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A KNN Approach for the Fault Diagnosis of a Hydraulic Rock Drill using Time-Based Data

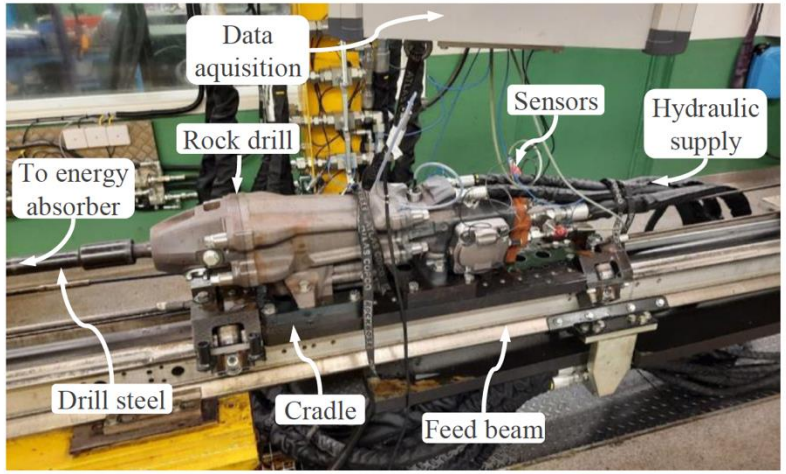
Topics:

- Data Formatting
  - Approaches
  - Choices
- KNN for time-based data
- Outcome/Observations

Challenge Objective

This year's data challenge addresses the problem of fault classification for a rock drill application under different individual configurations of the rock drill. The task is to develop a fault diagnosis/classification model using the provided pressure sensor data as input.

(2)



Rock Drill Degradation Data Set

11 Fault Classification Categories

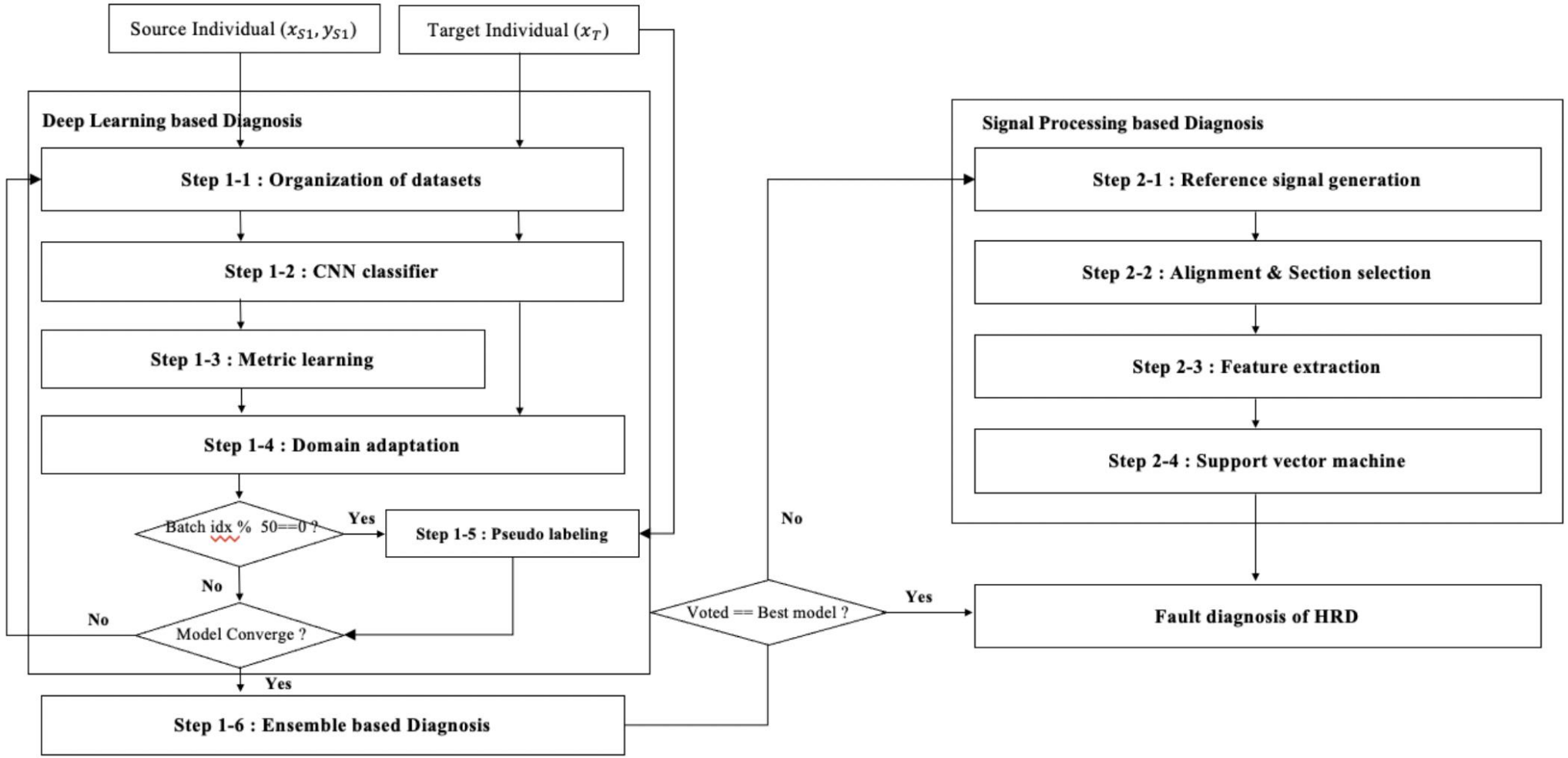
- 10 Different Failure Modes
- 1 Healthy/No Fault Condition

Winners:

Team-Nuri with 100% accuracy

Label	Letter	Description
1	NF	No-fault
2	T	Thicker drill steel.
3	A	A-seal missing. Leakage from high pressure channel to control channel.
4	B	B-seal missing. Leakage from control channel to return channel.
5	R	Return accumulator, damaged.
6	S	Longer drill steel.
7	D	Damper orifice is larger than usual.
8	Q	Low flow to the damper circuit.
9	V	Valve damage. A small wear-flat on one of the valve lands.
10	O	Orifice on control line outlet larger than usual.
11	C	Charge level in high pressure accumulator is low.

Approach of 2022 Winner



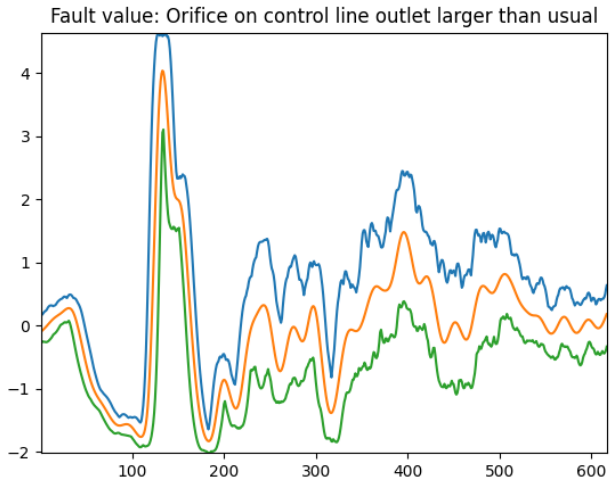
Data Formatting

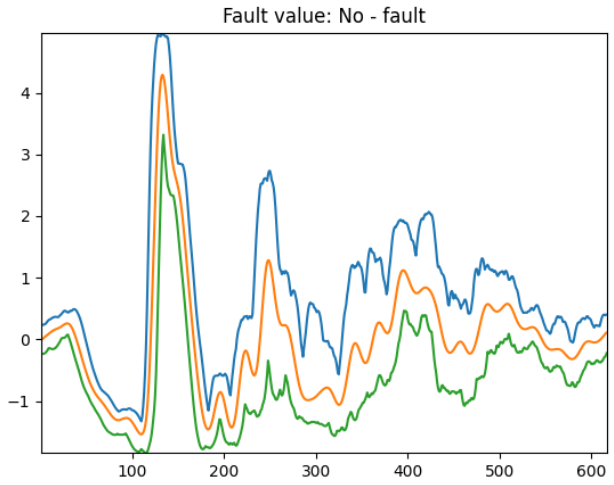
```
2,0.092714,0.026824,-0.031095,-0.076524,-0.110287,-0.124715,-0.124448,-0.106712,-0.073642,
-0.027723,0.025854,0.086811,0.148471,0.209197,0.265286,0.315150,0.355914,0.387719,0
.408974,0.422026,0.423098,0.413759,0.399284,0.377862,0.348820,0.309099,0.266829,0.225113,0
.178464,0.129183,0.085509,0.045428,0.003906,-0.039436,-0.076192,-0.112651,-0.149878,-0
.186181,-0.217292,-0.243434,-0.270999,-0.297759,-0.319689,-0.340057,-0.367612,-0.401190,-0
.439119,-0.480160,-0.528500,-0.580977,-0.638812,-0.704121,-0.774269,-0.844335,-0.912867,-0
.978230,-1.037876,-1.093476,-1.144632,-1.190524,-1.231639,-1.267416,-1.299349,-1.327440,-1
.355790,-1.380888,-1.405006,-1.424719,-1.444284,-1.463562,-1.480125,-1.498821,-1.518238,-1
.536814,-1.555696,-1.571806,-1.585320,-1.597199,-1.610252,-1.621604,-1.629124,-1.637566,-1
.644790,-1.651136,-1.653815,-1.658323,-1.662701,-1.667856,-1.674922,-1.683033,-1.689656,-1
.695947,-1.700704,-1.706172,-1.709101,-1.710449,-1.711373,-1.710514,-1.710856,-1.710181,-1
.708971,-1.704473,-1.707124,-1.708694,-1.710108,-1.712990,-1.716371,-1.719761,-1.720647,-1
```

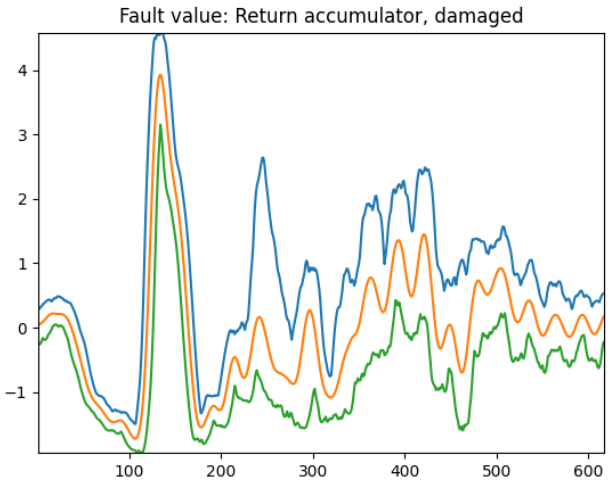
- Fault Label – (highlighted in box above)
- Data Sequence Length
- Missing Data

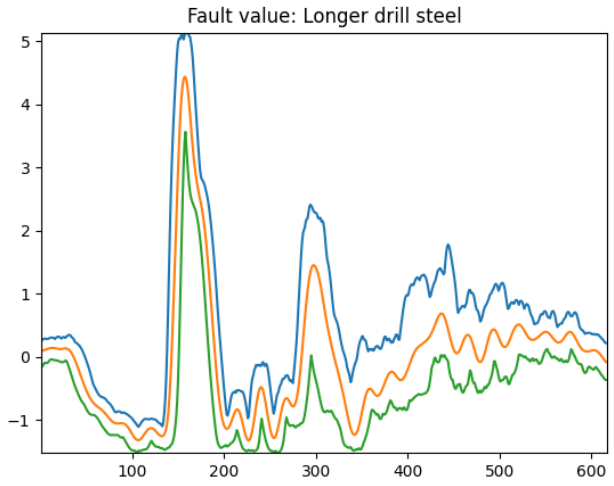
(1)

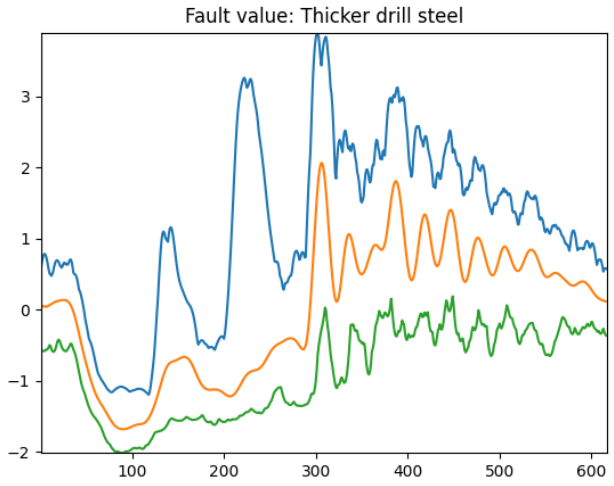
Blue: max values - Orange: mean values - Green: min values

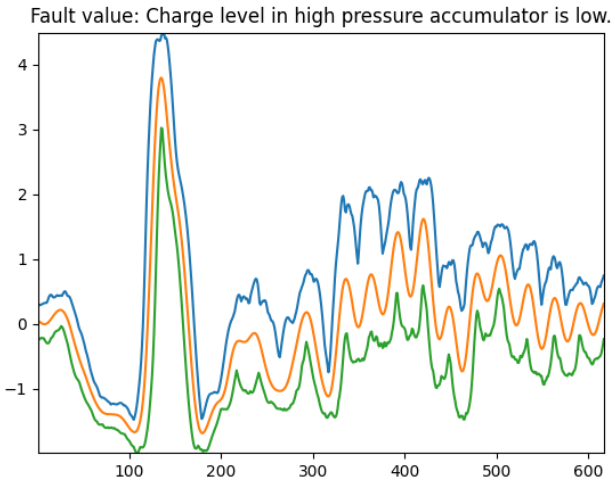






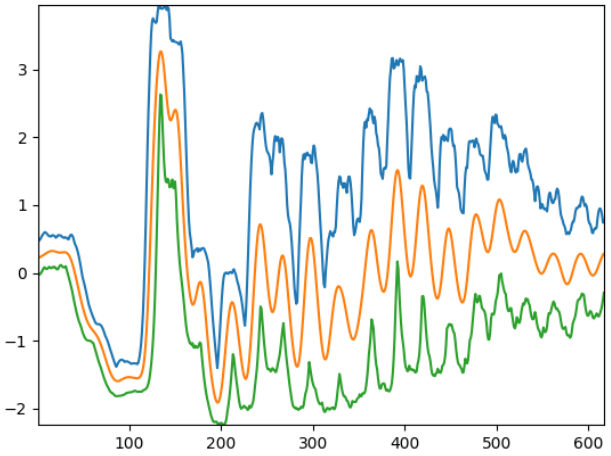




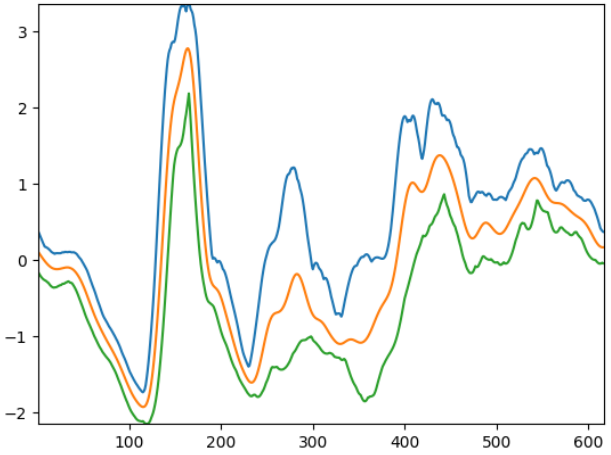


Blue: max values - Orange: mean values - Green: min values

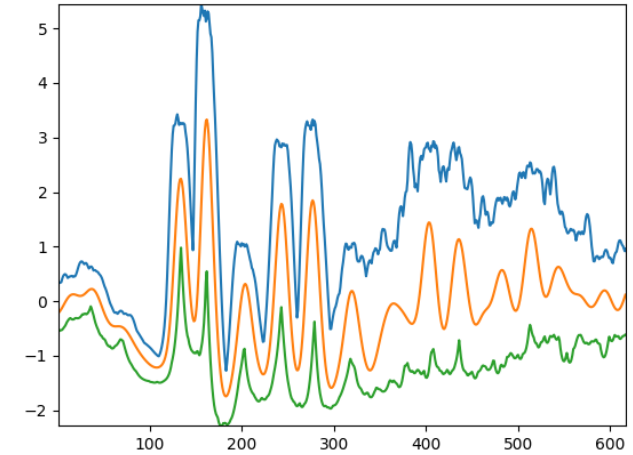
Fault value: A - seal missing. Leakage from high pressure channel to control channel



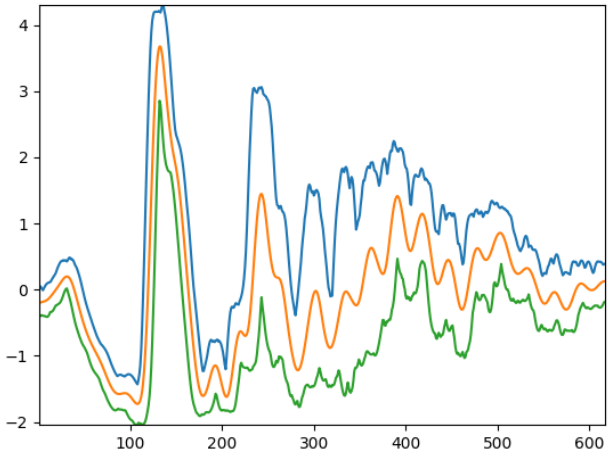
Fault value: B - seal missing. Leakage from control channel to return channel.



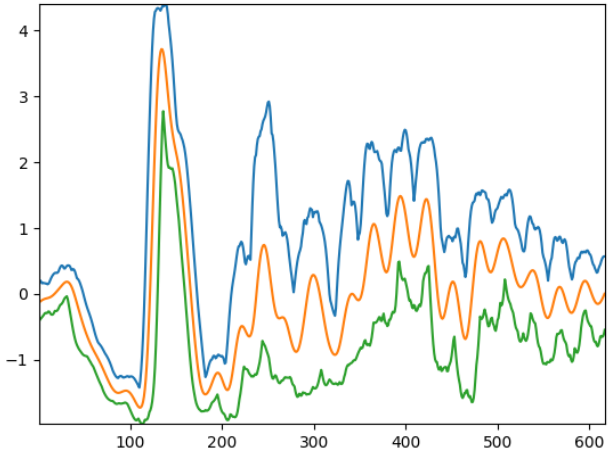
Fault value: Valve damage.A small wear - flat on one of the valve lands



Fault value: Damper orifice is larger than usual



Fault value: Low flow to the damper circuit

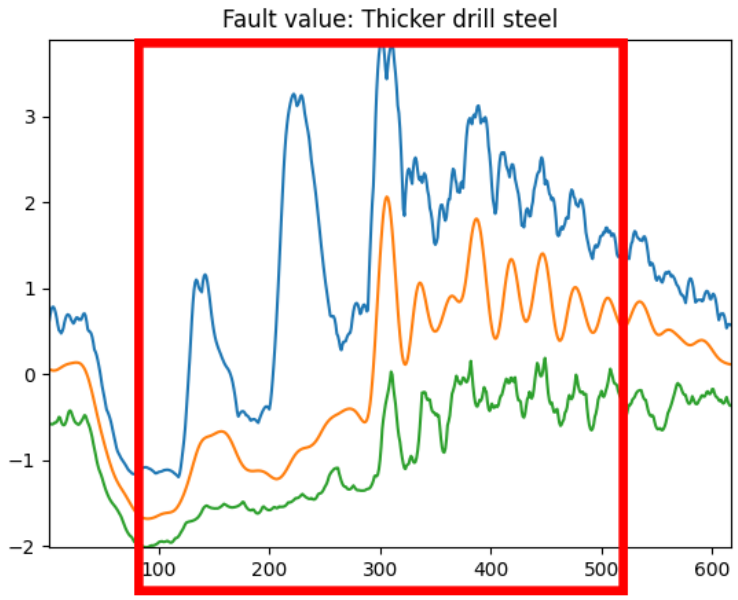


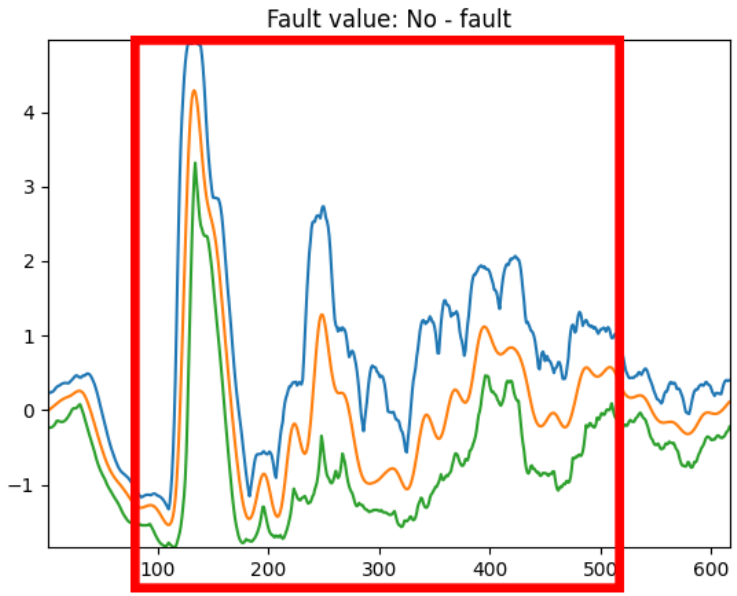
K Nearest Neighbors approach

- Effect on Time-based Data?
  - Nearest neighbor – lowest average absolute distance value
- Pros
  - Not much processing power needed
  - Data doesn't need to be massive
- Cons
  - Outliers
  - Faults that overlap

Missing Data Correction:

- Interpolation:
  - Linear
  - Sinusoidal
  - Mean
  - Pad
- Chopping:
  - Missing Data
  - Useless Data





Results

- Accuracy of 99.59% achieved
- 3rd place

Conclusion

- Goal:
  - Accomplished - Competitive results were achieved
- Previous Work:
  - Techniques used
    - Excessive
    - Increased processing that would not be reasonable in real world cases
    - Lacked justification for use

Questions?

Citations:

Oh, H. J., Yoo, J., Lee, S., Chae, M., Park, J., & Youn, B. D. (2022). A Hybrid Approach of Data-Driven and Signal Processing-Based Methods for Fault Diagnosis of Hydraulic Rock Drill. *Annual Conference of the PHM Society*, *14*(1). Retrieved from https://papers.phmsociety.org/index.php/phmconf/article/view/3408

Jakobsson, E., Frisk, E., Krysander, M., & Pettersson, R. (2022). A Dataset for Fault Classification in Rock Drills, a Fast Oscillating Hydraulic System. *Annual Conference of the PHM Society*, *14*(1). https://doi.org/10.36001/phmconf.2022.v14i1.3144