# Human Behavior Capturing and Retargeting in Tele-Presence

Li Bingbing (Phd studnet)

Supervisor: Prof. CHEN I-Ming

Co-Supervisor: Prof. Nadia MAGNENAT-THALMANN

BeingThere

NANYANG TECHNOLOGICAL UNIVERSITY

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# Outline

- Objectives and Motivation
- Introduction
- Direct Mapping
- Indirect Mapping
- Future work

# Human Behavior Capturing and Retargeting in Tele-Presence

- Objective
  - To build a whole system including both a tracking mechanism and kinematic model such we can
  - Track the real-time human body movement
  - Using the kinematic information to get the user's message within his movement
  - Transfer this information to a simpler motion containing the same message
  - Replay this motion in a remote robotic avatar

- Motivation
  - Current tracking method lack of tracking accuracy(leading to misunderstanding)
  - Non-simultaneous tracking
  - High Computational loads

# Immersive Tele-presence: Requirement

- Interacting with remote people as if face to face
  - Natural interaction
  - Invisible technology
  - Minimal cognitive load
  - High quality video
  - High quality audio
  - Perfect audio-visual sync (< 150ms)

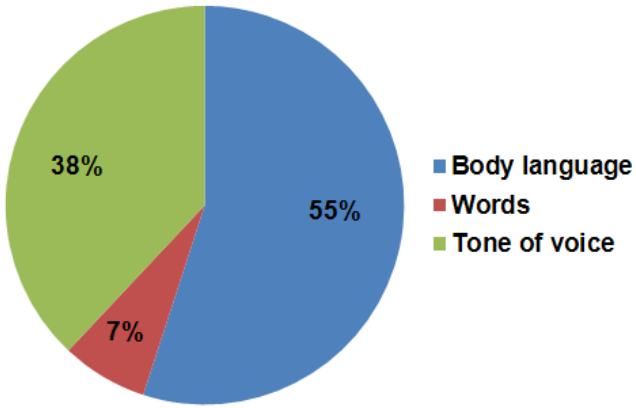
- Maintain Social presence & casual contact

# Motion retargeting: Why?

## Mehrabian's Communication Rule

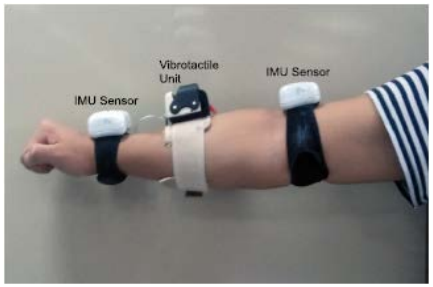
- Three elements account differently for the meaning of the message
  - Words account for 7%
  - Tone of voice account for 38%
  - Body language accounts for 55%

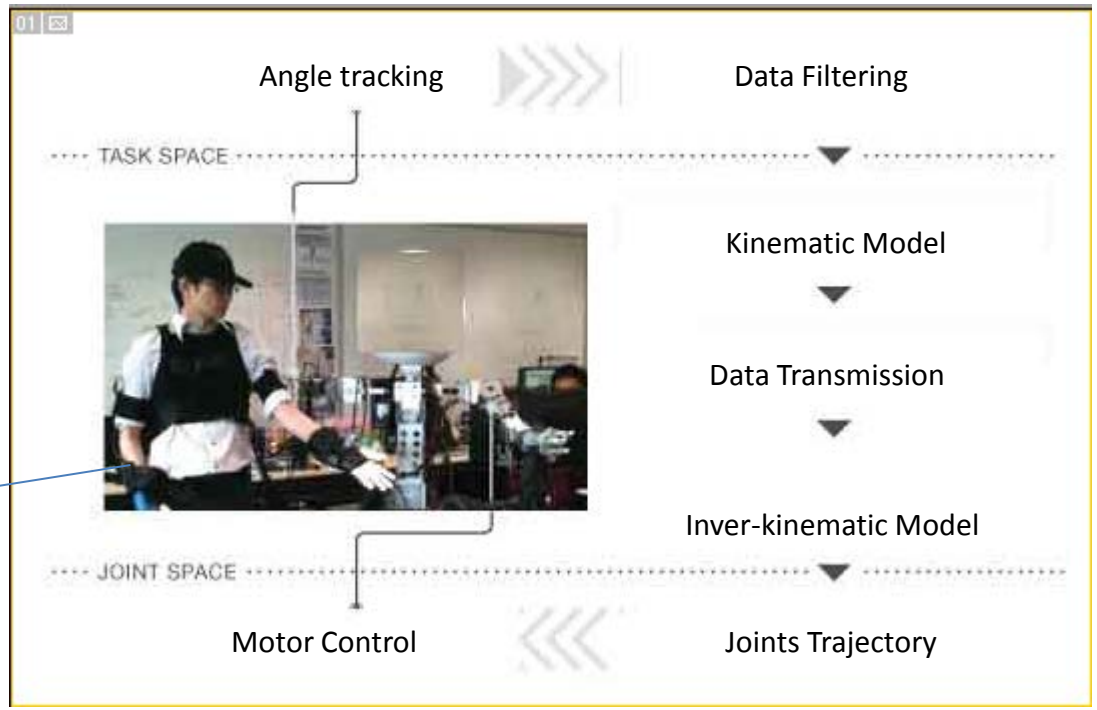
*NOT a general observation relevant to all communications



# General System Architecture

- Set-up

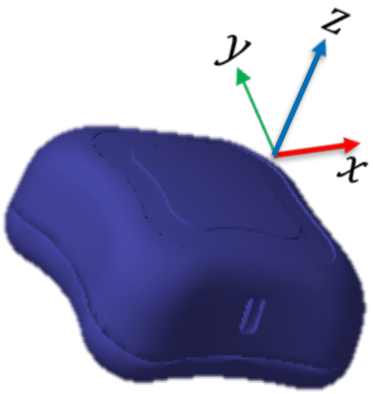


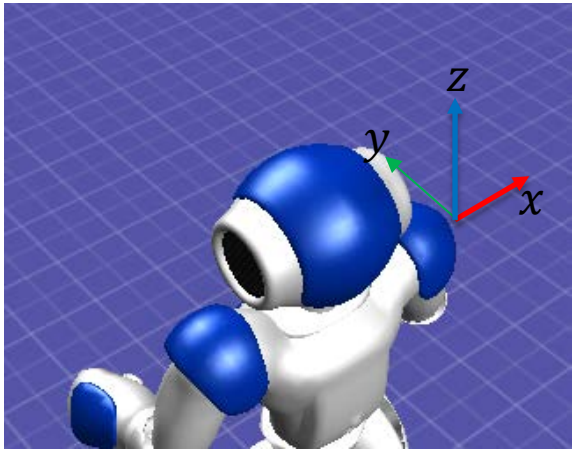




- Advantage:
  - Using 1-DOF acceleration for data comparison instead of image processing

# Direct Mapping

- 1 joint, From 3 DOF to 2 DOF



# Rotational Matrix

- IMU

$$\begin{pmatrix}\begin{pmatrix}1 & 0 & 0\\ 0 & \cos(\alpha) & \sin(\alpha)\\ 0 & -\sin(\alpha) & \cos(\alpha)\end{pmatrix}\end{pmatrix}\begin{pmatrix}\begin{pmatrix}\cos(\theta) & 0 & -\sin(\theta)\\ 0 & 1 & 0\\ \sin(\theta) & 0 & \cos(\theta)\end{pmatrix}\end{pmatrix}\begin{pmatrix}\begin{pmatrix}\cos(\psi) & \sin(\psi) & 0\\ -\sin(\psi) & \cos(\psi) & 0\\ 0 & 0 & 1\end{pmatrix}\end{pmatrix}$$

- NAO Head

$$\begin{pmatrix}\begin{pmatrix}1 & 0 & 0\\ 0 & \cos(\alpha) & \sin(\alpha)\\ 0 & -\sin(\alpha) & \cos(\alpha)\end{pmatrix}\end{pmatrix}\begin{pmatrix}\begin{pmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{pmatrix}\end{pmatrix}\begin{pmatrix}\begin{pmatrix}\cos(\psi) & \sin(\psi) & 0\\ -\sin(\psi) & \cos(\psi) & 0\\ 0 & 0 & 1\end{pmatrix}\end{pmatrix}$$

  - Rotation sequence: x, y, z

# Direct Mapping

- 1 joint, From 3 DOF to 2 DOF
  - Matching screw axis

IMU

Robot head

Rotational matrix

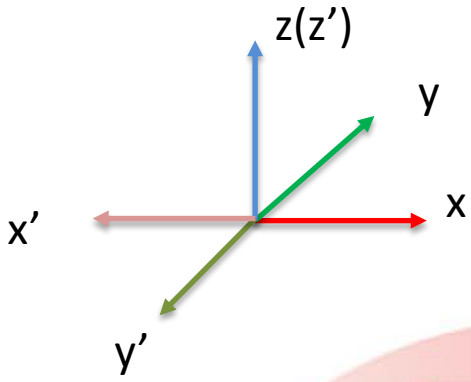
$$\begin{pmatrix} \cos(\theta)\cos(\psi) & \sin(\psi)\cos(\theta) & -\sin(\theta) \\ \sin(\alpha)\sin(\theta)\cos(\psi)-\sin(\psi)\cos(\alpha) & \sin(\alpha)\sin(\theta)\sin(\psi)+\cos(\alpha)\cos(\psi) & \sin(\alpha)\cos(\theta) \\ \sin(\theta)\cos(\alpha)\cos(\psi)+\sin(\alpha)\sin(\psi) & \sin(\theta)\sin(\psi)\cos(\alpha)-\sin(\alpha)\cos(\psi) & \cos(\alpha)\cos(\theta) \end{pmatrix} \begin{pmatrix} \cos(\psi) & \sin(\psi) & 0 \\ -\sin(\psi)\cos(\alpha) & \cos(\alpha)\cos(\psi) & \sin(\alpha) \\ \sin(\alpha)\sin(\psi) & -\sin(\alpha)\cos(\psi) & \cos(\alpha) \end{pmatrix}$$

$1 - 2\cos(\theta)$

$R_{11} + R_{22} + R_{33}$

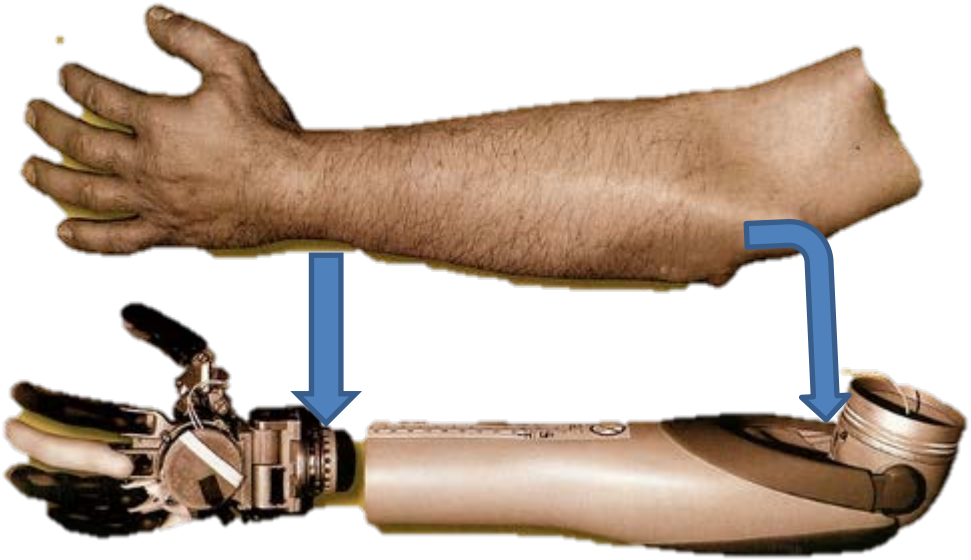
$\cos(\alpha + \psi)$

  - Algorithm
    - Minimize $|\theta_1 - \theta_2|$



# Direct Mapping

- Multiple Joints
  - Matching joints angle directly
  - Difficulty
    - Precision
    - Angle limit



# Direct Mapping

- Multiple Joints
  - Matching end factor speed (single IMU)

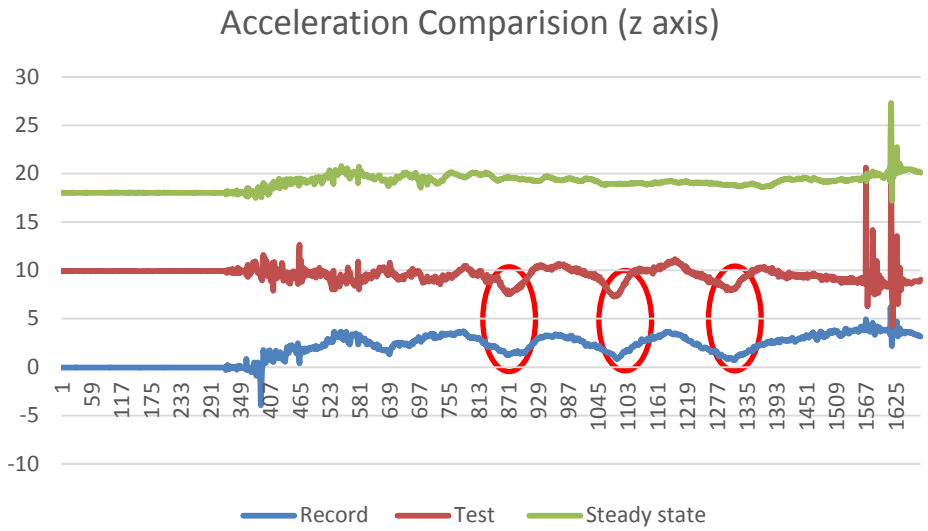
$$\frac{d}{dt}(P) = n\int_0^t (A_x, A_y, A_z, 0)$$

where $P = R_0^1 * R_1^2 * R_3^2 * P_3$ $and$ $n < 1$, integration from 0 to current time and reset when Az is around g

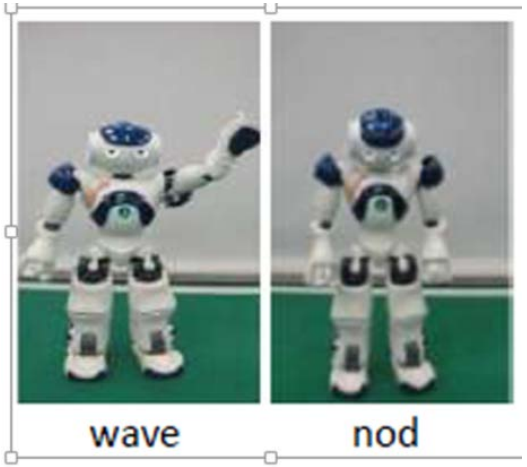
  - IMU drifting due to time

# Indirect Mapping

- Comparing the acceleration with pre-recorded data
- Choosing the most similar motion
- Replay the motion in robot

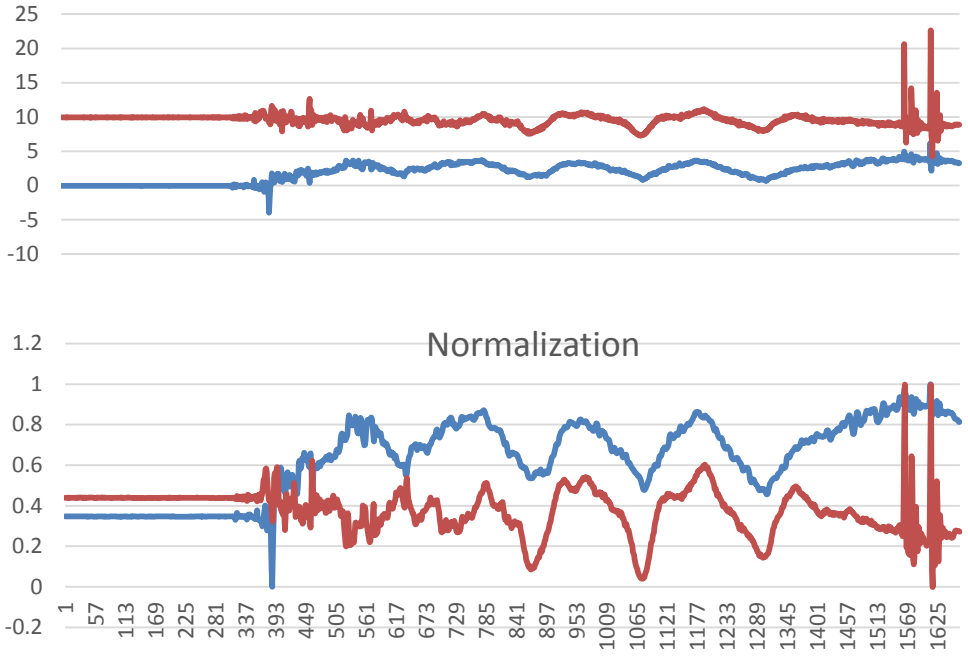



Start of period



# Matching Algorithm

- Raw Data
- Gaussian Smoothing
- Normalize
- Chi-square distance



# Future Work

- Future development
  - Motion projection in real space (Avatar)
    ( DOF matching )
  - Matching Algorithm
  - Full kinematic model
    - Increasing pre-set motion database
  - Motion prediction

# Q n A?