Stability Guaranteed Control of Flexible RH Manipulators

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Rationale

Most robotic manipulators are assumed rigid
• The ideal situation
• Slow motion, small interacting forces, bulky design to increase stiffness
• Robot’s own weight is considerable with respect to the maximum payload

Flexible robotic manipulators
• Flexibility = mechanical oscillations and static deflections
  → Challenges in motion control
  → Challenges in end-point position measurement (required for effective feedback control)
Rationale

ITER remote handling (RH) devices
• Cassette multifunctional mover (CMM)
• Multi-purpose deployer (MPD)
• Neutral beam system remote handling equipment
• Etc.
Research Focus

• End-point position measurement/estimation
  – Capturing the dynamic behavior due to flexibility
  – Fit for harsh environments
• Nonlinear model-based control of flexible manipulators
  – Novel methods
  – Mathematically guaranteed stability
End-Point Positioning of Flexible-Link Manipulators

Developed method is based on strap-on inertial sensor measurements

- MEMS IMUs used as the main sensors
  - Tri-axial acceleration and tri-axial rate-gyro measurements
- Angular velocity measurements
  → finite-element based observer
  → estimates of the flexural states
  → the estimated deformations at the tip are used for feedback control

- Additionally required: the joint angle
  - Encoder measurement

- Planar, single-flexible-link case tested
Experimental System

- Hydraulic manipulator with a 4.5-meter-long flexible link (high-strength steel)
- OptiTrack camera for verification purposes
End-Point Control of Flexible-Link Manipulators

Virtual Decomposition Control (VDC)
• Nonlinear and model-based control method
• Has been shown to produce state-of-the-art control performance with rigid hydraulic manipulators
• Subsystem-based control design
  – Number of control computations is proportional to the number of subsystems (in traditional robot control it is proportional to the 4th power of the number of degrees of freedom in the system)
• Stability can be guaranteed using the tools provided by the VDC approach
• Good initial results for a single-link flexible manipulator

Trajectory tracking using the VDC.
Thank you for your attention!
