

KDD2020- Tutorials



Real World Use Case: Structural Health Monitoring (SHM)

Raghav Chalapathy
Nguyen Lu Dang Khoa
Sanjay Chawla



Motivation

Why do we need Structural Health Monitoring (SHM)?

- Time-based maintenance
 - Preventative maintenance schedules
 - Too early or too late



Japan tunnel collapse 2012



Minneapolis bridge collapse 2007



Italy bridge collapse 2018

- Increase productivity and extend asset life.

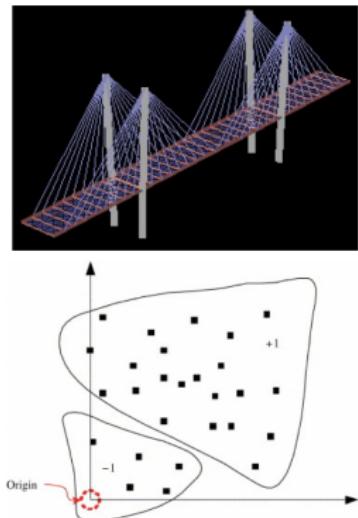
Levels of Damage Identification.

- Level 1 (Detection) : Is damage present?
- Level 2 (Localization) : Where is damage?
- Level 3 (Assessment) : How severe is damage?
- Level 4 (Prediction) : When will the structure fail?

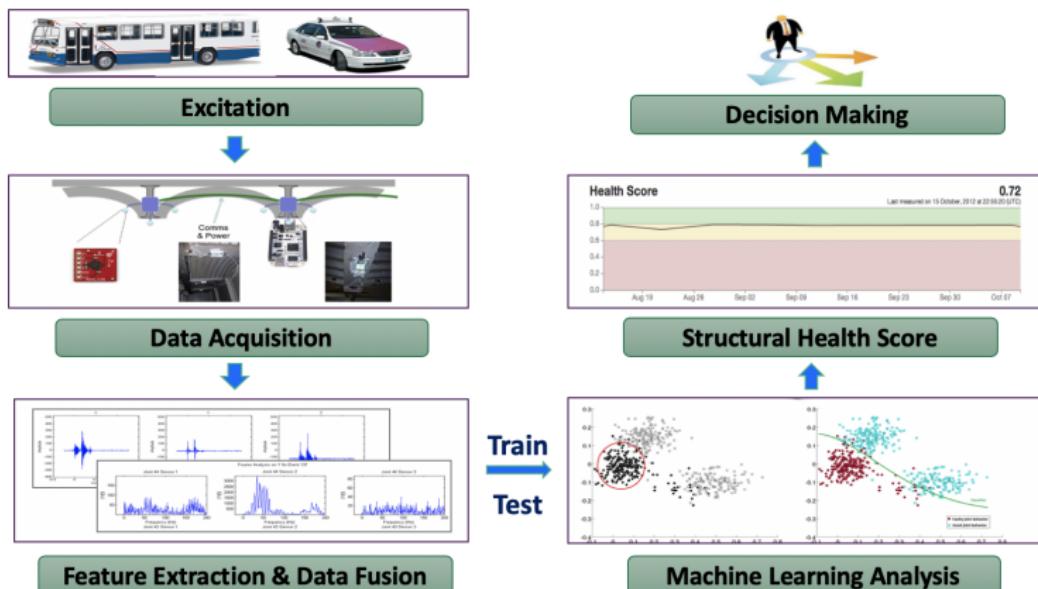


Damage Identification Techniques.

- Model-driven vs data-driven approach
 - Numerical model may not be available or accurate
 - Data-driven approach establishes a model from data.
- Our approach using deep models
 - Data corresponding to damage are often not available.
 - Only healthy data is available.

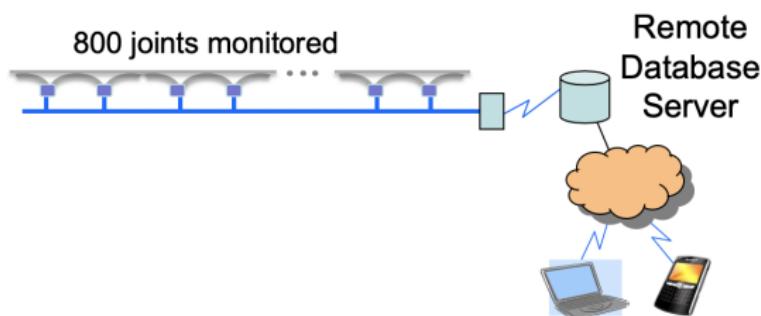
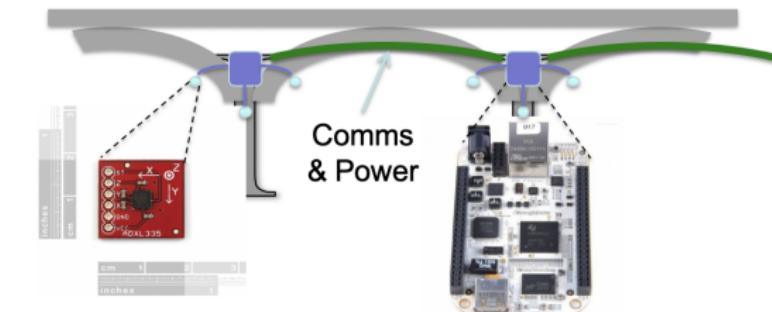


SHM : Machine Learning Flowchart.



Case studies

System SHM: Sydney Harbour Bridge

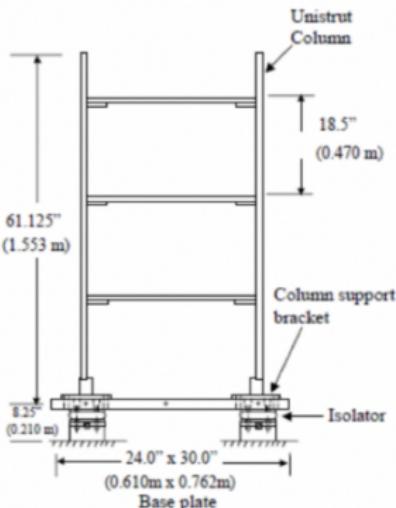


Structures Monitored



Sydney Harbour Bridge

- 3 Sensors
- Data Collected at 375 Hz for 1.6 secs
- Damage in 1 location



Bookshelf- Lab Based Building

- 24 Sensors
- Sampling at 1600 Hz
- Damage in 2 locations

Experiments

- Datasets: Two-Joint, BookShelf
- 900 for FFT features, 1800 for raw features
- Methods
 - One-Class Support Vector Machines (OCSVM)
 - Autoencoder
 - Robust Autoencoder (RAE)
 - One-Class Neural Network (OCNN)
 - Soft One-Class SVDD
 - One-Class SVDD

¹SVDD: Support Vector Data Description

Features Set

- Normalised using z-score
- Both Raw and Fast Frequency Transform (FFT) features
- Dimensions of Raw and FFT features are :

Dataset	Feature Dimensions
Two-Joints	1800
Bookshelf	98304

(a) Raw Data

Dataset	Feature Dimensions
Two-Joints	900
Bookshelf	49152

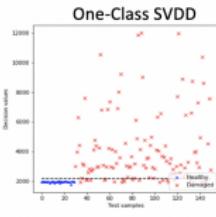
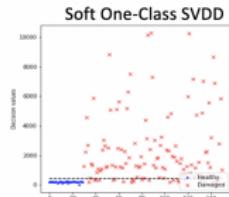
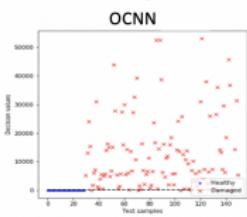
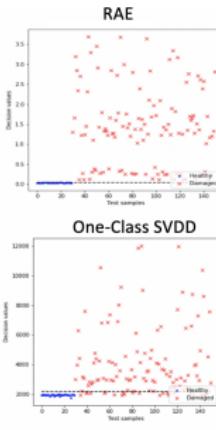
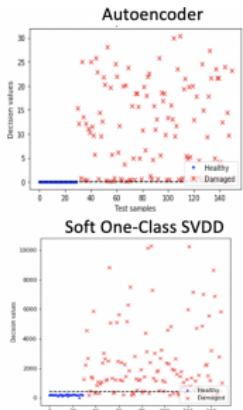
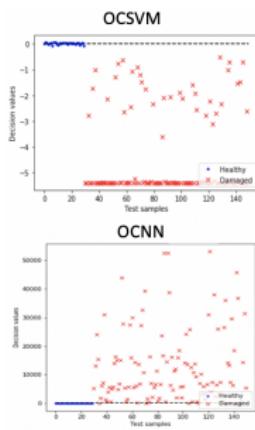
(b) Fast Fourier Transform (FFT)

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Results



(a) Two-Joints Decision Scores

(b) Evaluation Metrics

	Two Joints		Bookshelf	
	AUC	ACC	AUC	ACC
OCSVM	0.99	0.96	0.99	0.89
(OCNN)	0.95	0.90	0.99	0.95
One-Class SVDD	0.98	0.86	0.90	0.87
Soft One-Class SVDD	0.97	0.87	0.90	0.87
Robust Autoencoder (RAE)	0.98	0.97	0.99	0.98
Autoencoder (AE)	0.98	0.98	0.99	0.96

Conclusion

- Deep learning-based techniques slightly better than OCSVM for Sydney Harbour Bridge dataset.
- Bookshelf data, the deep learning-based models outperform the traditional OCSVM model.
- Deep learning-based models as a good alternative on high-dimensional SHM data.