The human body in motion

Research at the Max Planck Institute for Biological Cybernetics

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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
  - ~9,000 scientific staff
- ~4,600 guest scientists and stipends
- 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

Organism
- Environment
- Behavior
- Signals
- Action
- Cognition
- Perception
- Information Processing
- effectors
- response
- senses
Facilities
MOTION PERCEPTION AND SIMULATION
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?

[VIDEO]

The CyberMotion Simulator
Multi-sensory self-motion perception

- 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

- Psychophysical experiments to quantify perception in relation to physical stimuli
  - Motions are sensed by different senses
  - How information from different senses is integrated
  - How these processes lead to a percept of motion

- Measure perceptual thresholds
- Determine variability in perceptual sensitivities
- Study multi-sensory perception
Self-motion perception models

Connecting the physical space with the perceptual space

Physical Space

Physical motion:
- Translation
- Rotation

Perceptual Space

Perceived self-motion:
- How do I translate?
- How do I rotate?

Perception Model
- sensory dynamics
- sensory integration
- perceptual laws
Self-motion perception models

Connecting the physical space with the perceptual space

Physical motion:
• Translation
• Rotation

Perceived self-motion:
• How do I translate?
• How do I rotate?

Perception Model
• Sensory dynamics
• Sensory integration
• Perceptual laws

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
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

(Simulated) vehicle motion

Motion simulator

Accel X, Accel Y, Accel Z, Roll rate, Pitch rate, Yaw rate
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
**What is biodynamic feedthrough?**

*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.
Measuring, modeling and mitigating
Neuromuscular adaptation

Force-position relation depends on:
- Limb weight
- Muscle co-contraction
- Reflexive activity
- Control task
- ...

Neuromuscular admittance
BDFT depends on admittance

![Graph showing magnitude vs frequency for different tasks: Position task, Relax task, and Force task. The graph demonstrates how admittance affects these tasks within a certain frequency range.](image-url)
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

<table>
<thead>
<tr>
<th>Repetitions per condition</th>
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<tbody>
<tr>
<td><strong>Straight HITS</strong></td>
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<tr>
<td>PT</td>
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<td>RT</td>
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<tr>
<td><strong>Curved HITS</strong></td>
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<td>PT</td>
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Results: performance (tracking error)
Results: effort (steering speed)