



Human-robot Interaction Oriented Human-in-the-loop Real-time Motion Imitation on a Humanoid Tri-Co Robot

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Overview

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Motion Capture

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Setup of Humanoid Robot

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Real-time Motion Imitation

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Experimentation



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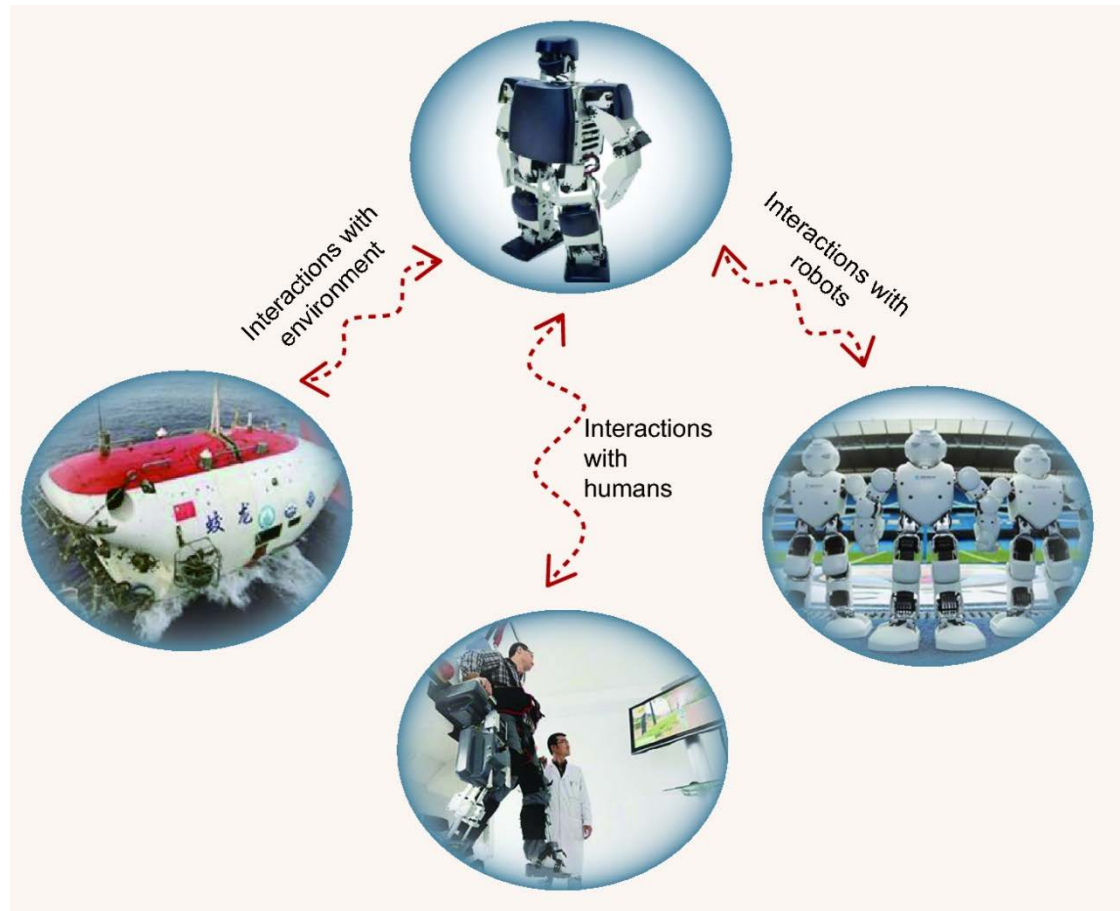
Experimentation



Motivation: Tri-Co Robot



- Coexisting
- Cooperative
- Cooperative

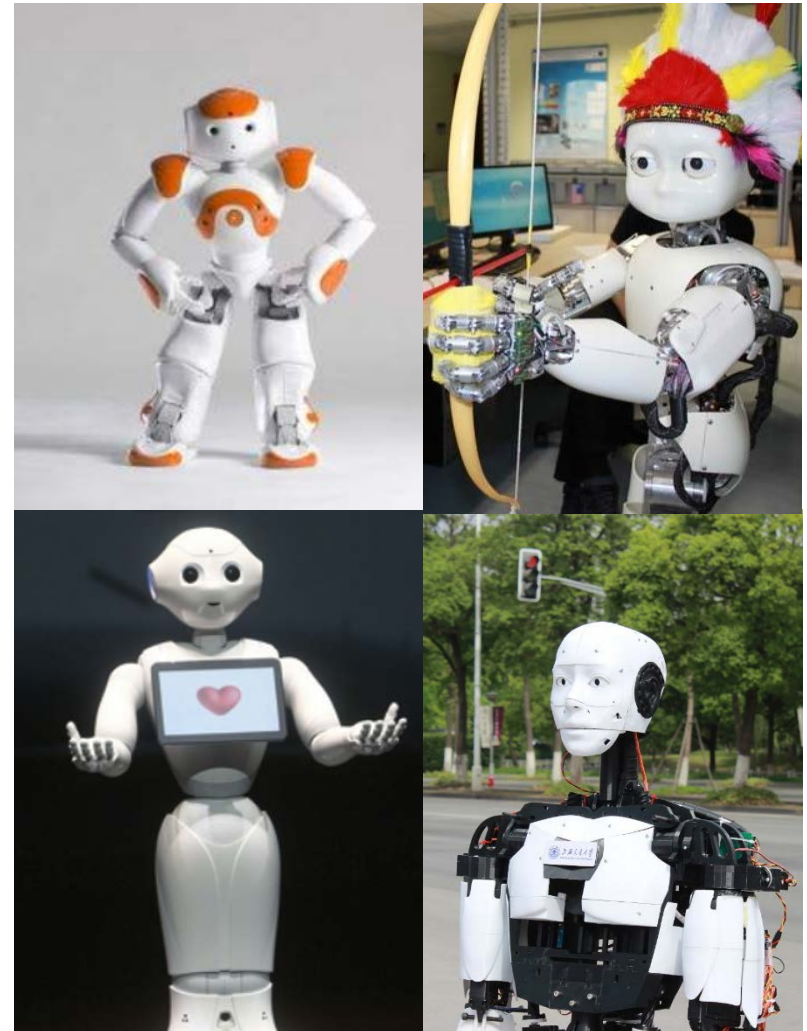


Ref: Tri-Co Robot: a Chinese robotic research initiative for enhanced robot interaction capabilities *Natl Sci Rev.* Published online December 18, 2017. doi:10.1093/nsr/nwx148

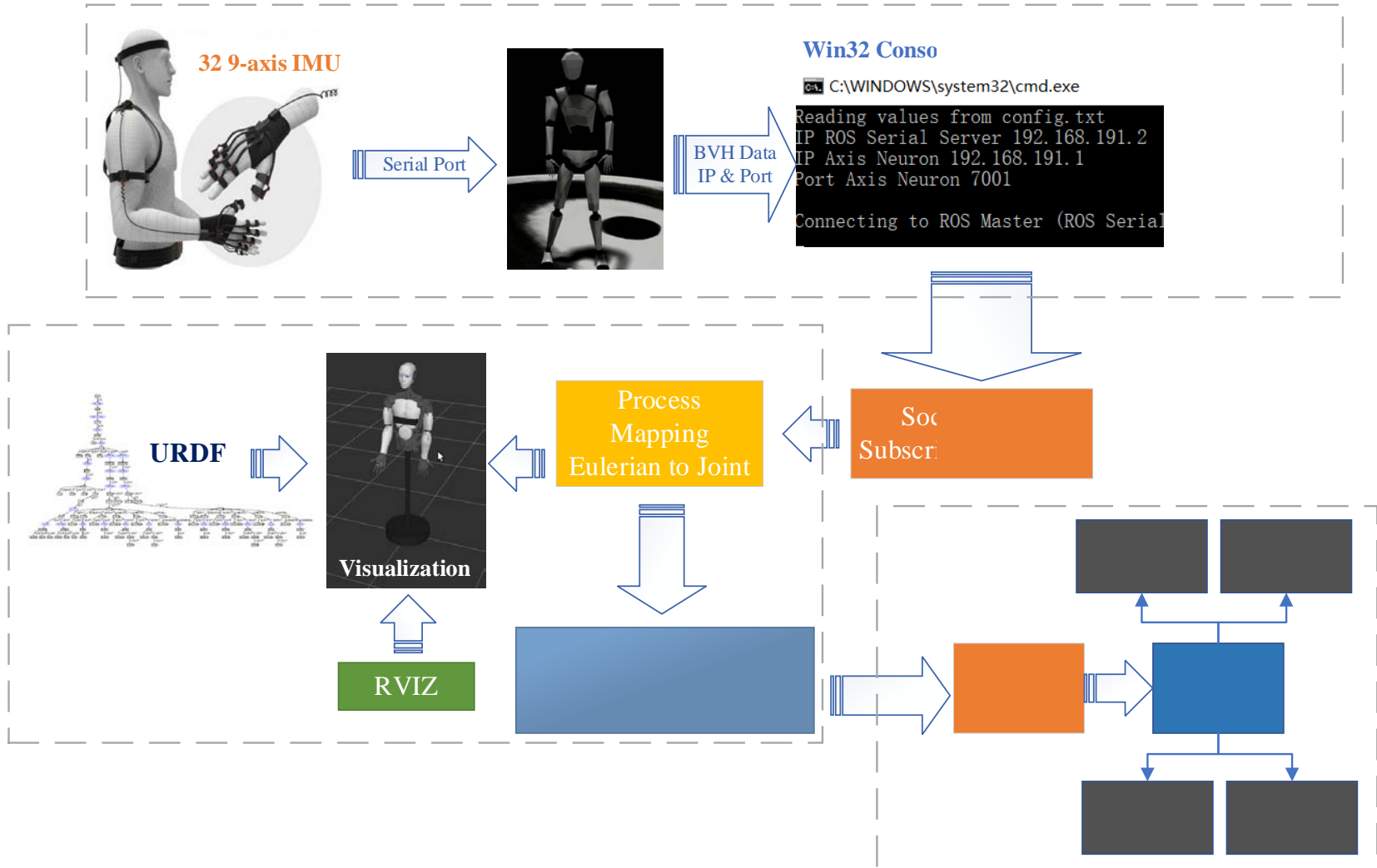
Motivation: Advantages of Humanoids



- **Human-like Structures and Scales**
- **A Natural Platform for HRI**
- **Resort to Human Civilization**



Overview of System Structure



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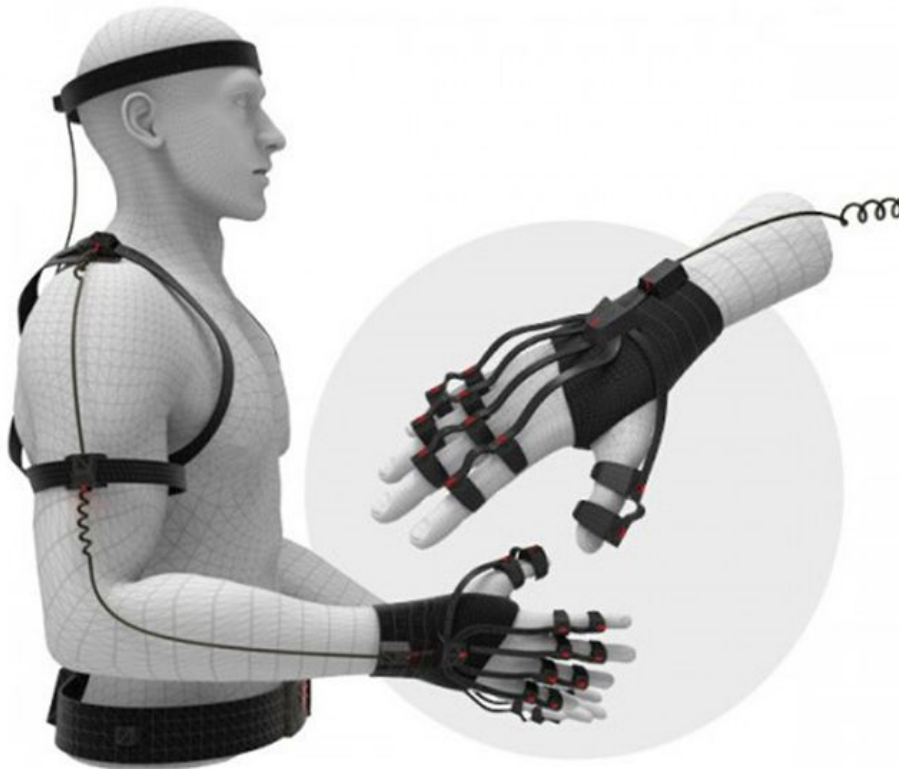
Real-time Motion Imitation

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Experimentation



Motion Capture System



32 wearable sensors



9-axis sensors

Motion Retargeting Method



HIERARCHY

ROOT Hips

{

OFFSET 0.00 104.19 0.00

CHANNELS 6 Xposition Yposition Zposition Yrotation Xrotation Zrotation

JOINT RightUpLeg

{

OFFSET -11.50 0.00 0.00

CHANNELS 6 Xposition Yposition Zposition Yrotation Xrotation Zrotation

JOINT RightLeg

{

OFFSET 0.00 -48.00 0.00

CHANNELS 6 Xposition Yposition Zposition Yrotation Xrotation Zrotation

JOINT RightFoot

{

OFFSET 0.00 -48.00 0.00

CHANNELS 6 Xposition Yposition Zposition Yrotation Xrotation Zrotation

End Site

{

OFFSET 0.00 -1.81 18.06

}

}

}

}

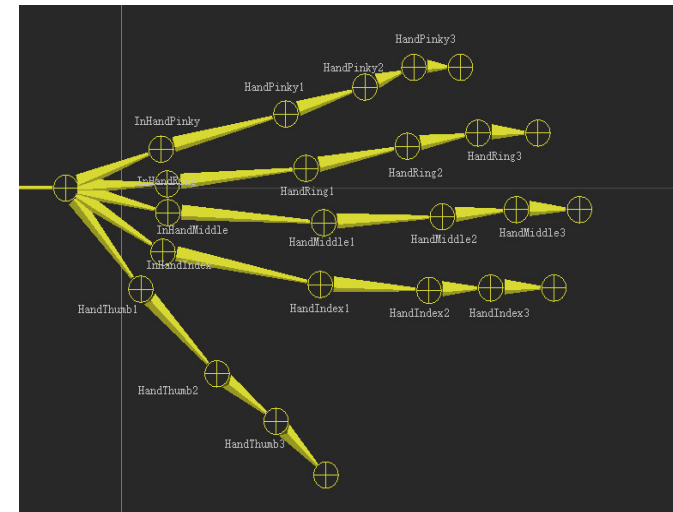
MOTION

Frames: 2

Frame Time: 0.04166667

-9.533684 4.447926 -0.566564 -7.757381 -1.735414 89.207932 9.763572

BVH Format



Hand Skeleton Modal

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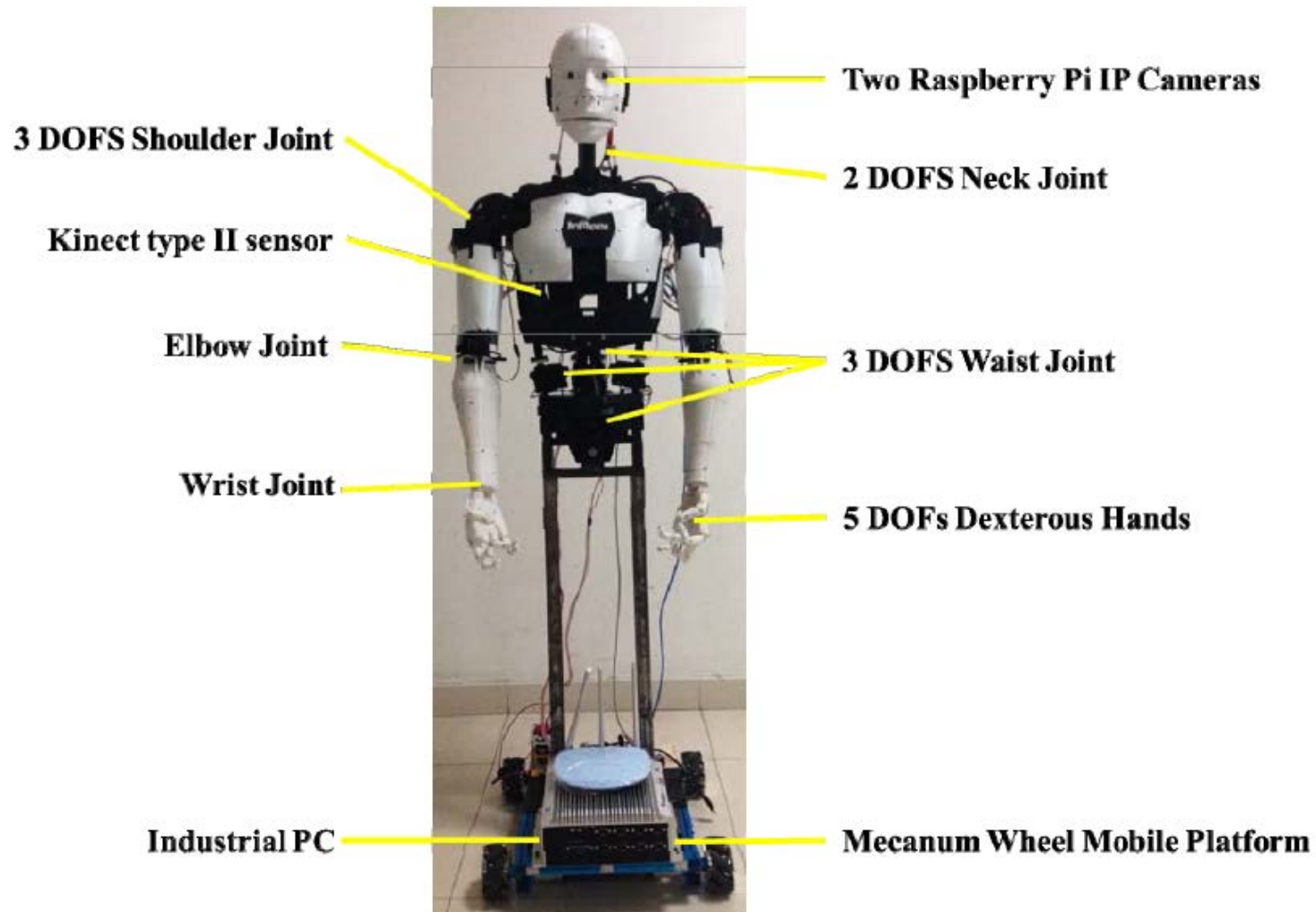
Real-time Motion Imitation

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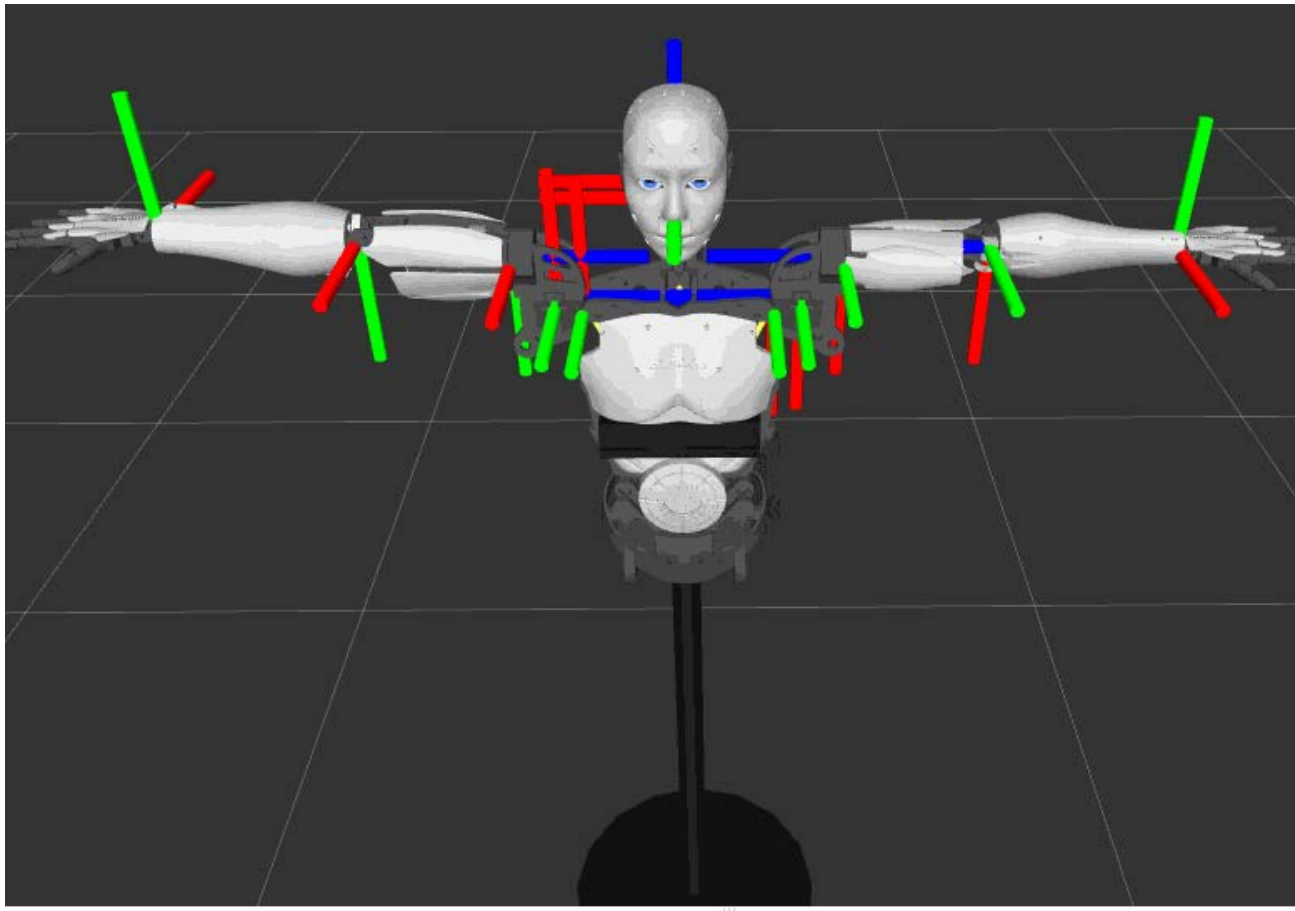
Experimentation



Setup of Humanoid Robot

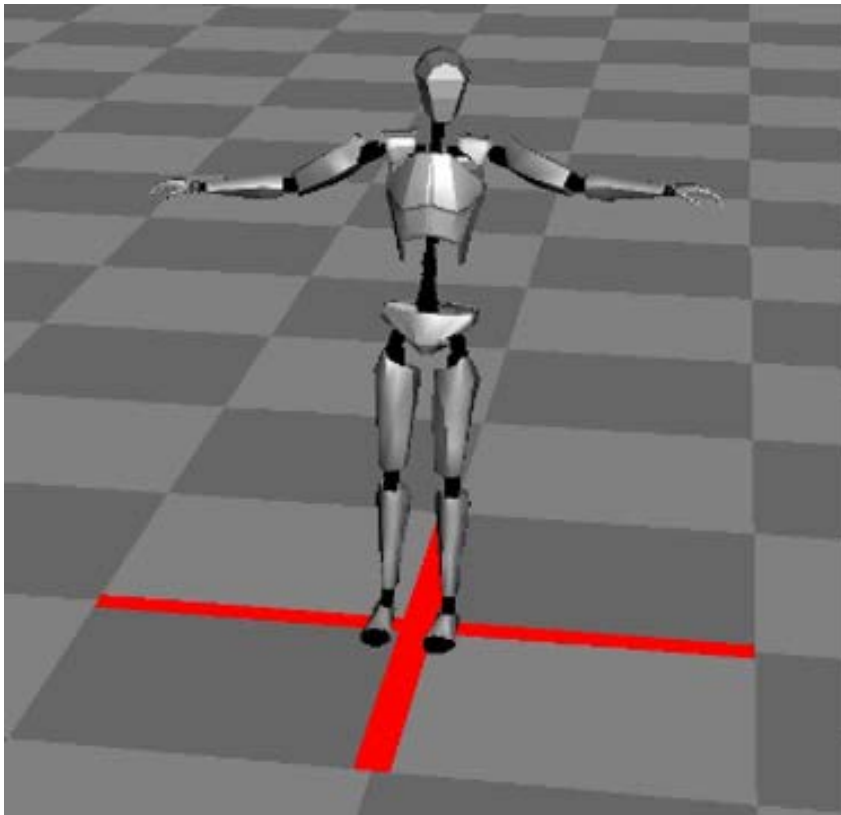


Robot Model

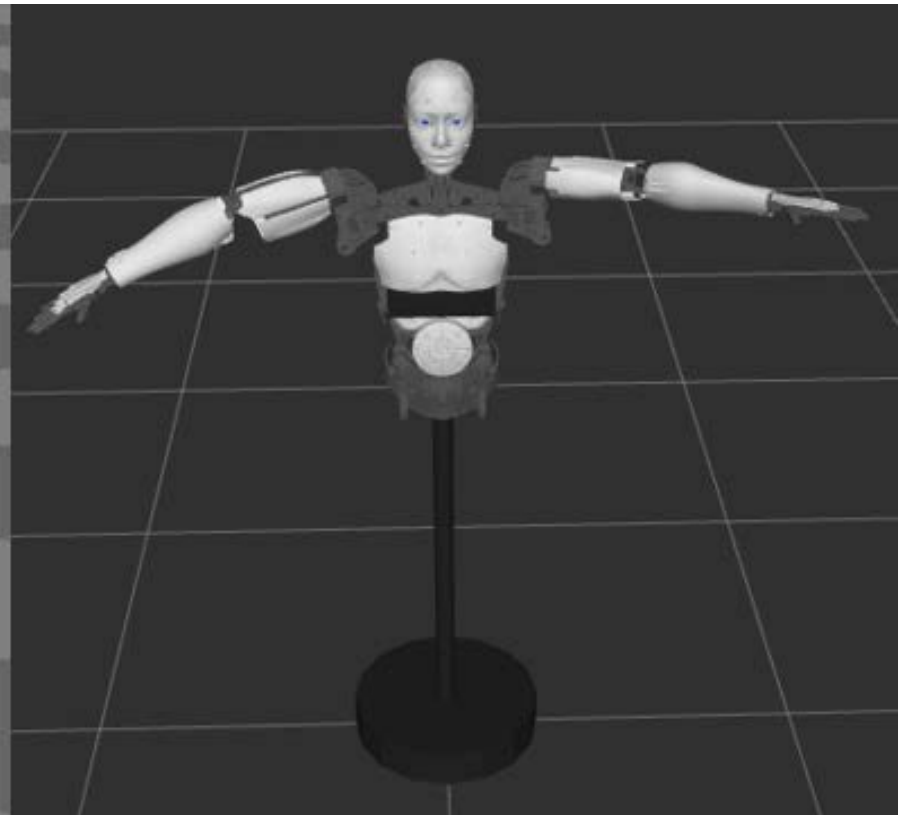


DOF of Robot (without fingers)

Visualization



Human Motion
Axis Neuron Pro



Robot Motion
ROS+Rviz

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Real-time Motion Imitation



Problem Statement of Mapping



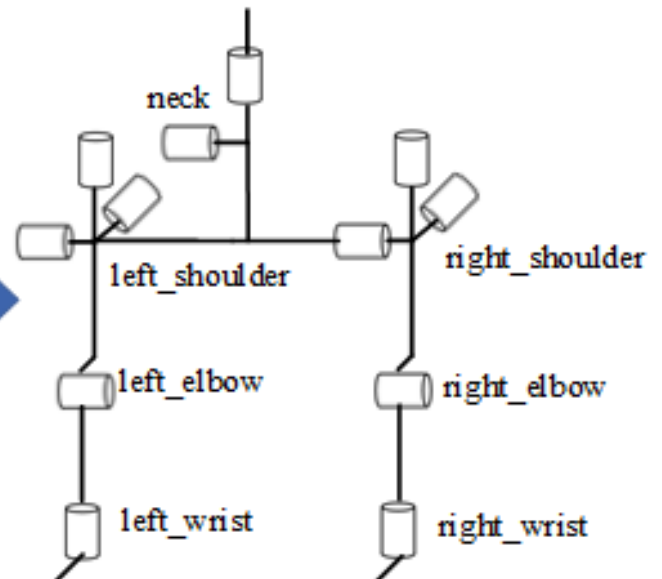
Actual Human Motion
Biological Constraint

(a)



BVH Motion
No Constraint

(b)



Robot Motion
Mechanical Constraint

(c)

Real-time Motion Imitation



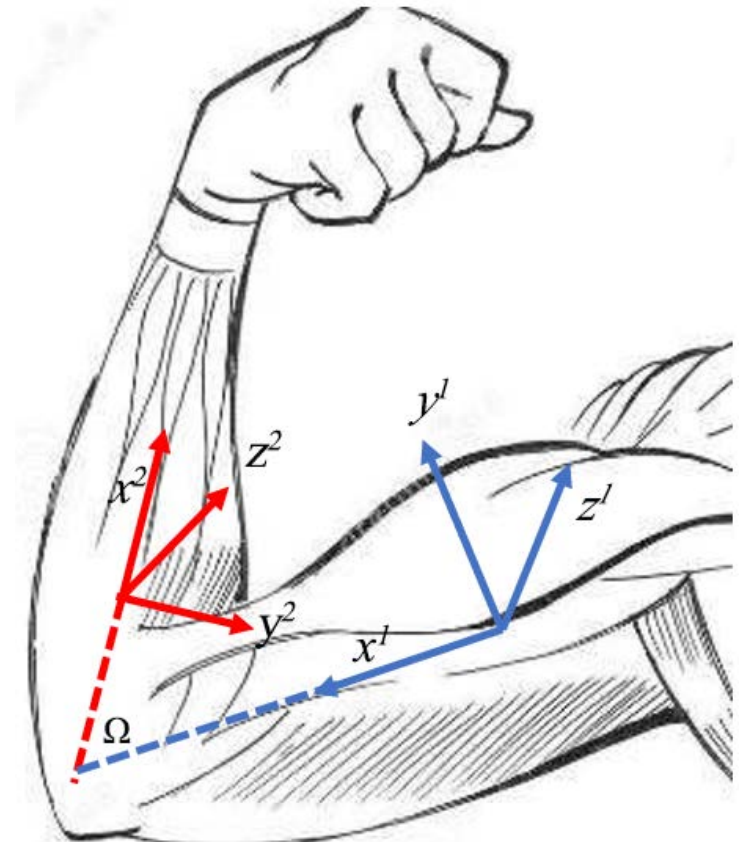
Example of Mapping Algorithm

$$\hat{x}_2^2 = (1, 0, 0)^T$$

$$\hat{x}_2^1 = R_2^1 \hat{x}_2^2 = (\cos\theta \cos\psi, \cos\theta \sin\psi, -\sin\theta)^T$$

$$\langle \hat{x}_2^1, \hat{x}_1^1 \rangle = \arccos(\cos\varphi \cos\theta)$$

$$\Omega = \pi - \langle \hat{x}_2^1, \hat{x}_1^1 \rangle = \pi - \arccos(\cos\varphi \cos\theta)$$

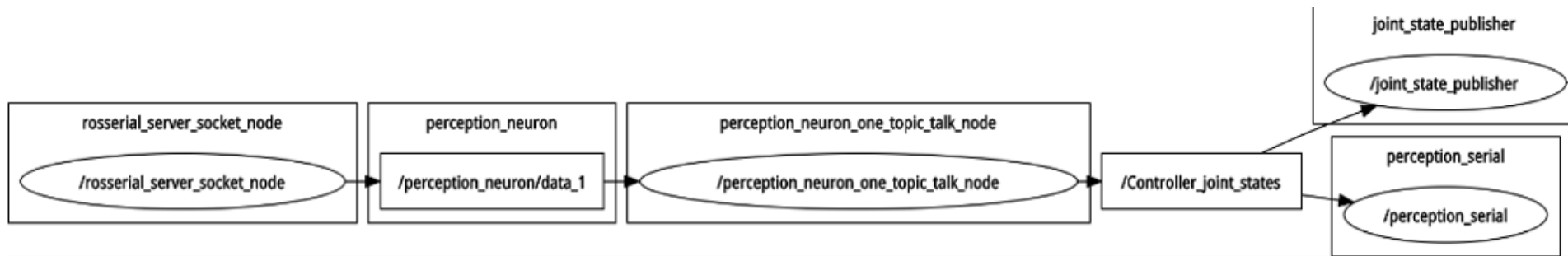


Elbow

Real-time Motion Imitation



Data Transmission



Data Flow



Communication Protocol

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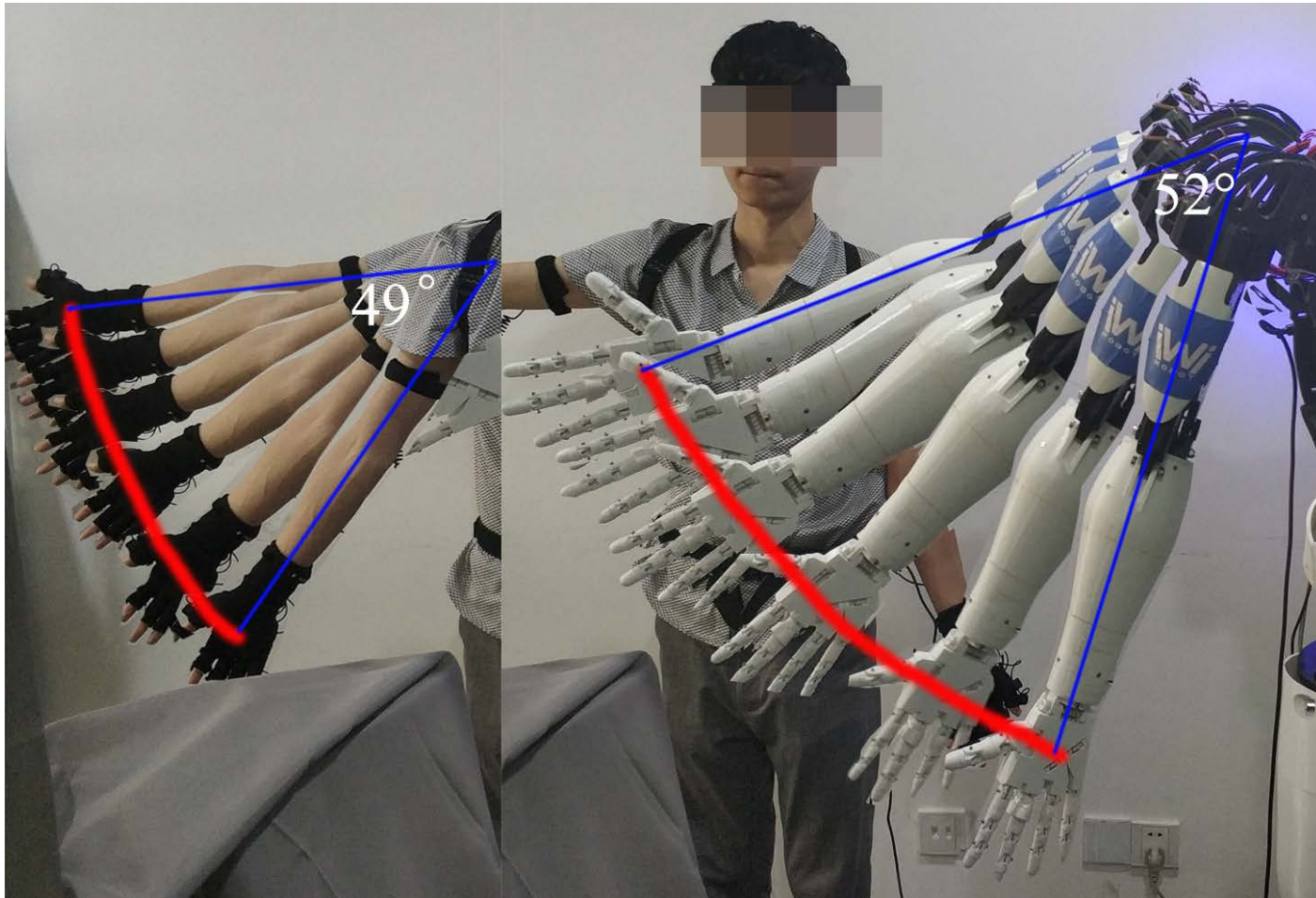


Complicated Gestures



Fingers

Experimentation



Accuracy

Thanks for Watching!

