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

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2018.7.20

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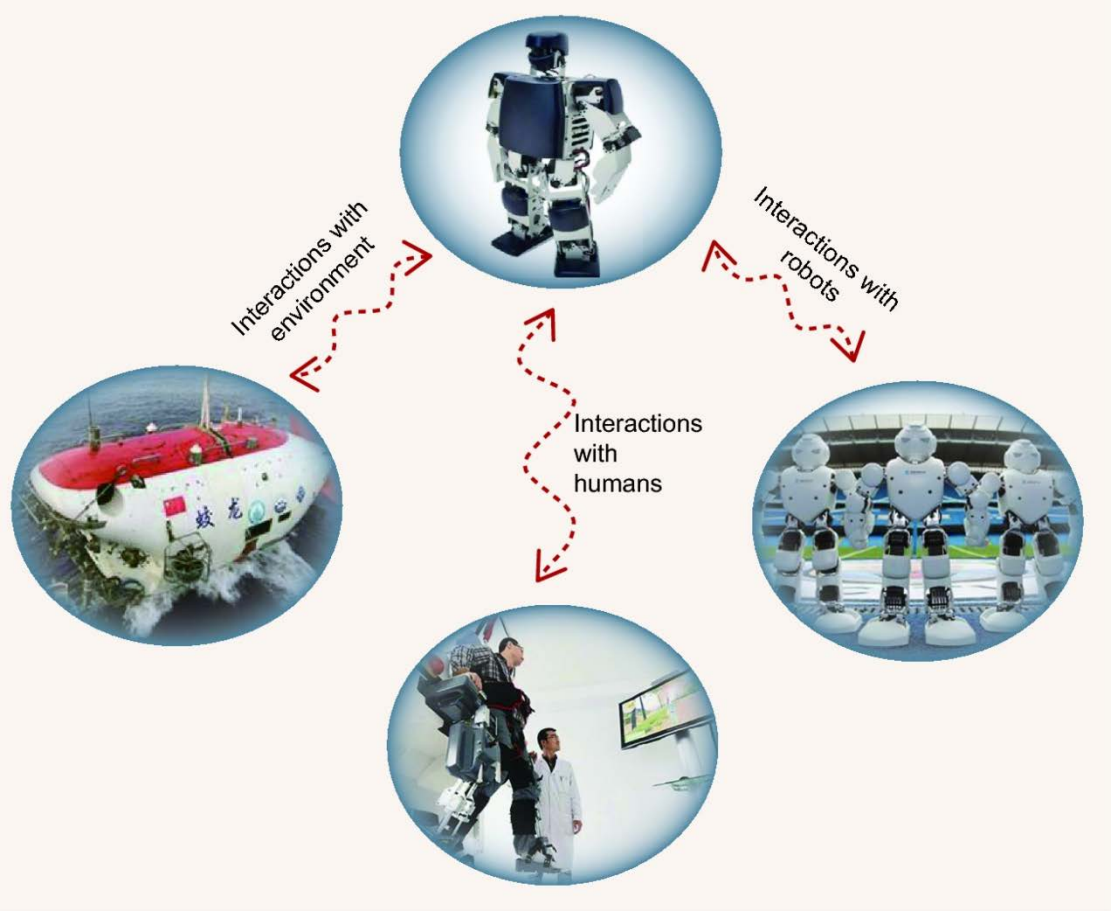
Motivation: Tri-Co Robot

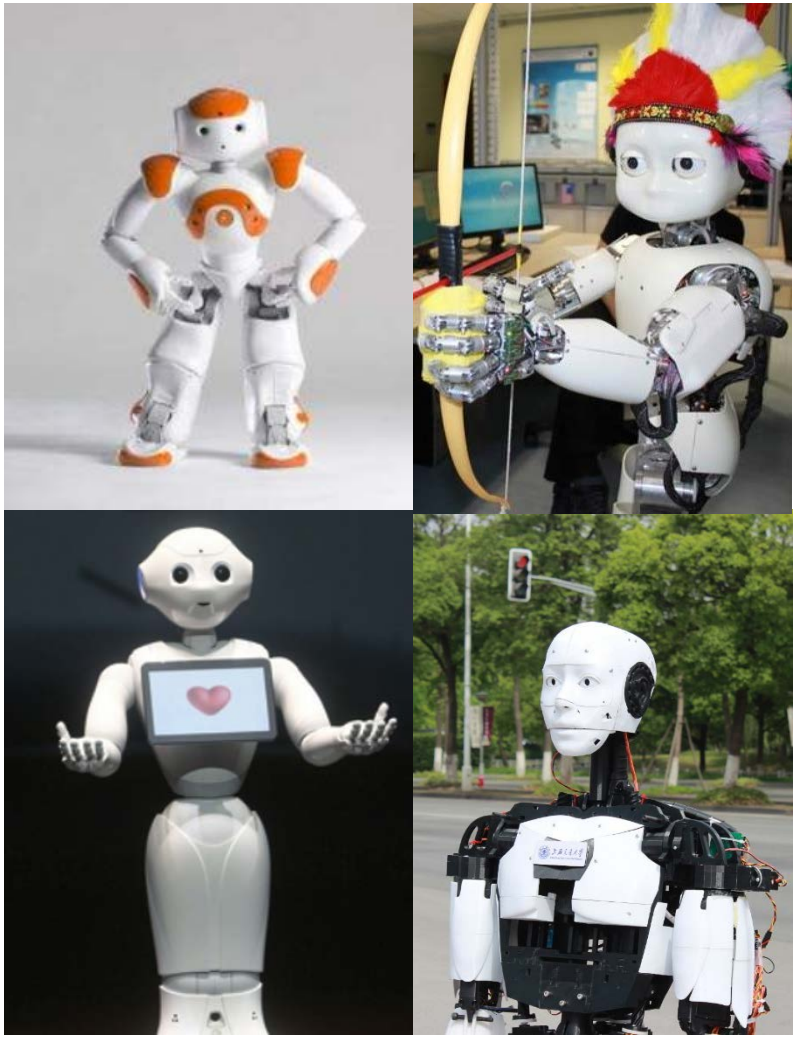
- **Coexisting**
- **Cooperative**
- **Cooperative**



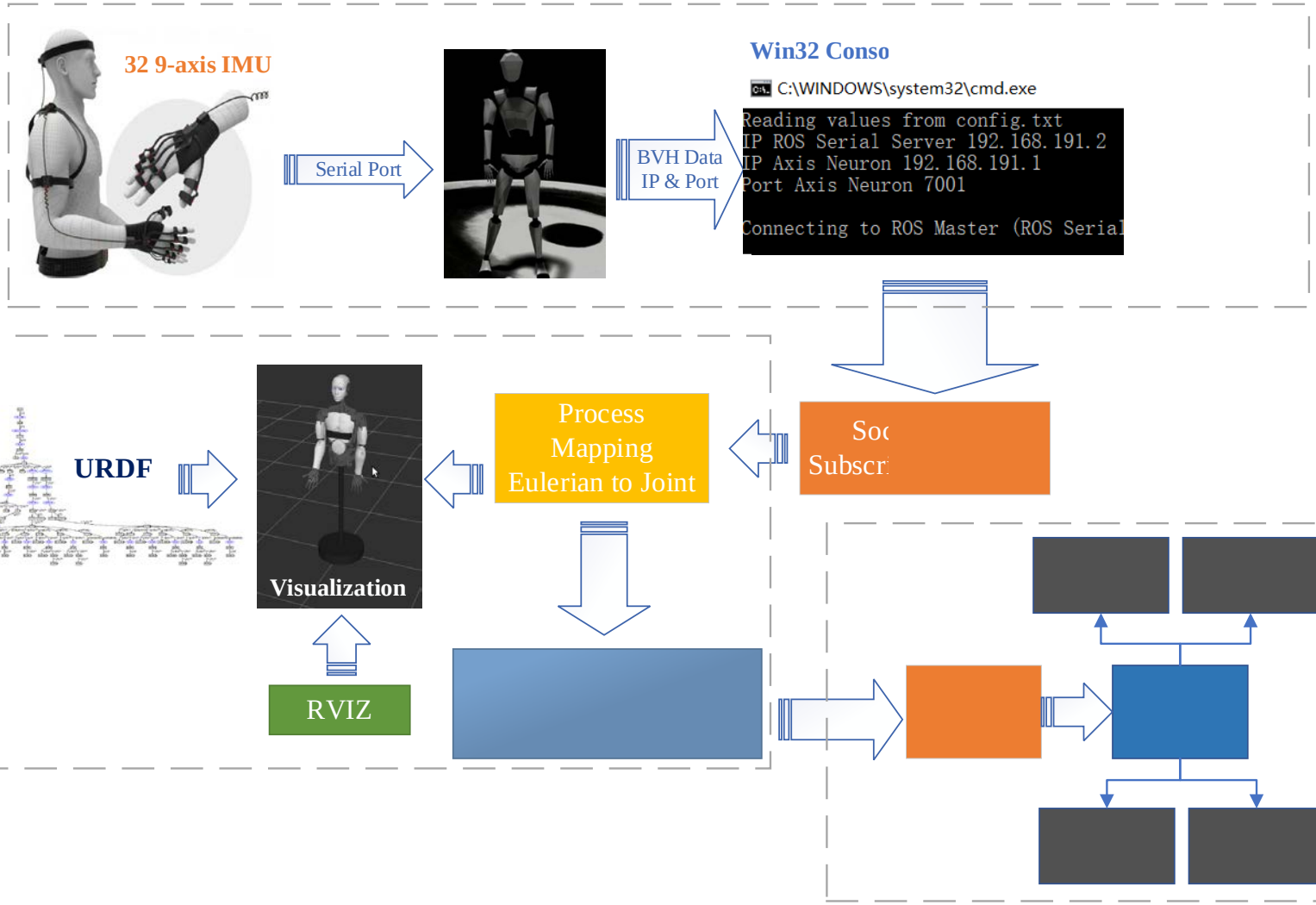
Ref: Tri-Co Robot: a Chinese robotic research initiative for enhanced robot interaction capabilities *Natl Sci Rev. Published online December 18, 2017. doi:10.1093/nsr/nwx148*

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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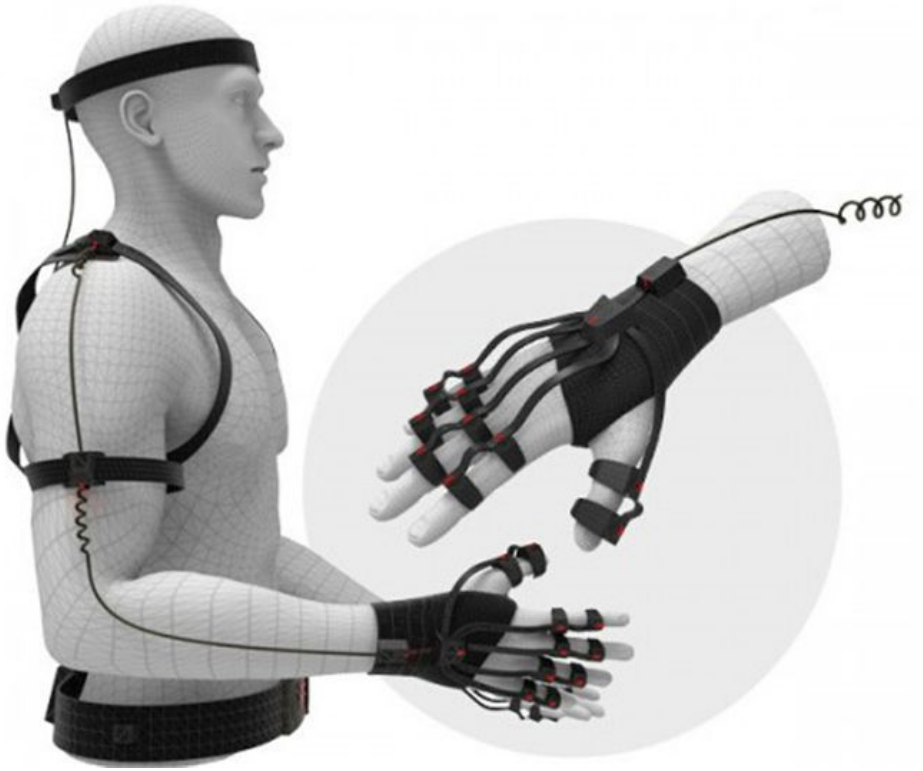
Motion Capture System



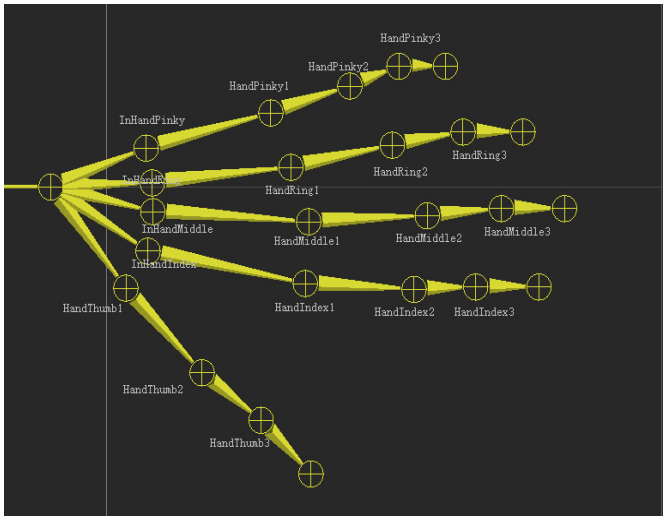
32 wearable sensors

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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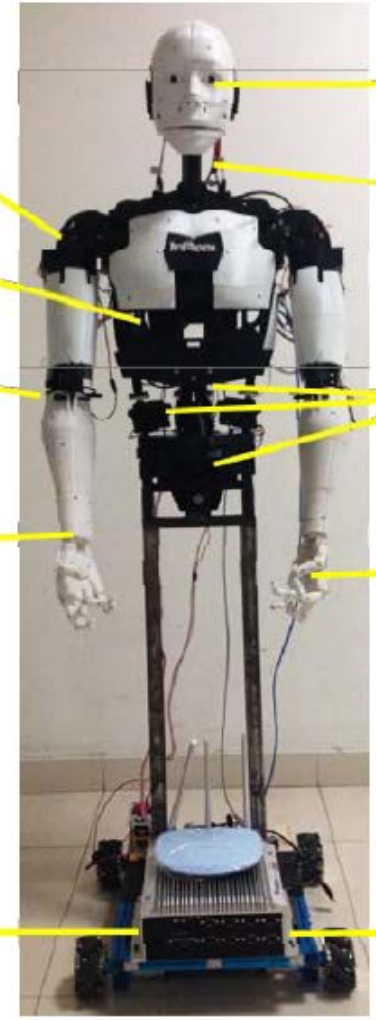
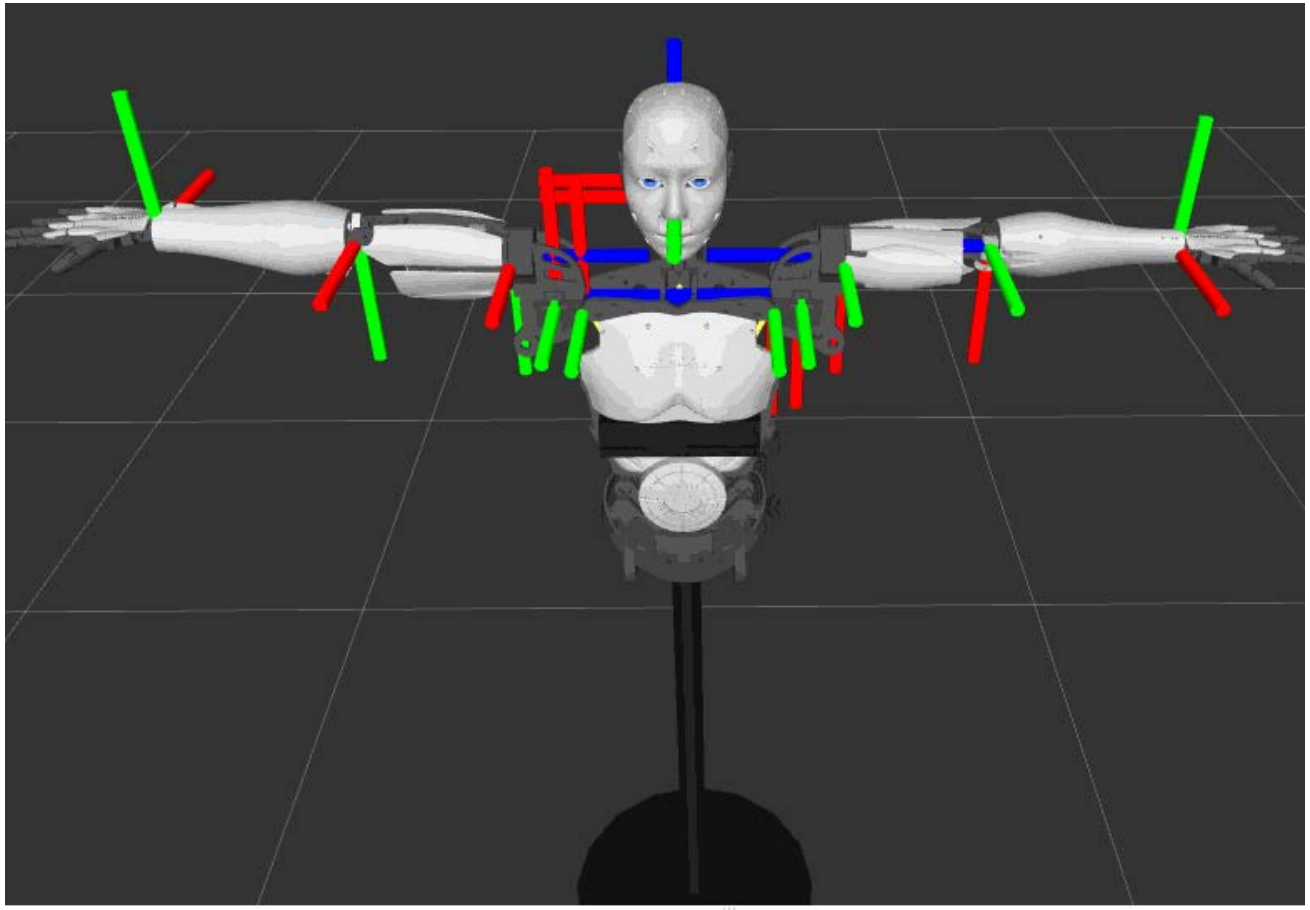
Setup of Humanoid Robot

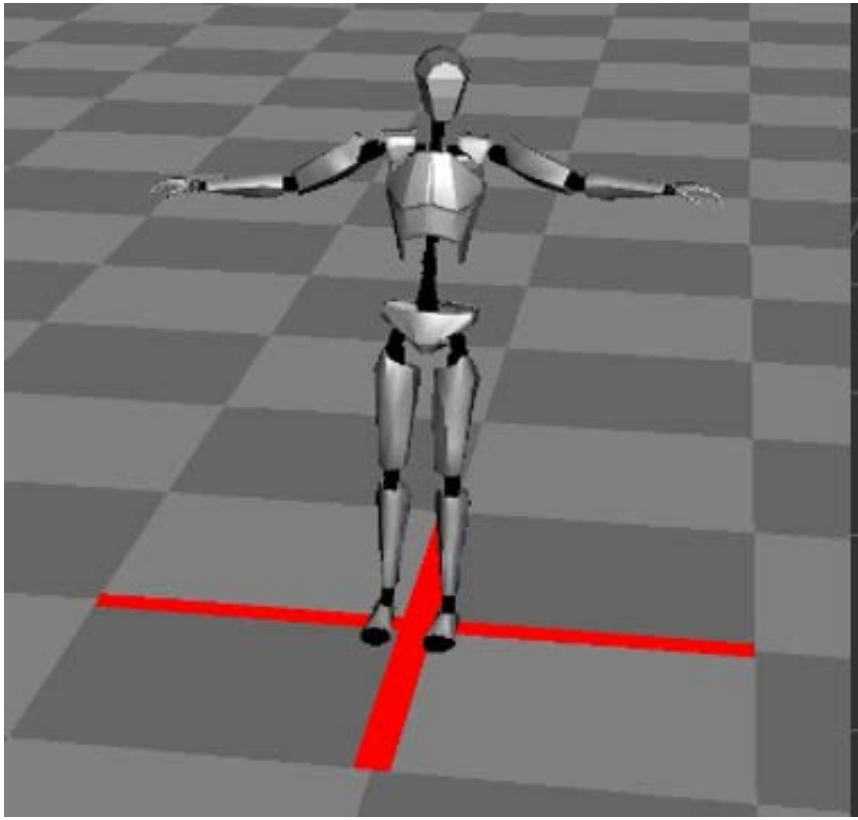


Robot Model

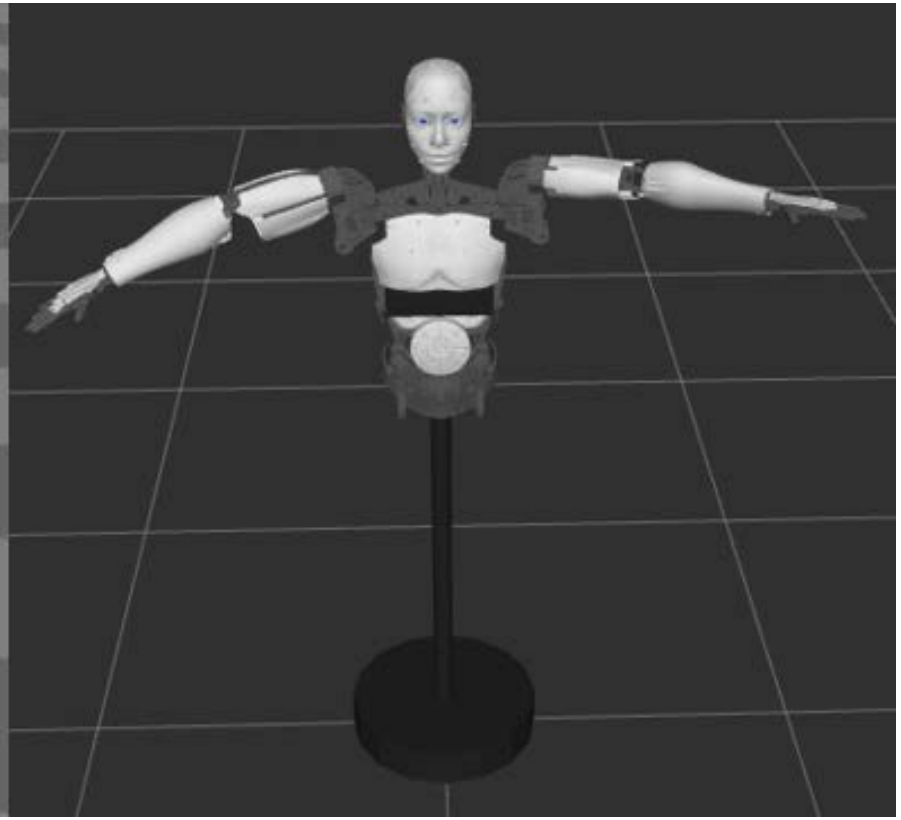


DOF of Robot (without fingers)

Visualization



Human Motion
Axis Neuron Pro



Robot Motion
ROS+Rviz

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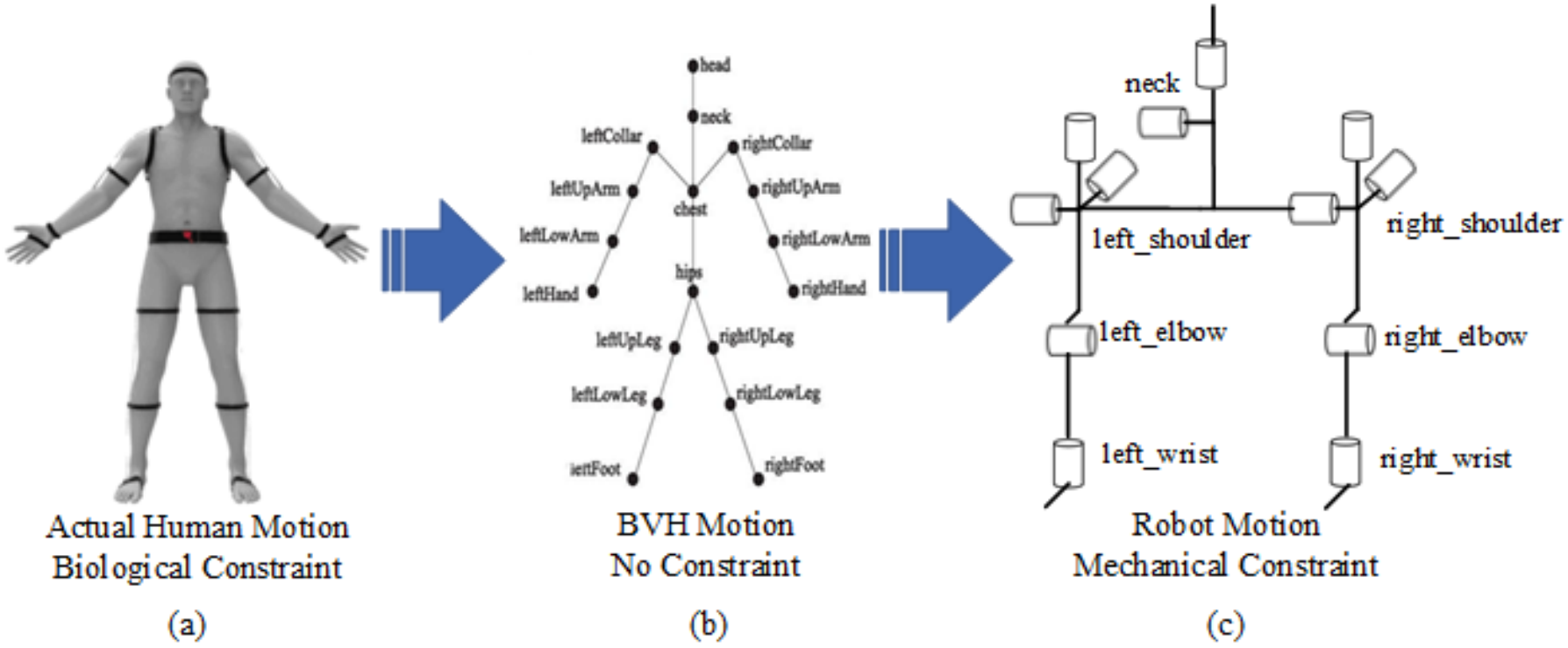
Real-time Motion Imitation

Problem Statement of Mapping



Actual Human Motion
Biological Constraint

(a)

BVH Motion
No Constraint

(b)

Robot Motion
Mechanical Constraint

(c)

Real-time Motion Imitation

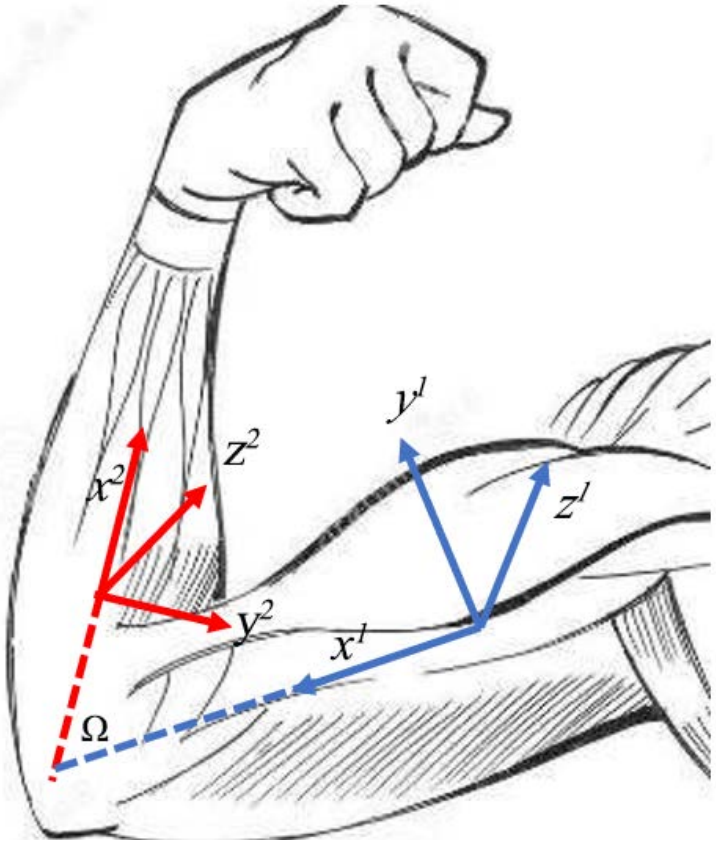
Example of Mapping Algorithm

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

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

$$< \hat{\boldsymbol{x}_2}^1, \hat{\boldsymbol{x}_1}^1 >= arccos(cos\varphi cos\theta)$$

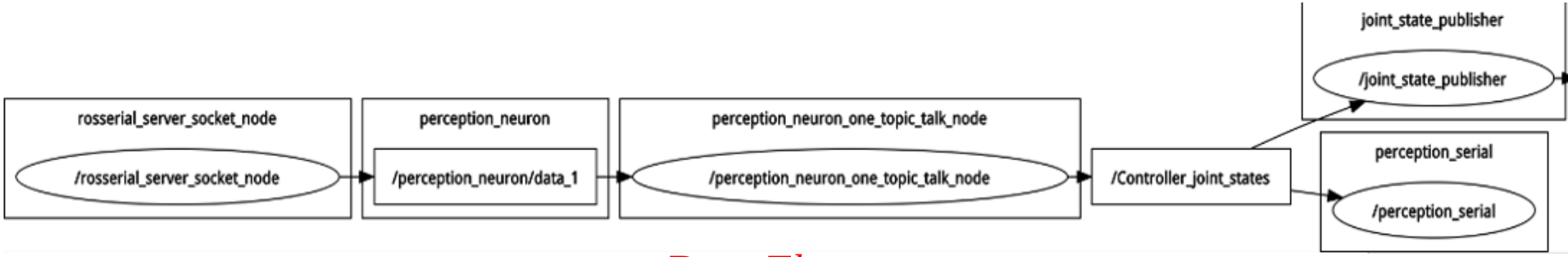
$$\Omega = \pi - < \hat{\boldsymbol{x}_2}^1, \hat{\boldsymbol{x}_1}^1 >= \pi - arccos(cos\varphi cos\theta)$$



Elbow

Real-time Motion Imitation

Data Transmission



Data Flow

Time Header 0-1	Joint Angles 2-23	CRC16 Check Sum 24-25

Communication Protocol

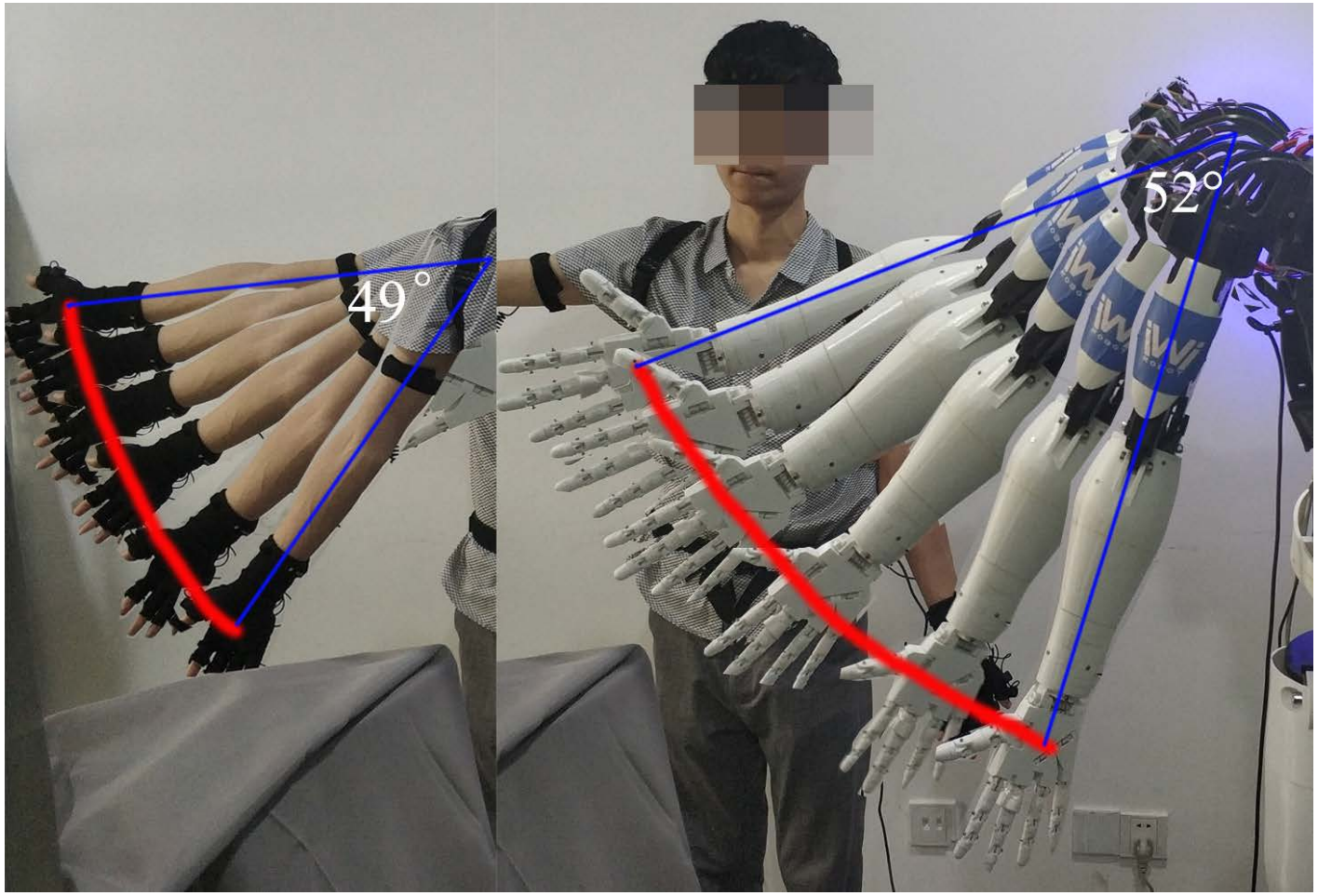
Contents

Experimentation

Complicated Gestures

Fingers

Experimentation



Accuracy

Thanks for Watching!