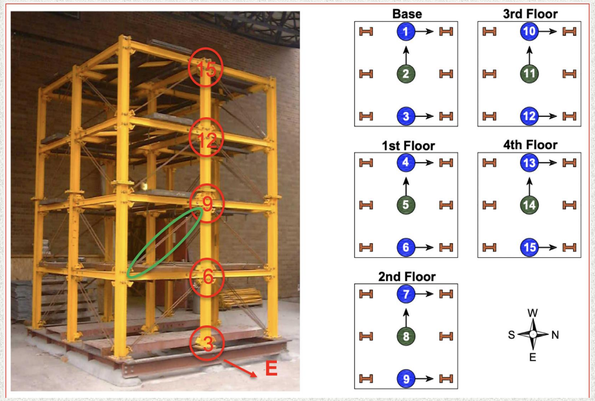
Damage Detection and Localization for Condition Assessment

Shaik Althaf V S[1], Aditya Chanodia[2], Viswarup Misra[3]

[1]PhD Candidate, Department of Civil Engineering , sav4@Illinois.edu , [2] Master's Student, Department of Statistics, adityac3@Illinois.edu , [3] Master's Student, Department of Statistics, vmisra3@Illinois.edu

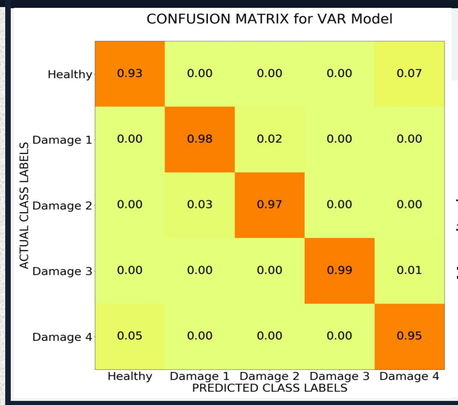
Problem Statement

- ***INPUT***: Ambient vibration data of 12 Accelerometers
- ***PREDICT:***
  - State of Building (Damaged or Healthy)
  - Damage Location
- ***CHALLENGES:***
  - Available Training data of only 300 secs
  - Limited number of sensors



No.	Cond.	Description
1	Healthy	Fully braced
2	Damage	Removing all braces - E. side
3	Damage	Removing all braces- one bay , S.E. corner
4	Damage	Removing braces of - 1st and 4th floors ,one bay, S.E. corner
5	Damage	Removing braces – 1st floor, one bay, S.E. corner

Vector Auto-Regressive (VAR) Model

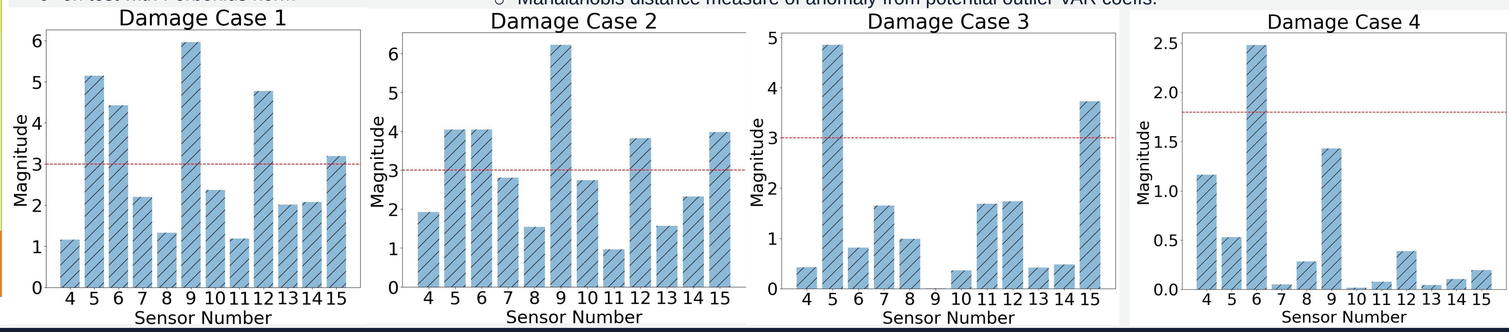


Classification :

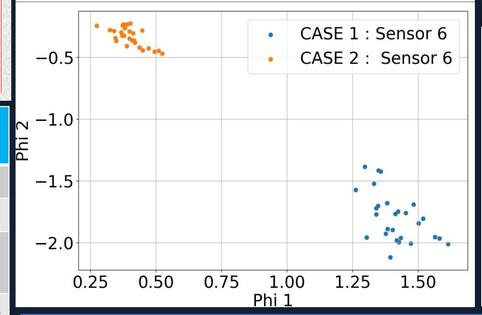
- Fit VAR coeffs. on train data & Evaluate
- on test with Forbenius norm

Damage Localization:

- Multivariate Gaussian distribution fit on VAR params of Healthy case
- Mahalanobis distance measure of anomaly from potential outlier VAR coeffs.

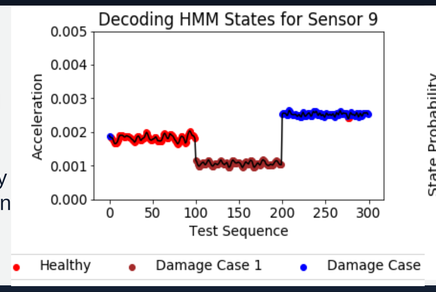


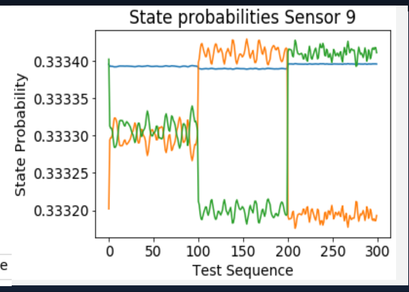
Damage Localization



Hidden Markov Model (HMM)

- Observables = acceleration data
- Hidden States = healthy and damage cases
- Supervised HMM followed by Viterbi algorithm works well in most cases but fails in some of the cases



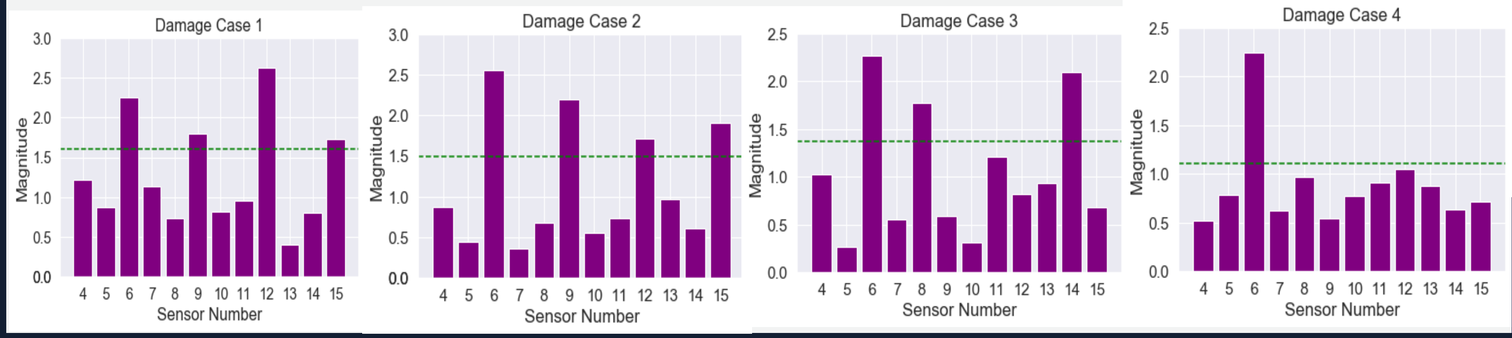


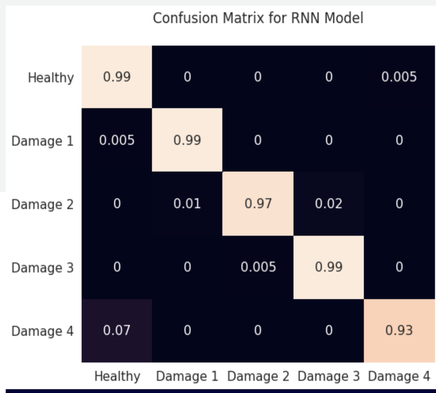
Conclusions & Next Steps

- The non-trivial task of damage localization can be well-tackled using ML algorithms.
- Seq2seq based LSTM – Autoencoder/Decoder for improved anomaly detection & quantification.
- Imposing Physics-guided constraints over NN.

Recurrent Neural Network (RNN)

- **LSTM** RNN model with one LSTM layer, one dropout layer, and one dense FC layer
- **Input:** 3D input with [*samples, time steps, features*] = [3460, 60, 12]
- **Hyperparametes:** '*relu*' activation function with *learning_rate* = 0.001, *batch_size* 64, *dropout* 0.5, and *categorical_crossentropy* loss function
- **Output:** a five-element vector containing probabilities for each class
- **Classfication** – Softmax Activation function
- **Localizaton** – SHAP Library and Feature Importance





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