LNA Dewar Monitoring Project Progress

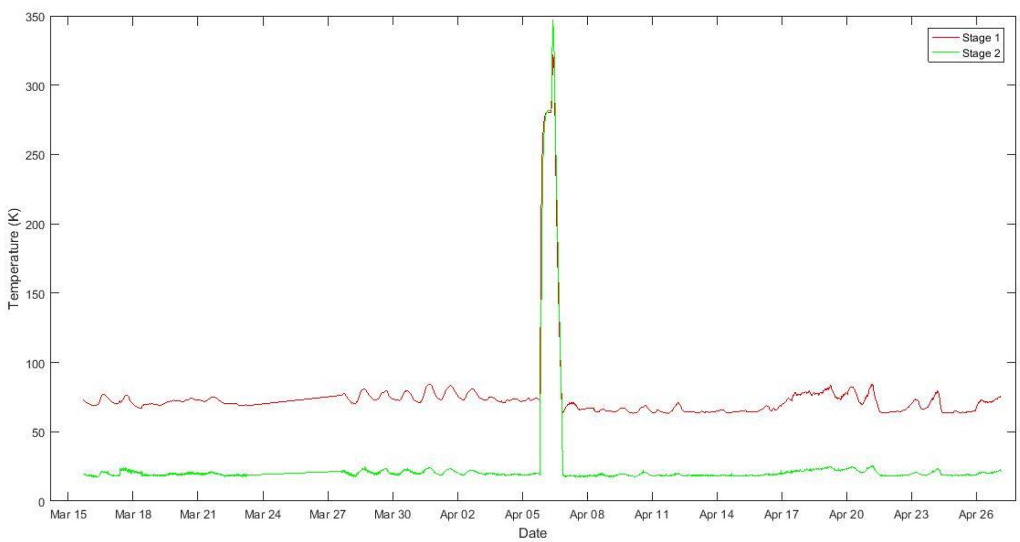
As a start for the project, I did some literature review on signal processing techniques that are used for trend analysis and anomaly detection. Specifically I looked into some of the techniques that are used in the vibrational analysis of mechanical systems. These included pure time-domain or frequency domain techniques and combined time-frequency domain analysis techniques.

I started working on MATLAB for the implementation of the approach that you suggested. I plan to prototype on MATLAB and then implement the final approach on C/C++.

Preparation of Data-sets

A data set for one day and a data set of one month was extracted using the UNIX timestamps from the files that you shared.

Data set for the month included a maintenance event. This can be seen from the time series temperature and pressure measurement plots below:



Spectrogram Generation

For the first analysis as you suggested, I made a custom MATLAB function to divide the selected time series data set into small slices and then to apply FFT on these individual slices.

For my case, I defined a slicePeriod which is in units of days.

The time series samples are 15 secs apart so I took the sampling frequency to be fs = (1/15). The total number of samples in the extracted data set is said to be N.

The function takes the slicePeriod, fs, N and the data samples as inputs.

Using the slicePeriod and fs, the noOfSamplesInOneSlice are calculated.

Using N and noOfSamplesInOneSlice, the noOfTotalSlices are calculated.

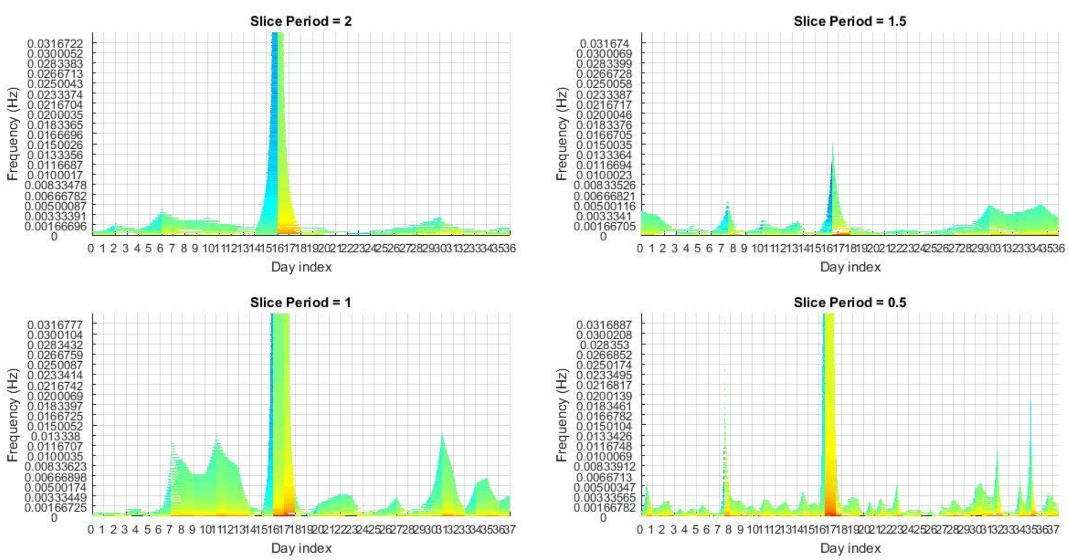
The data samples are then divided into noOfTotalSlices.

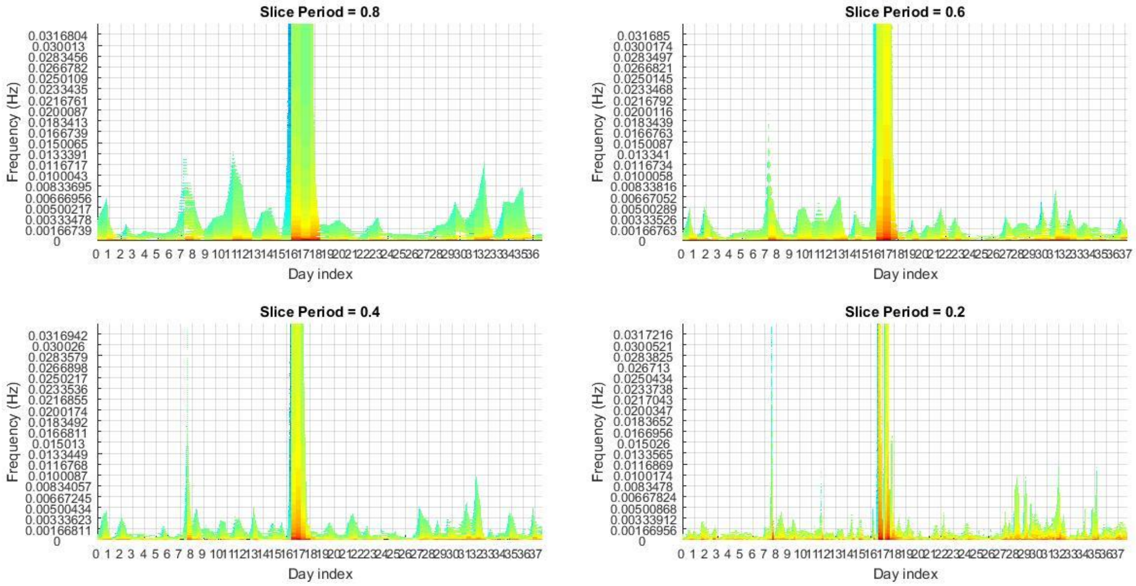
On each slice, the fft is applied and the results of each are concatenated to form the `fftSpectrogram` matrix in which the columns correspond to the slice index and the rows correspond to the fft values for each slice.

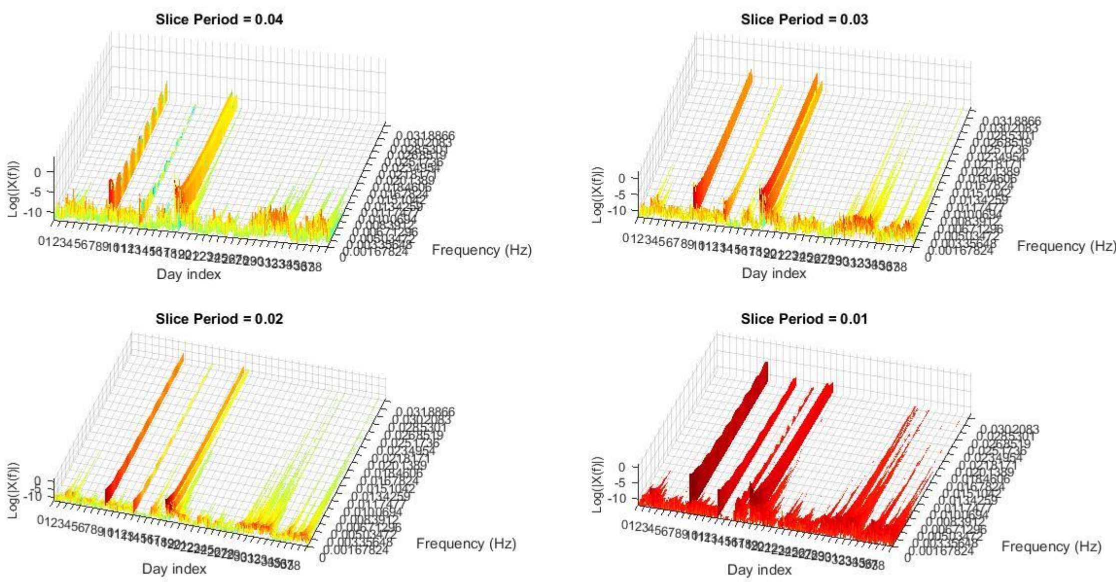
By changing the slicePeriod the noOfTotalSlices can be changed. The matrix is then plotted for different slicePeriods for analysis.

Results and Analysis

- For the following tests, the spectrogram for the Stage 1 temperature measurements were generated.
- The magnitude of the individual ffts were scaled by the log function and the z axis limits were set from -12 dB to +infinity so all values below 12dB were truncated.
- The horizontal time axis was scaled to the day index which represent the days that have passed after considering the day of Slice 1 as day 0.
- The maintenance event is noted have occurred on day 17.
- The intuitive expectation is to have some sort of spectral behavior that shows the dominance of certain frequencies just before the maintenance event i.e before day 17.
- As we can see, the spectral response highly depends on the slicePeriod. For higher periods (near 1), we can see that the spread of frequencies is significant before the maintenance event. Also the magnitude of the frequencies is high. However, the difference between the magnitudes before and after the event is not high.



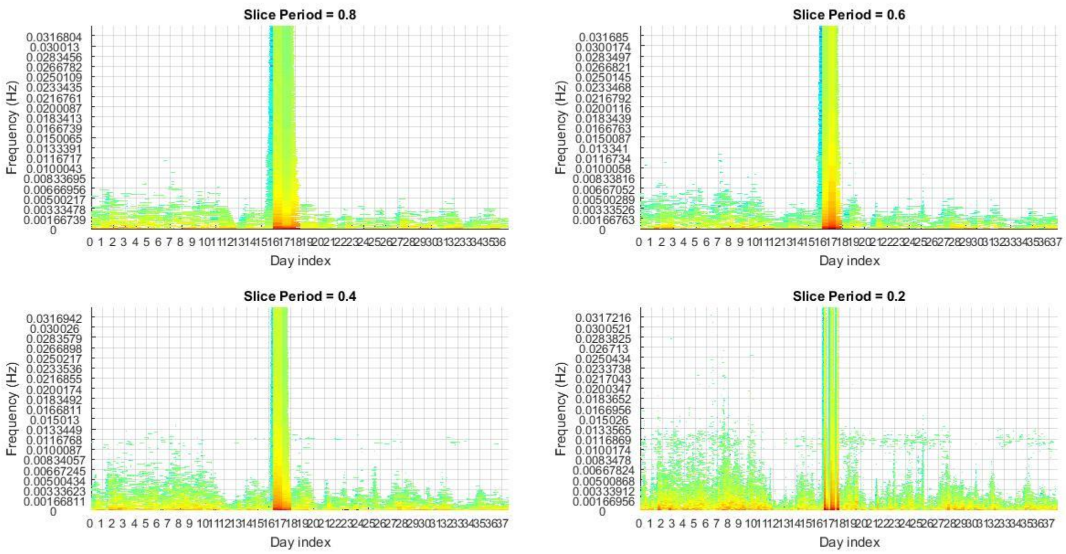




- As we reduce the spectral period, the spread along the time axis reduces. However, the difference in magnitude before and after the event increases. Of course we cannot use the difference as metric for detection and have to rely on the trend before the event.

Key-Observations

- The above spectrograms only show the trend for Stage 1 temperature. If I apply the same on Stage 2, the result is more gibberish and so less results can be drawn from this. This is probably due to the fact the time series signal of stage 2 is more noisy than Stage 1.



- There is obviously a correlation between the temperature signals. This can be used in the processing part, may be for developing the system model matrix M for the Kalman filter.

Way Forward

Uptil now, I have not applied any filter for smoothing the signals before applying FFT on them. I plan to apply the Kalman filter to get a better estimate of true signal values.

Also, I am considering finding the Power Spectral Density (PSD) for each time slice and would try to analyse how the energy content of the signal changes before the maintenance event.

Please provide your valuable feedback and suggestions regarding all this.