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Introduction
What is Telerobotics?
Haptics in Telerobotics
Telepresence
Research Issues
Systems
Telerobots
Haptic Interfaces
Control
Supervisory Control
Bilateral Control
Applications
Summary

Telerobotics and Haptics

Actual and Future Research Questions and Applications

Carsten Preusche

Institute of Robotics and Mechatronics
German Aerospace Center (DLR)

IST’06 - Advanced Haptics Workshop

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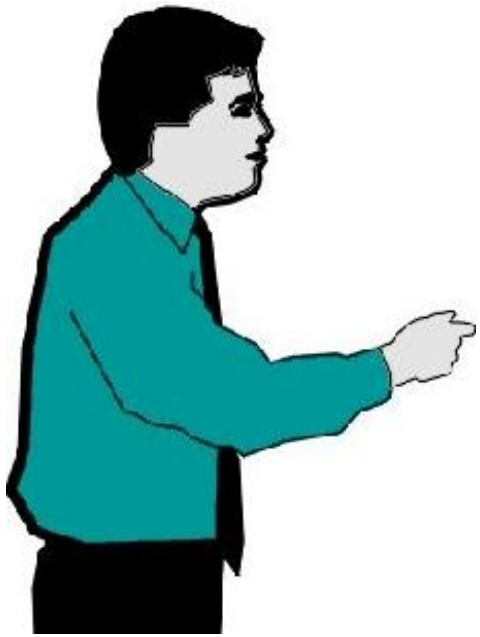
Tele-Robotics means to overcome a **barrier** between a human and a remote environment



remote

Environment

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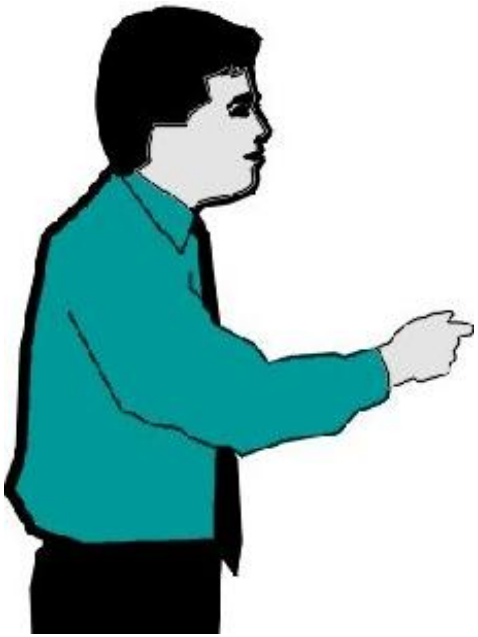

Distance

Danger

Matter

Scaling

remote

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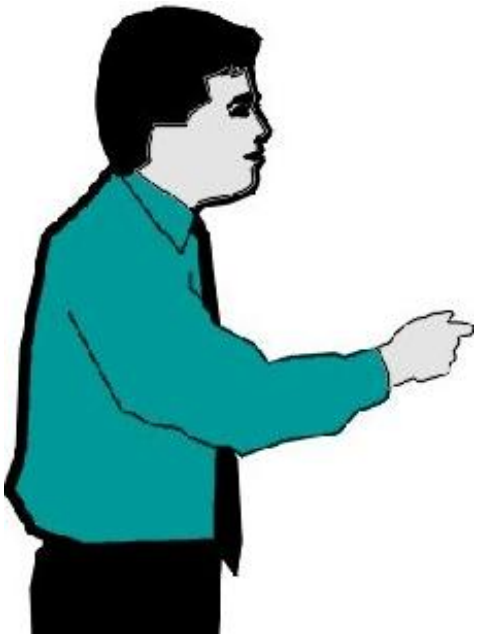
Tele-**Robotics** means that the human controls a robot to change a remote environment



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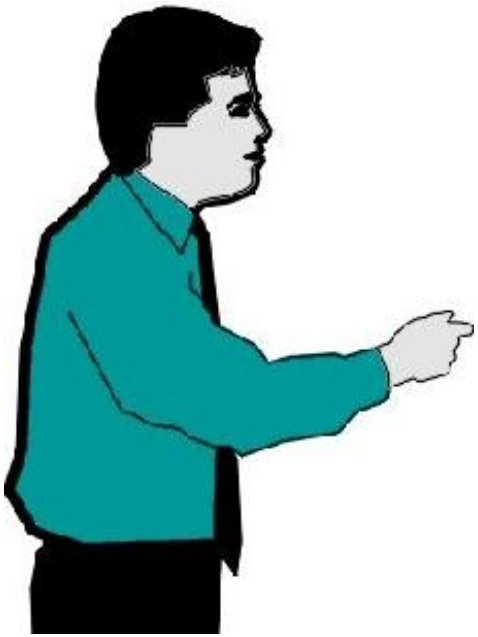

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Importance of Haptics for Telerobotics

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- Scene is mainly perceived by 3D Vision
- visual modality is dominant
- $\longrightarrow$ no haptics
- *but:* Material/Surface characteristics missing
- Haptic Exploration is needed

- Manipulation require a close human-environment interaction
- Force-Feedback is evident
- to Telerobot and Human Controller

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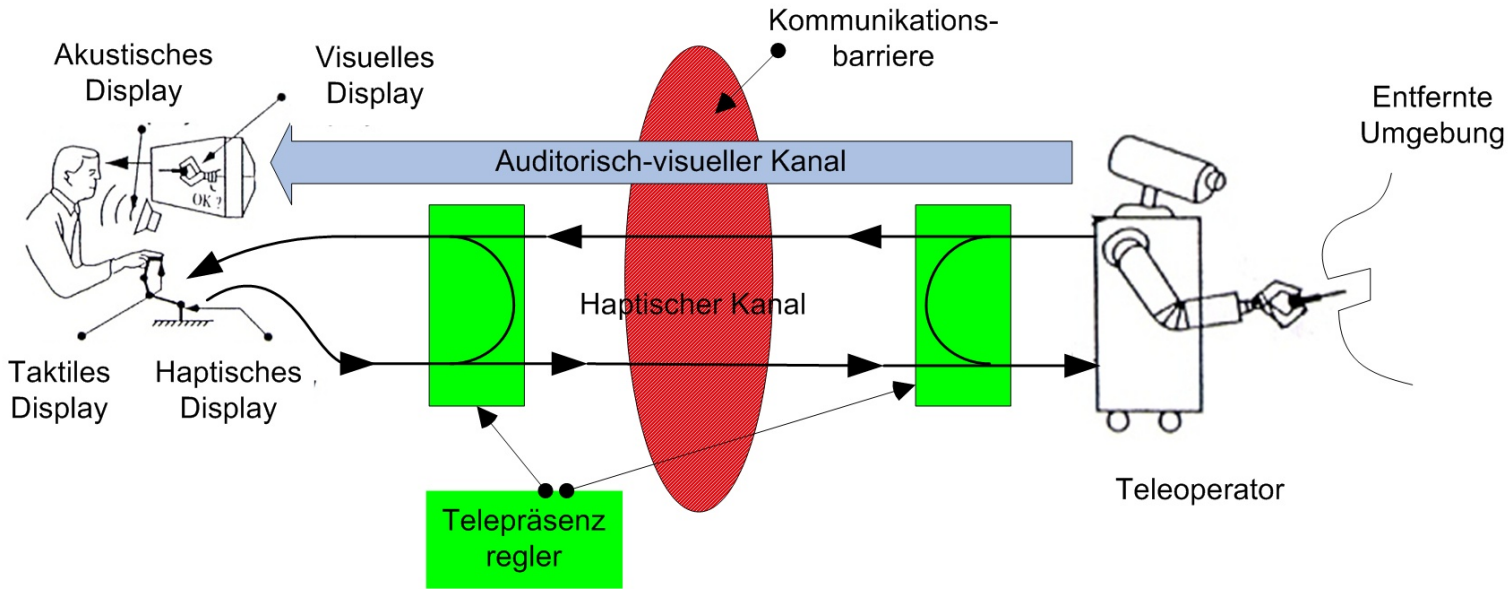

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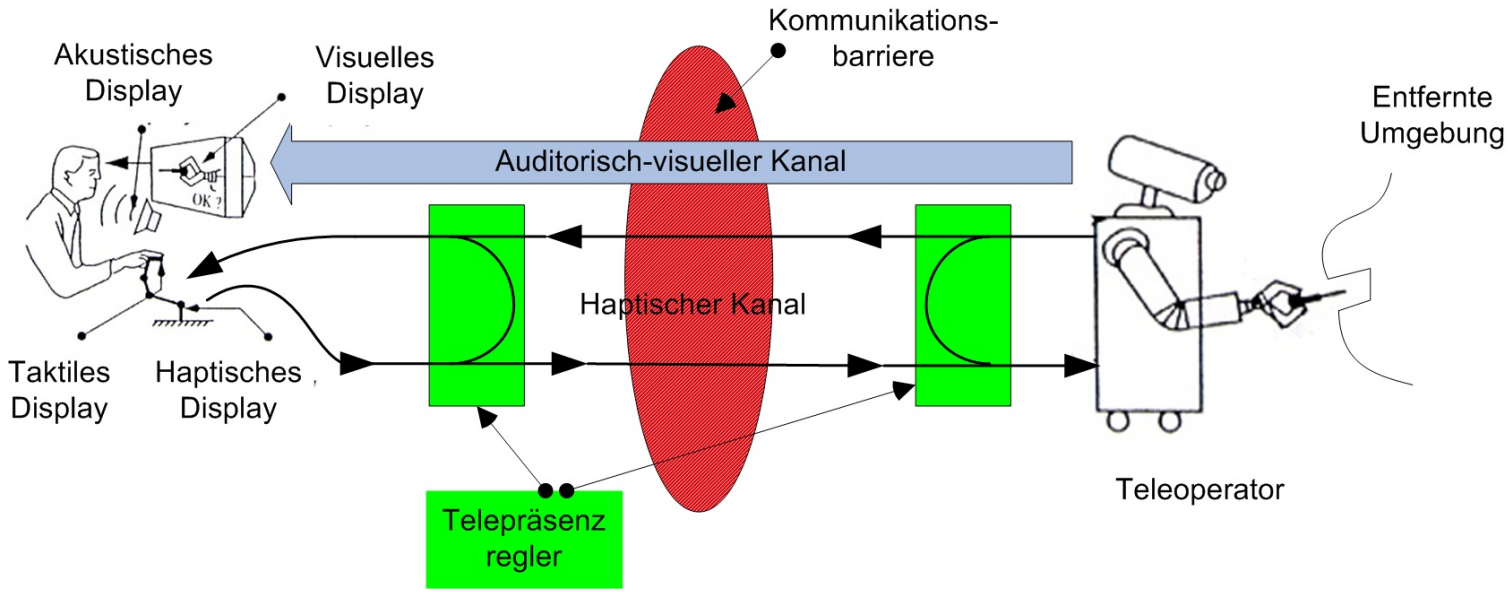

Manipulation

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Focus on haptics on Telerobotics

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Telepresence – Transparency

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Telepresence The human operator feel present at the remote location with all his/her sensor-actor modalities.

Transparency The human operator cannot distinguish between operating in the local or distant environment.

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Telepresence – Transparency

Telerobotics and Haptics

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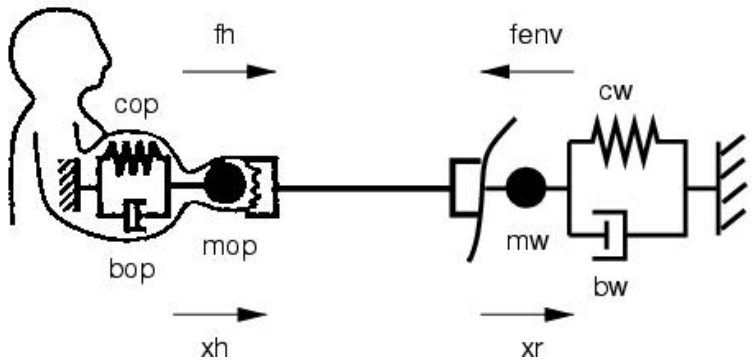

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Open Research Issues

Telerobotics and Haptics

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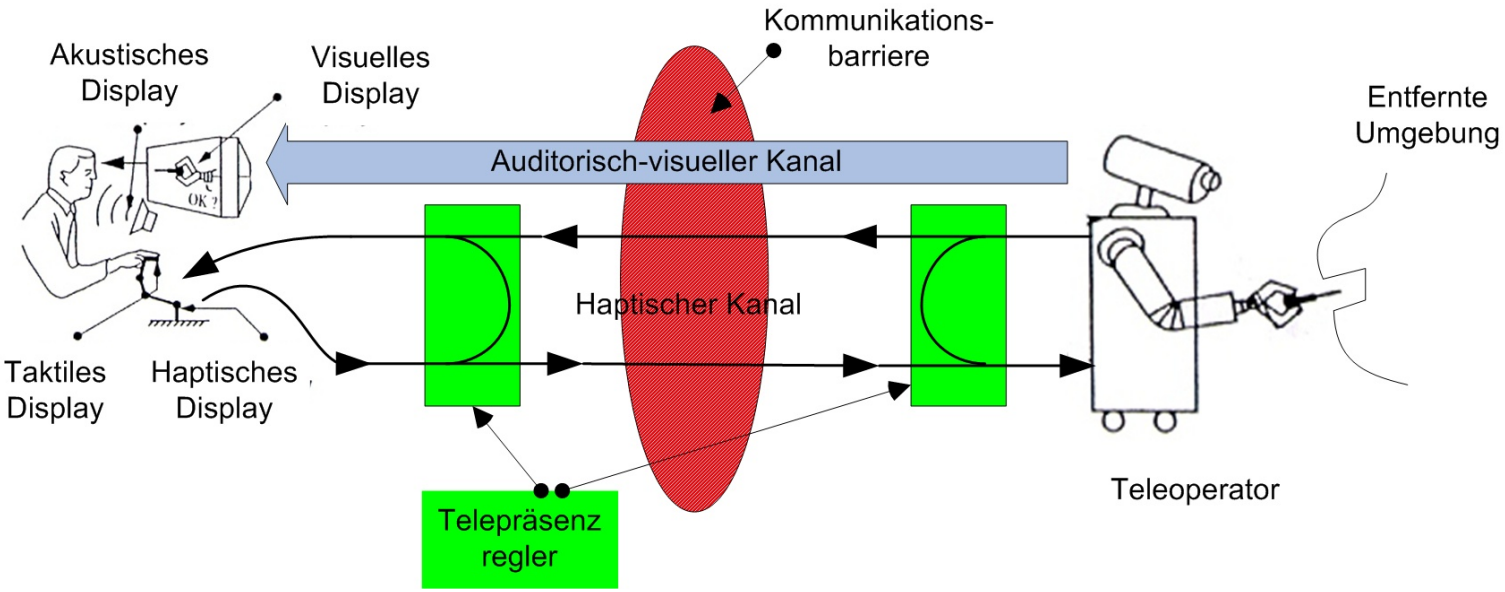

- Telerobots
- Haptic Interfaces
- Control (with Time-Delay)

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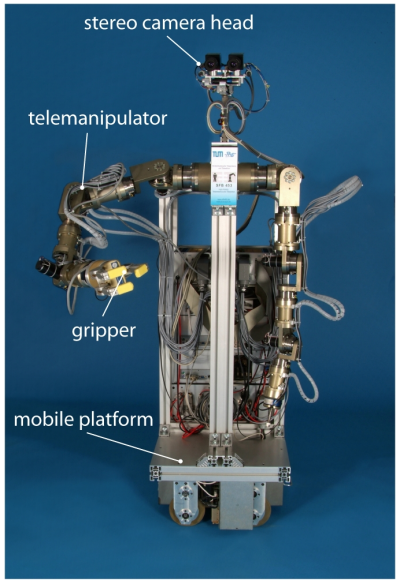
We need Humanoid Telerobots

Shape of Telerobot is important for Telepresence



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Asimo by Honda

DLR – Justin

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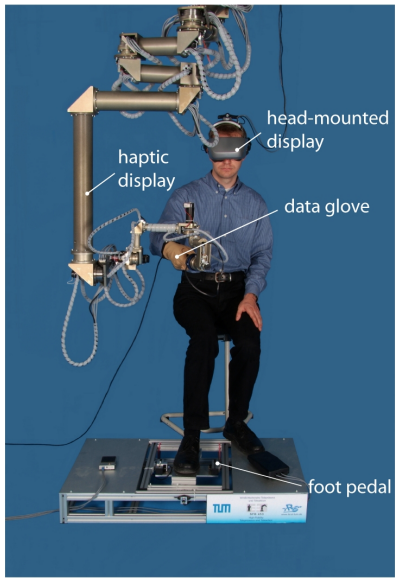
Haptic Interfaces

Integration of kinesthetic and tactile feedback



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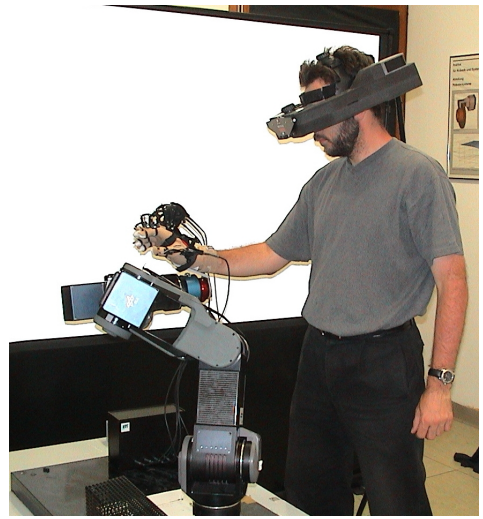
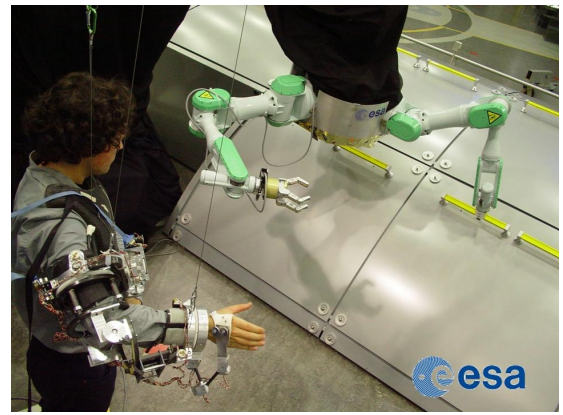


DLR



ESA

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Control Strategies

Telerobotics and Haptics

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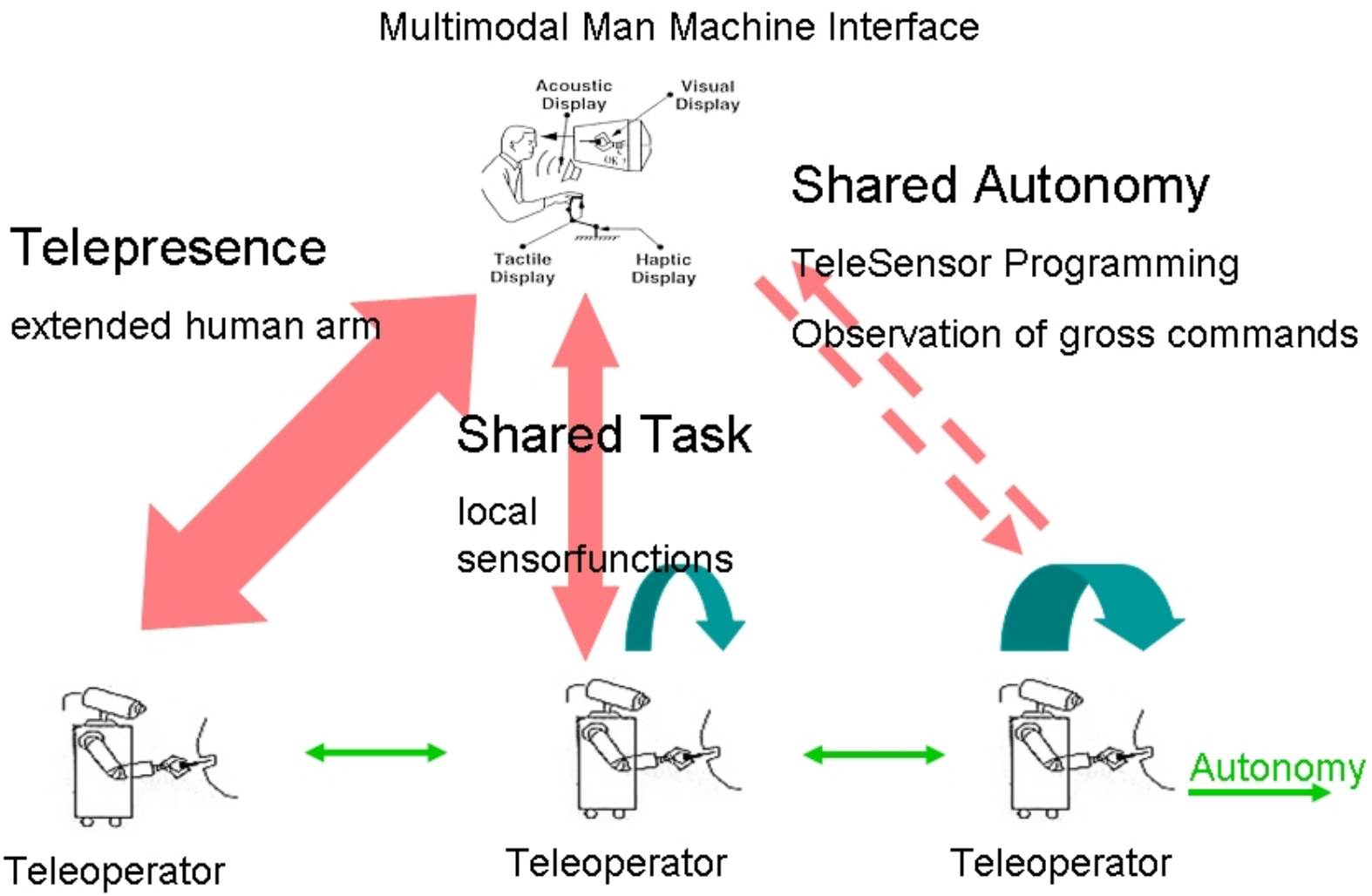

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Supervisory Control

Telerobotics and Haptics

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Shared Task

- direct 3D Control
- Overlay of Sensor values

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Supervisory Control

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Shared Task

- direct 3D Control
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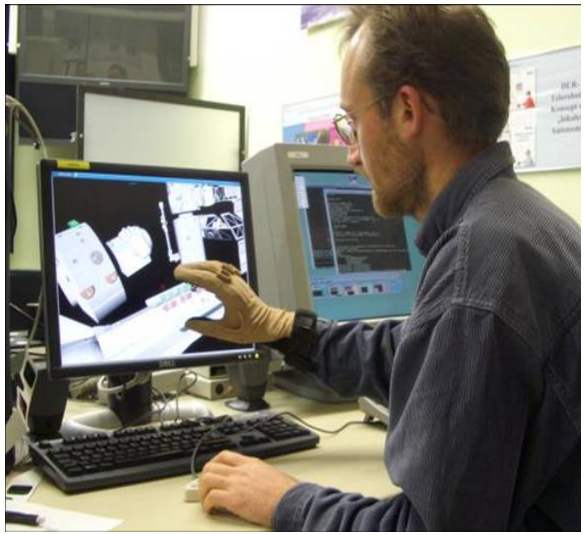
Shared Autonomy

- intuitive VR Programming
- Pre-simulation / Task Observation



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Supervisory Control

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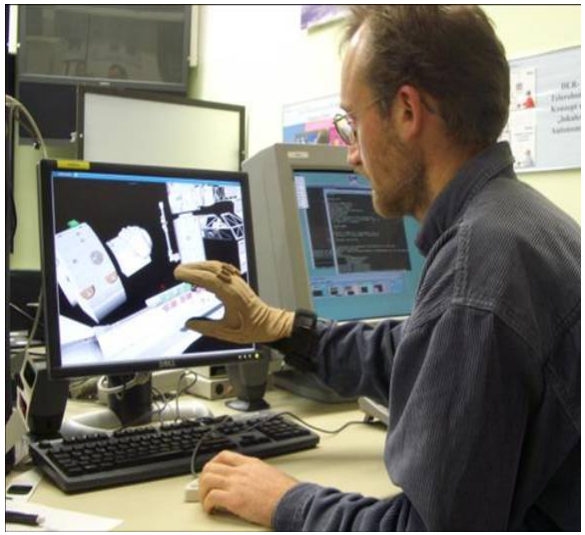

Haptics from world-model enhances presence and performance

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Bilateral Control

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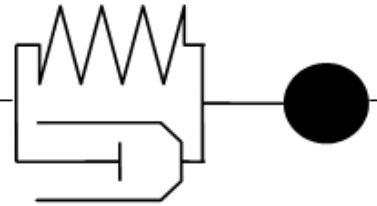
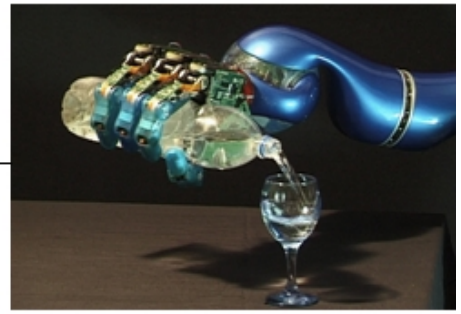
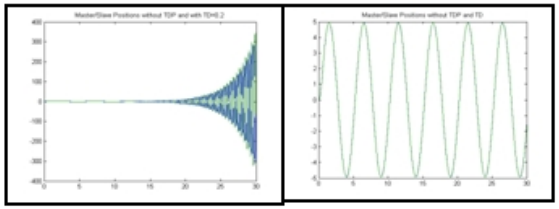
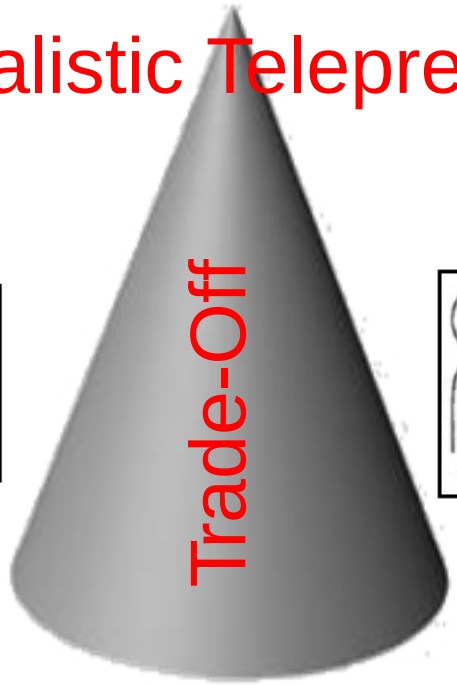




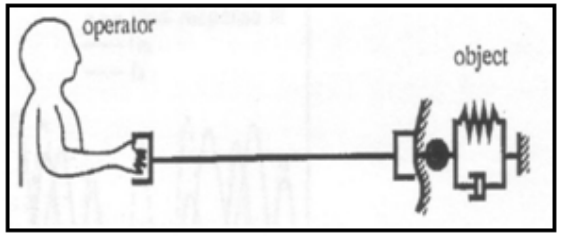
Realistic Telepresence

Stability

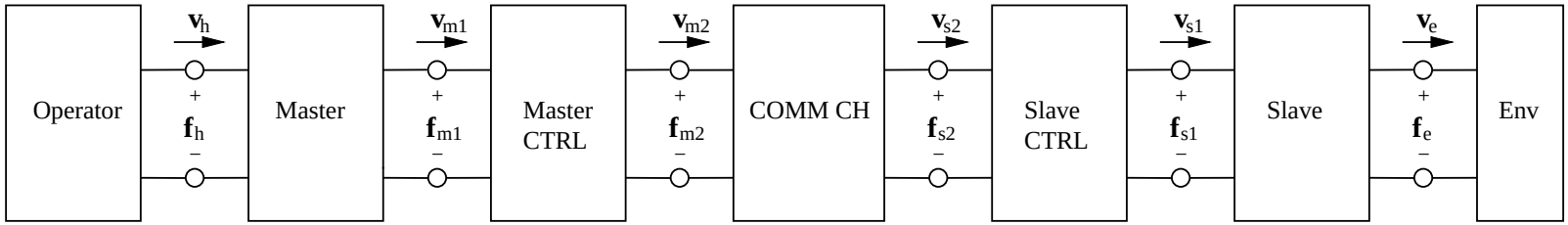




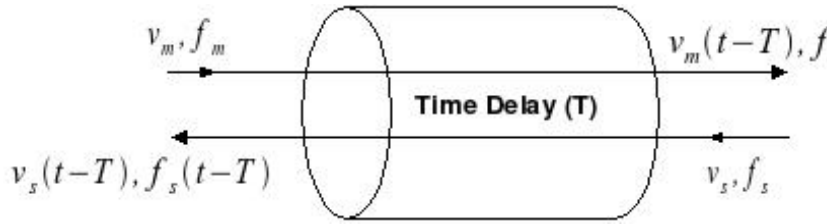
Transparency



Bilateral Control
Passivity



- network description for stability/passivity analysis
- whole system is passive, if all individual blocks are passive
- main problem-source of activity: communication delay



Bilateral Control

New Concepts

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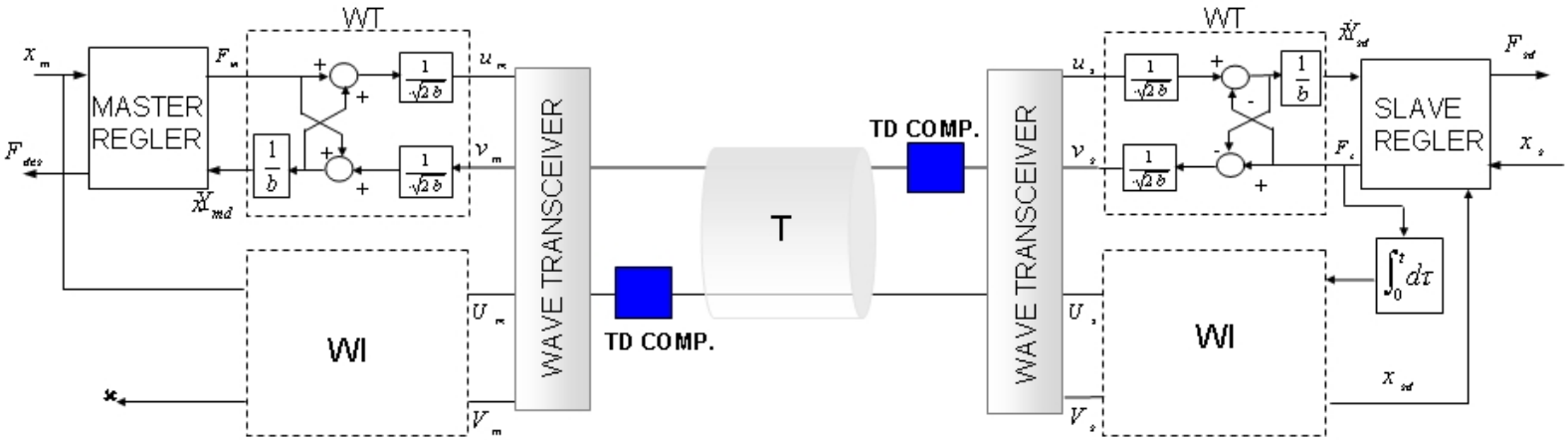

Improved Wave-Variables Scheme (Robotik 2004, Artigas, Preusche et.al.)

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Bilateral Control

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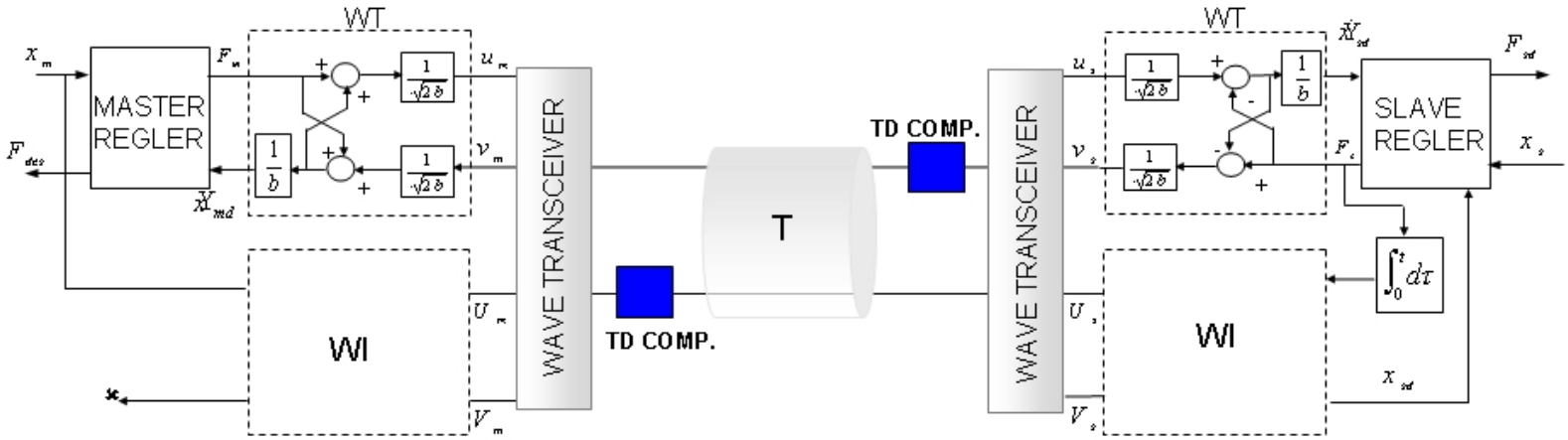

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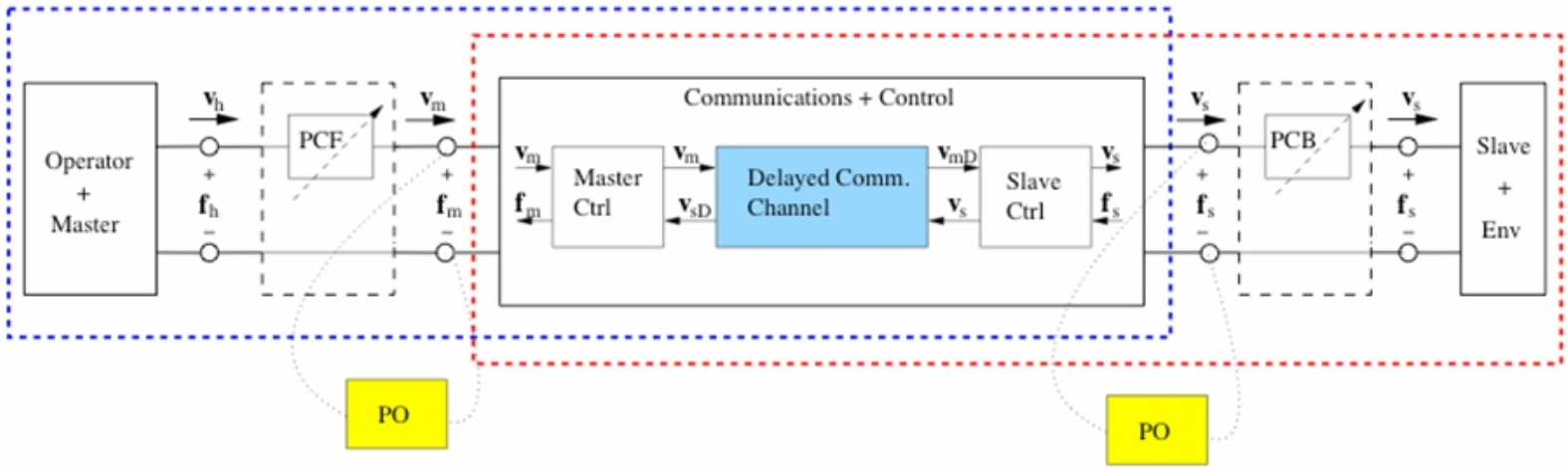

Time Domain Passivity Control Scheme (IROS 2006, Artigas, Preusche et.al.)

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Analysis of stable regions for a haptic rendering system

IROS 2006; Hulin,Preusche et.al.

Bilateral Control
Stability versus Passivity

Telerobotics and Haptics

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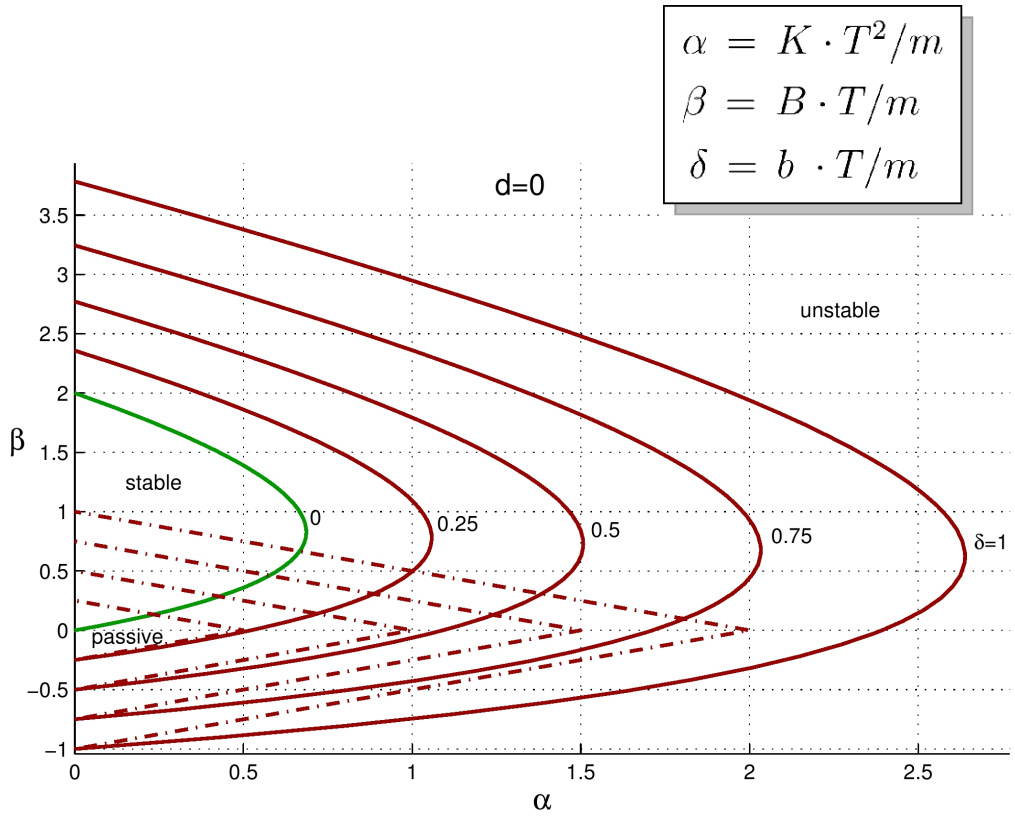
Analysis of stable regions for a haptic rendering system

IROS 2006; Hulin,Preusche et.al.

Passivity is more conservative than stability

$\longrightarrow$ less transparency



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Applications

Some Applications are presented from the following fields

- Rescue and Danger
- Surgery
- Maintenance and Manufacturing
- Space

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Applications
Rescue and Danger

Telerobotics and Haptics

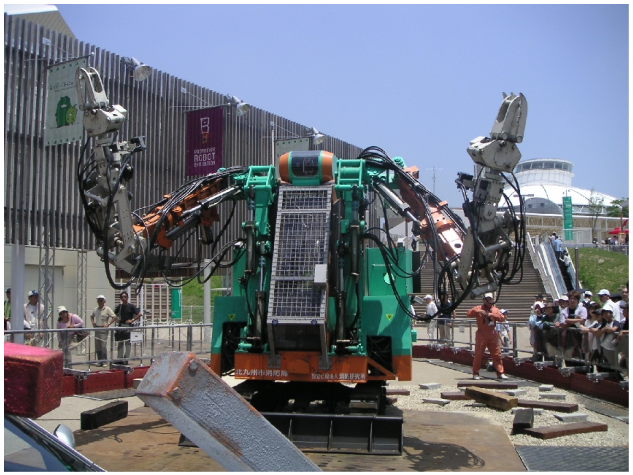
C. Preusche

Introduction
- What is Telerobotics?
- Haptics in Telerobotics
- Telepresence

Research Issues
- Systems
  - Telerobots
  - Haptic Interfaces
- Control
  - Supervisory Control
  - Bilateral Control

Applications

Summary



Rescue Support Dragon (Japan)

Telerob – tEODor

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Applications
Surgery

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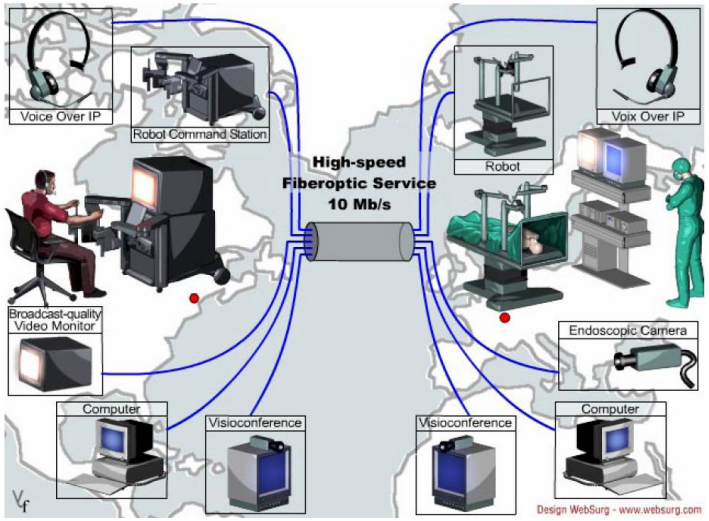
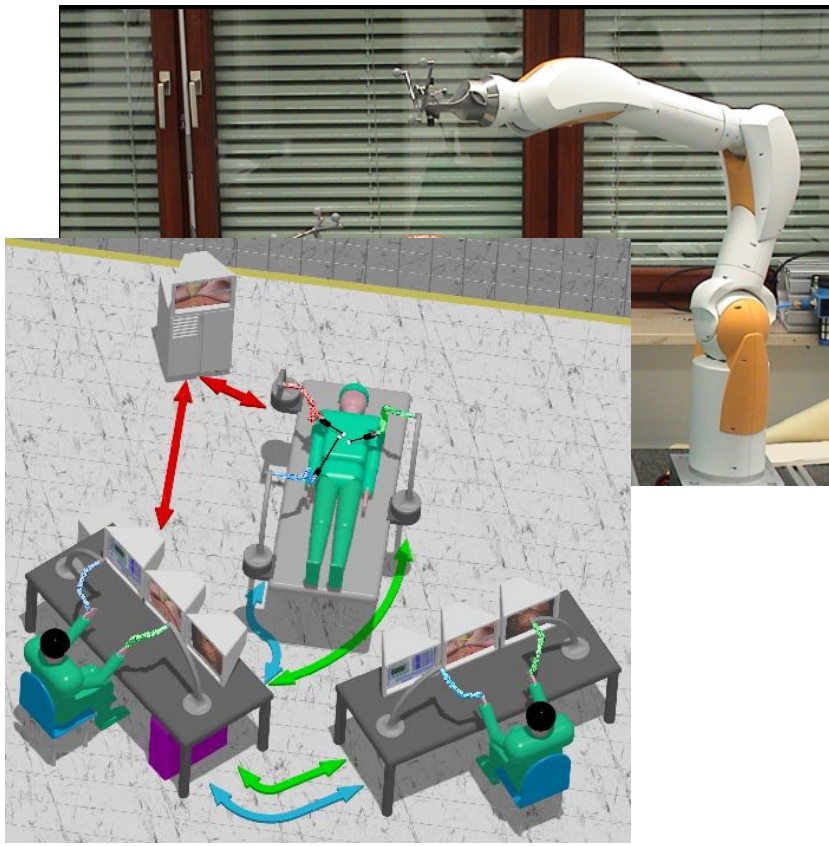


Operation Lindberg – The first transcontinental teler-obotic surgery (2001)



DLR – TeleSurgery Vision

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Applications
Maintenance / Manufacturing

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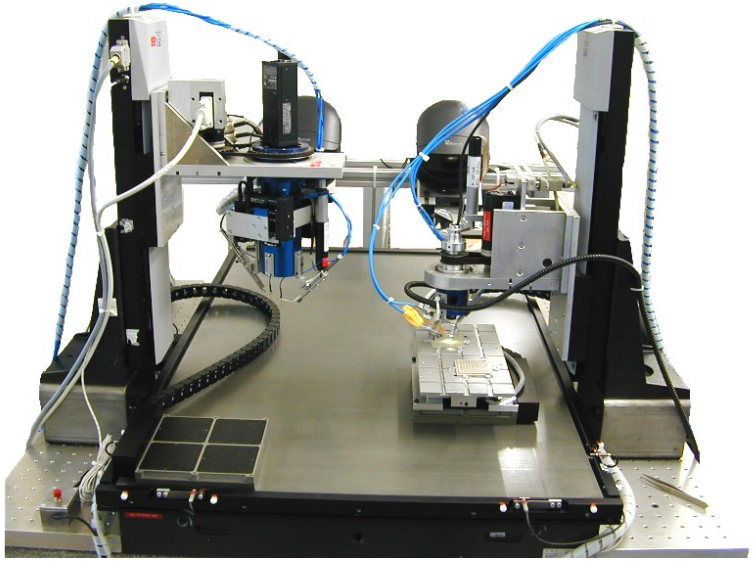
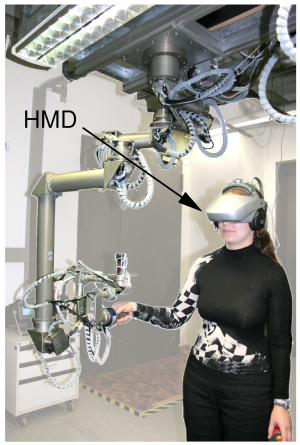


Microassembly (TUM)



ViSHaRD 10
master

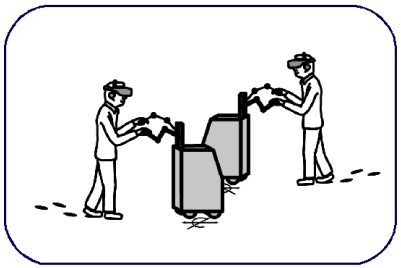
Position

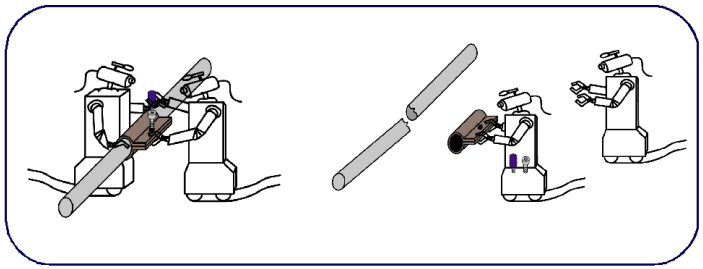
Force

Vision

7DoF Telerobot
slave

TeleMaintenance (TUM)





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Applications
Space

Telerobotics and Haptics

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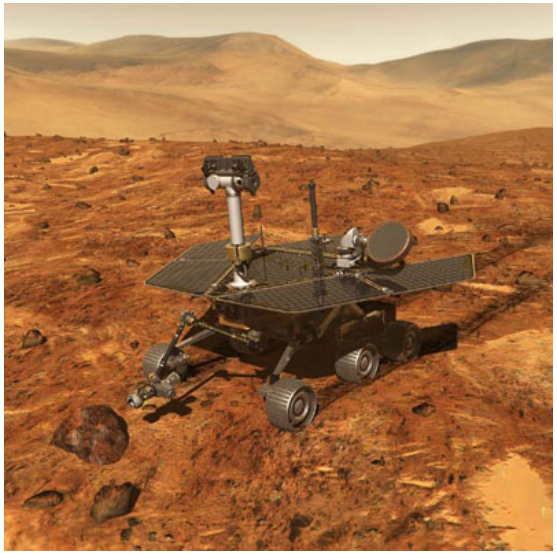
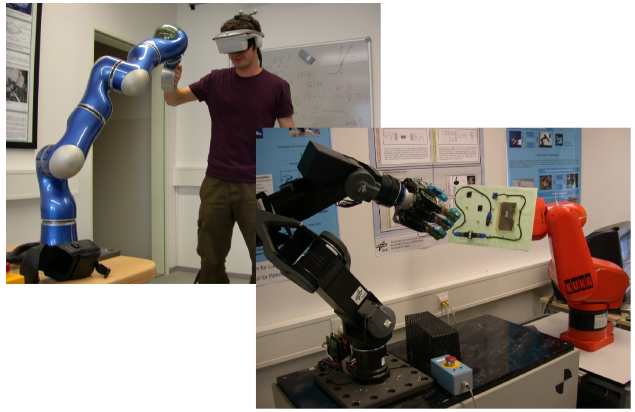
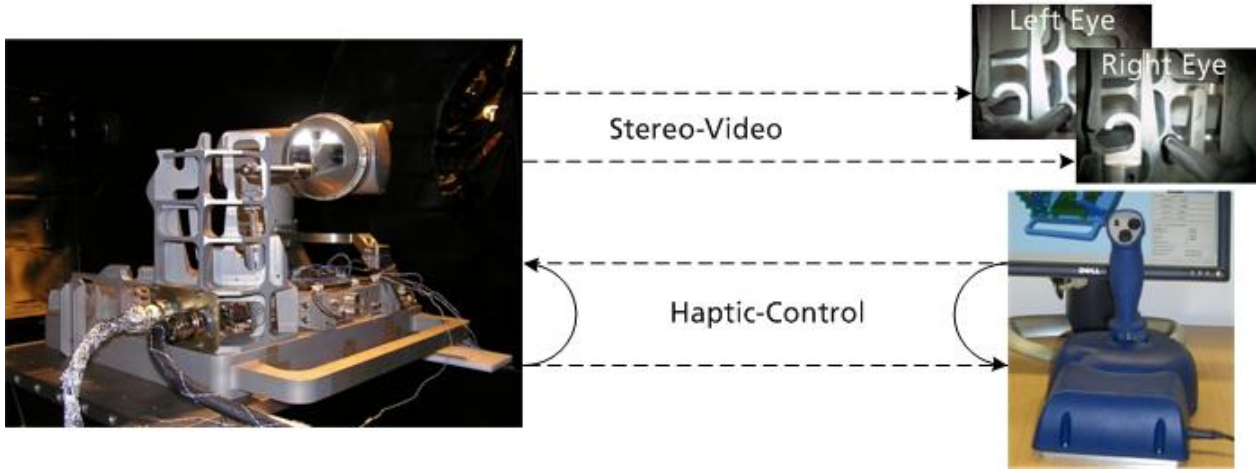


Opportunity (NASA)



Satellite Repair (DLR)



ROKVISS (DLR)

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Summary
Technical Systems

Telerobotics and Haptics

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- Need for human-like Teleoperators in terms of shape and sensor-actor abilities
- Integration of haptic stimuli (tactile, kinesthetic, proprioceptive) into one handheld device
- Reliable, fast and high-bandwidth communication networks

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Summary
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Summary
Control Theory

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- Overcome limitation of passivity towards evaluation of stability
- Measurement of transparency as index psychophysical versus engineering indices
- Adaption of bilateral control to unreliable networks e.g. Internet

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- There is an increasing interest in telerobotic systems
- The barrier of **danger** delivers a killing application

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Thank you for your attention!