Building Lifelike Humanoid (and Non-Humanoid) Characters

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Disney Research

Physical Characters in Theme Parks

Interactive/close ⟷ *Scripted/remote*

Meet and greet

Queue line

Attraction

Show

Building “Useless” Robots

Difficult to quantify the goal

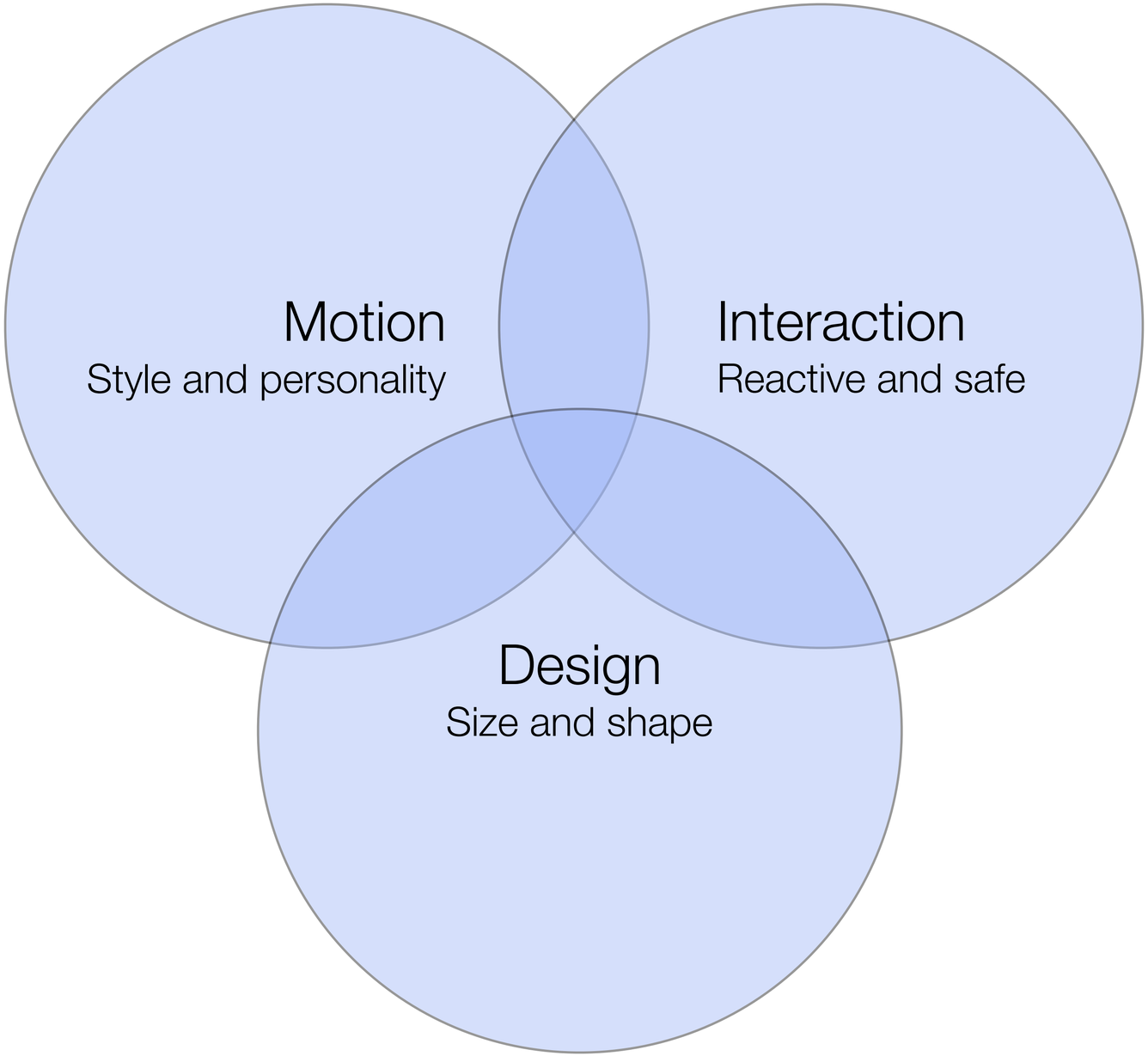
Technology must be transparent to users

Technology must be used to tell stories

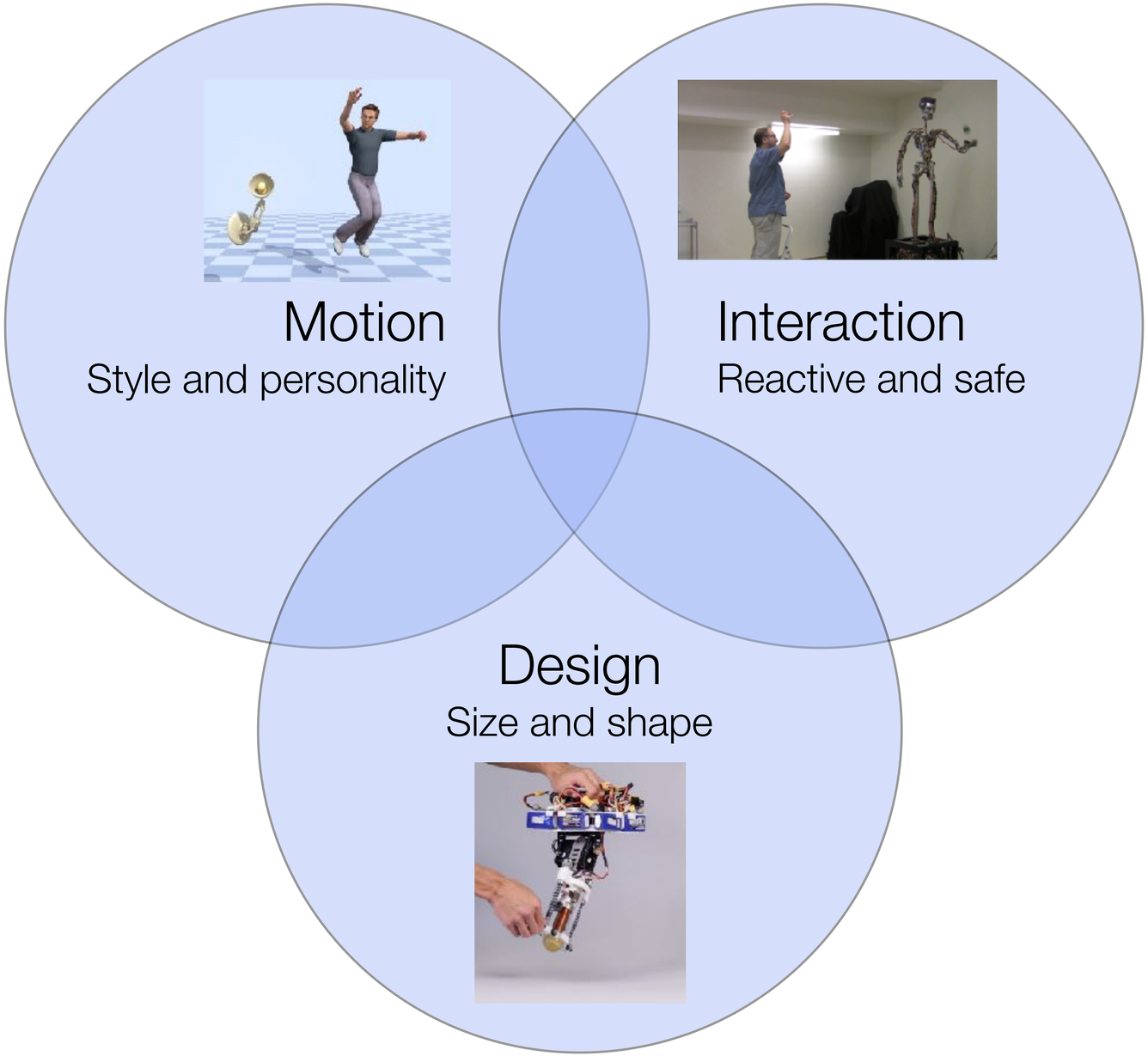
Requires human (anthropomorphic) form

Less environmental constraints

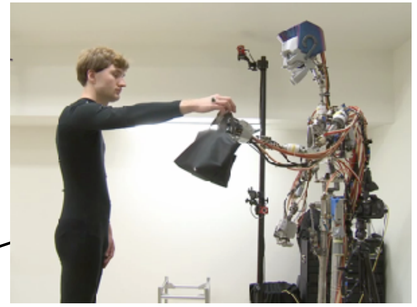
Lifelike Characters

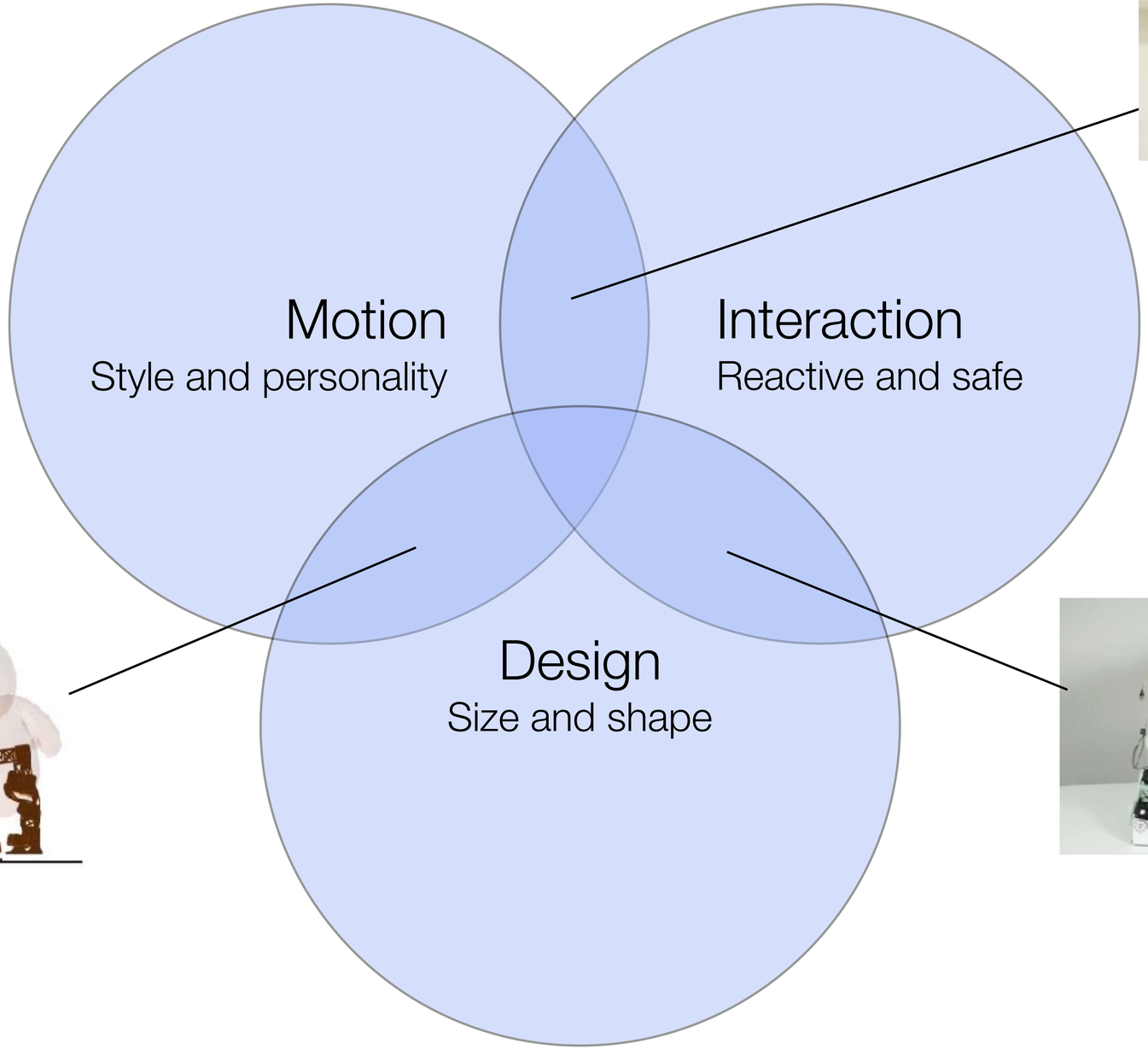


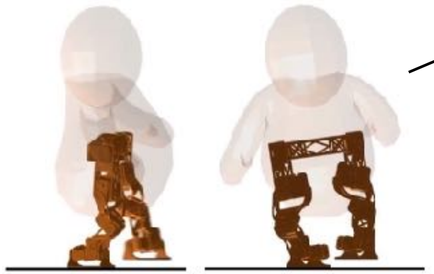
Talk Outline

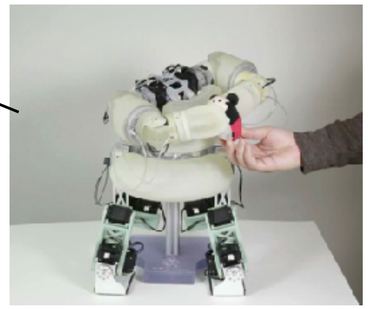


Talk Outline



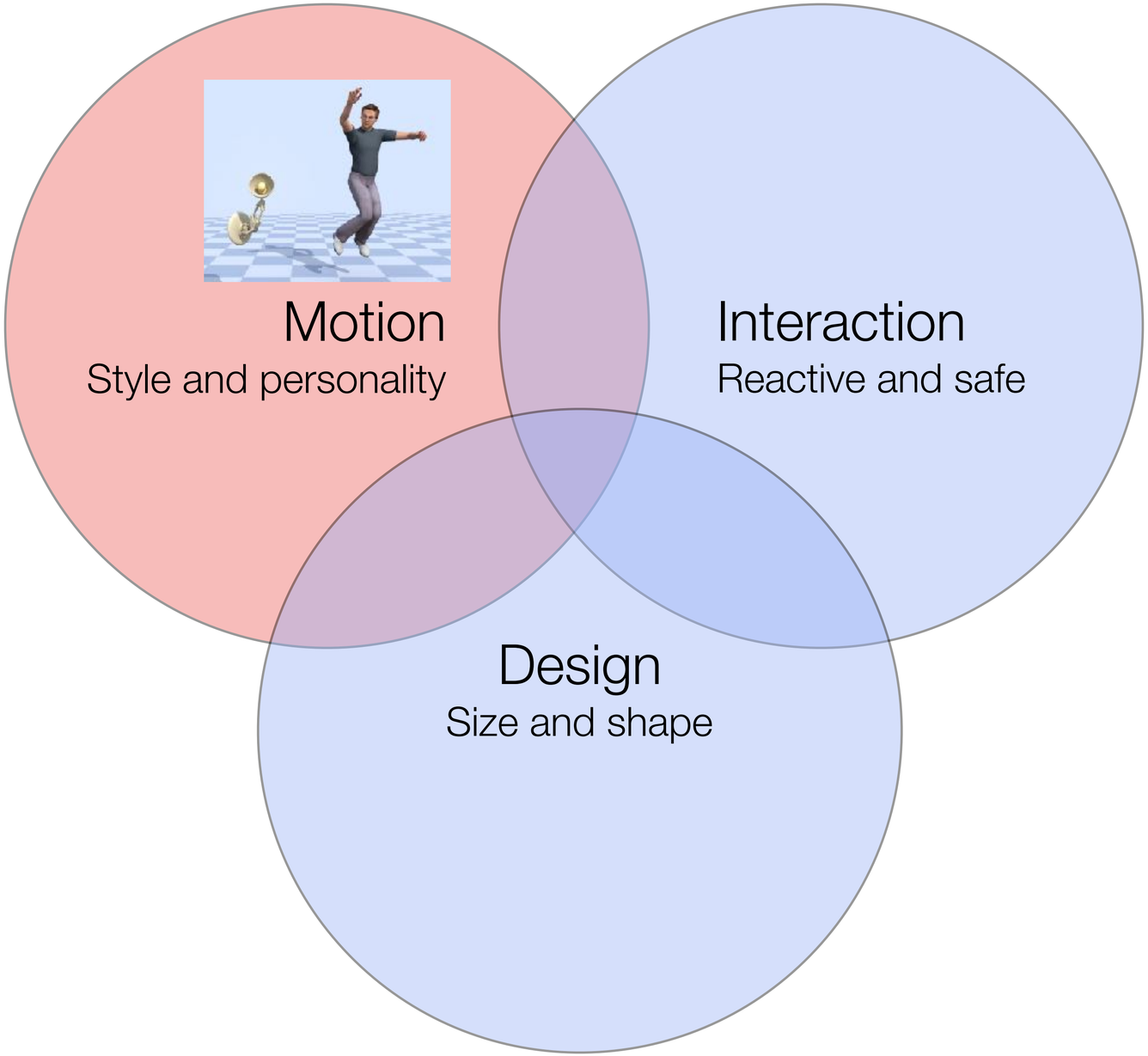






Motion

Style and personality



Motion

Style and personality

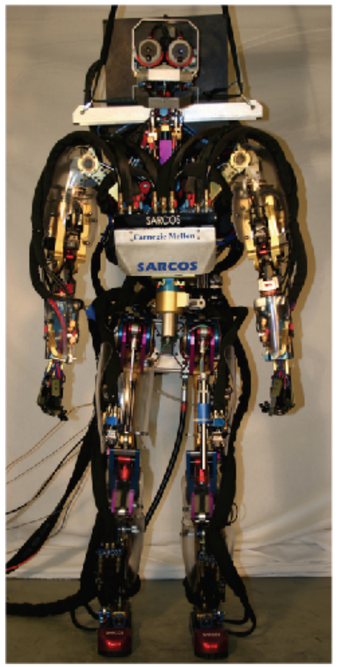
Created by animators (expensive)

No real locomotion/manipulation

Human to Humanoid Motion Retargeting

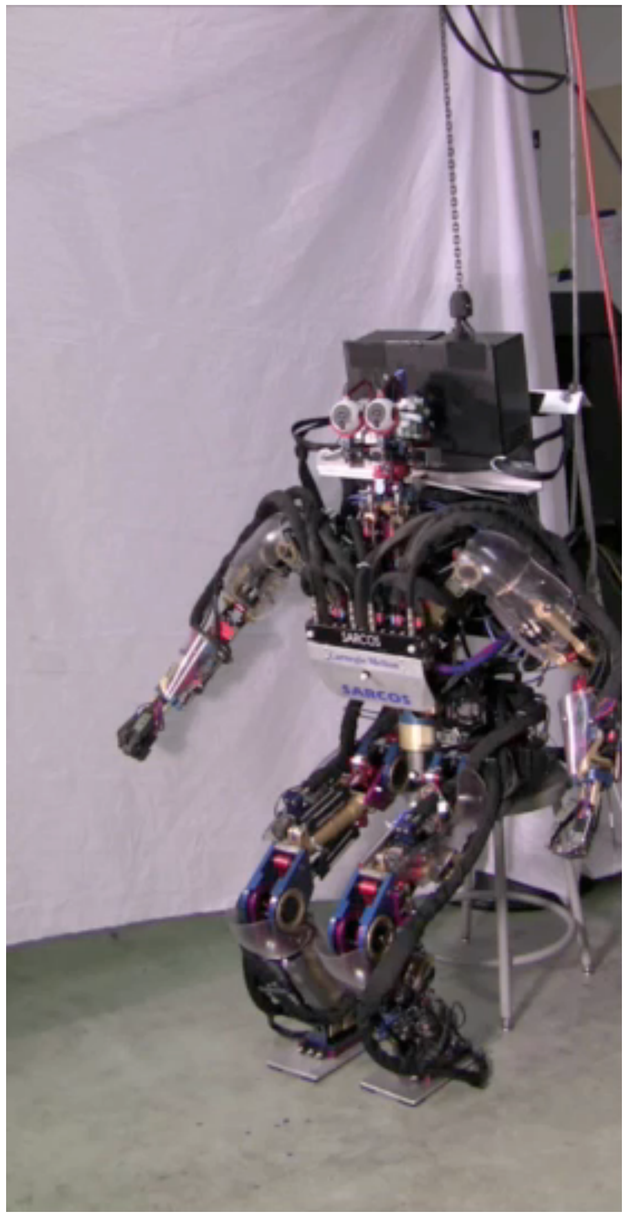
Already have style and personality but …

- Different kinematics and dynamics
- Different actuators
- Different constraints
  - Joint motion range
  - Joint velocity/acceleration limits
  - Joint torque limits
  - Contacts



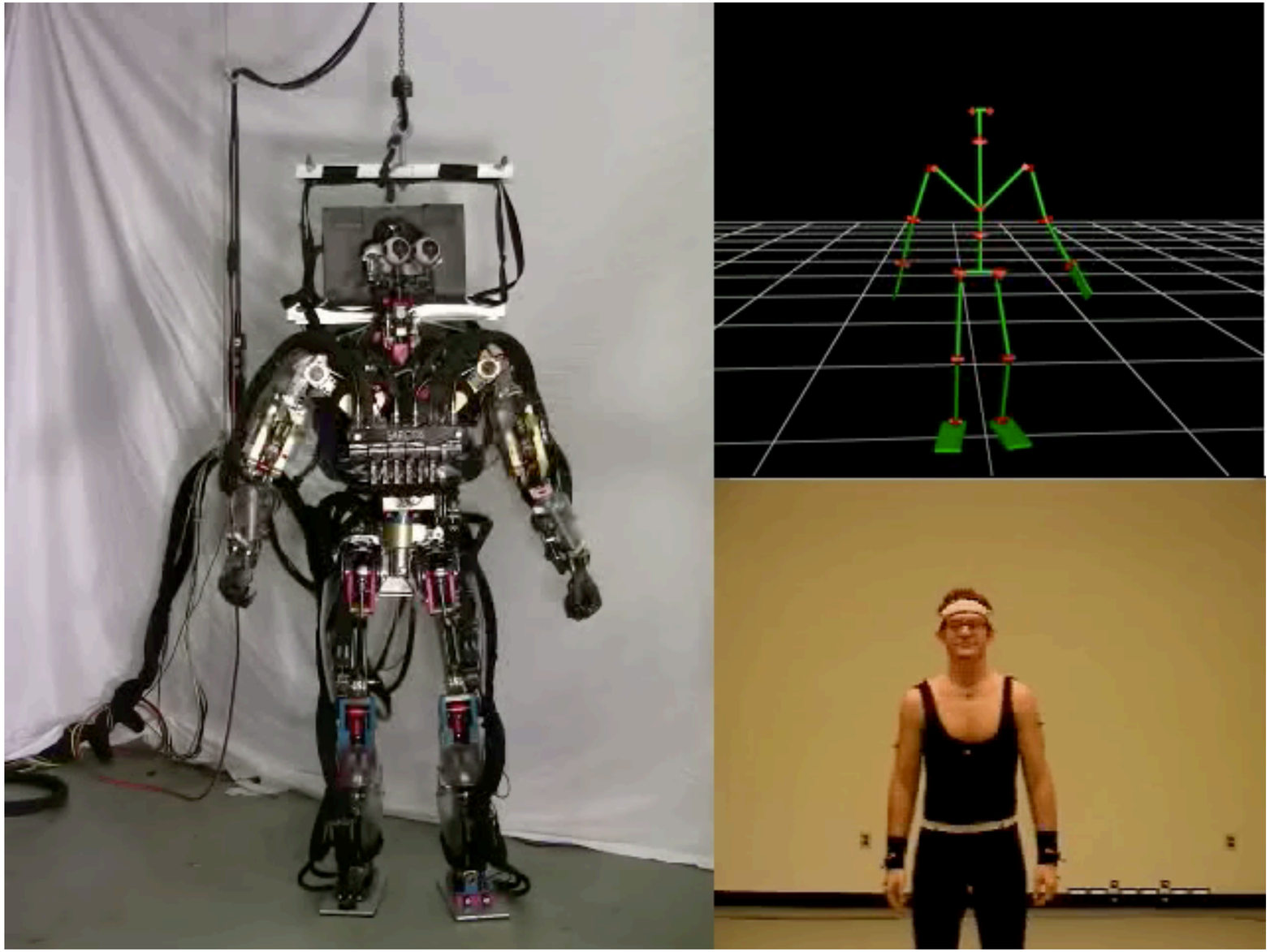
Human to Humanoid Motion Retargeting

[Mistry, Murai, Yamane, Hodgins 2010]

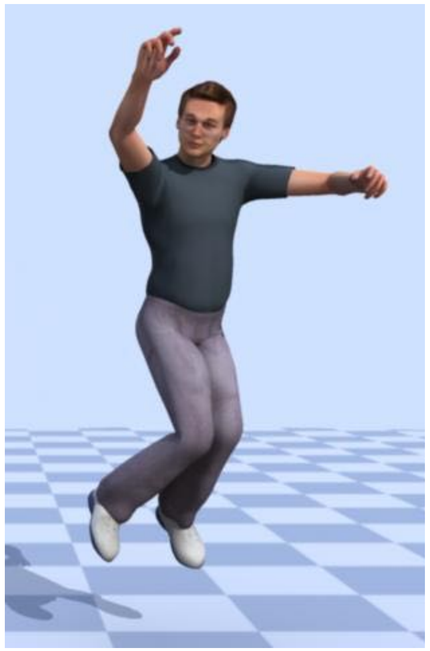


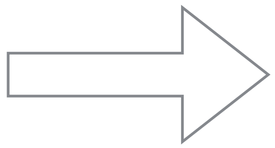
Human to Humanoid Motion Retargeting

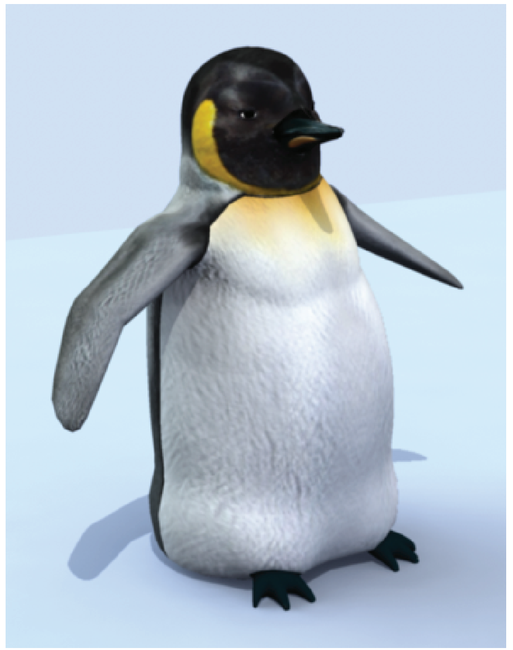
[Yamane, Anderson, Hodgins 2010]



Human to Non-humanoid Motion Retargeting

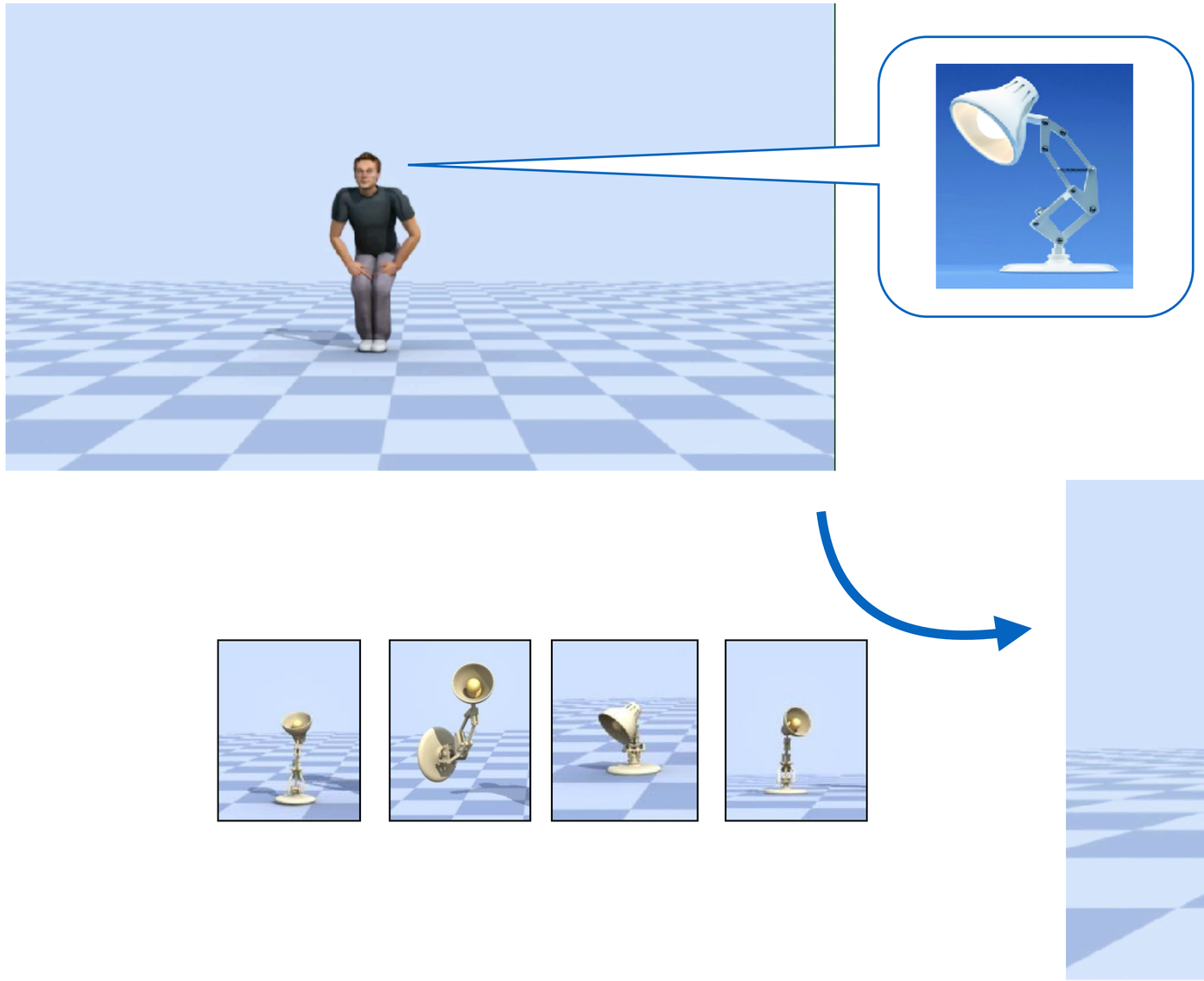






Human to Non-humanoid Motion Retargeting

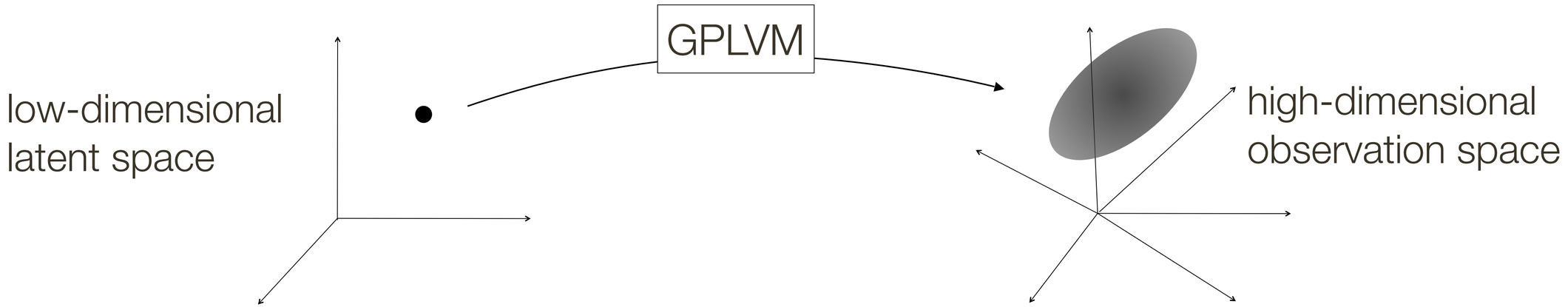
[Yamane, Ariki, Hodgins 2010]



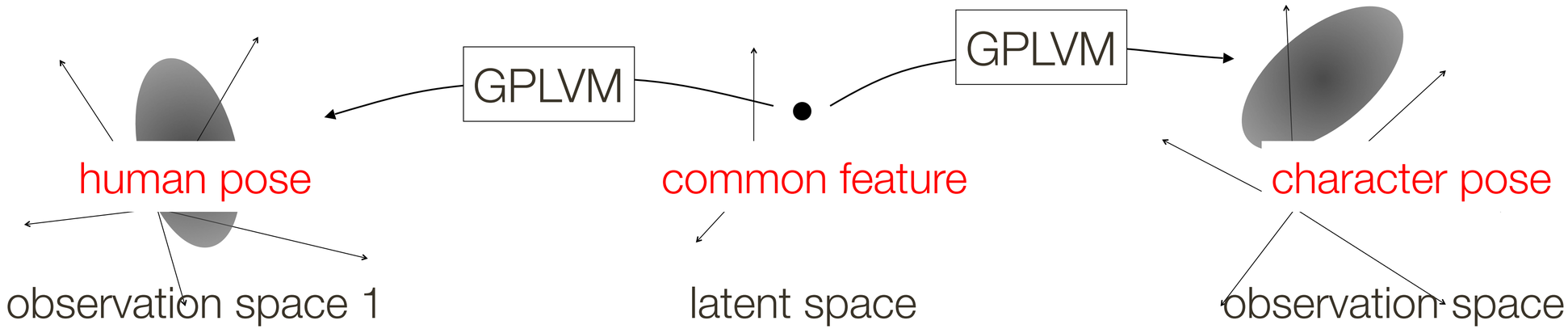
Mapping Function

[Yamane, Ariki, Hodgins 2010]

Gaussian process latent variable model (GPLVM) [Lawrence 2003]

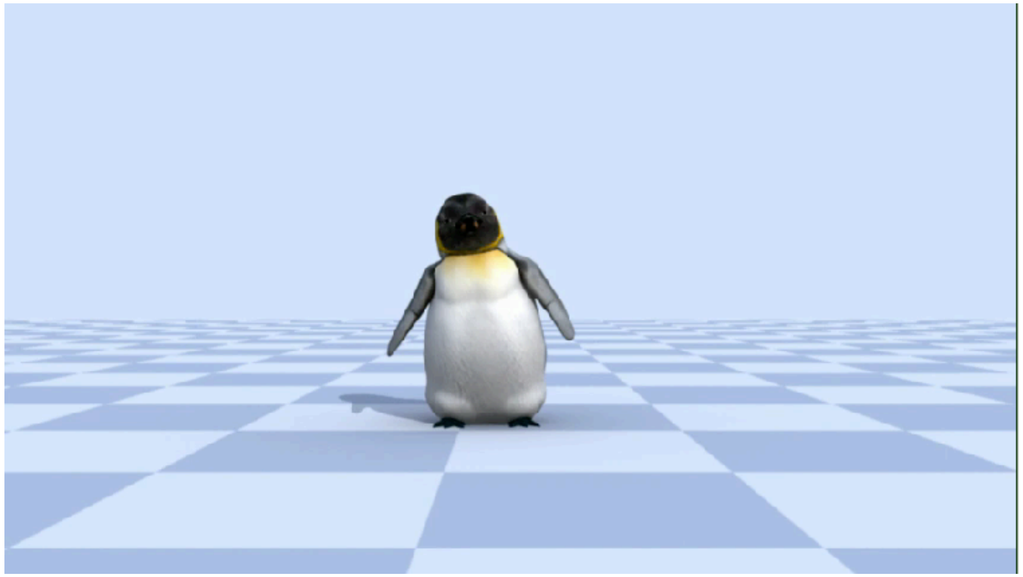


Shared GPLVM [Ek et al. 2007]



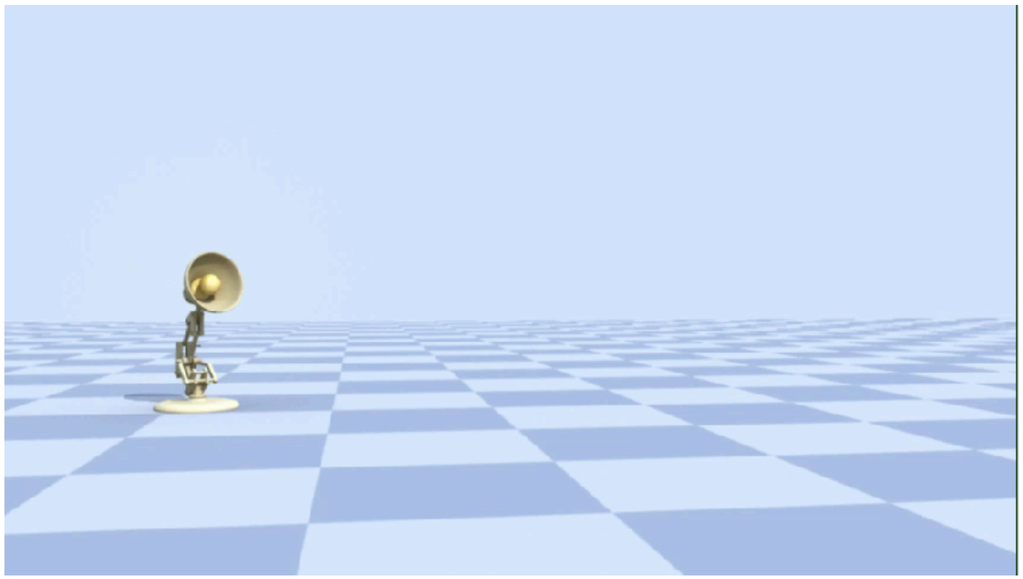
Results: Emotional Motions

[Yamane, Ariki, Hodgins 2010]

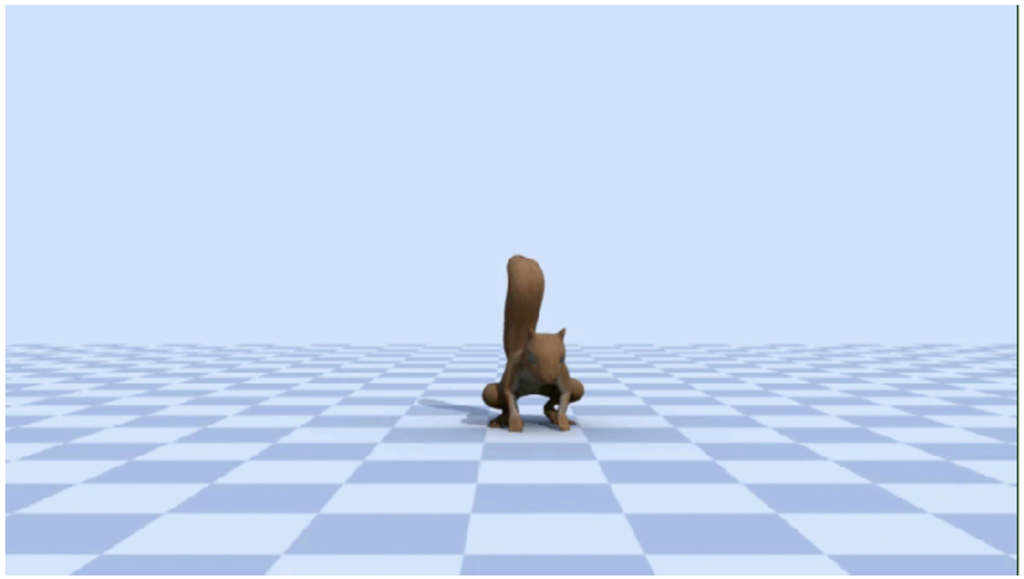


anger

disgust



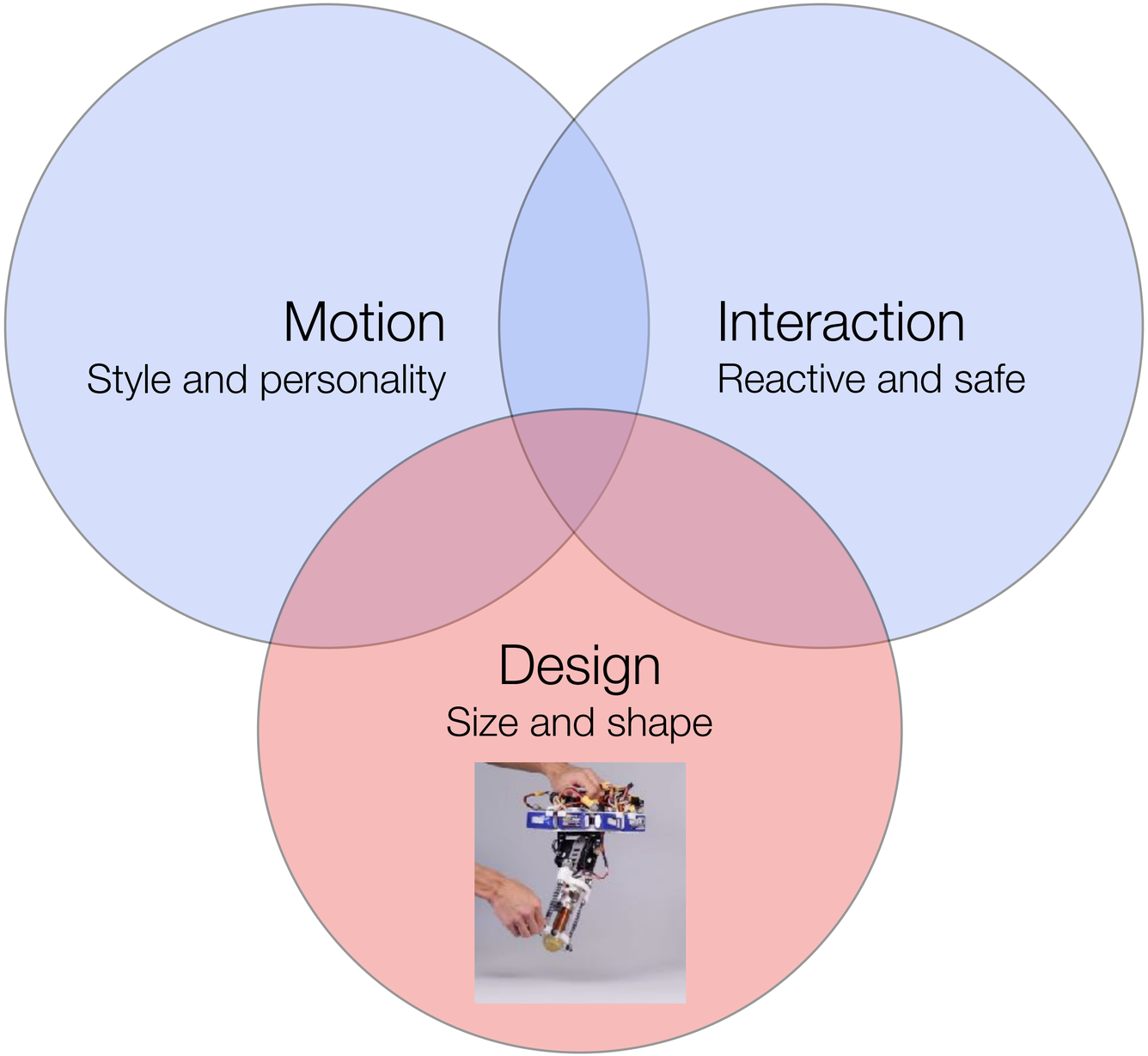
sadness



fear

Design

Size and shape



Design

Size and shape

Size/shape constraints

Untethered

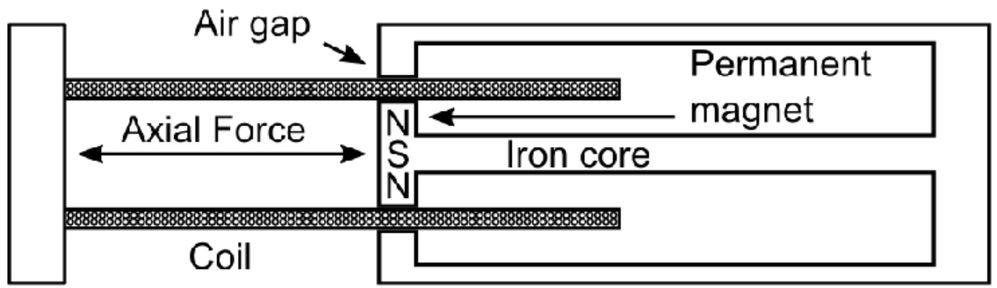
Lots of manual work

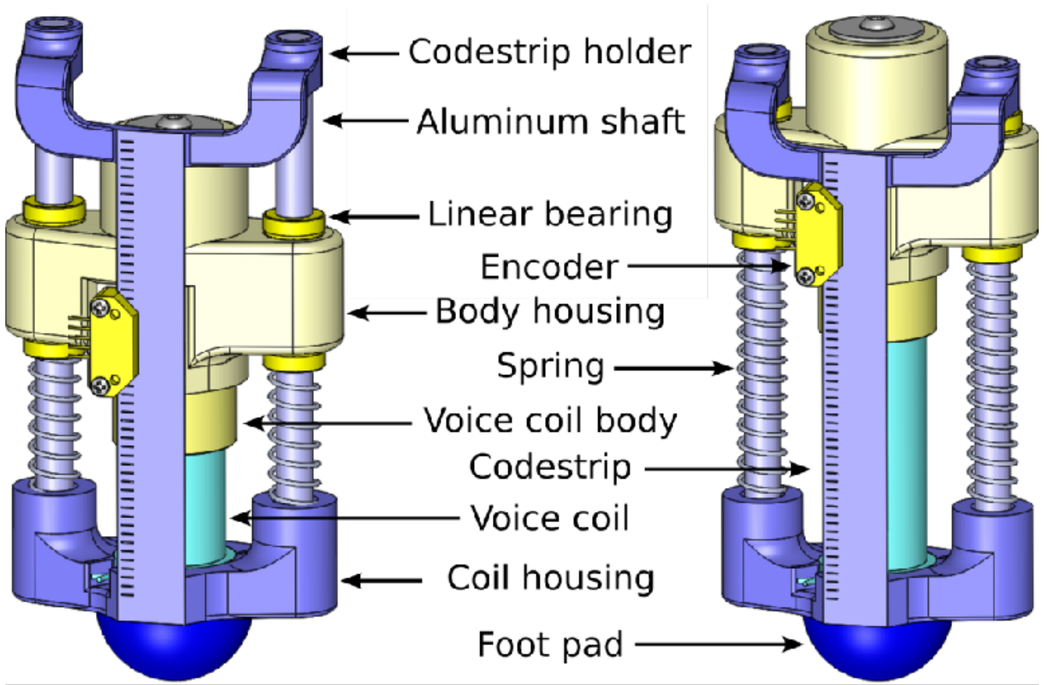
Untethered Hopping Robot

[Batts, Kim, Yamane 2016]

Linear Elastic Actuator in Parallel (LEAP)

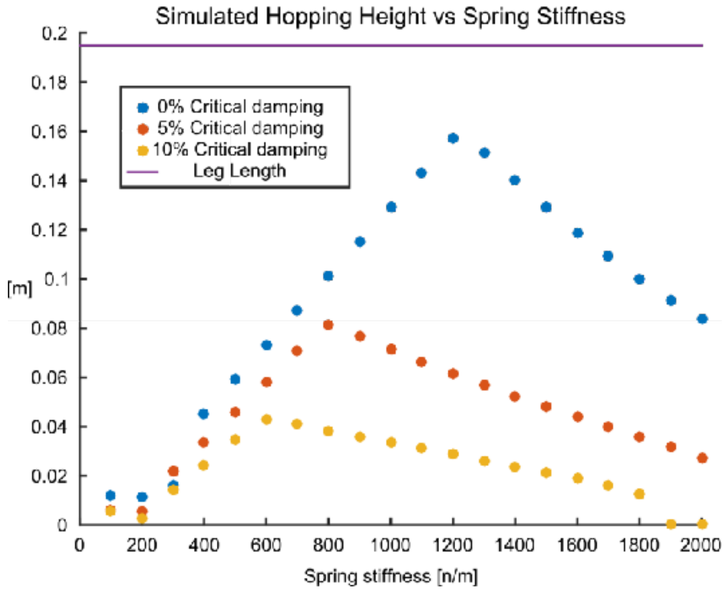
Voice coil

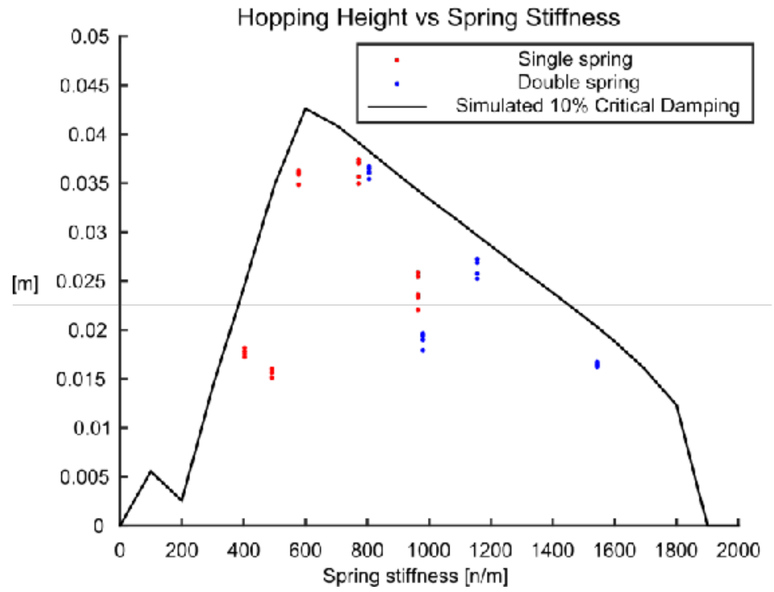




1D Testbed

Stiffness optimization





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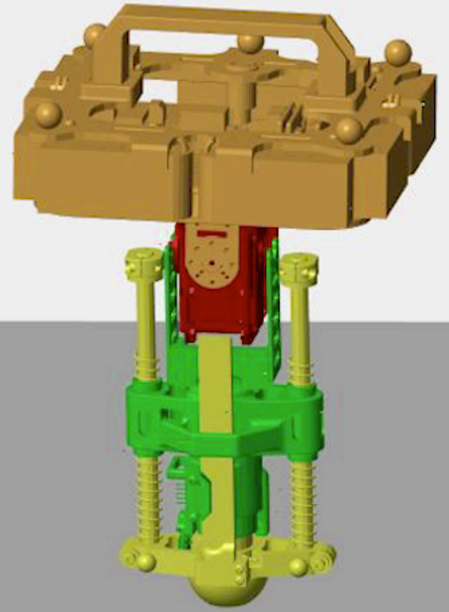

© Disney

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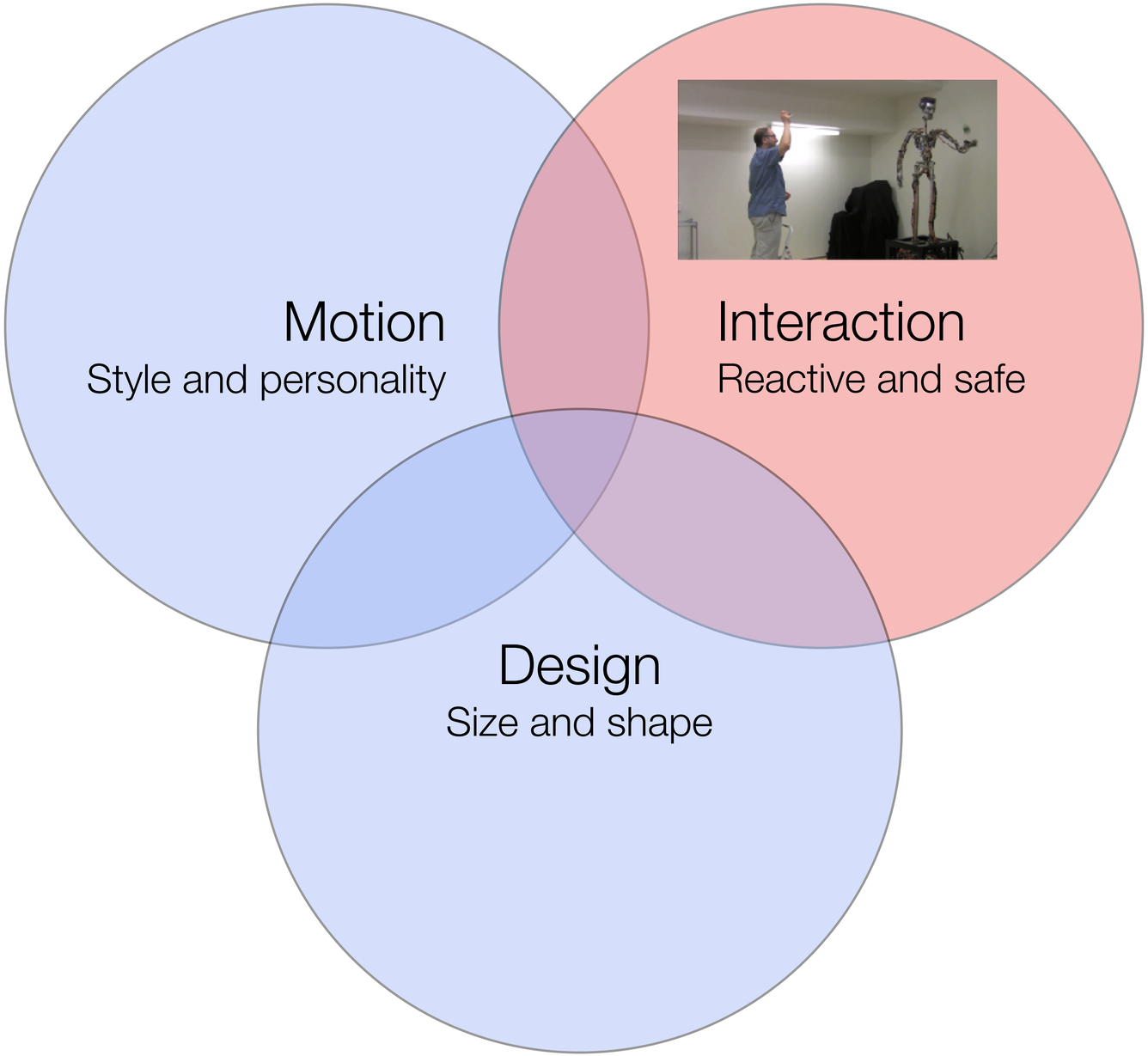
Lifelike Characters



Interaction

Reactive and safe

Teleoperation (expensive)

No physical interaction

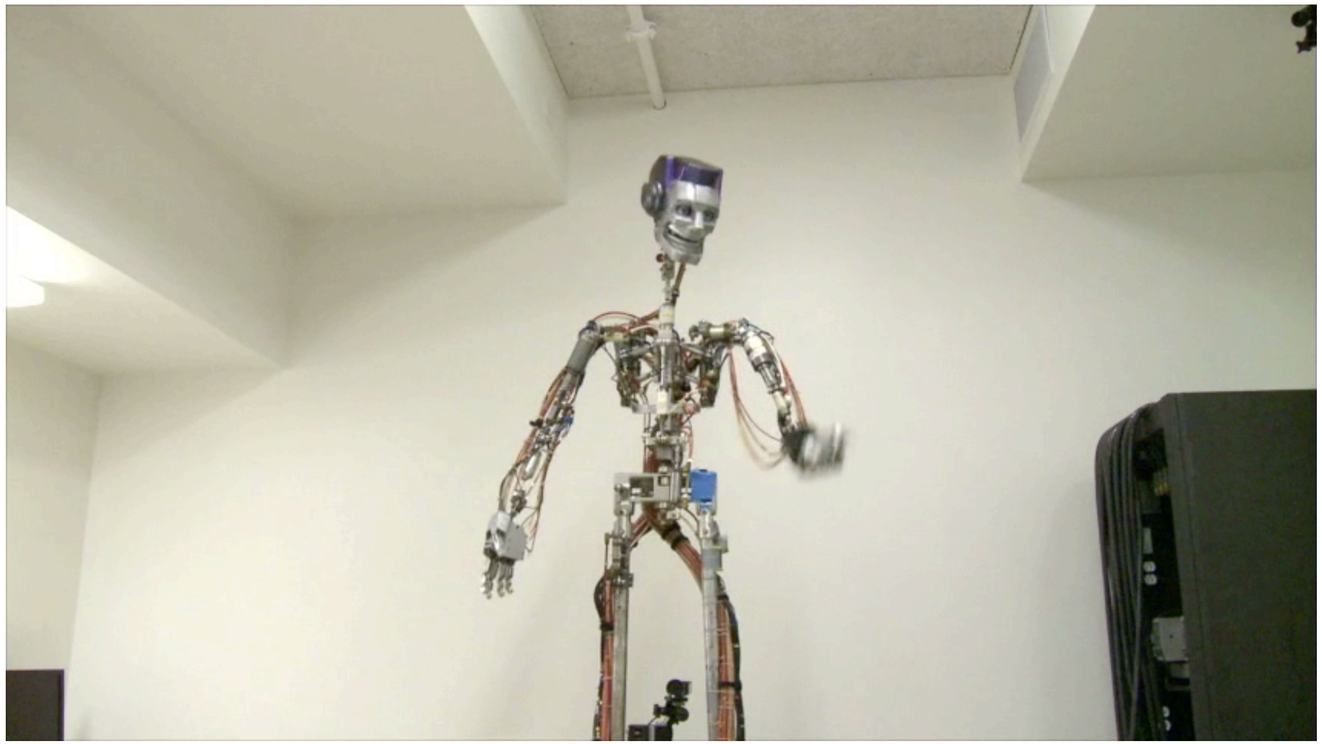
Safe Autonomous Interaction: Playing Catch

[Kober, Glisson, Mistry 2012] [Carter et al. 2014]

Safe physical interaction between guests and robot

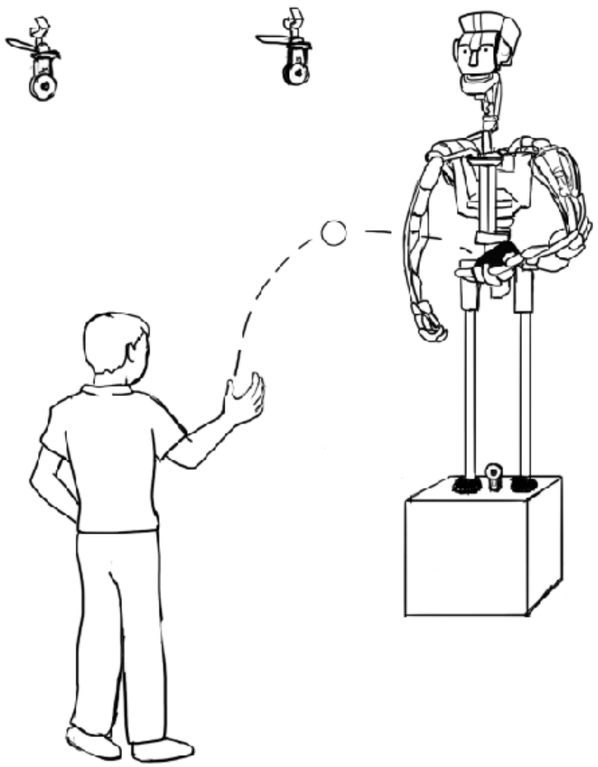
Uses existing Audio-Animatronic Figure and controller

Reaction to ball drop with social gestures



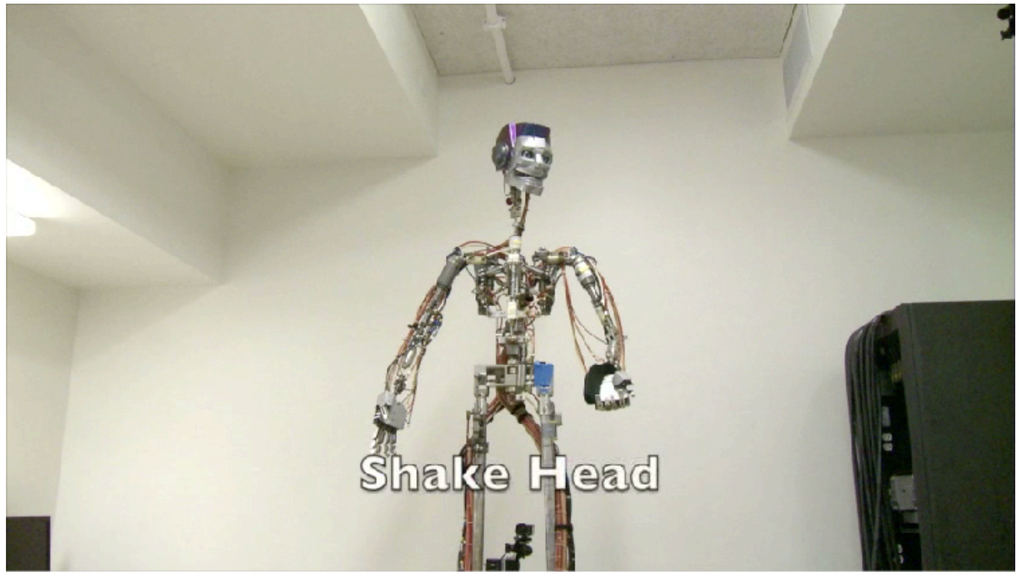
System Setup

Optional subtitle



Robot

- All gestures are hand-coded and invoked based on ball trajectory
- Lookup table for arm inverse kinematics



Stereo cameras

- Kalman filter to smooth trajectory in flight
- Predict catching location

Reaction to Ball Drop

[Kober, Glisson, Mistry 2012]

User Study

[Carter et al. 2014]

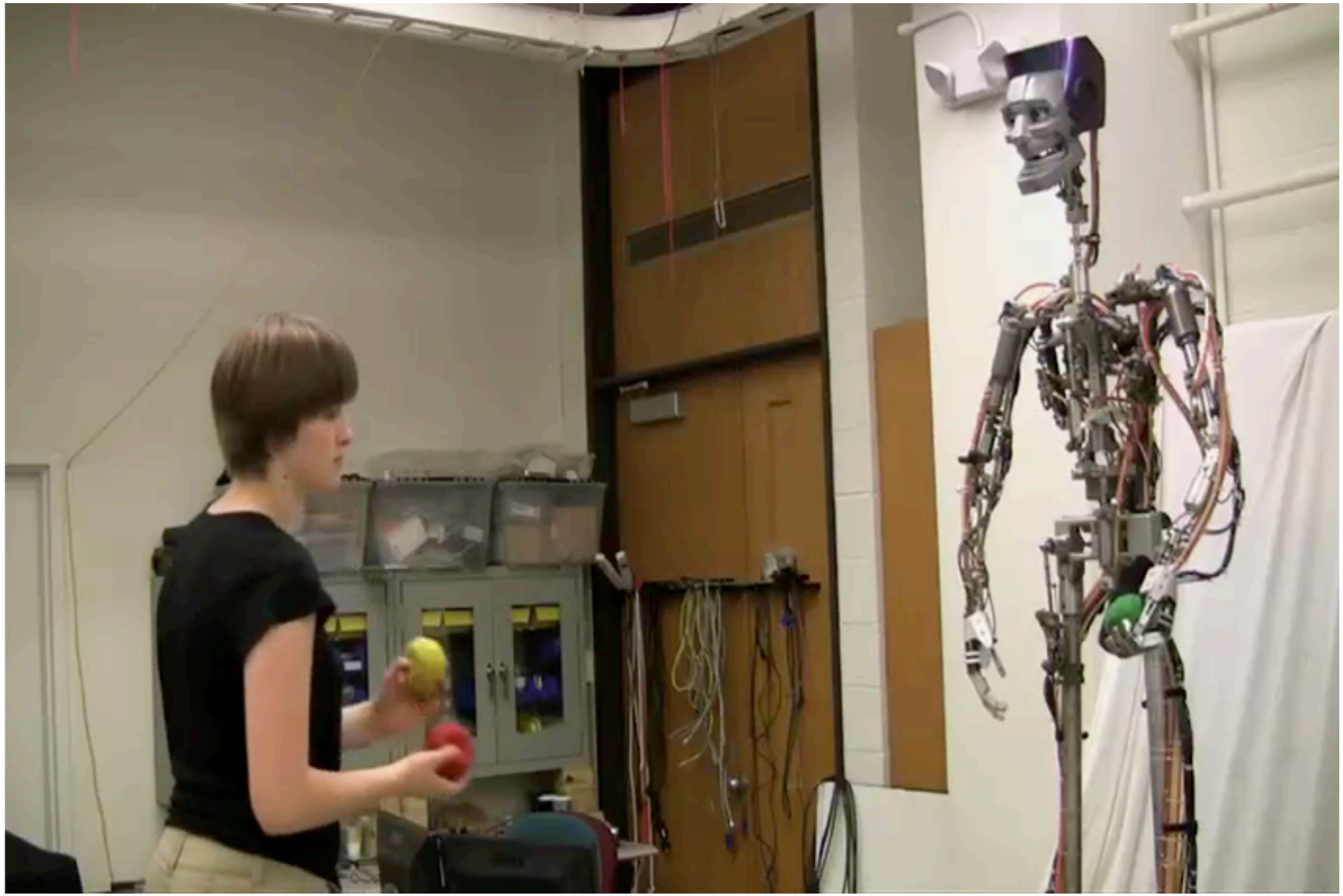
Questionnaire: more responsive, engaging, and humanlike when the robot displayed gestures

Smile detection: more smiles when the robot displayed gestures

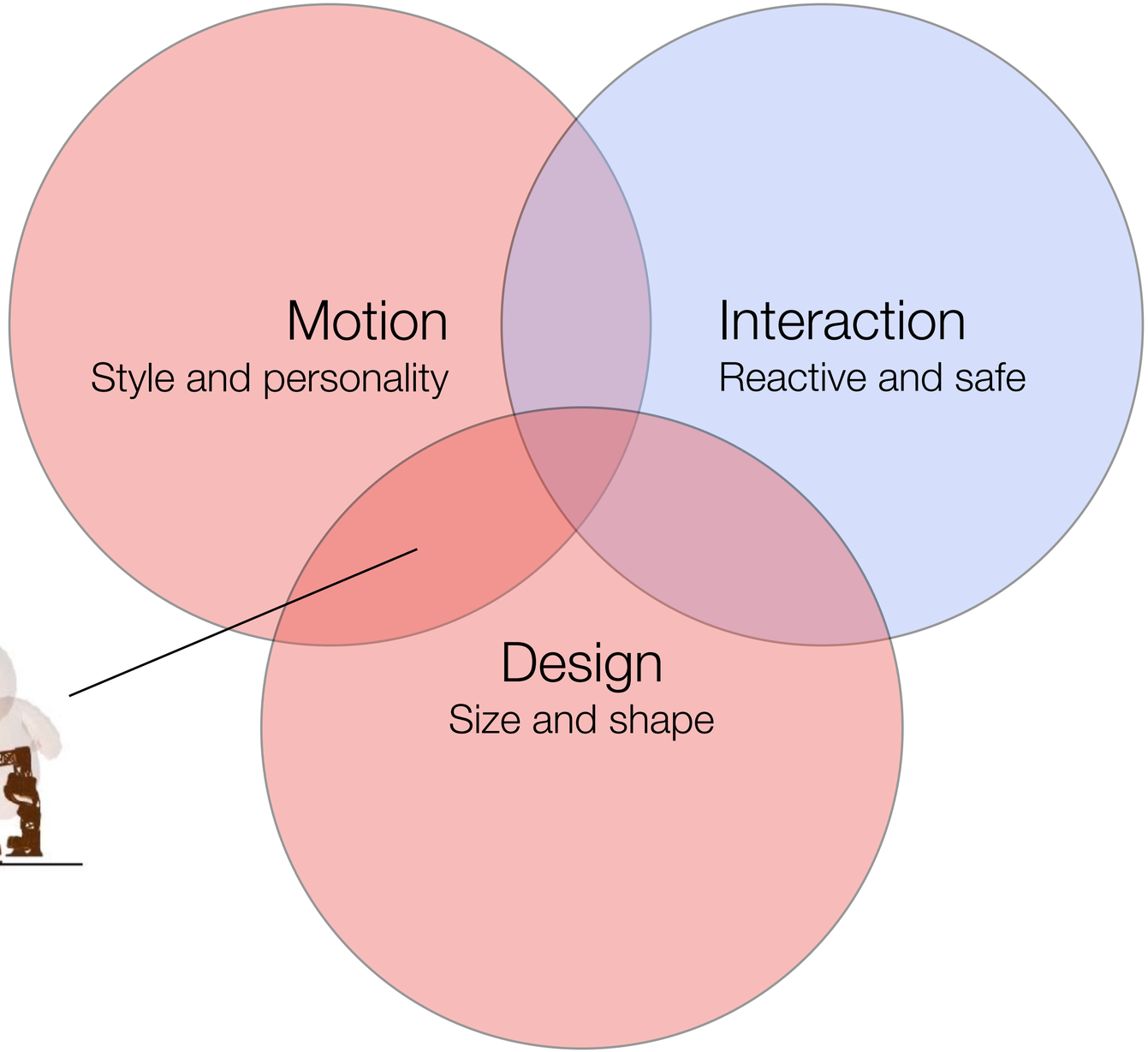
Long-term study necessary to address novelty effect

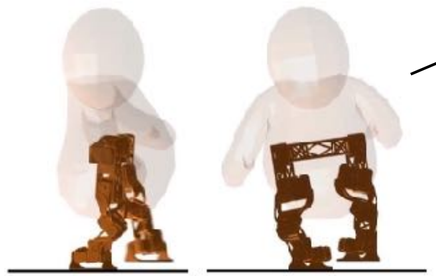
Juggling with Trained Users

[Kober, Glisson, Mistry 2012]



Lifelike Characters



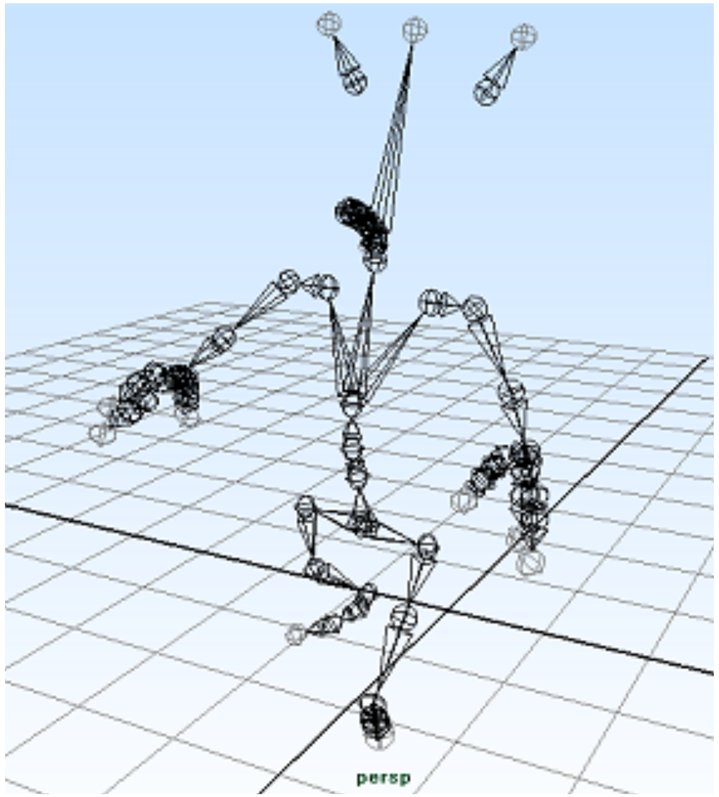


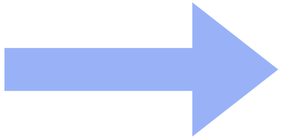
Robot from Animation Character

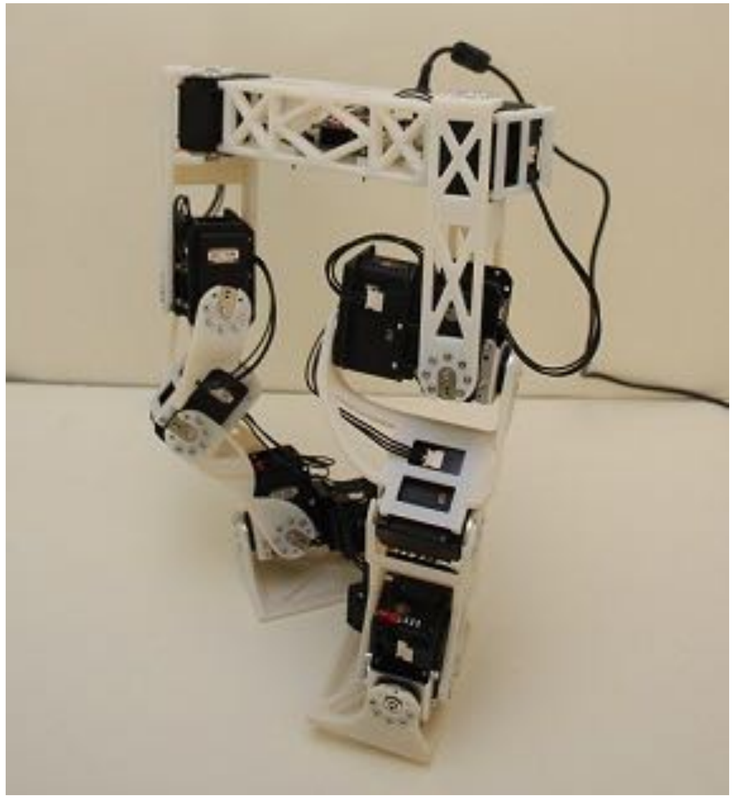
[Song, Kim, Yamane 2015]

Maya model→kinematics, shape

Maya animation→number of joints, range of motion and torque







Animation Retargeting

[Song, Kim, Yamane 2015]

Animation Retargeting

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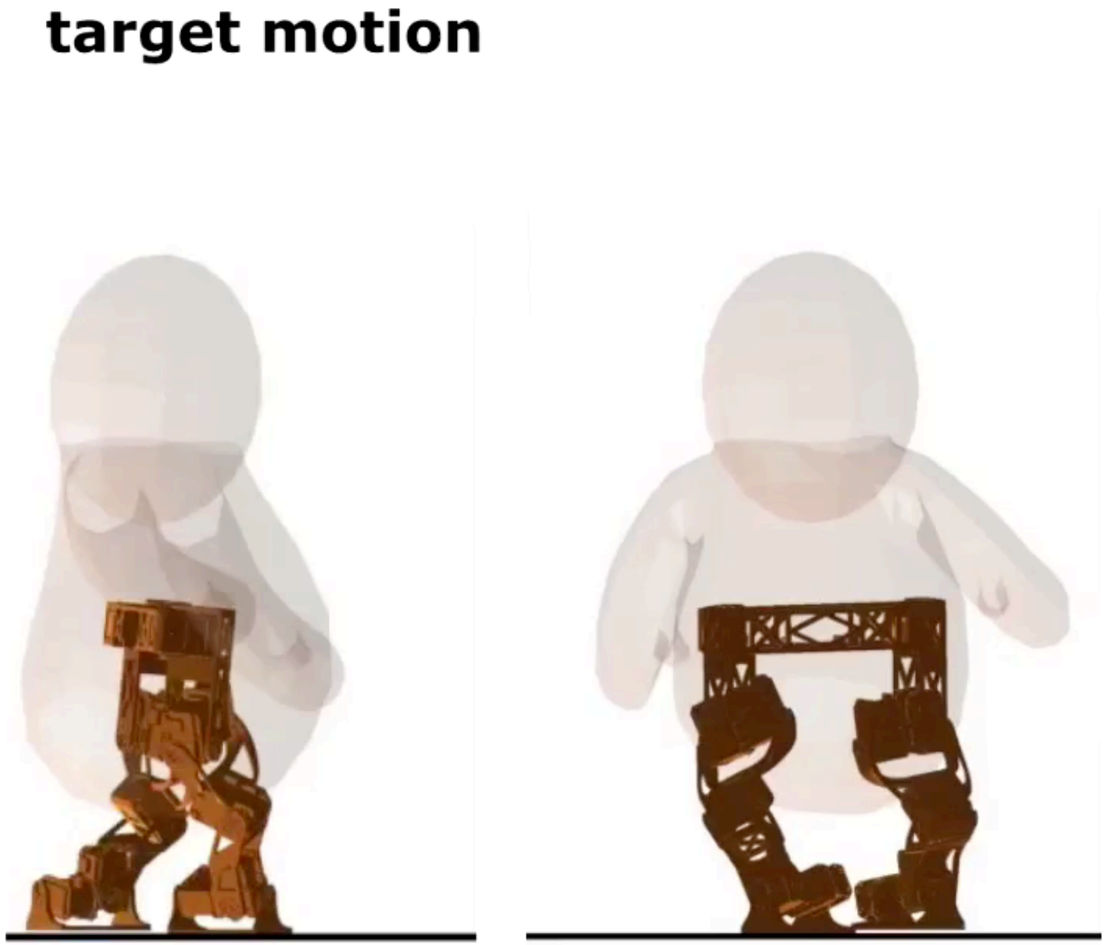
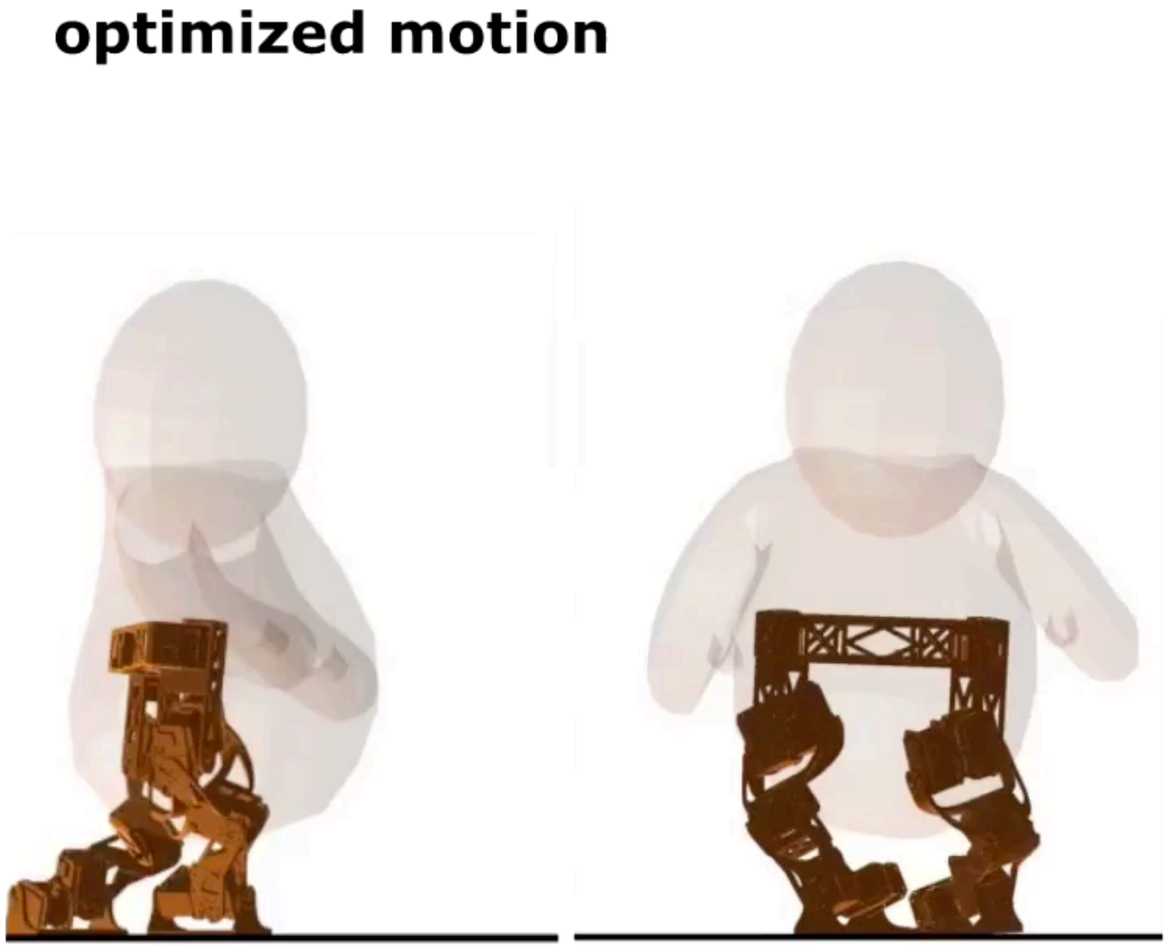


Animation Retargeting

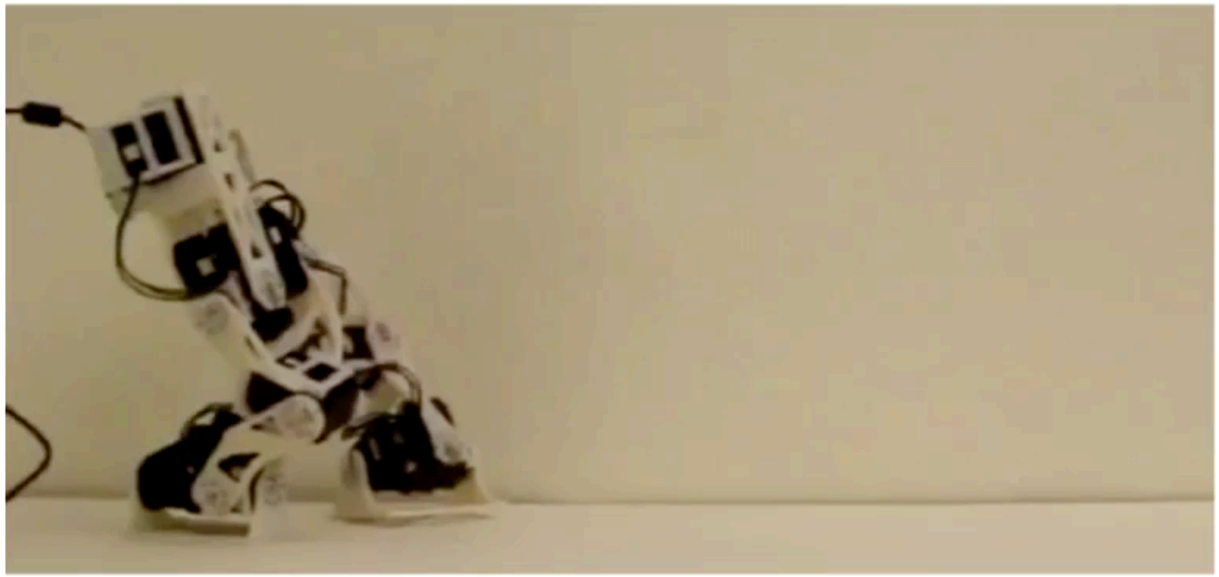
[Song, Kim, Yamane 2015]

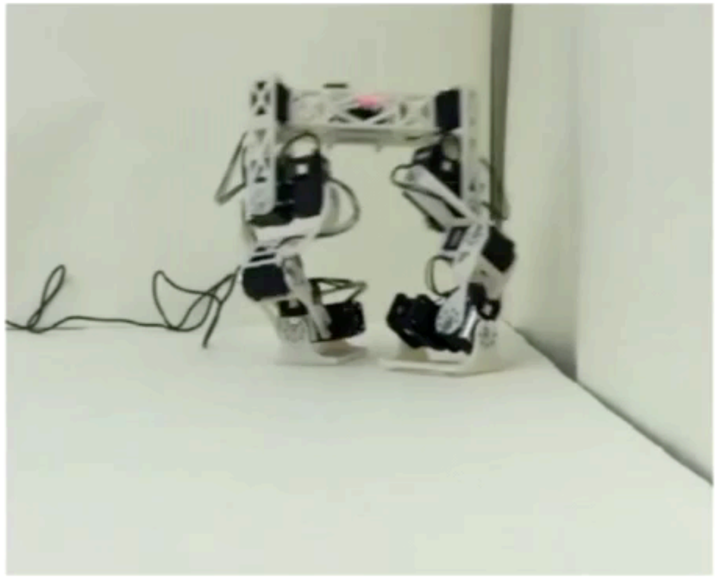


Animation Retargeting

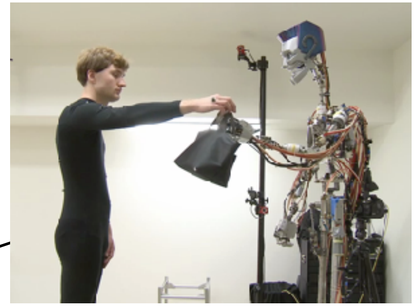
[Song, Kim, Yamane 2015]

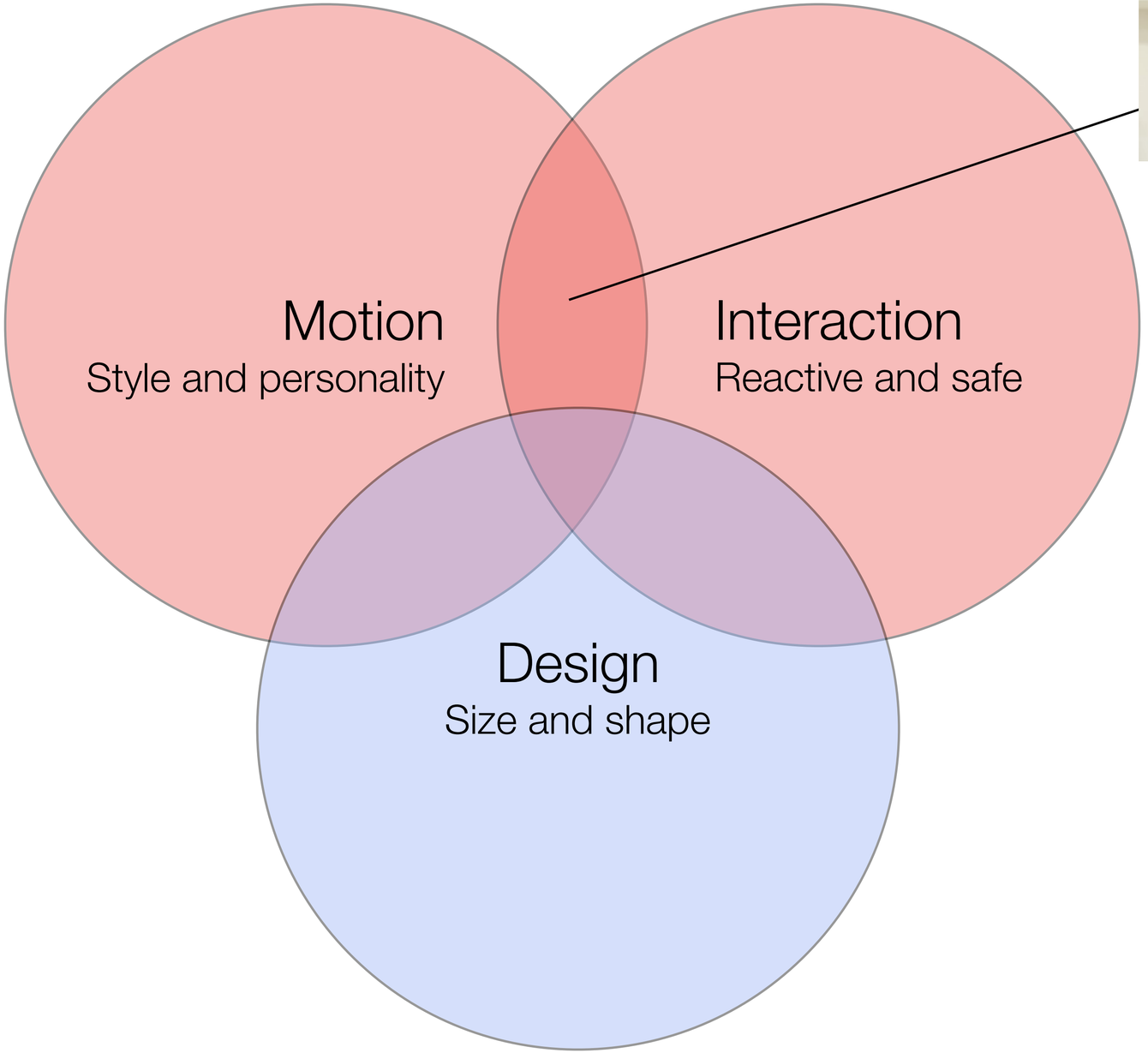
optimized walking on hardware





Lifelike Characters



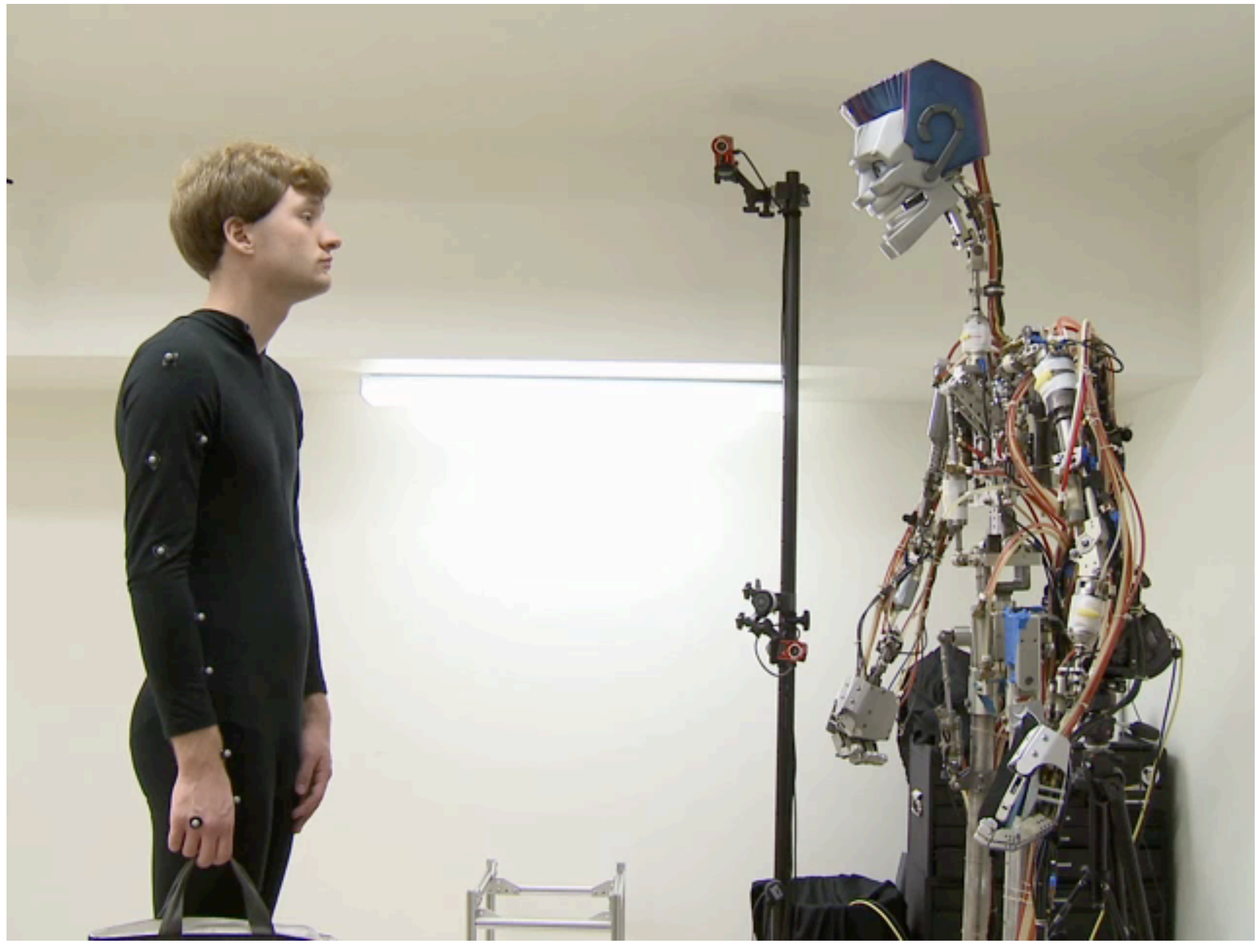


Human-to-Robot Handover

[Yamane, Revfi, Asfour 2013]

Quick and natural adaptation to human motion

Learn from human-to-human handover



Human-to-Human Handover

[Yamane, Revfi, Asfour 2013]

Passer starts moving the object

Receiver recognizes the intention and starts reaching out

Passer and receiver implicitly agree on handover position

Receiver grasps the object

Passer releases the object

Human-to-Robot Handover

[Yamane, Revfi, Asfour 2013]

Passer starts moving the object

Robot recognizes the intention and starts reaching out

Passer and robot implicitly agree on handover position

Robot grasps the object

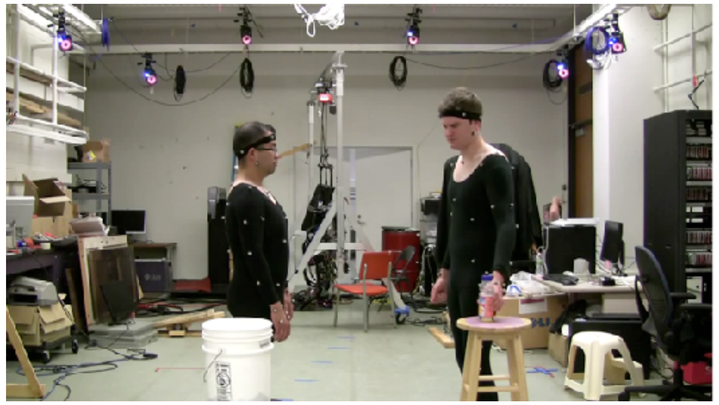
Passer releases the object

Observation

[Yamane, Revfi, Asfour 2013]

Similar motions in similar situations

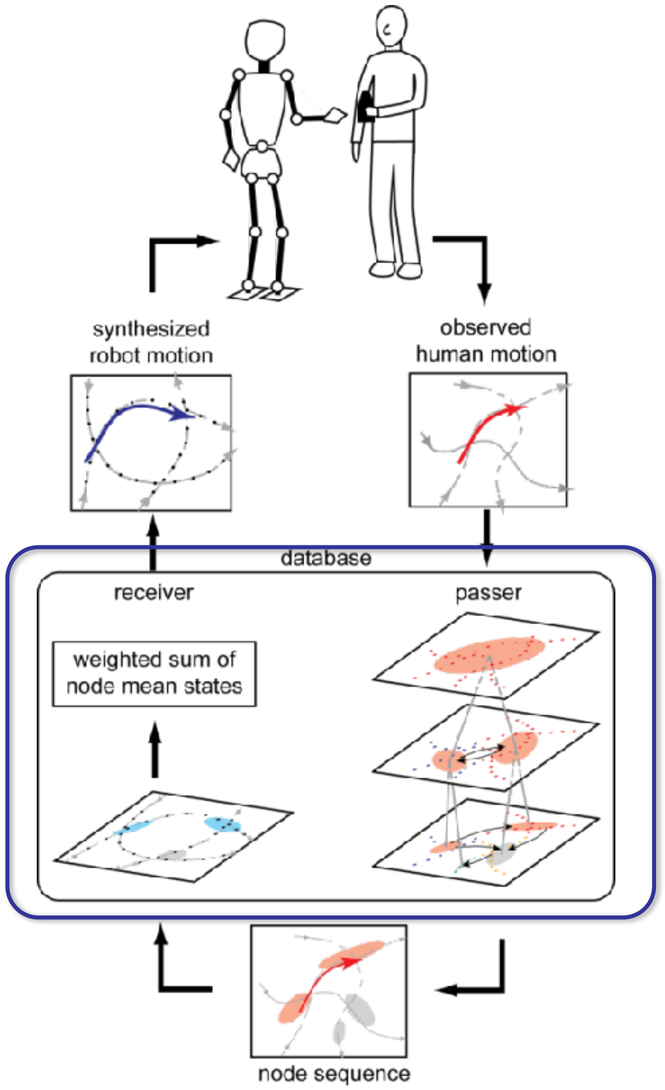
- Relative orientation and distance
- Object/grasp type



Predict the receiver's pose from the passer's with database

Method Overview

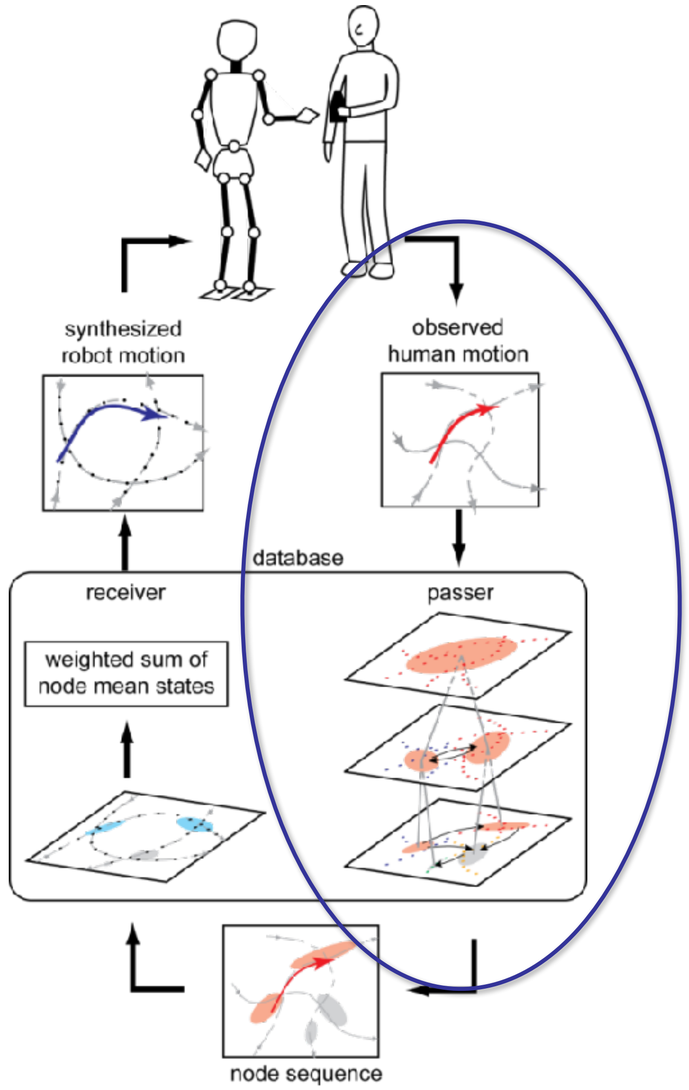
[Yamane, Revfi, Asfour 2013]



Database of human-to-human handover motions

Method Overview

[Yamane, Revfi, Asfour 2013]

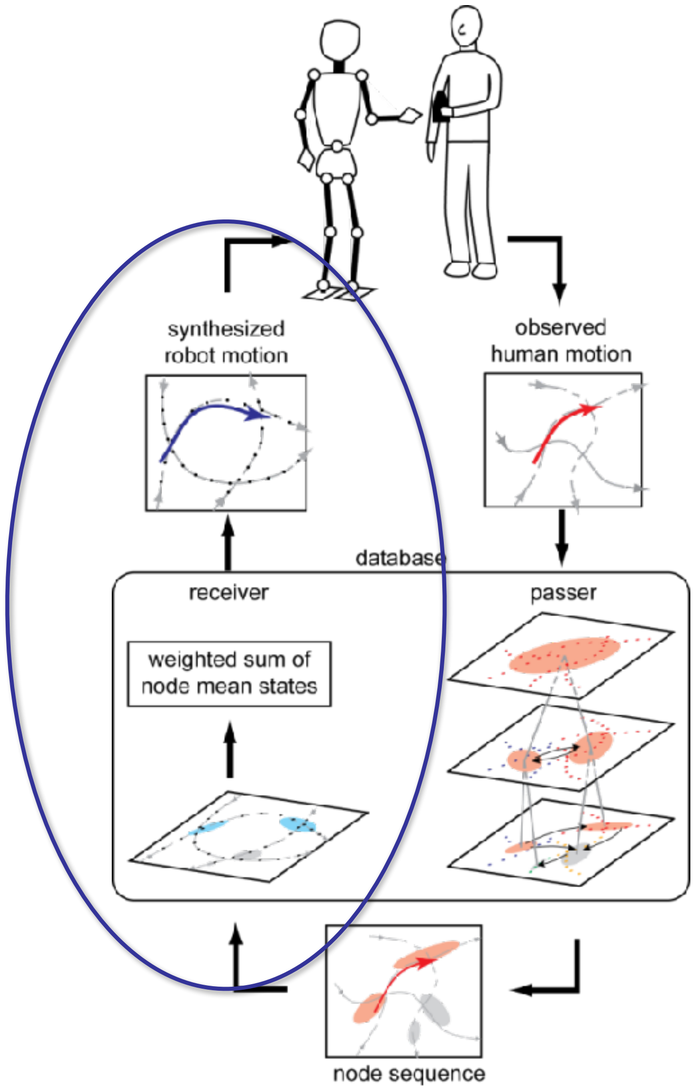


Search observed human motion within the passer motion database

Database of human-to-human handover motions

Method Overview

[Yamane, Revfi, Asfour 2013]



Synthesize robot motion based on the corresponding receiver motion

Search observed human motion within the passer motion database

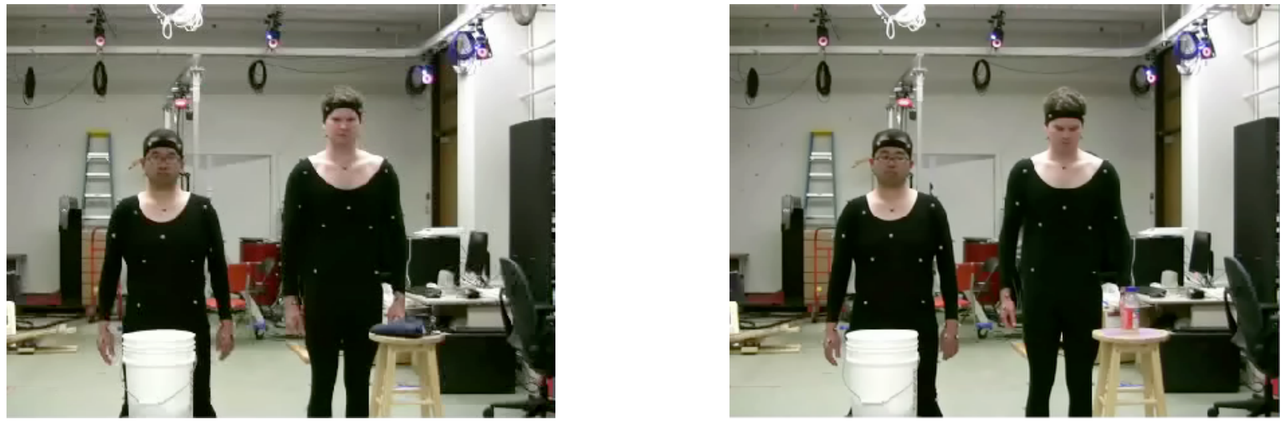
Database of human-to-human handover motions

Sample Data

[Yamane, Revfi, Asfour 2013]

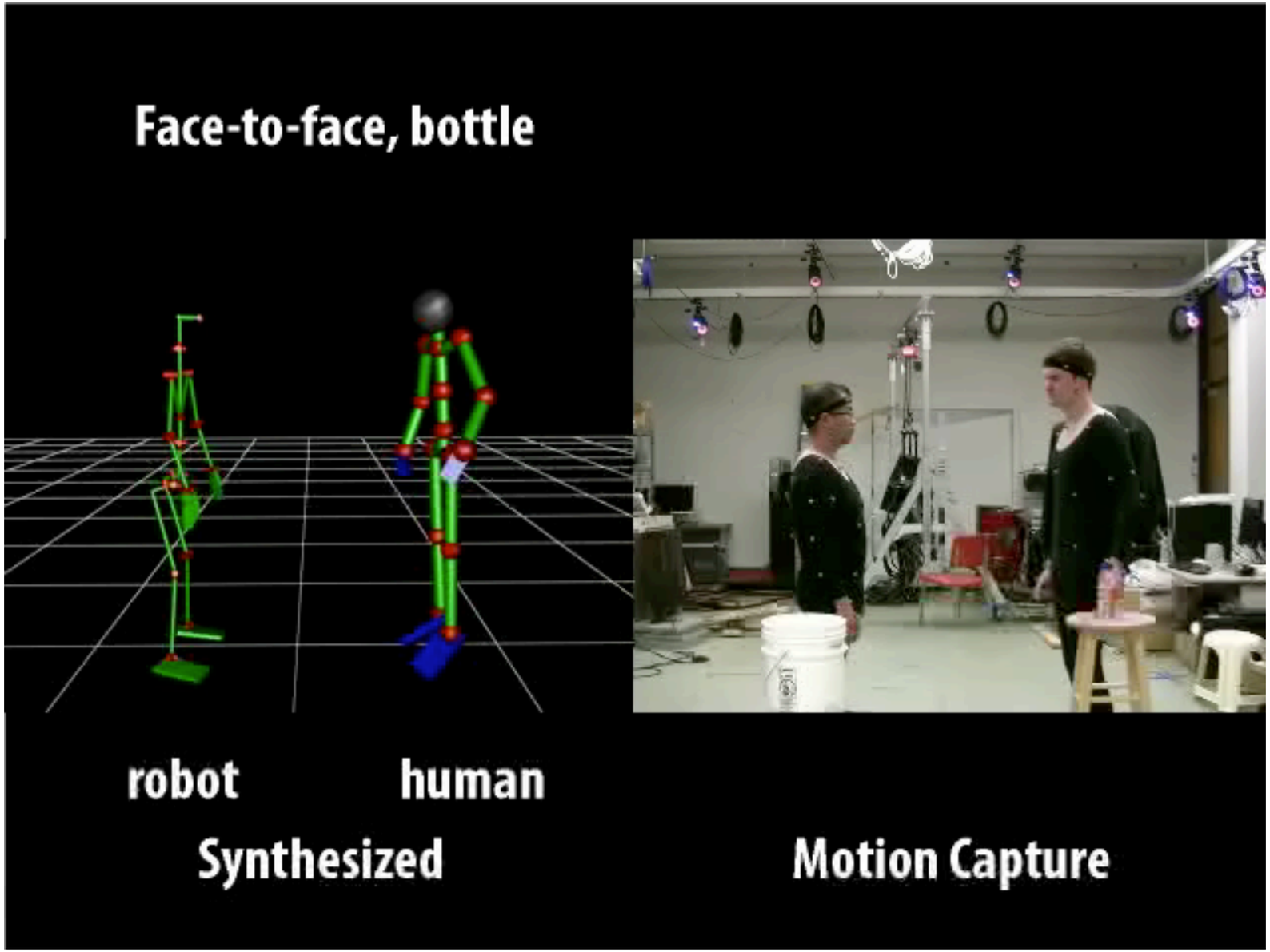
“Face-to-face” dataset (3 objects, 1686 frames, 10 layers)

“Side-by-side” dataset (2 objects, 863 frames, 9 layers)



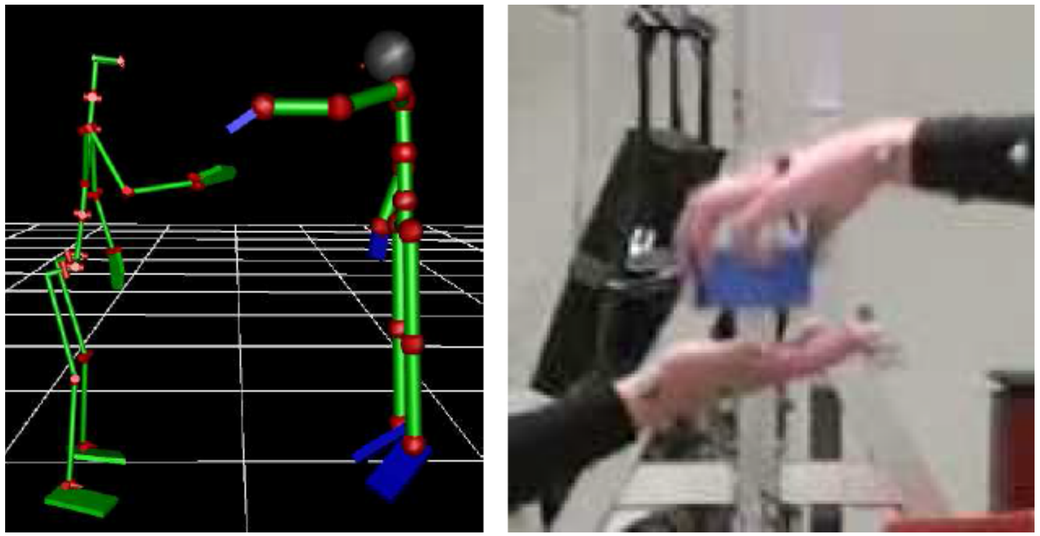
Simulation: Synthesis from Test Data

[Yamane, Revfi, Asfour 2013]

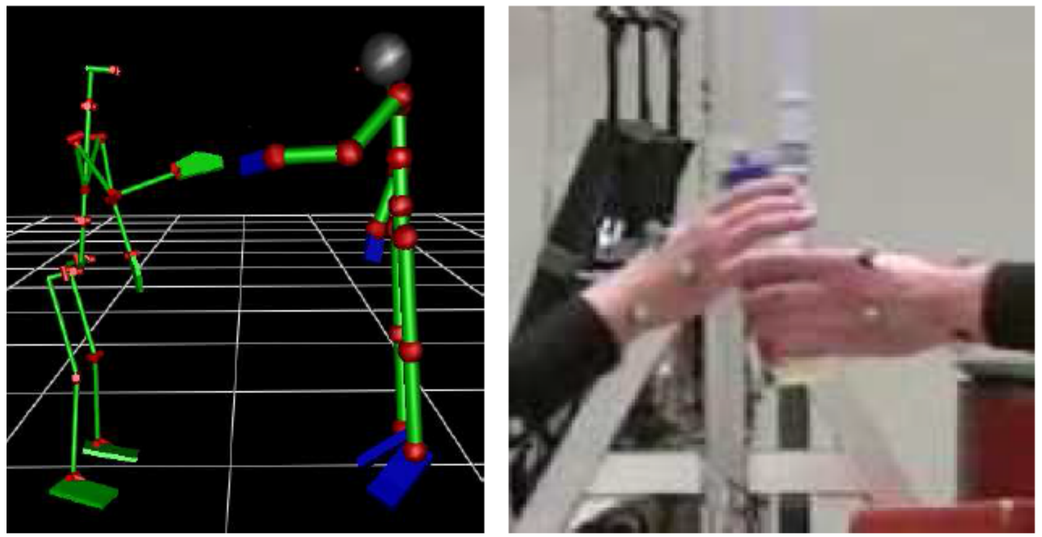


Simulation: Detailed View

[Yamane, Revfi, Asfour 2013]



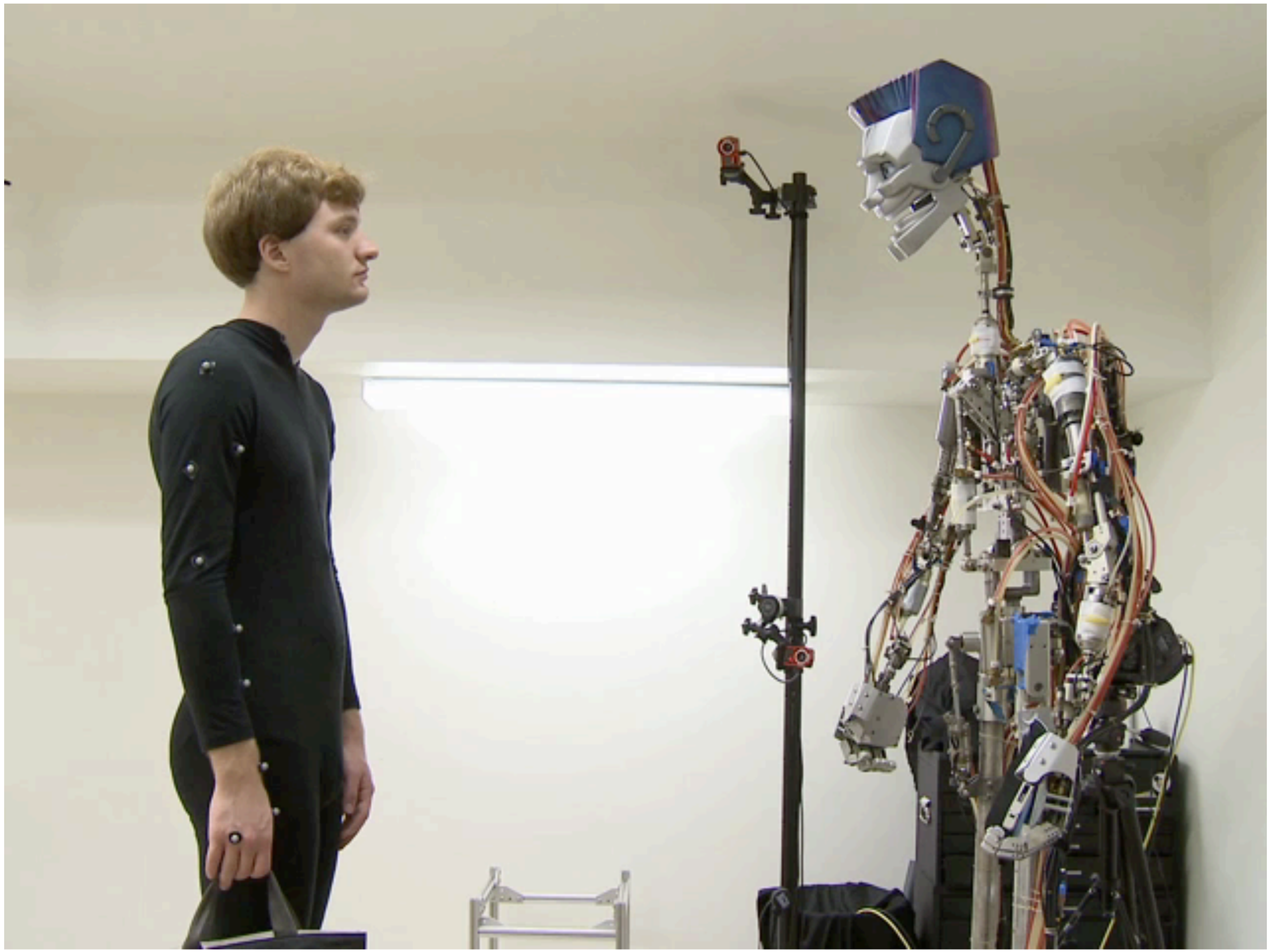
Tape



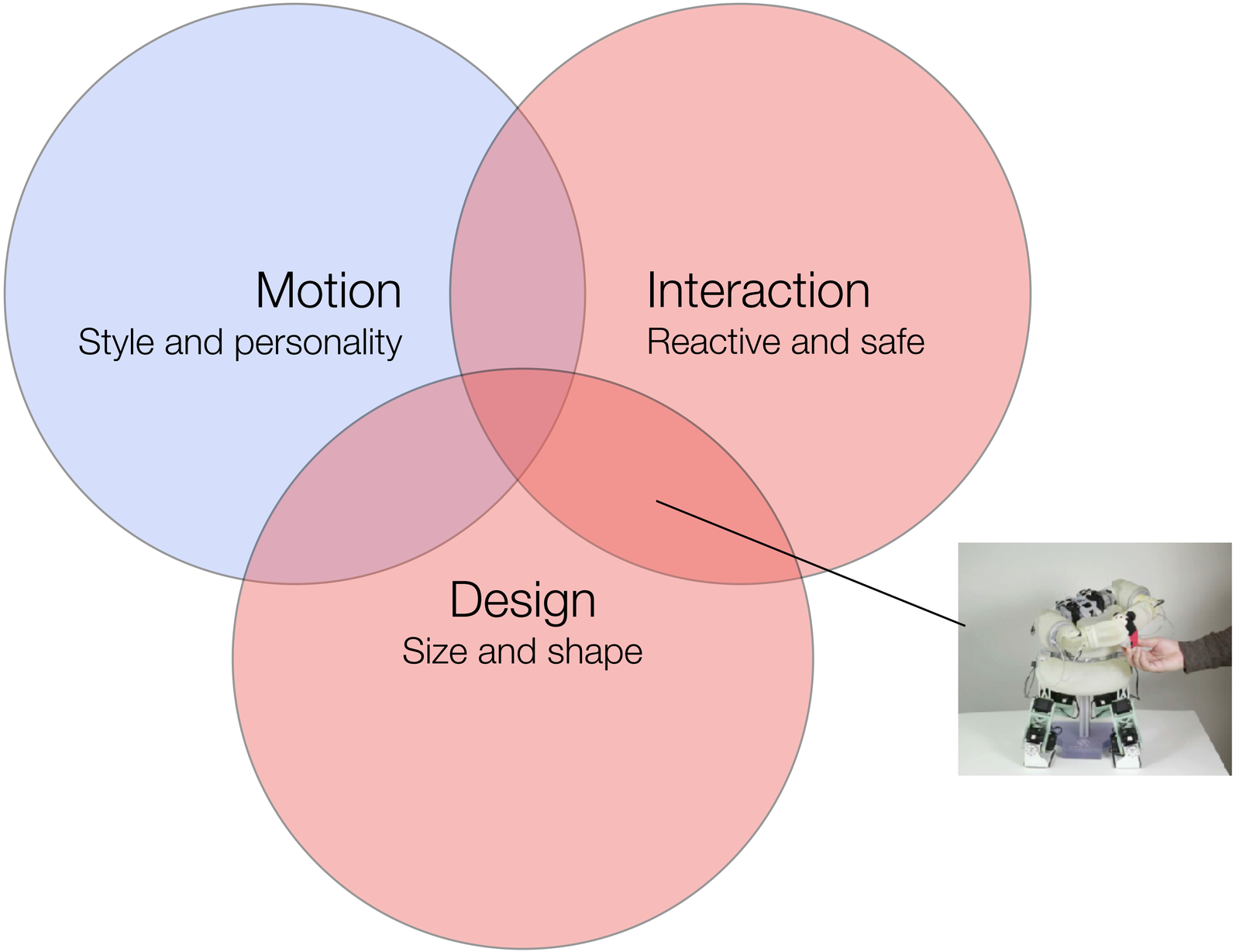
Bottle

Hardware Implementation

[Yamane, Revfi, Asfour 2013]



Lifelike Characters

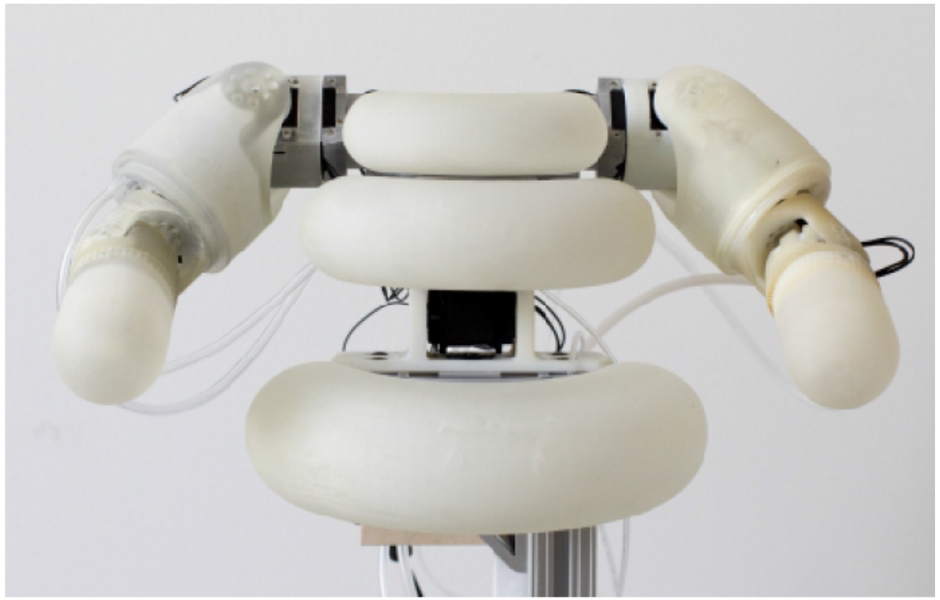


Intimate Physical Interaction

[Alspach, Kim, Yamane 2015]

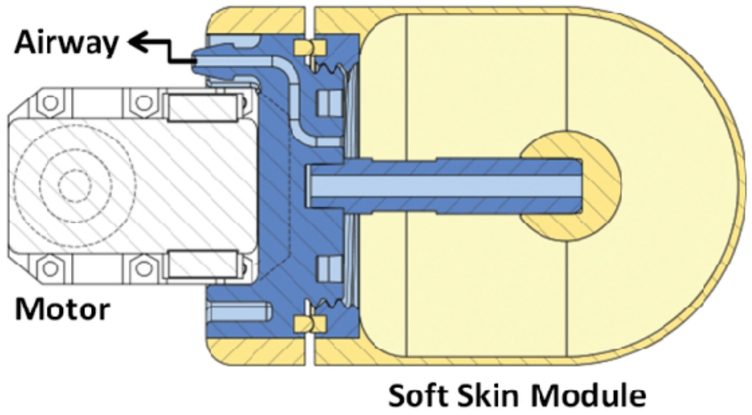
Bearbot

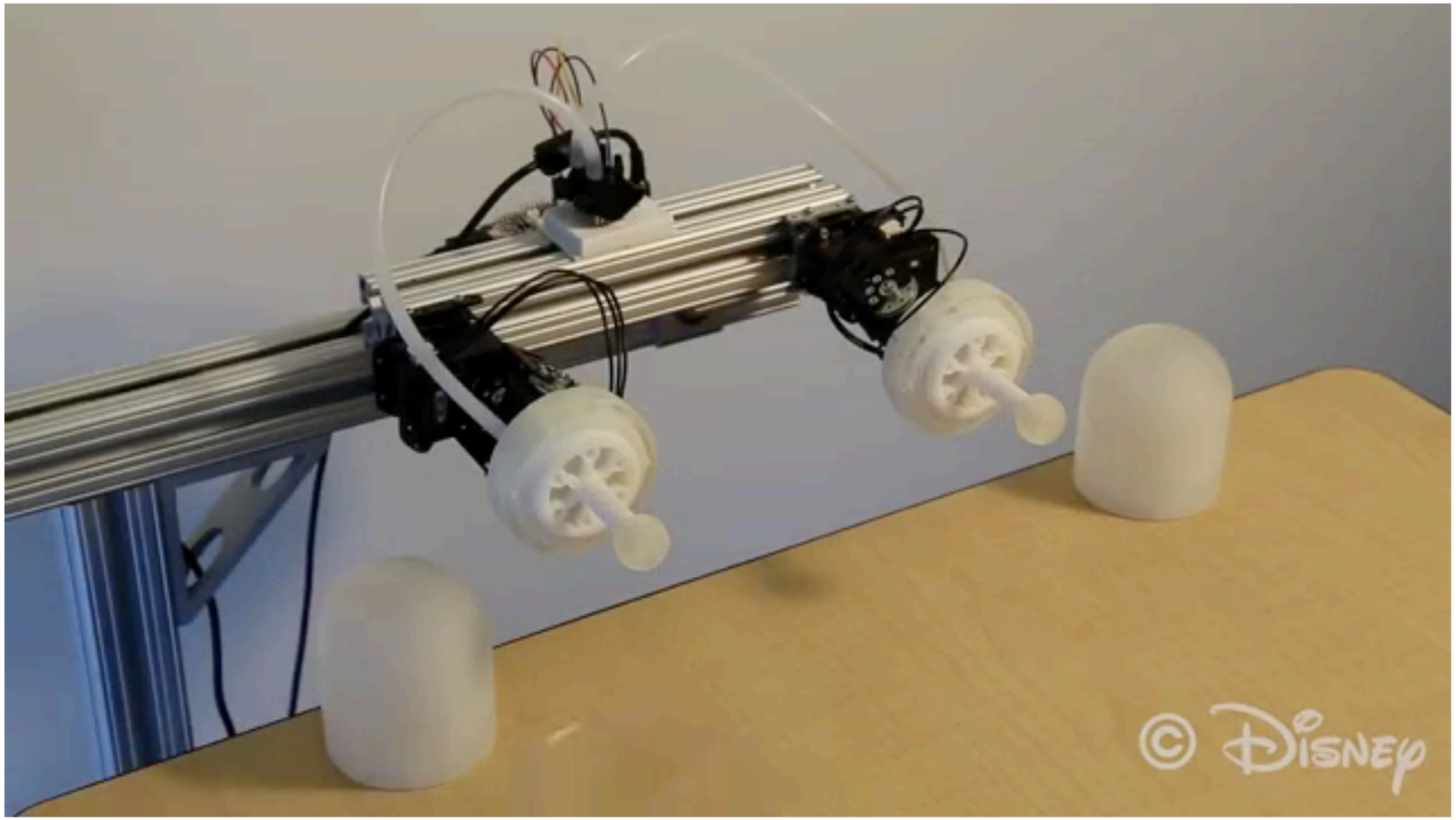
- Soft body for impact reduction and force sensing
- 3D printed air-filled modules with pressure sensor
- Fits an animation character’s shape



3D-Printed Air-Filled Module

[Kim, Alspach, Yamane 2015]



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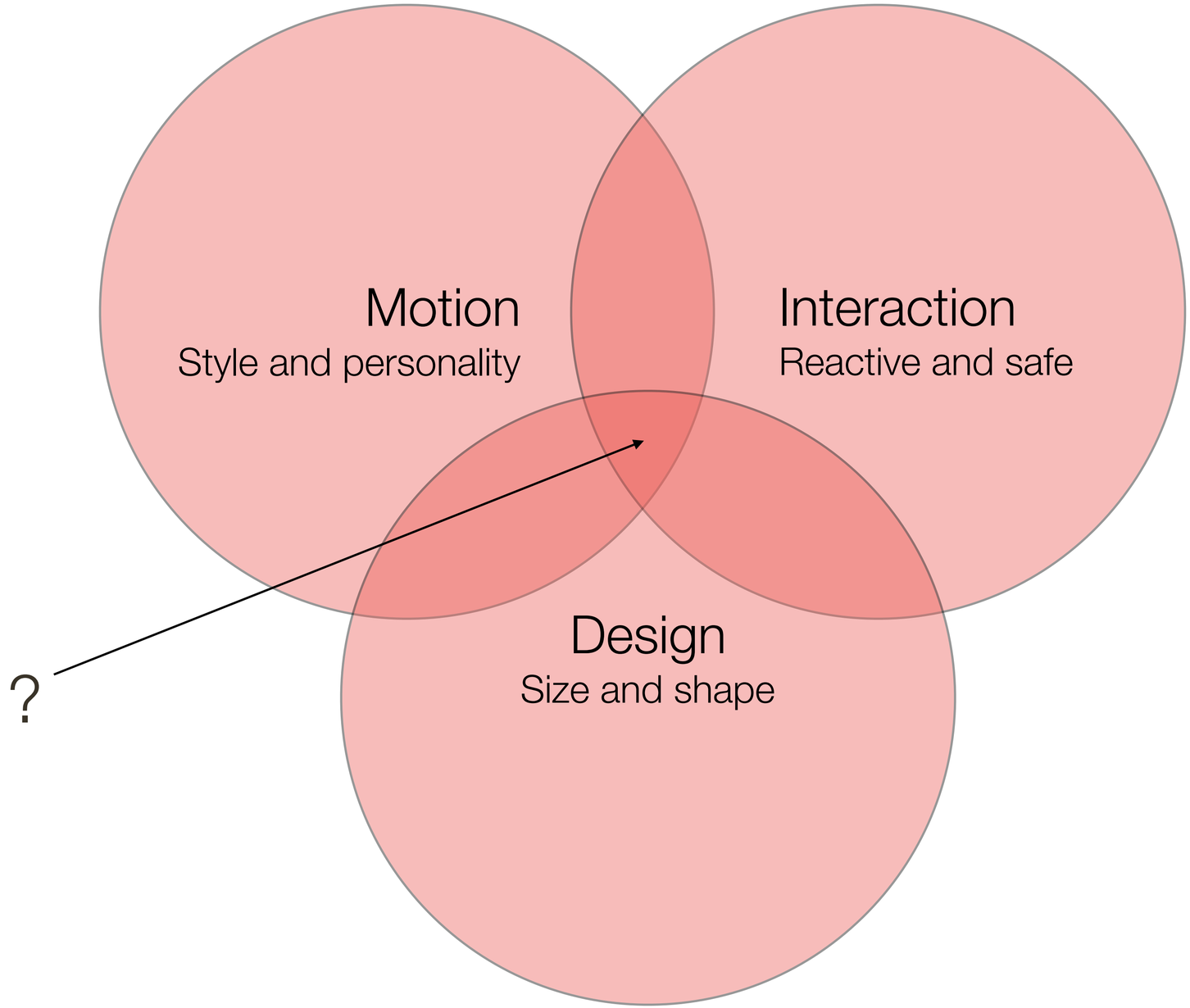
Future Direction



Questions?

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