Universität Bremen

Institute for Artificial Intelligence
University Bremen

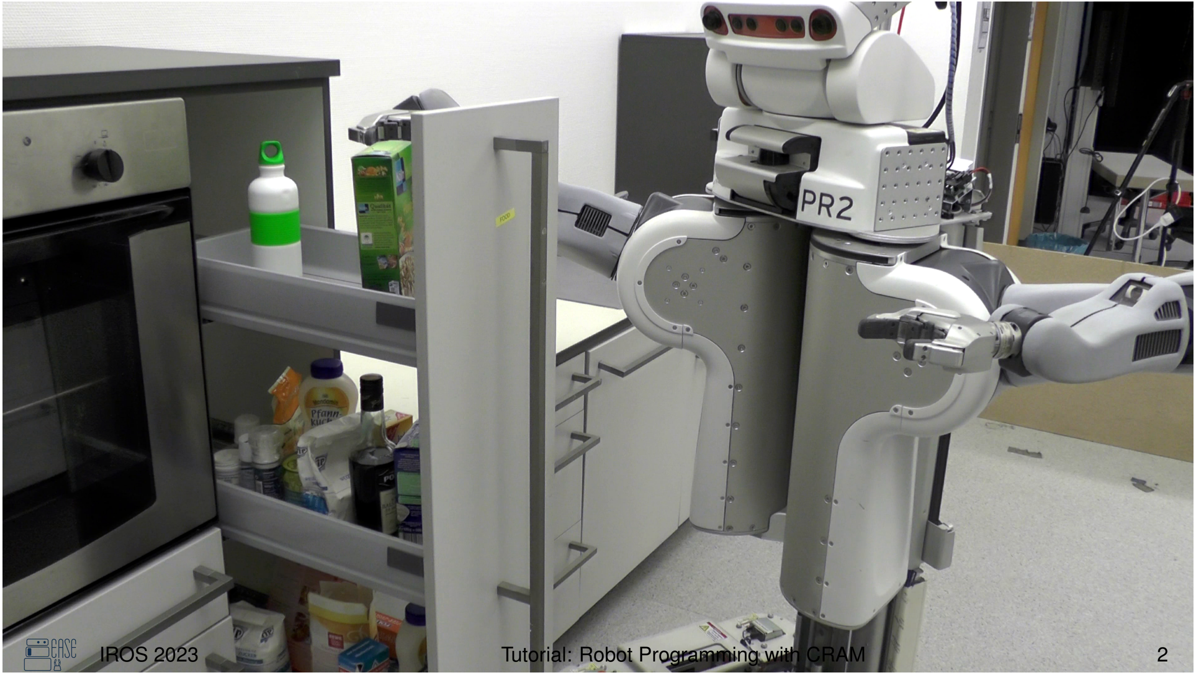
IROS 2023 Tutorial

Robot Programming with CRAM

Arthur Niedźwiecki
October 05th, 2023

EASE

Artificial Intelligence


PR2

Into the cloud - How we use to begin a Hands-On

First assignment:

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- Install Linux

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Into the cloud - Setup is frustrating

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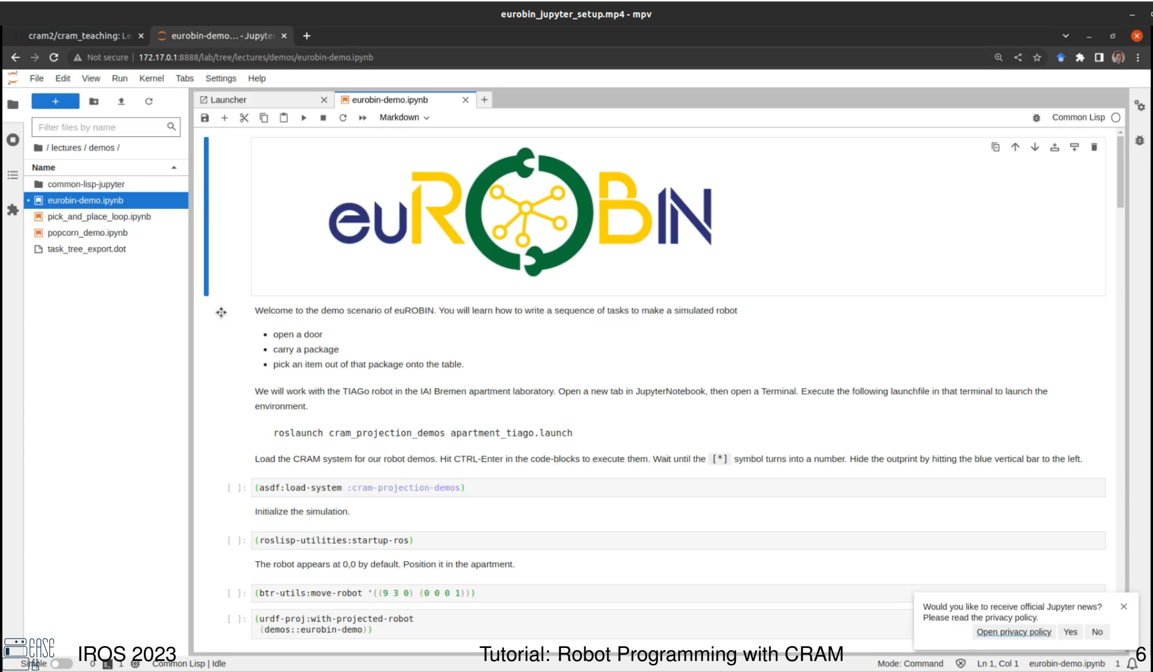
- Requires specific operating system
- Collides with existing software
- Complex and fragile setup takes time
- Documentation has low priority

Into the cloud - Virtualization

How can I make my platform easier accessible?


eurobin_jupyter_setup.mp4 - mpv
172.17.0.1:8888/lab/tree/lectures/demos/eurobin-demo.ipynb
File Edit View Run Kernel Tabs Settings Help
/ lectures / demos /
Name
common-lisp-jupyter
eurobin-demo.ipynb
pick_and_place_loop.ipynb
popcorn_demo.ipynb
task_tree_export.dot
Launcher
eurobin-demo.ipynb
Markdown
Common Lisp
Welcome to the demo scenario of euROBIN. You will learn how to write a sequence of tasks to make a simulated robot
open a door
carry a package
pick an item out of that package onto the table.
We will work with the TIAGo robot in the IAI Bremen apartment laboratory. Open a new tab in JupyterNotebook, then open a Terminal. Execute the following launchfile in that terminal to launch the environment.
roslaunch cram_projection_demos apartment_tiago.launch
Load the CRAM system for our robot demos. Hit CTRL-Enter in the code-blocks to execute them. Wait until the [*] symbol turns into a number. Hide the outprint by hitting the blue vertical bar to the left.
[ ]: (asdf:load-system :cram-projection-demos)
Initialize the simulation.
[ ]: (roslisp-utilities:startup-ros)
The robot appears at 0,0 by default. Position it in the apartment.
[ ]: (btr-utils:move-robot '((9 3 0) (0 0 0 1)))
[ ]: (urdf-proj:with-projected-robot
(demos::eurobin-demo))
Would you like to receive official Jupyter news?
Please read the privacy policy.
Open privacy policy Yes No
Common Lisp | Idle
Mode: Command Ln 1, Col 1 eurobin-demo.ipynb

Agenda

1. Abstract Machine
2. CRAM Plan Executive
   - Primitives
   - Parameters
   - Designators
3. Tutorials

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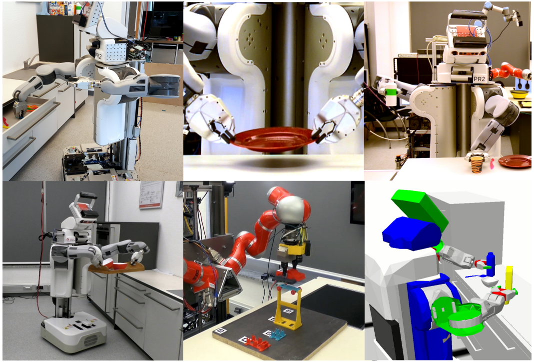
Motivation



One plan to accomplish all variations of fetch and place:

- different *objects, environments, robot platforms, applications*.

Abstract Machines in Computer Science

Adapted from Pedro Domingos: “What’s Missing in AI: the Interface Layer”

Field	**Interface Layer**	**Below the Layer**	**Above the Layer**
Operating Systems	virtual machines	hardware	software
Programming systems	high-level languages	compilers, optimizers, ...	programming
Databases	relational model	query optimization, db design, transaction mgmt	enterprise applications

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Personal robotics	***CRAM***	*grounding in robot, AI tools, the nuts and bolts of intelligent robotics, ...*	*robot application programming*

Raise the conceptual level at which service and personal robot applications are programmed!

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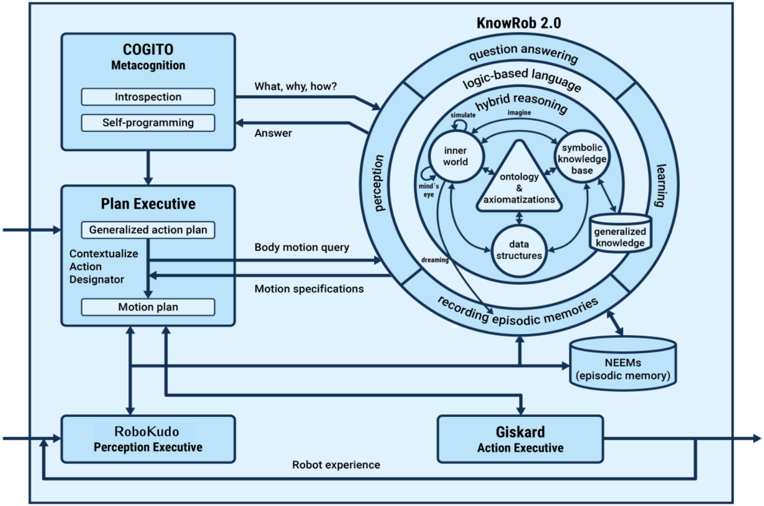
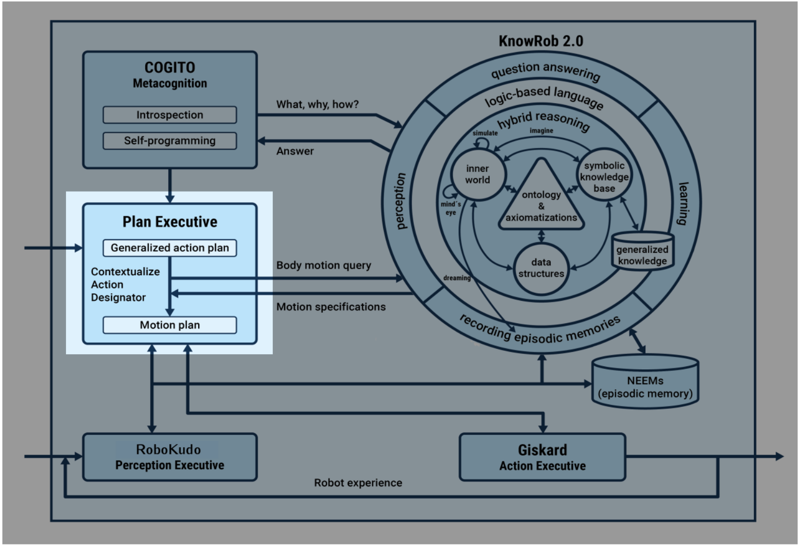
CRAM 2.0 system



CRAM 2.0 system - Plan Executive



Challenges Tackled by the Plan Executive

1. Define which actions to execute to achieve the goal.
2. Infer which parameters to use for each action.
3. Monitor task execution and react to failures.

Primitives: Motions and Percepts

Primitives of Mobile Pick and Place for PR2-like Robots

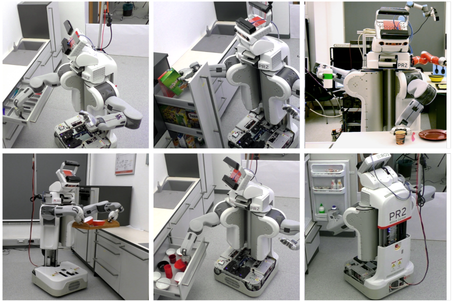
Primitive	Description
moving-base	Move the base to the target pose.
moving-arm	Move the joints of the arm / arms to the target configuration in joint, cartesian or constraint space.
moving-finger	Move the joint of the hand / hands to the target joint position.
gripping	Close the hand / hands to grasp an object.
moving-torso	Move the torso joint to the target joint position.
moving-neck	Move the neck to the target configuration or to direct the camera gaze to a target pose.
detecting	Detect the described object in the environment and update the internal world state with the acquired information.
monitoring-joint-states	Monitor if the joint positions of robot body parts exceed the given threshold.

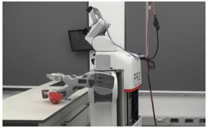
Parameters of Motion and Perception Primitives

Primitive	Parameters
moving-base	goal_pose, ..., speed, ...
moving-arm	goal_pose_for_hand, goal_positions, collisions, ...
moving-finger	goal_position
gripping	hand, grasping_force, object_properties, ...
moving-torso	goal_position, ...
moving-neck	goal_positions, goal_coordinate_to_look_at, ...
detecting	object_description, ...
monitoring-joints	joint_name, joint_value, monitoring_function, ...

Calculating parameter values that maximize success probability: heuristics, learning from experience, imitation learning, ask a human

Choice of Parameter Values is Crucial For Success

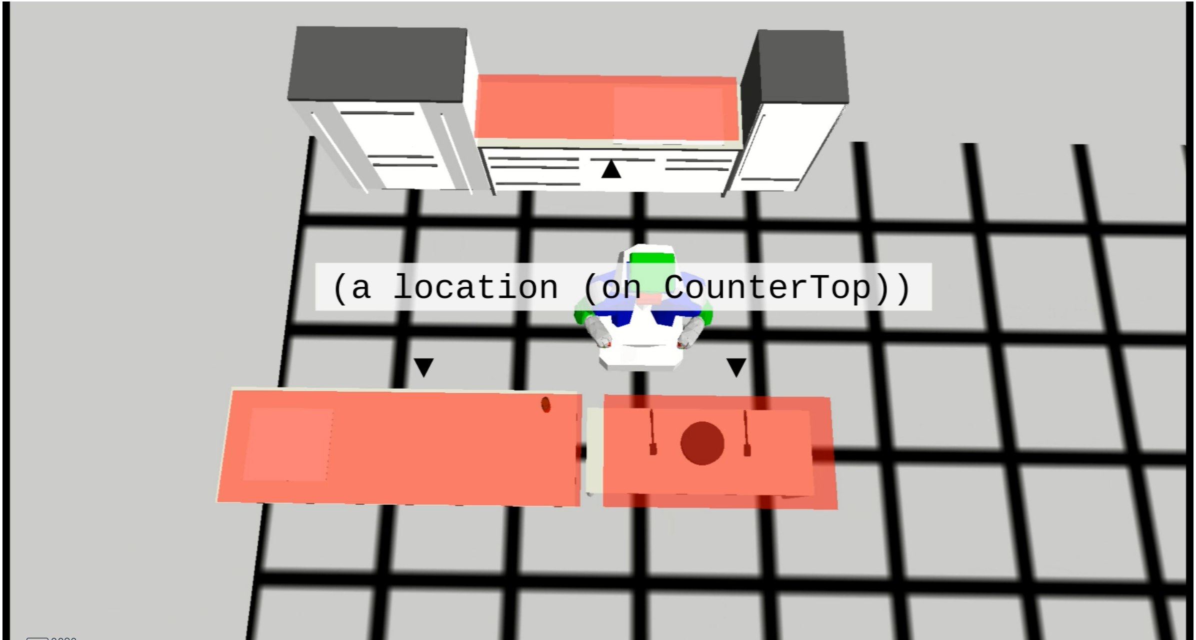




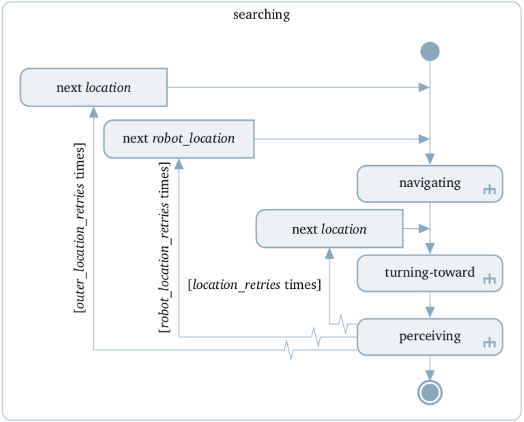
- Often very many possible values to choose from

  Example: from which side and with which hand to grasp?

- Effects can be:
  - immediate
  - short-term
  - long-term


(a location (on CounterTop))

Action Designators: Searching



Combining primitives into high-level actions

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Robot Control with PyCRAM

http://cram-system.org/tutorials/

Overview

Time	Session
8.30 - 8.45	Opening: Michael Beetz & Jörn Syrbe
8.45 - 10.00	Introduction - Michael Beetz
10.00 - 11.00	COFFEE BREAK
11.00 - 12.30	Hands-on Robot Control in CRAM – Arthur Niedźwiecki
12.30 - 1.30	LUNCH
1.30 - 3.00	Hands-On Robotics Simulation in Multiverse – Giang Nguyen
3.00 - 4.00	COFFEE BREAK
4.00 - 5.30	Hands-On Knowledge openEASE – Sascha Jongebloed
5.30	End