Simscape Model - Nano Active Stabilization System

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Contents

From last sections:

- Uniaxial: No stiff nano-hexapod (should also demonstrate that here)
- Rotating: No soft nano-hexapod, Decentralized IFF can be used robustly by adding parallel stiffness

In this section:

- Take the model of the nano-hexapod with stiffness 1um/N
- Apply decentralized IFF
- Apply HAC-LAC
- Check robustness to payload change
- Simulation of experiments

1 Control Kinematics

- Explained during the last section: HAC-IFF Decentralized IFF Centralized HAC, control in the frame of the struts
- To compute the positioning errors in the frame of the struts
  - Compute the wanted pose of the sample with respect to the granite using the micro-station kinematics (Section 1.1)
  - Measure the sample pose with respect to the granite using the external metrology and internal metrology for Rz (Section 1.2)
  - Compute the sample pose error and map these errors in the frame of the struts (Section 1.3)
- The complete control architecture is shown in Section 1.4

  positioning_error: Explain how the NASS control is made (computation of the wanted position, measurement of the sample position, computation of the errors)

  Schematic with micro-station + nass + metrology + control system =¿ explain what is inside the control system

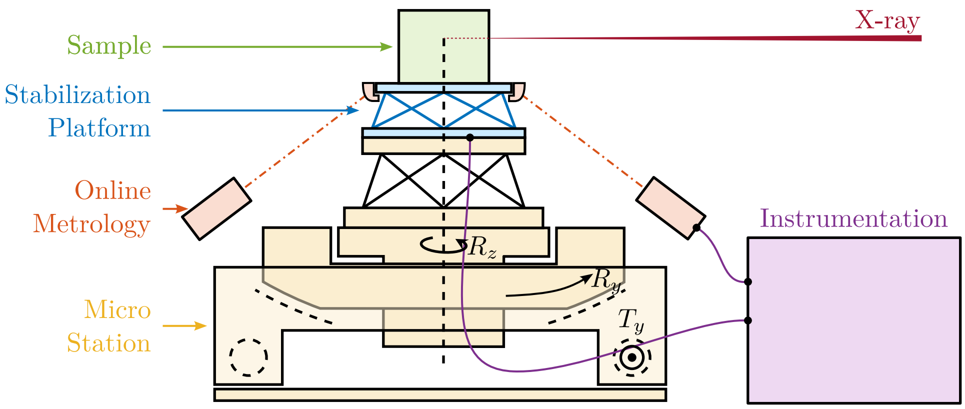

Figure 1.1: Figure caption

1.1 Micro Station Kinematics

- from ??, computation of the wanted sample pose from the setpoint of each stage.

wanted pose = Tdy * Try * Trz * Tu

1.2 Computation of the sample's pose error

From metrology (here supposed to be perfect 6-DoF), compute the sample's pose error. Has to invert the homogeneous transformation.

In reality, 5DoF metrology =¿ have to estimate the Rz using spindle encoder + nano-hexapod internal metrology (micro-hexapod does not perform Rz rotation).

1.3 Position error in the frame of the struts

Explain how to compute the errors in the frame of the struts (rotating):

- Errors in the granite frame
- Errors in the frame of the nano-hexapod
- Errors in the frame of the struts =¿ used for control

1.4 Control Architecture

- Say that there are many control strategies. It will be the topic of chapter 2.3. Here, we start with something simple: control in the frame of the struts

  block diagram of the complete control architecture

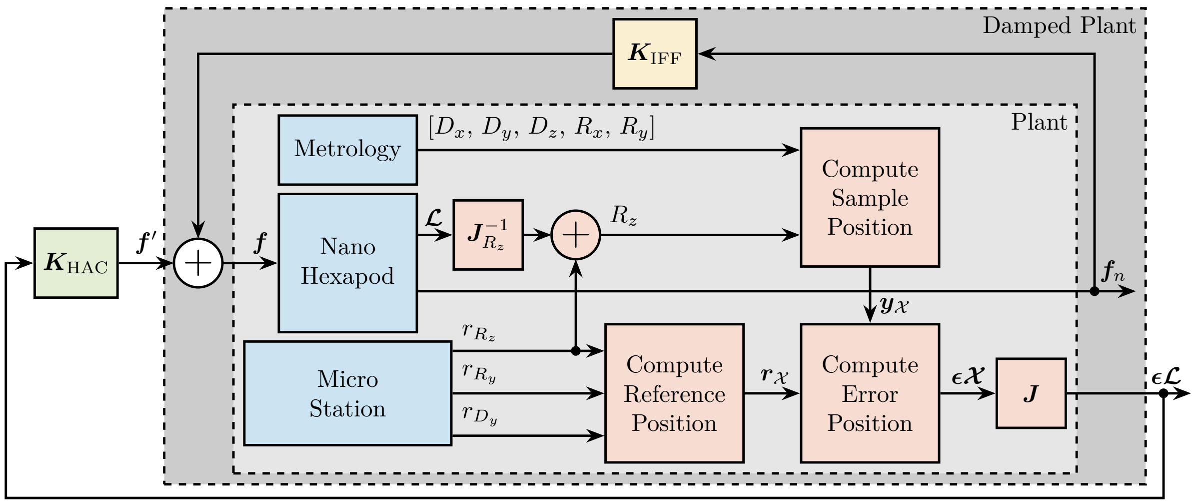

Figure 1.2: Figure caption

2 Decentralized Active Damping

- How to apply/optimize IFF on an hexapod?
- Robustness to payload mass
- Root Locus
- Damping optimization

Explain which samples are tested:

- 1kg, 25kg, 50kg
- cylindrical, 200mm height?

  control_active_damping

  active damping for stewart platforms

  Vibration Control and Active Damping

2.1 IFF Plant

Show how it changes with the payload mass (1, 25, 50)

Effect of rotation (no rotation - 60rpm)

Added parallel stiffness

2.2 Controller Design

- Use Integral controller (with parallel stiffness)
- Show Root Locus (show that without parallel stiffness =¿ unstable?)
- Choose optimal gain. Here in MIMO, cannot have optimal damping for all modes. (there is a paper that tries to optimize that)
- Show robustness to change of payload (loci?) / Change of rotating velocity ?

- Reference to paper showing stability in MIMO for decentralized IFF

2.3 Sensitivity to disturbances

Disturbances:

- floor motion
- Spindle X and Z
- Direct forces?
- Compute sensitivity to disturbances with and without IFF (and compare without the NASS)
- Maybe noise budgeting, but may be complex in MIMO. . . ?

3 Centralized Active Vibration Control

uncertainty_experiment: Effect of experimental conditions on the plant (payload mass, Ry position, Rz position, Rz velocity, etc...)

- Effect of micro-station compliance
- Effect of IFF
- Effect of payload mass
- Decoupled plant
- Controller design

From control kinematics:

- Talk about issue of not estimating Rz from external metrology? (maybe could be nice to discuss that during the experiments!)
- Show what happens is Rz is not estimated (for instance supposed equaled to zero =¿ increased coupling)

3.1 HAC Plant

Compute transfer function from $\boldsymbol{f}$ to $\boldsymbol{\epsilon\mathcal{L}}$ (with IFF applied) for all masses

Show effect of rotation

Show effect of payload mass

Compare with undamped plants

3.2 Controller design

Show design HAC with formulas and parameters

Show robustness with Loci for all masses

3.3 Sensitivity to disturbances

- Compute transfer functions from spindle vertical error to sample vertical error with HAC-IFF Compare without the NASS, and with just IFF
- Same for horizontal

3.4 Tomography experiment

- With HAC-IFF, perform tomography experiment, and compare with open-loop
- Take into account disturbances, metrology sensor noise. Maybe say here that we don't take in account other noise sources as they will be optimized latter (detail design phase)
- Tomography + lateral scans (same as what was done in open loop here)
- Validation of concept

4 Conclusion