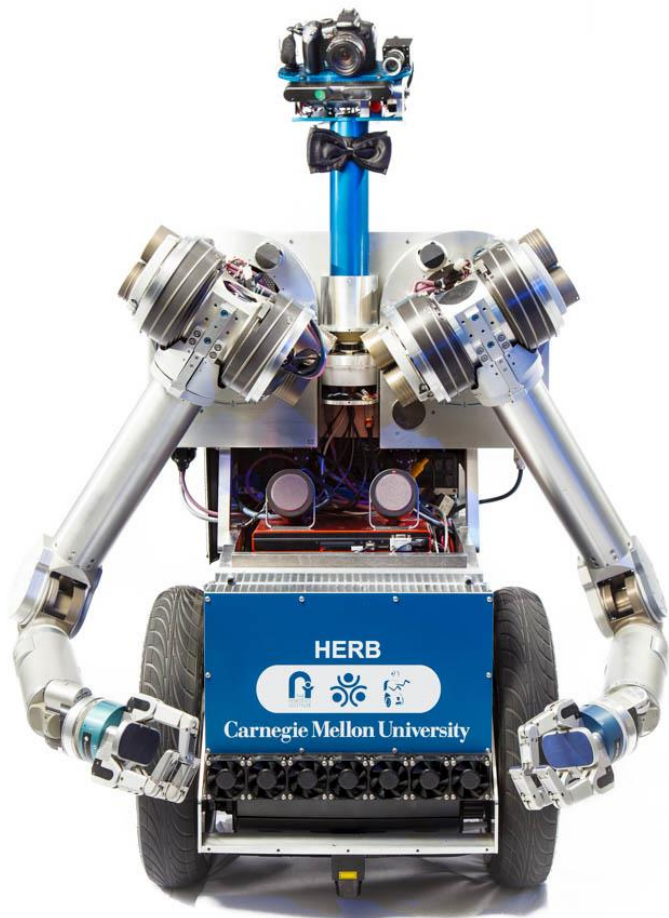


# Robot Gesture Engine

Rachel Holladay  
Siddhartha Srinivasa

The Robotics Institute  
Carnegie Mellon University





# Personal Robotics Laboratory

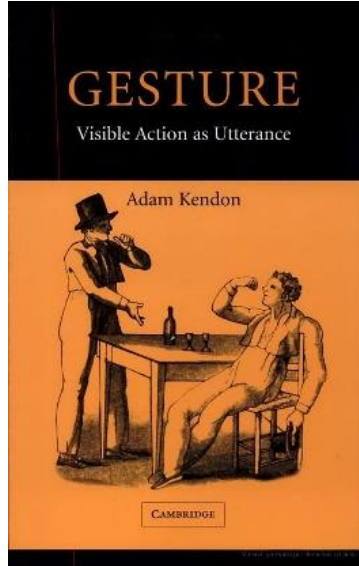
# Hardware and Software Platform to Enable Computing Research in HRI

Hardware and *Software* Platform to  
Enable Computing Research in HRI

Hardware and *Software* Platform to  
Enable Computing Research in HRI  
*Through a Gesture Library*



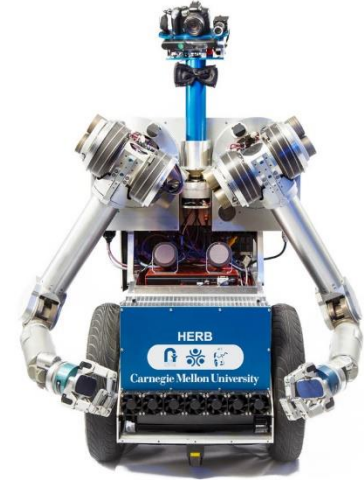
*Key Contribution:*  
*Robot Gesture Engine (RoGuE)*



Literature  
Review

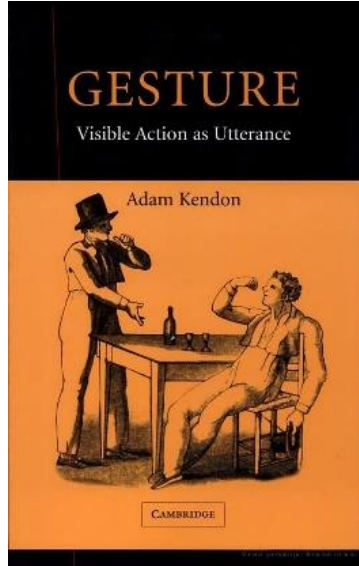
$$\left[ \begin{array}{ll} x_{min} & x_{max} \\ y_{min} & y_{max} \\ z_{min} & z_{max} \\ \psi_{min} & \psi_{max} \\ \theta_{min} & \theta_{max} \\ \phi_{min} & \phi_{max} \end{array} \right]$$

Mathematical  
Formulation



Robotic  
Systems





Literature  
Review

$$\left[ \begin{array}{ll} x_{min} & x_{max} \\ y_{min} & y_{max} \\ z_{min} & z_{max} \\ \psi_{min} & \psi_{max} \\ \theta_{min} & \theta_{max} \\ \phi_{min} & \phi_{max} \end{array} \right]$$

Mathematical  
Formulation



Robotic  
Systems

Kendon	McNeill & Levy	Rimé & Schiaratura	Efron	Identifying Characteristics
physiographic	iconic	physiographic	kinetographic	picture the content of speech
ideographic	metaphoric	iconic	ideographic	portray the speaker's ideas, but not directly the speech content
gesticulation	beats/Butterworths	speech-marking	baton	marking the rhythm of speech
autonomous gestures	symbolic	symbolic	symbolic/emblematic	standardized gestures, complete within themselves, without speech
— none —	deictic	deictic	— none —	pointing at thing/area; space around body used

Wexelblat, Alan. "Research challenges in gesture: Open issues and unsolved problems." *Gesture and sign language in human-computer interaction*. Springer, 1997.

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[Calinon 2007]



[Kopp 2000]



[Bremner 2009]



[Cassell 2001]



[Salem 2009]



[Sauppe 2014]



[Calinon 2007]



[Kopp 2000]



[Bremner 2009]



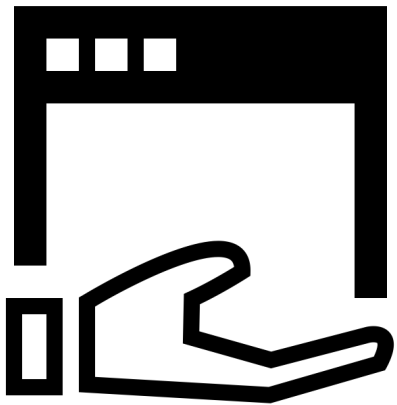
[Cassell 2001]



[Salem 2009]



[Sauppe 2014]



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from Noun Project

Presenting



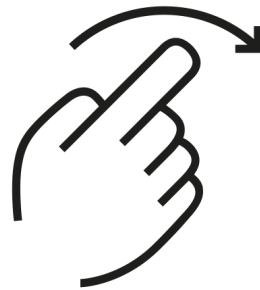
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from Noun Project

Pointing



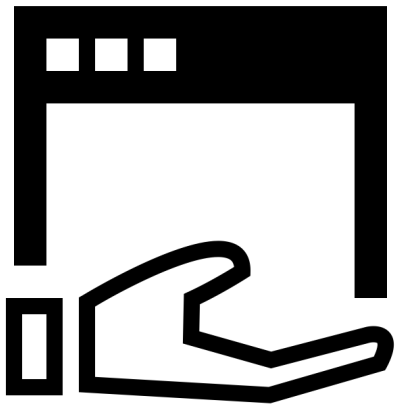
Created by Takao Umehara  
from Noun Project

Exhibiting



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Sweeping



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Presenting



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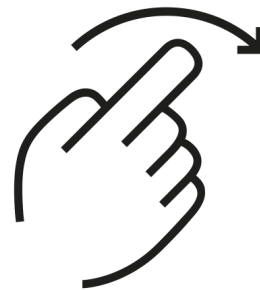
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Pointing



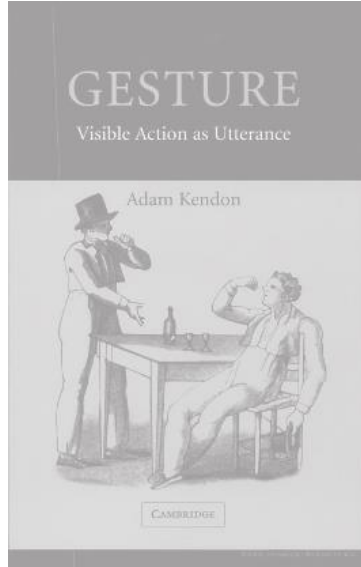
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from Noun Project

Exhibiting



Created by Darren Wilson  
from Noun Project

Sweeping



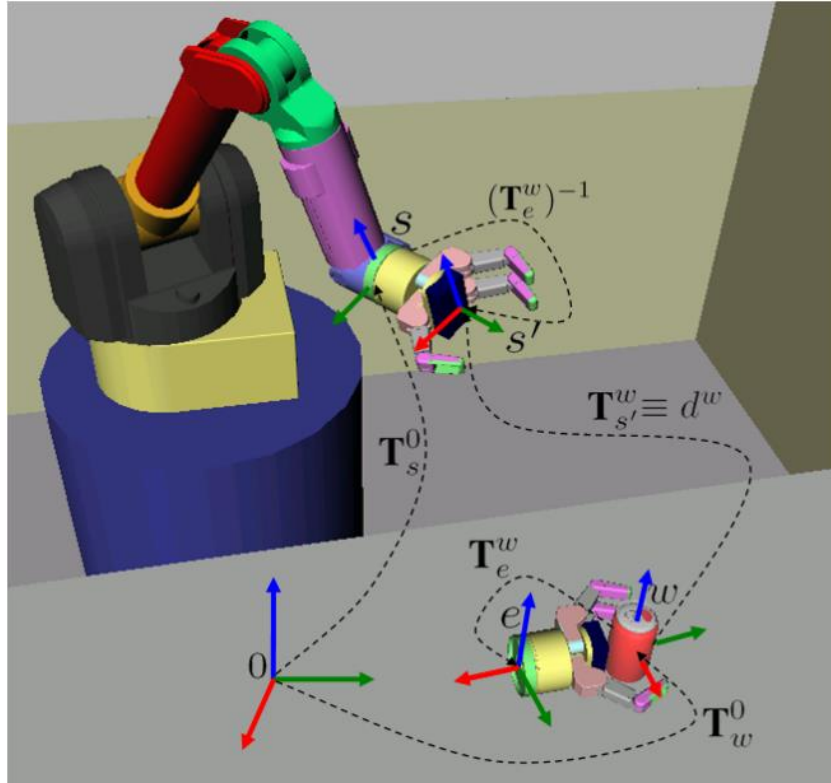
Literature  
Review

$$\left[ \begin{array}{ll} x_{min} & x_{max} \\ y_{min} & y_{max} \\ z_{min} & z_{max} \\ \psi_{min} & \psi_{max} \\ \theta_{min} & \theta_{max} \\ \phi_{min} & \phi_{max} \end{array} \right]$$

Mathematical  
Formulation



Robotic  
Systems



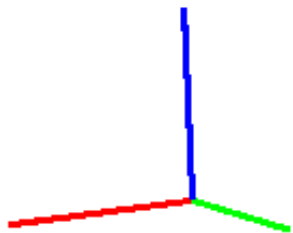
# Task Space Region

Berenson, Dmitry, Siddhartha S. Srinivasa, and James Kuffner. "Task space regions: A framework for pose-constrained manipulation planning." *IJRR* (2011).

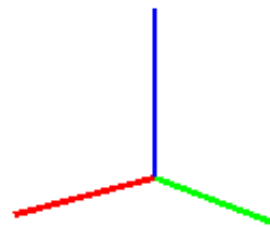
$T_w^0$  $T_e^w$  $B_w$

$T_w^0$

$$T_w^0$$

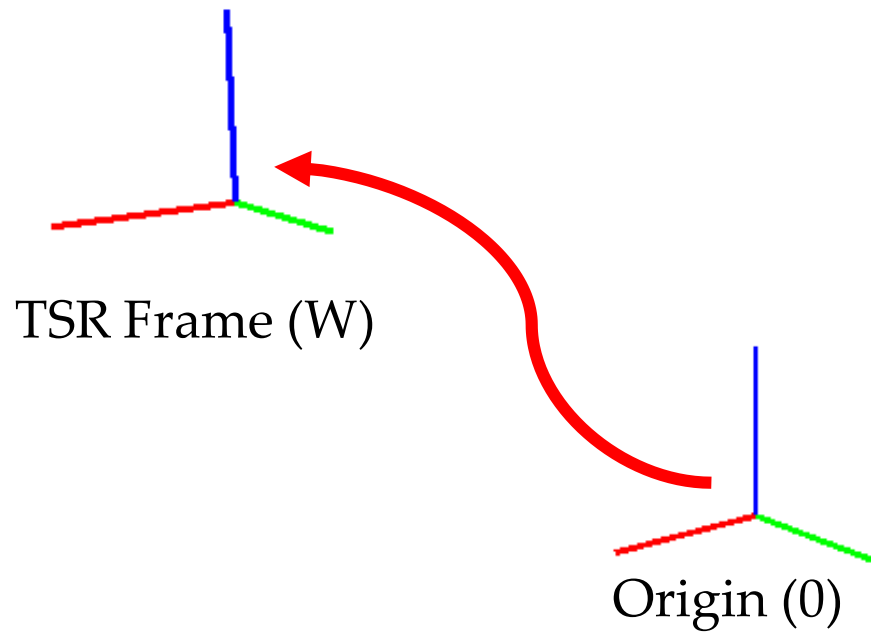


TSR Frame (W)



Origin (0)

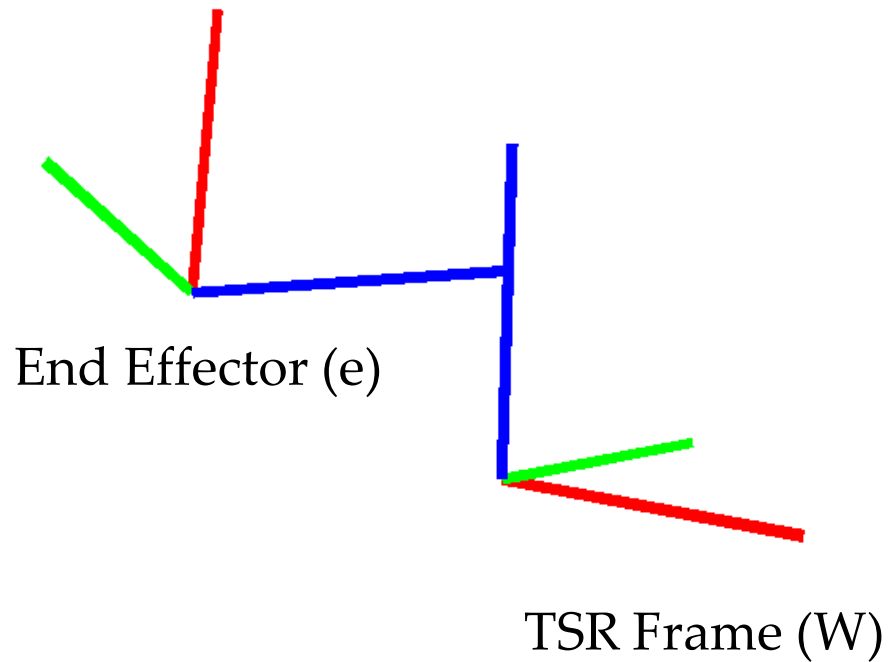
$$T_w^0$$



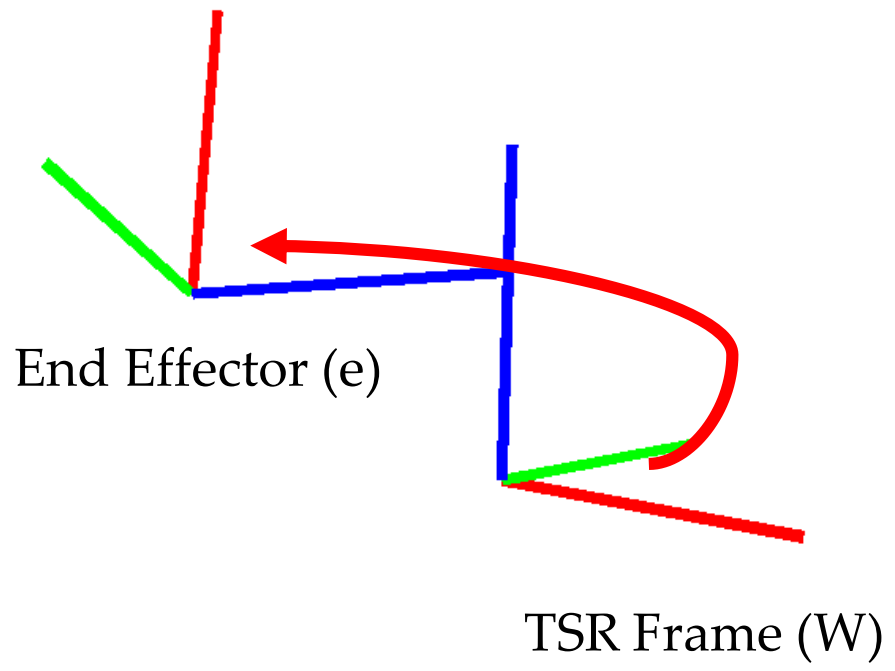


$T_e^w$

$$T_e^W$$

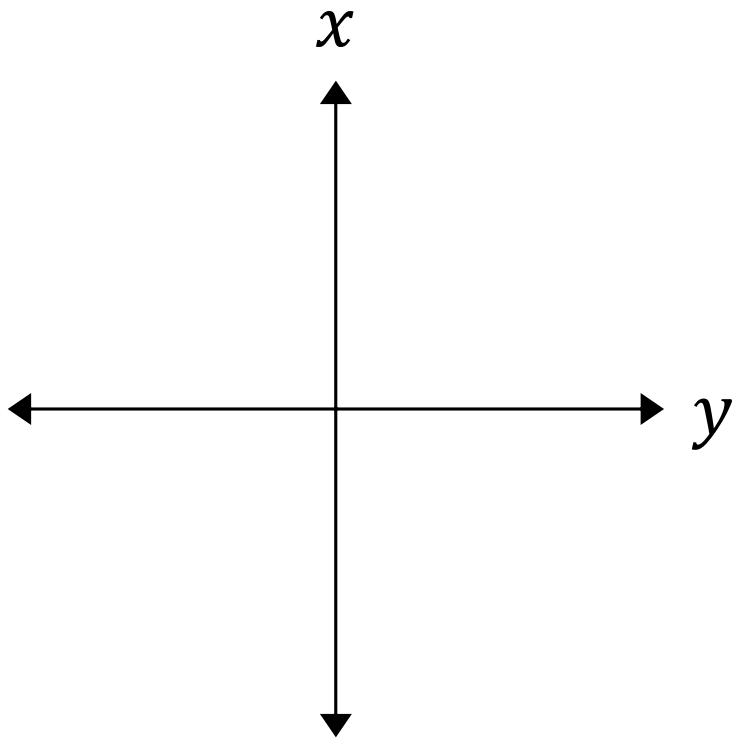


$$T_e^W$$

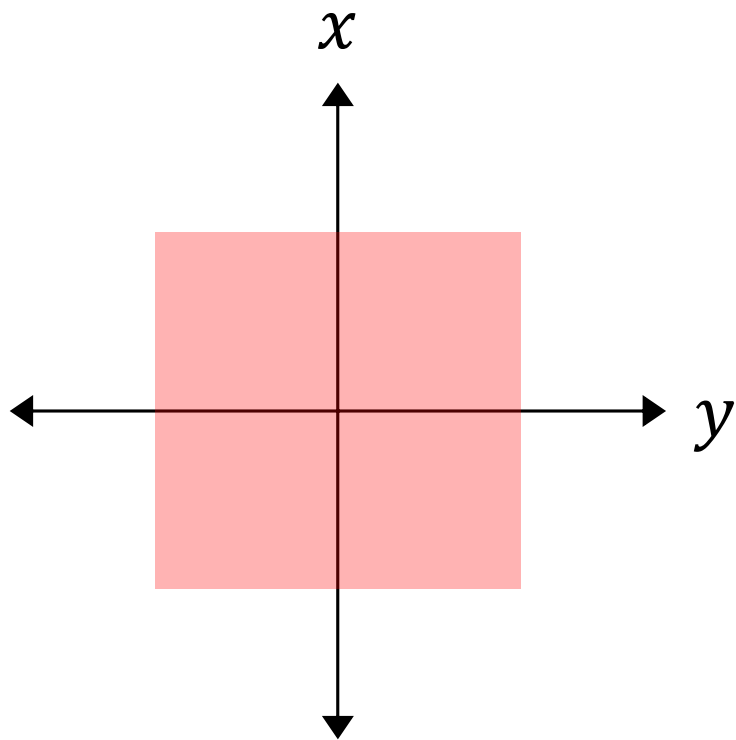


$B_w$

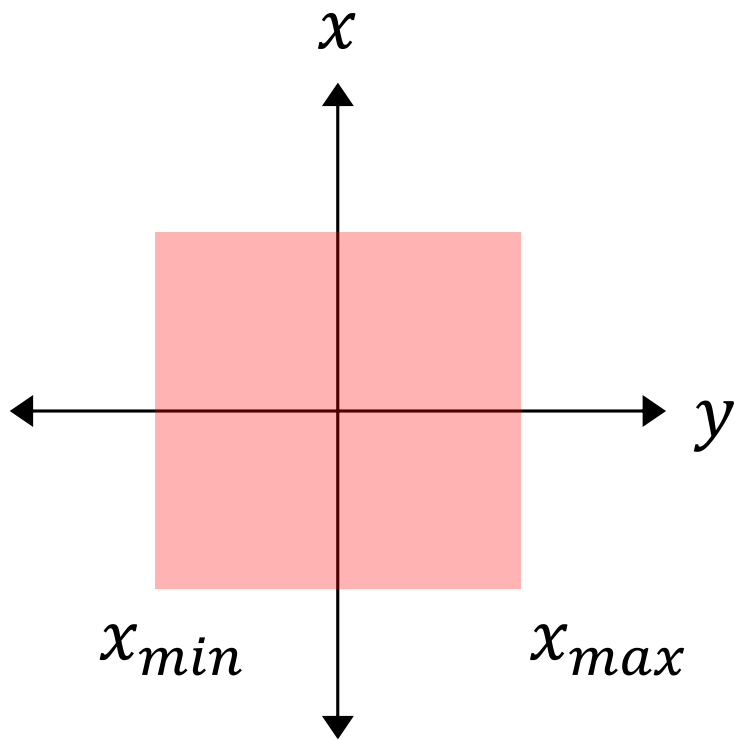
$B_w$



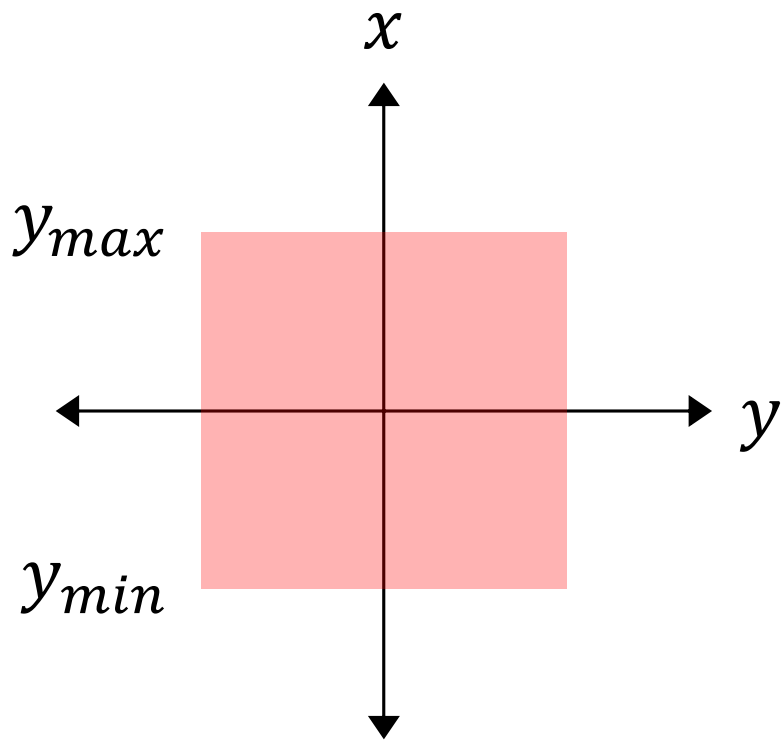
$B_w$



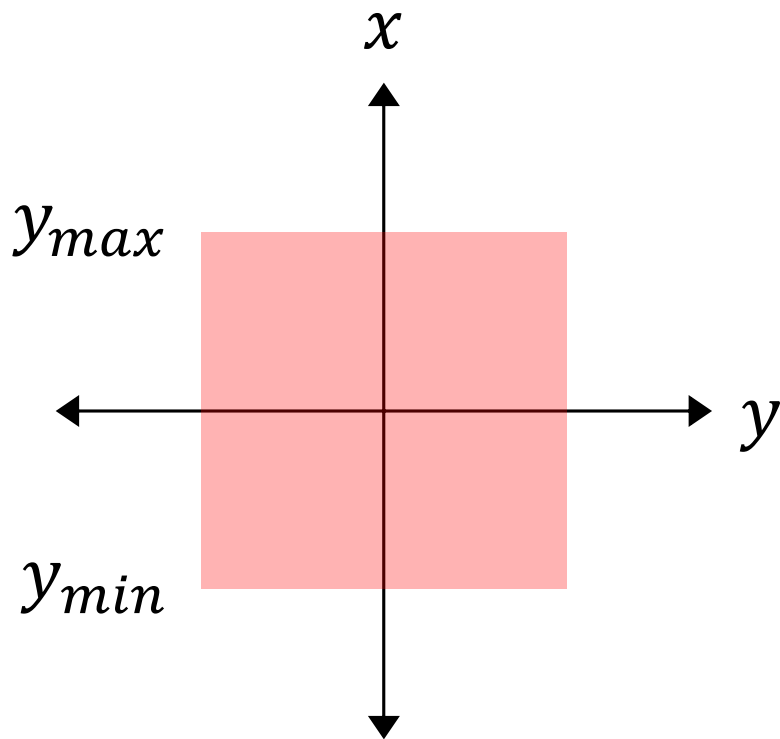
$B_w$



$B_w$

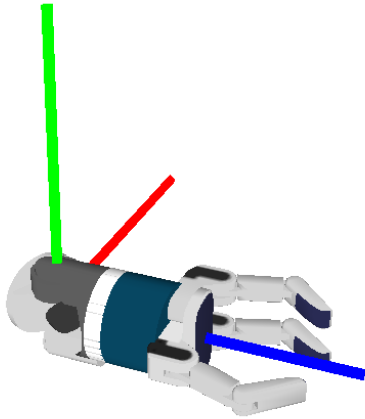




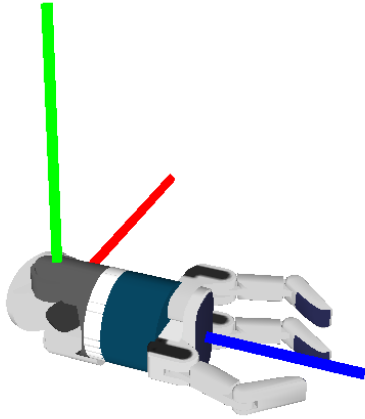
$B_w$ 

$$\begin{bmatrix} x_{min} & x_{max} \\ y_{min} & y_{max} \\ z_{min} & z_{max} \\ \psi_{min} & \psi_{max} \\ \theta_{min} & \theta_{max} \\ \phi_{min} & \phi_{max} \end{bmatrix}$$

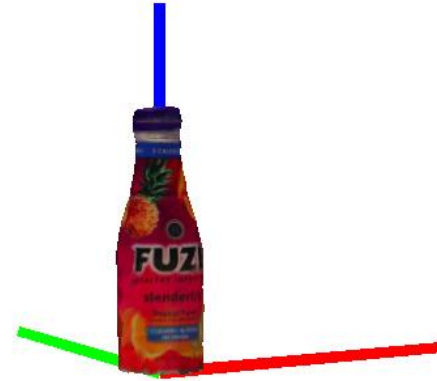
# End Effector Assumptions

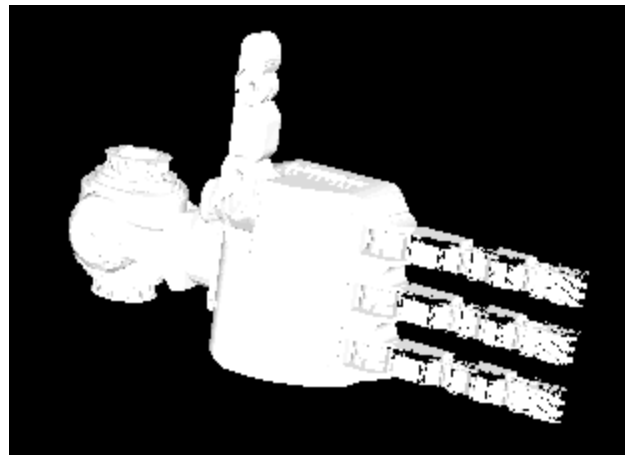
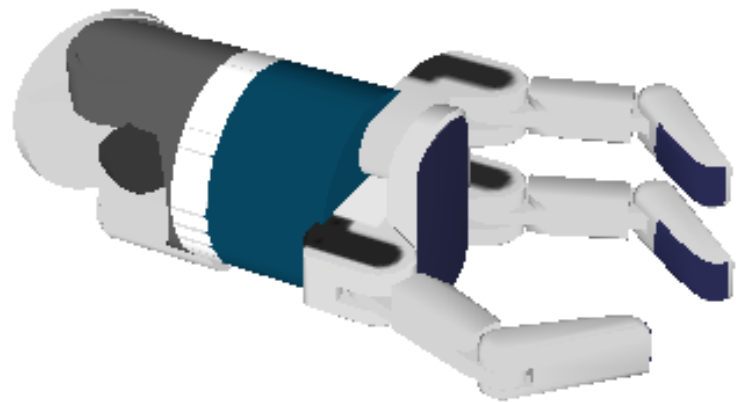


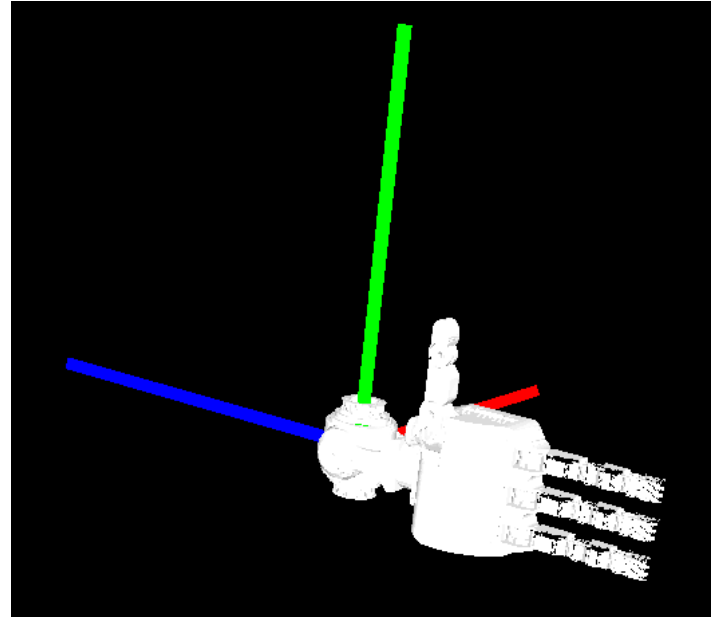
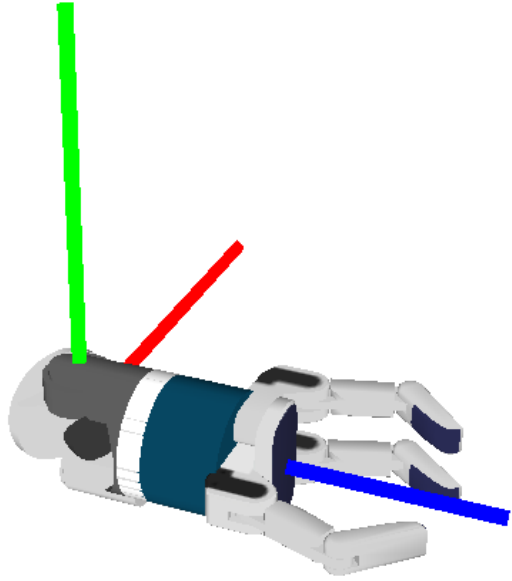
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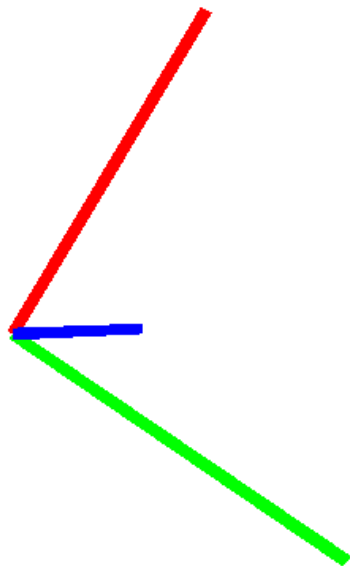
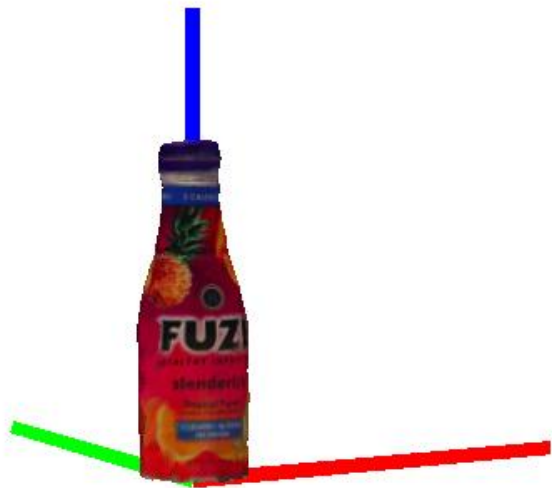


# Reference Assumptions





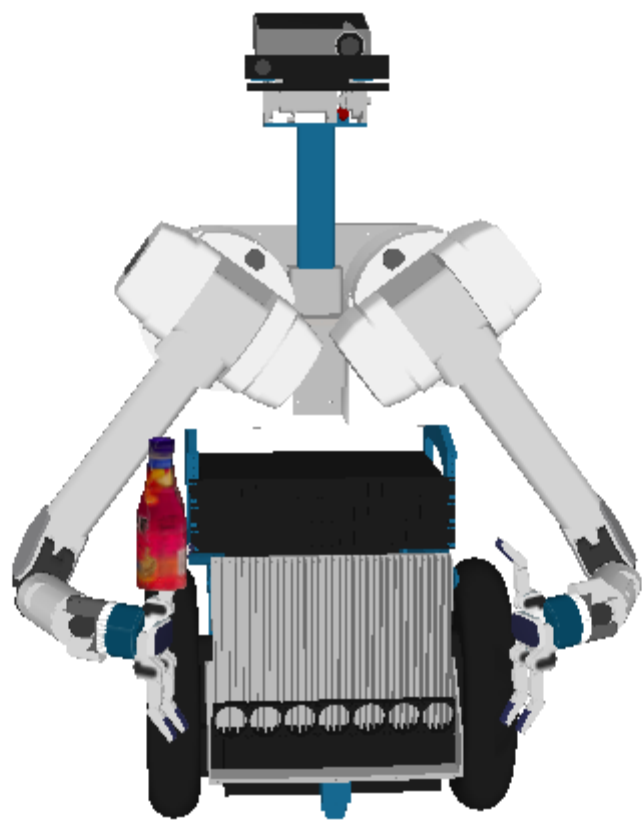




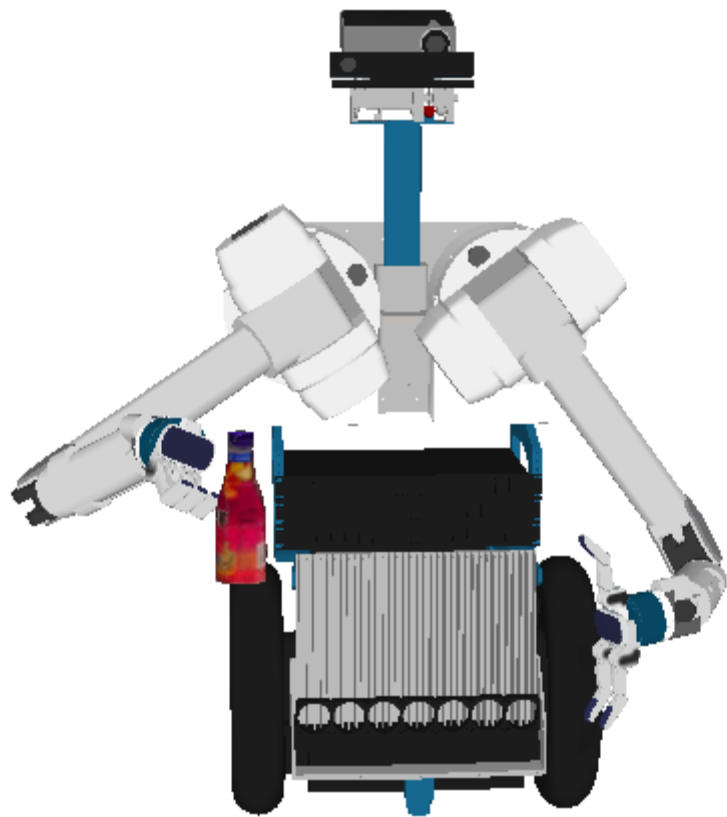


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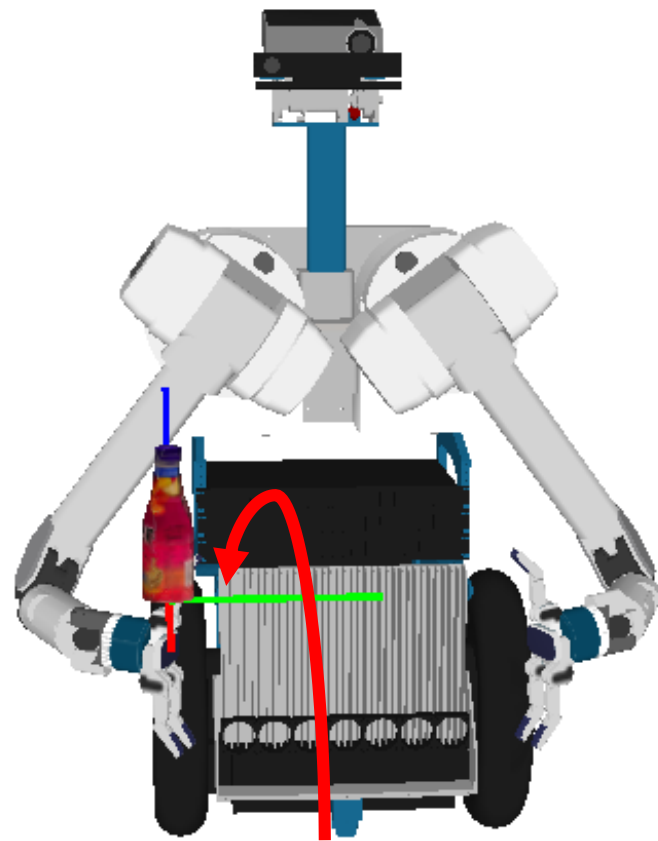
# Presenting



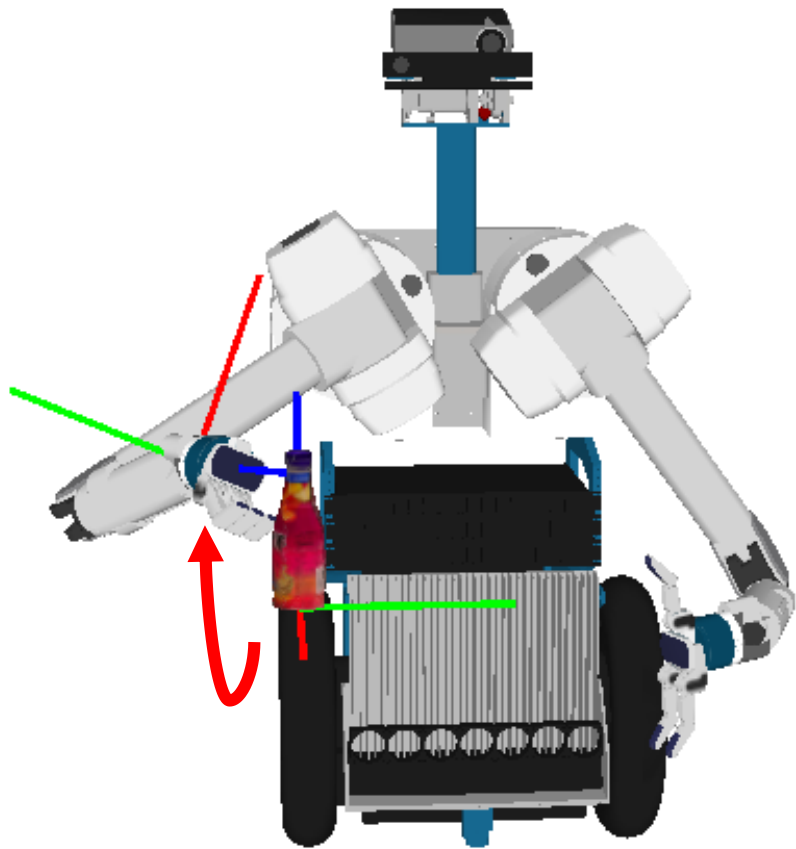




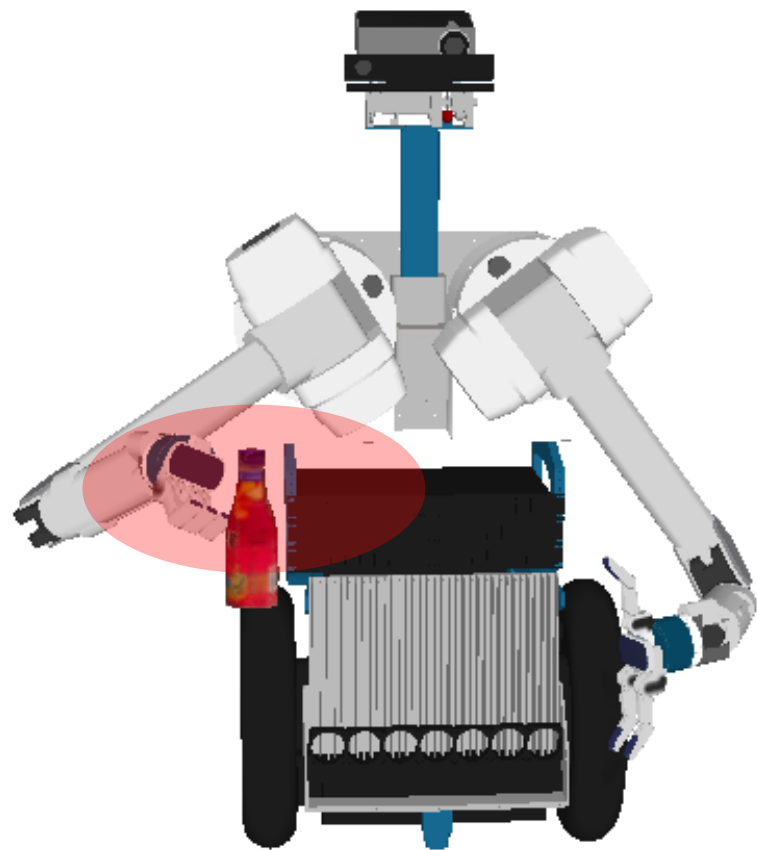
$T_w^0$



$T_e^w$



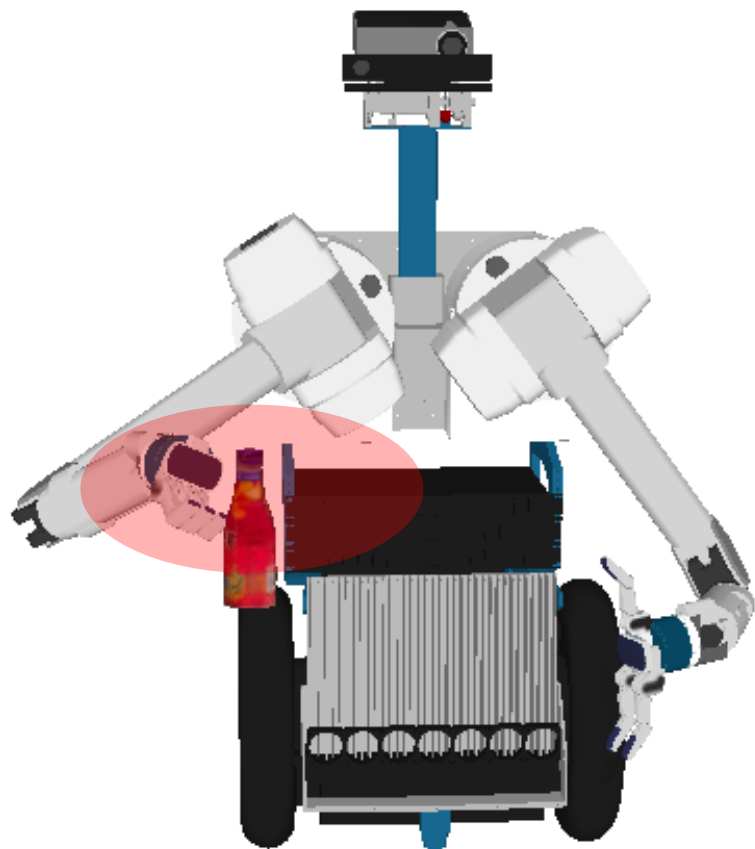
$B_w$

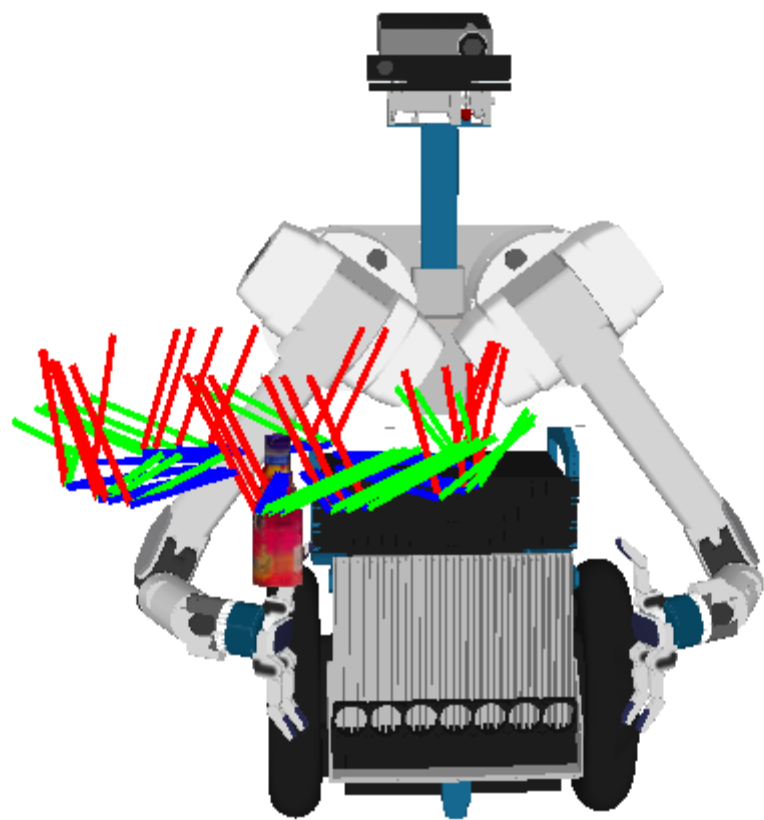


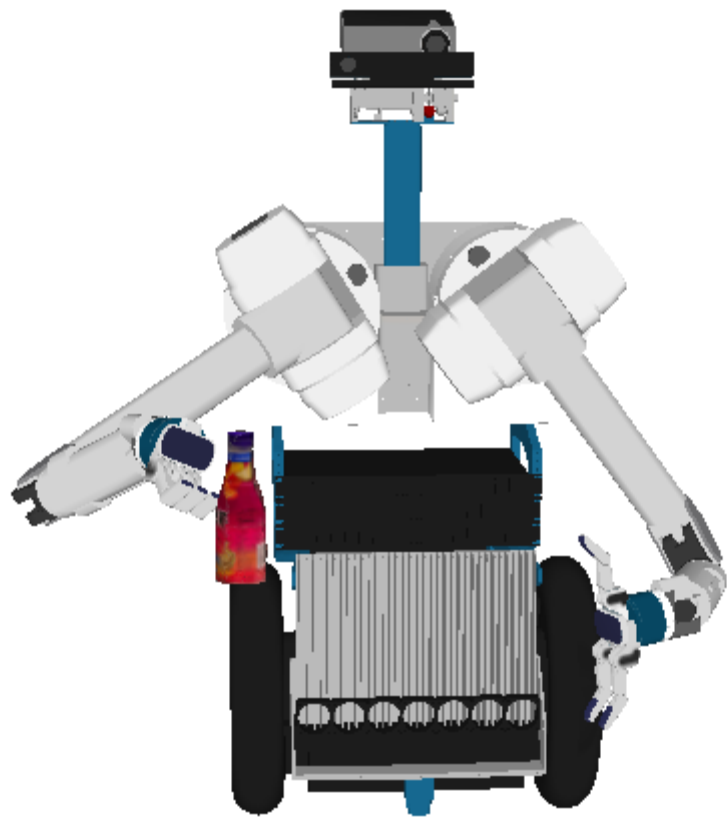
$$\begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ -\pi & \pi \\ 0 & 0 \end{bmatrix}$$



Pitch







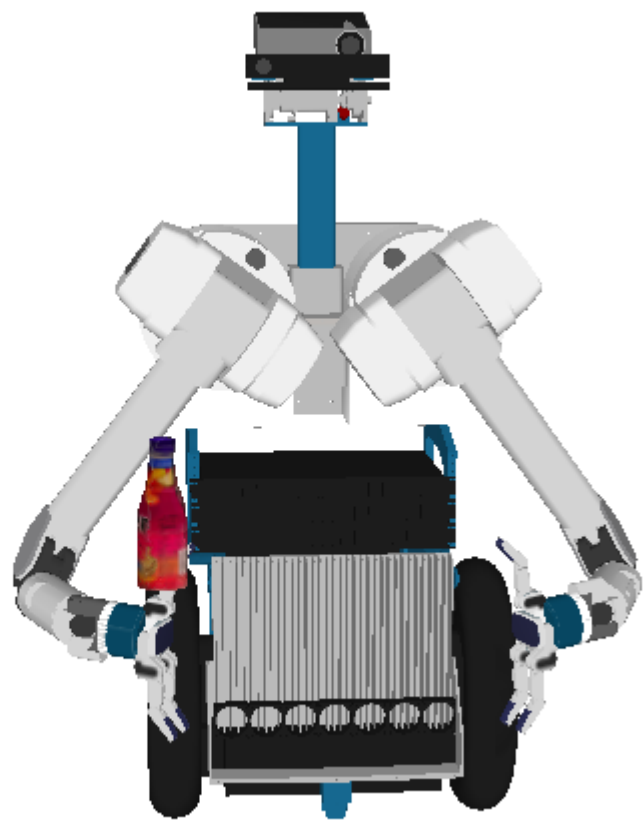


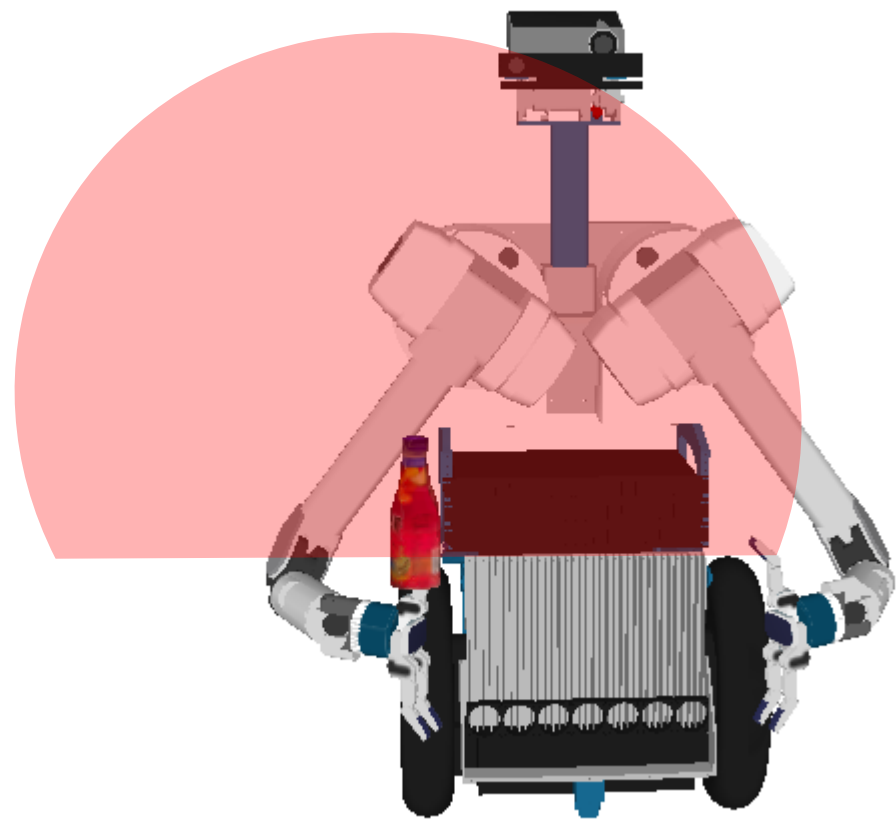


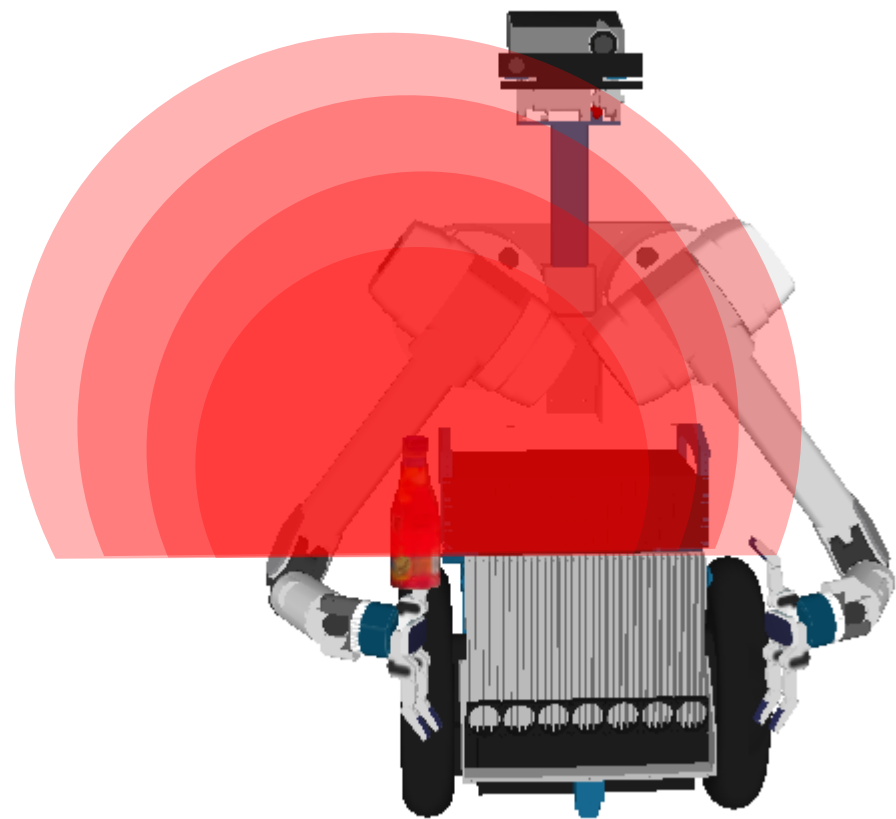


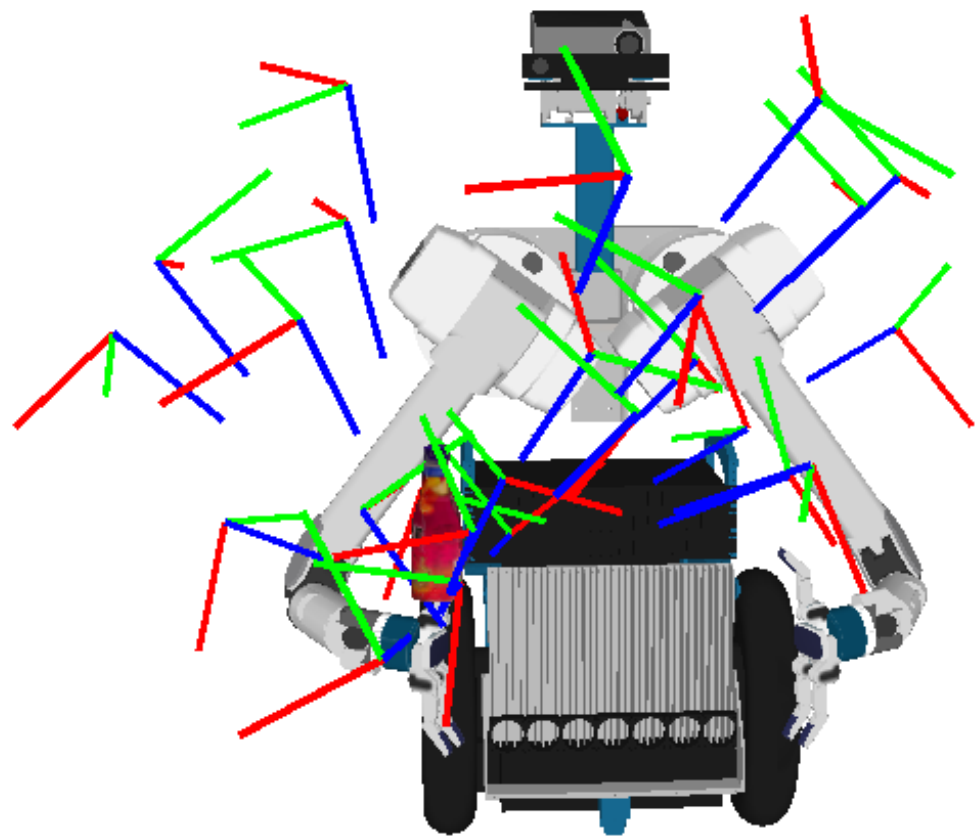
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from Noun Project

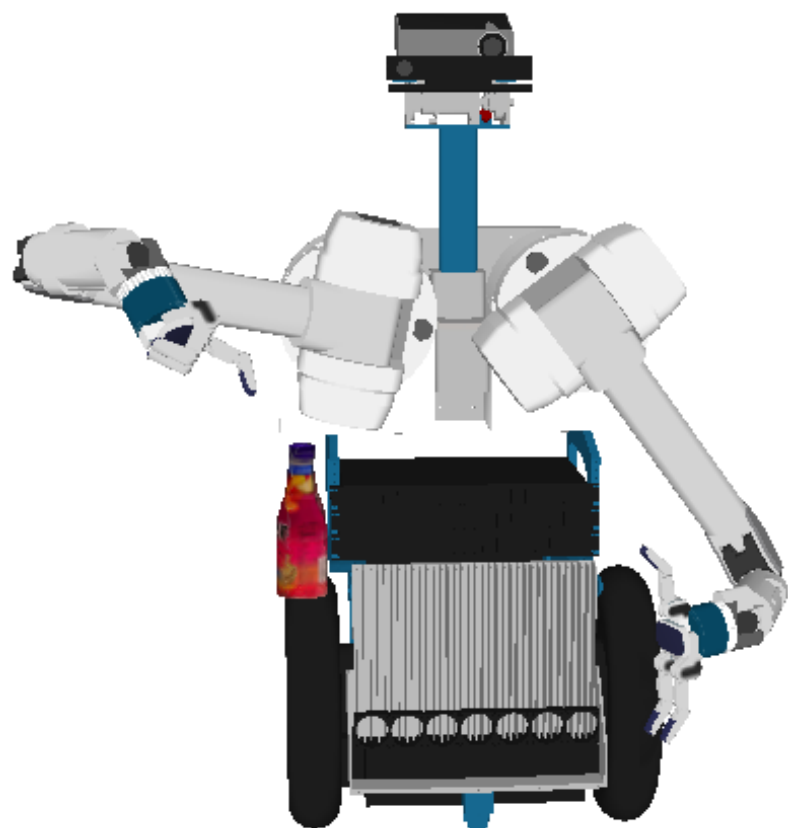
# Pointing

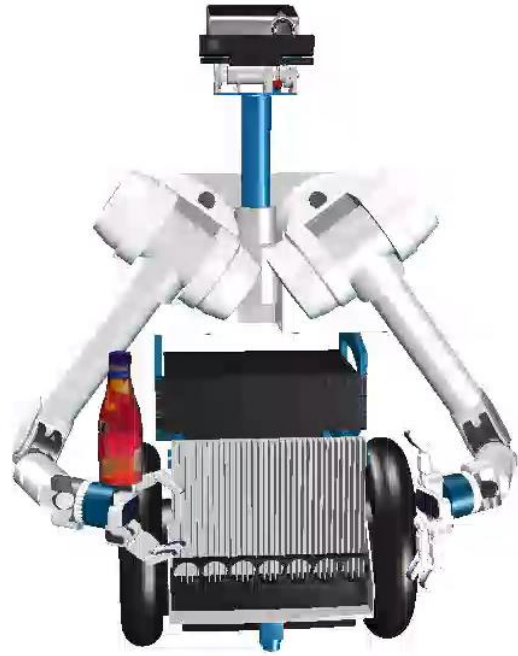












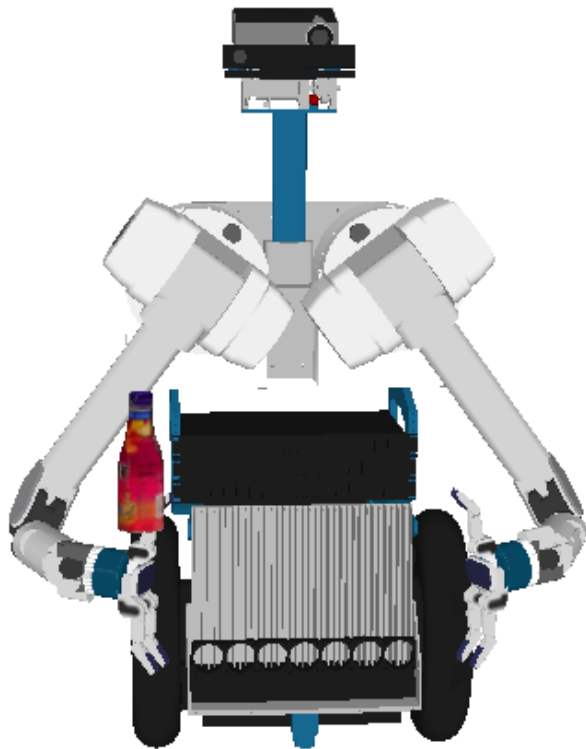


Exhibiting

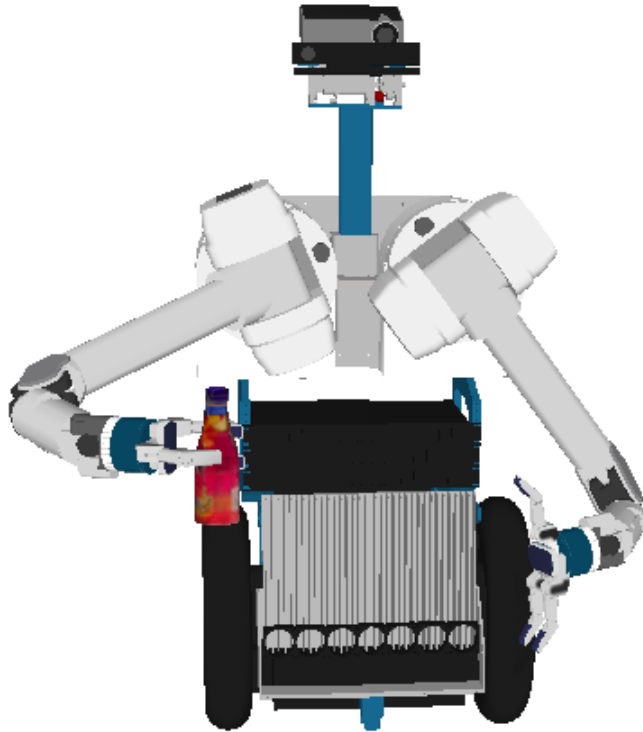
Created by Takao Umehara  
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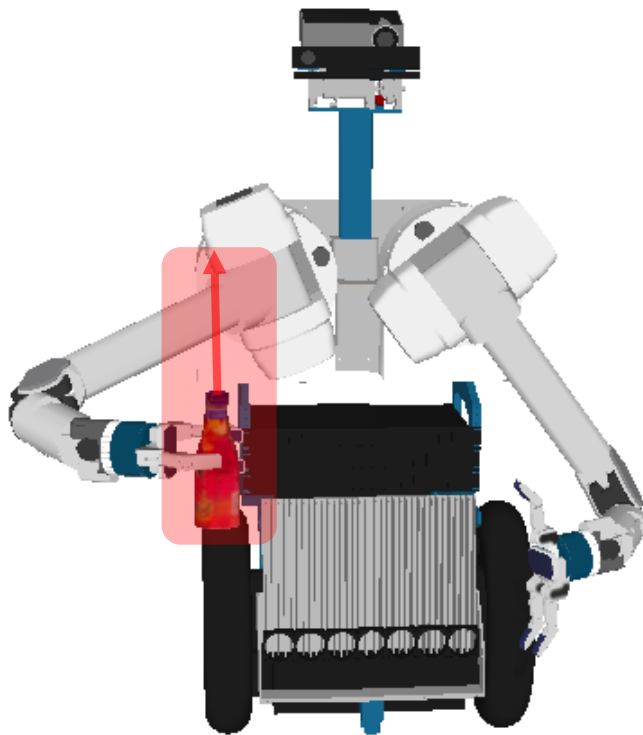
# Planning Call #1: Grasping



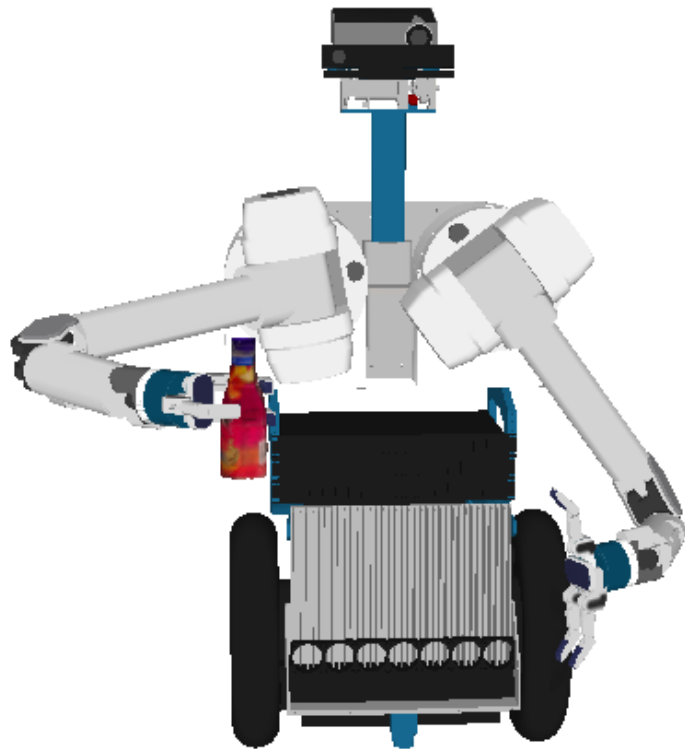
# Planning Call #1: Grasping



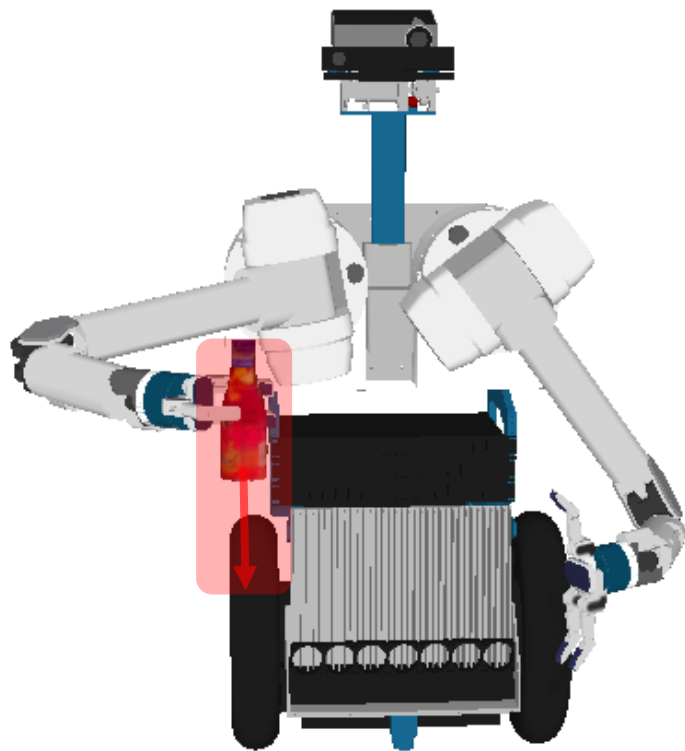
# Planning Call #2: Exhibiting



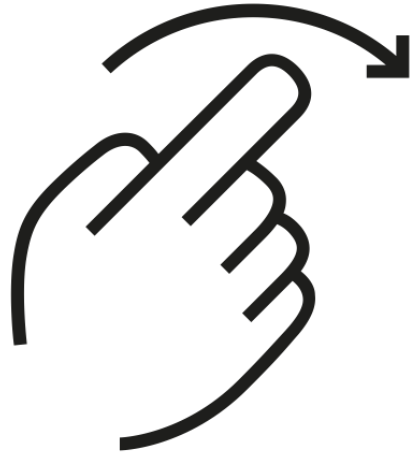
# Planning Call #2: Exhibiting



# Planning Call #3: Exhibiting



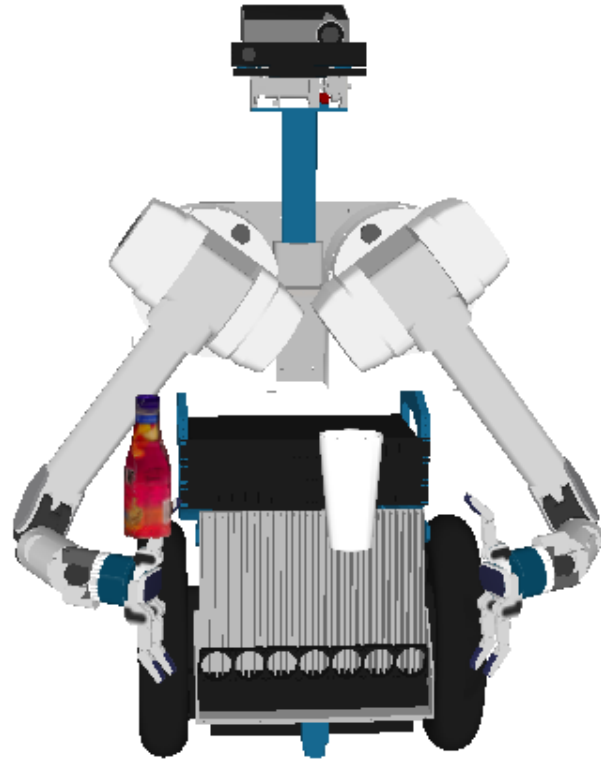




Sweeping

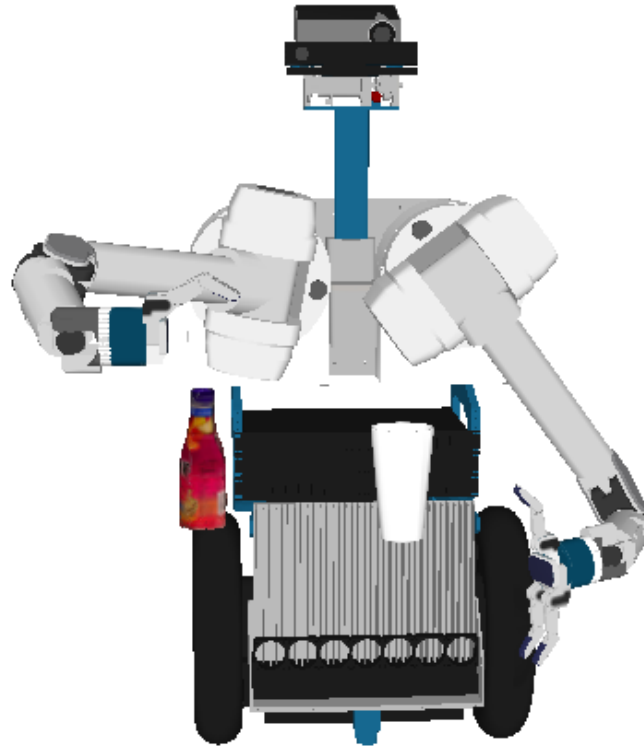
Created by Darren Wilson  
from Noun Project

# Planning Call #1: Place Hand

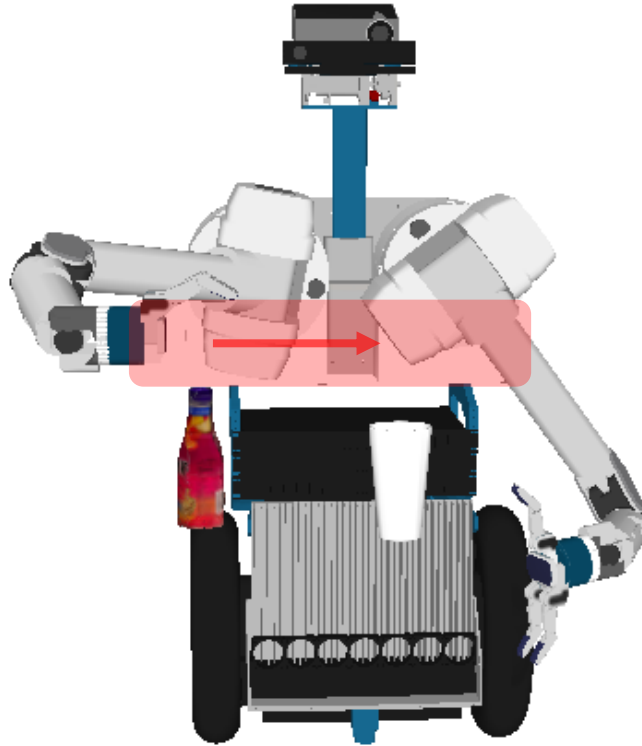




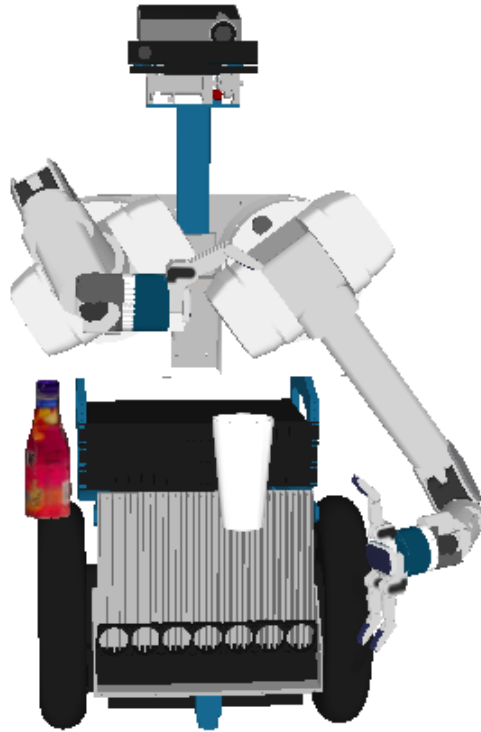
# Planning Call #1: Place Hand

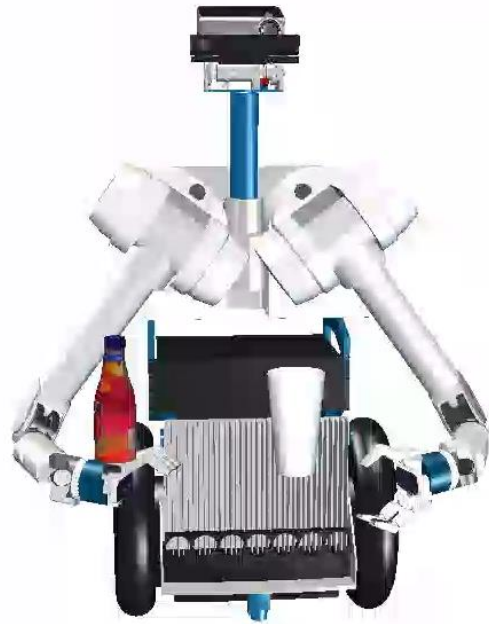


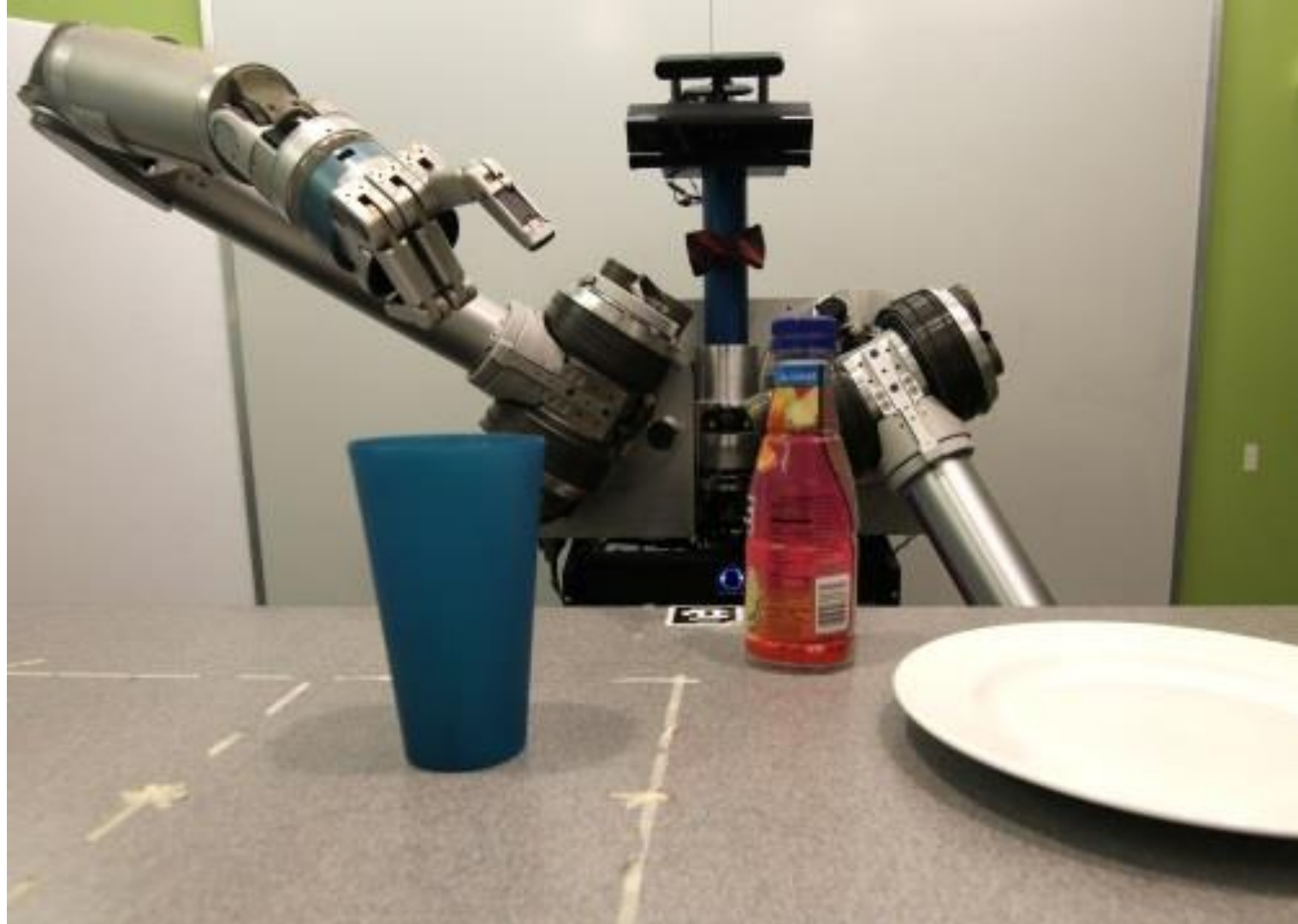
# Planning Call #2: Sweeping

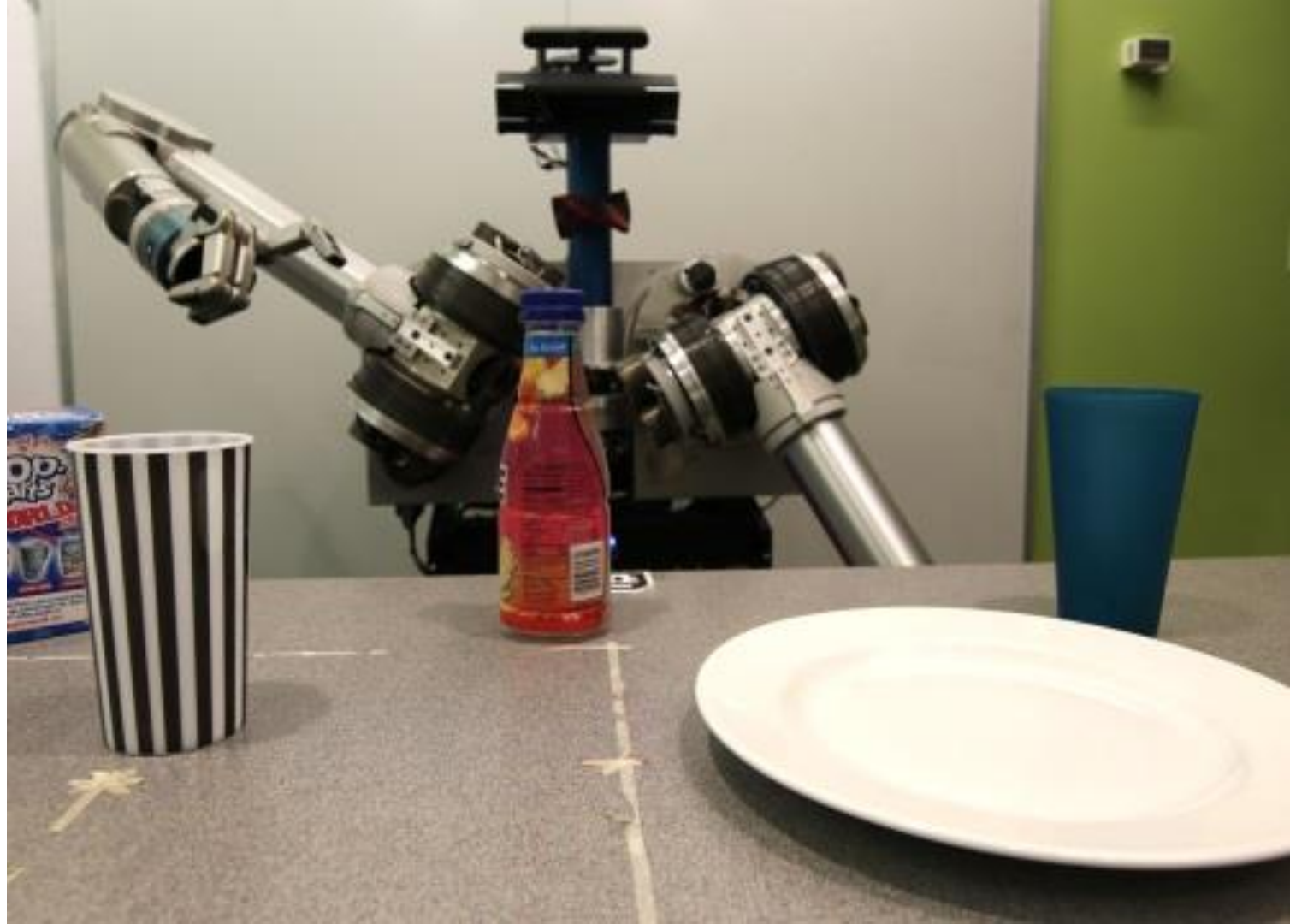


# Planning Call #2: Sweeping

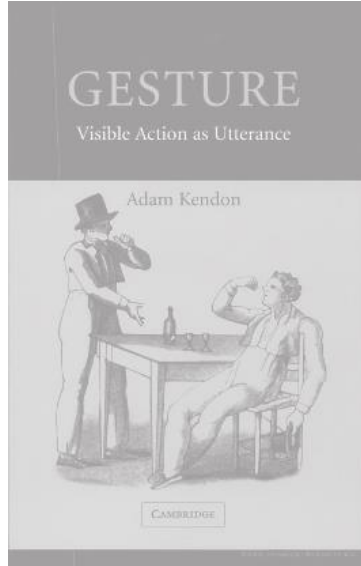








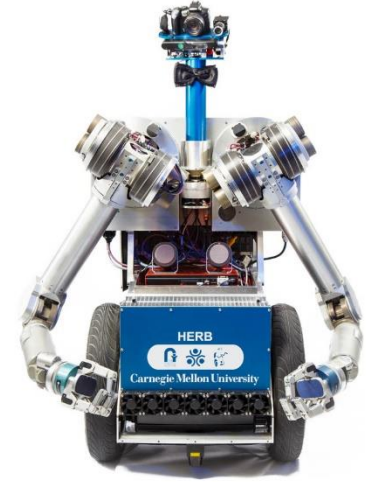




Literature  
Review

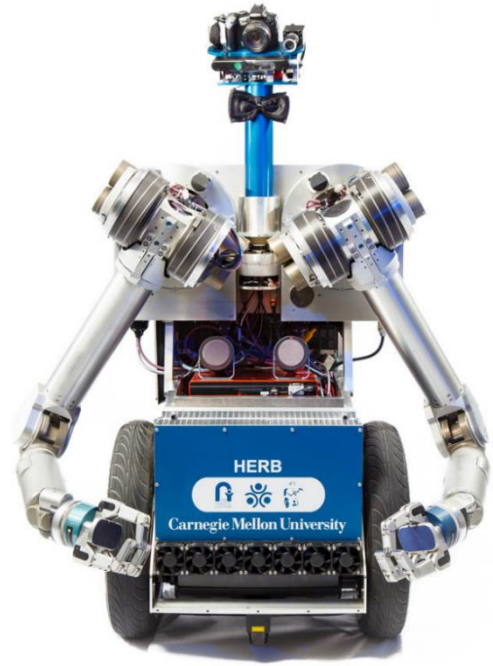
$$\left[ \begin{array}{ll} x_{min} & x_{max} \\ y_{min} & y_{max} \\ z_{min} & z_{max} \\ \psi_{min} & \psi_{max} \\ \theta_{min} & \theta_{max} \\ \phi_{min} & \phi_{max} \end{array} \right]$$

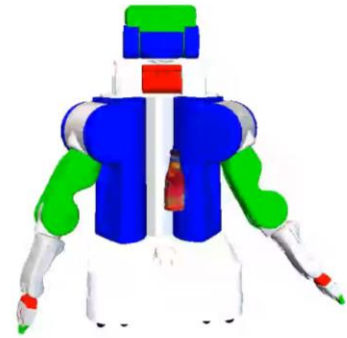
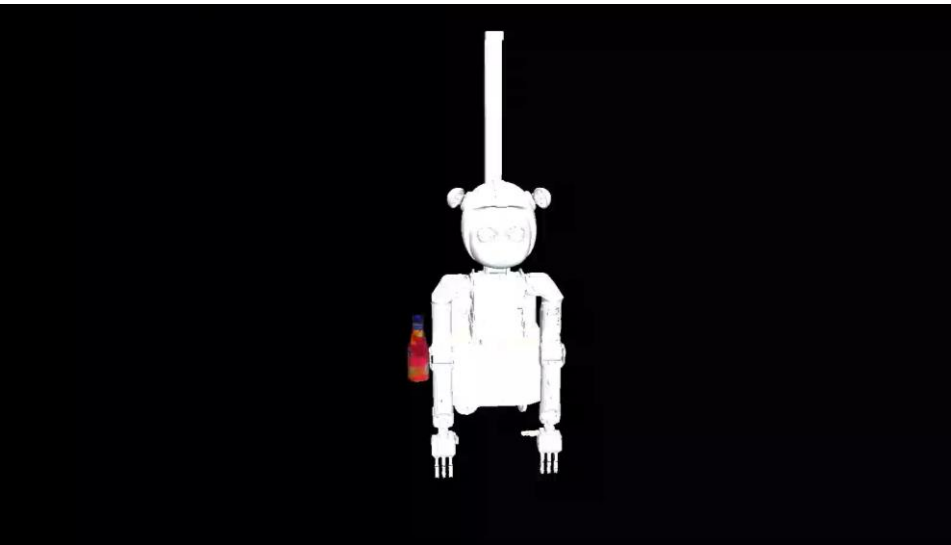
Mathematical  
Formulation



Robotic  
Systems





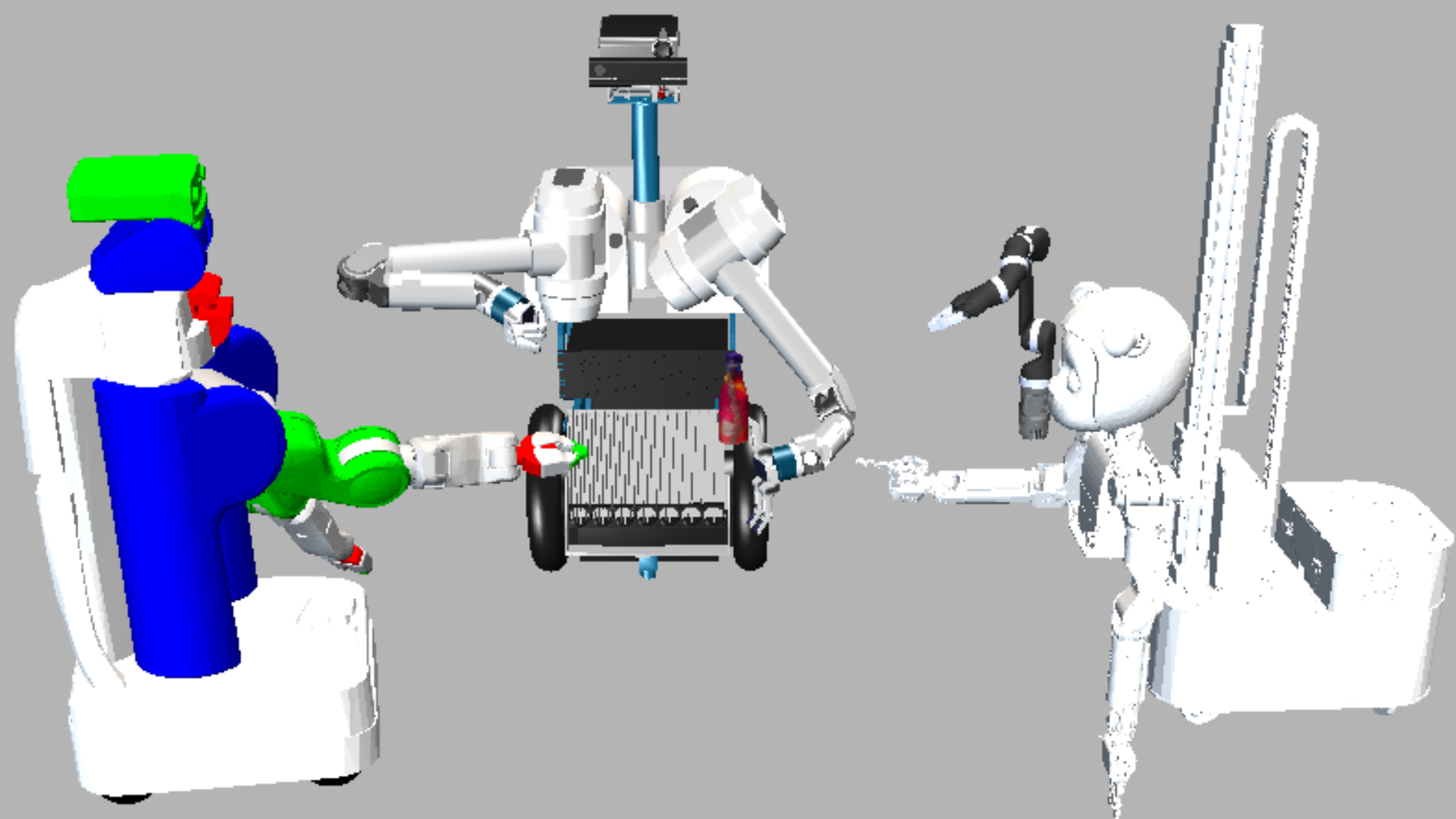


```
def Present_HERB(robot, focus, arm):  
    present_tsr = robot.tsrlibrary('present', focus, arm)  
    robot.PlanToTSR(present_tsr)  
    preshape = {finger1=1, finger2=1,  
                finger3=1, spread=3.14}  
    robot.arm.hand.MoveHand(preshape)
```

```
def Present_ADA(robot, focus, arm):  
    present_tsr = robot.tsrlibrary('present', focus, arm)  
    robot.PlanToTSR(present_tsr)  
    preshape = {finger1=0.9, finger2=0.9}  
    robot.arm.hand.MoveHand(preshape)
```

```
def Present_HERB(robot, focus, arm):  
    present_tsr = robot.tsrlibrary('present', focus, arm)  
    robot.PlanToTSR(present_tsr)  
    preshape = {finger1=1, finger2=1,  
                finger3=1, spread=3.14}  
    robot.arm.hand.MoveHand(preshape)
```

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def Present_ADA(robot, focus, arm):  
    present_tsr = robot.tsrlibrary('present', focus, arm)  
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*Key Contribution:*  
*Robot Gesture Engine (RoGuE)*

# Robot Gesture Engine

Rachel Holladay  
Siddhartha Srinivasa

[www.personalrobotics.ri.cmu.edu](http://www.personalrobotics.ri.cmu.edu)

