TOWARDS ACTIVE STRUCTURAL CONTROL STRATEGIES FOR ELECTRONIC ASSEMBLIES IN HIGH-RATE DYNAMIC ENVIRONMENTS

Trotter Roberts[1], Ryan Yount[1], Jacob Dodson[3], Adriane Moura[4], and Austin R.J. Downey[1,2]

1. University of South Carolina Department of Mechanical Engineering.
2. University of South Carolina Department of Civil Engineering.
3. Air Force Research Laboratory.
4. Applied Research Associates.

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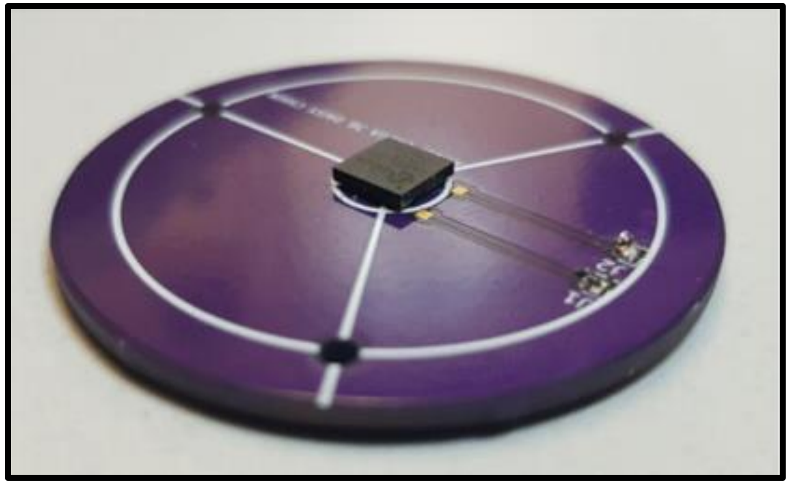
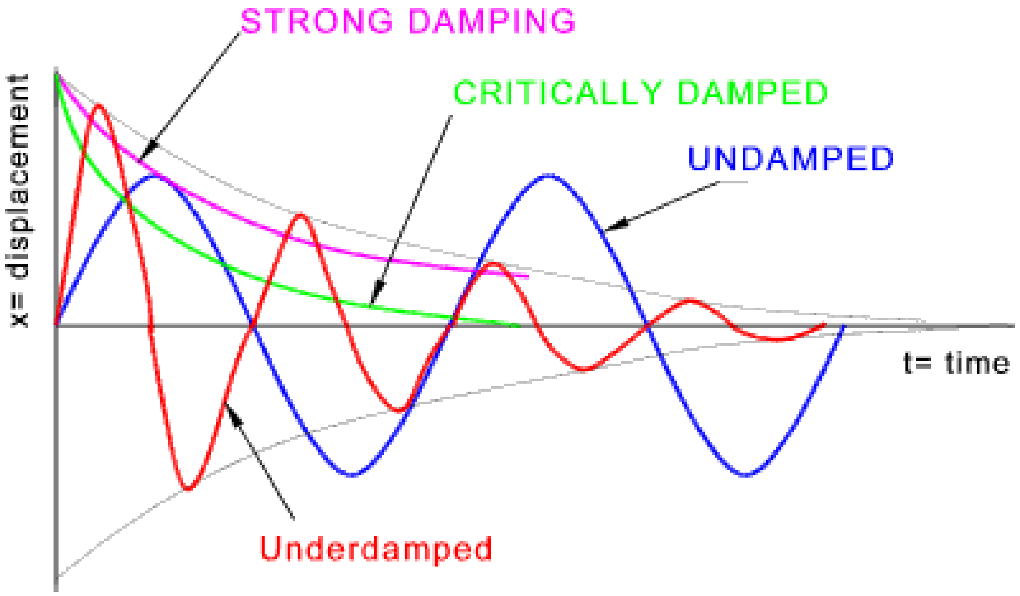
OVERVIEW

- Introduction to High-Rate Impacts
- Project Motivation and Support
- Ongoing Work
  - Shock Testing
  - Board Design
- Focused Study
  - Experiment
  - Simulation
  - Analysis
  - Conclusion
- Future Work
  - Control
  - Placement





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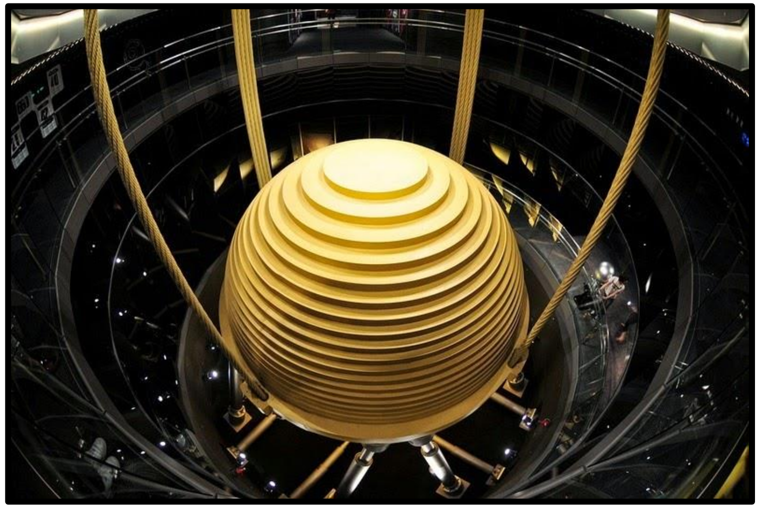
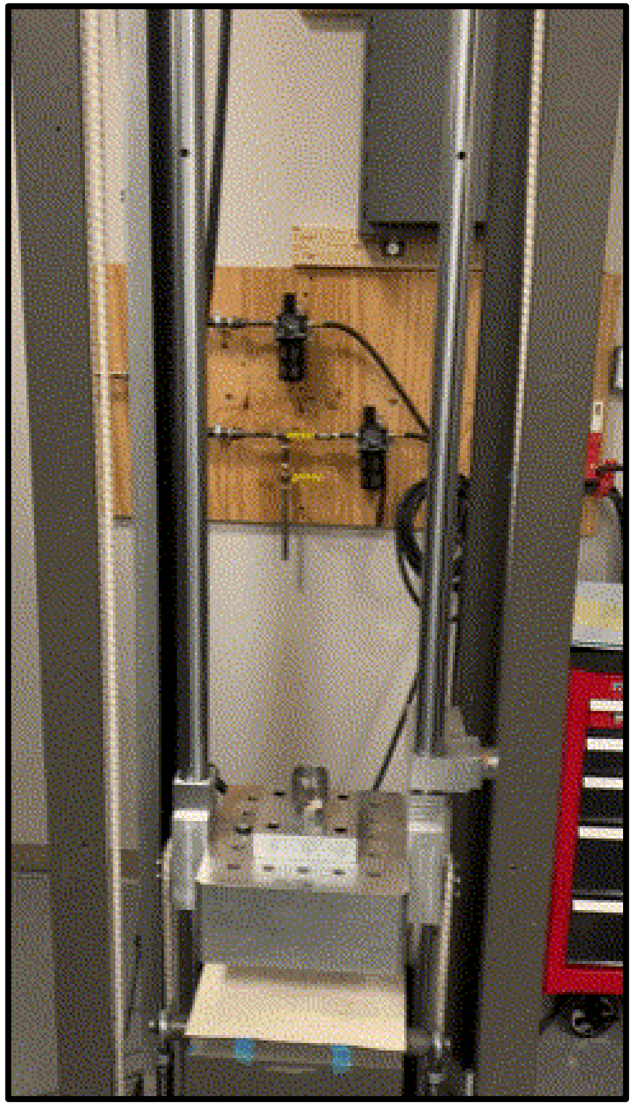
INTRODUCTION

- Shock occurs when a system undergoes a dramatic and sudden change in acceleration.
- Shock can cause damage to the system, contributing to objective failure.
- Active control of these systems can dampen shock and prevent damage.





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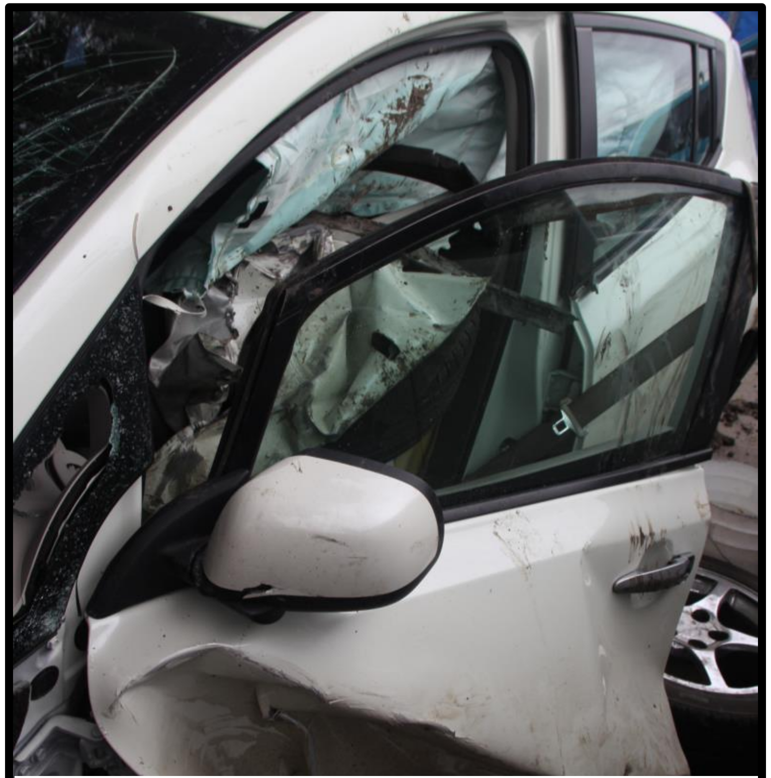
MOTIVATION

Blast Against Civil Structures

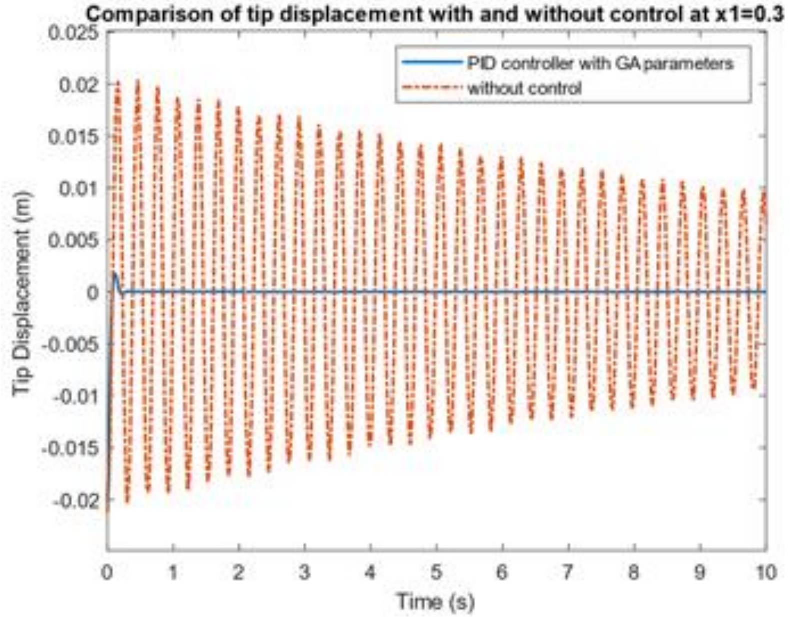


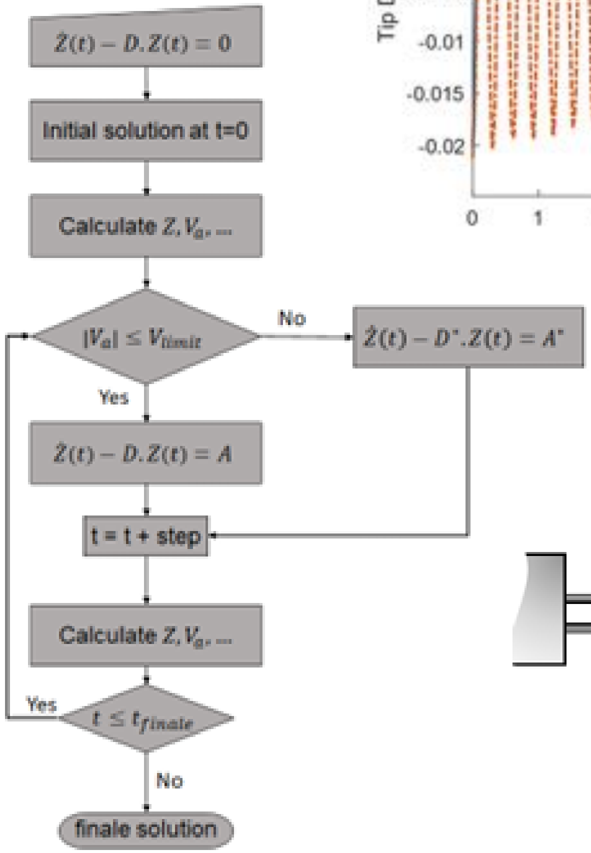
Automotive Impact and Crashes

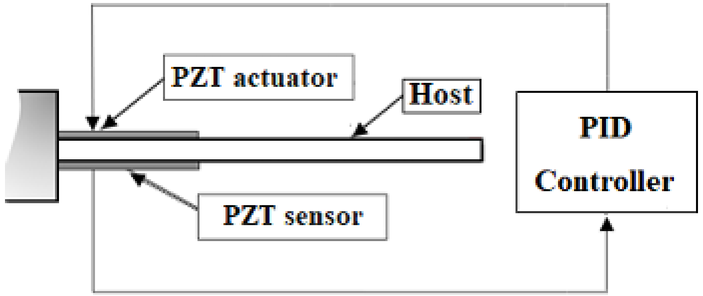
High-speed Aircraft and Airframes

ACTIVE CONTROL

- Key Point: Optimized control of cantilever beam vibrations.
- Content:
  - **Study**: Awada, A, et al. (2022)
  - **Conclusion**: The genetic algorithm developed in this study successfully optimizes active control of a smart cantilever beam using piezoelectric actuators, significantly reducing beam vibrations.
  - **Takeaway**: A simple PID controller may demonstrate the potential for stable and efficient vibration control in smart structures.







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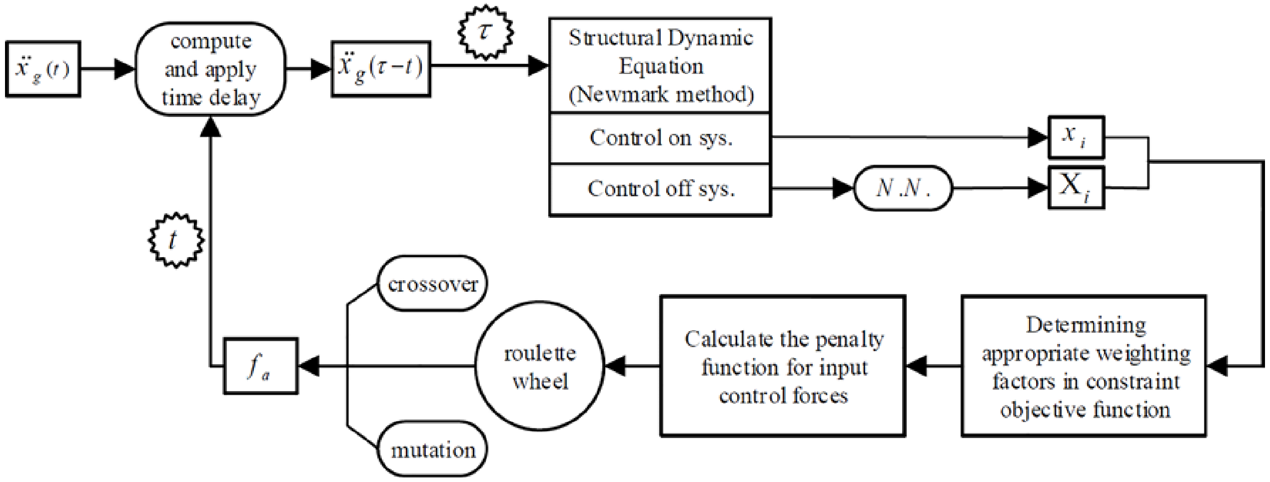
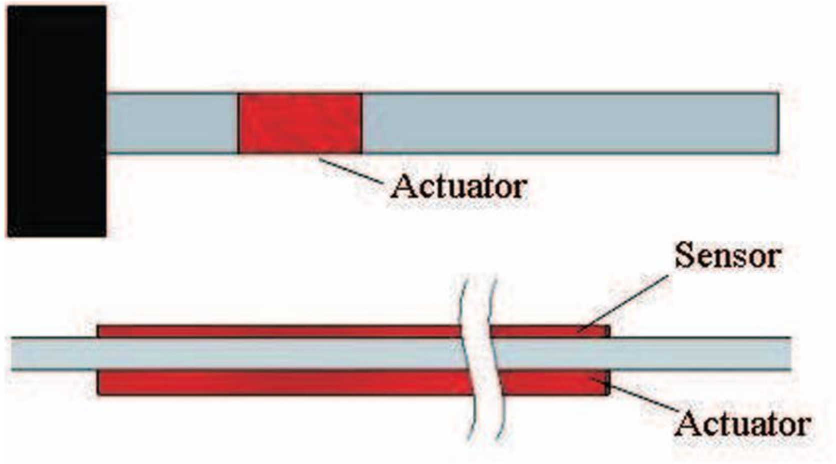
CONTROL STRATEGIES

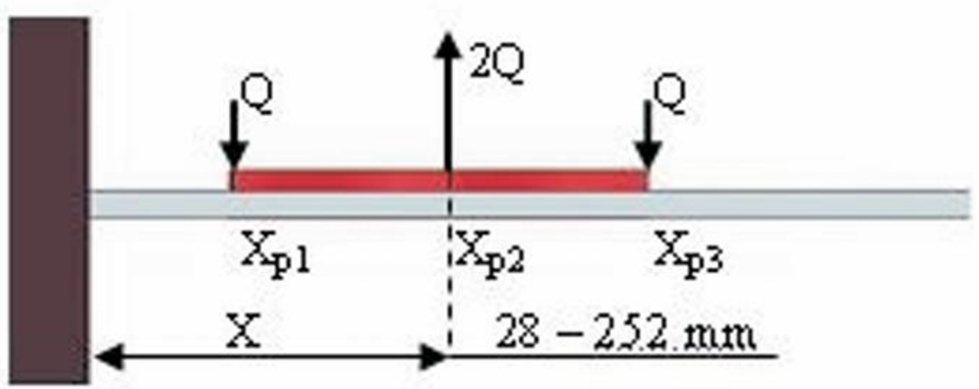
- Key Point: Improved performance in structural control through adaptive algorithms.
- Content:
  - **Study**: Banaei, Ali, et al. (2023)
  - **Conclusion**: The introduction of dynamic weighting factors in the genetic algorithm's constrained objective function leads to improved vibration reduction in complex, large-scale structural systems.
  - **Takeaway**: This approach enhances the adaptability of control systems in varying conditions, making it more suitable for complex structural applications.

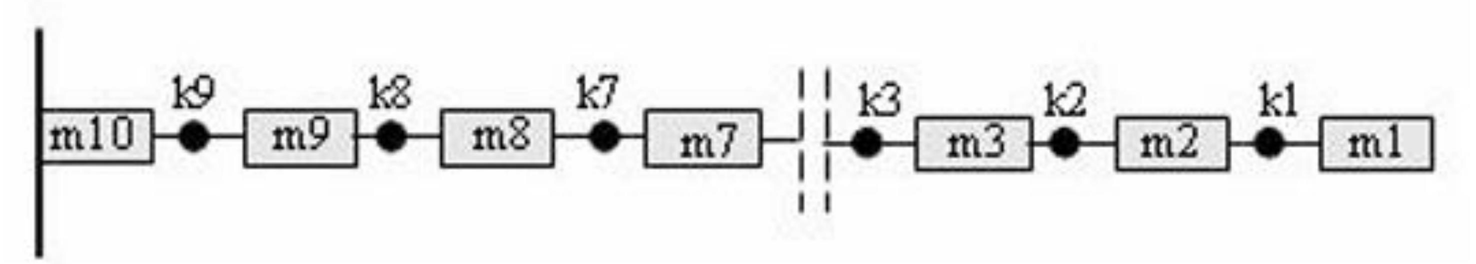


PIEZO ACTIVE STRUCTURES



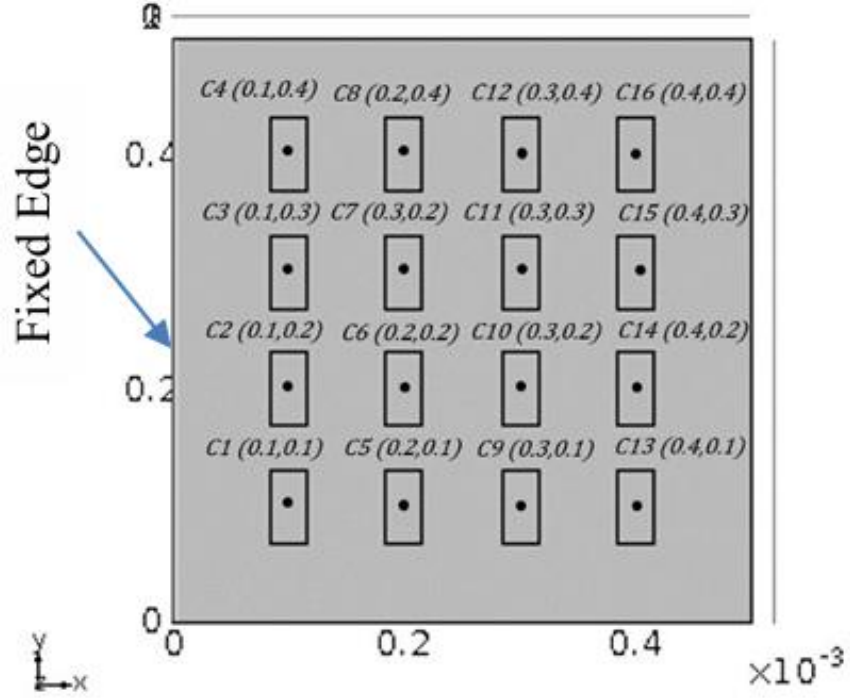
- Key Point: Application-focused development of piezoelectric actuator systems.
- Content:
  - **Study**: Gosiewski, Z, et al. (2023)
  - **Conclusion**: Experimental tests on different configurations of piezoelectric actuators reveal the most effective designs for real-world vibration control applications, offering practical improvements in piezoelectric structure performance.
  - **Takeaway**: Real-world testing of piezoelectric materials and actuator configurations helps refine design parameters for improved vibration control.





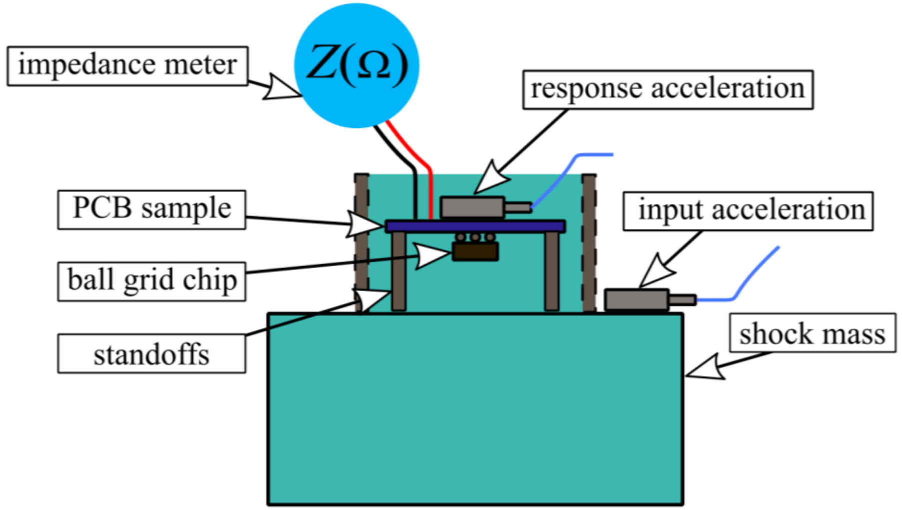
ACTUATOR PLACEMENT

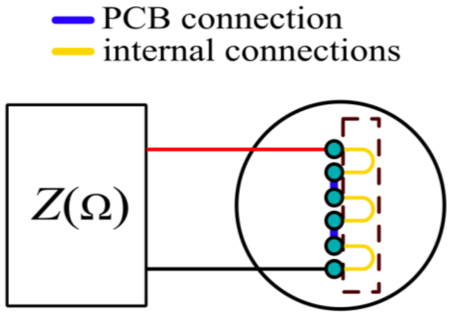
- Key Point: Vibration reduction through strategic placement of piezoelectric patches.
- Content:
  - **Study**: Labanie, Mohammad F, et al. (2017)
  - **Conclusion**: Finite element analysis identifies the optimal locations for piezoelectric patch placement on structures, significantly improving vibration control efficiency.
  - **Takeaway**: Strategic patch placement, determined through simulation, maximizes the effectiveness of vibration control systems, offering better performance for specific structural designs.

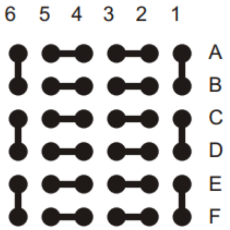


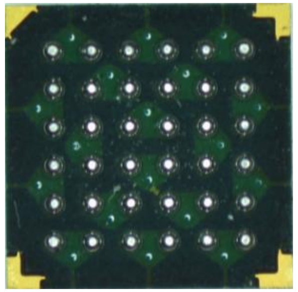
ONGOING WORK

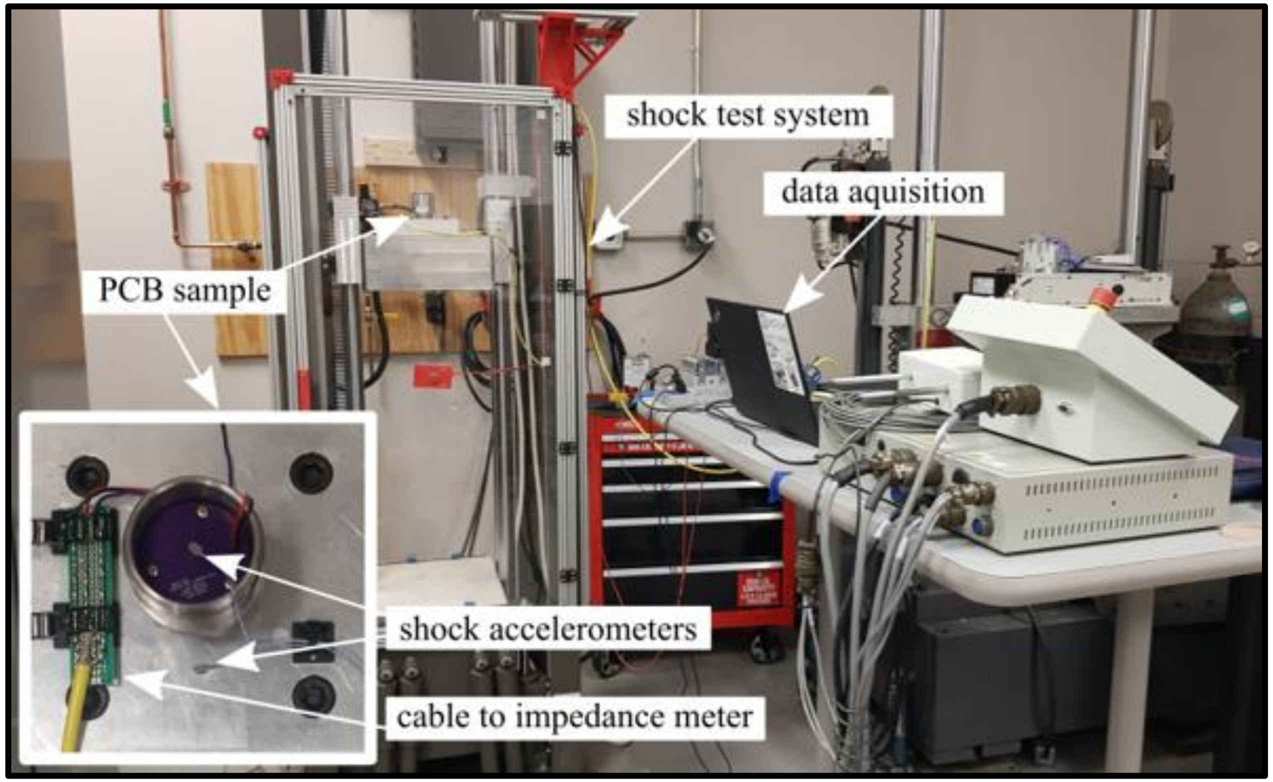
- Shock Test Experimentation
- PCB and Component Design

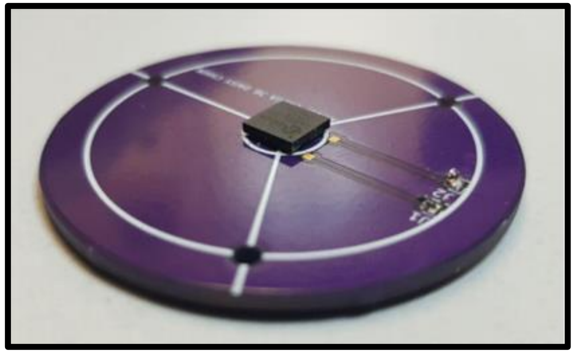












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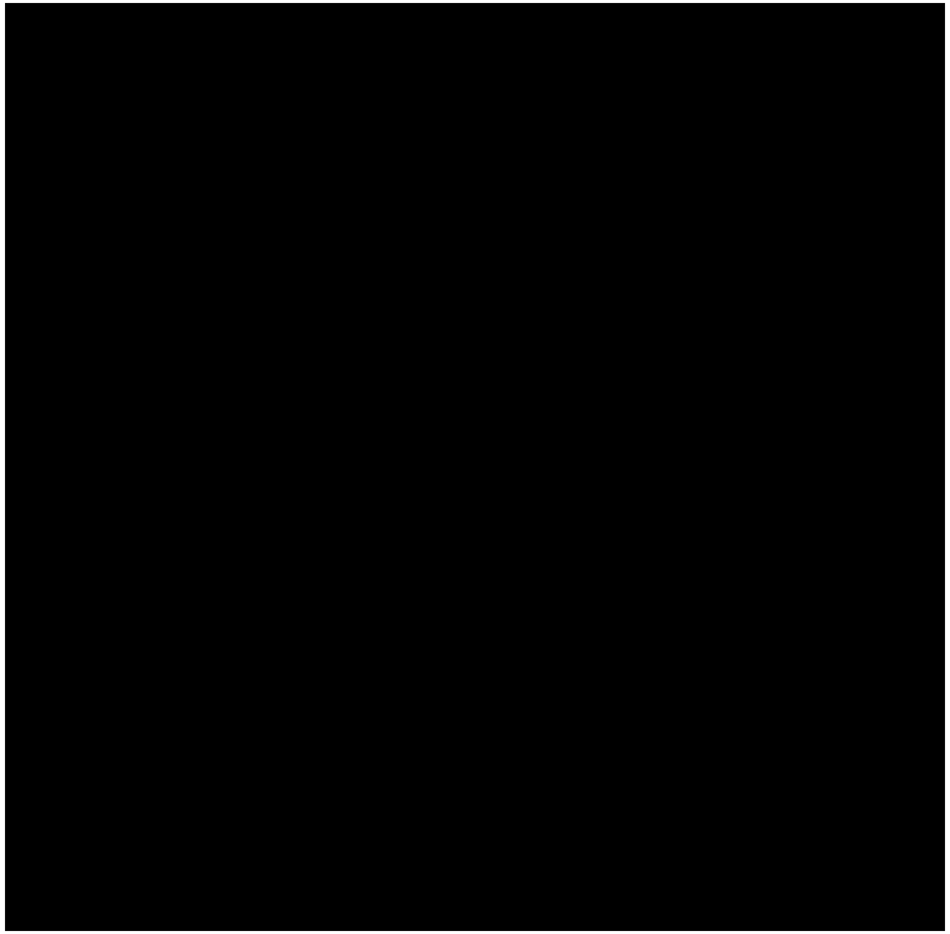
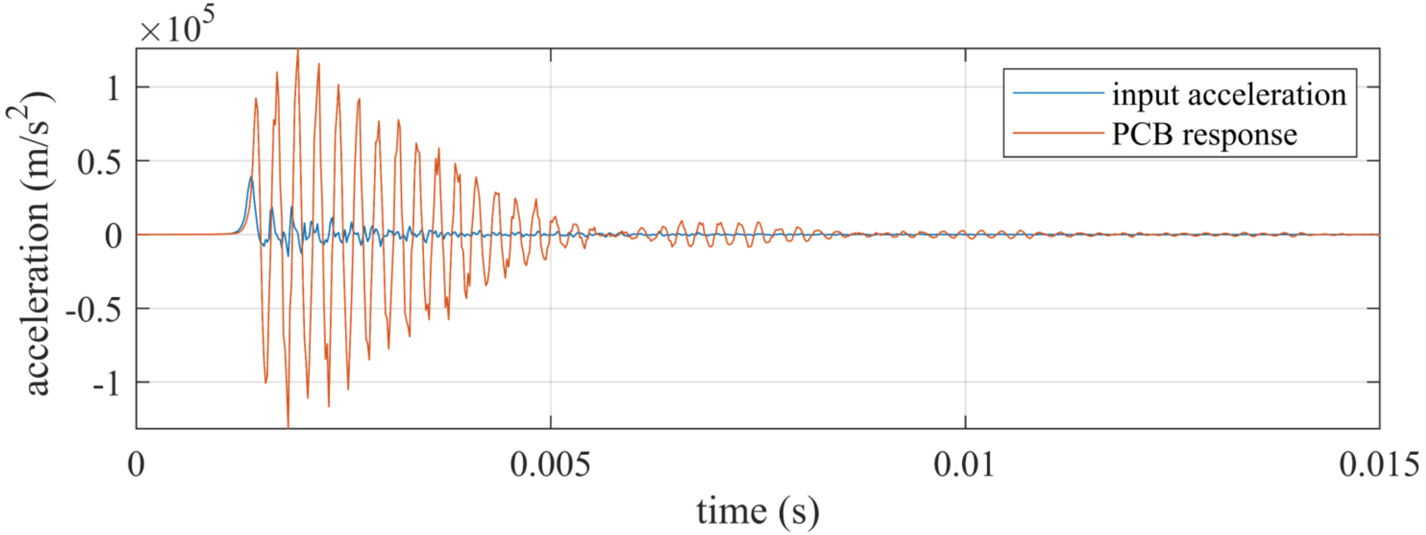
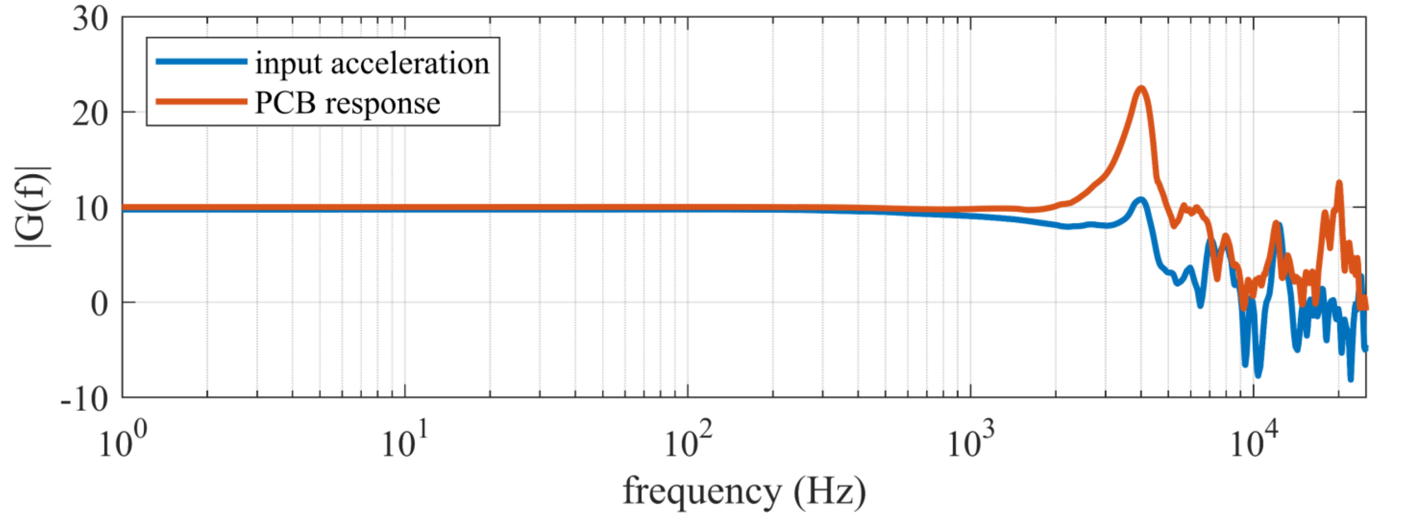
ONGOING WORK

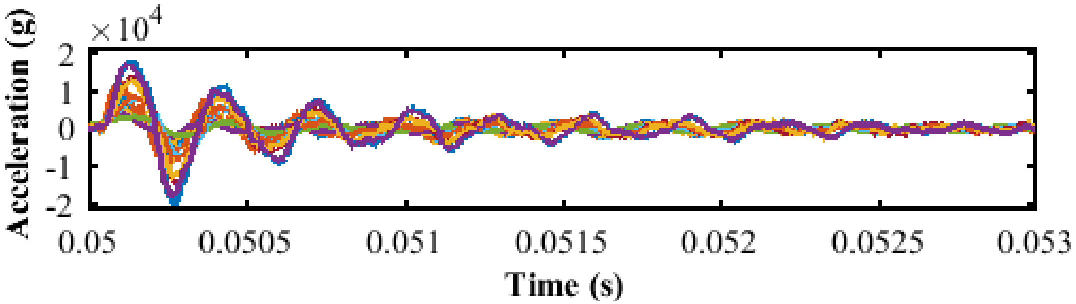




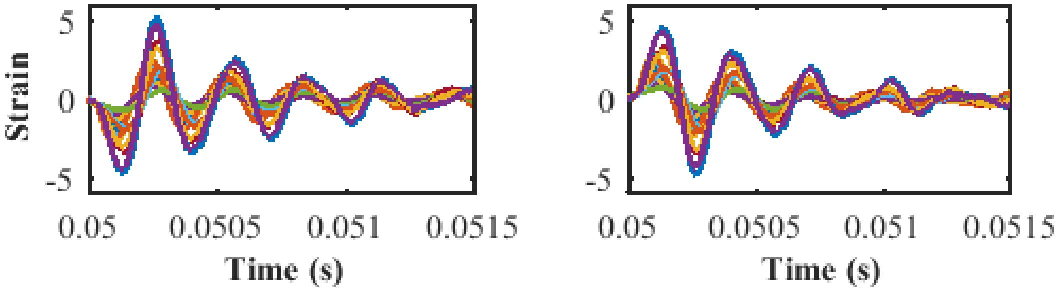


FOCUSED EXPERIMENT

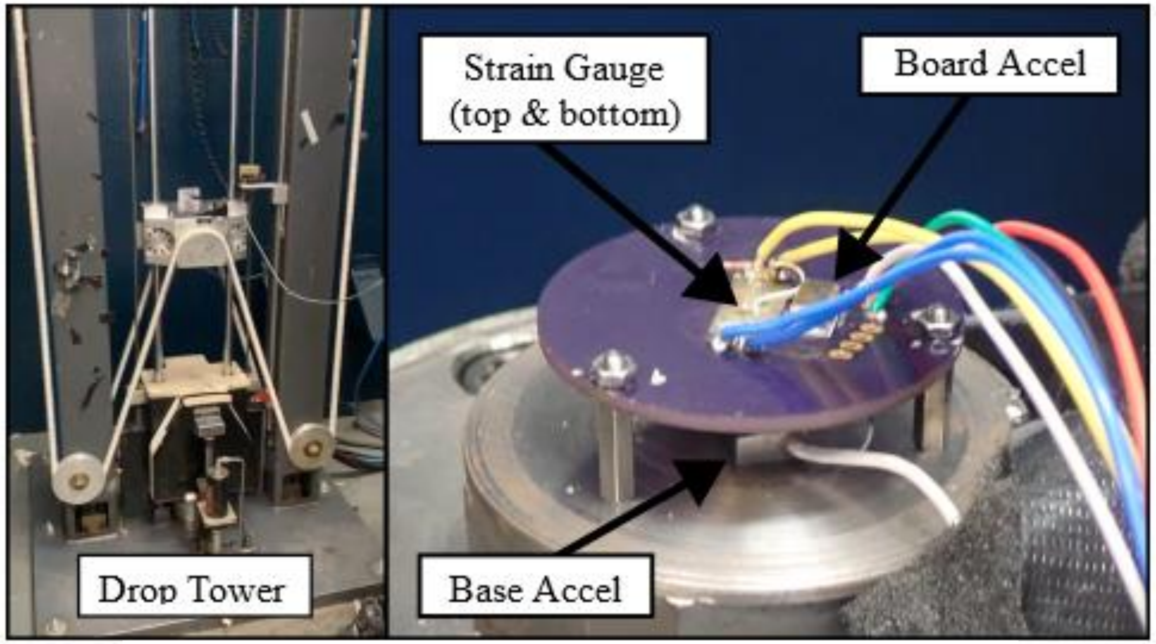
- Acceleration and strain measurement at varying drop heights.
- Dataset creation for later use.



Board Acceleration over Time.



Top (left) and Bottom (right) Strain over Time.



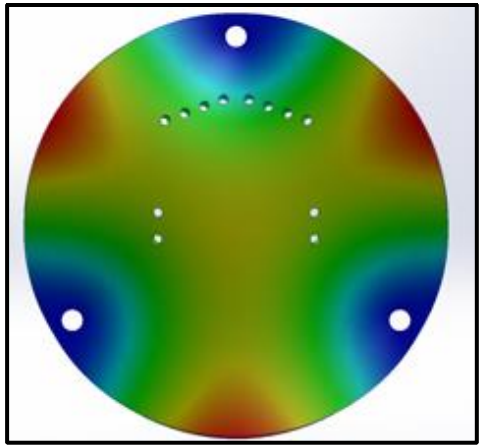
Drop Tower and Tested Printed Circuit Board.

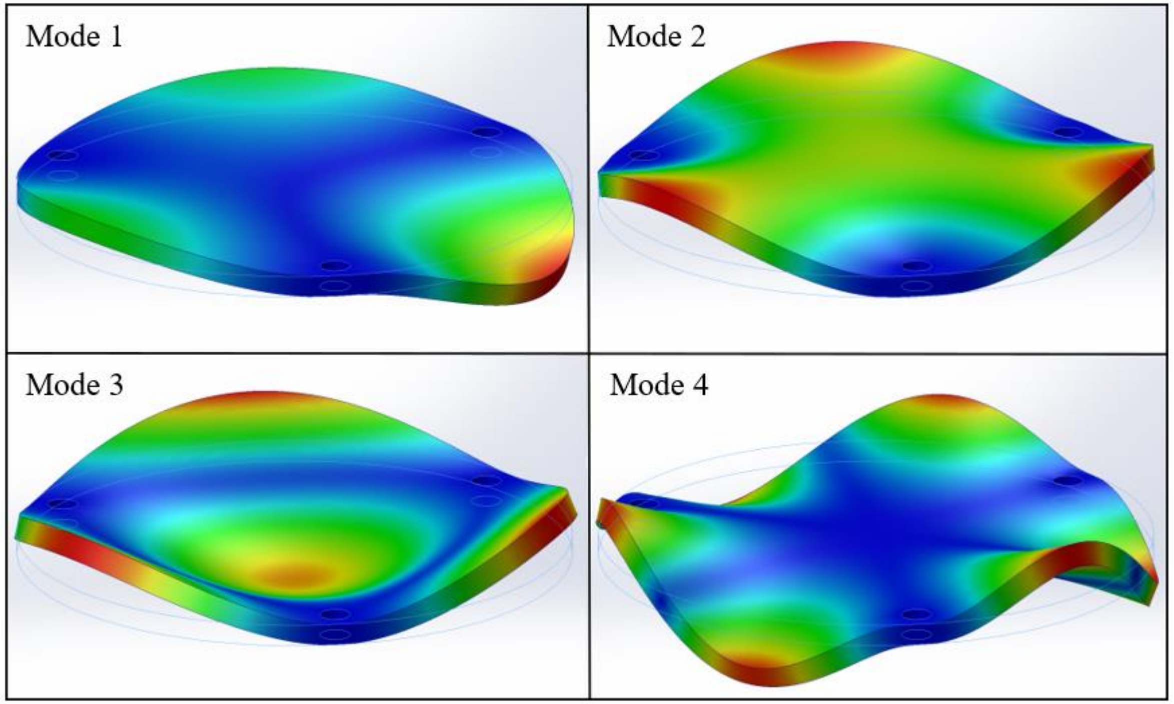
SIMULATION

- SolidWorks
  - Frequency
  - Strain
  - Stress
  - Displacement

Diameter	Thickness	Hole Placement	Density	Young's Modulus	Poisson Ratio
1.625 in	0.063 in	1.450 in	1900 kg/m³	18.6 GPa	0.2

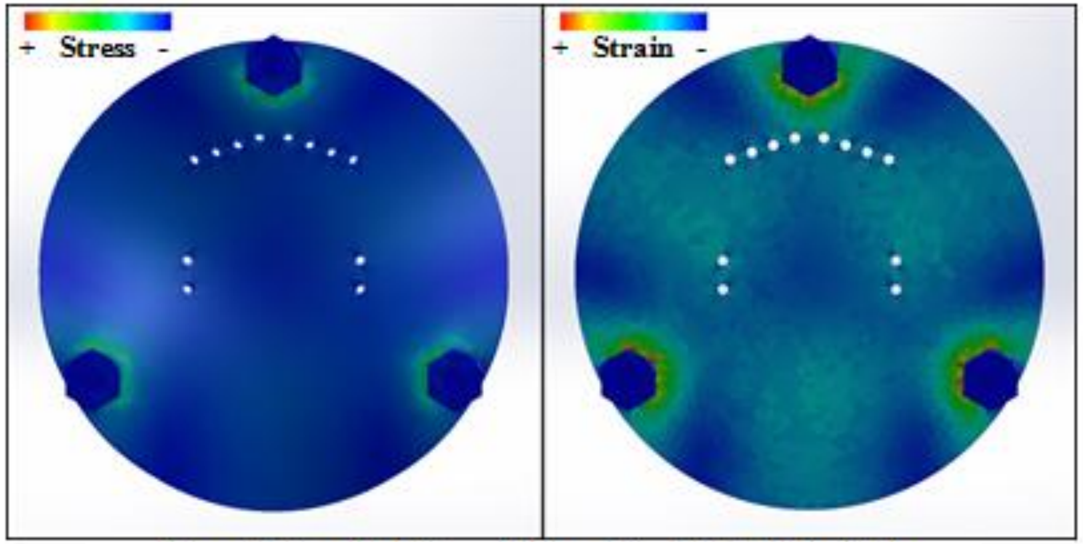
System Specifications used in Simulations.


Displacement Magnitude



	Mode 1	Mode 2	Mode 3	Mode 4
Frequency	3681 Hz	3909 Hz	5671 Hz	10316 Hz

Simulated Mode Shapes and Natural Frequencies.



Simulated Stress (left) and Strain (right) Magnitude.

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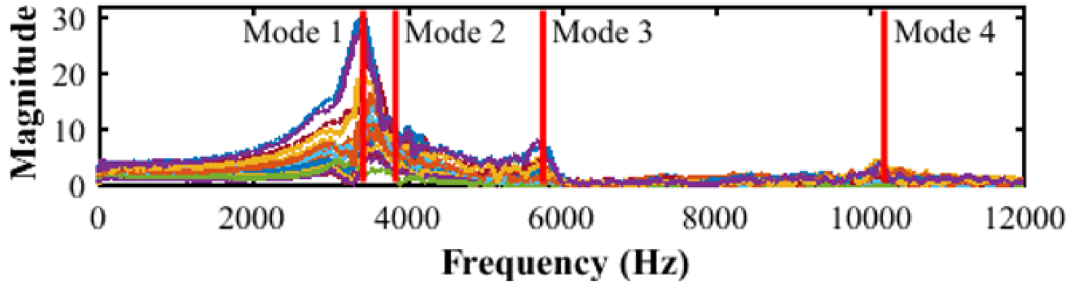
ANALYSIS

- Data processing to confirm simulation accuracy.
- Natural frequency comparison.

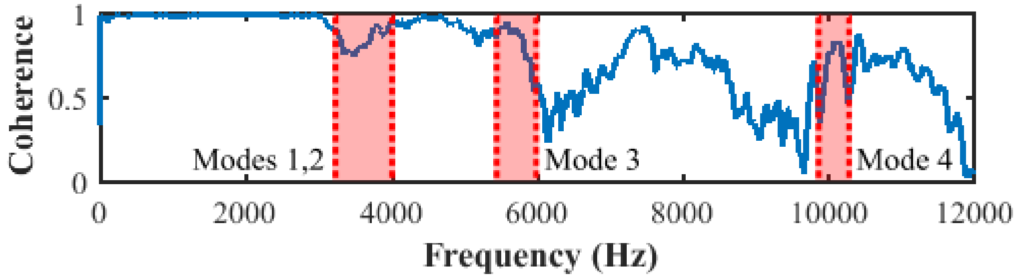


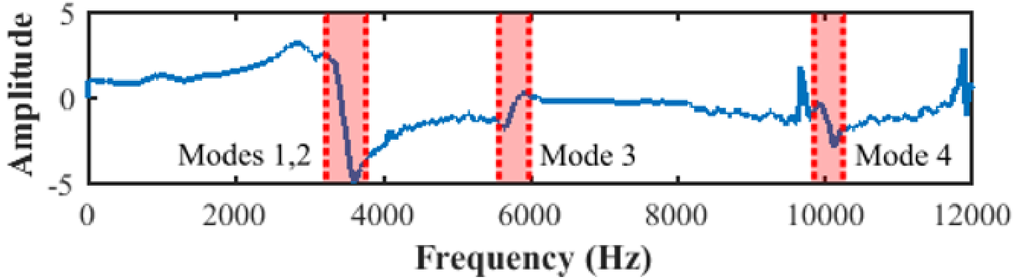
System Response Fast Fourier Transform

	Mode 1	Mode 2	Mode 3	Mode 4
Simulated Frequency	3681 Hz	3909 Hz	5671 Hz	10316 Hz
Experimental Frequency	3600 Hz	4000 Hz	5800 Hz	10200 Hz
Margin of Error	2.20 %	2.33 %	2.27 %	1.13 %

Simulated vs Experimental Natural Frequencies and Margin of Error

System Coherence





System Frequency Response Function

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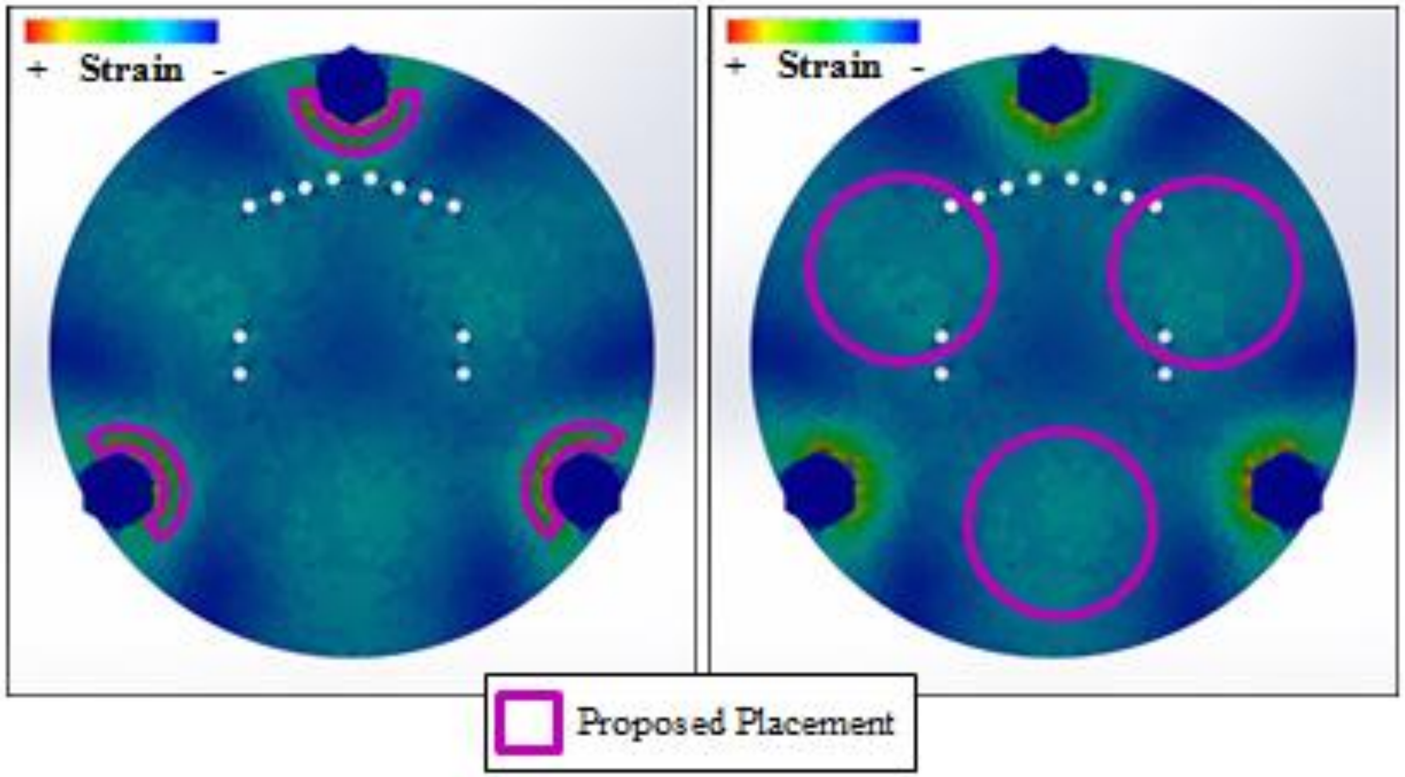
CONCLUSION

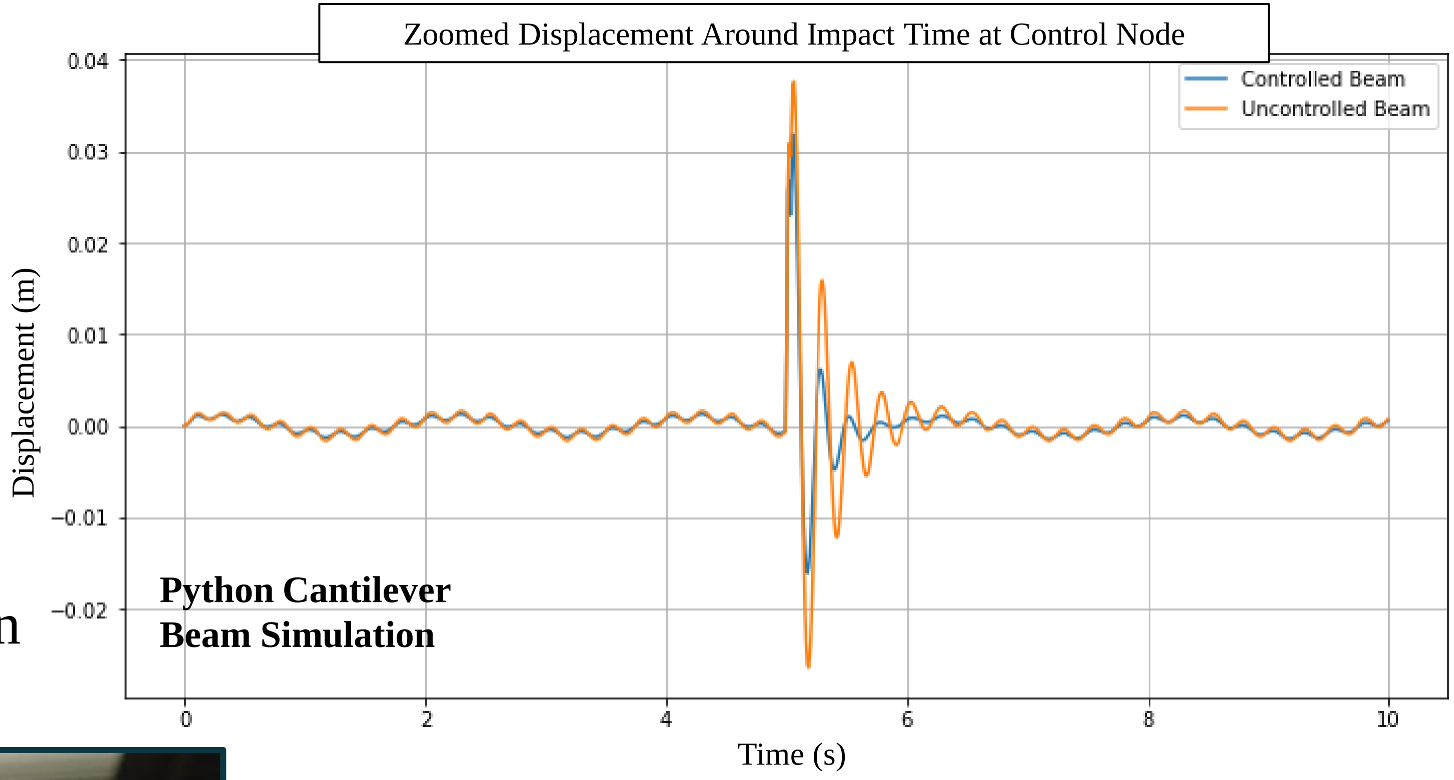
- Focusing on areas of most strain, optimal placement of piezoelectric actuators proposed to dampen system impacts.
- Alternative placement proposed for direct comparison.

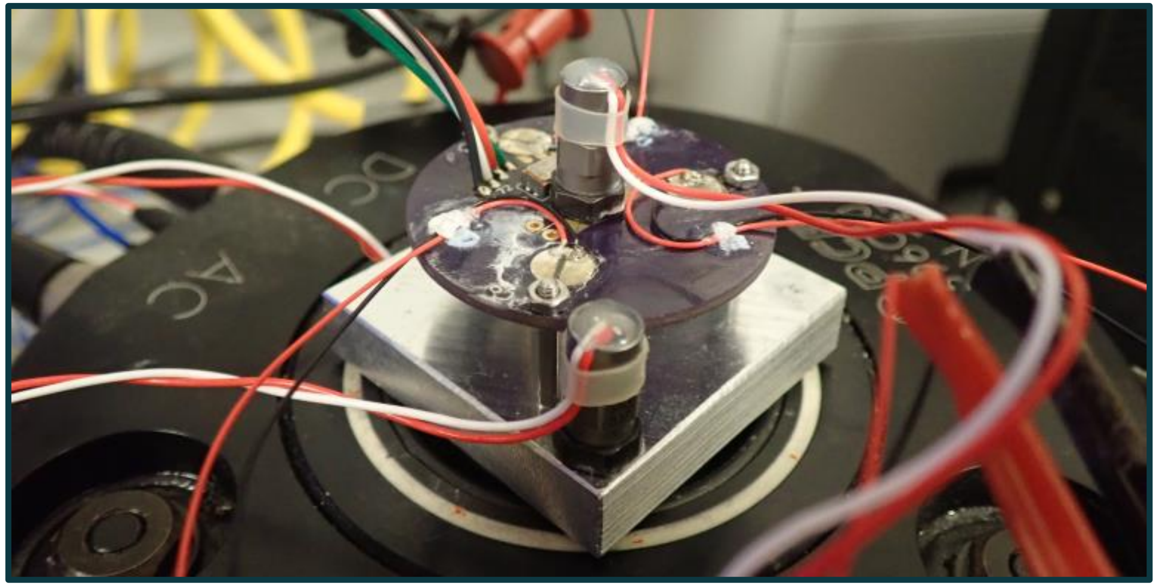


Proposed (left) and Possible Alternative (right) Actuator Placement for Optimization.

FUTURE WORK

- Progress toward control strategies
  - LabView FPGA
  - Python Simulations
  - Simulink
- Piezoelectric sensing and actuation experimentation.





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QUESTIONS?