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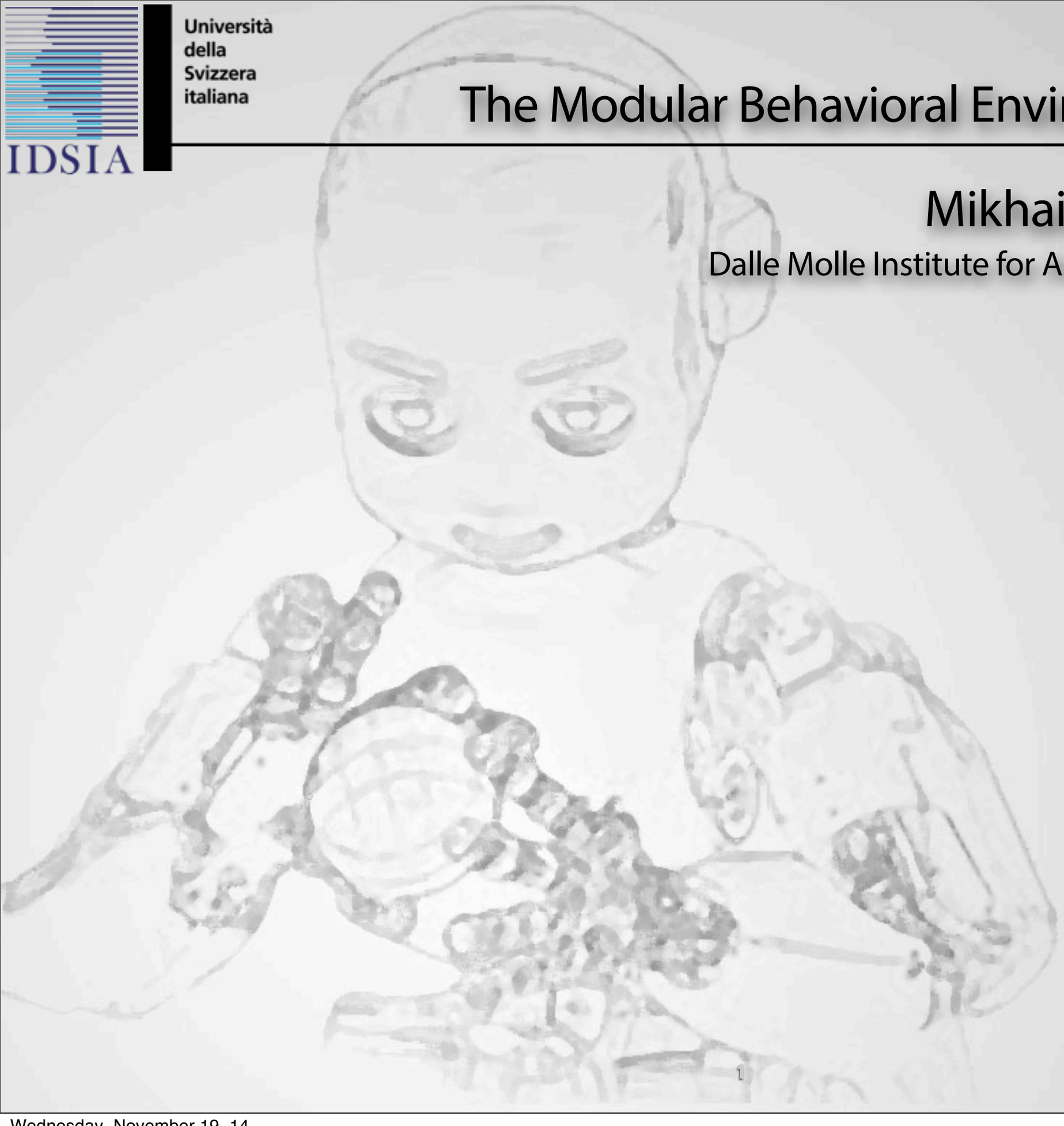
The Modular Behavioral Environment (MoBeE)

Mikhail Alexander Frank

Dalle Molle Institute for Artificial Intelligence (IDSIA)



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Planning Motions is Complex

Why is it difficult?

- Dealing with the WHOLE configuration space
- High dimensionality
- Time varying geometric, kinematic, and dynamic constraints

"We have a brain for one reason and one reason only -- and that's to produce adaptable and complex movements."

-Daniel Wolpert, Neuroscientist

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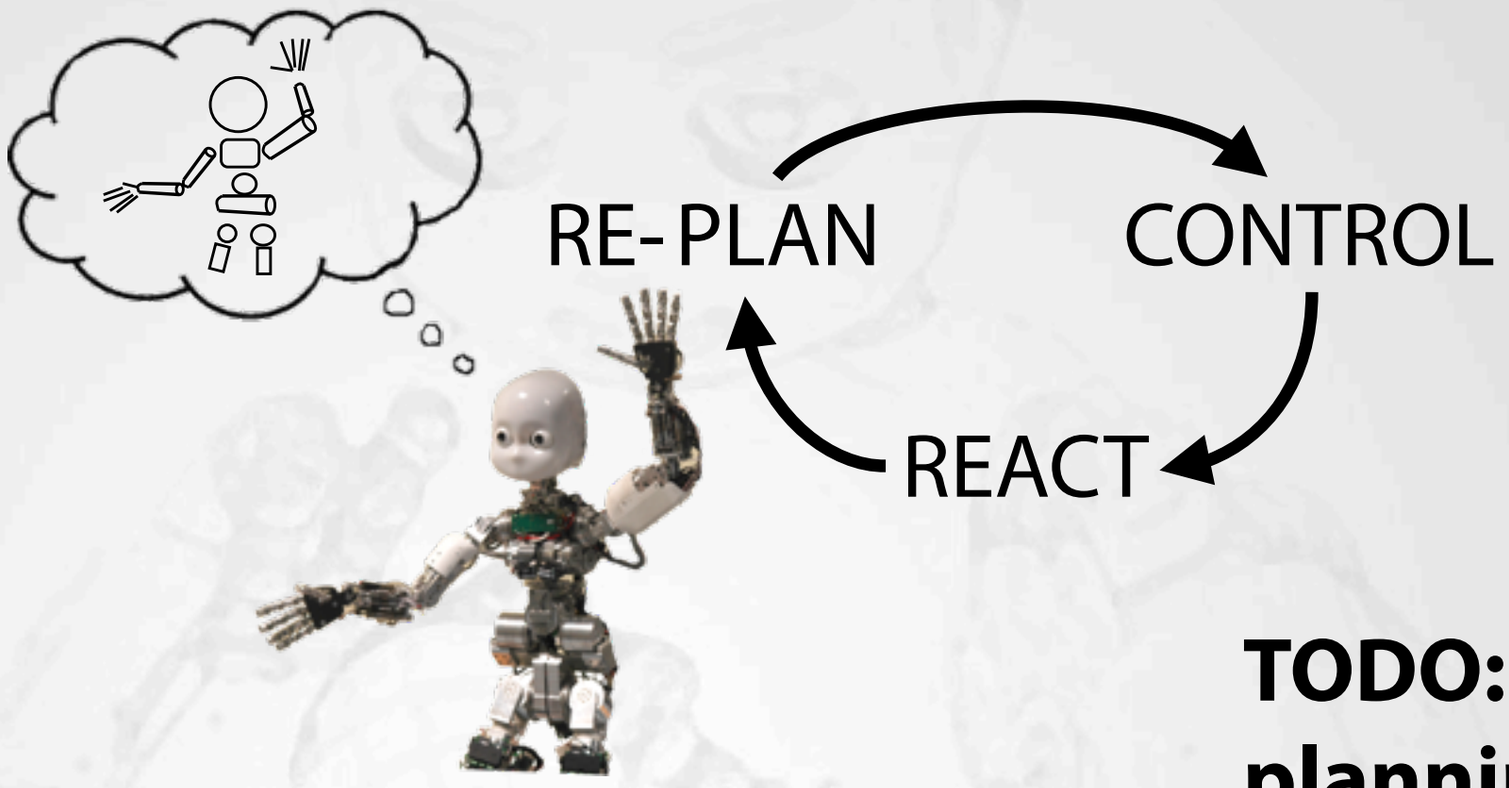
"The best laid schemes o' mice an' men...

...Gang aft agley."

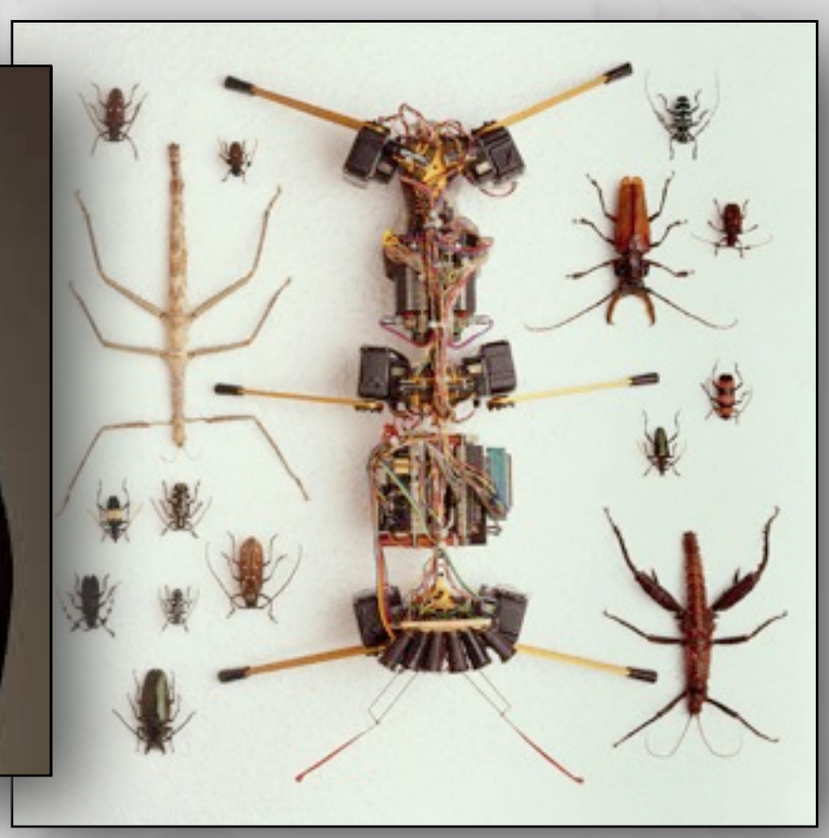
-Robert Burns 1785



TODO: Tightly integrate planning and control

1. Embody the planner
2. Safe and robust action primitives
3. Real-time re-planning

Reactive Control is Simple and Robust



Critters 1980s

- Sensors coupled directly to actuators
- Simple hard-coded control laws
- Surprising robustness in real-world environments

"Let the world be its own model."

-Rodney Brooks, Roboticist

MoBeE Contents

1. What it does

   Dynamic constraint avoidance

2. Features it offers

   Easy model reconfiguration

3. Just the model please

   Pure (offline) motion planning

Chapter 1: What MoBeE Does?

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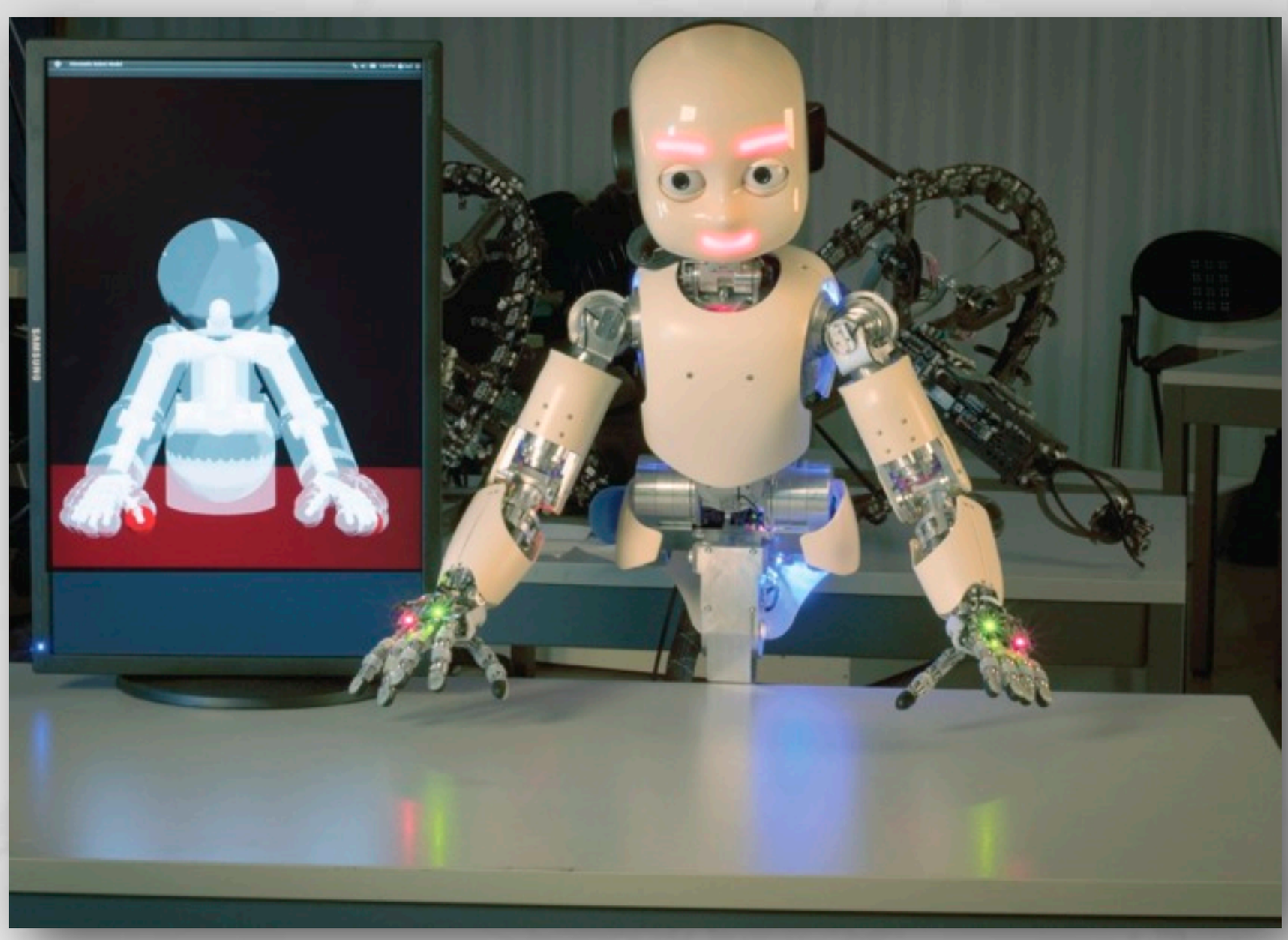
The iCub as a Distributed System



iCub YARP Ports

/icub/head/state:o
/icub/head/cmd:i
/icub/head/rpc:i

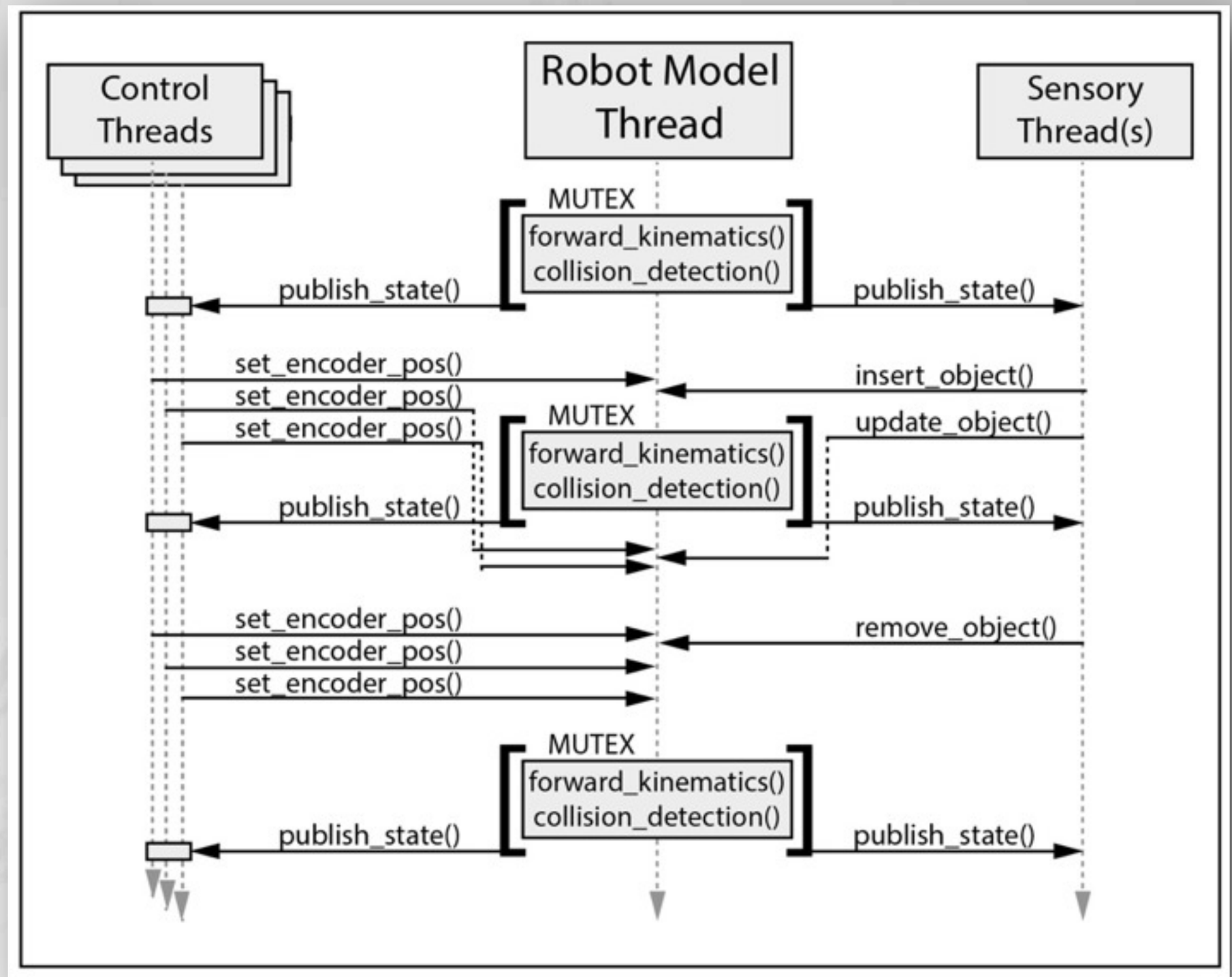
/icub/torso/state:o
/icub/torso/cmd:i
/icub/torso/rpc:i

/icub/right_arm/state:o
/icub/right_arm/cmd:i
/icub/right_arm/rpc:i

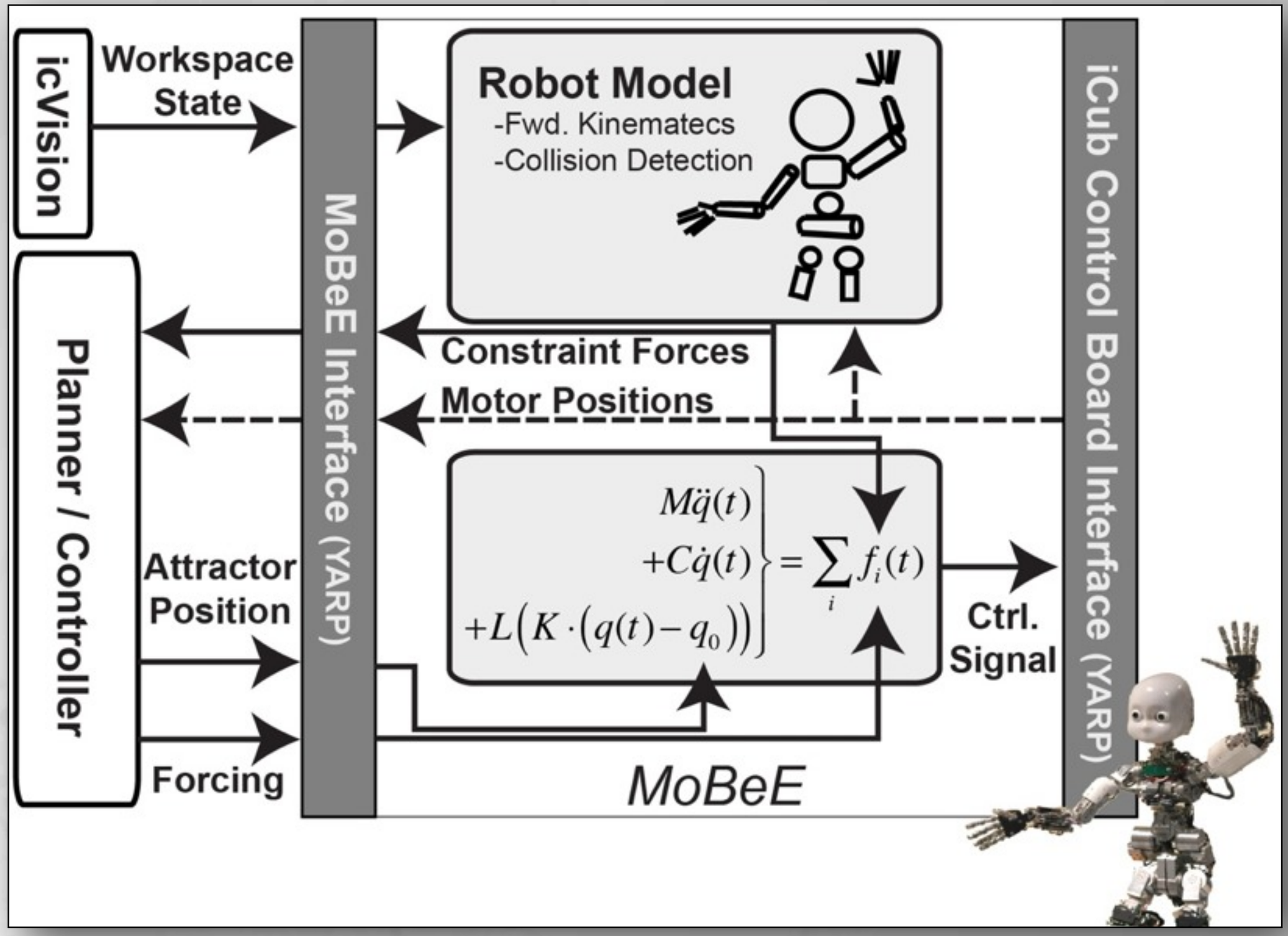
/icub/left_arm/state:o
/icub/left_arm/cmd:i
/icub/left_arm/rpc:i

/icub/cameraL
/icub/cameraR

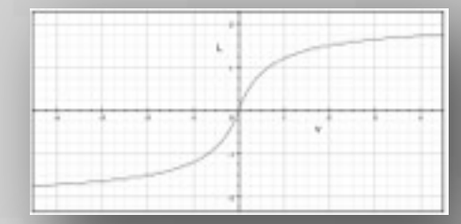
A Multi-Threaded Robot Behavior

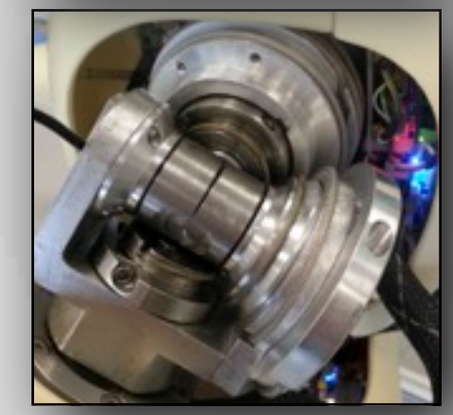


MoBeE Architecture



MoBeE Functionality





- Reactive Constraint Avoidance
  - Nonlinear forcing with Lyapunov functions
  - Avoids collisions + joint limits + cable lengths
- Access To Jacobians (Markers)
  - Pursuit/Avoidance with fictitious forces in cartesian space

$$J = \frac{\partial x}{\delta q} \rightarrow \dot{q} = J_{q*}^{-1}\dot{x}$$

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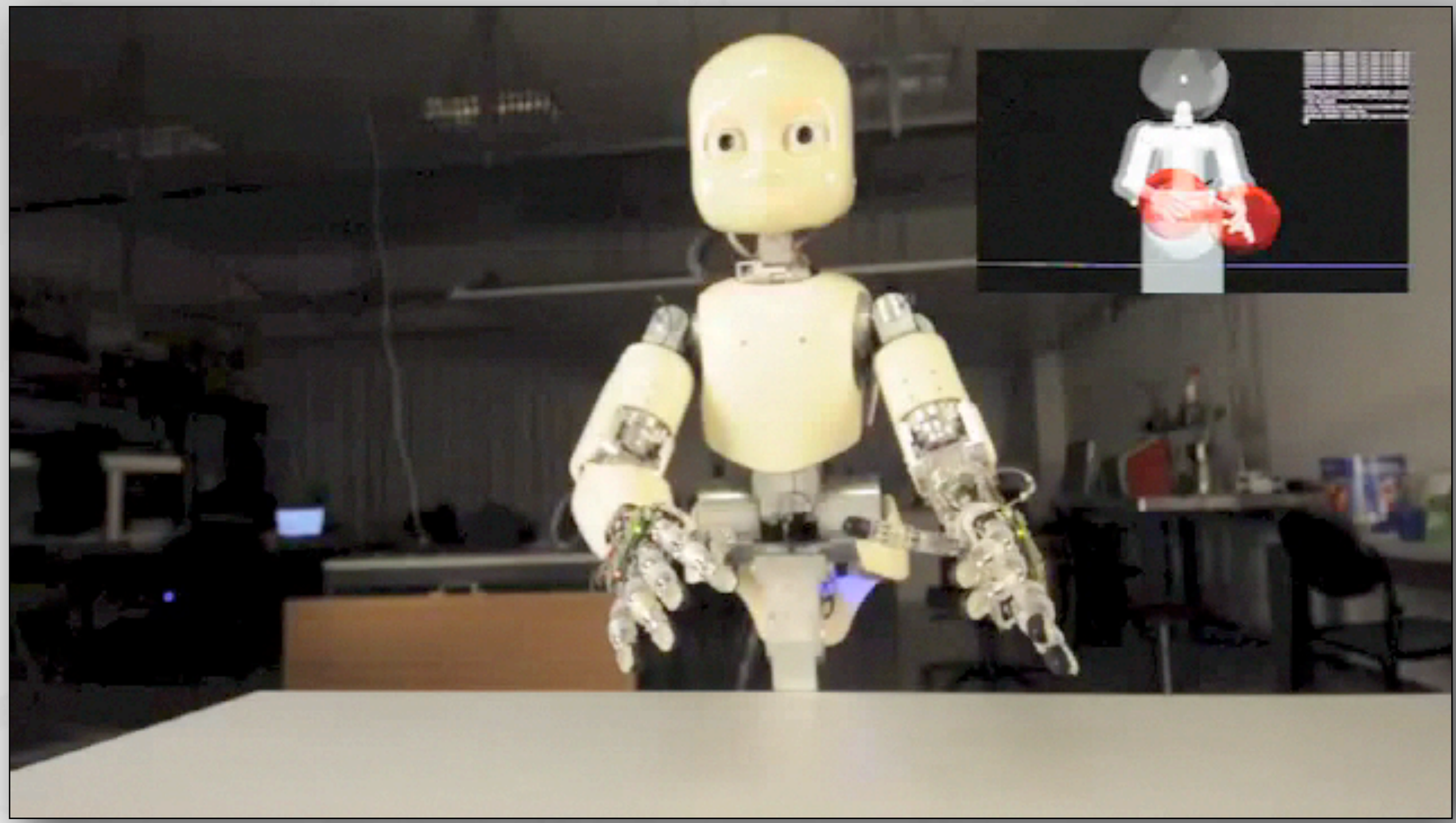
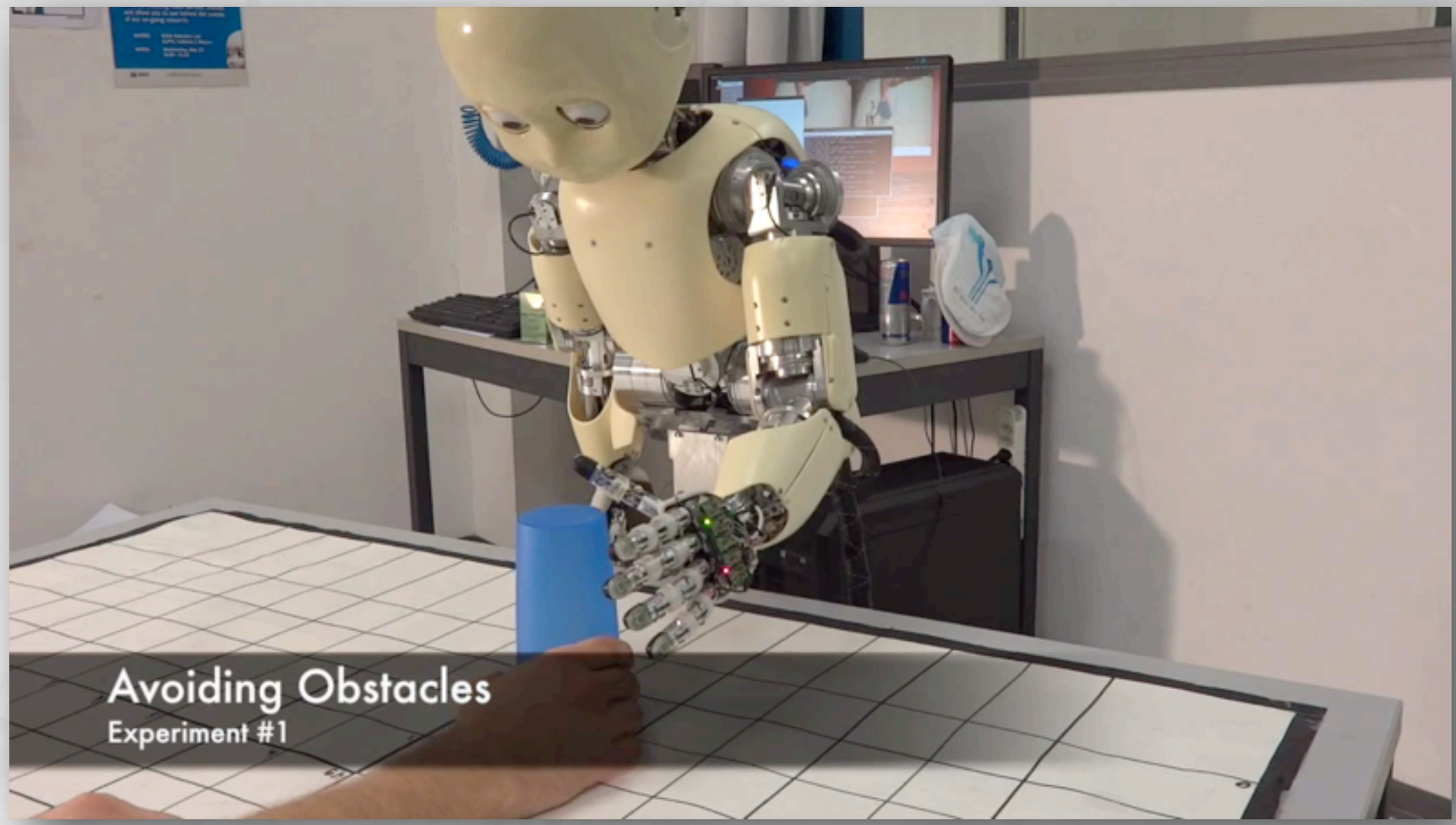
MoBeE Demo



Reactive Reaching



http://juxi.net/media/

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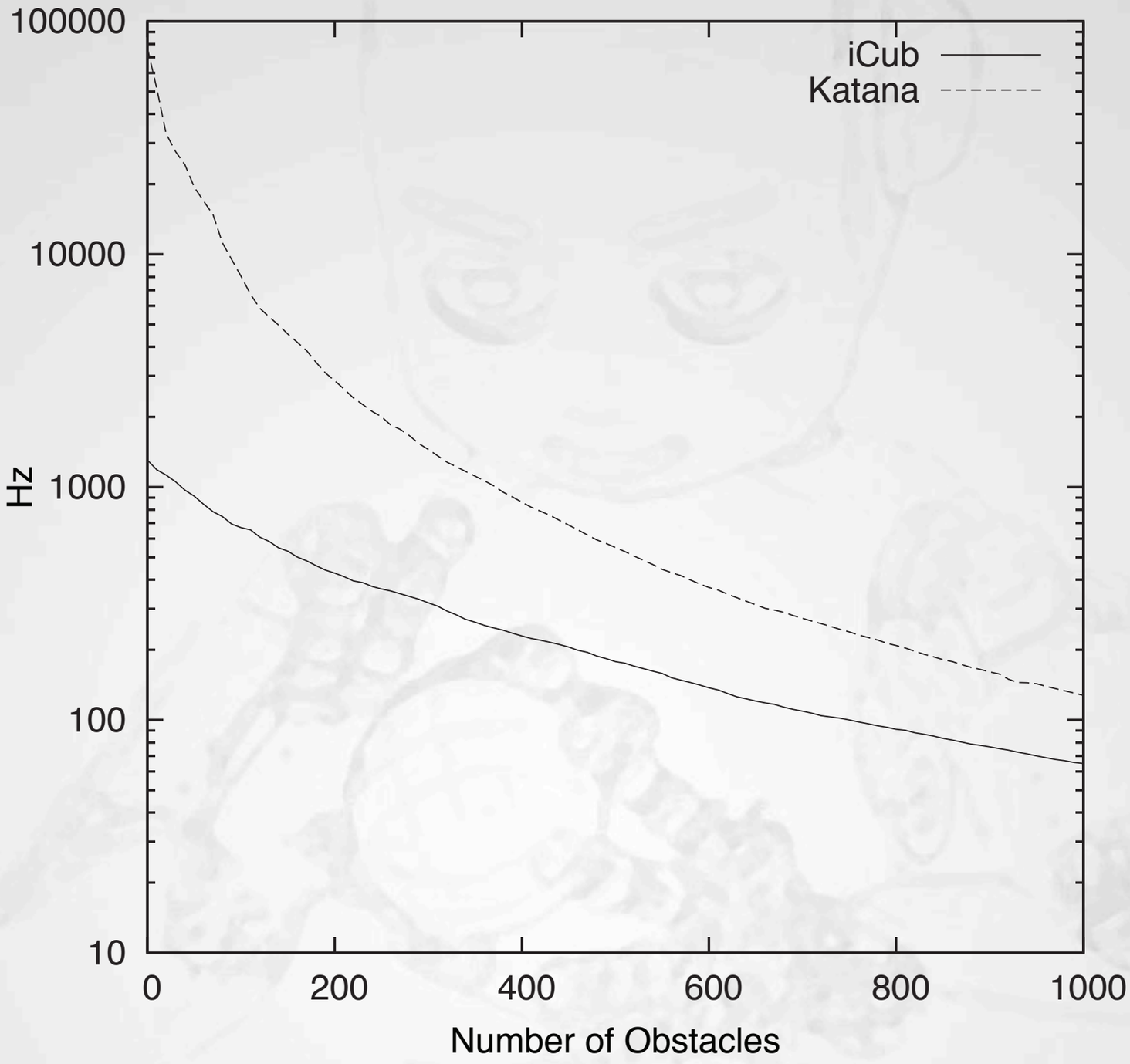
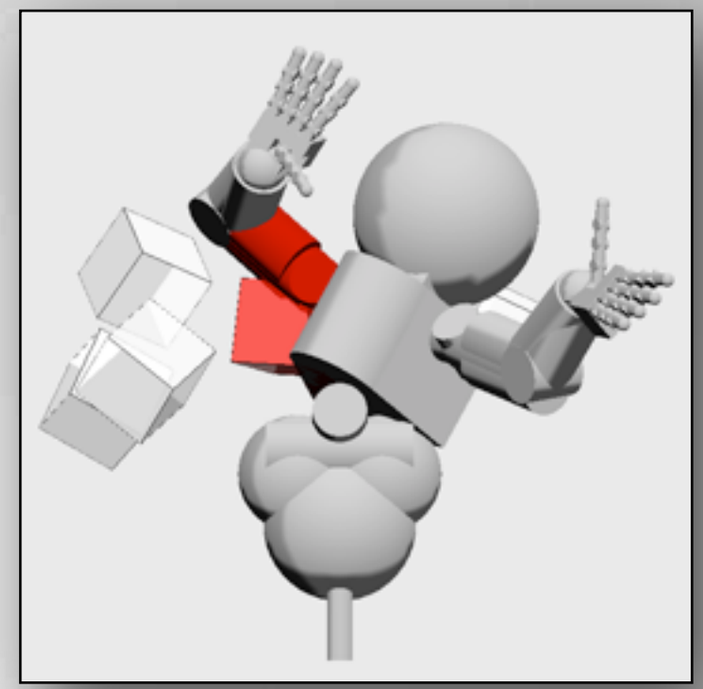
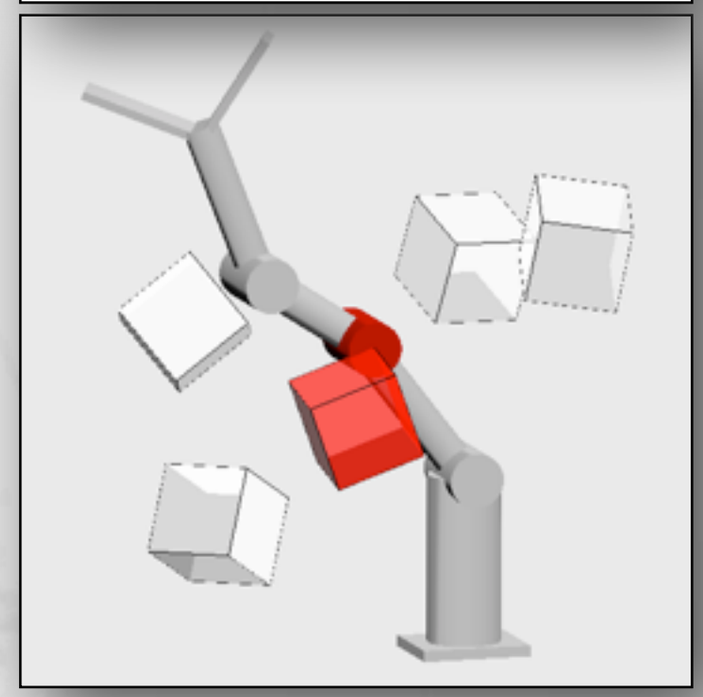
MoBeE Performance







Conclusions - What it Does

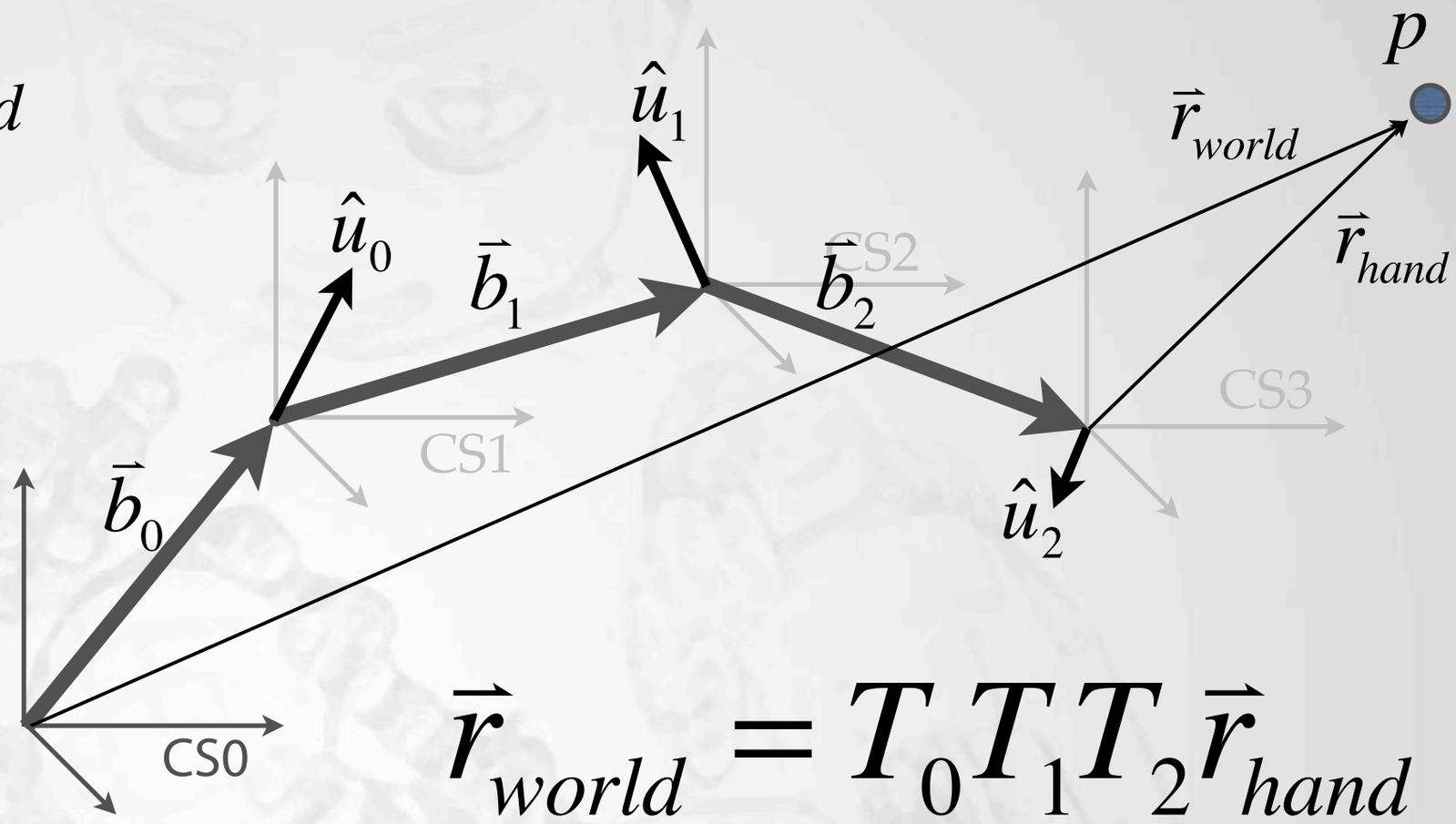
1. Provides Simplicity + Robustness
2. Allows the iCub to be its own dynamic model
3. Implements Reactive Constraint Avoidance

Chapter 2: Features

Zero Position Kinematics

Given: $\vec{q}, \vec{r}_{hand}$

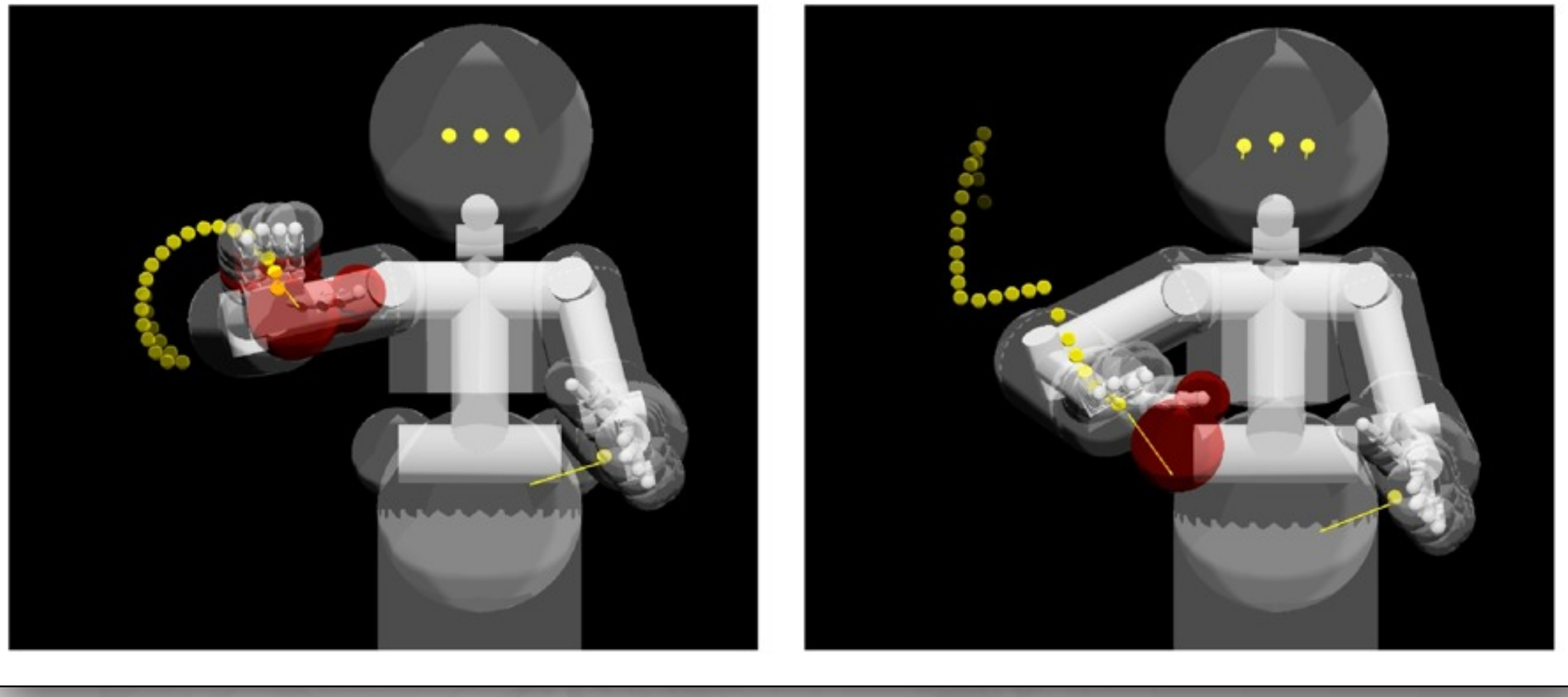
Find: $\vec{r}_{world}$



$$\vec{r}_{world} = T_0 T_1 T_2 \vec{r}_{hand}$$

Kinematic analysis of manipulators using the zero reference position description - Gupta,K.C. (1986)

Markers



RPC Interface

1. Add/Remove/Update Workspace Objects
2. Switch objects between obstacle/target
3. Query Markers for position/orientation/ Jacobian
4. Synchronization with iCub_SIM world
5. Attach objects to markers

Conclusions - Features

1. Easy Re-modeling
   - Zero Position Kinematics
   - XML Robot Model
2. Realtime Interaction with World Model
   - RPC Interface
   - Markers

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Chapter 3: Just The Model Please

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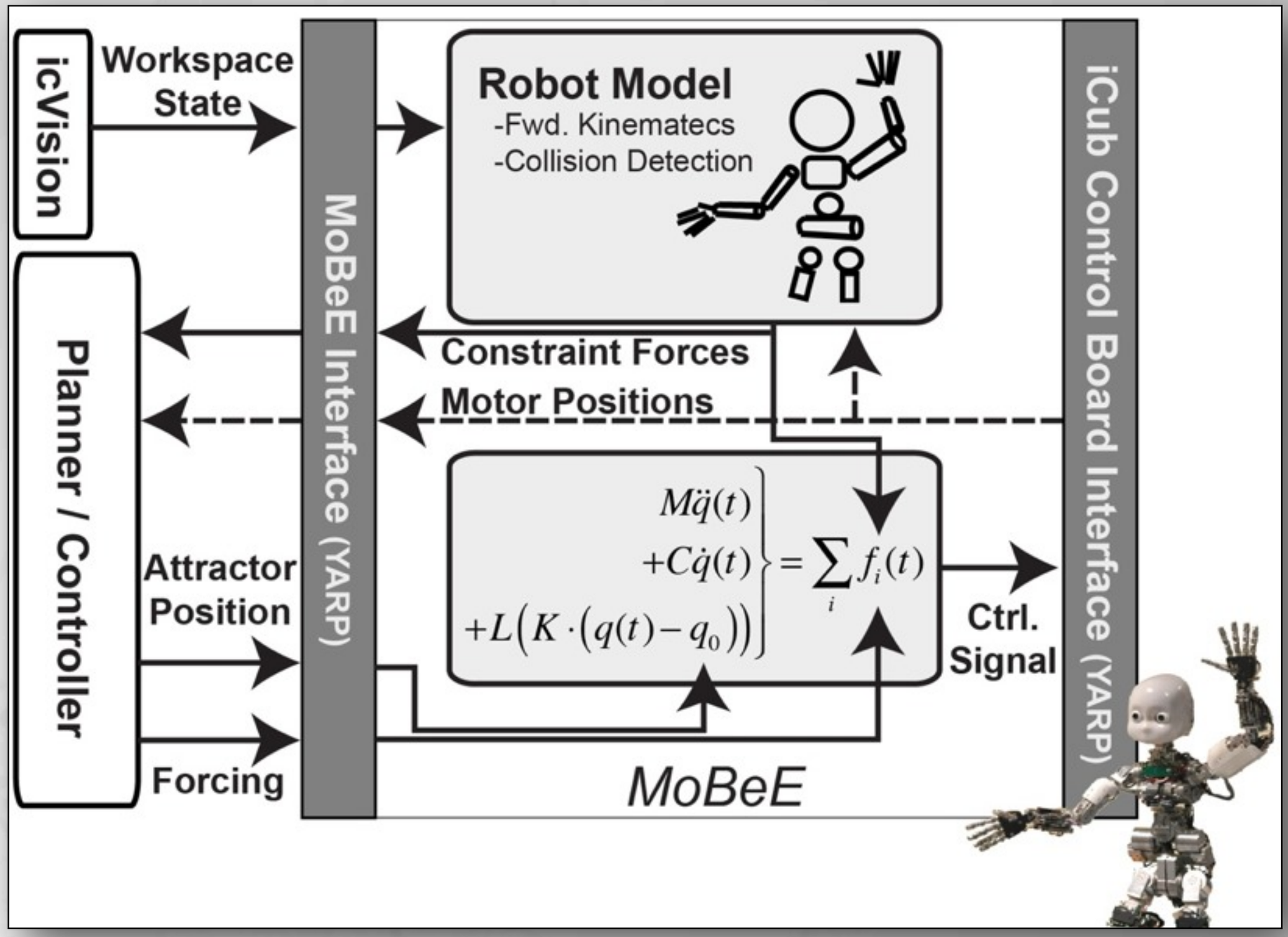
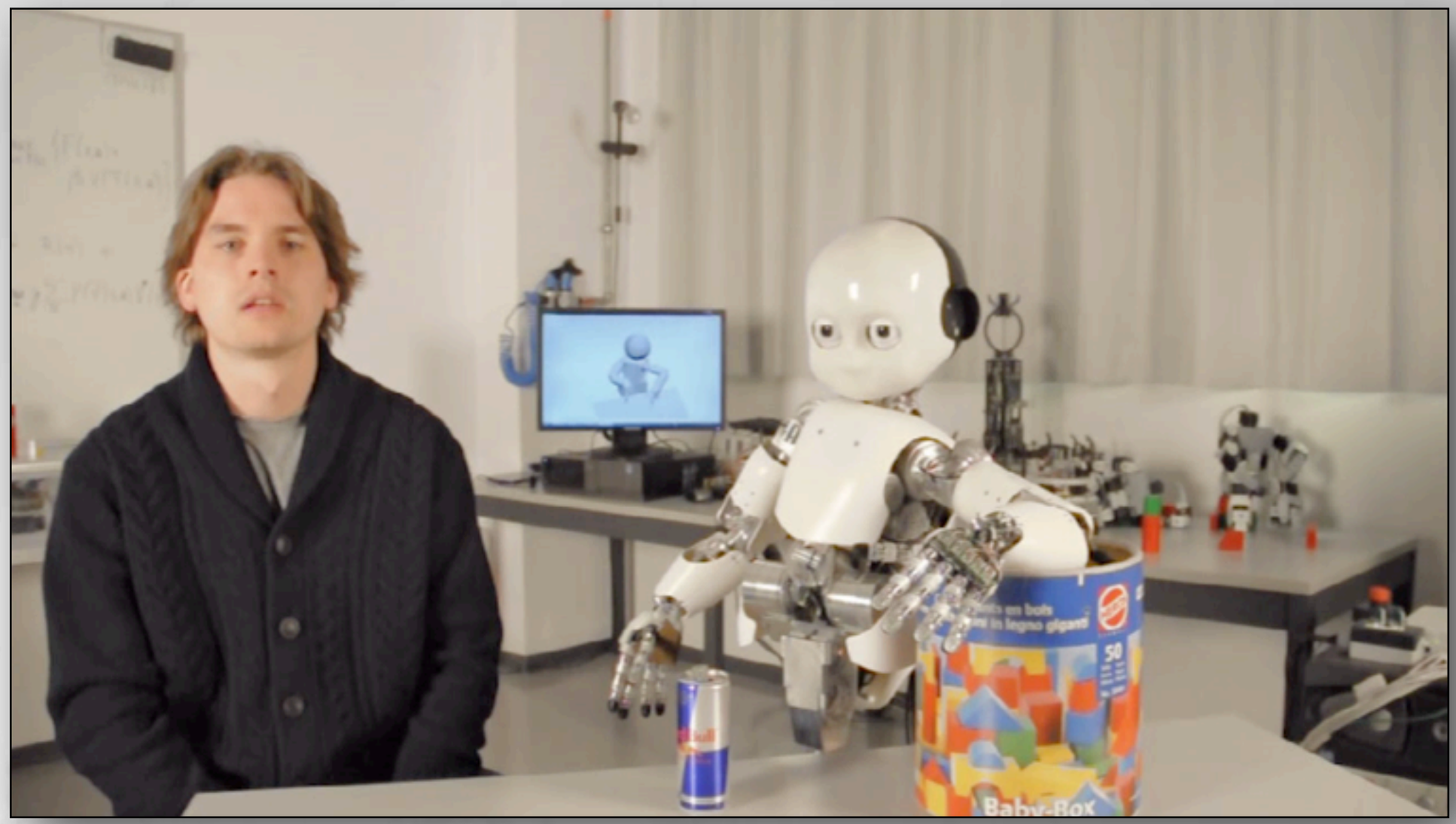
MoBeE Architecture

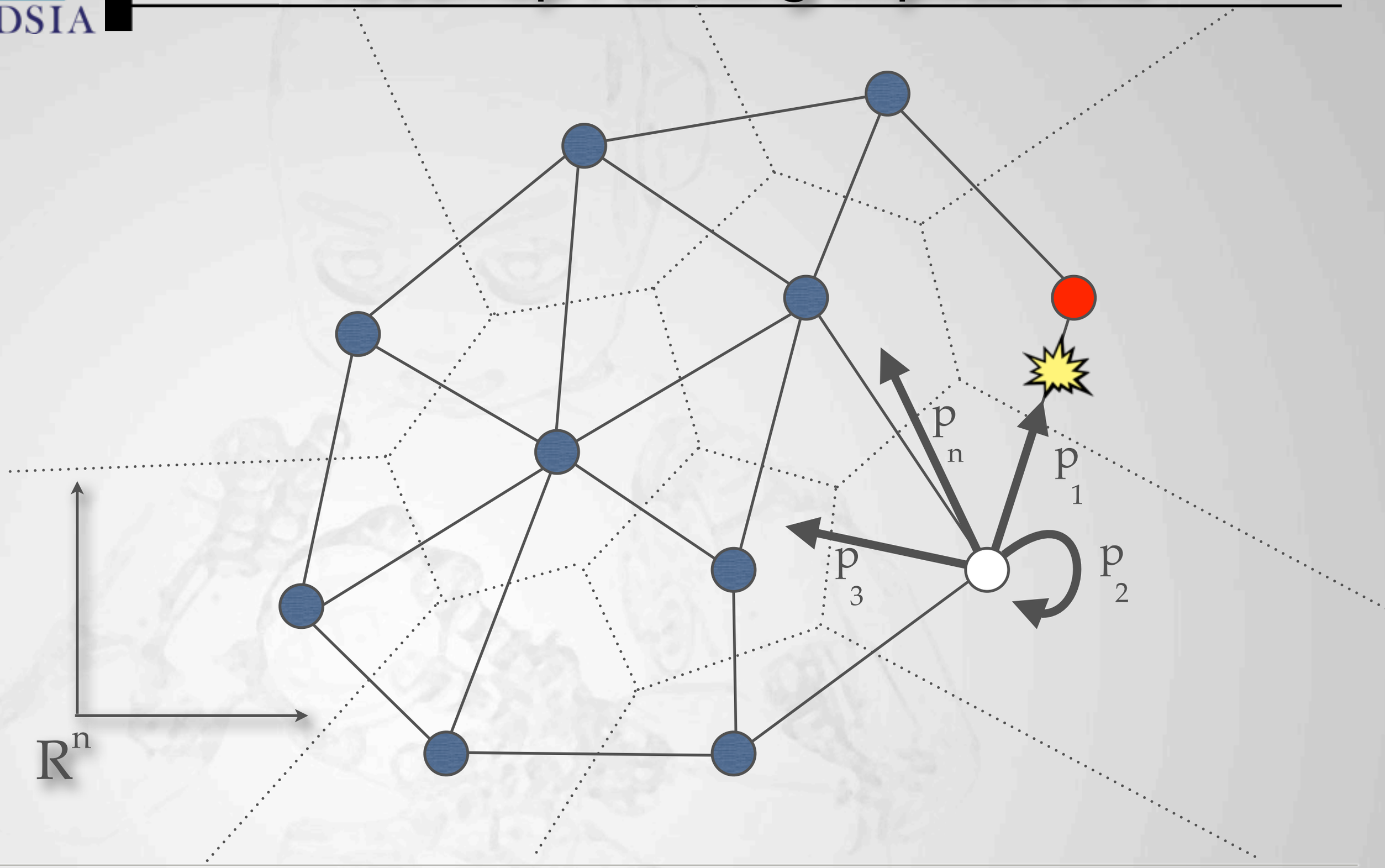


Task Relevant Roadmaps



https://www.youtube.com/watch?v=N6x2e1Zf_yg

Roadmap Planning Implications



MoBeE Summary

1. What it does

   Dynamic constraint avoidance

   Efficient/convenient search for poses

2. Features it offers

   Easy model reconfiguration

Thank You!

Alexander Förster
Juxi Leitner
Leo Pape
Marijn Stollenga

https://github.com/kailfrank/MoBeE