

Automatic container model crane

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Gruppe 633

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Agenda

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- ▶ Minimally invasive surgery
- ▶ Surgical robots teleoperated by console
- ▶ Visual feedback received by surgeon

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- ▶ Surgeon has to estimate the force exerted by the tool
- ▶ Studies show haptic feedback reduces error rate

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- ▶ Force feedback teleoperation of surgical tool
- ▶ Geomagic Touch
 - ▶ 3 actuated degrees of freedom
 - ▶ Cartesian force feedback
 - ▶ Outputs up to 3 N of force

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- ▶ Communication
 - ▶ Minimize delays in communication
- ▶ Force estimation
 - ▶ Sensors too expensive for short lifetime of tools
- ▶ Control
 - ▶ Remove oscillations in force feedback

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System overview

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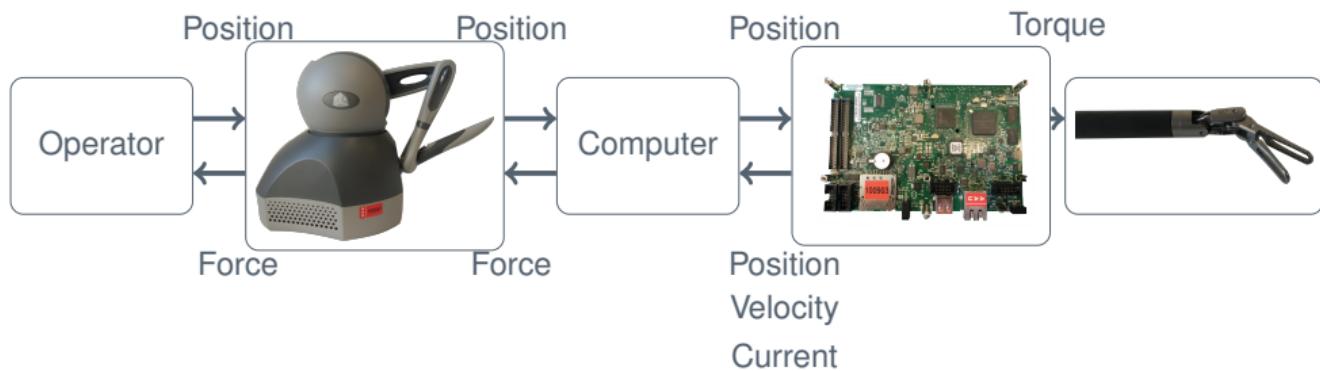
System overview

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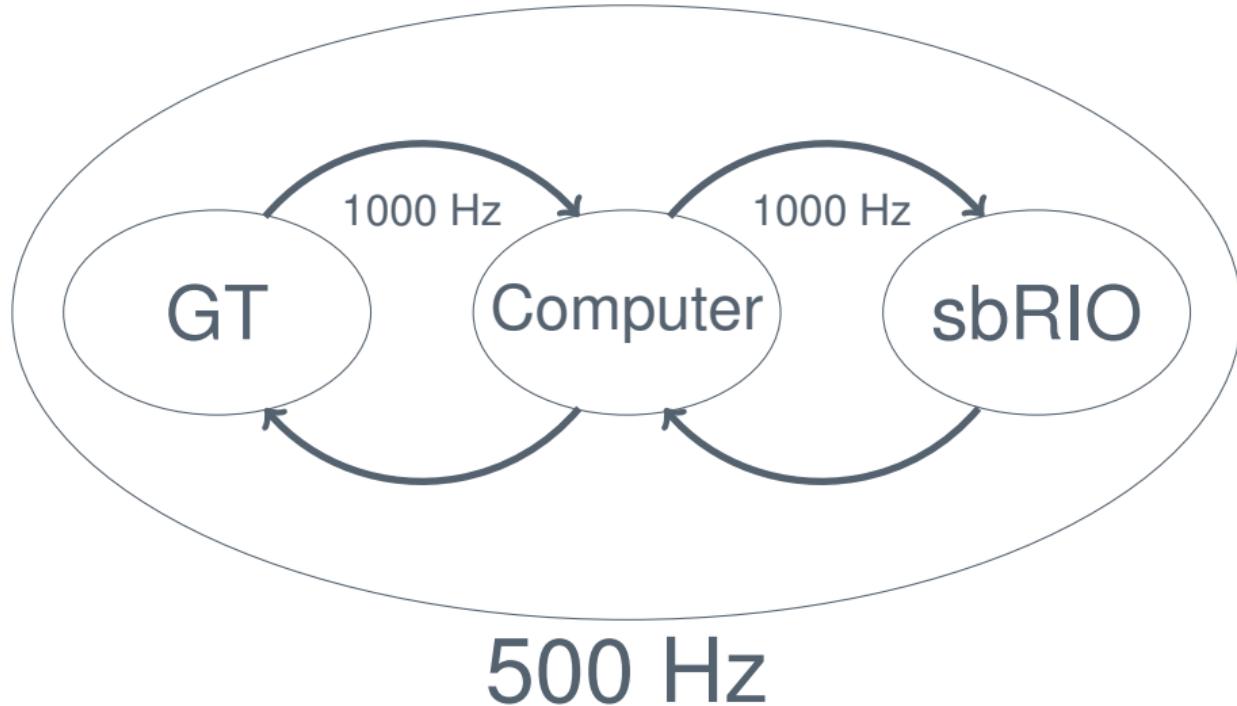


Communication

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Communication

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- ▶ Requirement for force feedback: 1000 Hz

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Communication

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- ▶ Requirement for force feedback: 1000 Hz
- ▶ Maximum for the initial system: 100 Hz

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Communication

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- ▶ Requirement for force feedback: 1000 Hz
- ▶ Maximum for the initial system: 100 Hz
- ▶ Our approach:

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- ▶ Requirement for force feedback: 1000 Hz
- ▶ Maximum for the initial system: 100 Hz
- ▶ Our approach:
 - ▶ Reducing the size of exchanged data

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- ▶ Requirement for force feedback: 1000 Hz
- ▶ Maximum for the initial system: 100 Hz
- ▶ Our approach:
 - ▶ Reducing the size of exchanged data
 - ▶ Changing the transport protocol

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- ▶ Requirement for force feedback: 1000 Hz
- ▶ Maximum for the initial system: 100 Hz
- ▶ Our approach:
 - ▶ Reducing the size of exchanged data
 - ▶ Changing the transport protocol
- ▶ Results: maximum of 638 Hz

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Filip Maric

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Force estimation model

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- ▶ Model approach
- ▶ Nonlinearities in the EndoWrist dynamics
 - ▶ Hammerstein Wiener Models

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Figure : Hammerstein-Wiener model.

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Force estimation model

Linear model

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- ▶ Linear model
 - ▶ Choice of inputs affects model quality
 - ▶ Inputs: effort, velocity
 - ▶ Outputs: force
- ▶ Black-box identification
 - ▶ Subspace identification
 - ▶ Hankel singular value analysis

Include picture with effort force fit here!!

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Force estimation model

Hammerstein Wiener Models

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- ▶ Input and output nonlinearities

- ▶ Effort
- ▶ Force

Include picture with effort force fit here!!

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Force estimation model

Hammerstein Wiener Models

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► Nonlinearities

- Deadzone nonlinearities
- Input/Output -saturation

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State estimation

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- ▶ Modeling for additional outputs allows correction of the model using an estimator
- ▶ A multiple output model that adequately captures the dynamics of the system could be used in a Kalman filter to create a state estimate
- ▶ The state estimates can be used in a state feedback loop to change system dynamics
- ▶ Reference following capabilities can be added to the system, despite the nonlinear characteristics of the dynamics



State estimation

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- ▶ The hypothesis was tested in simulation
- ▶ Simulation results show that full reference following is possible despite the input nonlinearities in the system
- ▶ While the transient behaviour of the reference value is replicated, offsets and parasitic gains need to be compensated
- ▶ Could be implemented with improved model, doesn't improve estimate of current one.

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