BAXTER


UHCL
ROBOTICS

University of Houston Clear Lake

# Baxter the friendly robot: Applications, architecture, and features

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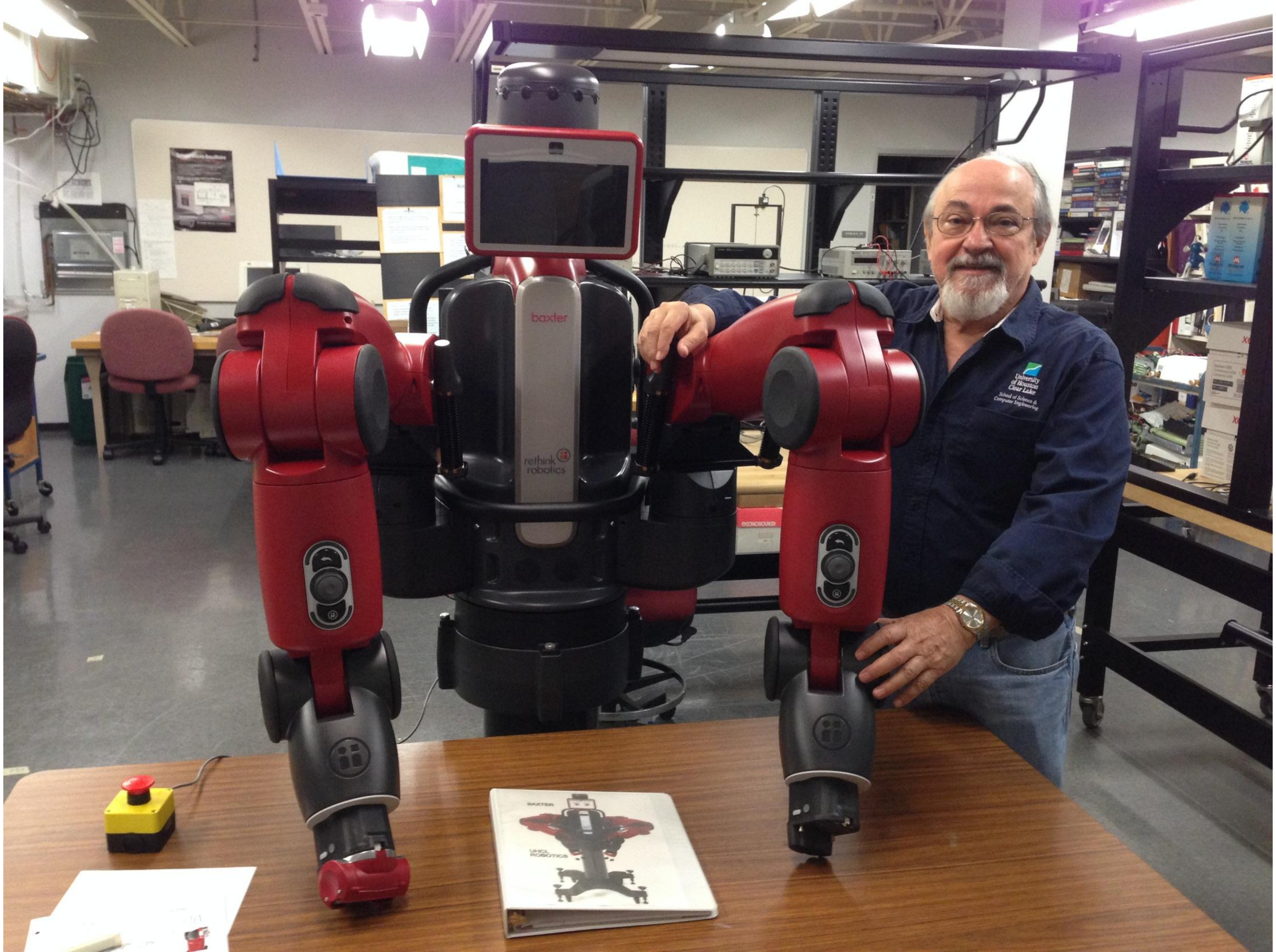
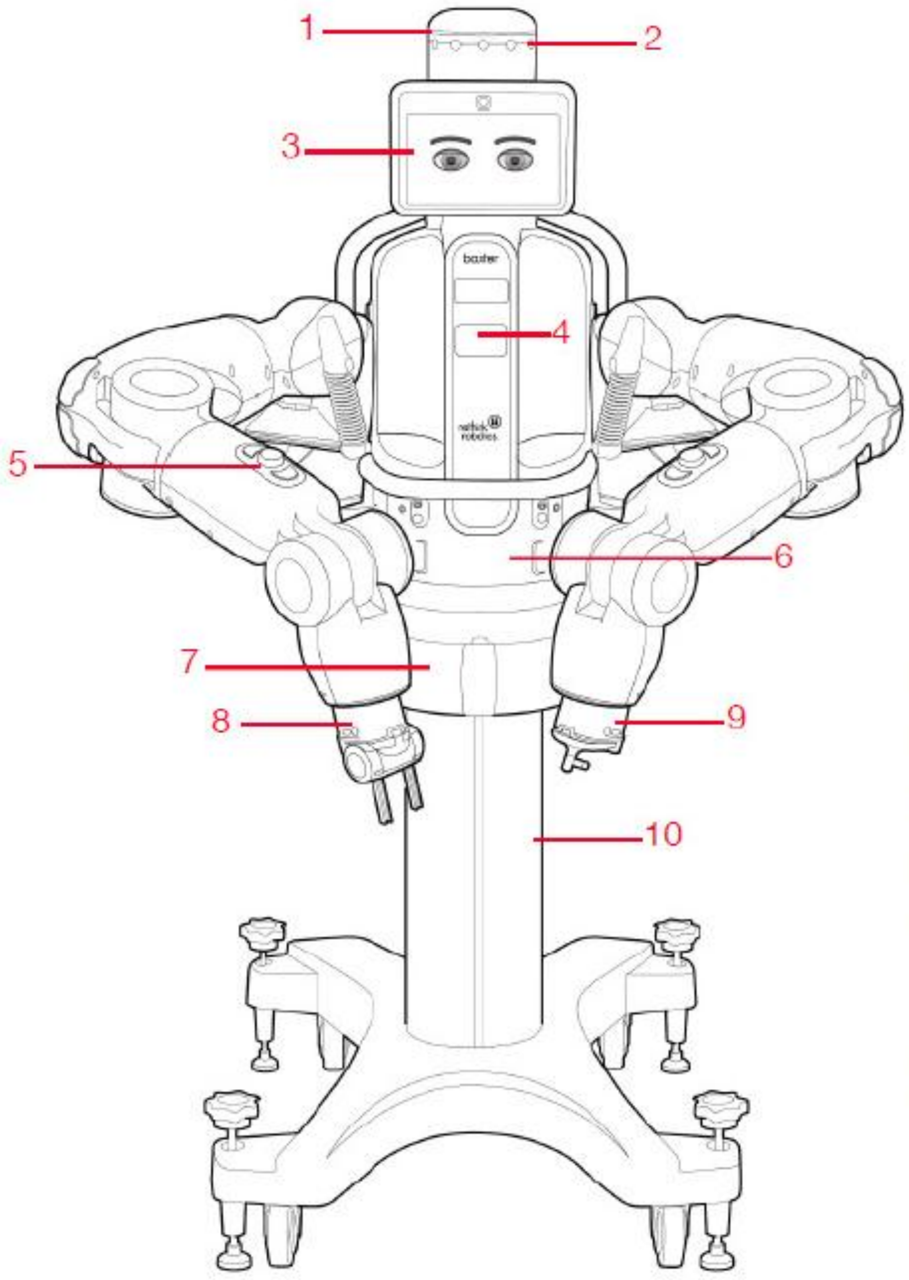
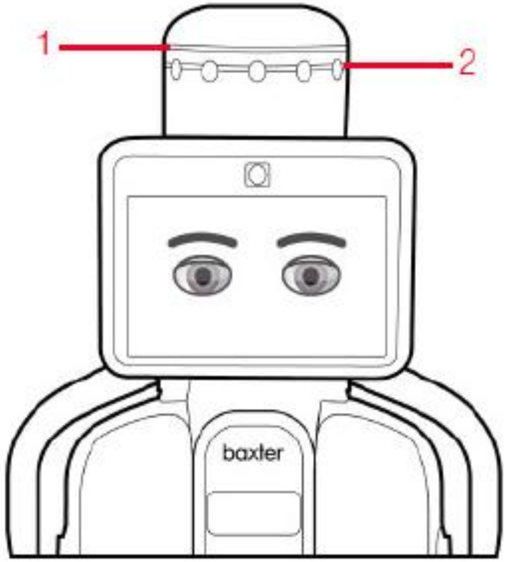
University of Houston Clear Lake


baxter


baxter
rethink robotics
BAXTER
UHCL ROBOTICS


RODNEY BROOKS
Image: © Boston Business Journal/W. Marc Bernsau




1. Condition ring
2. Attention ring
3. Display
4. Work lights
5. Navigator
6. Lower front panel
7. Waist
8. Training cuff with parallel gripper
9. Training cuff with vacuum gripper
10. Pedestal

Miscellaneous Specifications

Screen Resolution 1024 x 600 pixels

Positional Accuracy +/- 5 mm

Max Payload (including end-effector) 5 lb / 2.2 kg

Gripping Torque (max) 10 lb / 4.4 kg

Infrared Sensor Range 1.5 – 15 in / 4 – 40 cm

Standard 120VAC power. Robot power bus and internal PC both have “universal” power supplies and support 90 - 264V AC (47 - 63Hz)

6A at 120V AC, 720W max per unit

# COMPUTER INSIDE

| | |
|---|---|
| Processor | 3rd Gen Intel Core i7-3770 Processor (8MB, 3.4GHz) w/HD4000 Graphics |
| Memory | 4GB, NON-ECC, 1600MHZ DDR3 |
| Hard Drive | 128GB Solid State Drive |


A FACE TO LOVE
MANUFACTURING VERSION OF BAXTER

# A FACE TO USE

## A ROBOT'S EMOTIONS

Brooks didn't set out to build a humanoid robot, but he found that giving Baxter a face was the most intuitive way to communicate information.

**NEUTRAL**
Ready for training

**ASLEEP**
On standby

**CONCENTRATING**
Learning a task

**FOCUSED**
Working away without a problem

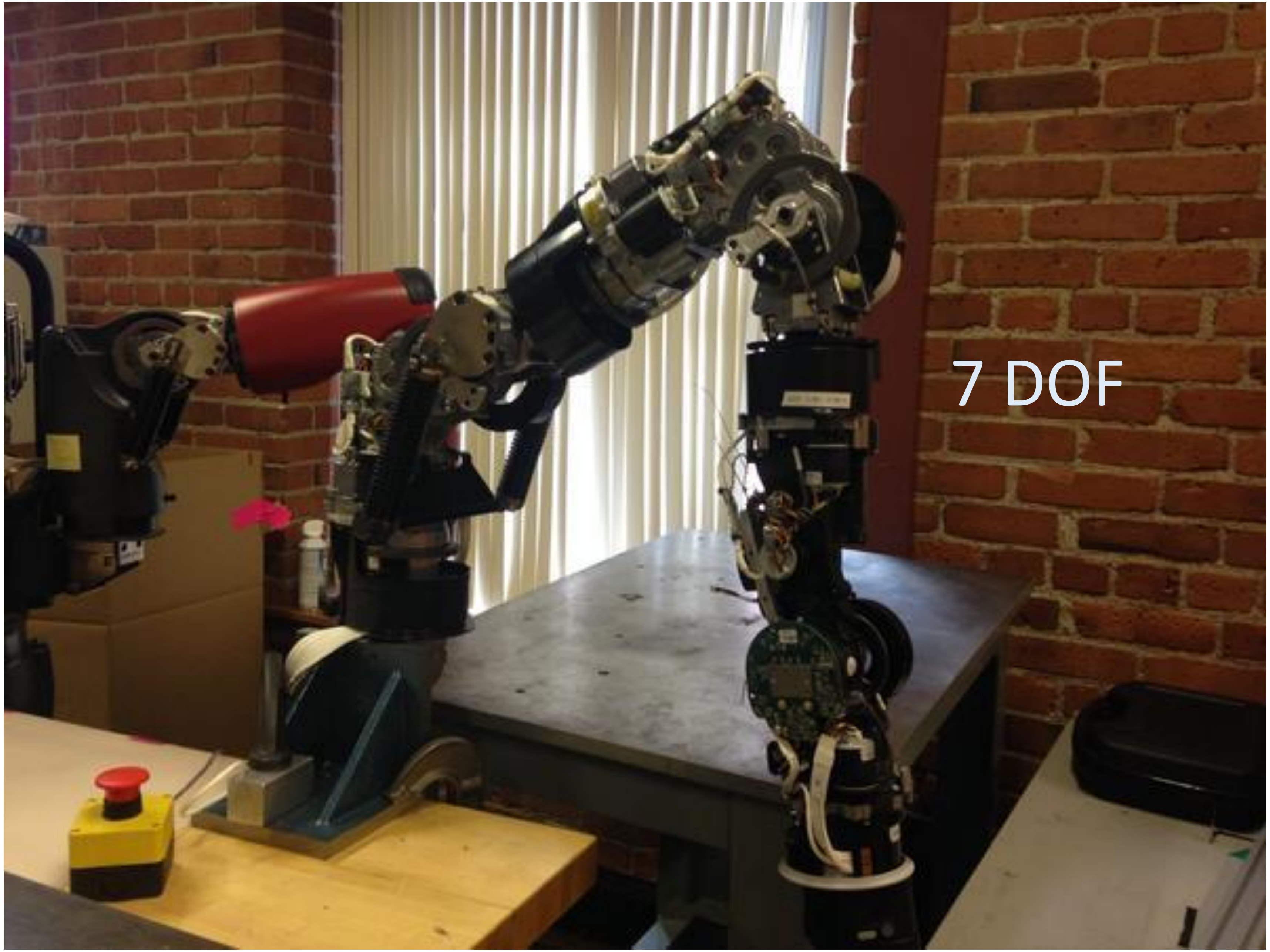
**SURPRISED**
A human has approached

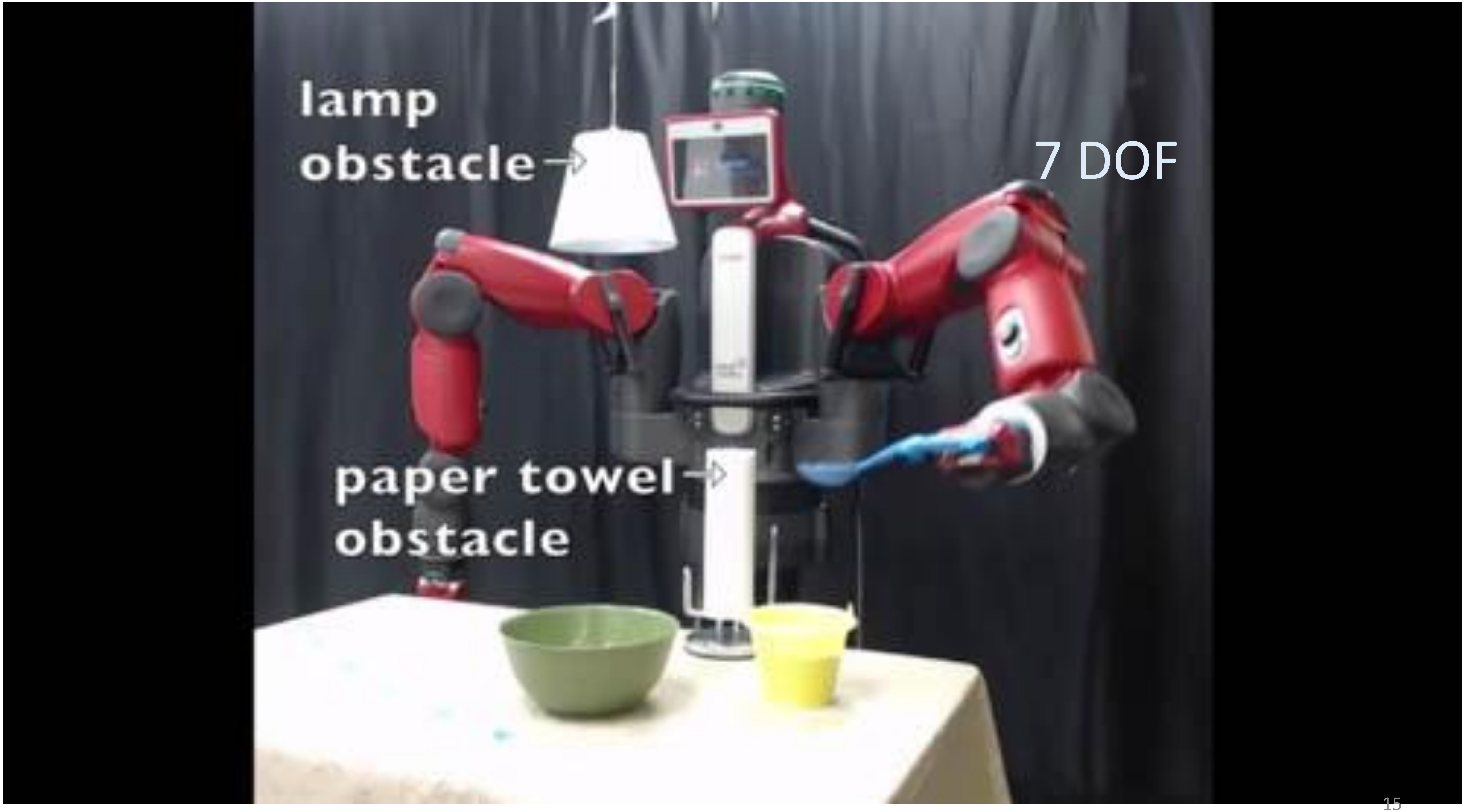
**CONFUSED**
Having trouble finding an object or otherwise completing a task

**SAD**
Given up trying to complete a task; there's a problem


TRAINING NOT
PROGRAMMING

# PICK AND PLACE


7 DOF


lamp
obstacle
7 DOF
paper towel
obstacle

# APPLICATIONS OF RESEARCH BAXTER

# Human-Robot Interaction-

Quadriplegic using Baxter and electric wheelchair

David Using Jammster

Baxter does Magic

Magic Robot - The Illusion of the Thinking Machine

Baxter On Wheels

Baxter on wheels retrieving jacket

SEE **Rethink Robotics WEB site**

Baxter Kinects

[Baxter Robot control using body tracking with Kinect]

Baxter Dresses Someone

[Clothing and Unclothing Assistance by Baxter]

# Planning and Manipulation

- Baxter Coordinated Dual-Arm Force Control
- Baxter Research Robot Solves Rubik's Cube

- Teaching with Gestures
- Baxter Research Robot: Mimicry using Kinect
- Online human upper body imitation using BAXTER robot

# Manipulation and Mechatronics

Baxter Recognizes bicycle tires (soft objects)

- Optimal Parameter Identification of Flexible Objects via Manipulation

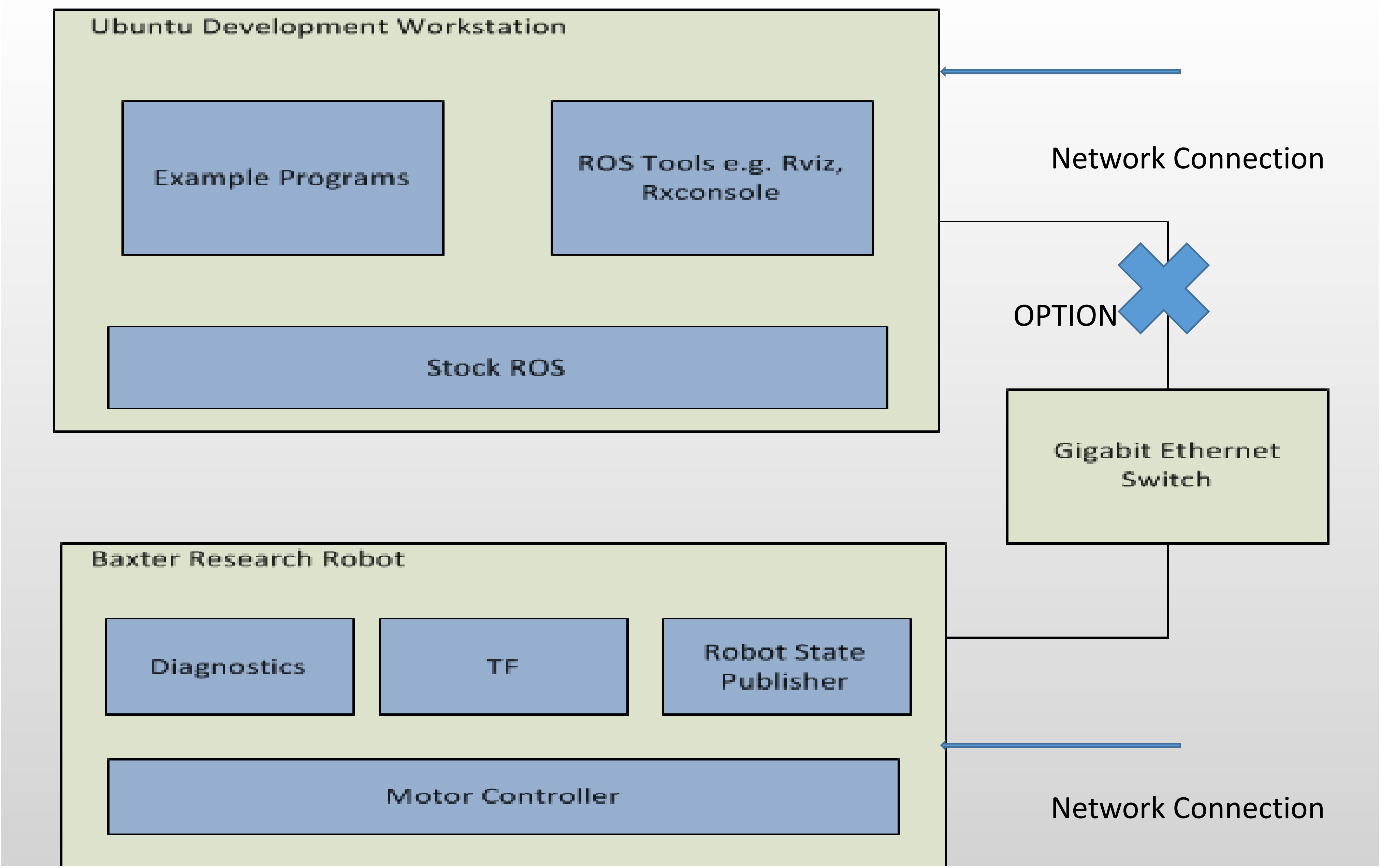
- Teleoperating Multiple Baxter Robots Using Kinect v2 Dan Kruse

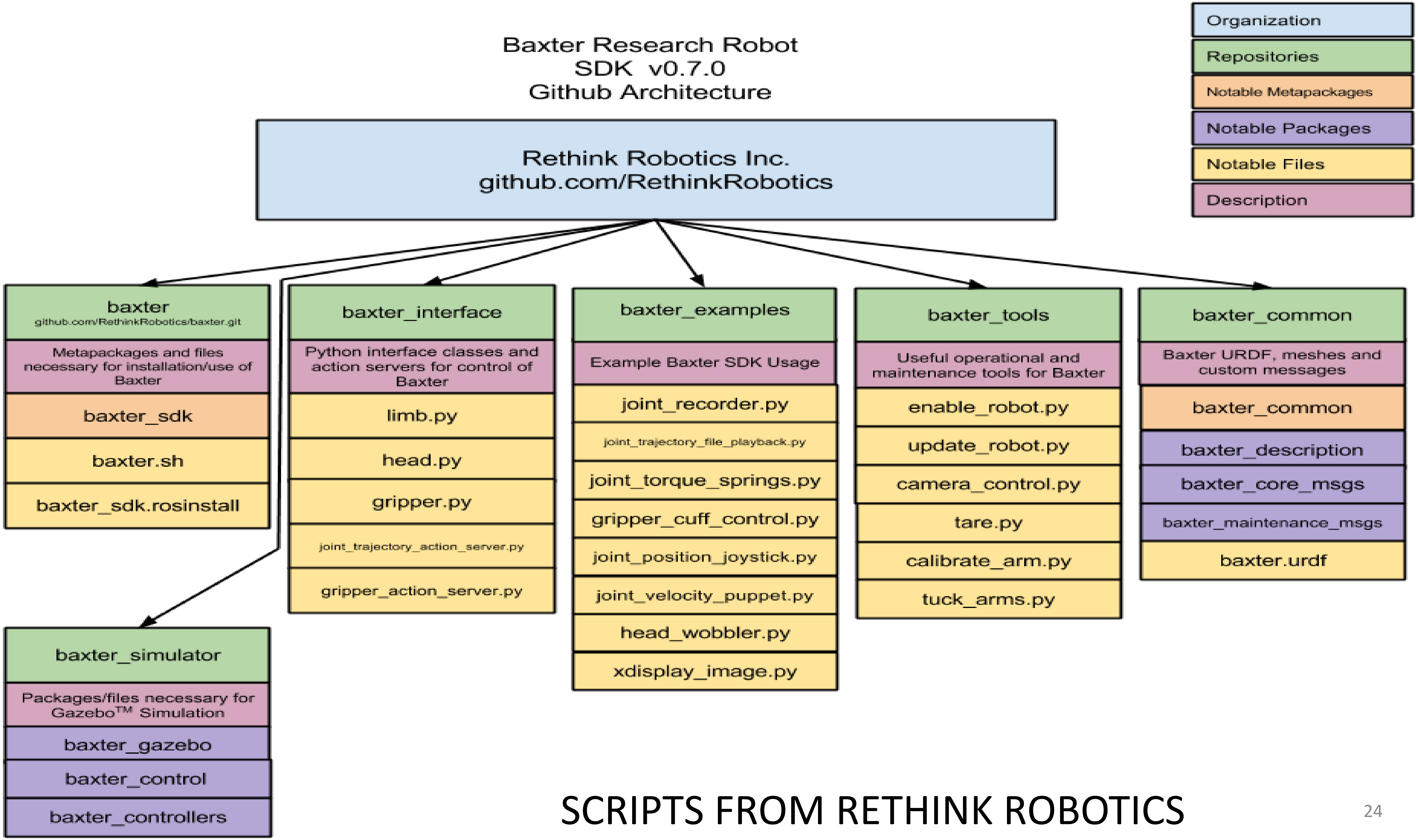
# Computer Vision - Baxter Knows Colors

- Happy Easter from the RRC Robotics and Automation Team - Sort the Easter Eggs
- Automated Lego Sorting
- Automated Checked Baggage Inspection System
- BAXTER Sort Colored Balls - Author's View Brandon Boyce

# Programming Research Baxter

1. UBUNTU OPERATION SYSTEM
2. ROBOT OPERATING SYSTEM - ROS
3. PYTHON SCRIPTS
4. BAXTER API SCRIPTS
5. OUR OWN SCRIPTS
6. SIMULATORS


Ubuntu Development Workstation
Example Programs
ROS Tools e.g. Rviz, Rxconsole
Stock ROS
Network Connection
OPTION
Gigabit Ethernet Switch
Baxter Research Robot
Diagnostics
TF
Robot State Publisher
Motor Controller
Network Connection




# SCRIPTS FROM RETHINK ROBOTICS

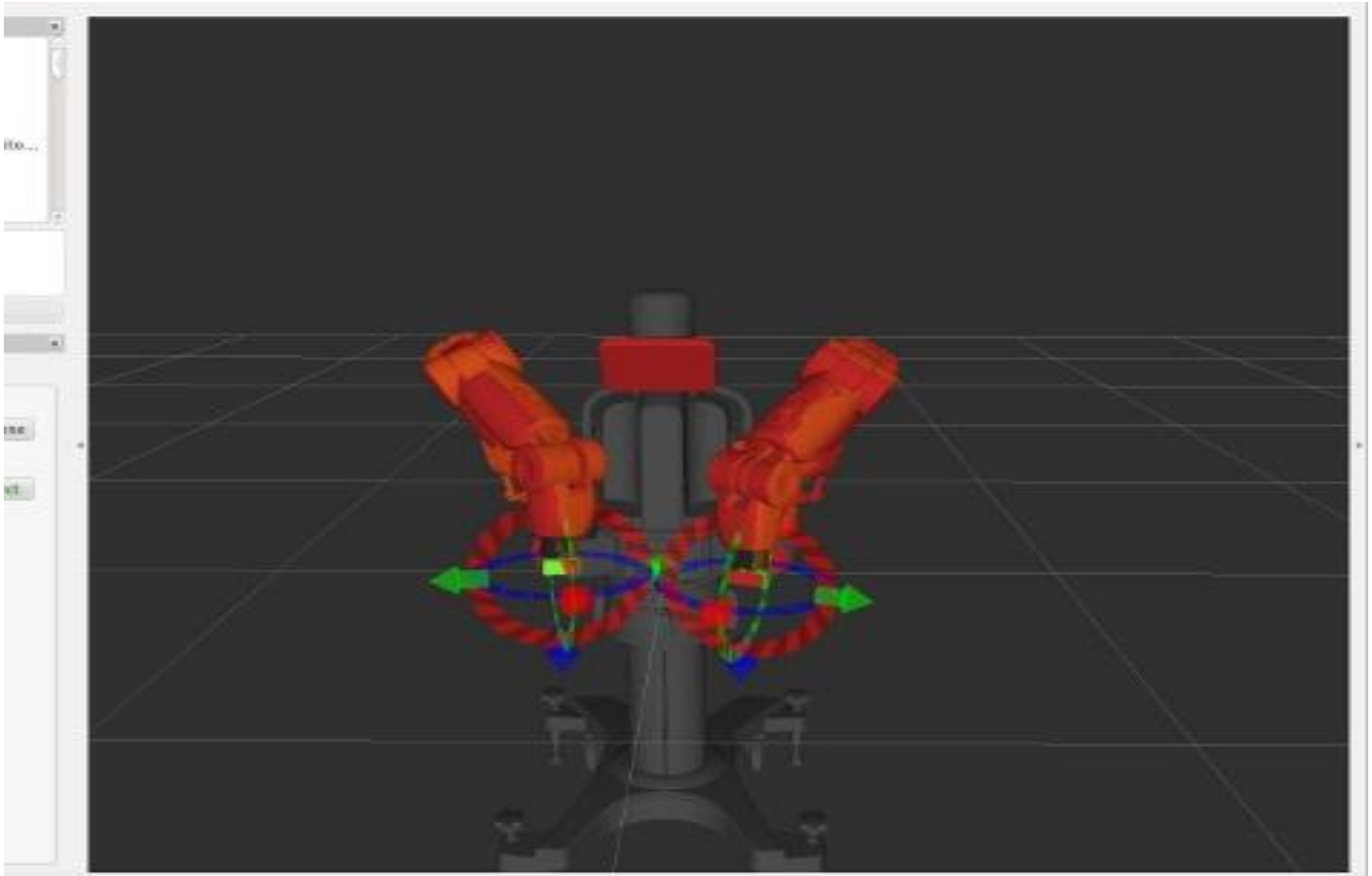
# SIMULATION

- MOVE IT
- GAZEBO

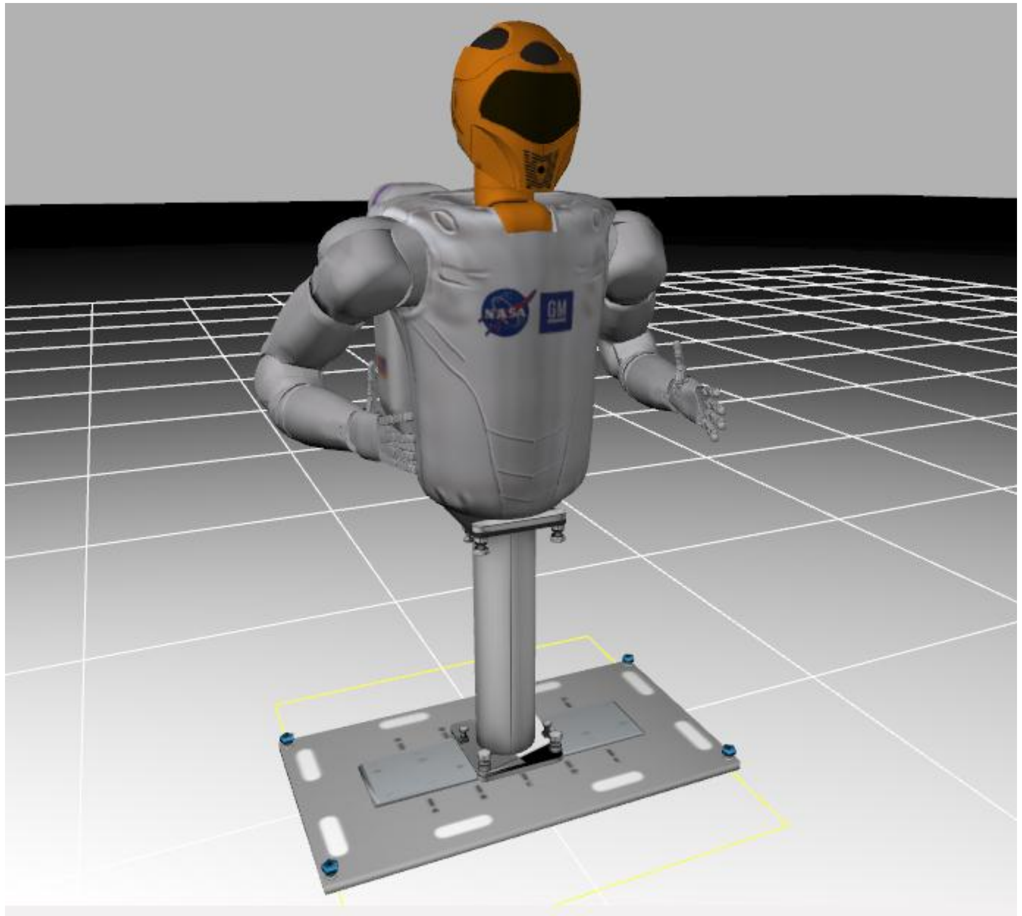
THESE USE THE URDF FORMAT

TO DESCRIBE THE ROBOTS

# MOVE IT   MOTION PLANNING FOR BAXTER



# SIMULATORS, ROBONAUT AND BAXTER

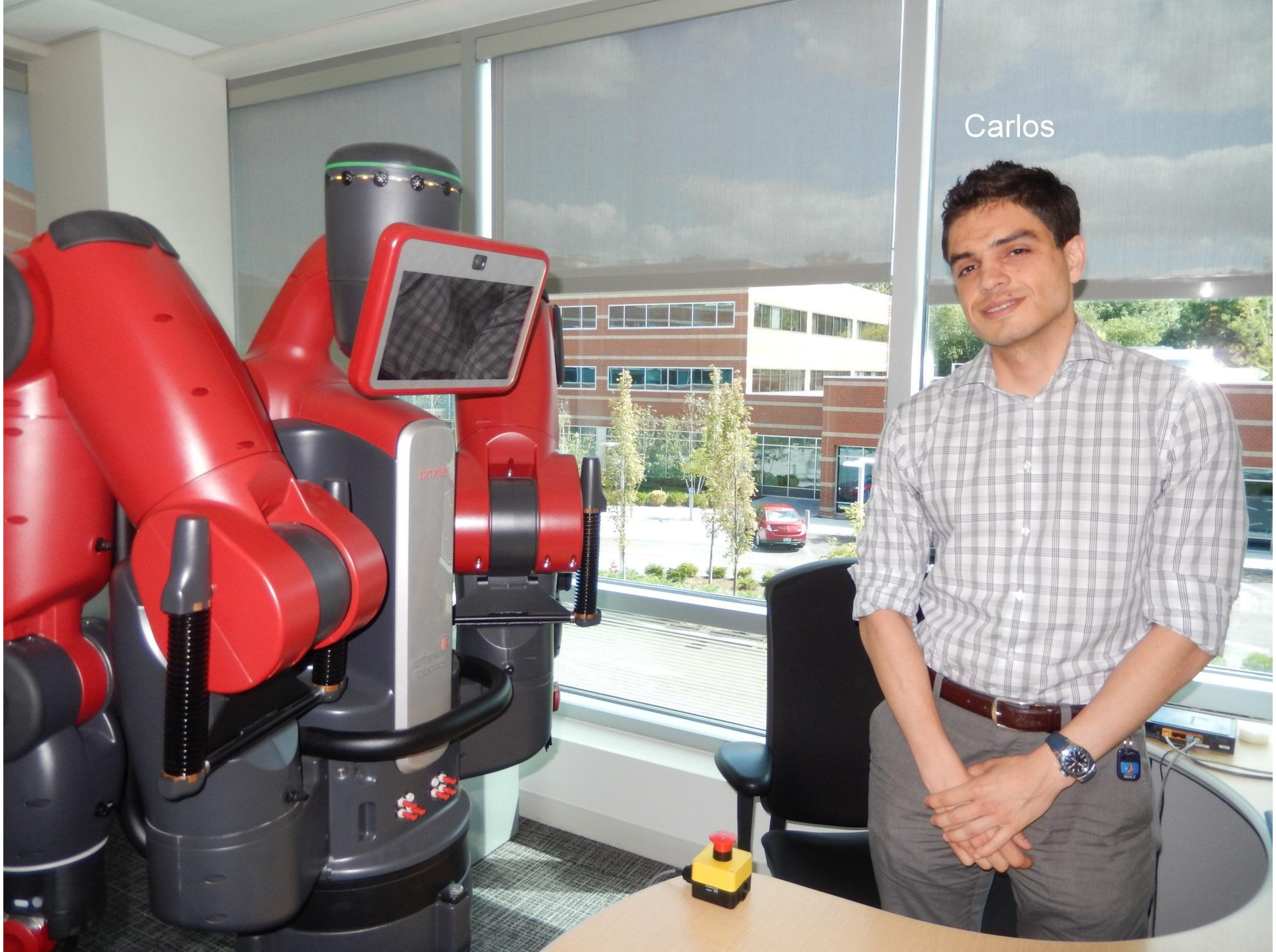

http://wiki.ros.org/Robots/Robonaut2

GAZEBO SIMULATOR

Universal Robotic Description Format (***URDF***) is an XML file format used in ROS to describe all elements of a robot.

```
robot name is: baxter
---------- Successfully Parsed XML ---------------
root Link: base has 3 child(ren)
    child(1):  collision_head_link_1
    child(2):  collision_head_link_2
    child(3):  torso
        child(1):  head
            child(1):  dummyhead1
            child(2):  head_camera
            child(3):  screen
                child(1):  display
        child(2):  left_arm_mount
            child(1):  left_upper_shoulder
                child(1):  left_lower_shoulder
                    child(1):  left_upper_elbow
                        child(1):  left_lower_elbow
                            child(1):  left_upper_forearm
```

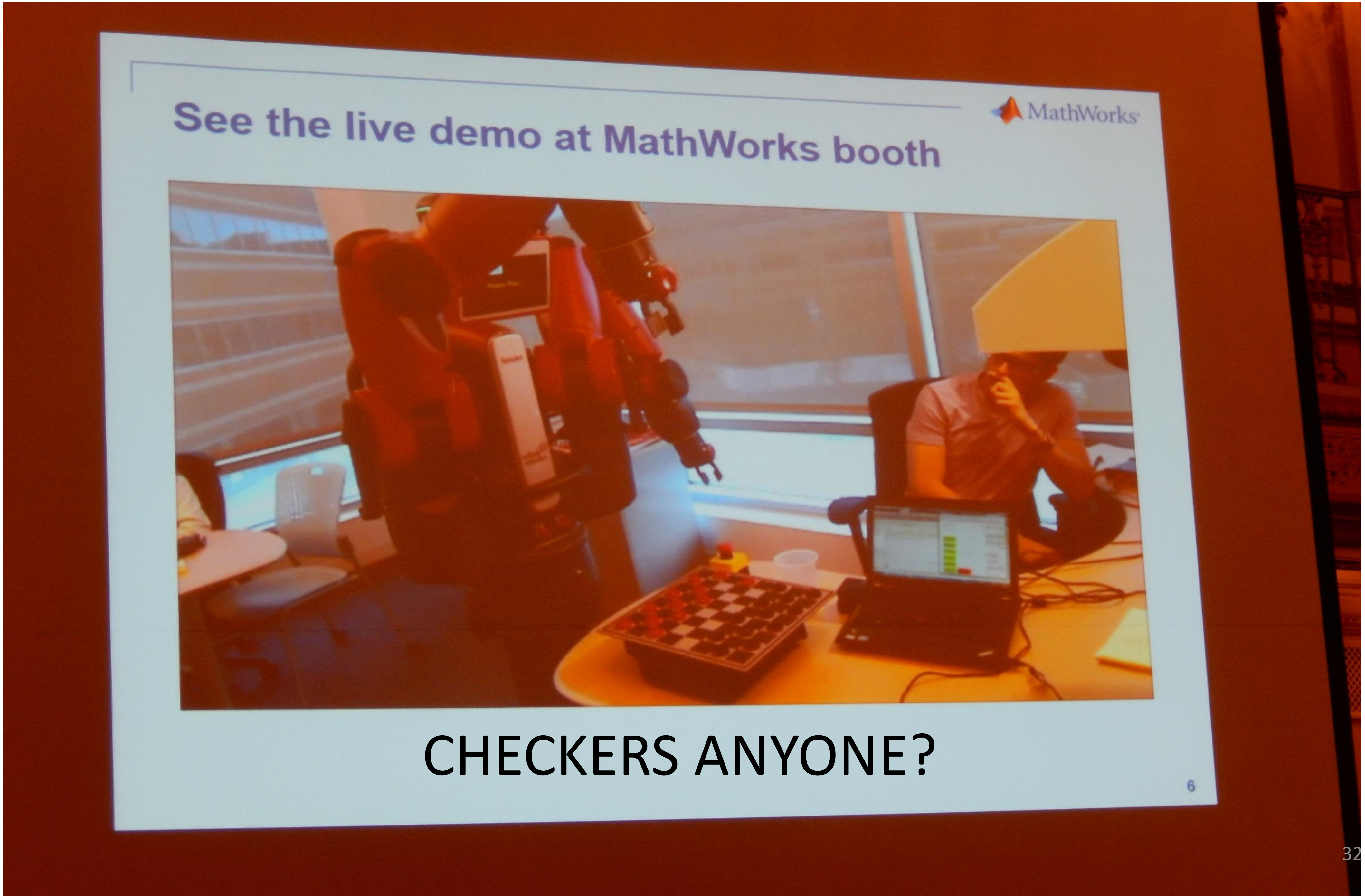
# THE MATHWORKS PROGRAMS BAXTER


Carlos

# How to Use MATLAB-ROS Interface to Prototype Robotics Algorithm for ROS-Powered Robots

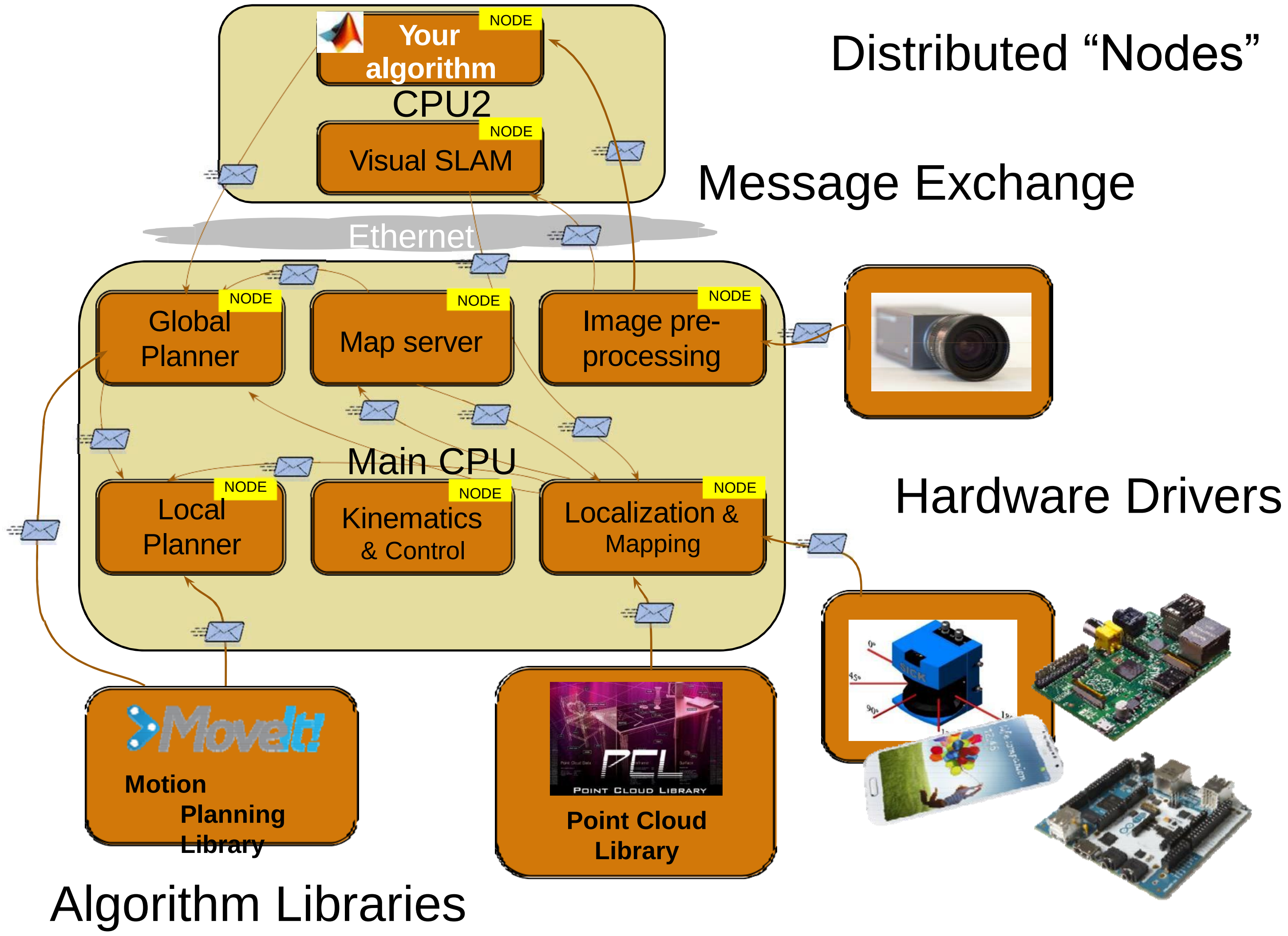
**Yanliang Zhang (MathWorks)**
**Ren Sang Nah (MathWorks)**
**Remo Pillat (MathWorks)**
**Carlos Santacruz-Rosero (MathWorks)**
**Giampiero Campa (MathWorks)**

2014 ★ CHICAGO

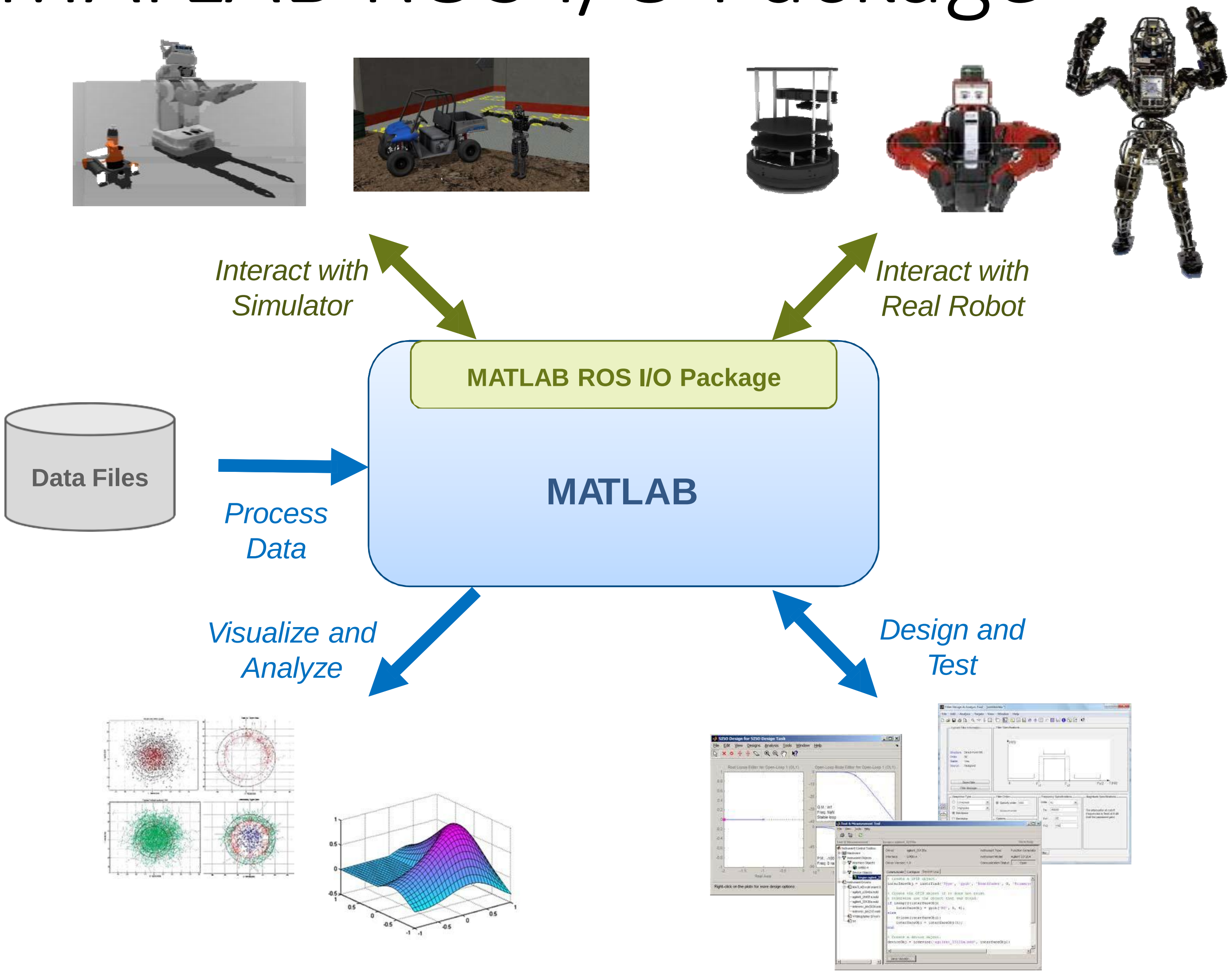



CHECKERS ANYONE?

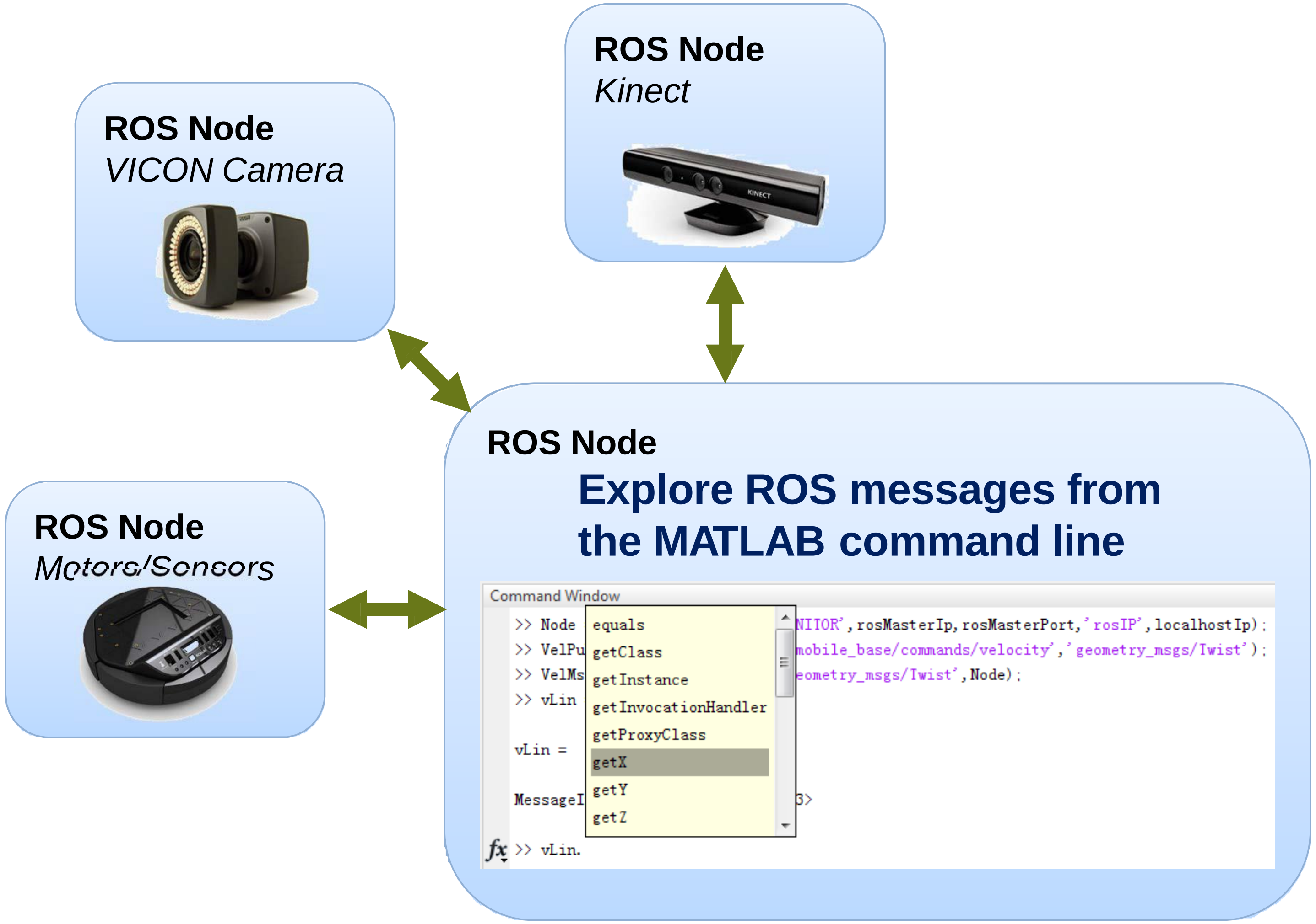
# With MATLAB ROS I/O Package



# MATLAB ROS I/O Package



# Interactive Exploration of Robot Data



# Closing Remarks

- Allow MATLAB/ROS users to take advantage of both
  - Power of MATLAB in data analysis and algorithm design
  - Flexibility of ROS in handling a network of applications
- Enable multi-platform access to ROS from MATLAB
- Available for download at official MathWorks website
  - http://www.mathworks.com/ros
  - Search for “MATLAB ROS”
- TurtleBot example available at MATLAB Central
  - http://www.mathworks.cn/matlabcentral/fileexchange/44853-use-matlab-ros-i-o-package-to-interact-with-the-turtlebot-simulator-in-gazebo
  - Search for “MATLAB ROS TurtleBot”

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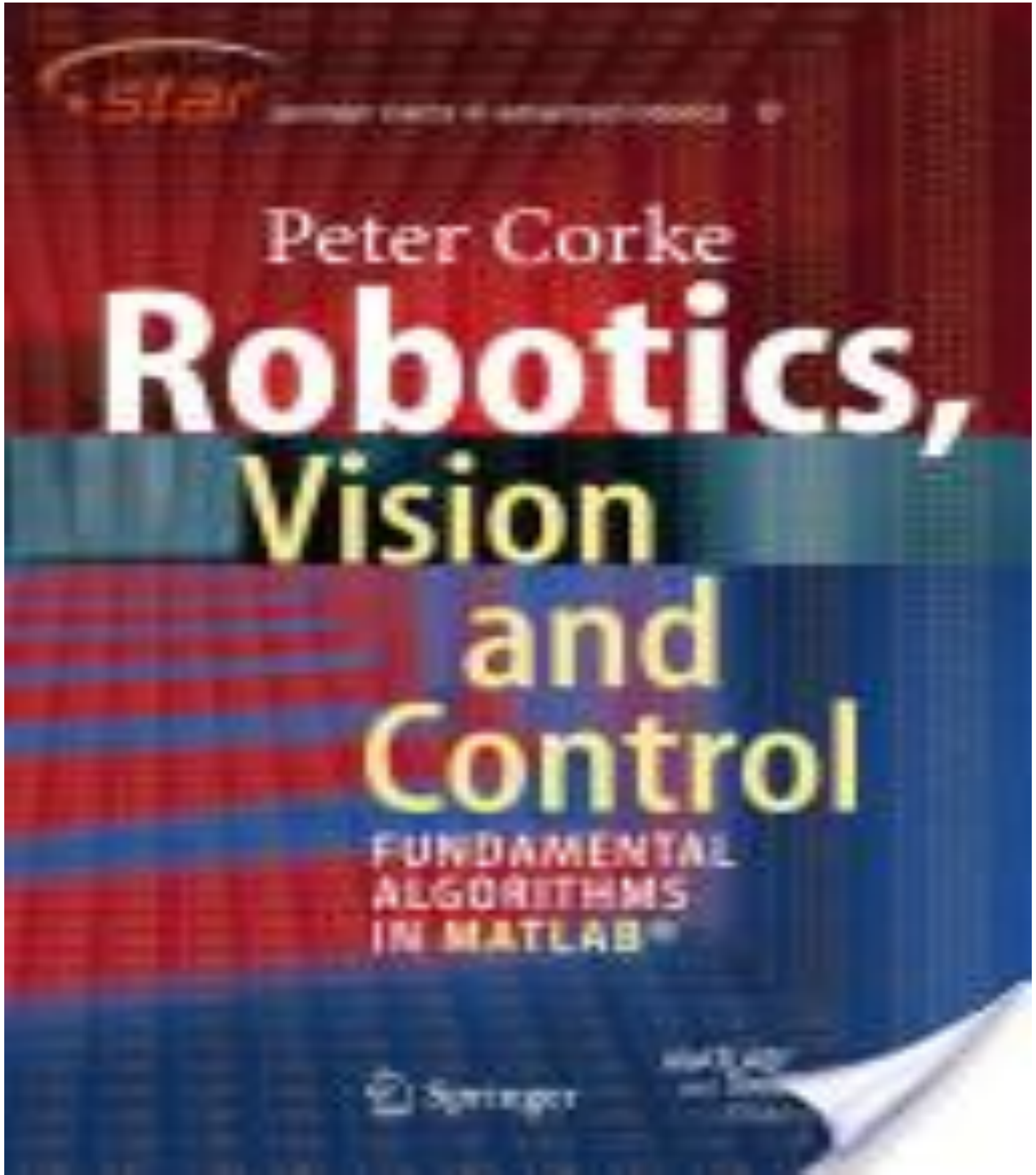
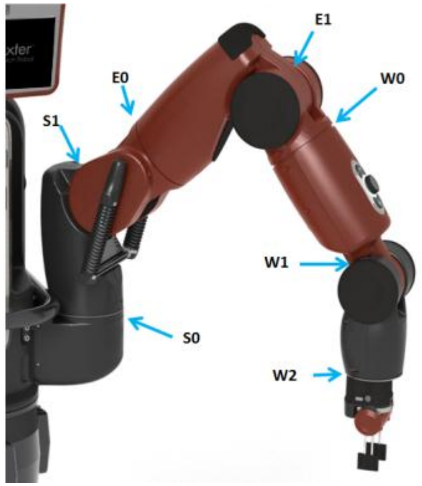
the quest for
robotic
vision
Peter Corke
U-5
QUT
Queensland University
of Technology
ARC Centre of Excellence for
ROBOTIC VISION

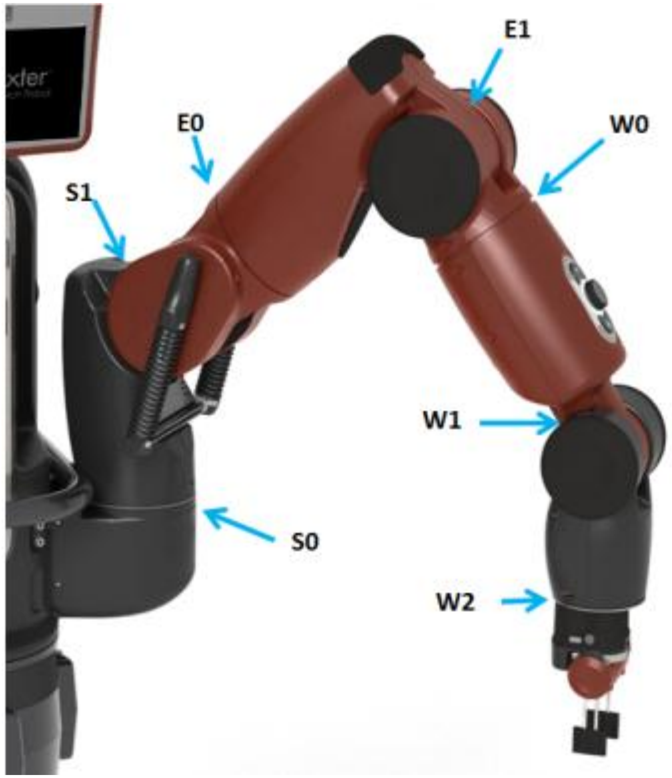

Peter Corke
Robotics,
Vision
and
Control
FUNDAMENTAL
ALGORITHMS
IN MATLAB®
Springer

# Baxter Kinematics   Dr. James Dabney

- Each arm independent
- Seven degrees of freedom (per arm)
- Additional degrees of freedom in gripper or end effector
- All arm joints are revolute



# Joint Configuration




- **S0** - Shoulder Roll
- **S1** - Shoulder Pitch
- **E0** - Elbow Roll
- **E1** - Elbow Pitch
- **W0** - Wrist Roll
- **W1** - Wrist Pitch
- **W2** - Wrist Roll

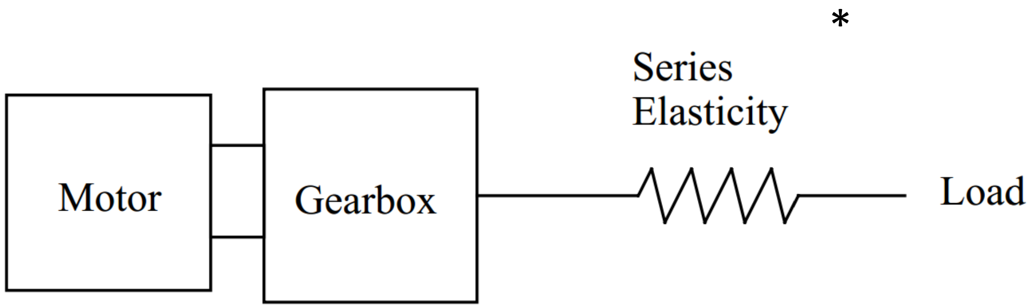
Source: http://sdk.rethinkrobotics.com/wiki/Arms#Joint_Naming

# Series Elastic Actuators

- Improve operational safety
- More closely model human operator
- Easier (much) to control force
  - Springs convert force control into position control
  - Large error tolerance

# Series Elastic Actuator Dynamics

- Electrically actuated
- Springs for compliance
- Actuator equation of motion




$$J\ddot{\theta}_M + c\dot{\theta}_M + k(\theta_M - \theta_L) = \tau_L$$

where $\Theta_M$ is the motor angular position, *c* is internal damping, and *k* is the spring constant .
J is the moment of inertia of the motor and gear train.

* Source: http://groups.csail.mit.edu/lbr/hrg/1995/mattw_ms_thesis.pdf

# Baxter Actuators

Source: http://sdk.rethinkrobotics.com/mediawiki-1.22.2/images/4/41/Baxter_arm_naked.png

# Baxter Control Strategies

- Simple control via Python scripts
  - Position
  - Torque
- Native control using flexible manipulator techniques
- Impedance-based control developed for haptic systems

# RESEARCH OBJECTIVES AT UHCL

## 1. MODEST RESEARCH GOALS

- DETERMINE PRECISION OF GRIPPING AND VISION
- USE BAXTER AS AN ASSEMBLY ASSISTANT
- IMPLEMENT GESTURE AND VOICE CONTROL

## 2. WORK WITH MATHWORKS TO IMPLEMENT AND TEST MATLAB MODULES WITH BAXTER

# COORDINATE MULTIPLE BAXTERS

# RESEARCH OBJECTIVES AT UHCL

Dr. McKay's "Big Idea"