ISTITUTO ITALIANO
DI TECNOLOGIA
ARTIFICIAL AND MECHANICAL
INTELLIGENCE

iCub 3 Avatar System

Daniele Pucci

XPRIZE AVATAR | ANA

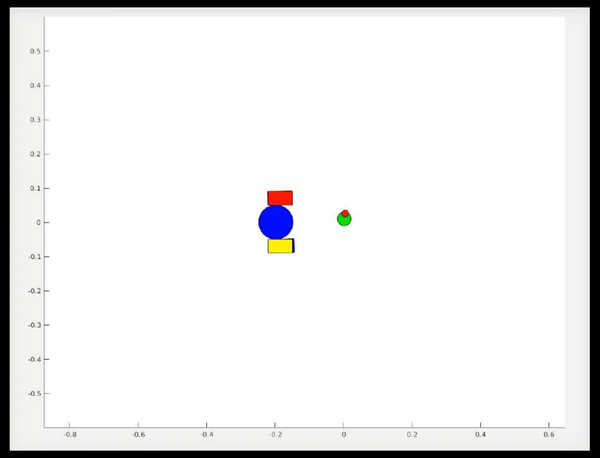
RANK	TEAM	TIME ON COURSE	TASK	POINTS JUDGED	TOTAL	LEADER STATS TO BEAT	
3	ICUB	10:38	4	0	4	24:30	8.5

All ended with a walk

… and all started with a walk

All started with a walk

December 2017



Trajectory optimisation

CoP

Simplified model control

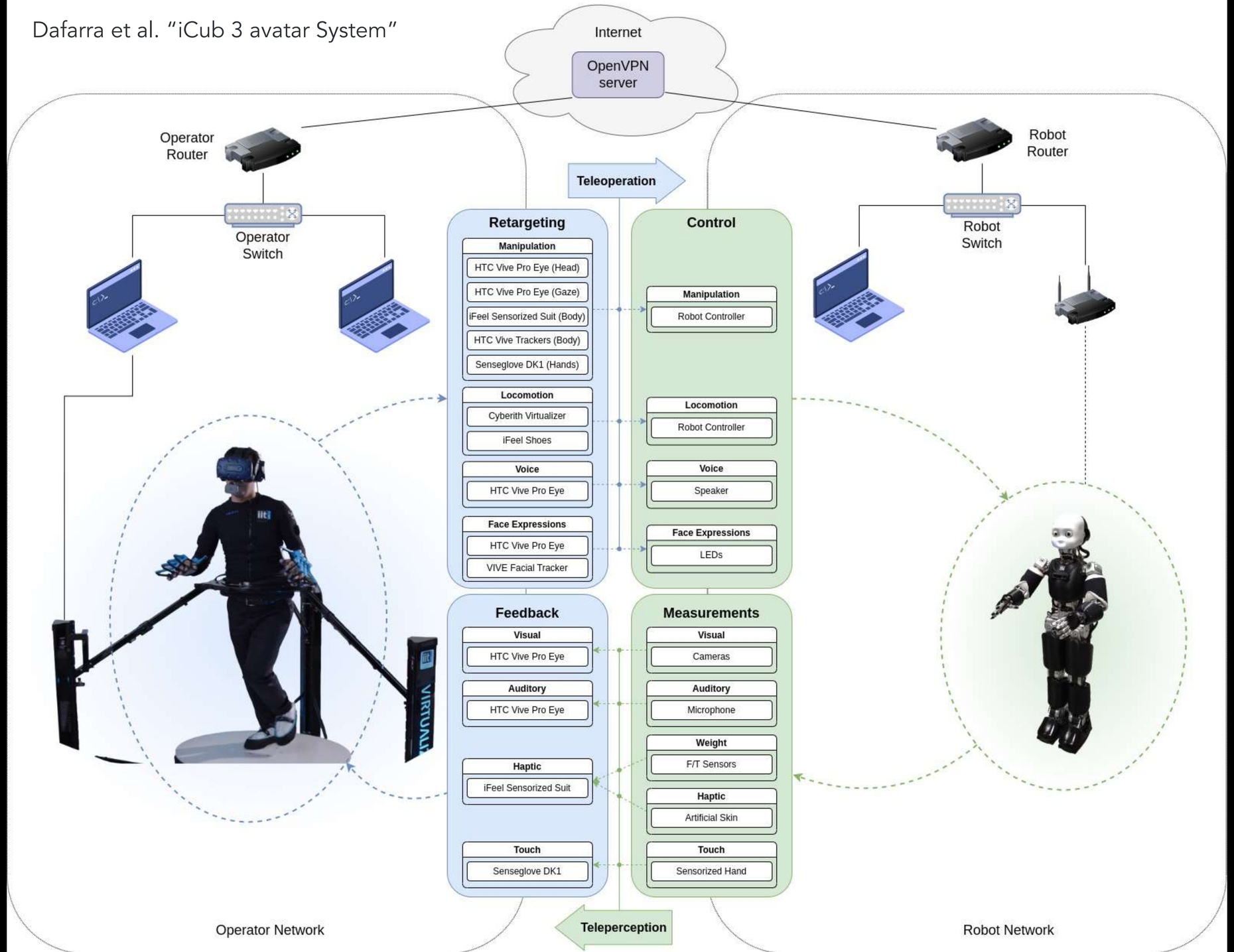
Whole-body QP control

Positions

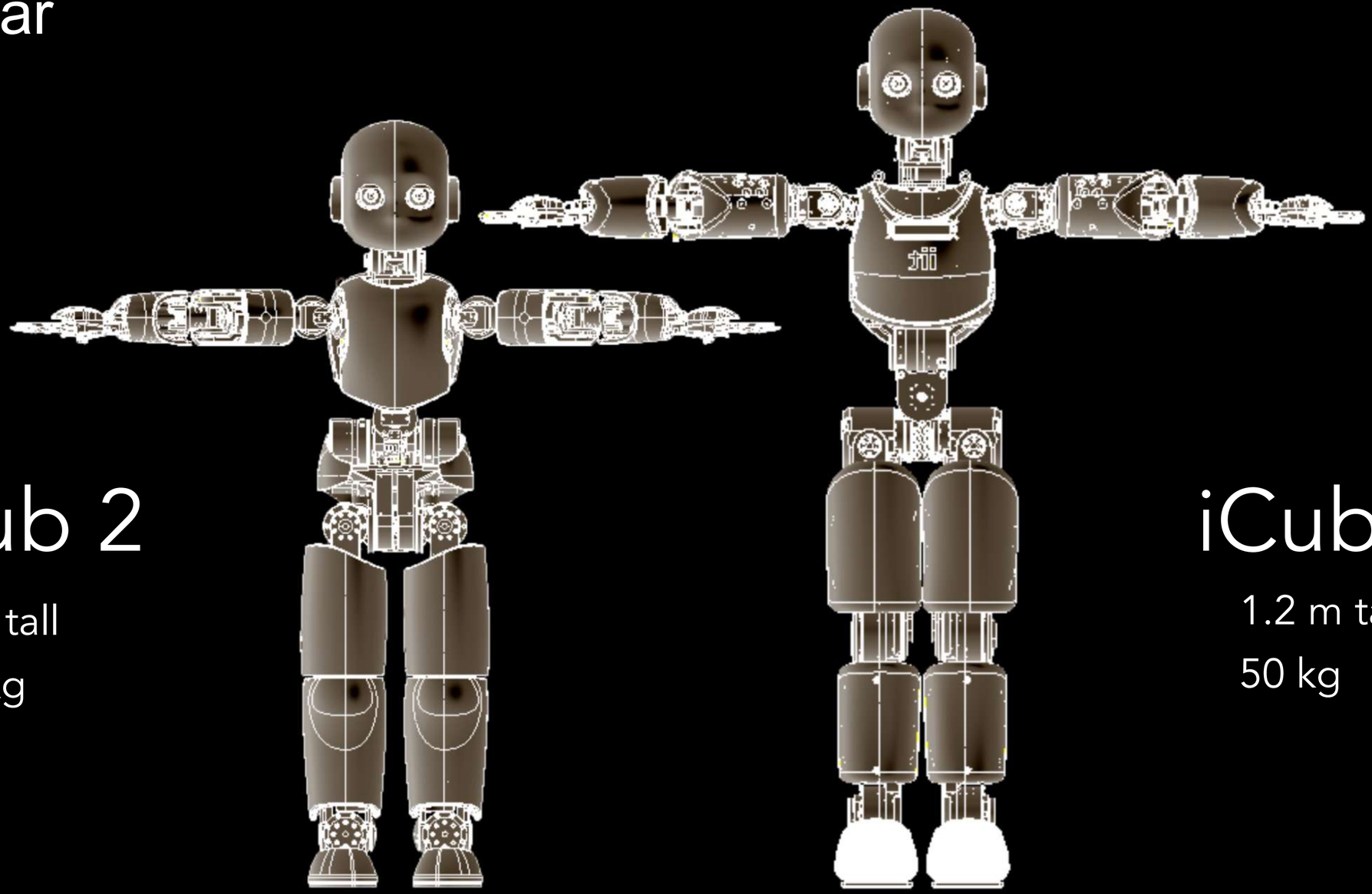
How to develop interfaces for robot desired motions?

To develop a general system for Telexistence: allow a human to exist elsewhere via a robotic avatar

Dafarra et al. “iCub 3 avatar System”



The avatar



iCub 2

1 m tall

33 kg

iCub 3

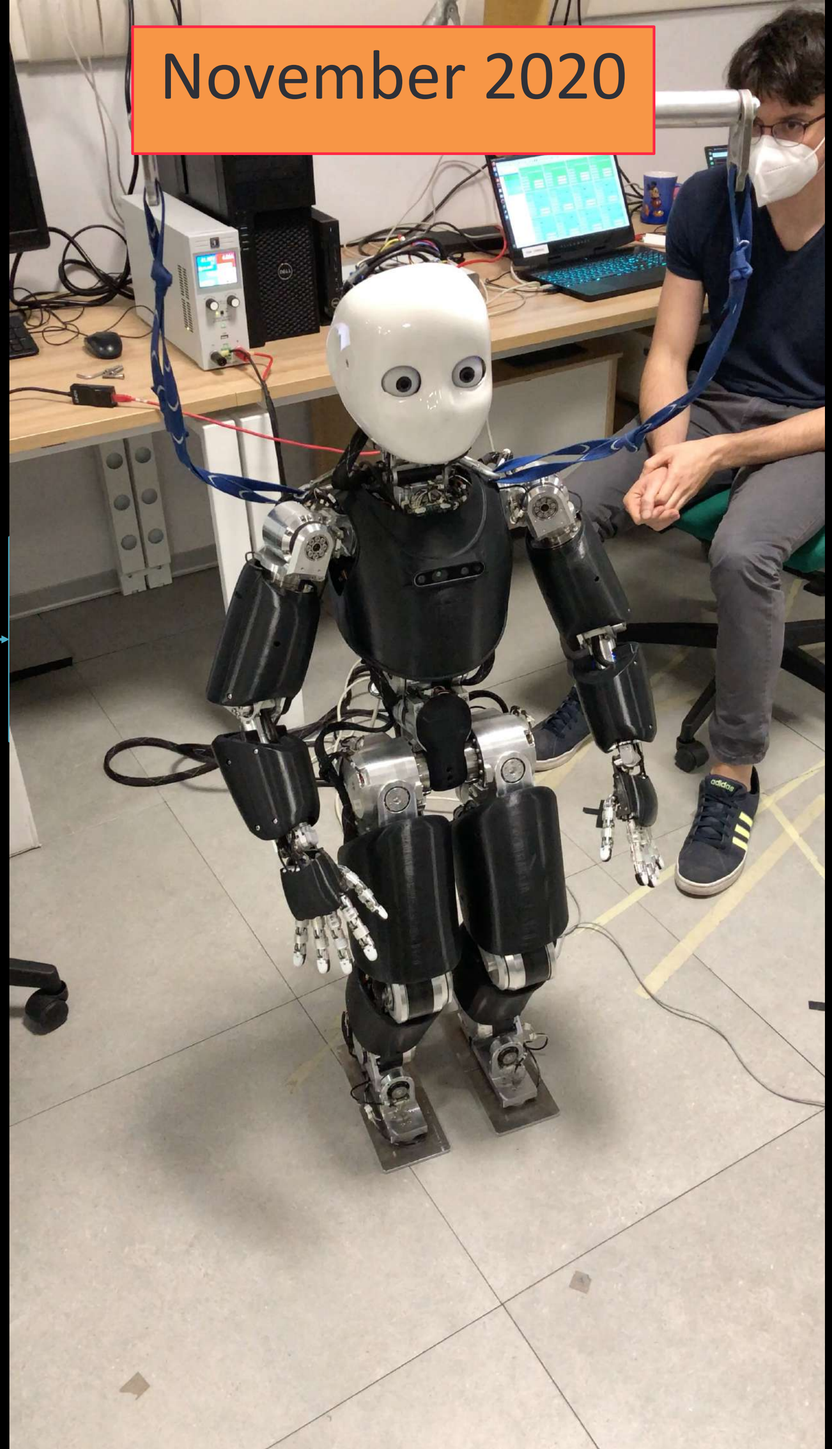
1.2 m tall

50 kg

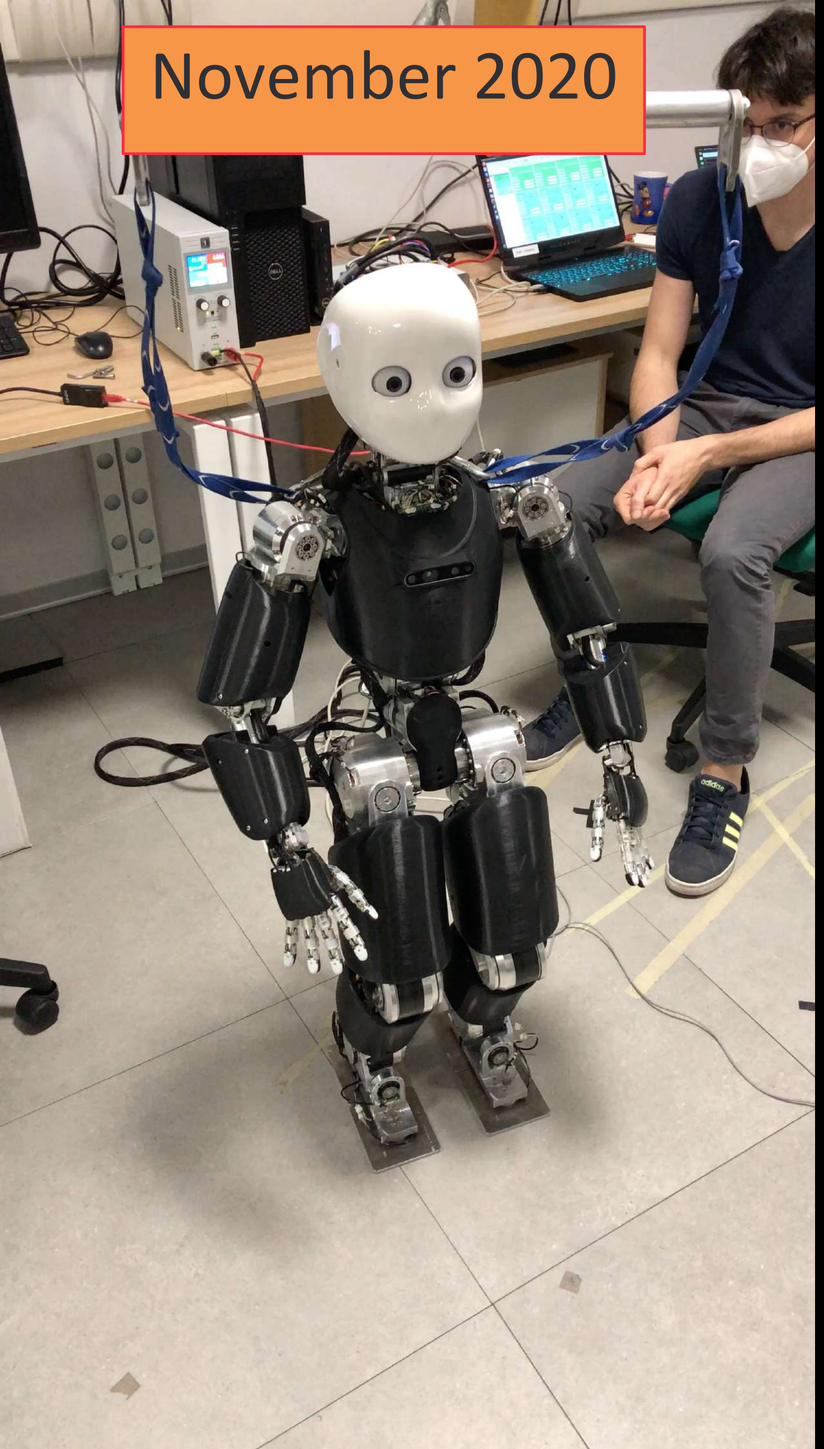
September 2020

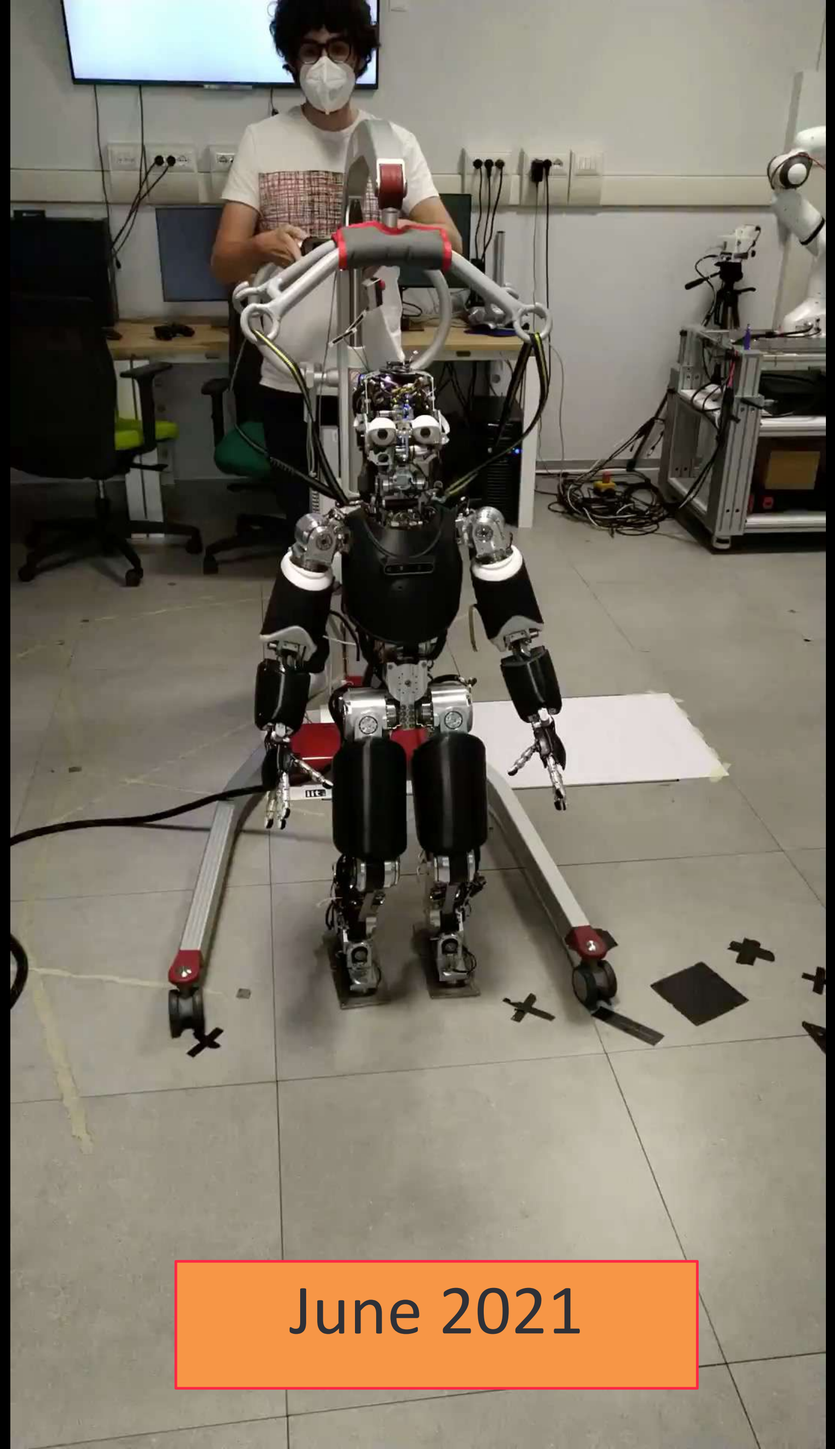
Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

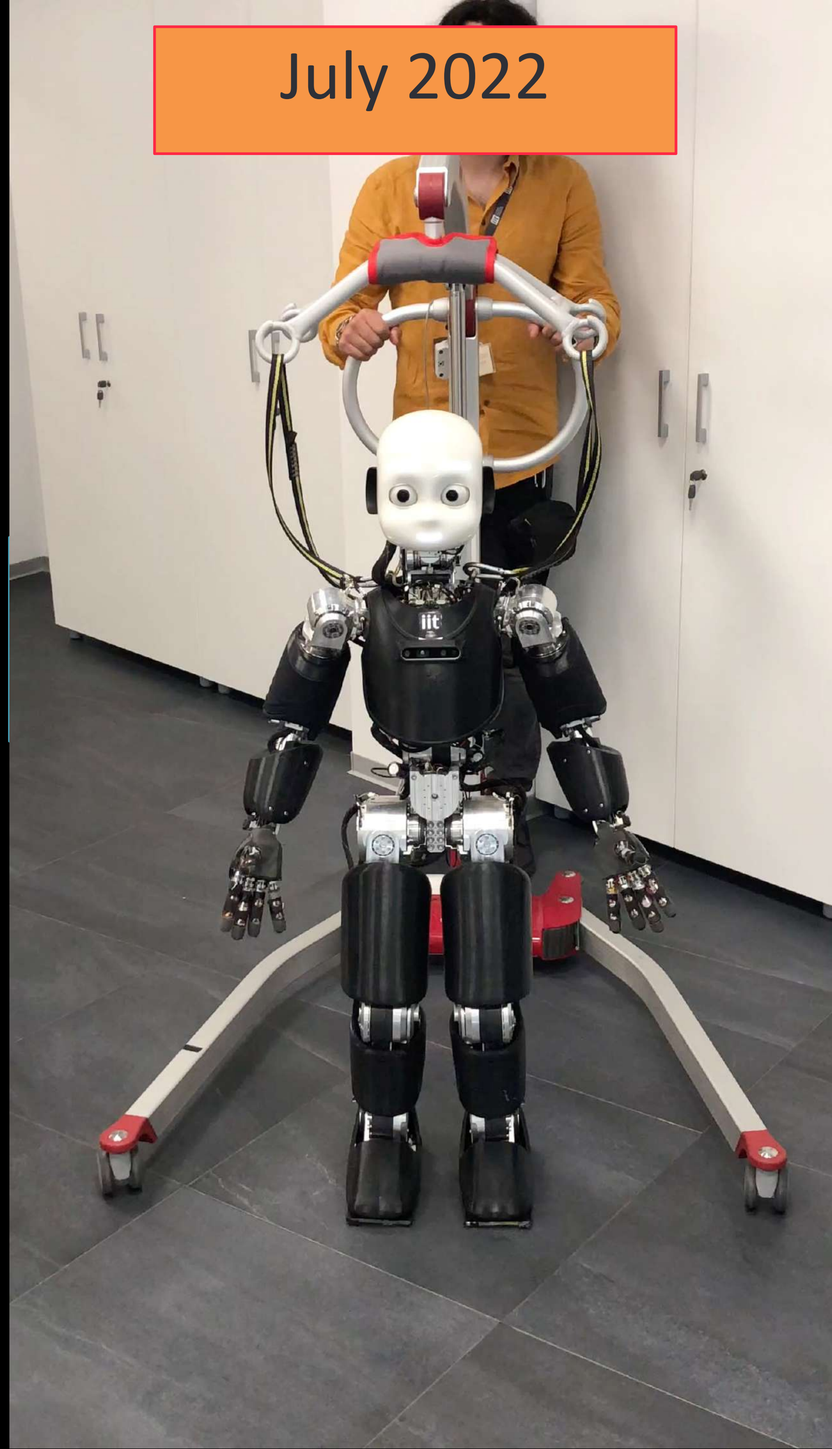
The avatar locomotion control interface



Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022


November 2020

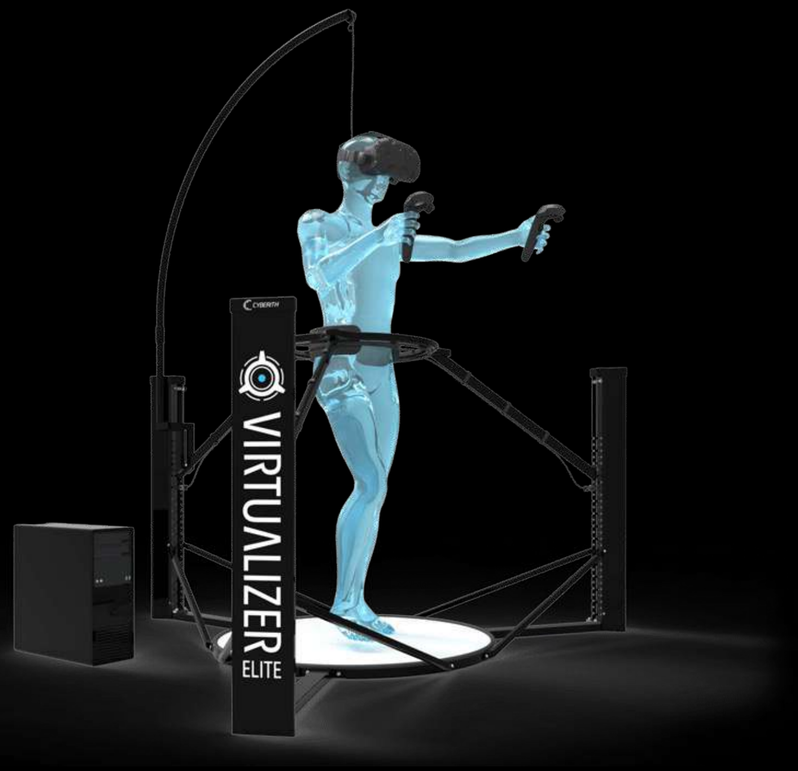

June 2021


July 2022

The avatar locomotion control interface

Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

The operator



1. Monitor human upper body for manipulation
2. Monitor human lower body for locomotion
3. Monitor human expressions for facial mimicry
4. Bring auditory, visual, haptic, force feedback

Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

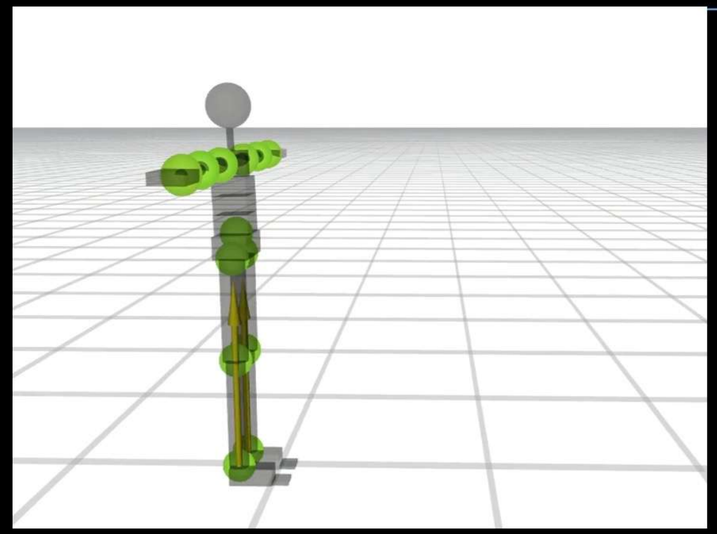
The operator

1. Monitor human upper body for manipulation

Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

Monitor human upper body for manipulation

- IMUs
- Wireless
- Haptic feedback
- Temperature
- Network

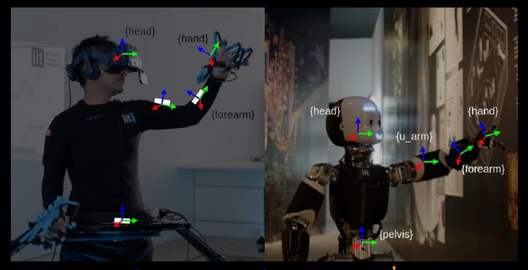


https://ifeeltech.eu/

Monitor human upper body for manipulation

Robot model

IMU

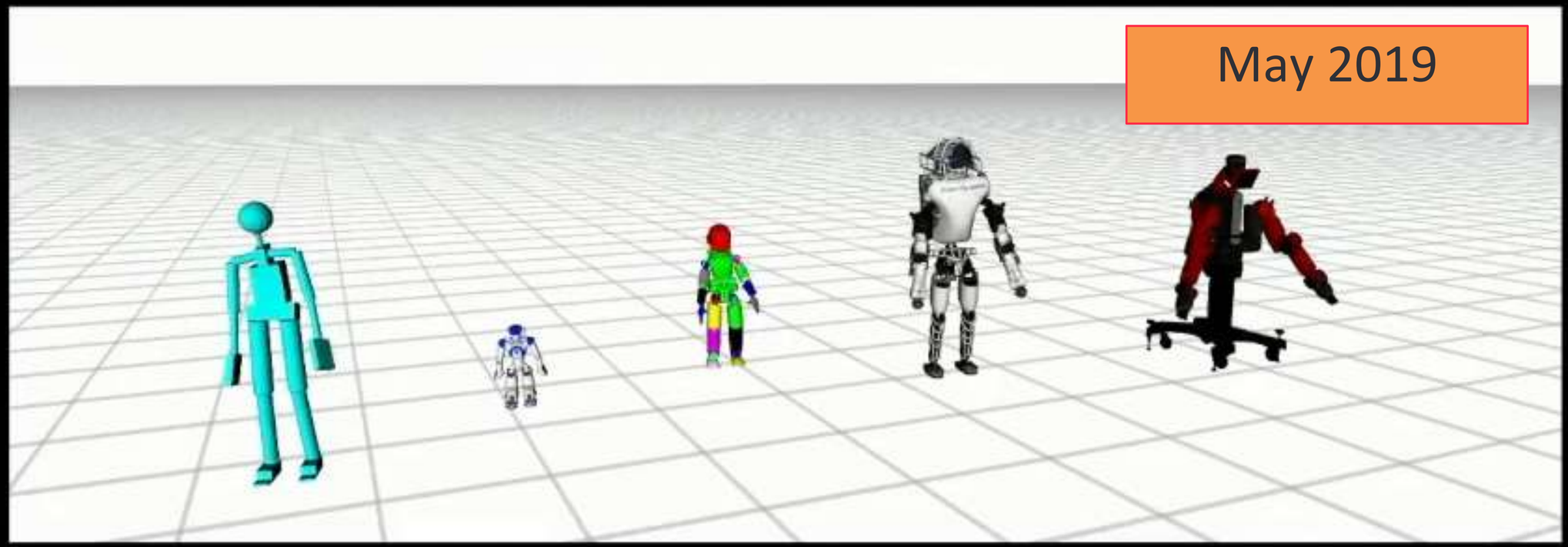


RETARGETING via ONLINE WHOLE-BODY IK

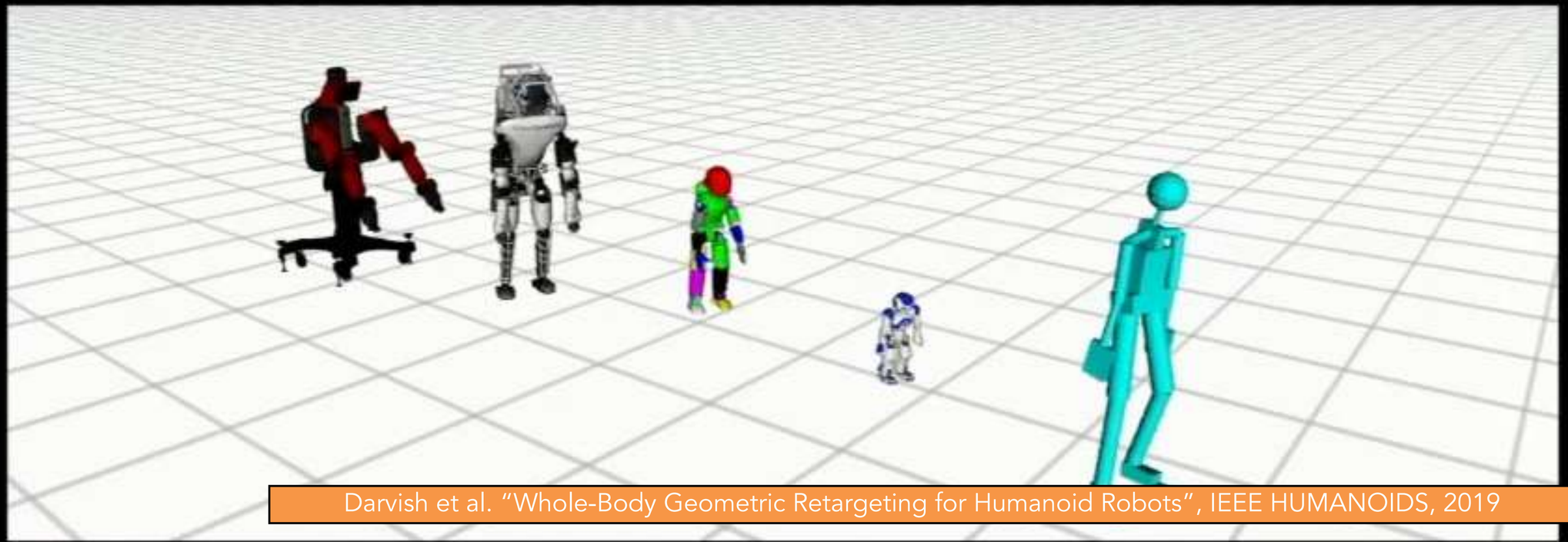
Retargeted motions

Rapetti et al. "Model-based real-time motion tracking using dynamical inverse kinematics" Algorithms, 2021

Darvish et al. "Whole-Body Geometric Retargeting for Humanoid Robots", IEEE HUMANOIDS, 2019



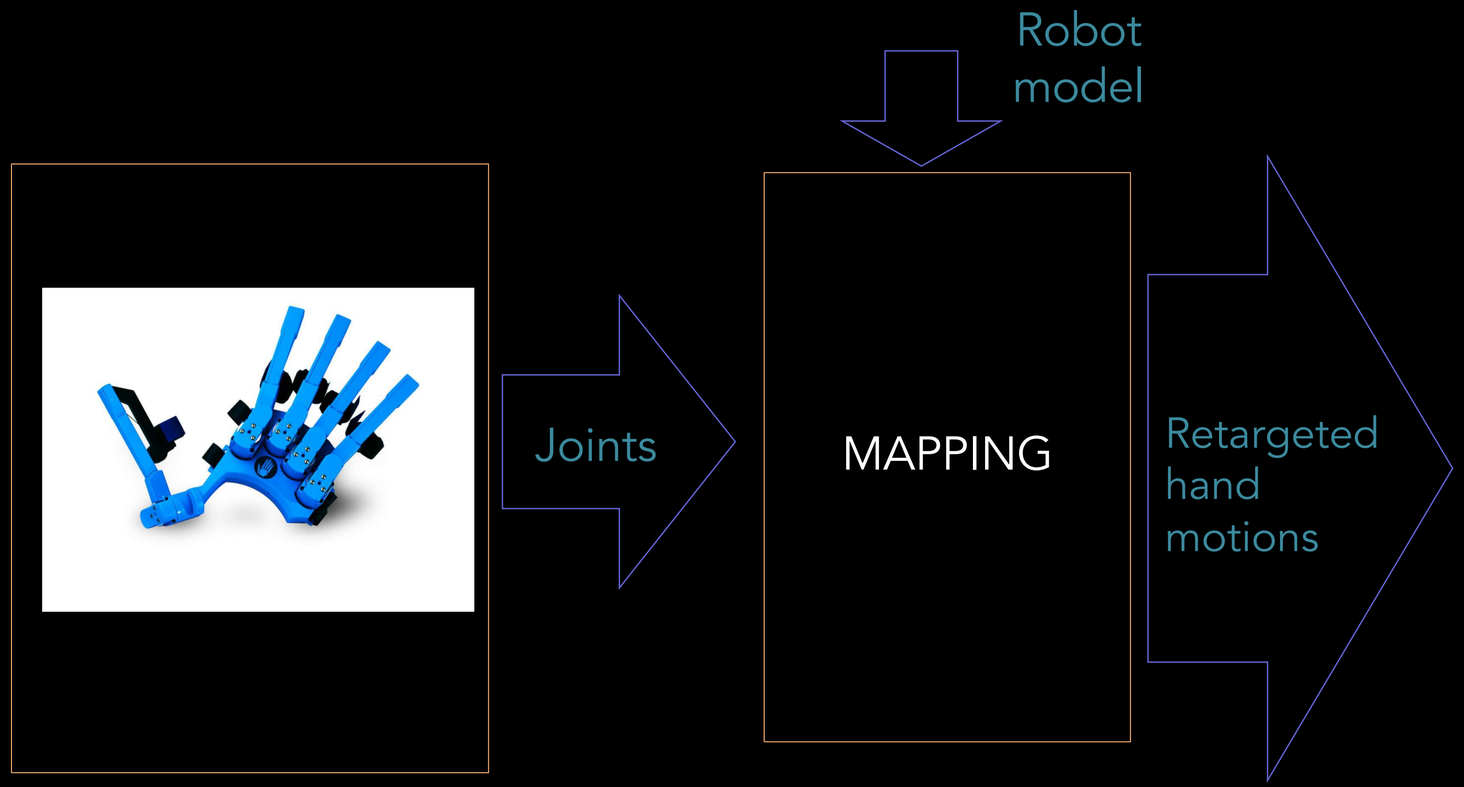
May 2019



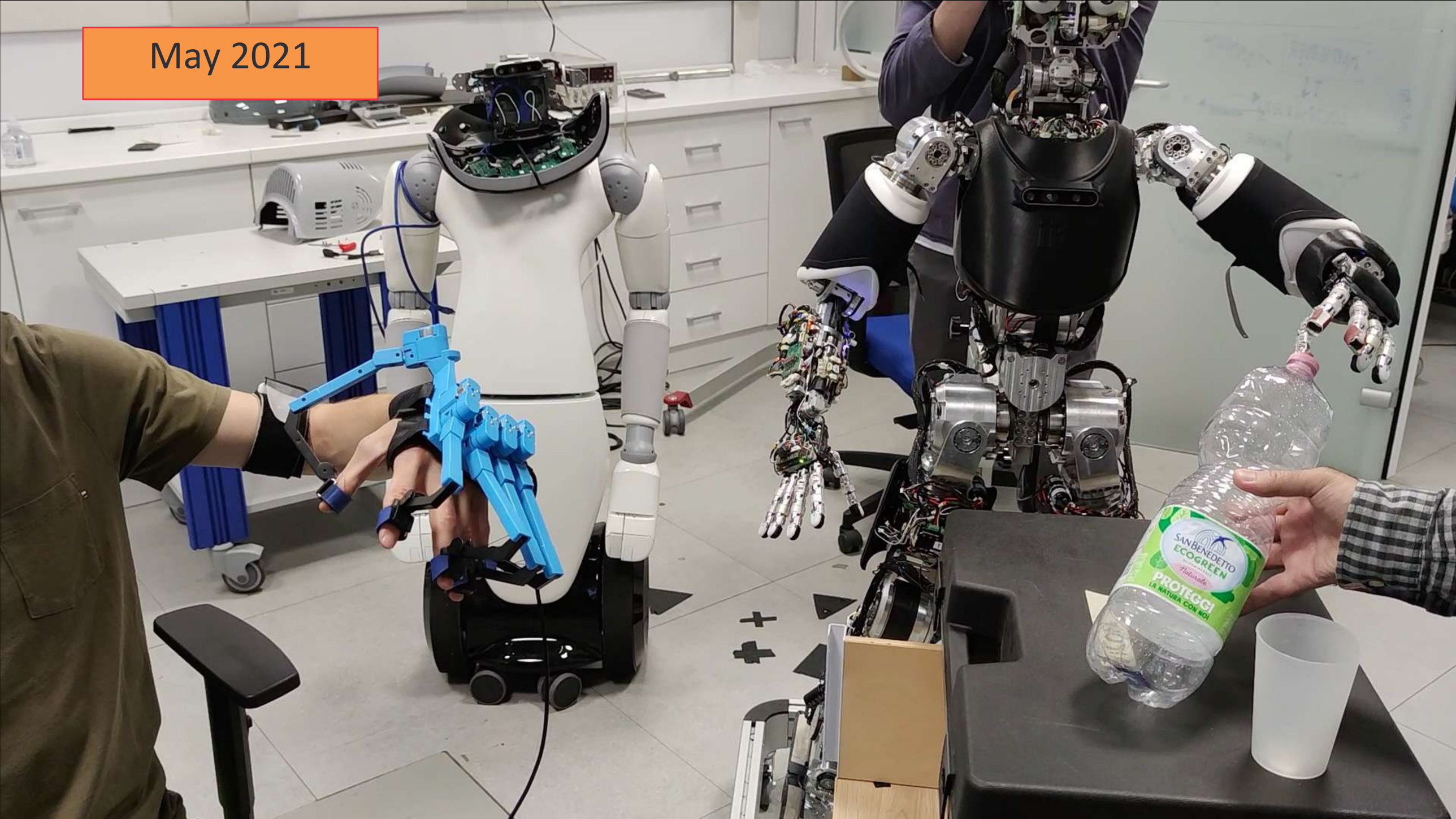
Darvish et al. “Whole-Body Geometric Retargeting for Humanoid Robots”, IEEE HUMANOIDS, 2019

Darvish et al. “Whole-Body Geometric Retargeting for Humanoid Robots”, IEEE HUMANOIDS, 2019

Monitor human upper body for manipulation



Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022


May 2021
SAN BENEDETTO
ECOGREEN
PROTEGGI
LA NATURA CON NOI

The operator

1. Monitor human upper body for manipulation
2. Monitor human lower body for locomotion

Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

Monitor human lower body for locomotion

Retargeting

Desired walking directions

CONTROL ARCHITECTURE FOR WALKING

Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

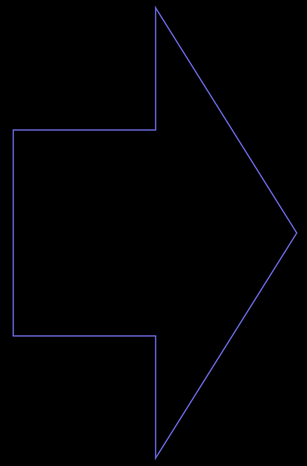
Darvish et al. “Whole-Body Geometric Retargeting for Humanoid Robots”, IEEE HUMANOIDS, 2019

Monitor human lower body for locomotion

- Not easy to transfer oversees
- Needing a lot of training
- No lateral steps

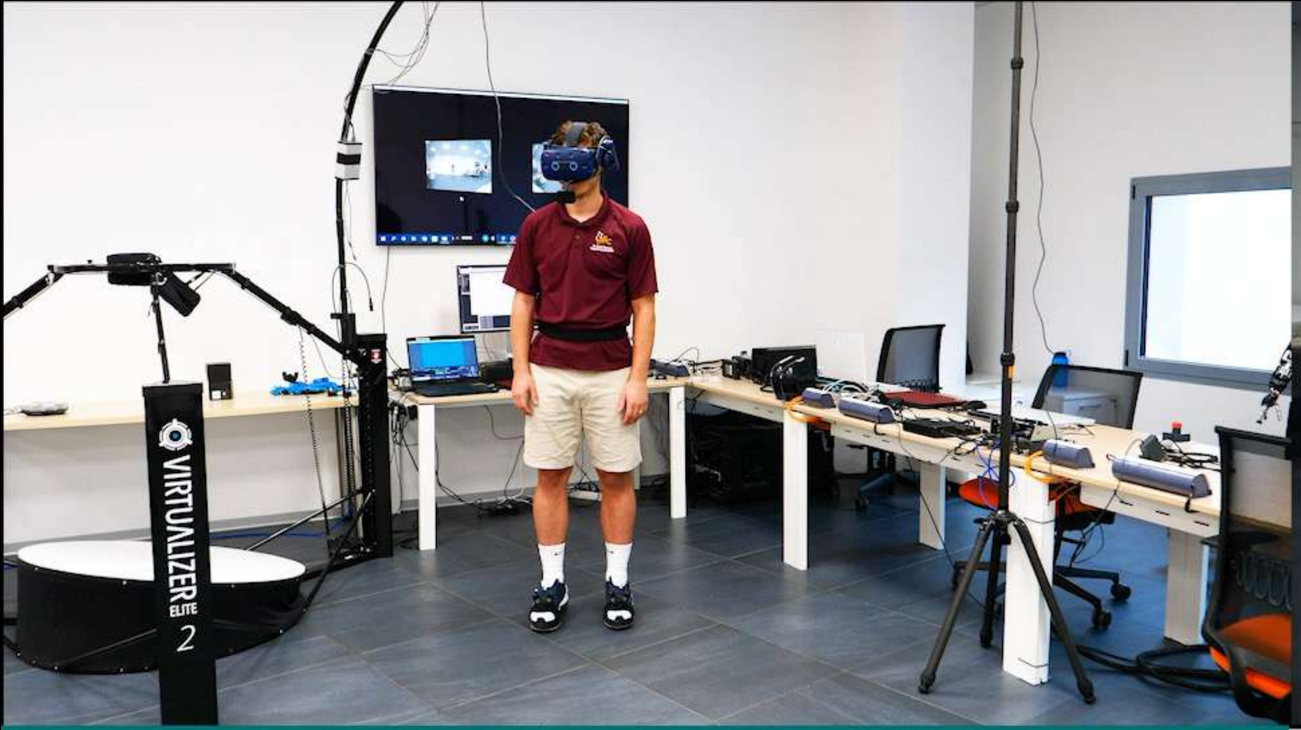
Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

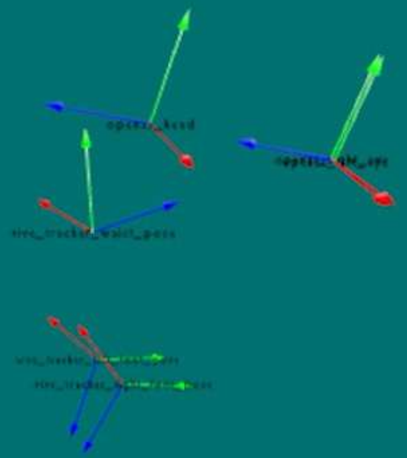
Monitor human lower body for locomotion



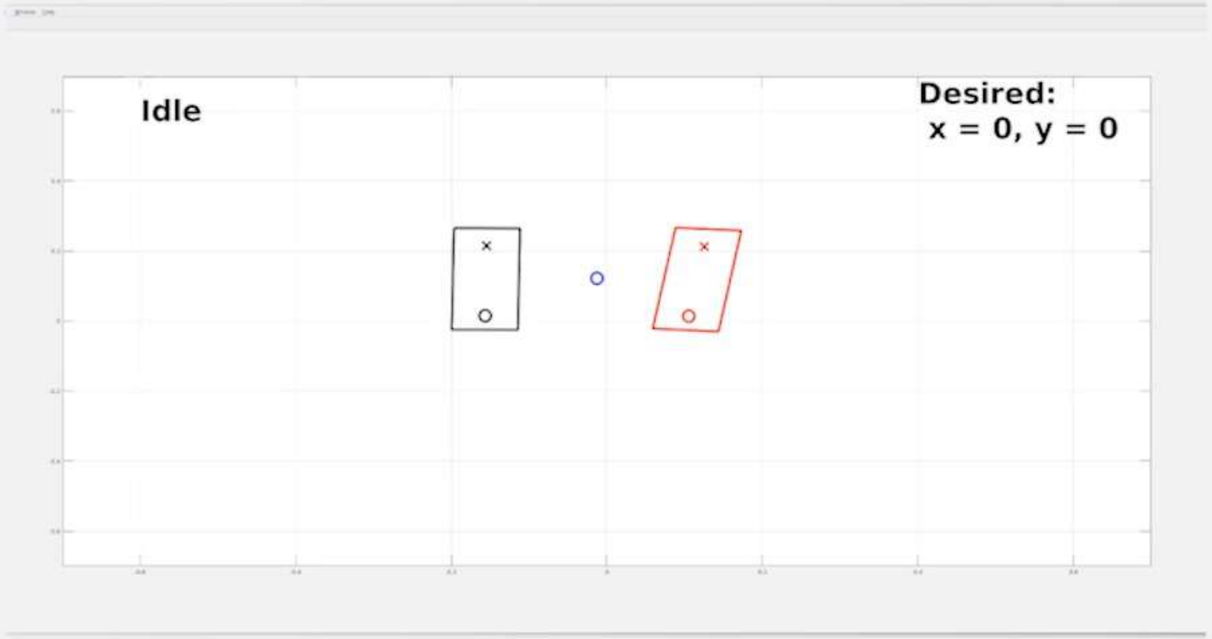
Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

Intention recognition
and activation





Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

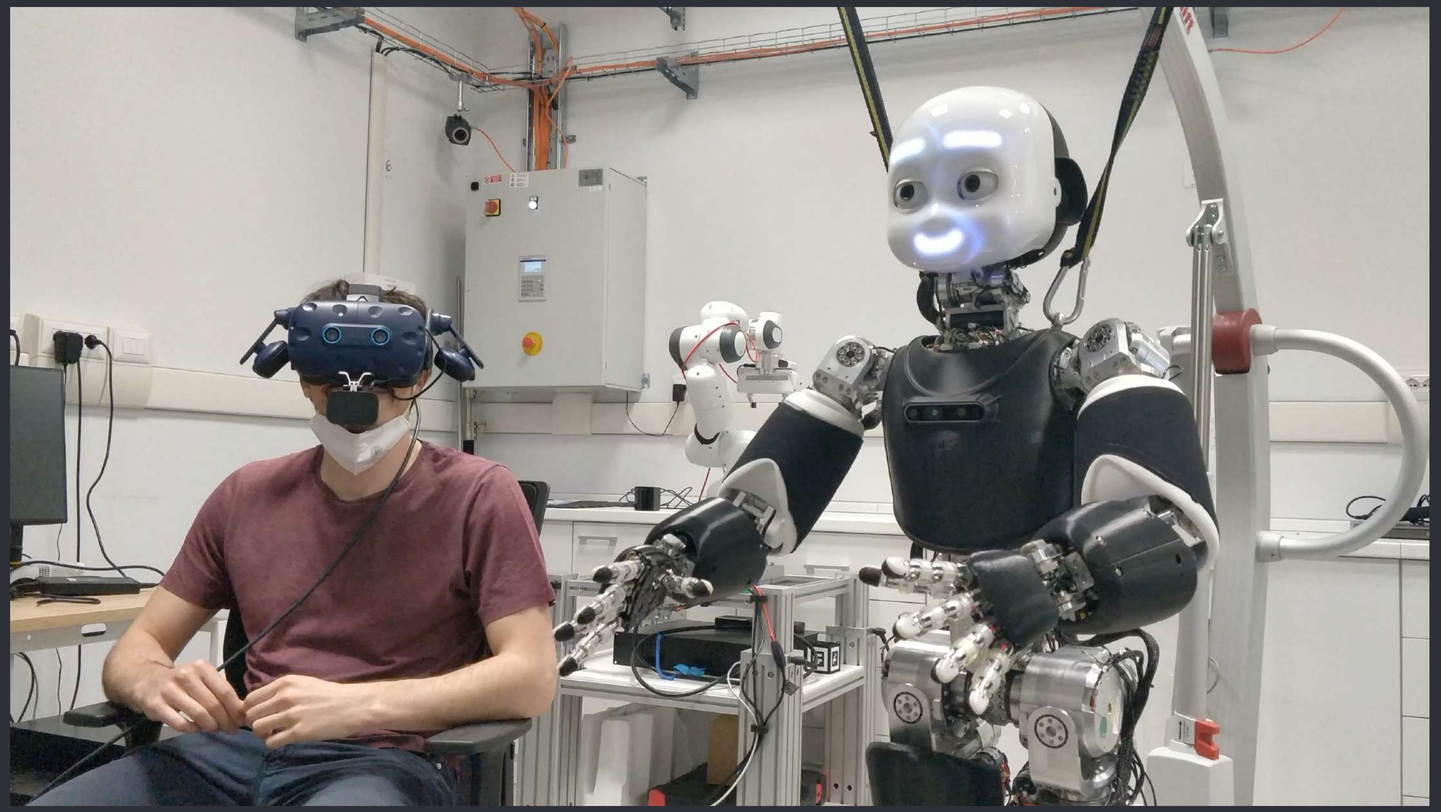


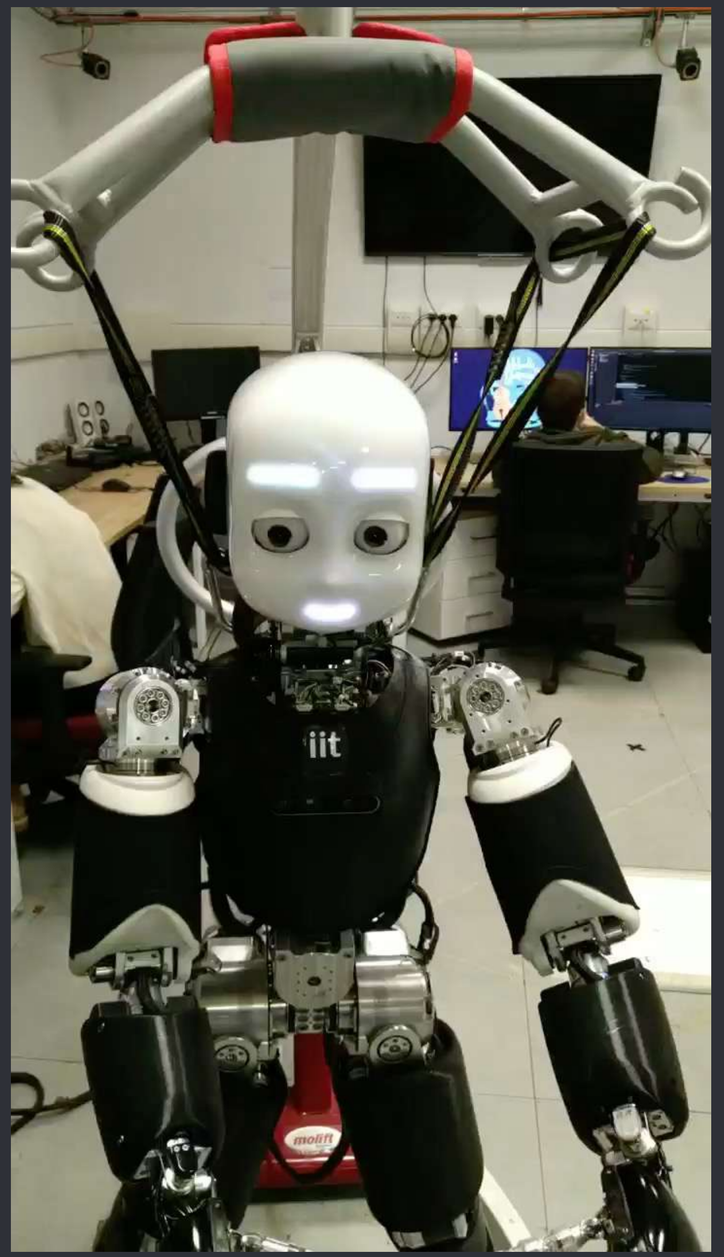
CHAPERON

The operator

1. Monitor human upper body for manipulation
2. Monitor human lower body for locomotion
3. Monitor human expressions for facial mimicry

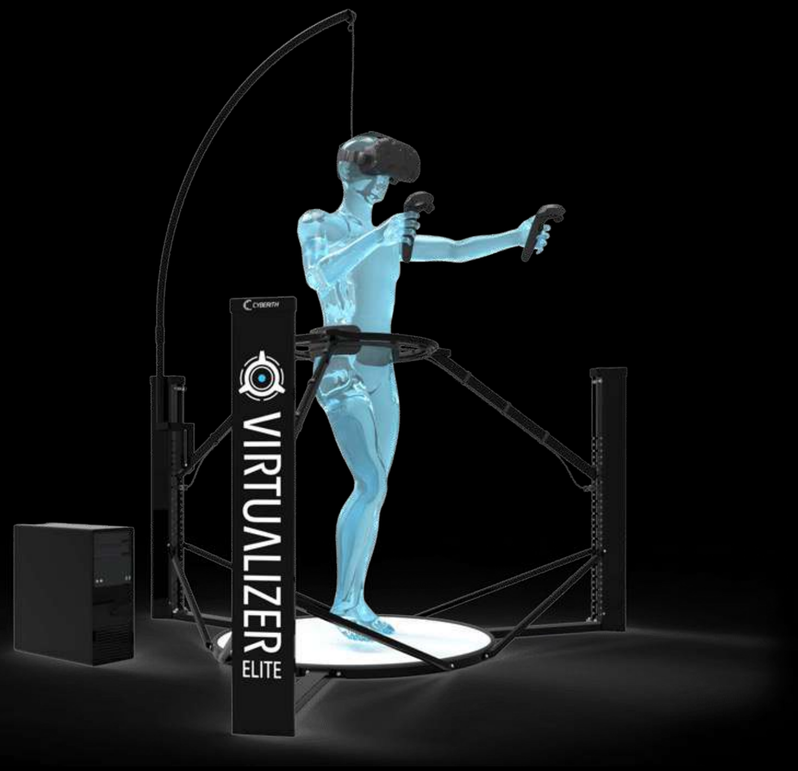
Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022





Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

The operator



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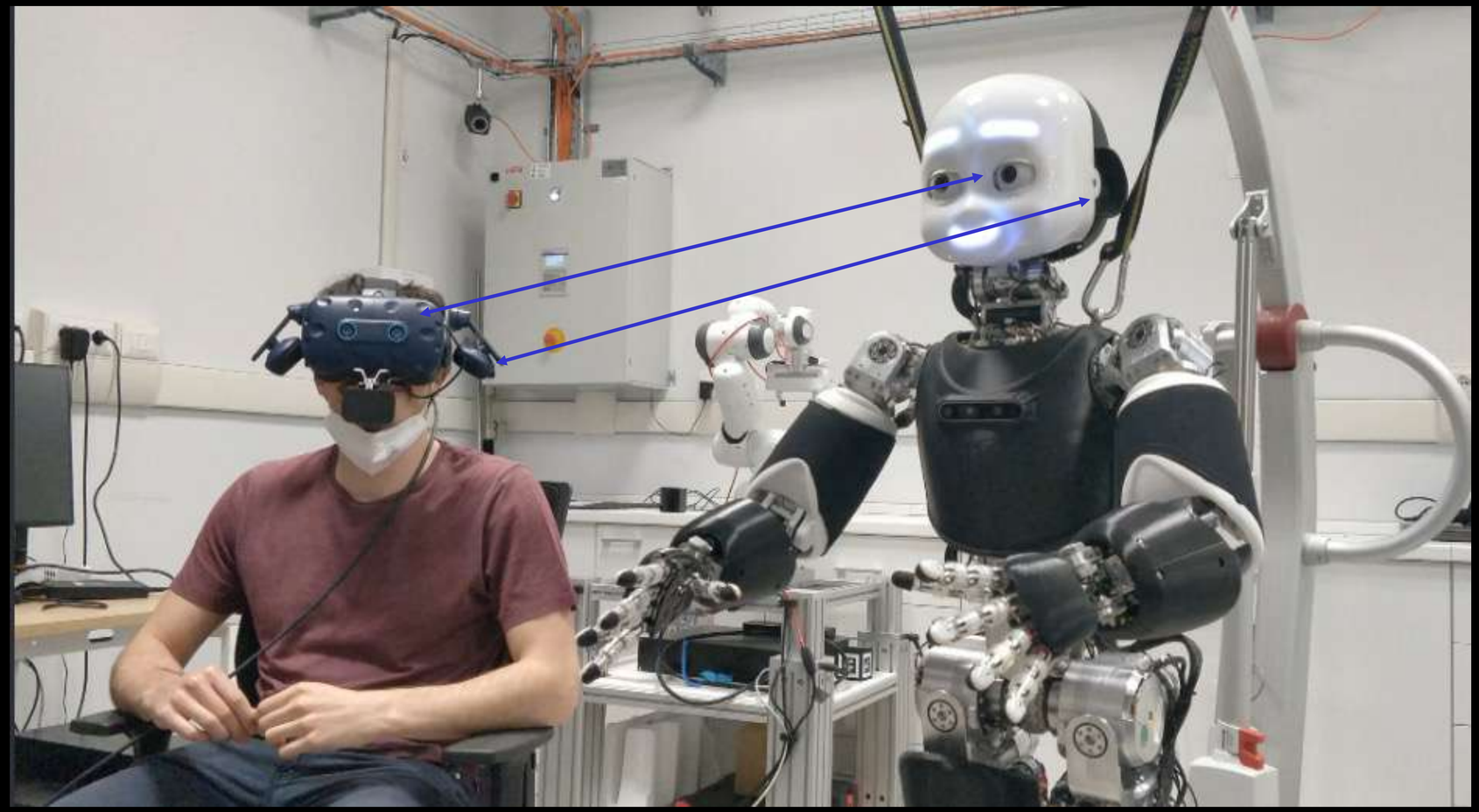
4. Bring auditory, visual, haptic, force feedback

Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

Bring auditory and visual feedback

Auditory feedback

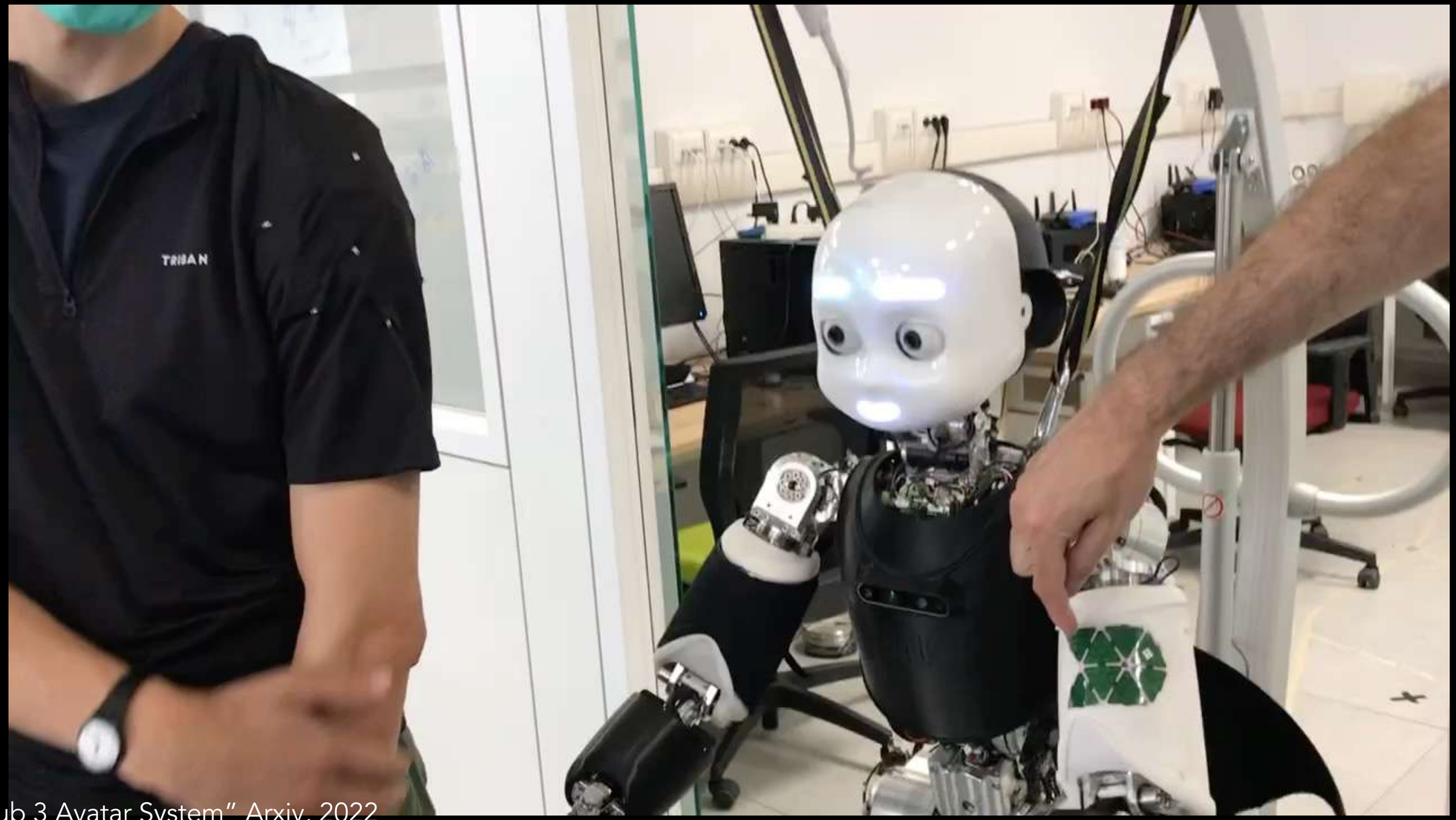
Visual feedback



Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

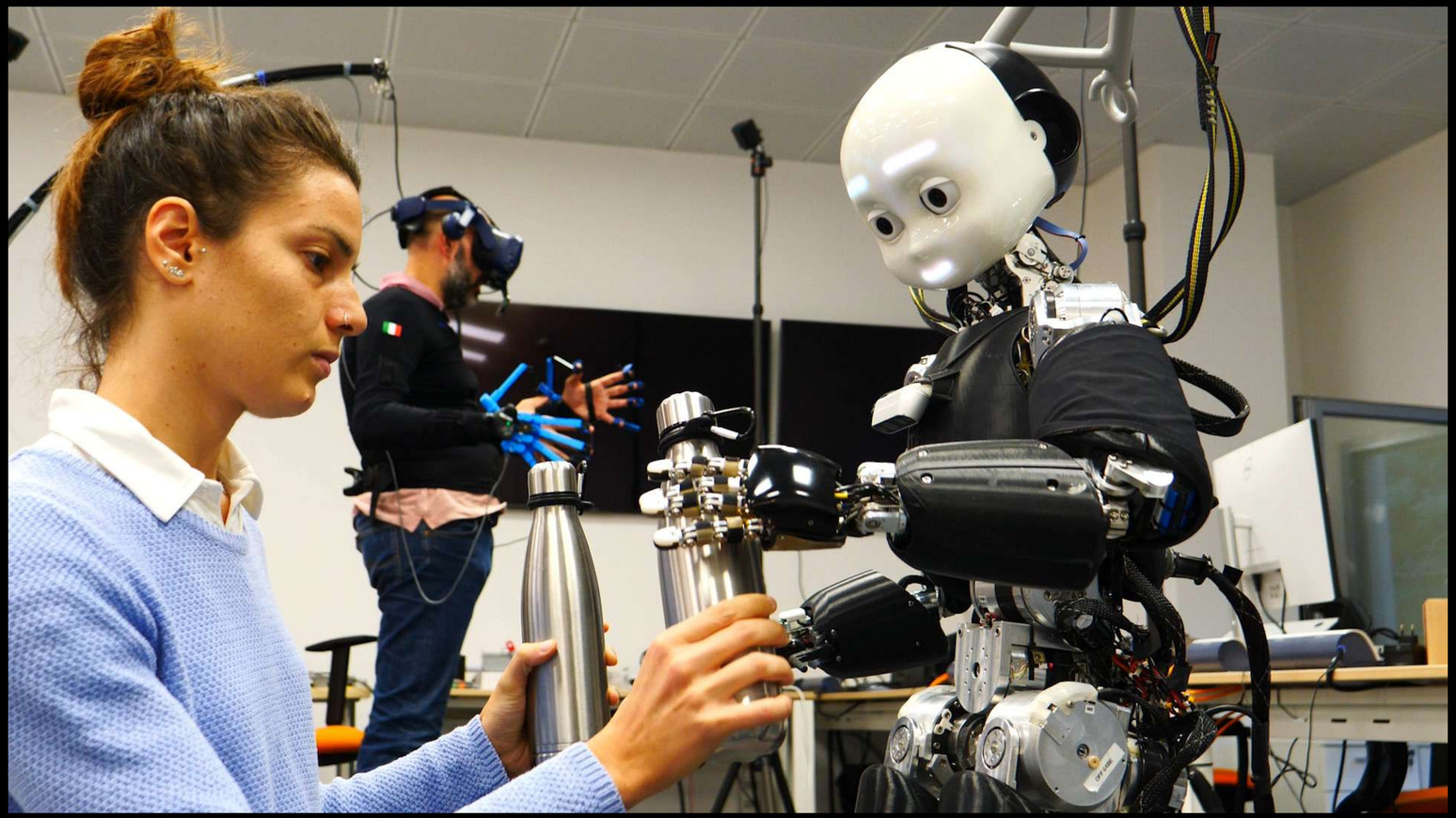
Bring haptic and force feedback

Touch retargeting



Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

Bring haptic and force feedback

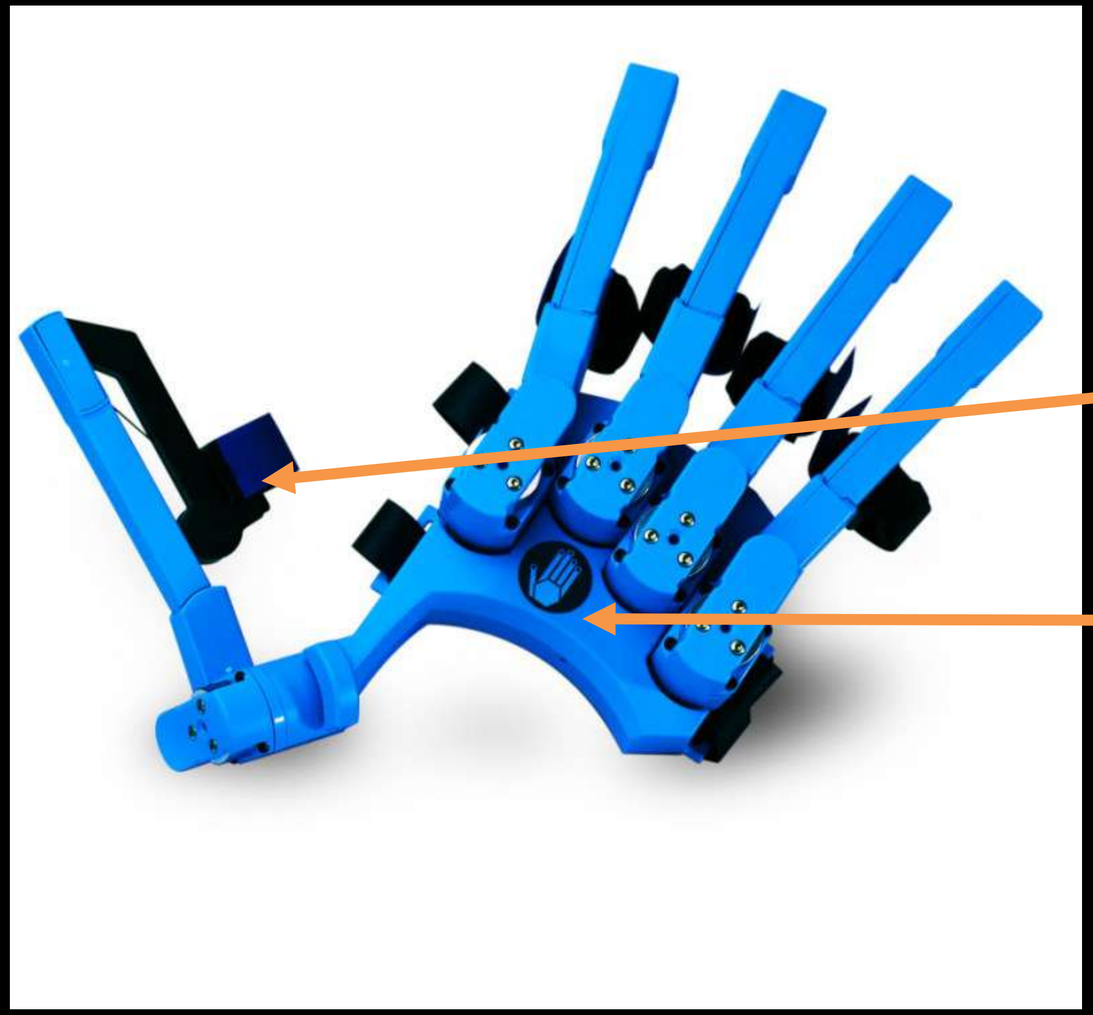


Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

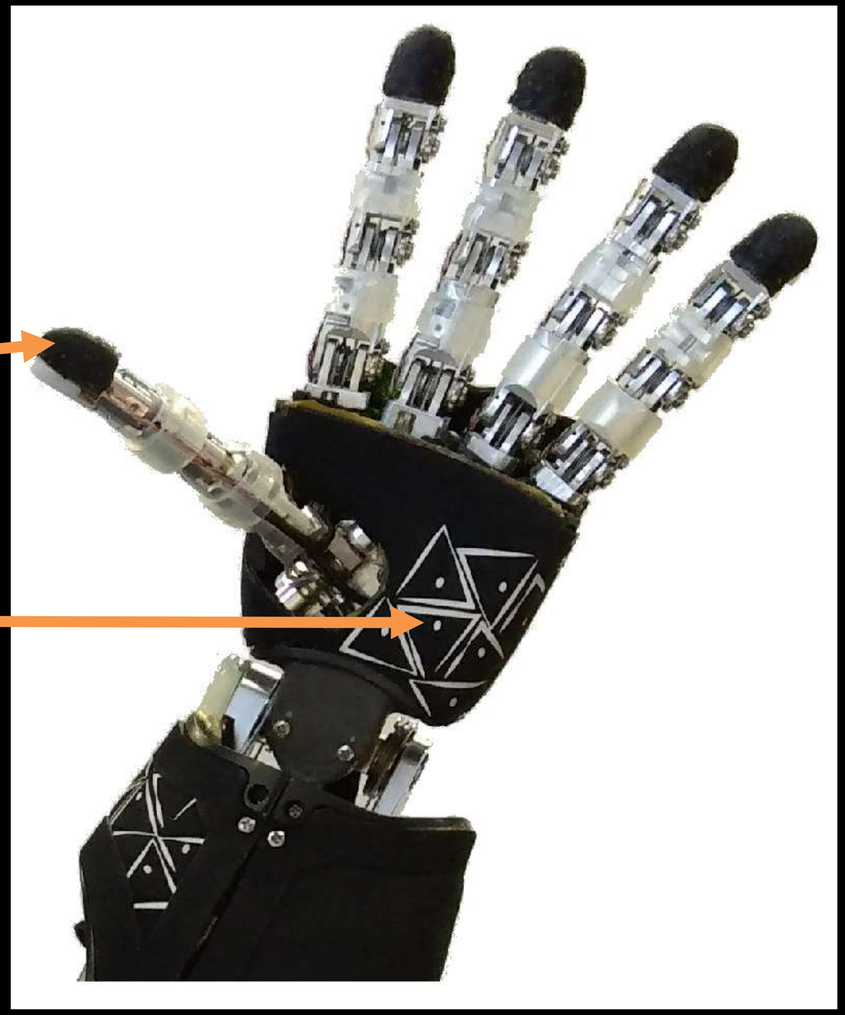
Vibrations using upper body haptics

Visualization using headset

Bring haptic and force feedback

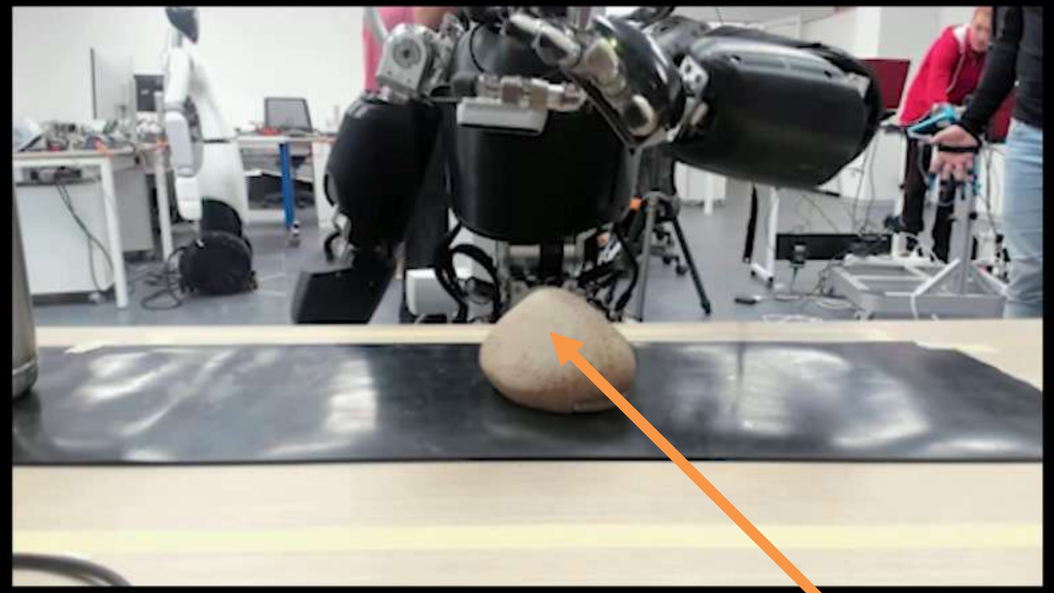


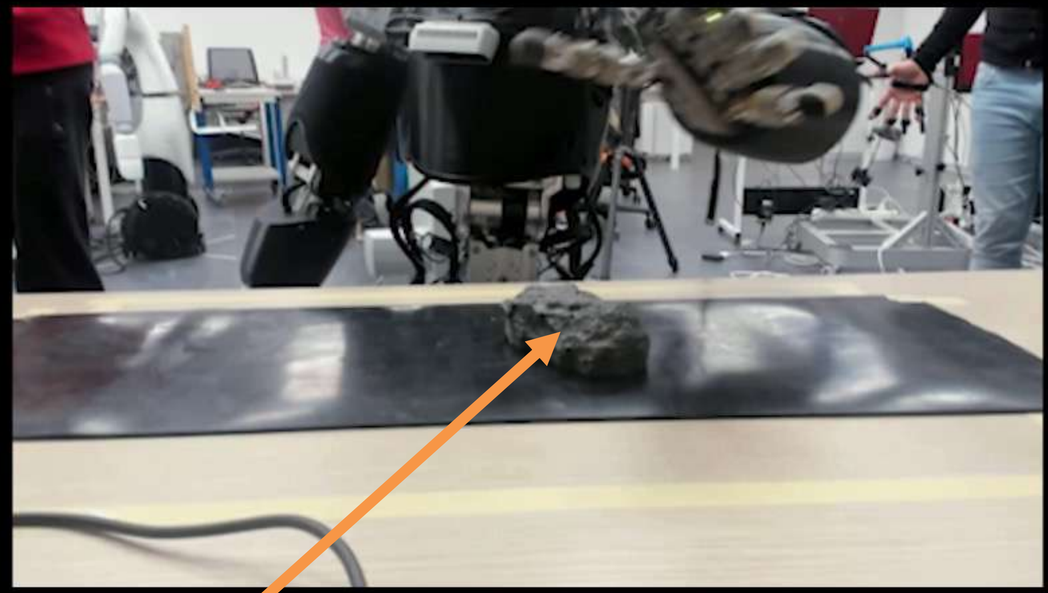
From iCub hand skin to vibrations

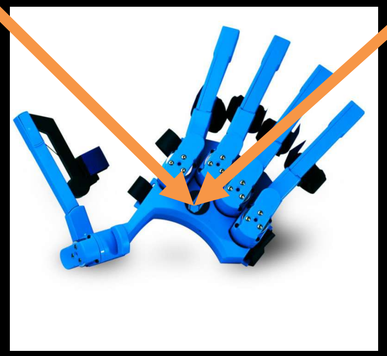


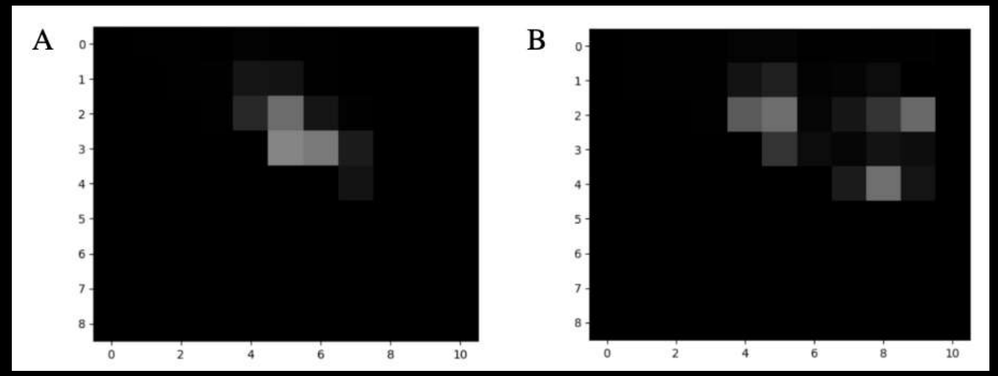
Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

- Vibration pattern resembling either plain or rough texture
- Neural network trained to classify the type of contact (i.e., rough or plain) from 48 tactile sensors
- Measurements interpreted as a 9x11-pixels grayscale image, where each pixel
- Classifier obtained as customized version of AlexNet architecture



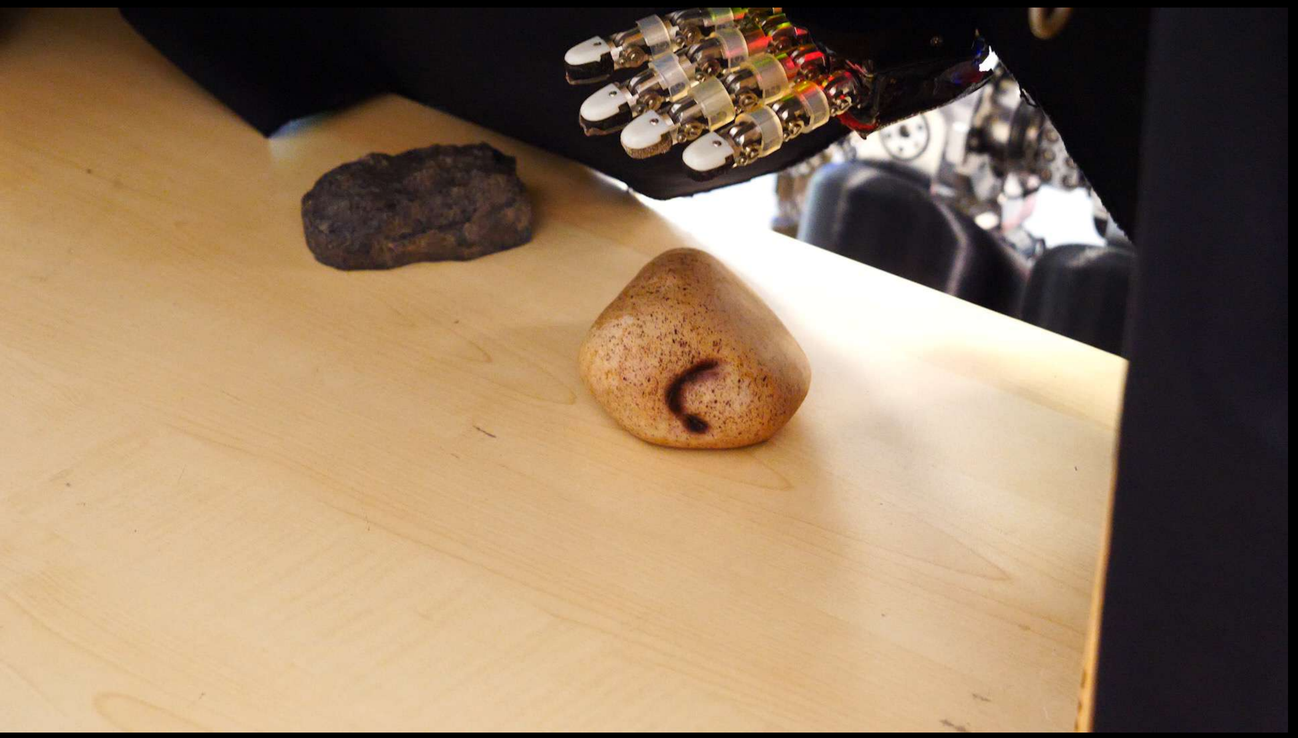






Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

Bring haptic and force feedback

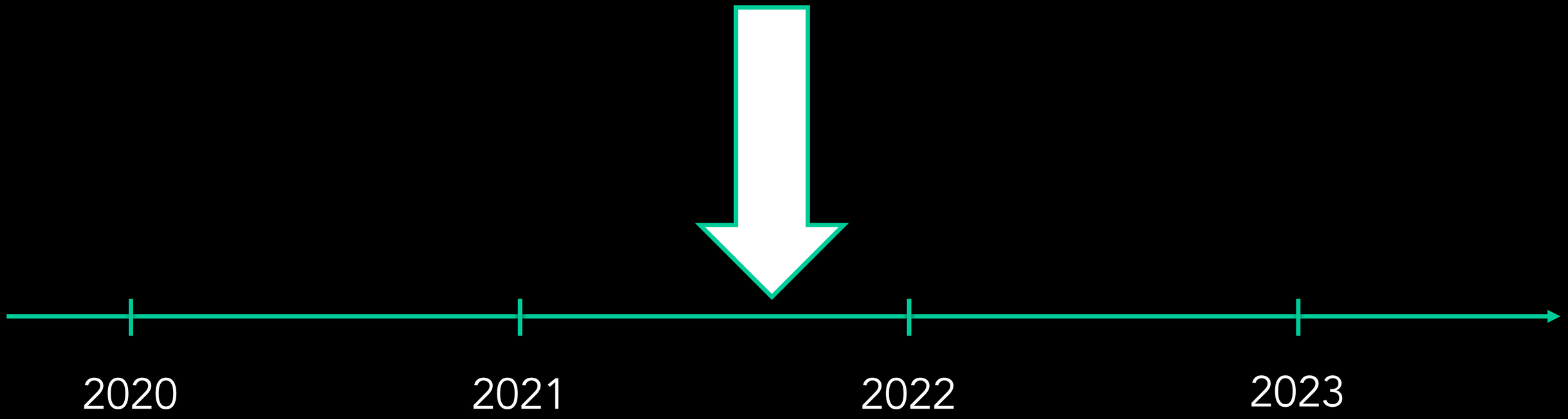


Dafarra et al. “iCub 3 Avatar System” Arxiv, 2022

To develop a general system for Telexistence: allow a human to exist elsewhere via a robotic avatar

ANA AVATAR | XPRIZE

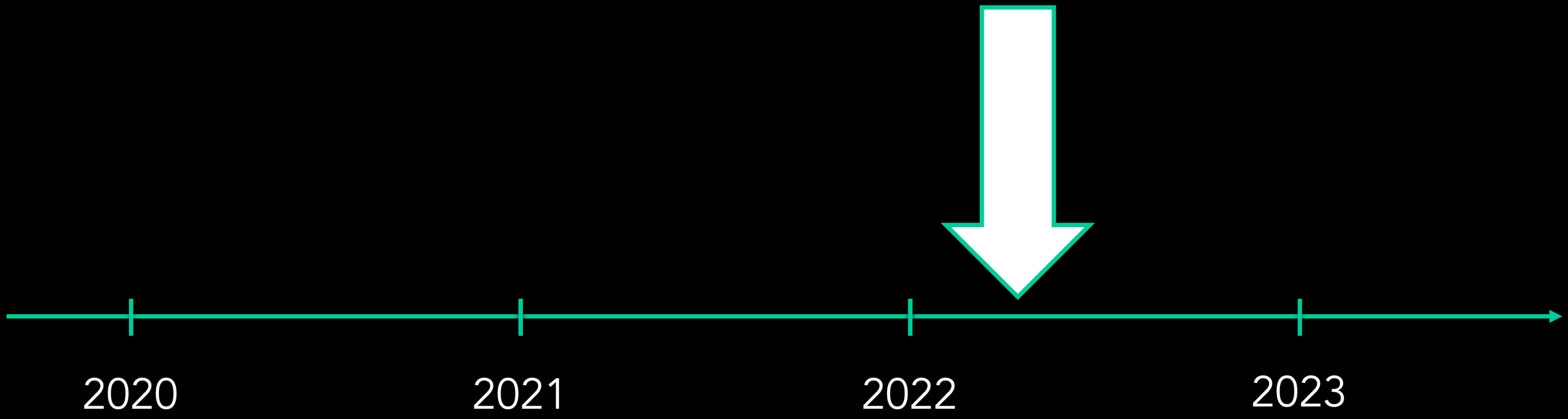
Remote testing




PORTO ANTICO

ANA AVATAR | XPRIZE

Semifinals

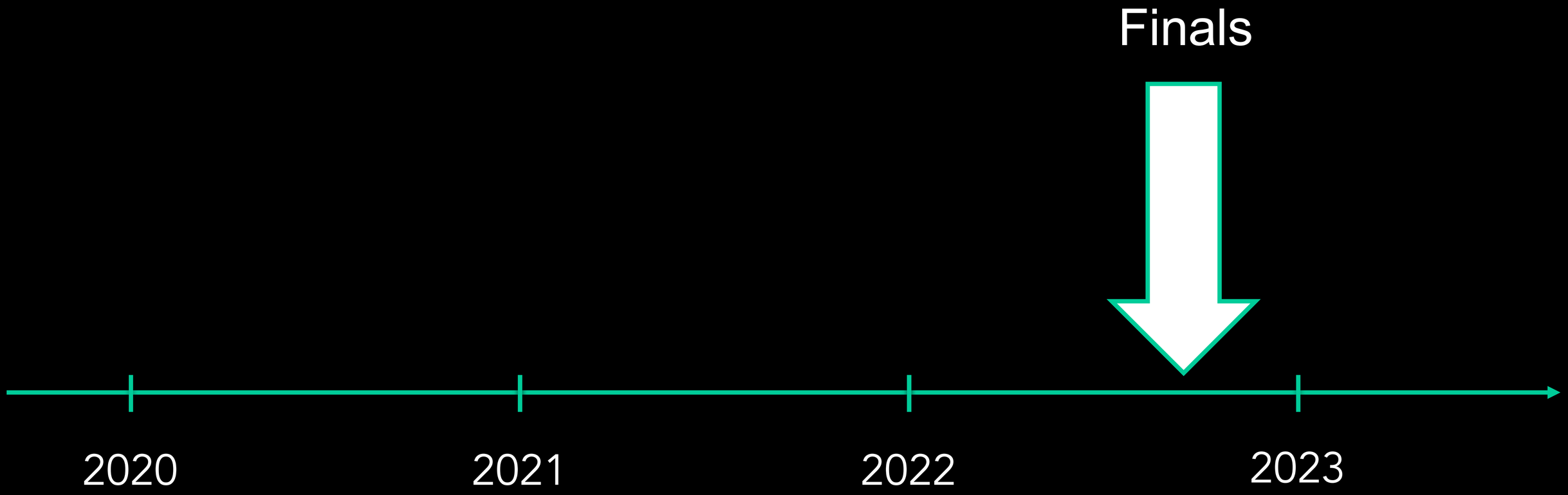


Semifinals in Genoa: April 2022

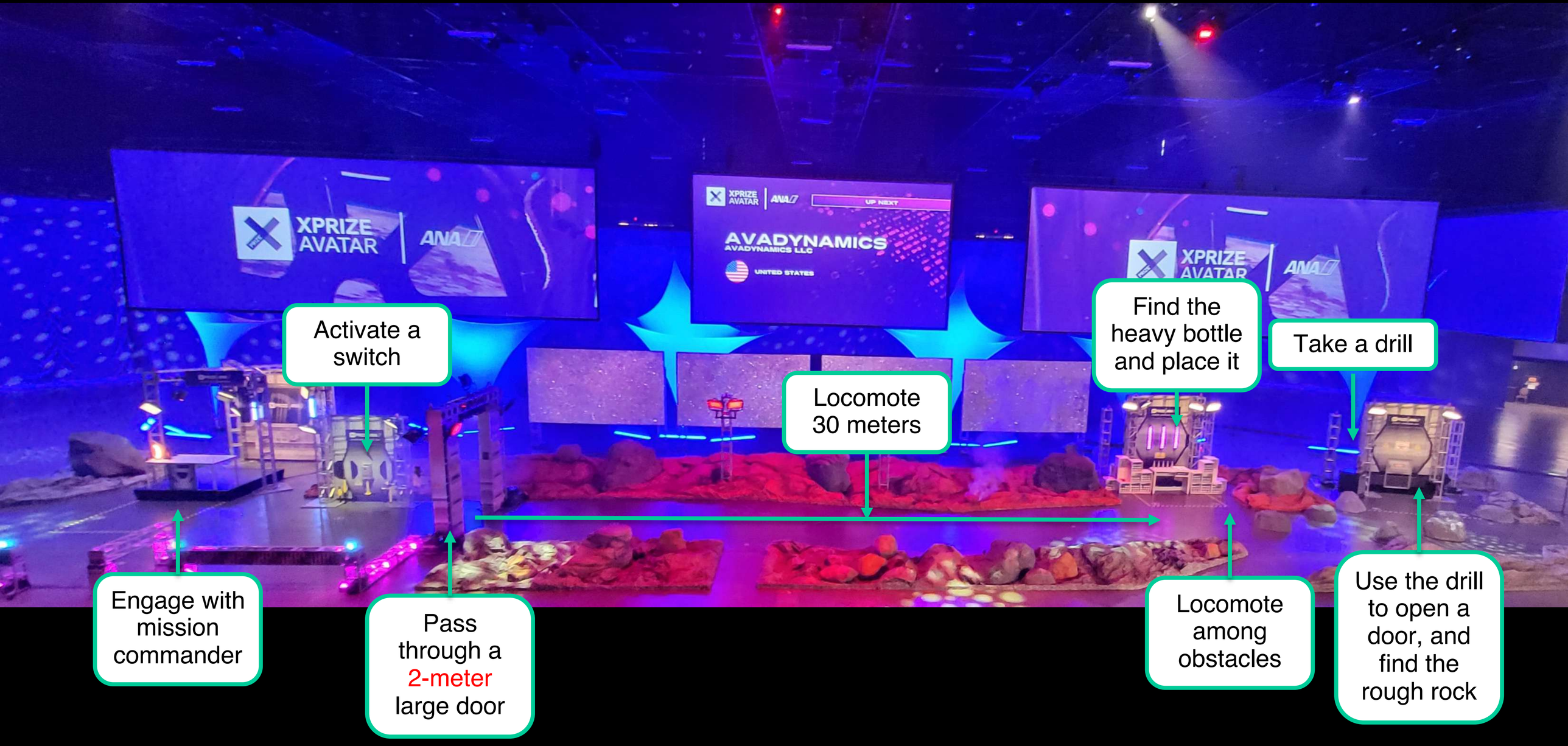
Unknown XPRIZE operator

2nd place after semifinals

ANA AVATAR | XPRIZE



Finals in Los Angeles: November 2022



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ICUB

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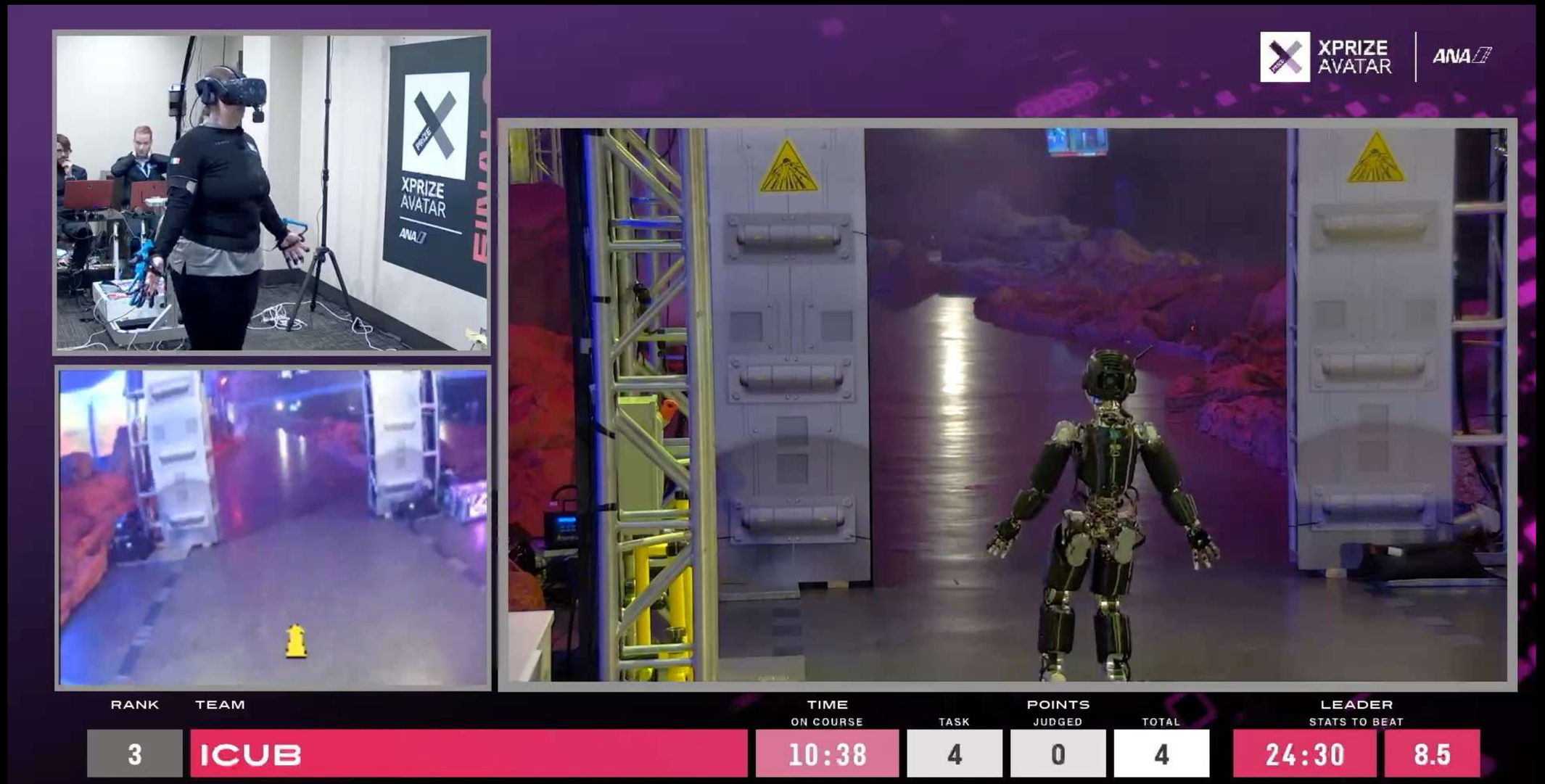
ITALY

Next

Next: cognitive effort



Next: cognitive effort

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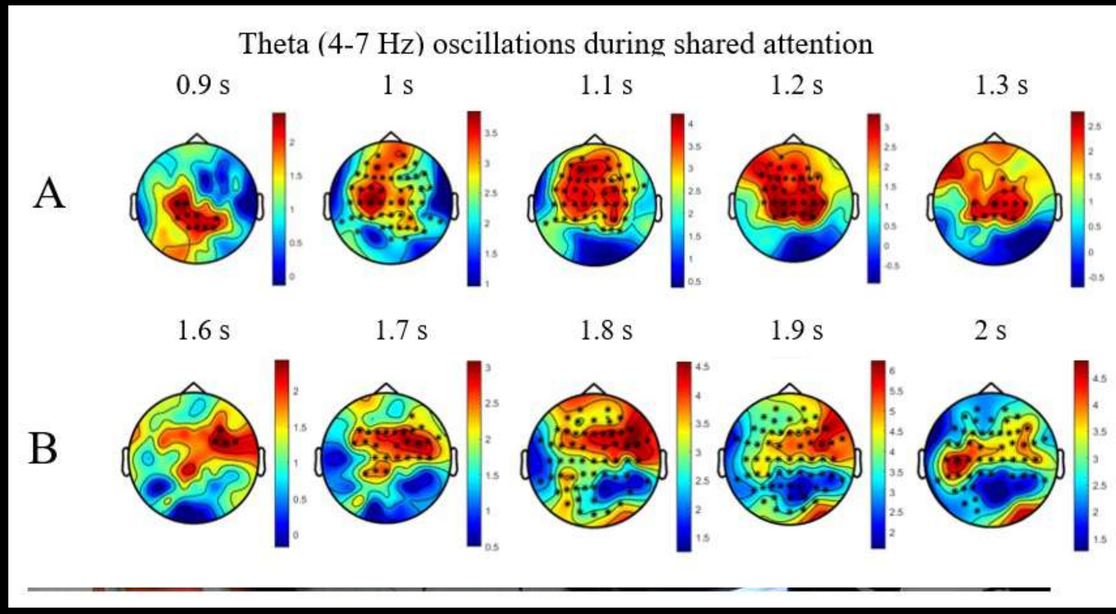
DI TECNOLOGIA
SOCIAL COGNITION IN
HUMAN-ROBOT INTERACTION



Next

https://ergocub.eu/

ergoCub

Human-Robot Collaboration

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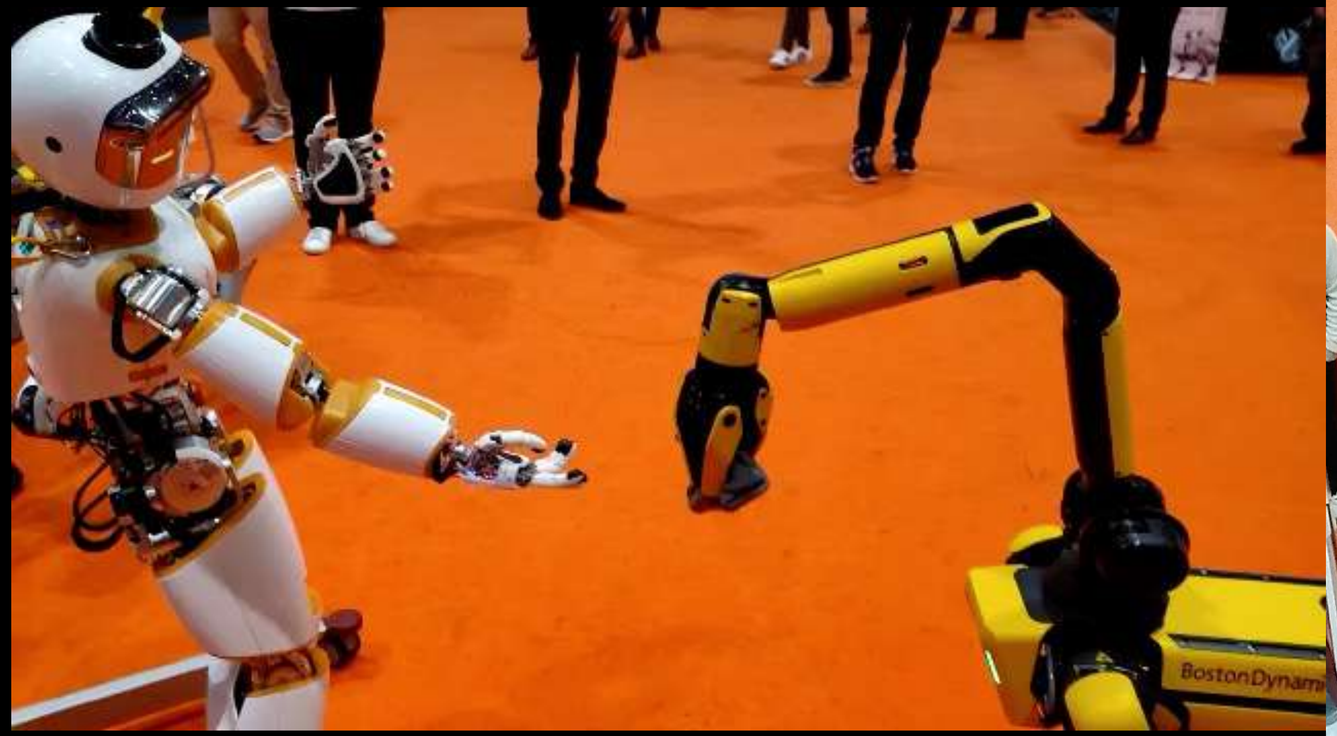
Next



Conclusions

- Making humanoids is complex, making humanoid avatars is more complex
- How to achieve embodiment for locomotion is still an open issue
- Shared autonomy might be useful for avatars, but still a challenge
- Avatar technologies are ideal infrastructures to acquire data and take steps towards autonomous systems

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