The human body in motion

Research at the Max Planck Institute for Biological Cybernetics

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Department Human Perception, Cogntion and Action

MPI FOR BIOLOGICAL CYBERNETICS

Max Planck Society for the Advancement of Science

Fundamental research on Biology, Medicine, Natural Science, Social Science and Humanities

- Since 1948
- 83 Institutes
- 17 Nobel Laureates
- ~17.000 employees[1]
  - ~9.000 scientific staff[1]
- ~4.600 guest scientists and stipends[1]
- Germany's Ideal Employer 2013

- Fostering Creative Potential
- Shaping Globalization
- Driving Progress through Interaction
- Applying Scientific Findings

[1] Jan. 2014

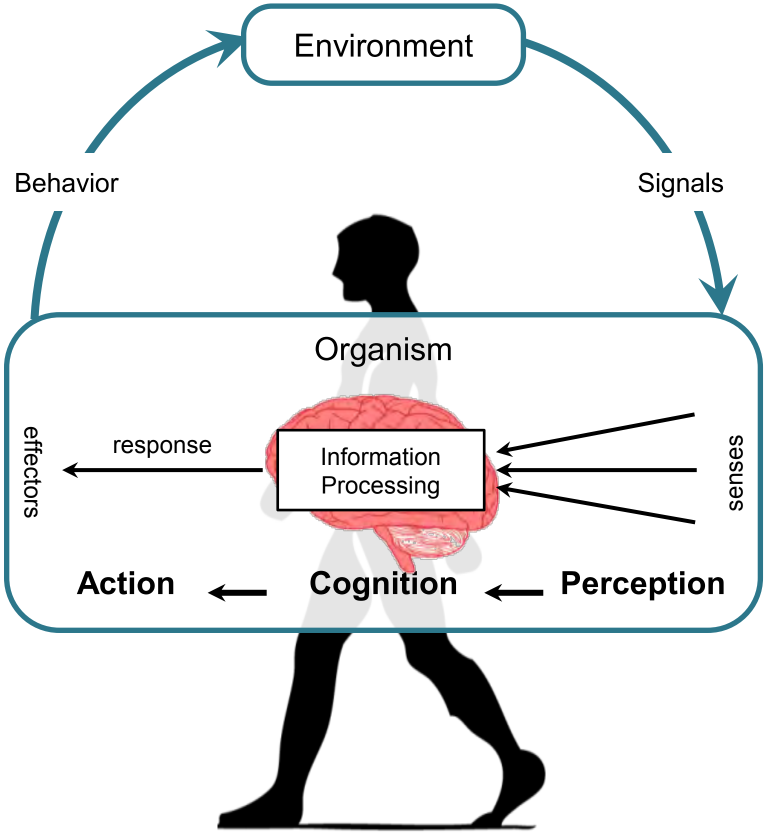
Max Planck Institute for Biological Cybernetics

"How does the brain work?"
Fundamental research on biological information processing

Human Perception, Cognition and Action

- How information from **different senses** provides a **representation of the environment**
- How **knowledge** about the environment drives the **interaction** with it

Human Perception, Cognition and Action



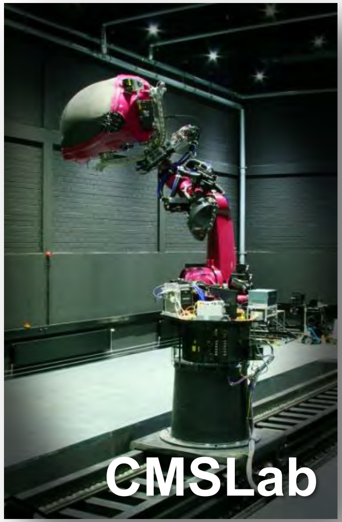
Humans in environment

Multi-Sensory perception

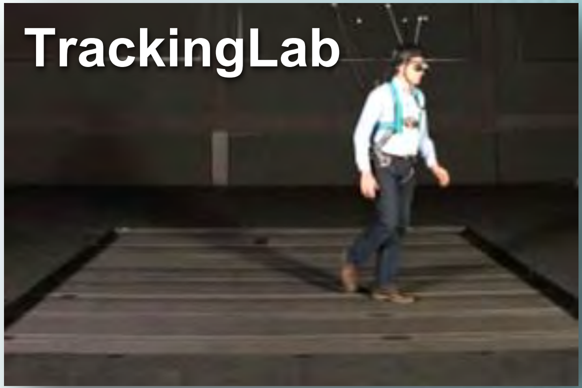
Virtual Reality

Human Actions

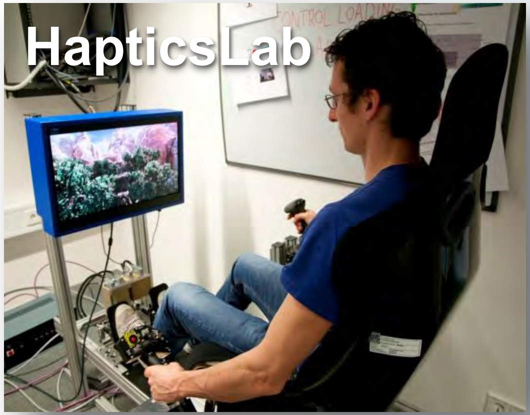
Facilities


CMSLab


MotionLab


TrackingLab


HeliLab


HapticsLab


PanoLab

MOTION PERCEPTION AND SIMULATION

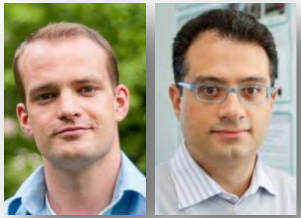
PhD Students

Research Scientists

Aerospace Engineering
Biomedical Engineering
Cognitive Science
Computer Science
Human Movement Science
Physics
Psychology

Master Student

Project Leaders



Technical Research staff

Motion Perception and Simulation

1. Multi-Sensory Self-Motion Perception
2. Self-Motion Perception Models
3. Motion Cueing Algorithms
4. Control Behavior in Simulation

How do we study motion perception?

Multi-sensory self-motion perception

[VIDEO]

- Psychophysical experiments to quantify perception in relation to physical stimuli
- Goal: understand how
  – Motions are sensed by different senses
  – How information from different senses is integrated
  – How these process leads to a percept of motion

Multi-sensory self-motion perception

Measure perceptual thresholds

Determine variability perceptual sensitivities

Study multi-sensory perception

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– How these process leads to a percept of motion

Self-motion perception models

Connecting the physical space with the perceptual space

Physical Space

Physical motion:

- Translation
- Rotation

Perception Model

- sensory dynamics
- sensory integration
- perceptual laws

Perceptual Space

Perceived self-motion:

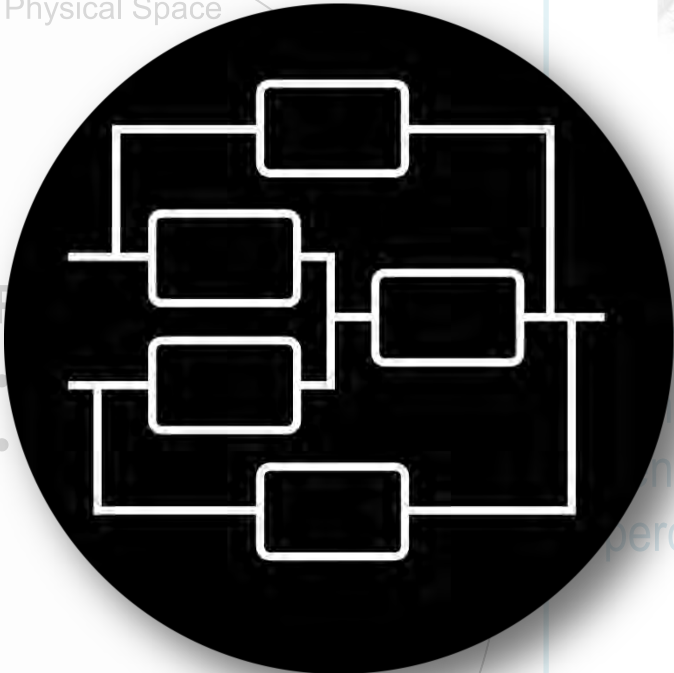
- How do I translate?
- How do I rotate?

Self-motion perception models

Connecting the physical space with the perceptual space

Physical Space

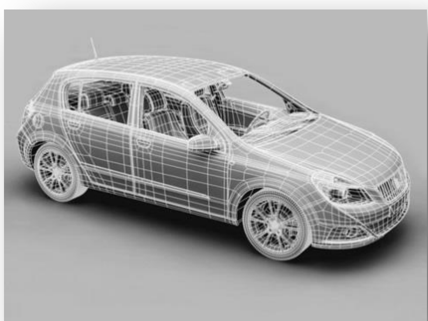
Perceptual Space



- Implement variable sensitivities
- Model sensory integration
- Validate perception models

Development of motion cueing algorithms

Motion cueing: conversion from computed or measured physical motion to simulator inputs



(Simulated) vehicle

Accel X
Accel Y
Accel Z
Roll rate
Pitch rate
Yaw rate
…

vehicle motion

Axis 1
Axis 2
Axis 3
Axis 4
Axis 5
Axis 6
Axis 7
Axis 8

simulator inputs

Motion simulator

Development of motion cueing algorithms

Motion cueing: conversion from computed or measured physical motion to simulator inputs

Develop perception-based MCAs

Evaluate quality of MCAs

Continuous quality measurement

(Simulat

icle motion

MC

Axis 2

simulator inputs

Motion simulator

Control Behavior in Simulation

Effects of visual and inertial stimuli on operator performance

Control Behavior in Simulation

Effects of visual and inertial stimuli on operator performance

Effect of motion feedback in tele-operation

Effect of fog on speed perception in driving

BIODYNAMIC FEEDTHROUGH


Involuntary control inputs
Accelerations

What is biodynamic feedthrough?

Ambulance

Helicopter

[VIDEO]

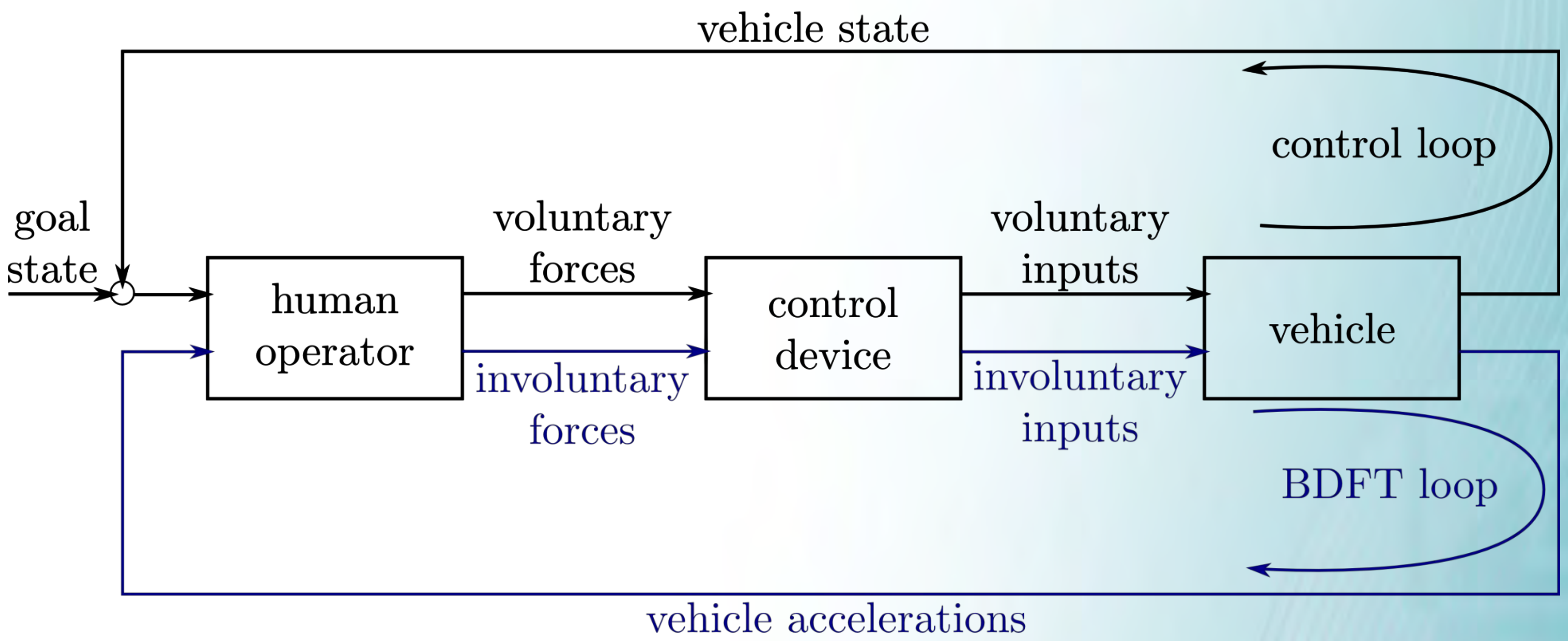
[VIDEO]

Biodynamic feedthrough (BDFT)
the transfer of accelerations through the human body during the execution of a manual control task, causing involuntary forces being applied to the control device which may result in involuntary control device deflections.

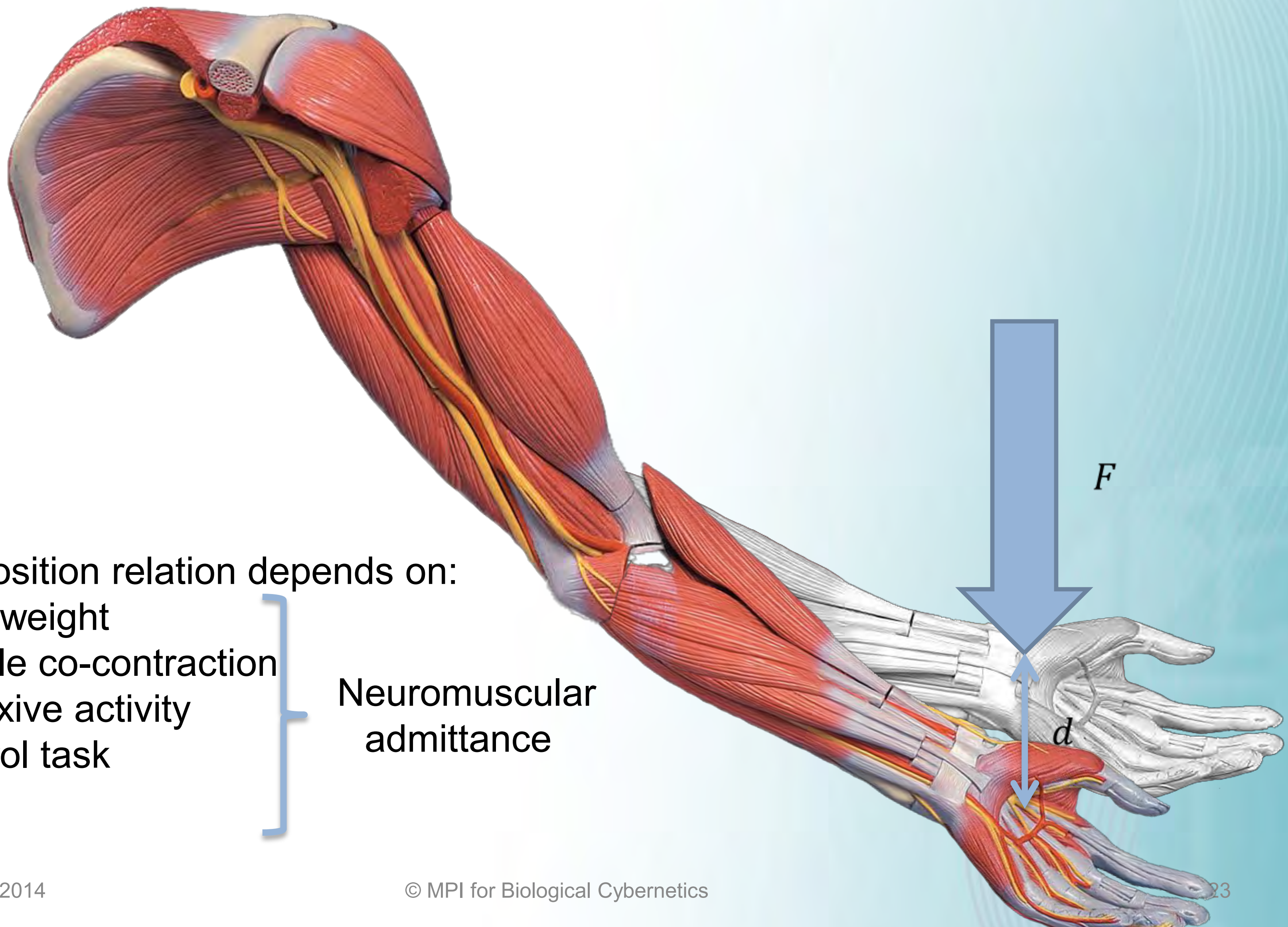
[VIDEO]

[VIDEO]

Measuring, modeling and mitigating



Neuromuscular adaptation

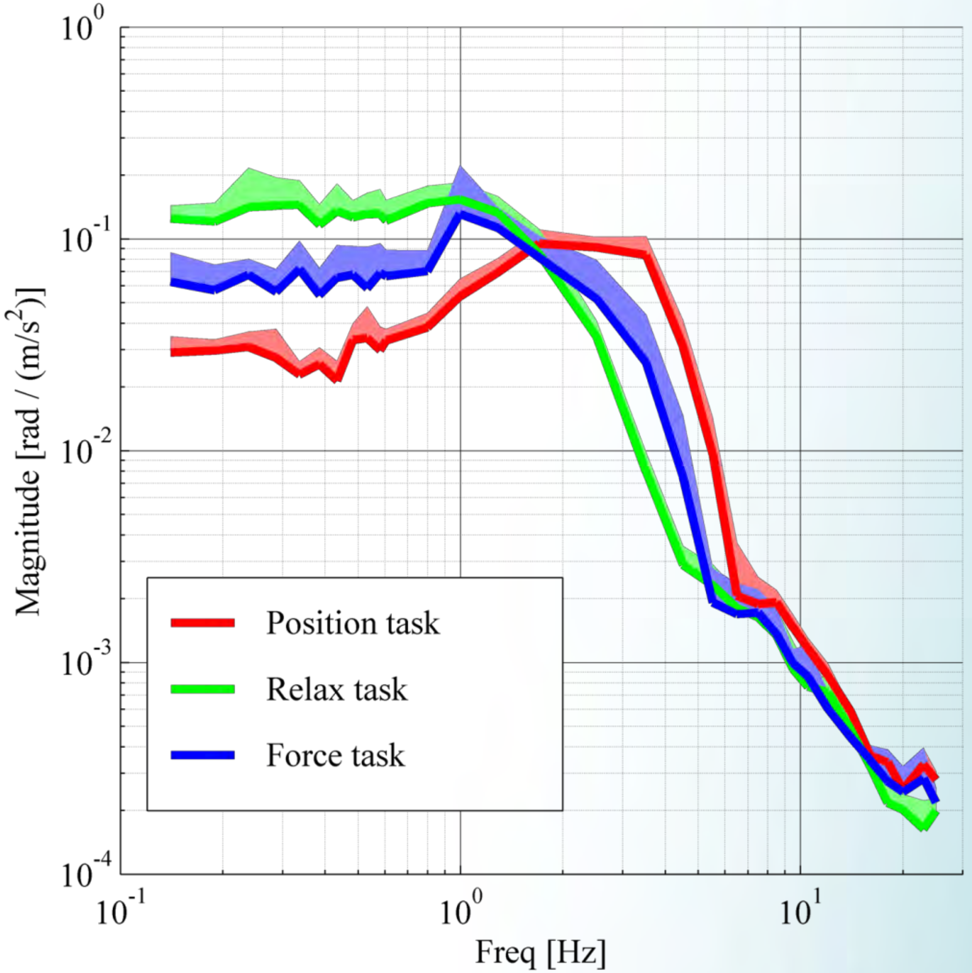


Force-position relation depends on:

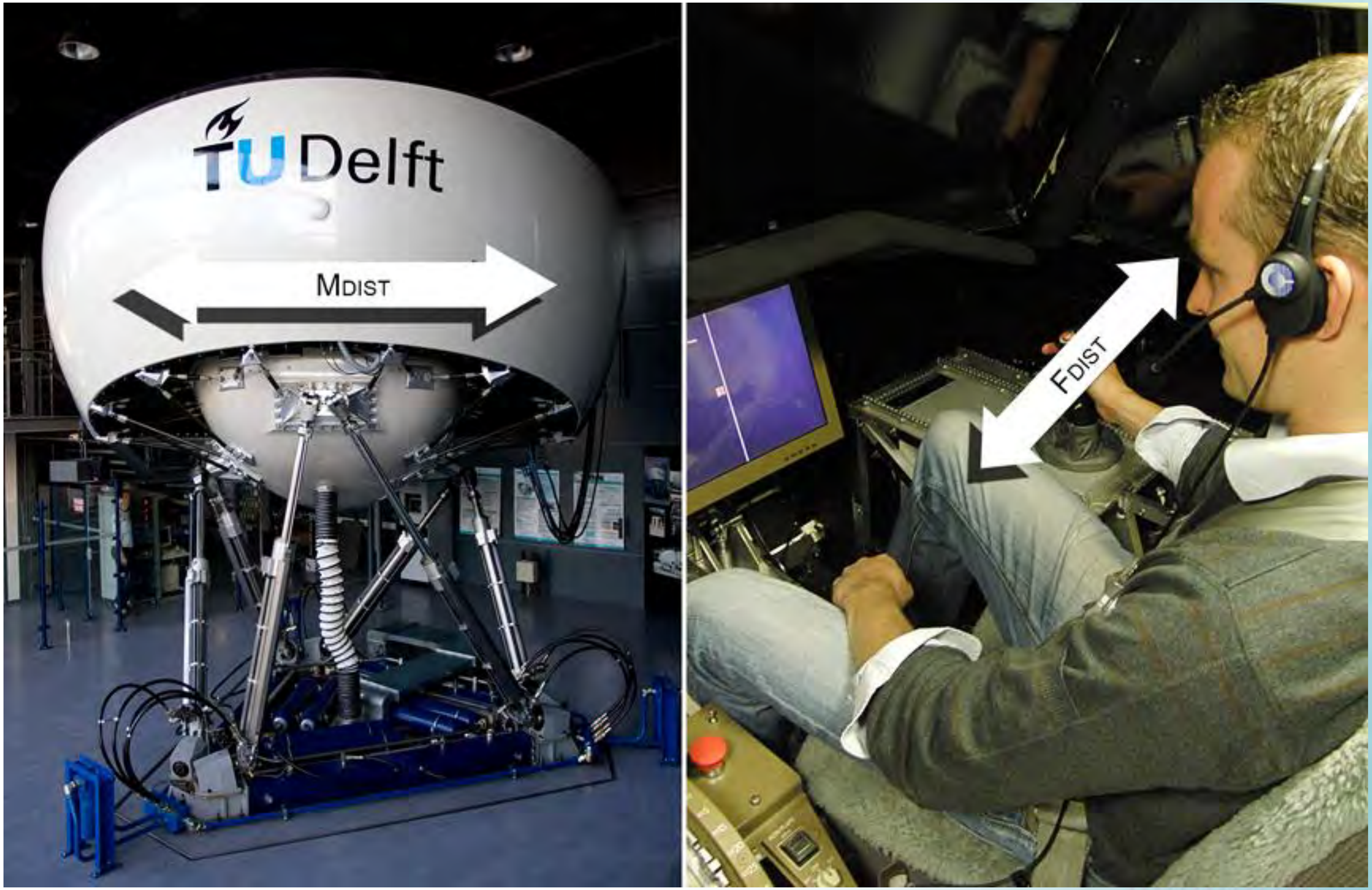
- Limb weight
- Muscle co-contraction
- Reflexive activity
- Control task
- …

$\left.\right\}$ Neuromuscular admittance

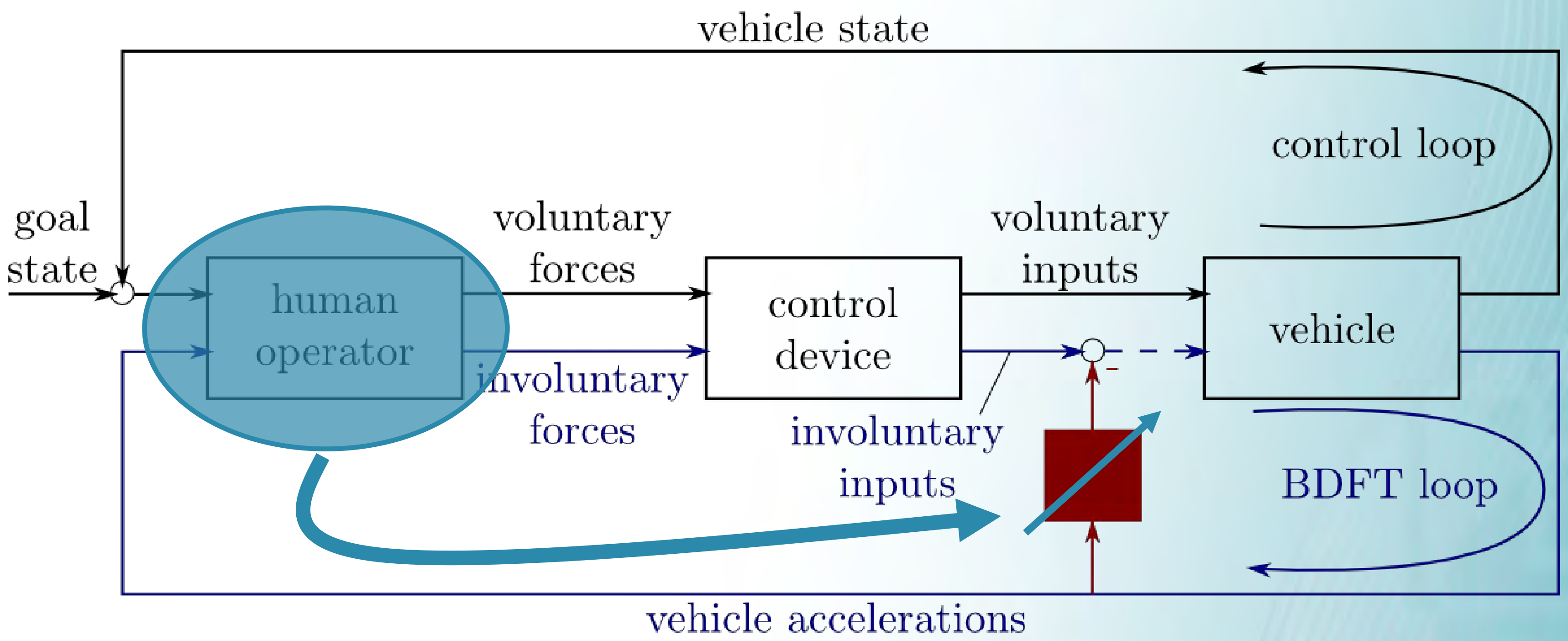
BDFT depends on admittance



Venrooij et al. (2011) *IEEE Trans. On Systems, Man, And Cybernetics—Part B: Cybernetics* 41 (4)

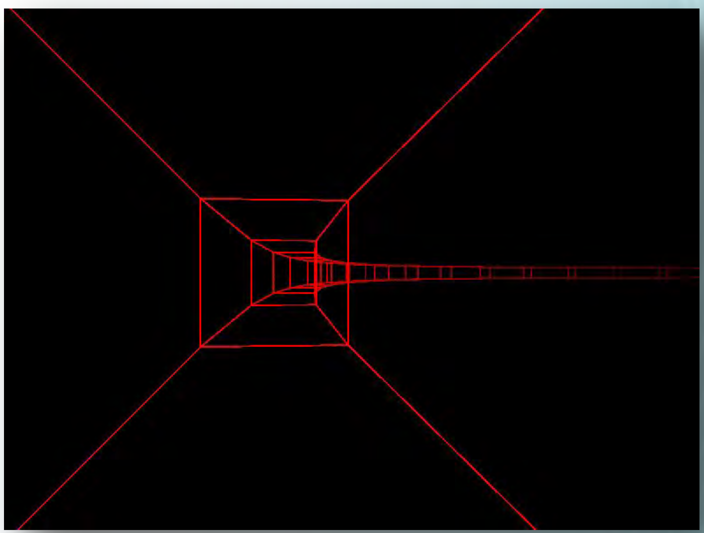

TU Delft
MDIST
FDIST

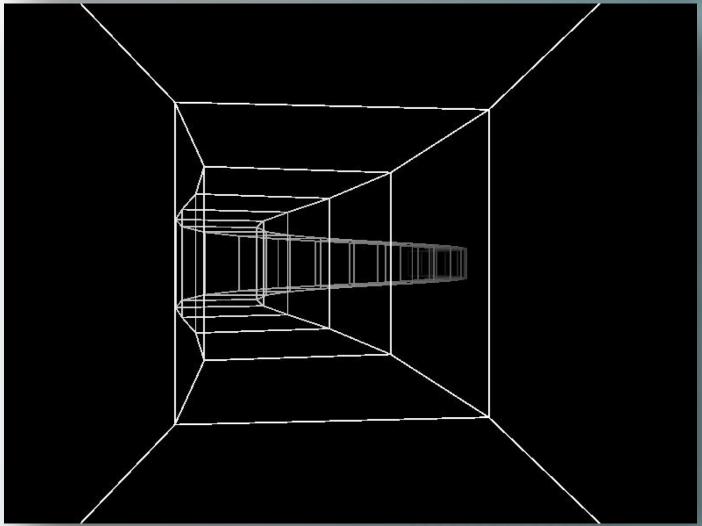
Biodynamic feedthrough mitigation



Experiment description

- Goal: proof-of-concept for admittance-adaptive model-based BDFT cancellation approach
- Experiment loosely based on a rotorcraft application
- Task: fly through virtual tunnel: highway-in-the-sky (HITS)
- Neuromuscular adaptation: ‘stiff’ (PT) and ‘relaxed’ (RT)





Experiment conditions

- HITS Tunnel (TUN)
  - Straight tunnel (STR)
  - Curved tunnel (CUR)
- Task (TSK)
  - Position task (PT): "stiff"
  - Relax task (RT): "relax"
- Identification measurements
- Condition (COND)
  - Static (STA): motion OFF (no BDFT)
  - Motion (MOT): motion ON, cancellation OFF
  - Cancellation (CAN): motion ON, cancellation ON

REPETITIONS PER CONDITION

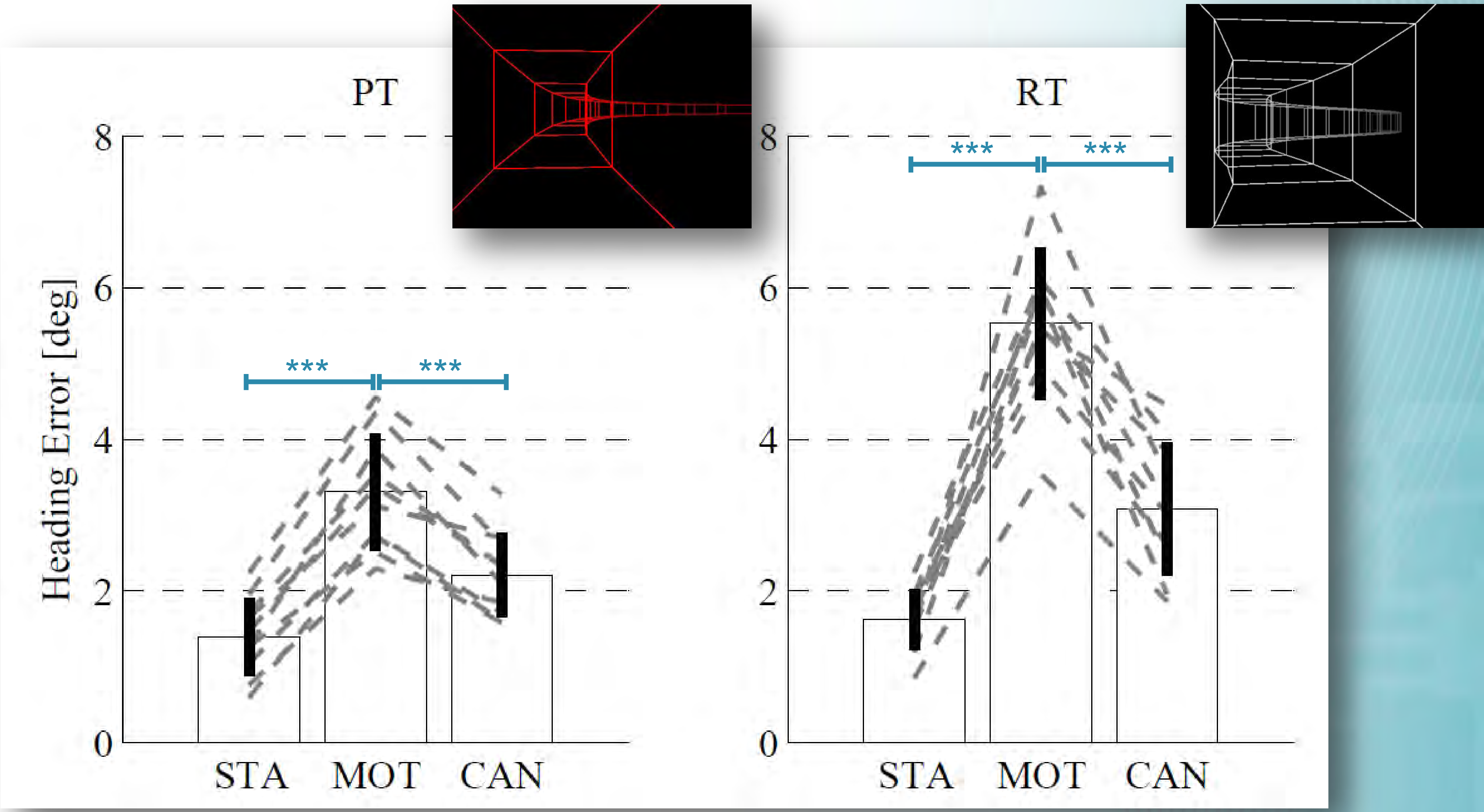
Straight HITS

	STA	MOT	CAN	INC
PT	3	3	3	x
RT	3	3	3	x

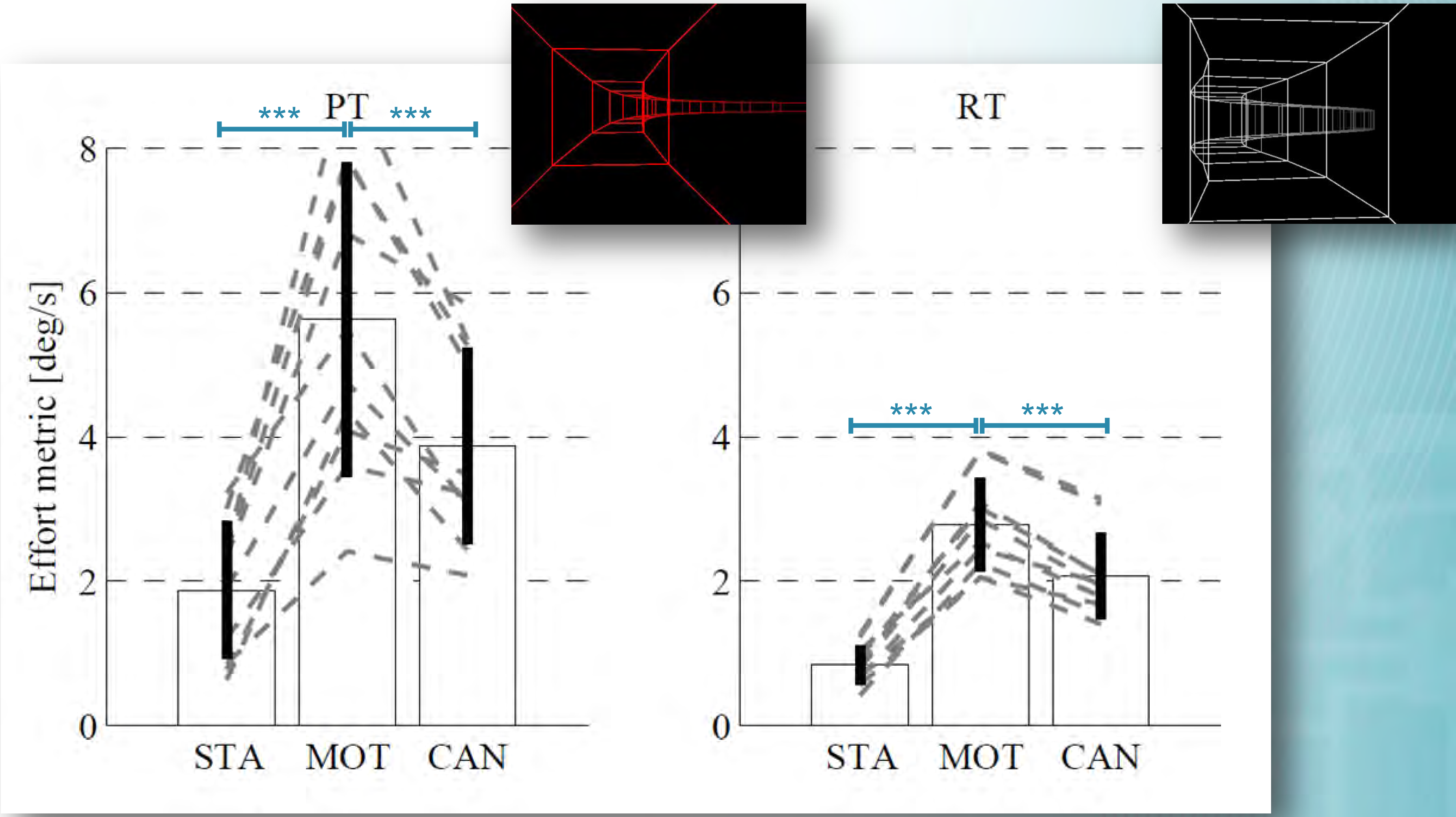
Curved HITS

	STA	MOT	CAN	INC
PT	6	6	6	6
RT	6	6	6	6

Results: performance (tracking error)



Results: effort (steering speed)



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