Advanced motion control for high-precision motion systems

Wataru Ohnishi, ohnishi@koseki.t.u-tokyo.ac.jp

Preactuation perfect tracking control for system with unstable zeros

Unstable zeros problem
- Unstable poles in inversion system
- Undershoot in step response

Example: High-precision stage, boost converter, airplane...

Solution
- Stable inversion by
  - Time axis reversal & imaginary axis flipping
  - Multirate feedforward

Modeling results using frequency domain identification

High-precision motion control by pneumatically actuated stage

Pneumatic actuation

Advantages
- High power to weight ratio
- Low heat generation
- Low cost

Disadvantages
- Time delay
- Position-dependent resonances
- Valve & air dynamics nonlinearity

Time delay compensation by modified Smith predictor

Position FB bandwidth
Conv: 9.4 Hz (Gm:13dB, Pm 35deg)  
Prop: 31Hz (Gm:6.4dB, Pm:35deg)

Position FB bandwidth
Conv: 5.3 Hz (Gm:7dB, Pm:22deg)  
Prop: 11Hz (Gm:9.6dB, Pm:26deg)

Acoustic wave equation based modeling and vibration cancellation

Precise modeling by damping considered wave equation

Resonance cancellation by wave equation based SINGLE filter

Wataru Ohnishi, ohnishi@koseki.t.u-tokyo.ac.jp

Advantages
- High power to weight ratio
- Low heat generation
- Low cost

Disadvantages
- Time delay
- Position-dependent resonances
- Valve & air dynamics nonlinearity

Precise pressure control achieved