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Inverse methods for identifying pressure loading on aerospace vehicles using structural response

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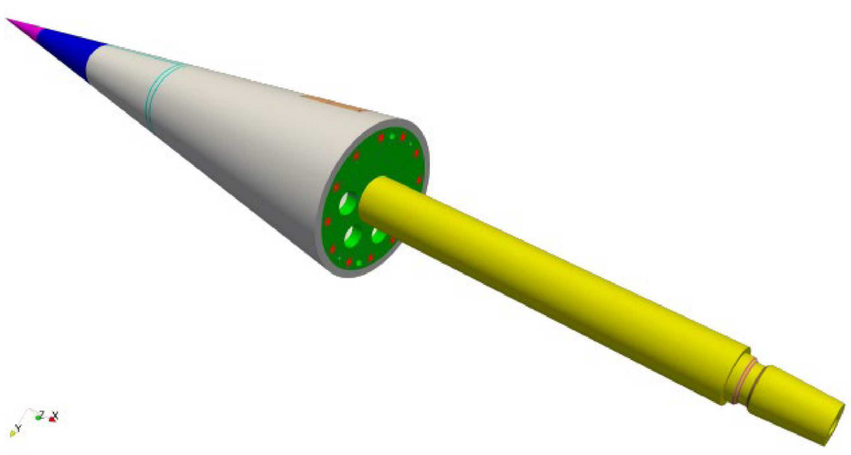
Introduction

To enable the design and analysis of aerospace vehicles, it is important to fully understand flight environments and the consequent dynamic response of the vehicle. In this context, the varying surface pressure is a cause of structural vibration, which is difficult to measure experimentally with high resolution over the body. Therefore, it is desirable to use models in conjunction with an experimentally determined structural response to identify the pressure variation over the surface of the vehicle in the time domain.



Background

- Experiments were conducted for a 7-degree, half angle cone in Sandia's Hypersonic Wind Tunnel (HWT)
- Accelerometers measured the structural response, which are to be used as inputs to the inverse modal transient solution in Sierra/SD (target nodes)
- The spatial variation of the pressure loading can be discretized by "patches" on the surface of the cone, which are to be considered independent loads for the study of inverse methods using Sierra/SD.

Objective

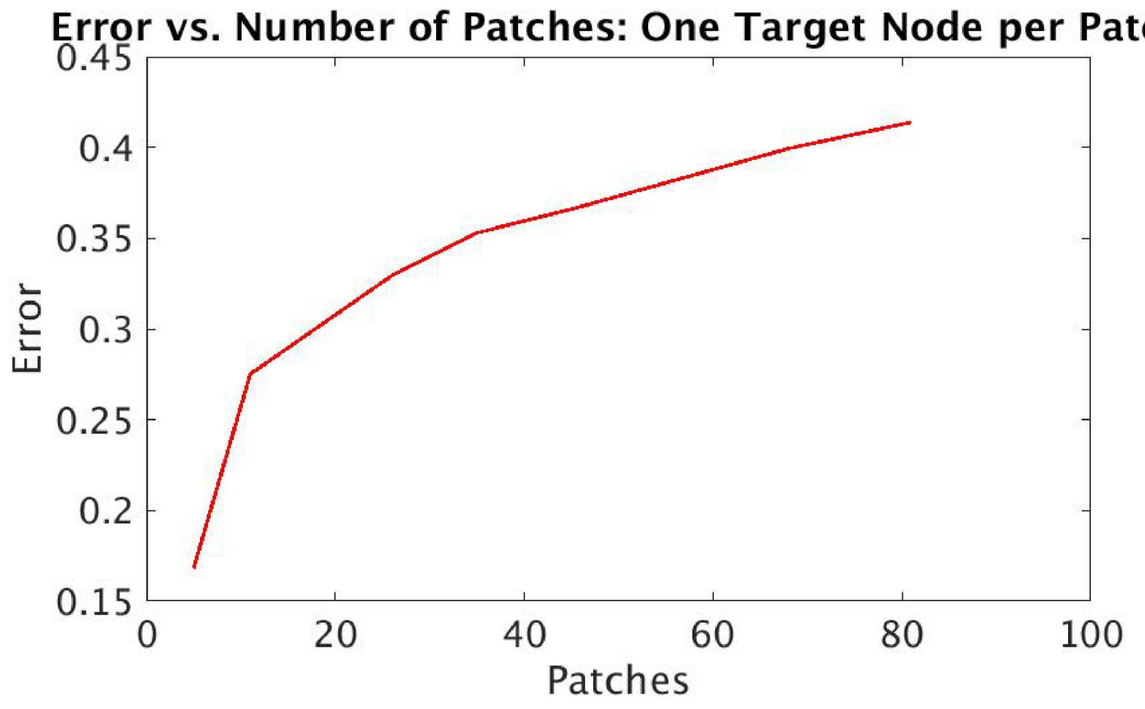
Evaluate time-domain inverse load identification capabilities in Sierra/SD.

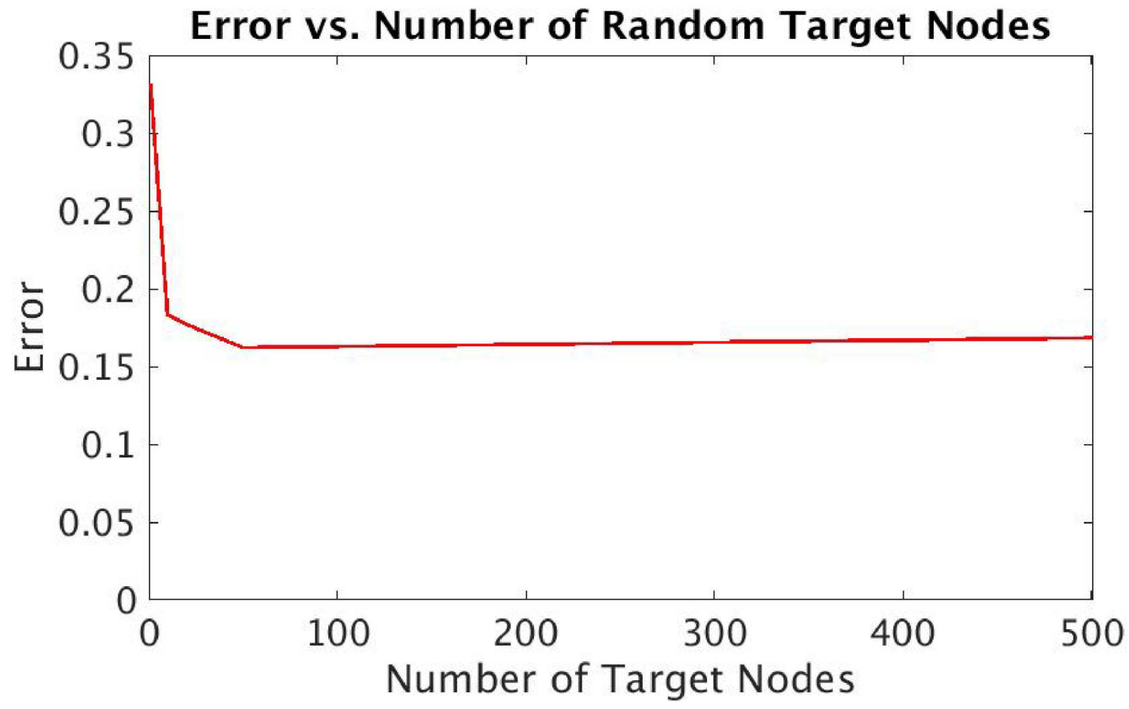
- ➢ *How many unique patch loads can we identify given sparse accelerometer data using Sierra?*

Methods: Blunt cone case study

- Generated known, random, and unique pressure loads for each patch on surface and conducted forward analysis to get target node data
- Varied number of patches, number of target nodes, and location of target nodes as inputs to Sierra
- Compared Sierra's identified pressures to original pressures and calculated error

Results





Conclusions

- Accuracy is dependent on how well the target nodes capture the structural response (how well they are placed)
- Optimization solver tolerances and iteration limits largely influence error
- Non-unique solutions exist and have been demonstrated, so introducing additional information about known or predicted relationships between patch pressures would be useful in guiding the solution

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