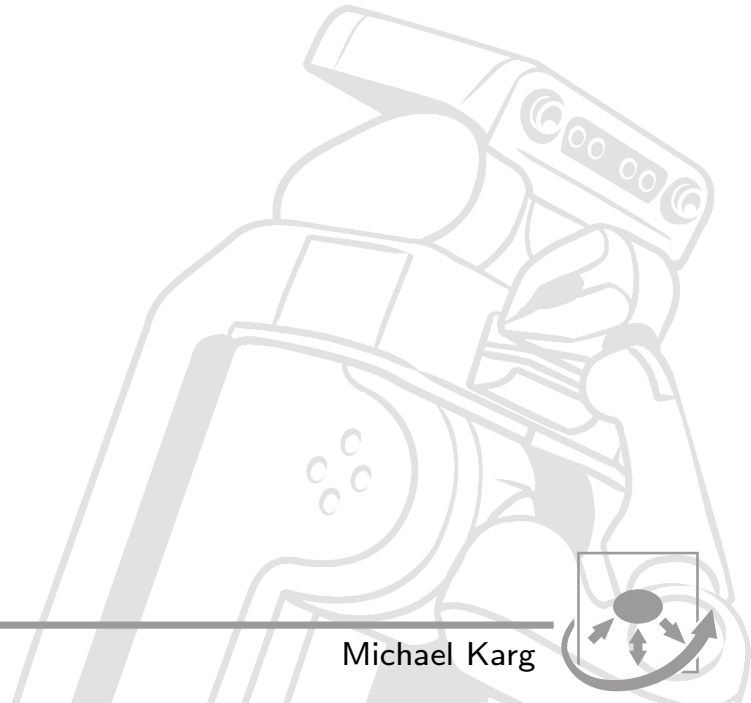


Robot Operating System

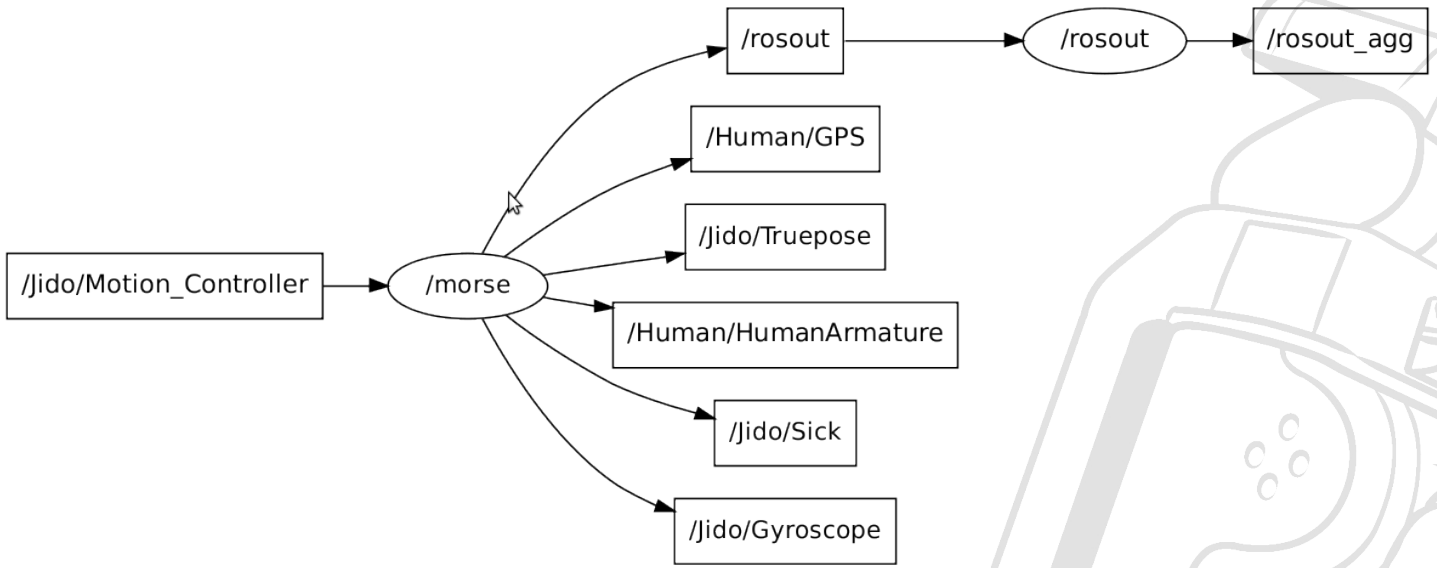
- Operating system for robotics by Willow Garage
- Open source, BSD licensed
- Big, active community
- Documentation, tutorials, tech support

More information:

`http://www.ros.org`

The MORSE - ROS middleware

- ROS uses so called nodes and topics for communication with one master node
- The ROS-middleware in MORSE creates a MORSE-rosnode and one topic for every sensor and actuator according to the following scheme: [robot name]/[sensor or actuator name]
- Communication with roscore using standard ROS messages to assure compatibility with standard ROS components



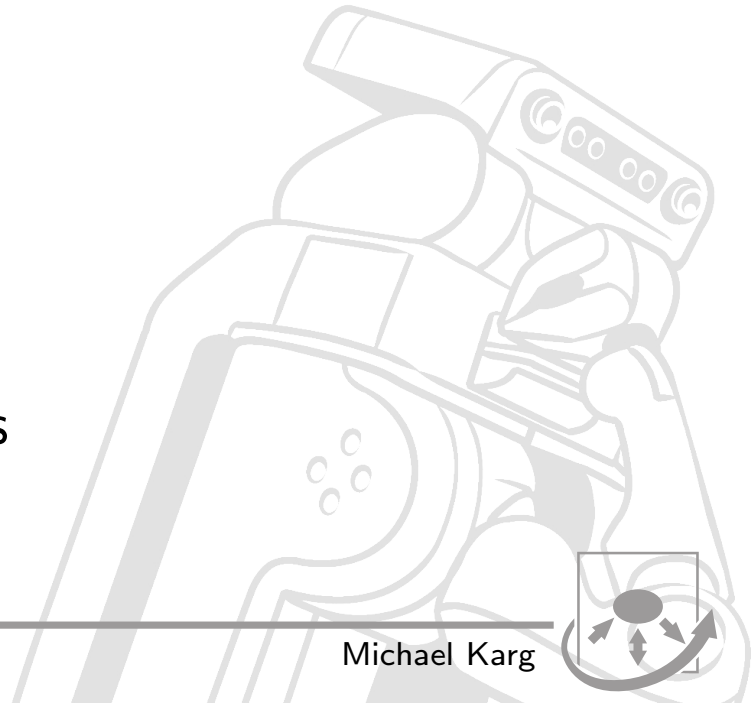
Python 2 VS Python 3

- Blender uses Python3
- ROS uses Python 2.6
- Python 3 is NOT downwardly compatible
- Porting of ROS-messaging parts to work on Python 2 AND 3
- Can safely be used with ROS overlays without affecting your Python2-ROS-installation
- Easy installation by executing one rosinstall-file

Installation instructions:

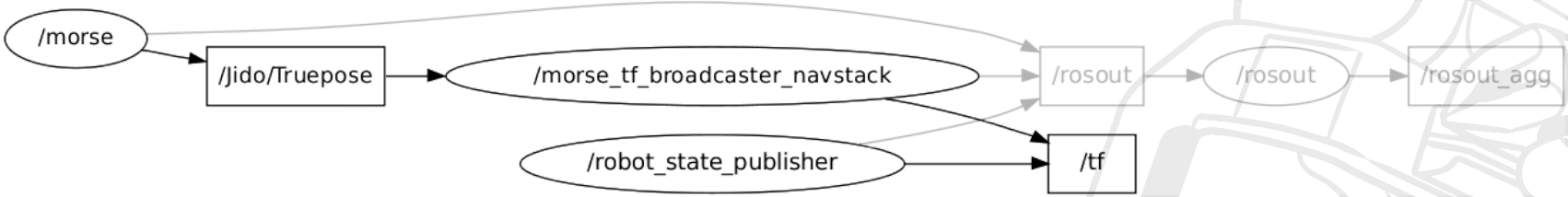
`http://www.openrobots.org/wiki/morse`

Outline



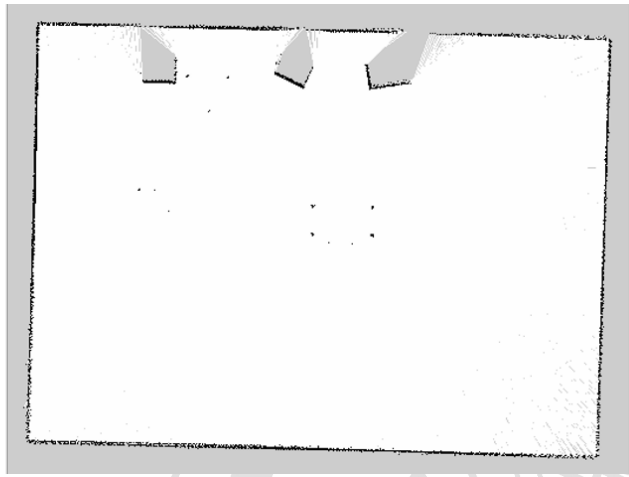
Transform between multiple coordinate frames

- ROS TF builds a tree of all coordinate frames and provides means of conversion between them
- Create map and odometry coordinate frames based on the origin of the blender map and the robot truepose
- Create coordinate-frames of the robot using a robot-URDF and ROS robot state publisher
- Robot can easily exchanged if you have a URDF-file of it

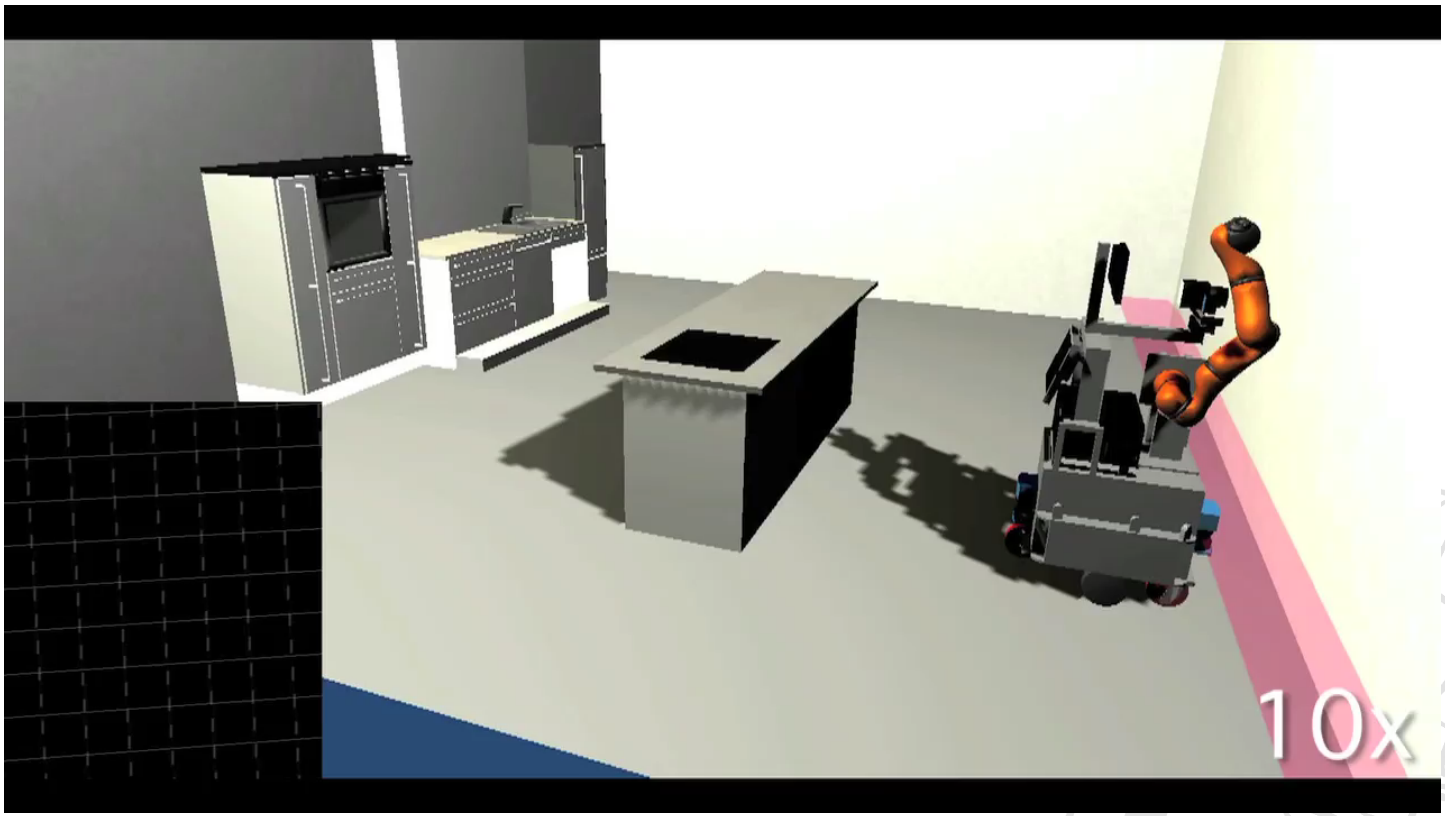


Using ROS Gmapping

- Easy way to create maps of Blender scenarios
- Works out of the box
- Needs robot pose (Truepose or Localization), TF-tree and data of laserscanner
- Collision bounds define collision with laser scan

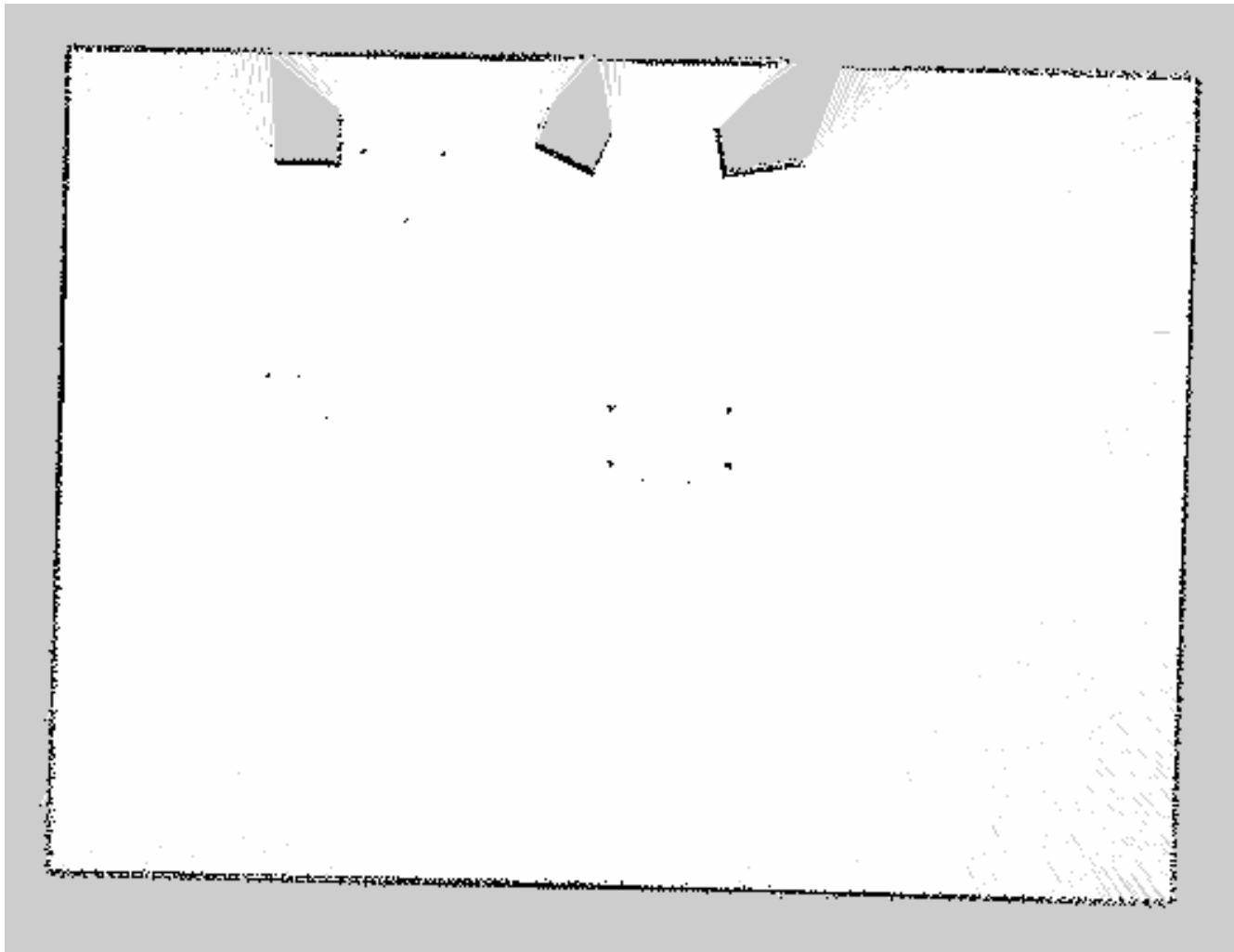


Video: Gmapping in MORSE (1)



Video: Gmapping in MORSE (2)

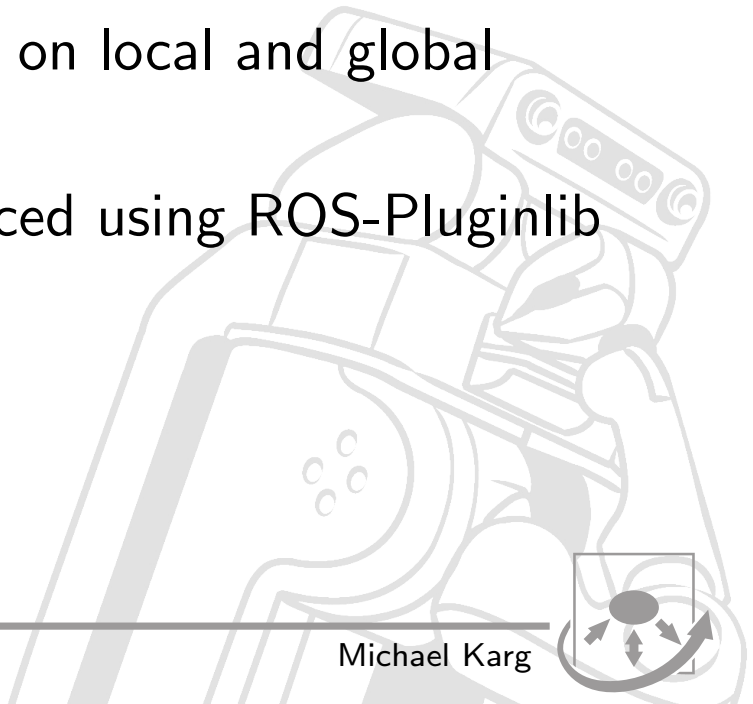
Video: Gmapping in MORSE (3)



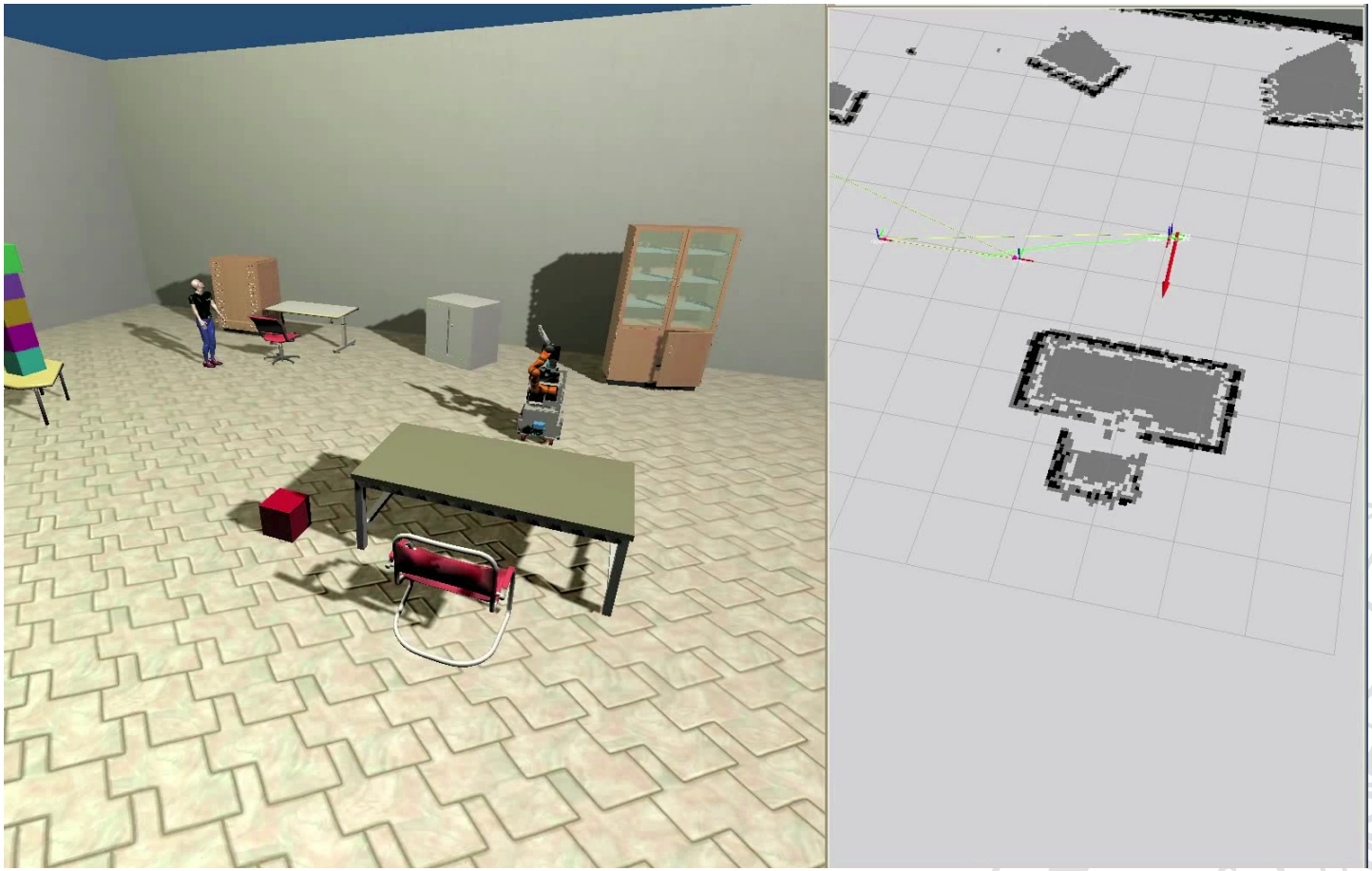
Video: Gmapping in MORSE (3)

Using the ROS navigation stack in MORSE

- 2D navigation
- Takes information from odometry, sensor streams and a goal-pose and outputs safe velocity commands that can be used by a MORSE motion-actuator
- Uses TF-tree and map
- Comes with obstacle avoidance based on local and global costmaps
- Global and local planner can be replaced using ROS-Pluginlib
- Works with real PR2-robot

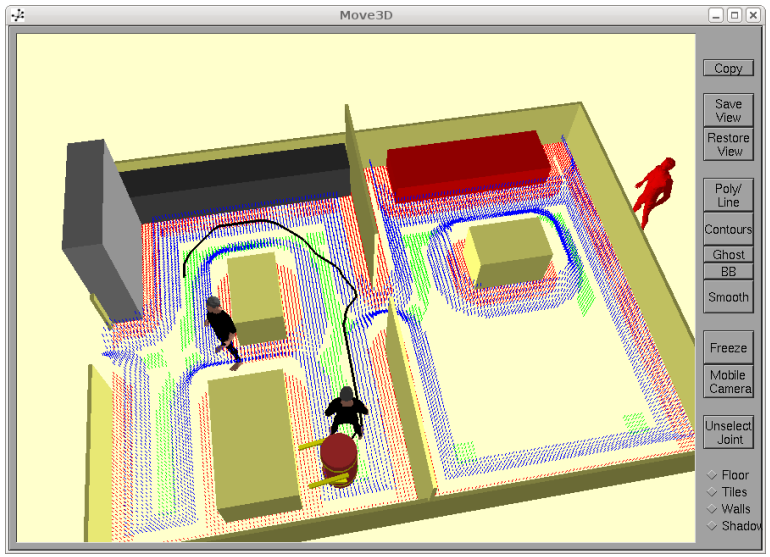


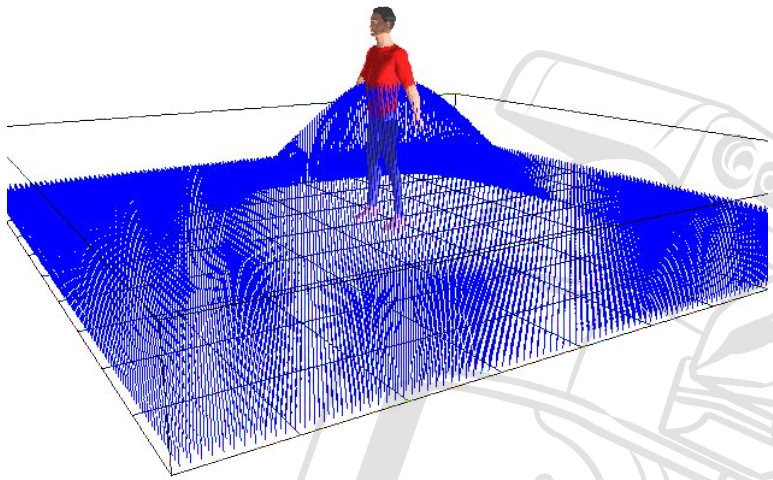
Video: ROS Navigation stack in MORSE



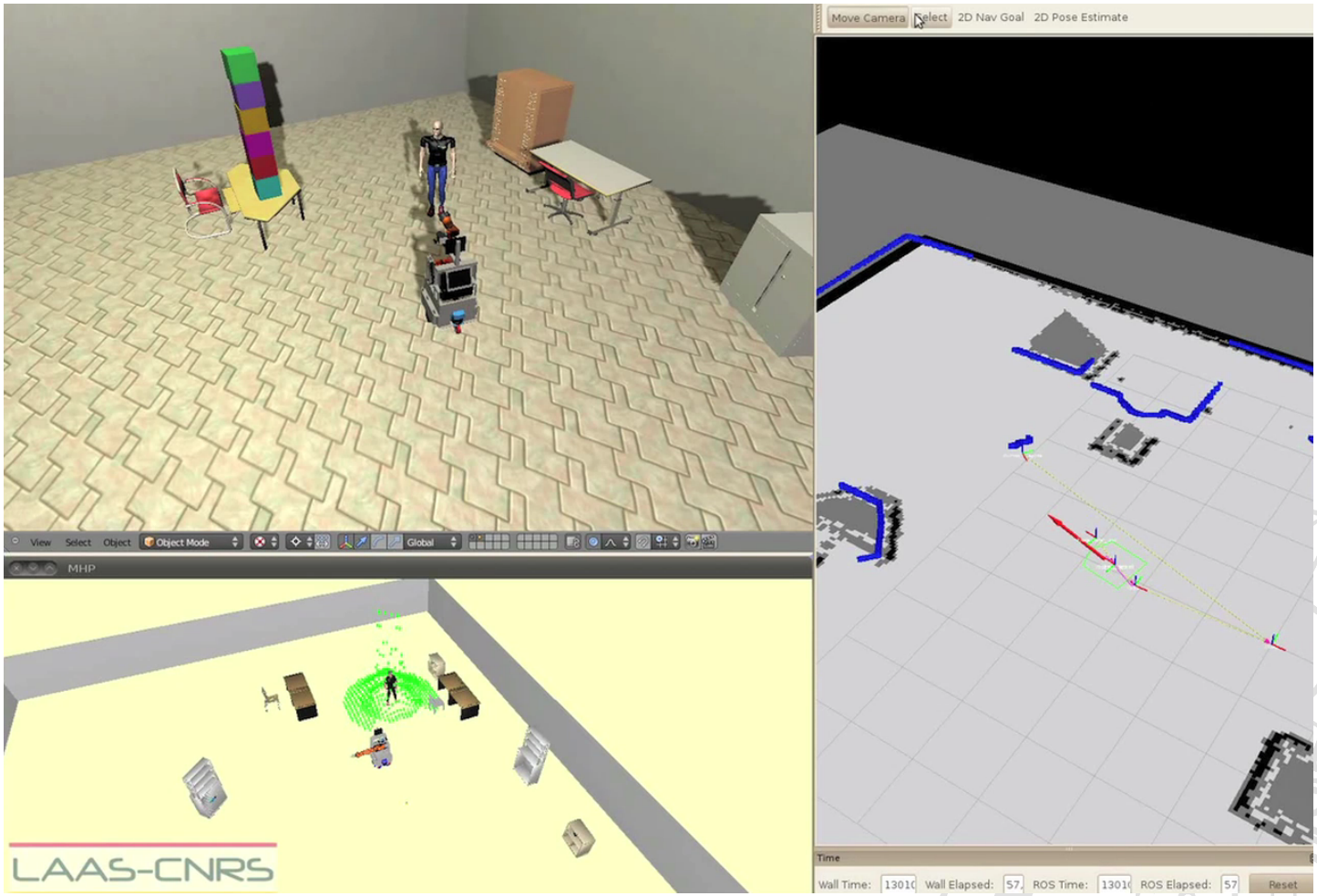
Human friendly navigation

- Replaces global planner of navigation stack
- Integrates human into robot path-planning
- Based on Move3D by LAAS CNRS
- Collision-free motion planning
- Social cost-function around the human pose





Video: Human friendly navigation



Controlling the Kuka-arm

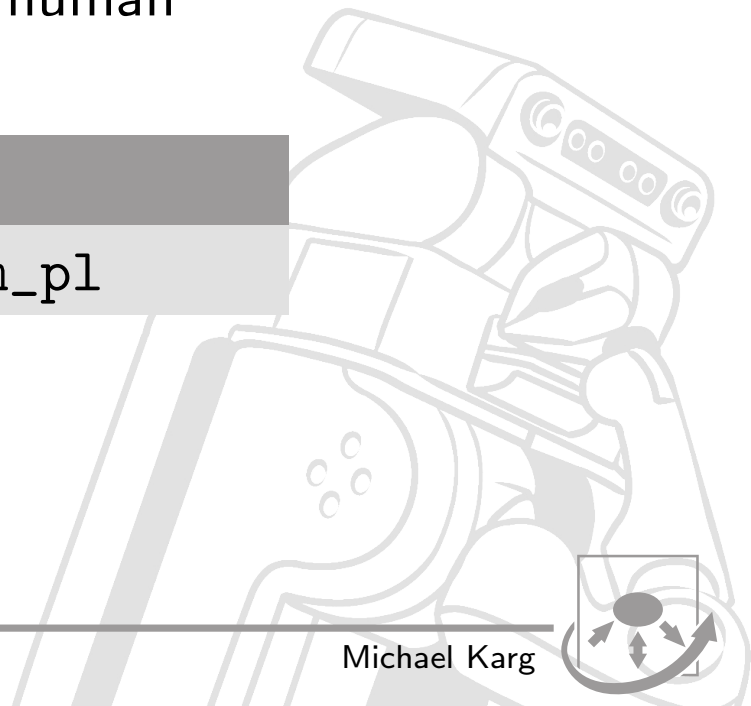
- Send ROS-Jointstate-message to control every joint of the arm

Outlook: CRAM bindings for MORSE

- Cognitive Robot Abstract Machine
- Plan-based control of autonomous robots
- Based on CommonLISP
- Complex failure handling
- Task synchronization, parallel execution, resource management
- Goal: Perform complex activities in a human household

CRAM-PL ROS-package:

`http://www.ros.org/wiki/cram_pl`



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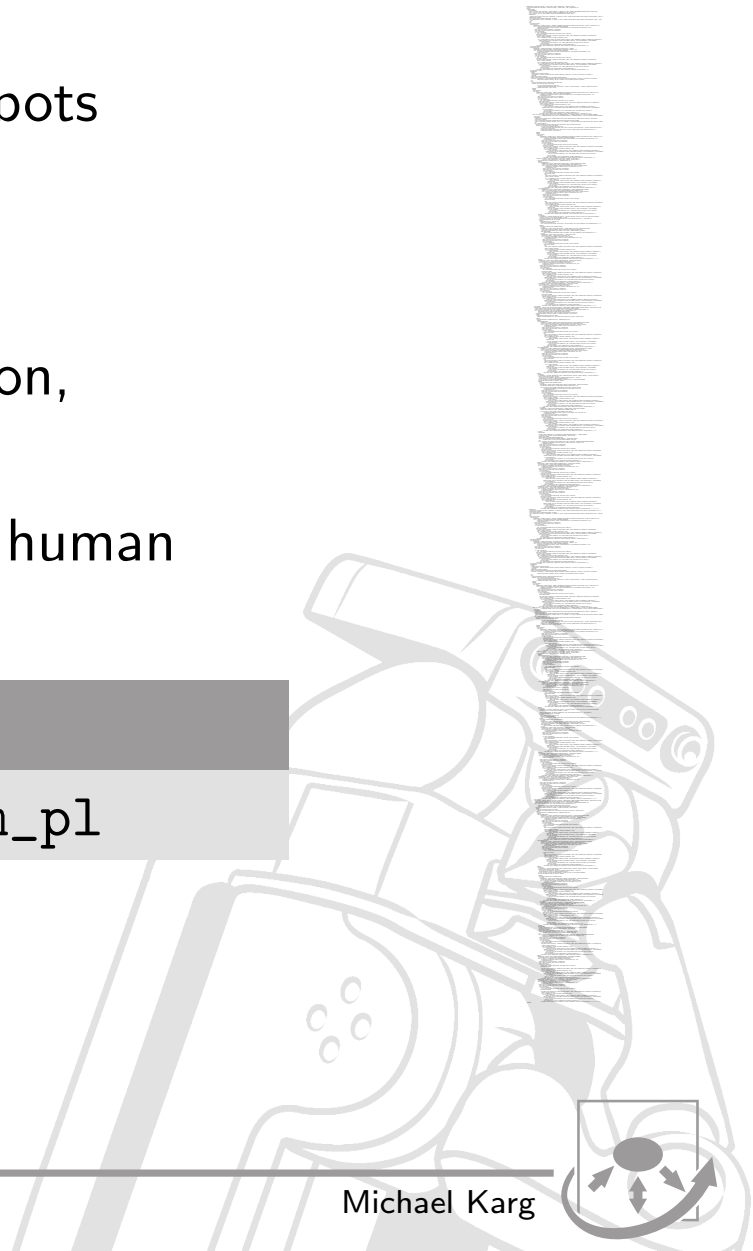

Outlook: CRAM bindings for MORSE

```
(LET ((INNER-CONTACTS NIL))
  (WITH-FAILURE-HANDLING FAILURE ((CARRY-TRIES-COUNT CARRY-TRIES) (GRIP-TRIES-COUNT
   (RECOVER ((TYPEP FAILURE 'ENTITY-LOST-FAILURE)
             (LET ((SIDE (ENTITY-GRIPPING-SIDE ENTITY NIL)))
               (HANDLE-PLAN-FAILURE CARRY-TRIES-COUNT :ENTITY ENTITY :DO-ALWAYS ((E
            ((TYPEP FAILURE 'GRIP-FAILURE)
             (HANDLE-PLAN-FAILURE GRIP-TRIES-COUNT :ENTITY ENTITY :DO-RETRY ((RECOV
            (T (HANDLE-PLAN-FAILURE 0 :ENTITY ENTITY)))
   (MONITOR)
   (PERFORM
    (:TAG FIND-ENTITY
     (SETF ENTITY
           (EXPANDED-GOAL (:PERCEIVE ENTITY) :PERCEIVE ((DESIGNATOR TR-RULE-NAME SK
            (LET* ((#:GOAL1359 (MAKE-INSTANCE 'ENTITY-FOUND :DESIGNATOR DESIGNATOR)
                   (#:ROUTINE1360 (ARBITRATION #:GOAL1359 (COGITO::FILTER-SETTINGS
                   (#:ROUTINE-RES1361 NIL))
              (SETGV :GOAL-TASK (TYPE-OF #:GOAL1359) #:TAG-GOAL1363)
              (PULSE (GETGV :GOAL-START-FLUENT (TYPE-OF #:GOAL1359)))
              (:TAG #:TAG-GOAL1363
               (IF (NULL #:ROUTINE1360)
                   (FAIL :CLASS NO-ROUTINE-FOUND-FAILURE :GOAL-CLASS (TYPE-OF #:GOA
                 (EVAP-AND-FAIL-PROTECT
                  (SEQ (WHEN (TYPEP #:ROUTINE1360 'EXTERNAL-LOW-LEVEL-ROUTINE) (ADD
                   (COGITO::ADD-GOAL #:GOAL1359)
                   (LET ((#:TIMEMODEL1364 (COGITO::GET-MODEL #:ROUTINE1360 :TIME)))
```


Summary

- MORSE in combination with ROS offer modular simulation adapted to your level of detail with widely used components and a big community
- Outlook:
  - Full Python3 support for ROS
  - High-level HRI scenarios using CRAM language
  - Intuitive Interface for human control
  - Human robot interaction (Cooperative kitchen scenarios)

Summary:

Start using MORSE and ROS today!

The end

Any questions?