

Damage Detection and Localization for Condition Assessment

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ILLINOIS

Sensor Number

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Problem Statement Vector Auto-Regressive (VAR) Model Classification: CONFUSION MATRIX for VAR Mode ❖ INPUT: Ambient vibration data of 12 Accelerometers Damage Localization: o Fit VAR coeffs. on train data & Evaluate Multivariate Gaussian distribution fit on VAR params of Healthy case **PREDICT:** State of Building (Damaged or Healthy) o on test with Forbenius norm o Mahalanobis distance measure of anomaly from potential outlier VAR coeffs. Damage Location Damage Case 1 Damage Case 2 Damage Case 3 Damage Case 4 ❖ CHALLENGES: ➤ Available Training data of only 300 secs > Limited number of sensors Damage 1 <u>12</u>→ H 4 5 6 7 8 9 101112131415 4 5 6 7 8 9 10 11 12 13 14 15 4 5 6 7 8 9 10 11 12 13 14 15 Damage 1 Damage 2 Damage 3 Damage 4 15→ ⊨ Sensor Number Sensor Number Sensor Number Sensor Number Conclusions & Next Damage Localization Hidden Markov Model (HMM) Steps CASE 1: Sensor 6 State probabilities Sensor 9 Decoding HMM States for Sensor 9 Observables = acceleration CASE 2: Sensor 6 The non-trivial task of damage WWWWWWWWW data localization can be well-tackled 0.33340 0.004 using ML algorithms. Cond. Description 0.33335 Hidden States = healthy and 0.003 damage cases 0.002 0.33330 Seq2seq based LSTM – Fully braced Autoencoder/Decoder for ਰ 0.33325 Supervised HMM followed by Damage Removing all braces - E. side improved anomaly detection & Viterbi algorithm works well in $\mathcal{M}_{\mathcal{M}}$ 0.33320 100 150 200 250 300 quantification. Damage Removing all braces- one bay, S.E. -2.0most cases but fails in some Imposing Physics-guided 100 150 200 250 300 of the cases corner 1.00 1.25 1.50 0.75 0.50 constraints over NN. Damage Case Test Sequence Phi 1 Removing braces of - 1st and 4th floors ,one bay, S.E. corner Recurrent Neural Network (RNN) Removing braces – 1st floor, one bay, S.E. corner **LSTM** RNN model with one LSTM layer, one dropout layer, and one dense FC layer Confusion Matrix for RNN Model Ambient Vibration: Healthy Case **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 Damage 1 **Classfication** – Softmax Activation function **Localizaton** – SHAP Library and Feature Importance Damage Case 4 Damage Case 3 Damage Case 2 Damage Case 1 2.5 2.0 Damage 1 Damage 2 Damage 3 Damage 4

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