HUMS2025 Data Challenge Result Summary

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Publishable: Yes

1. Summary of Findings

- This was an interesting gearbox data set to investigate as there are really two confounding signals within the data set
  - First: simple signals indicate a gradual and continual failure path from the start of the data set
  - Second: several derived frequency-based methods show distinct phases of gearbox life
  - Prediction
    a. Crack propagation was detected at or around: Day006_20240402_091931_126%TT.mat across the following signals
       i. Full Frame Mean of Spectral Kurtosis across all accelerometers 2, 3 and 4
    b. With acceleration to failure at or around: Day020_20240521_152315_125%TT.mat
  - We did not predict a trend of the crack gowth

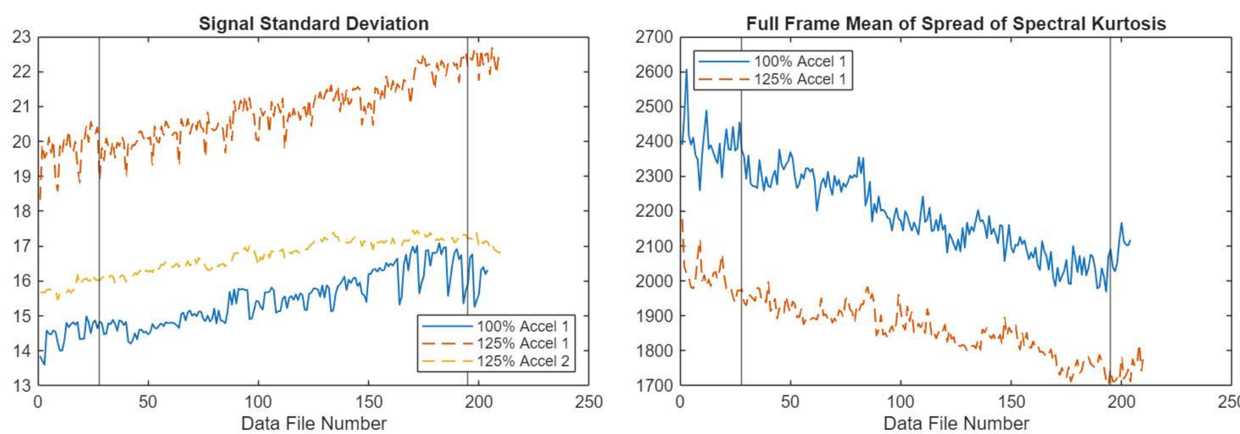

Figure 1: Signal Plots for Continuous Degradation Signals

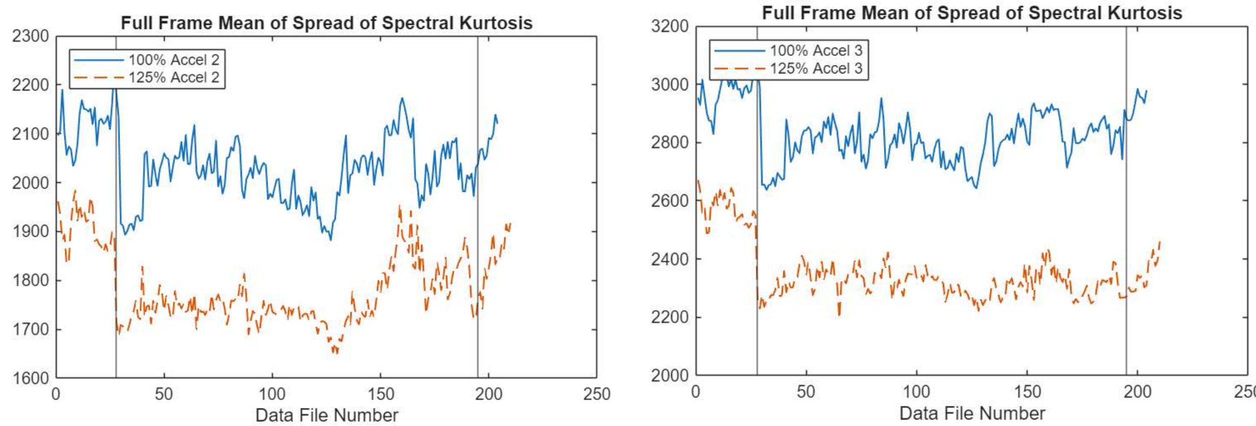

Figure 2: Example Signal Traces for Discontinuous Degradation Indicative of Crack Propagation

2. Description of Analysis Methods

As we are not gearbox maintenance specialists, we opted for a data driven approach.

We examined the value of working on full data frames, where a single data file is treated as a single data unit, as opposed to sub-dividing the data files into sub-frames. Upon examination there was no added value for working with sub-frames as the data within individual files was, essentially, statistically equivalent. Hence the results presented here are on full frame data sets.

From there we computed 18 diagnostic features across all four accelerometer signals from simple statistical measures such as mean, standard deviation, etc through to spectral frequency analysis via time-domain quantities such as peak to peak distance of the raw signals.

To find the jump points we initially examined the signals visually and classified into three categories:

1. Monotonic: which are indicative of continuous degradation signals
2. Jump signals: which we have interpreted as due to the crack initiation and propagation
3. “confused” singles in where there was no discernable trend because they contained turning points or no distinct regions

We investigated unsupervised clustering to assist with the identification of the system change points but the results were unstable, indicating a dependency on the random selection of data rather than a characteristic of the data itself. However, in general the clustering partially supported the jump points presented in Figure 2. Specifically, between 30 and 50% of the computation runs supported the jump points shown by segregating into matching regions. Unfortunately the remaining runs the clusters became randomized, indicating sensitivity to a low volume of data.

We then focused on the jump signals as indicators of the change points in the system state where something significant occurred. We interpreted this as changes in the crack composition.

3. Key Fault Characteristics for Early Detection

See Figure 2 for the prediction of early detection.

4. Fault Progression Trending Curve

We did not estimate the crack propagation trend curve.

5. Supplementary Information

No additional supplementary information is to be presented at this stage.