# Teleoperation of a surgical robot using force feedback

December 22, 2016

Group 735

Dániel Bolgár
Filip Marić
Nicolas Silvani
Simon Bjerre Krogh

Institut for elektroniske systemer
Aalborg Universitet
Danmark

AALBORG UNIVERSITY
DENMARK

# Agenda





## Communication

## Force estimation

## Improvements

# Communication

- Requirement for force feedback: 1000 Hz

# Communication

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

# Communication

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

# Communication

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

# Communication

- 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

# Communication

- 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

Communication

Force estimation

Improvements

# Force estimation model



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


Figure : Hammerstein-Wiener model.

# Force estimation model
## Linear model



- 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!!

# Force estimation model

## Hammerstein Wiener Models



- Input and output nonlinearities
  - Effort
  - Force

Include picture with effort force fit here!!

- Nonlinearities
  - Deadzone nonlinearities
  - Input/Output -saturation

include two pictures here worksheet 4.6, 4.6 or 4.7

# State estimation



- Modeling for additional outputs allows correction of the model using an estimator

# State estimation

- Modeling for additional outputs allows correction of the model using an estimator
- A multiple output model that adequatley captures the dynamics of the system could be used in a Kalman filter to create a state estimate

# State estimation

- Modeling for additional outputs allows correction of the model using an estimator
- A multiple output model that adequatley 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

# State estimation

- Modeling for additional outputs allows correction of the model using an estimator
- A multiple output model that adequatley 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
- This means that reference following capabilities can be added to the system, dispite the nonlinear characteristics of the dynamics

# State estimation

- The hypothesis was tested in simulation

# State estimation



- The hypothesis was tested in simulation
- Simulation results show that full reference following is possible despite the input nonlinearities in the system

# State estimation

- 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

# State estimation



- 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.