Active Mass Damping in Flexible Robotics

by Ryan Krauss

Project Goals

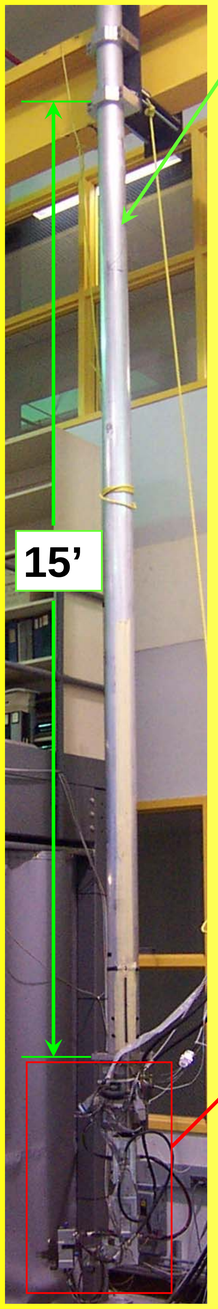
- Expand the field of active vibration suppression
- Implement novel controls approaches

Abstract

This research focuses on vibration suppression in long reach robots, by using the motion of a micro-manipulator to damp vibration of a macro-manipulator.

Recent Work: Instability

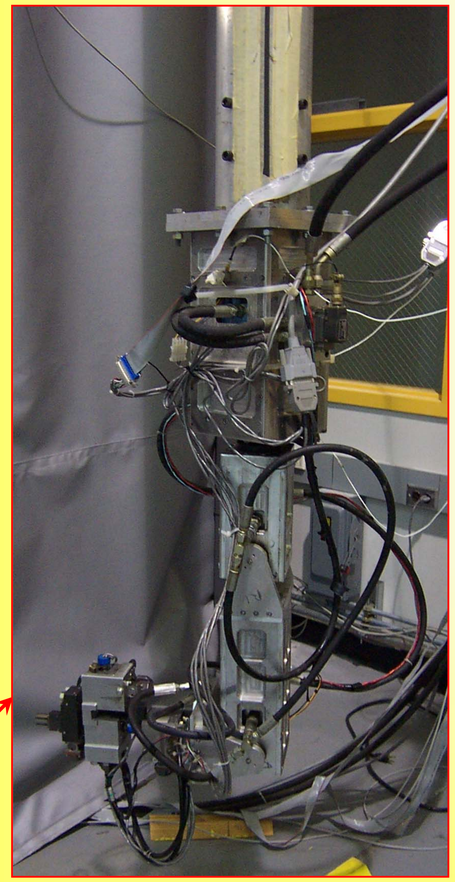
While attempting to recreate the work of previous students, an instability problem was uncovered. Interaction between the actuator and first two modes of the flexible base has been highlighted as a cause of the instability. System identification and root locus analysis have lead to physical insight into the cause of the instability.



Macro-manipulator

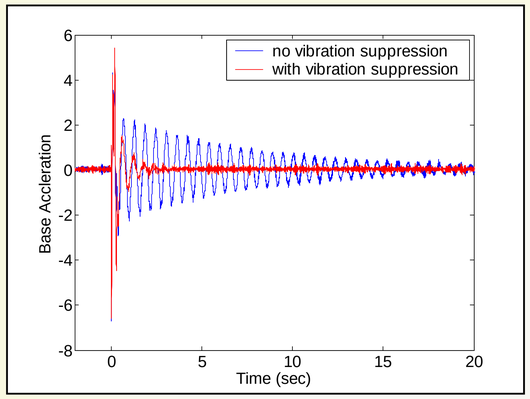
A cantilevered beam represents a long arm that would move the smaller robot into position.

Micro-manipulator



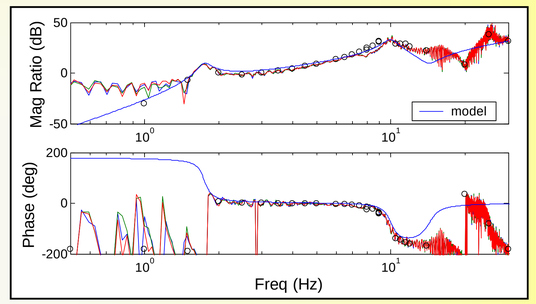
This research uses a micro-manipulator known as SAMII which stands for Small Articulated Manipulator II. SAMII is small and rigid compared to his long, flexible base.

Suppression Performance



The above graph shows that active mass damping significantly reduces the duration of vibrations caused by motion of the micro-manipulator.

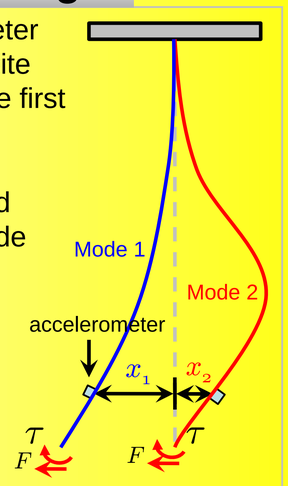
System Identification



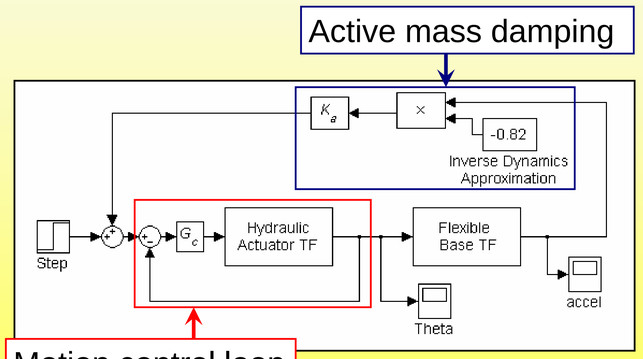
A model for the system was determined based on frequency response data. A Bode plot for the flexible base is shown above (acceleration/angular position).

Physical Insight

The accelerometer moves in opposite directions for the first two modes. While the controller added damping to mode 1 it subtracted damping from mode 2.

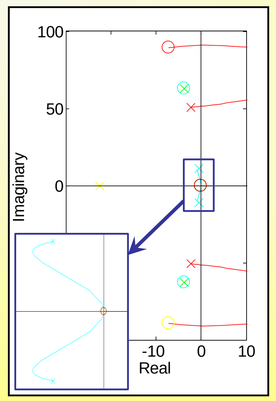


Block Diagram



A block diagram of the system is shown above. It is assumed that the motion control loop is designed first and then the active mass damping is added.

Root Locus



Root locus analysis played a key role in understanding the cause of instability and enabled possible changes to the system to be simulated. The plot at left shows a root locus of the initial controller. Damping is being added to the first mode, but subtracted from the second mode so that the second mode is destabilized.

Credits

This work builds on the work of previous students:

- David Cannon
- Cameron Loper
- Lynnane George

Future Direction

- Model the interaction between the structure and the actuators more precisely
- Develop a mass damping controller that produces no interaction torque
- Investigate global stability of the controller

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