DAMAGE SPEAKS:

Acoustical Monitoring Framework for Structures Subjected to Earthquakes

Travis Thonstad, Civil and Environmental Engineering
Valentina Staneva, eScience Institute

Motivation

- The assessment of the integrity and safety of structures subjected to earthquakes relies on a combination of visual inspection and engineering judgement.
- This process is time consuming and can miss critical damage that is not visible.

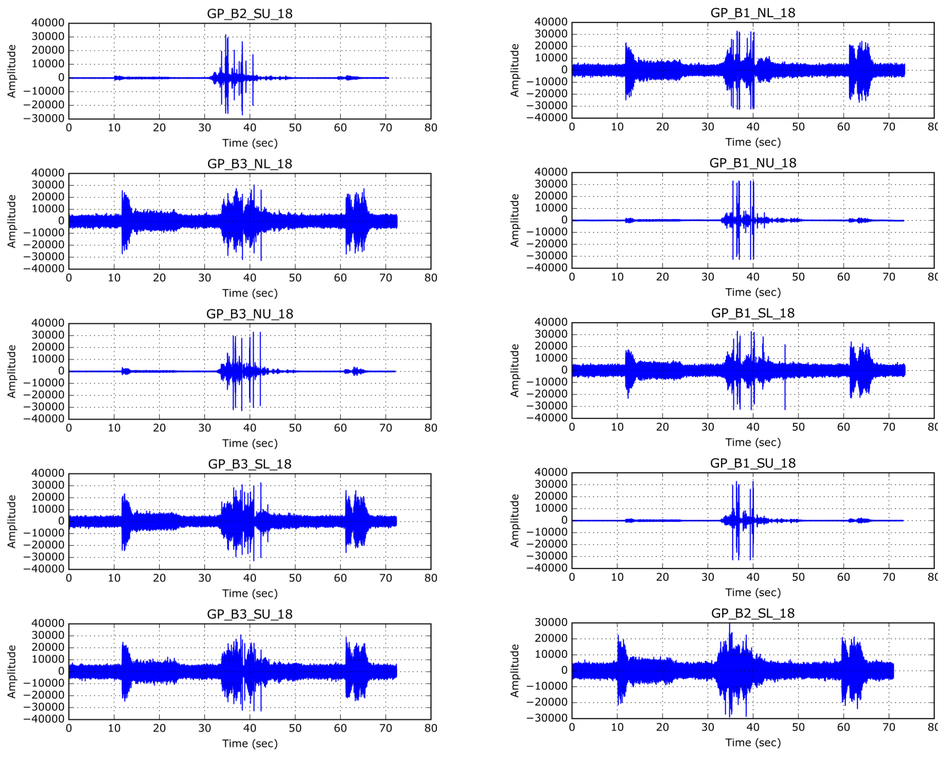


Goals

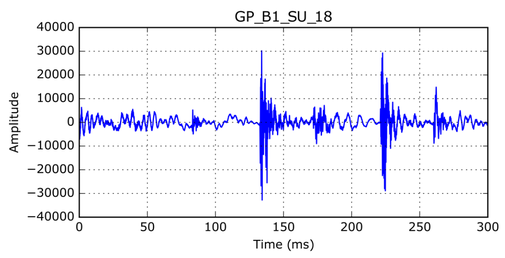
- Detect structural damage from audio recordings.
- Develop a framework for acoustical monitoring in the field.

Technical Challenges

- Camera recordings are not synchronized.



- Multiple bar fractures occur at nearly the same instant.



- The signals include high levels of noise from machinery, other forms of damage within the structure and human speech.

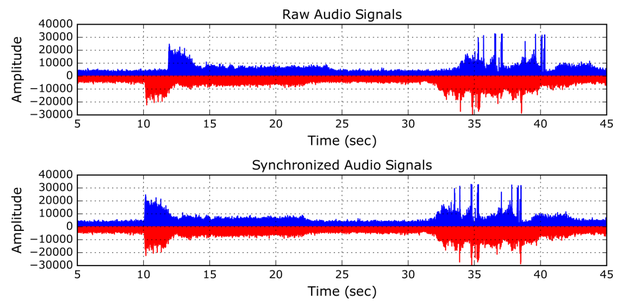
2014 Shake Table Test

- Quarter scale, two-span bridge tested at the University of Nevada, Reno.
- Instrumented with cameras to detect visible signs of damage.
- Reinforcing bar fractures were heard during the test by observers.
- Post-test inspection revealed 72 instances of fractured reinforcement.

Methodology

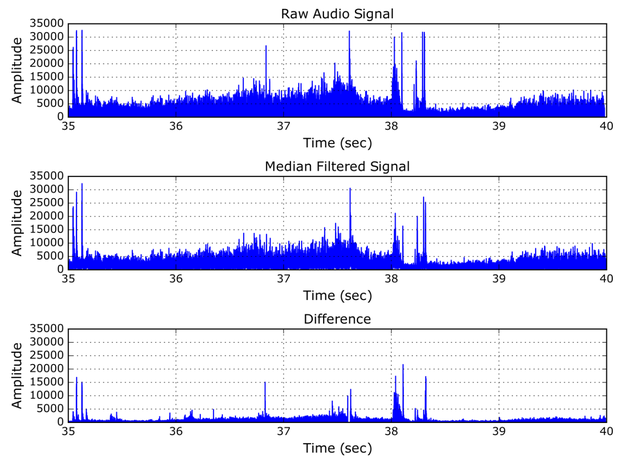
Synchronization

Cross-correlation between signals



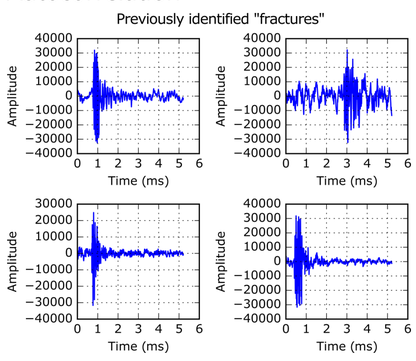
Noise Removal

Median filtering is sensitive to neighborhood choice.



Feature-based Clustering

Power Spectral Density
Autocorrelation

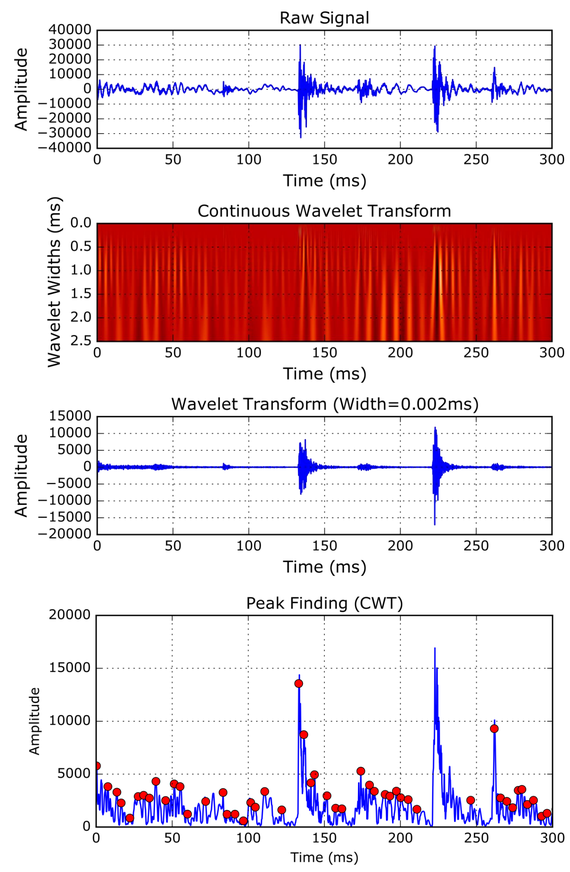


Acoustical Features?

Pitch-related measures

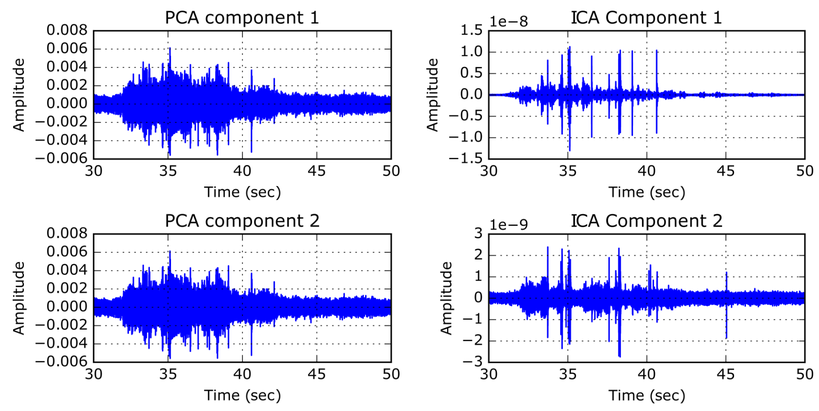
Wavelet Transform

Continuous Wavelet Transform (CWT) falsely identifies peaks in noise.



Signal Decomposition

Principal Component Analysis (PCA) and Independent Component Analysis (ICA) modes are not informative.



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Next Steps

- Use recorded data from the structure as peak predictors.
- Incorporate prior information from fatigue models.
- Estimate fracture locations within the structure using time of arrival differences.
- Apply methodology to other experiments available through the Network for Earthquake Engineering Simulation (NEES) data repository.