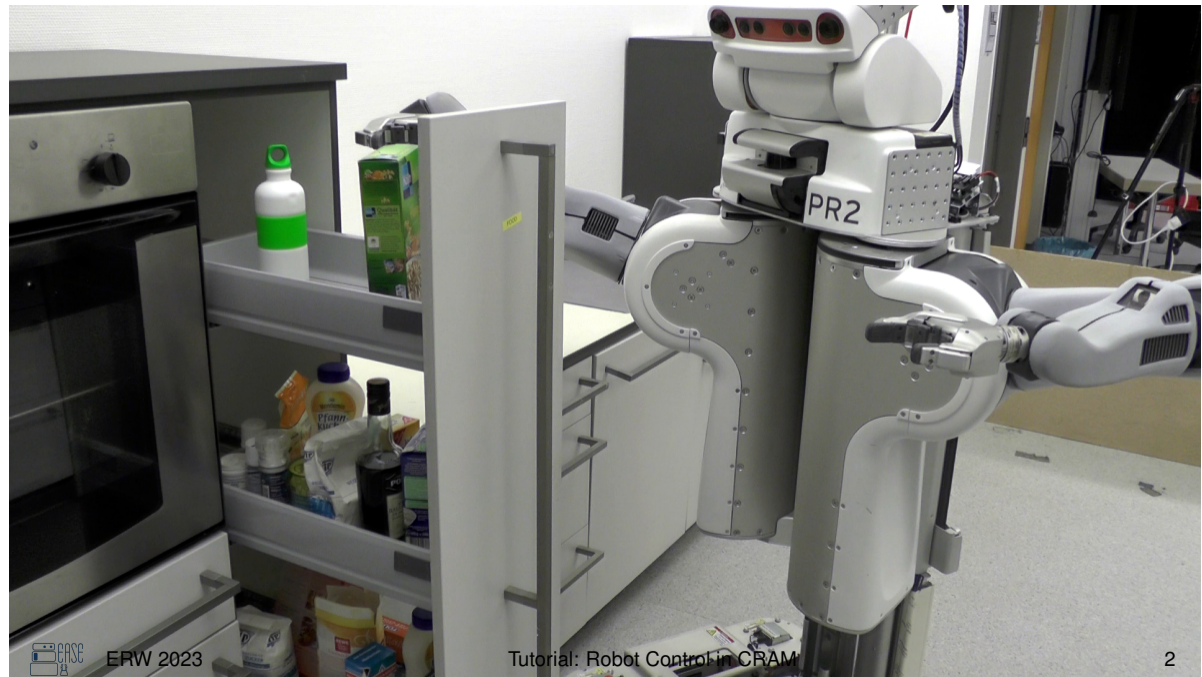


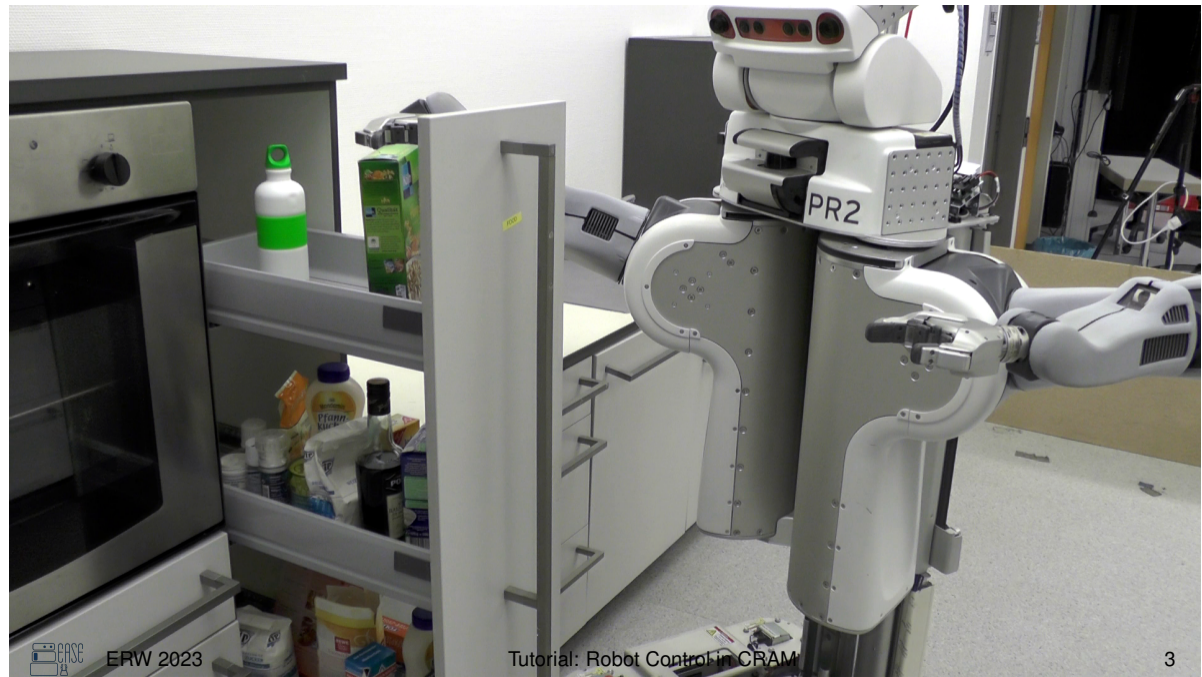
# EU Robotics Week 2023

Robot Control in CRAM

Arthur Niedźwiecki  
November 23th, 2023







# Into the cloud

How to set up a system fast?

# Into the cloud - How to set up a system fast



# Into the cloud - How to set up a system fast

- Install Linux



# Into the cloud - How to set up a system fast

- Install Linux
- Set up SSH and GitHub



# Into the cloud - How to set up a system fast

- Install Linux
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- Install Robot Operating System (ROS)





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- Install this...



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# Into the cloud - Setup is frustrating

- Requires specific operating system



# Into the cloud - Setup is frustrating

- Requires specific operating system
- Collides with existing software



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- Complex and fragile setup takes time



# Into the cloud - Setup is frustrating

- 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?



## Available courses



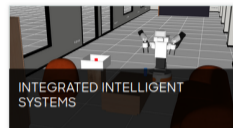
EASE HOUSEHOLD CHALLENGE



WELCOME TO THE VIRTUAL RESEARCH, INNOVATION, AND TRAINING BUILDING

Category: Robotics

Go to course



INTEGRATED INTELLIGENT SYSTEMS



InTEL CoRo

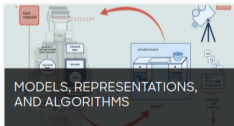
INTRODUCTION TO COGNITIVE ROBOTICS



KNOWLEDGE REPRESENTATION & REASONING



SUSTAINABILITY IN ROBOTICS



MODELS, REPRESENTATIONS, AND ALGORITHMS



EASE FALL SCHOOL 2023

Cognition-enabled Robot Manipulation



EUROBIN

THE EUROPEAN EXCELLENCE NETWORK ON AI-POWERED ROBOTICS







## Available courses



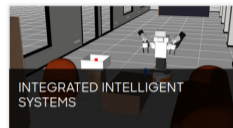
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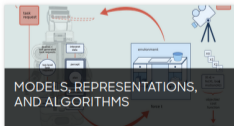
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# Into the cloud - Server-side Architecture

Applications



GISKARD



KnowRob

RoboKudo<sup>®</sup>

# Into the cloud - Server-side Architecture

Packaging



GISKARD



KnowRob

RoboKudo<sup>®</sup>

# Into the cloud - Server-side Architecture

Orchestrator



**kubernetes**



binderhub



docker



GISKARD



**KnowRob**

**RoboKudo** 

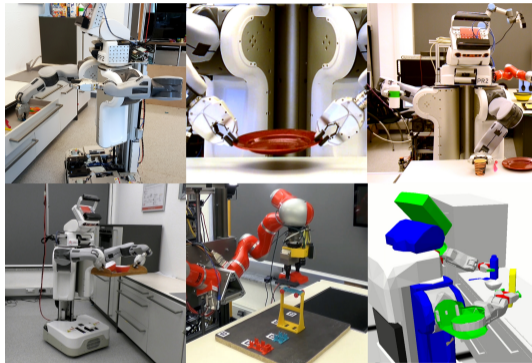
# Agenda

- 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"*

<b>Field</b>	<b>Interface Layer</b>	<b>Below the Layer</b>	<b>Above the Layer</b>
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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<i>Personal robotics</i>	<b>CRAM:</b> <i>Cognitive Robot Abstract Machine</i>	<i>grounding in robot, AI tools, the nuts and bolts of intelligent robotics, ...</i>	<i>robot application programming</i>

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

# Agenda

1 Abstract Machine

2 CRAM Plan Executive

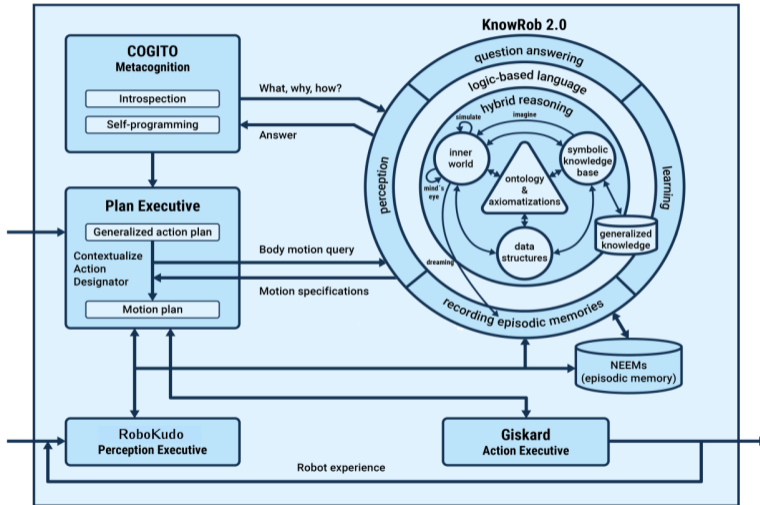
Primitives

Parameters

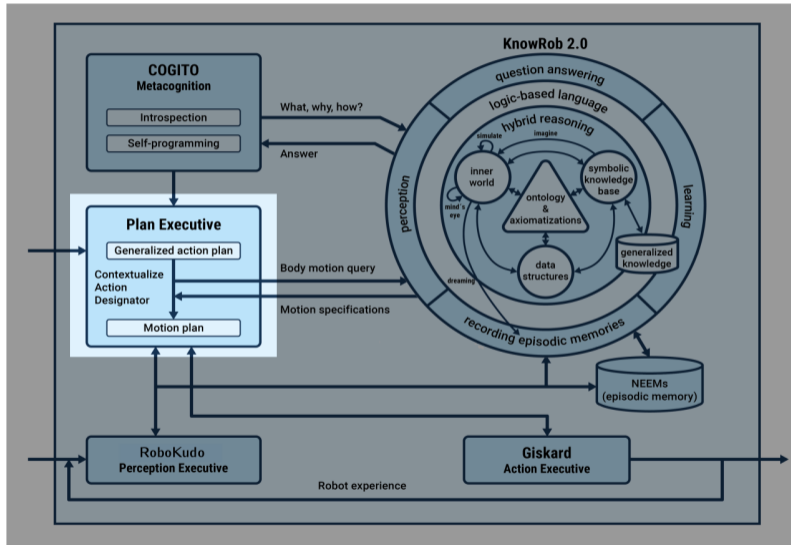
Designators

3 Tutorials

# 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: Motions and Percepts

## Primitives of Mobile Pick and Place for PR2-like Robots

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

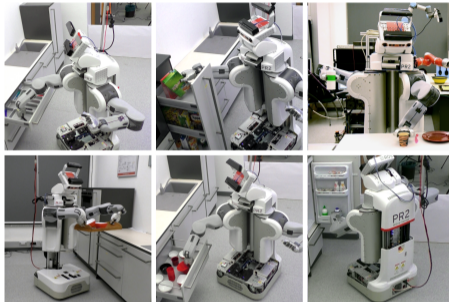
# Parameters of Motion and Perception Primitives

<b>Primitive</b>	<b>Parameters</b>
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

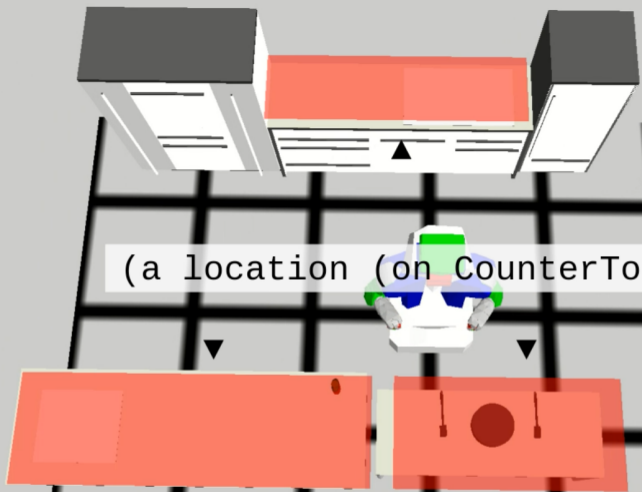


- Often very many possible values to choose from

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

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

## Designators



(a location (on CounterTop))

## Symbolic entity descriptions

### **on-counter-location:**

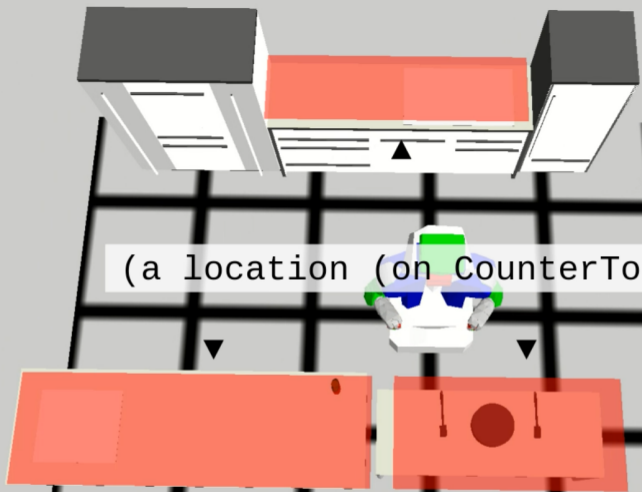
```
(a location  
  (on CounterTop))
```

### **container-object:**

```
(an object  
  (type ContainerBottle)  
  (at on-counter-location))
```

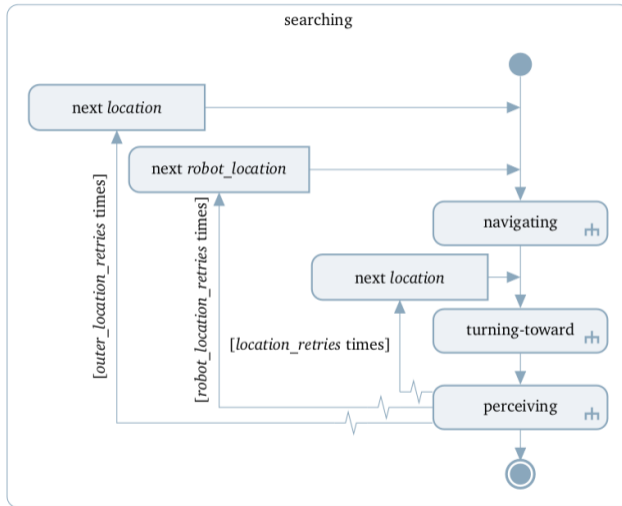
### **picking-up-action:**

```
(an action  
  (type PickingUp)  
  (theme (some stuff (type PancakeMix))  
  (object-acted-on container-object))
```



(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/>