Vibration Analytic for Smart Facilities

Final Presentation

20223382
CHUNG King To

Table of Content

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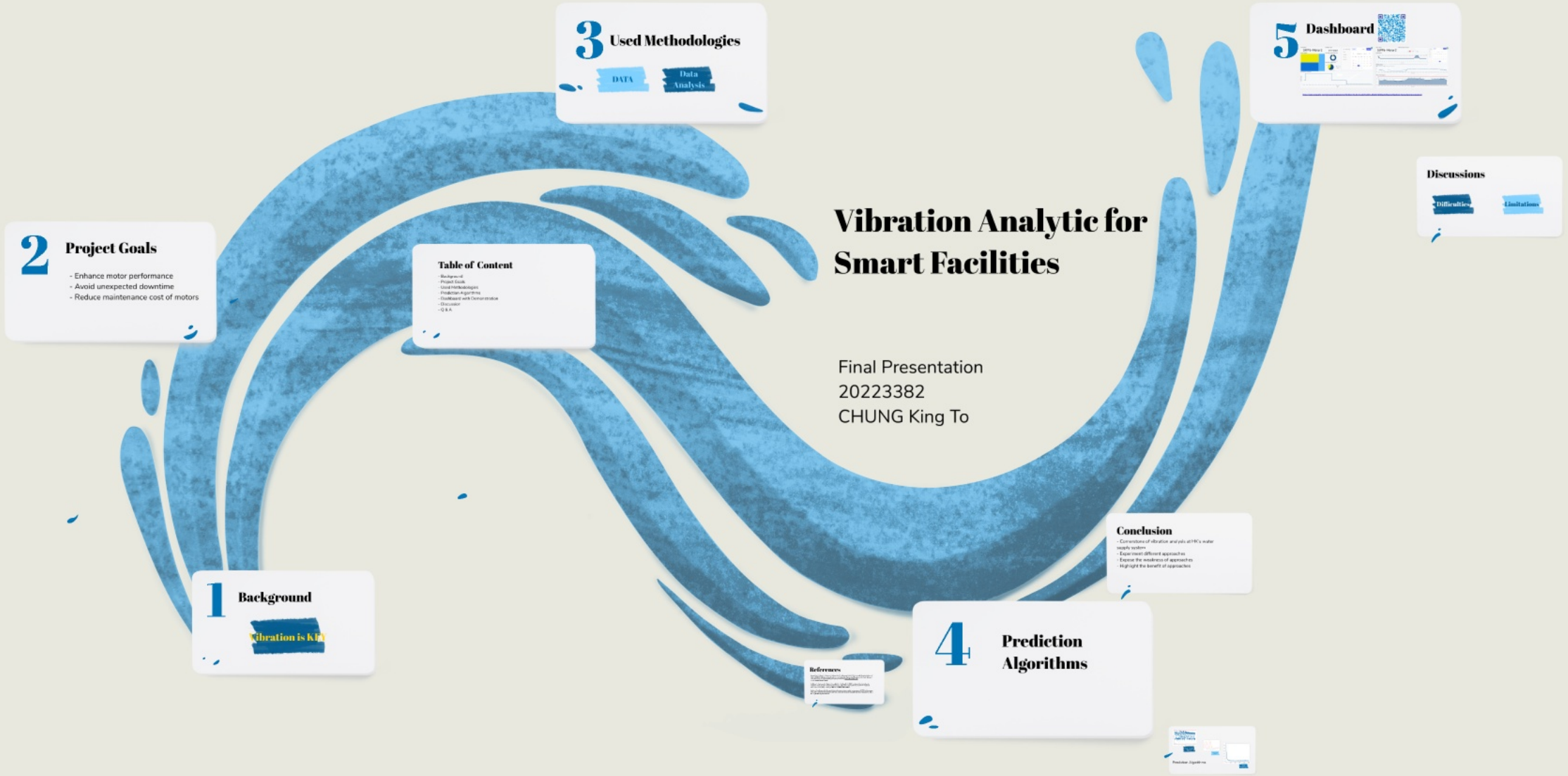


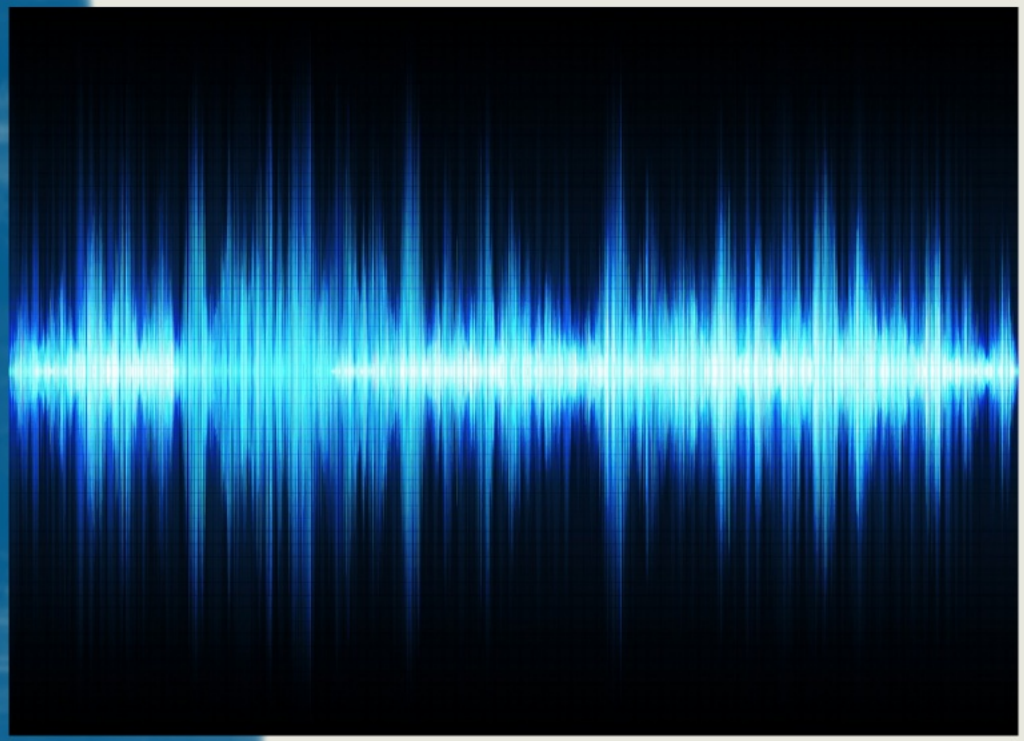
1 Background

Vibration is KEY

What is Vibration?

- Periodic back-and-forth motion of particles
  - Elastic body
  - Medium

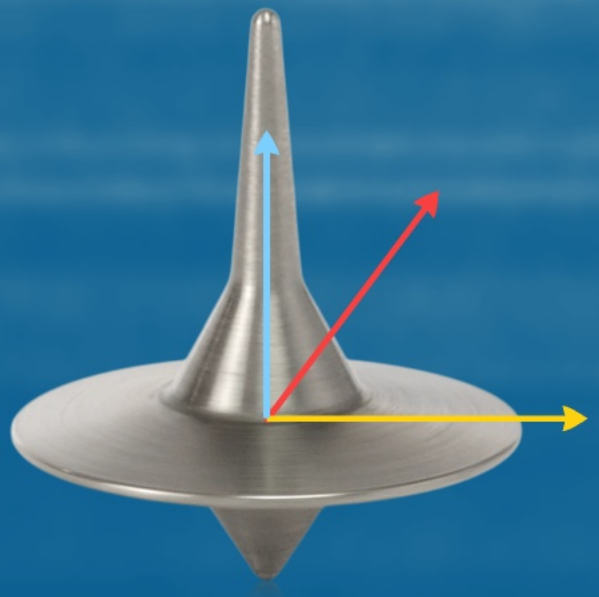
WHAT does it mean?



WHAT does it mean?

Vibration signals at X,Y,Z axes can reveal significant insights about the motor's operational status.

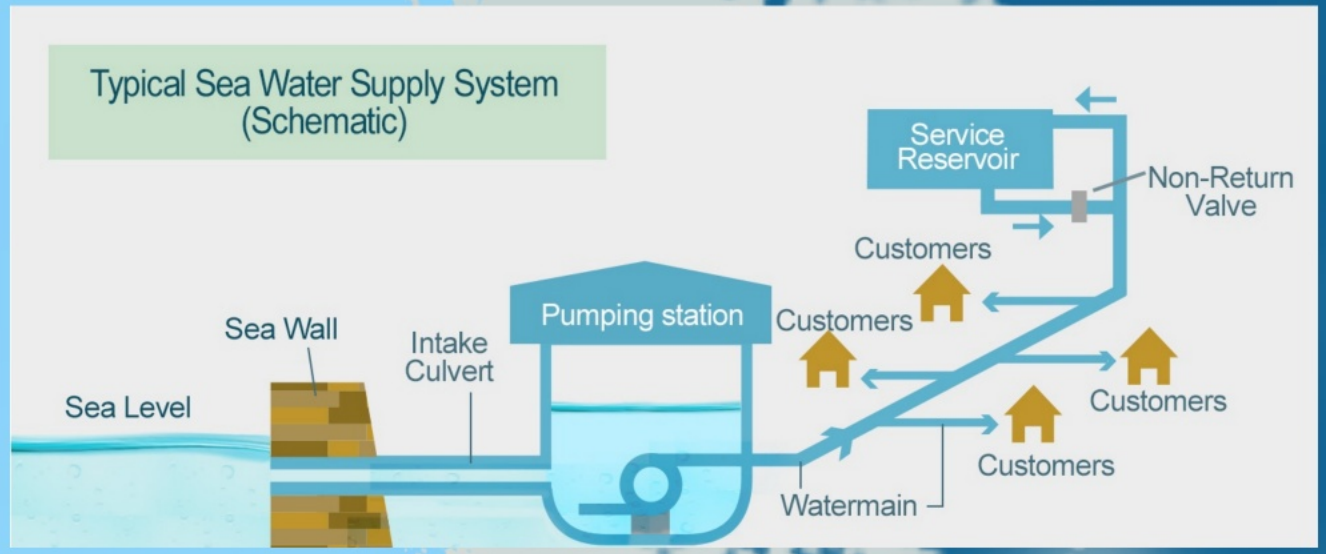
(Ramtekkar et al.,2023)



WHY does it matter?

WHY does it matter?

- Reliable water supply system
  - Ensure the daily operation of a modern society



2

Project Goals

- Enhance motor performance
- Avoid unexpected downtime
- Reduce maintenance cost of motors

3 Used Methodologies

DATA

Data Analysis

DATA

- 8th Nov 2022 to 11th Aug 2023
- Total of 7 motors and pumps
- Pilot study --> Motor 2

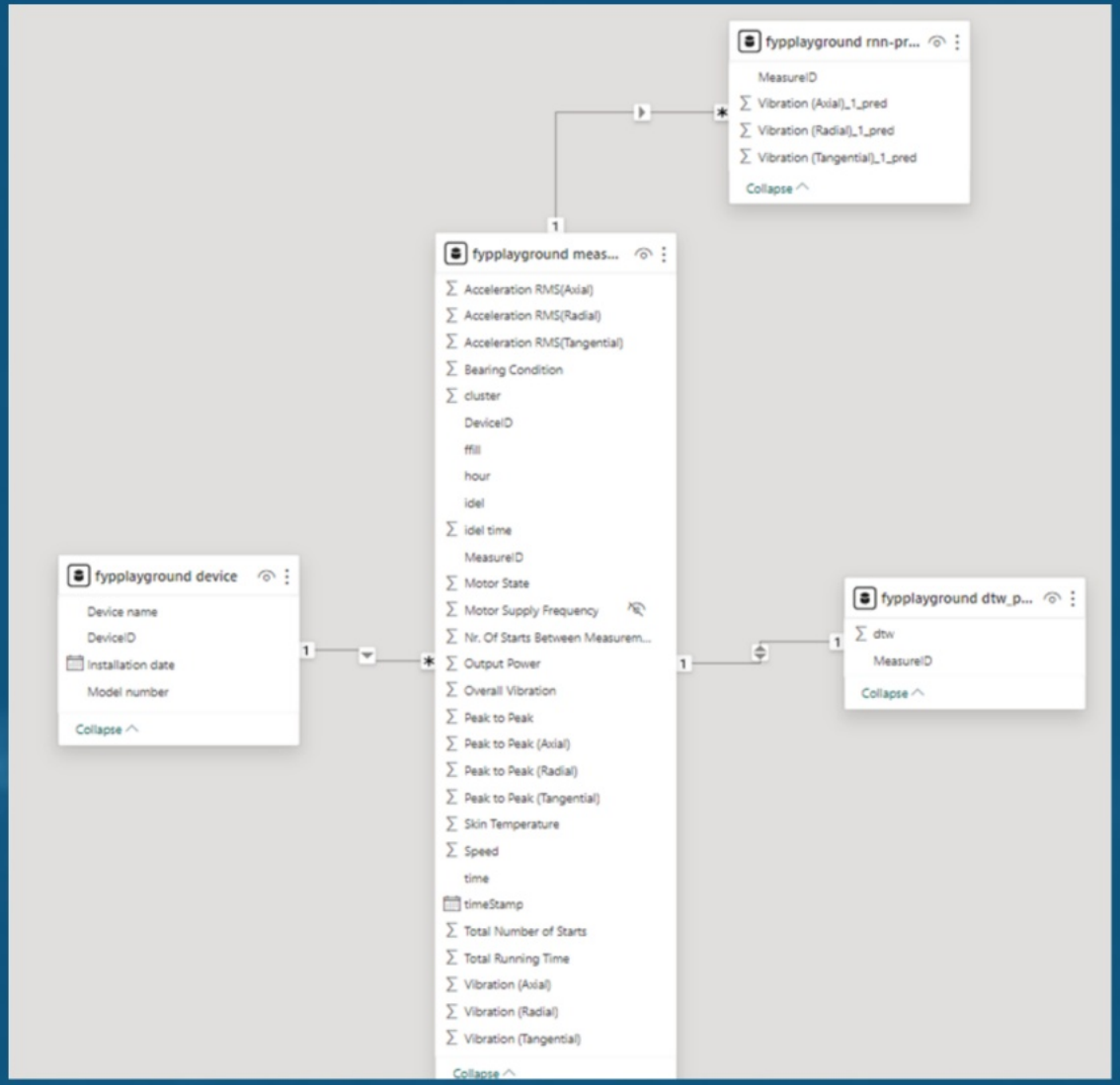
Data Storage

Data Storage

- MySQL 8.0

- Star Schema

- Total of 4 tables
  - Measure
  - Device
  - DTW-prediction
  - RNN-prediction



3 Used Methodologies

DATA

Data Analysis

Exploratory Data Analysis

Understand Data

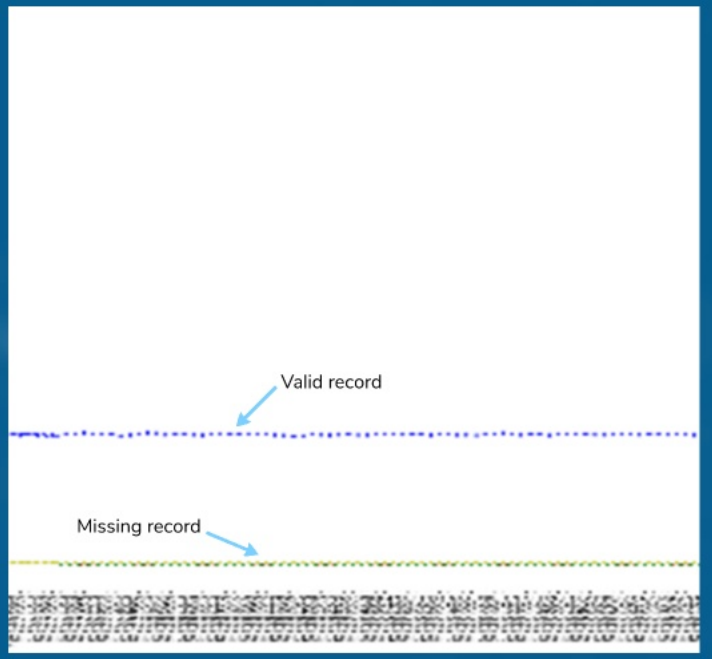
Heat Map

Clustering

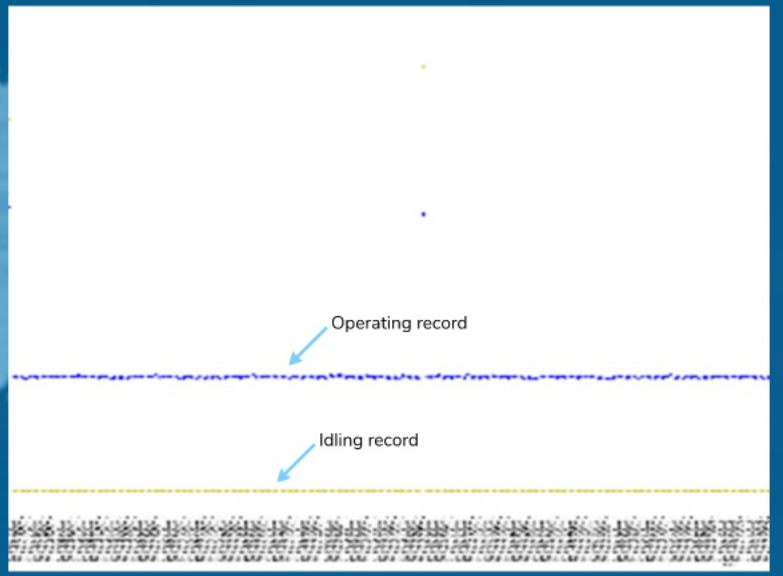
Missing Value

- Contain high percentage of missing value

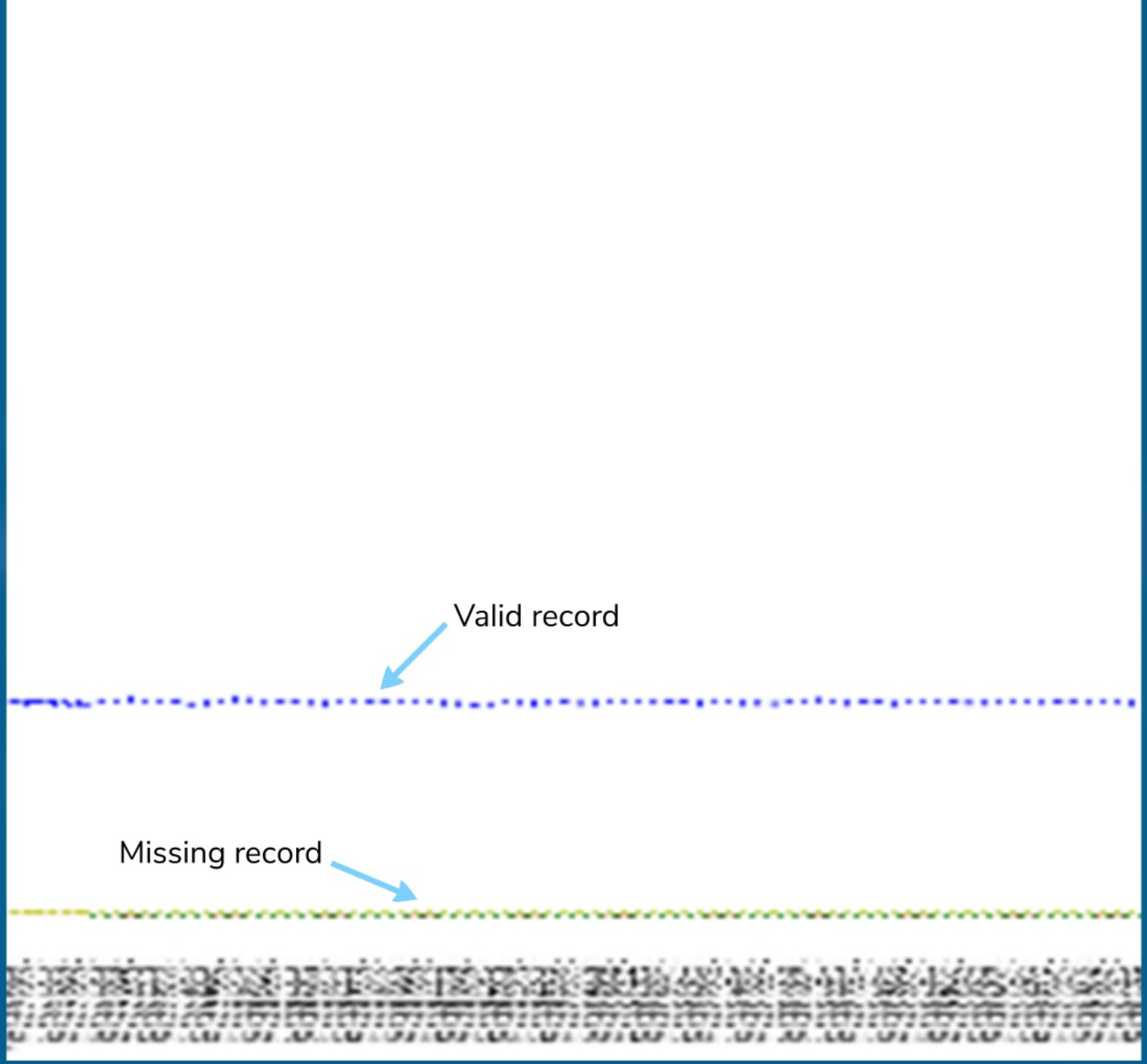
- High idling time



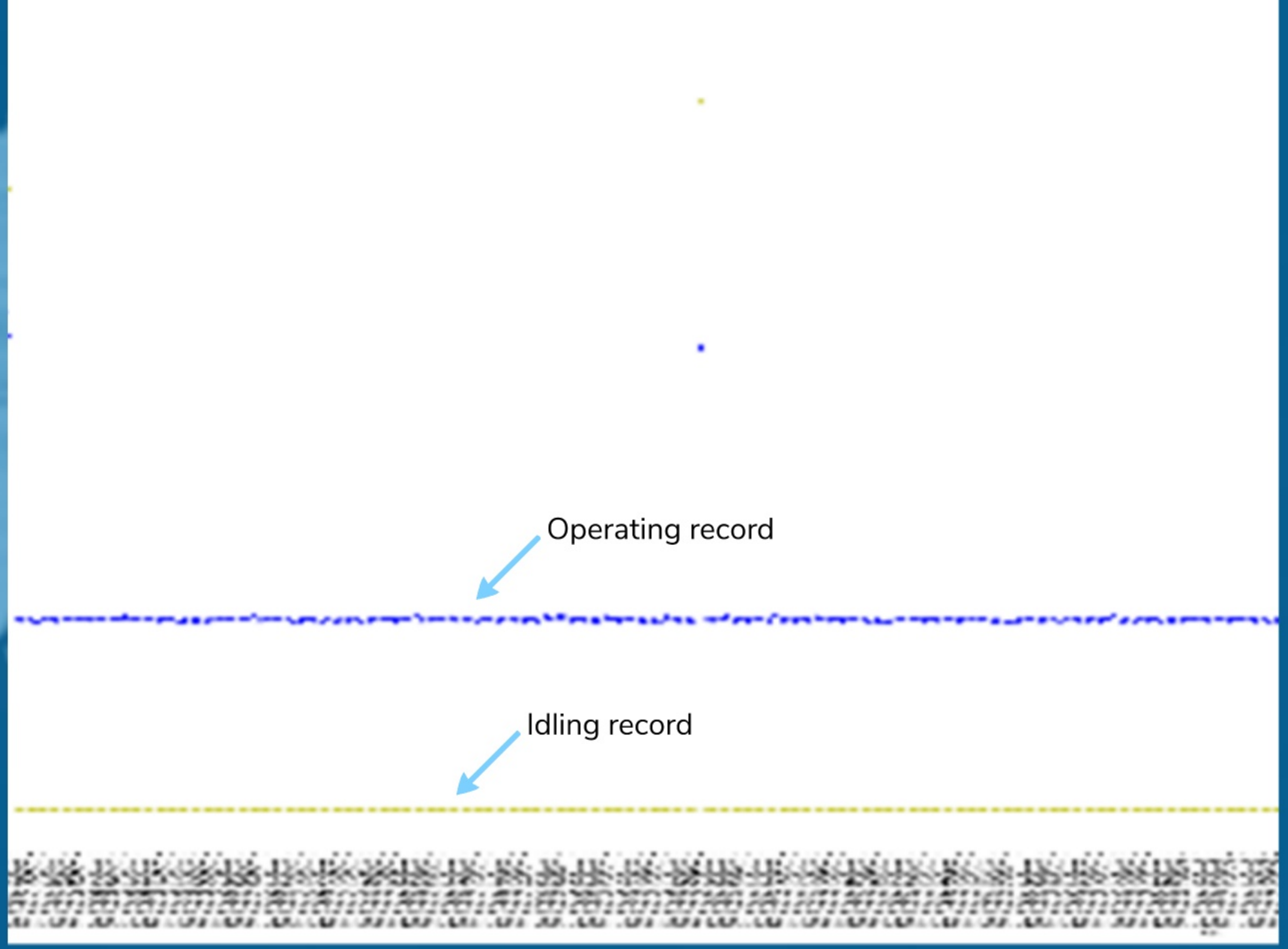
Contain high percentage of missing value



High idling time



Contain high percentage of missing value



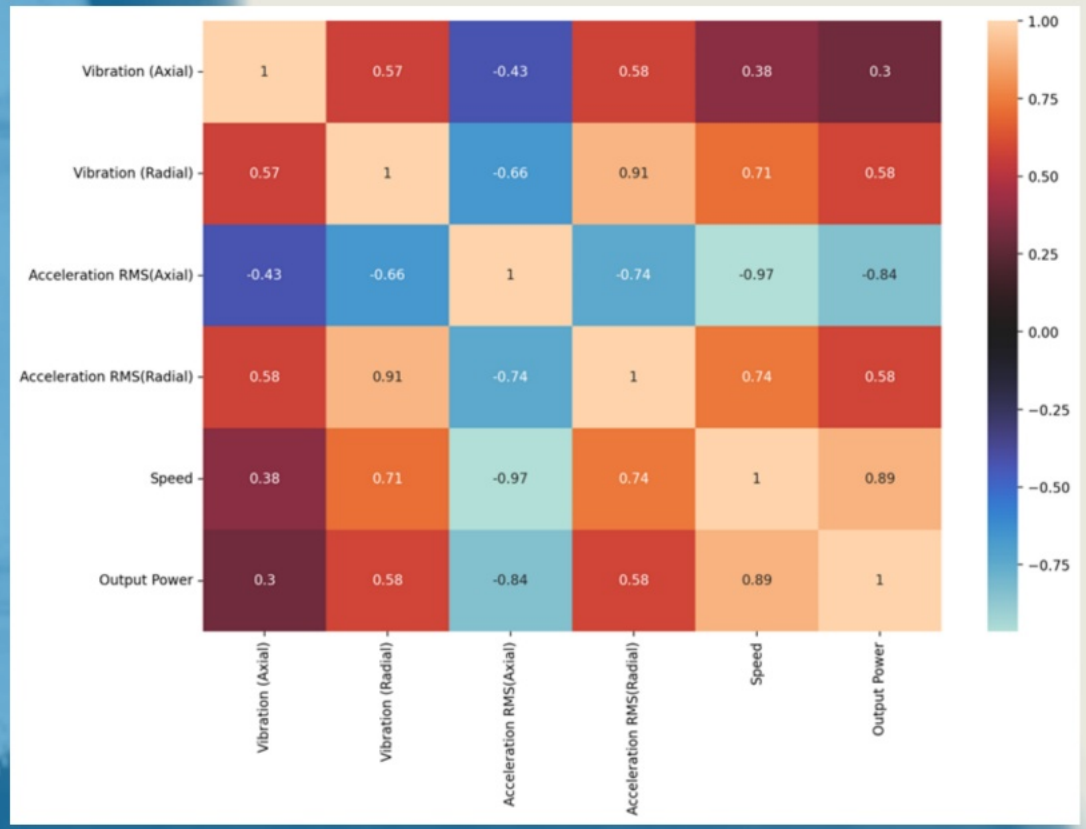
High idling time

Heat Map

- High correlation between columns

- Acceleration RMS (Axial) and Speed have high NEGATIVE correlation

- Acceleration RMS (Radial) and Vibration (Radial) have high POSITIVE correlation



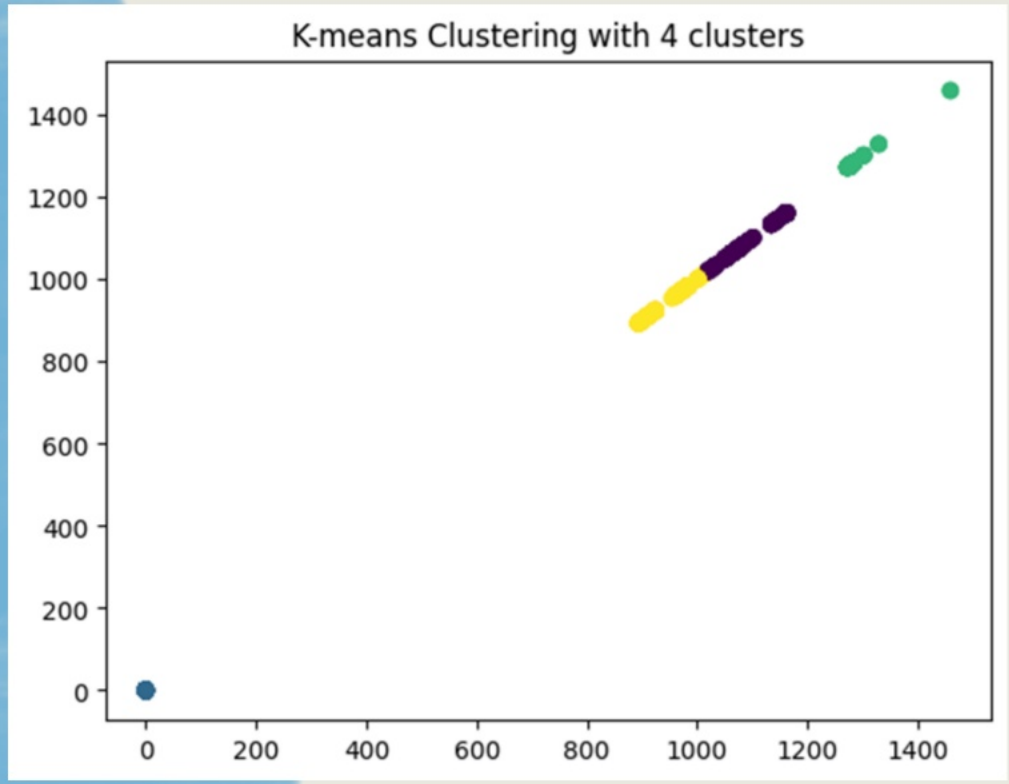
Clustering

Cluster 0: off, Speed = 0

Cluster 1: Low, 894 < Speed < 1020

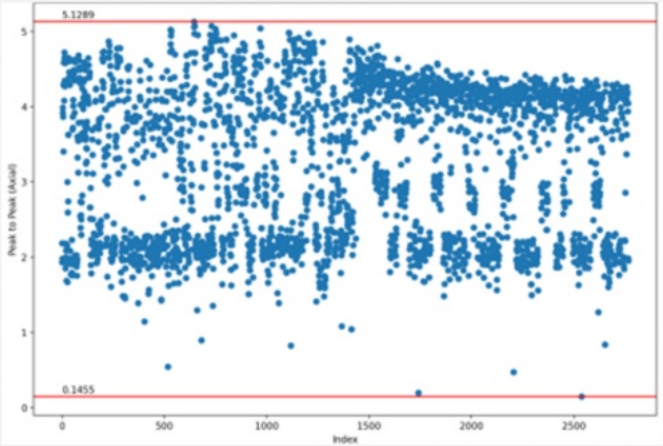
Cluster 2: Medium, 1021 < Speed < 1271

Cluster 3: High, 1272 < Speed

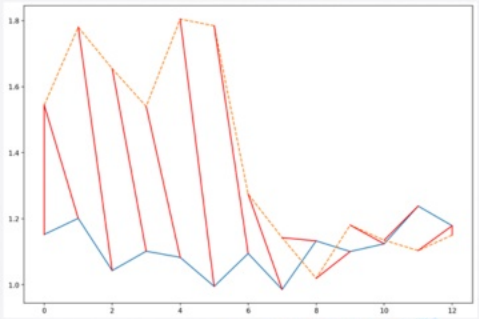


4

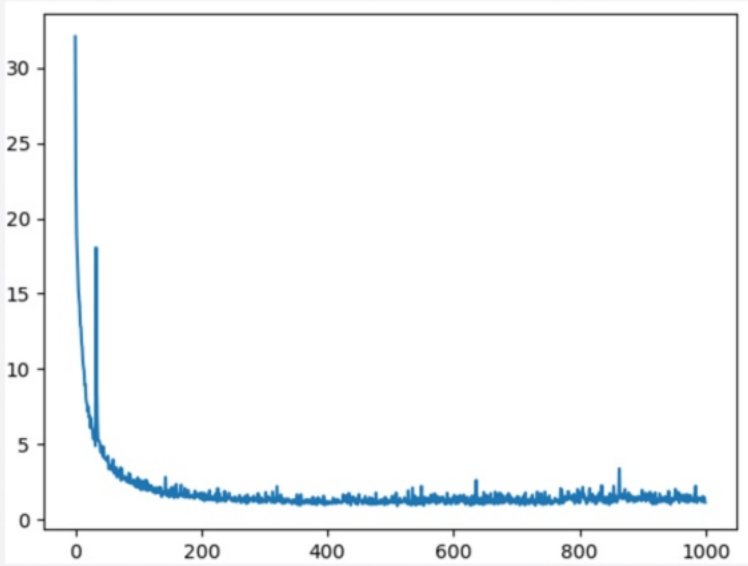
Prediction Algorithms



Peak-to-peak analysis

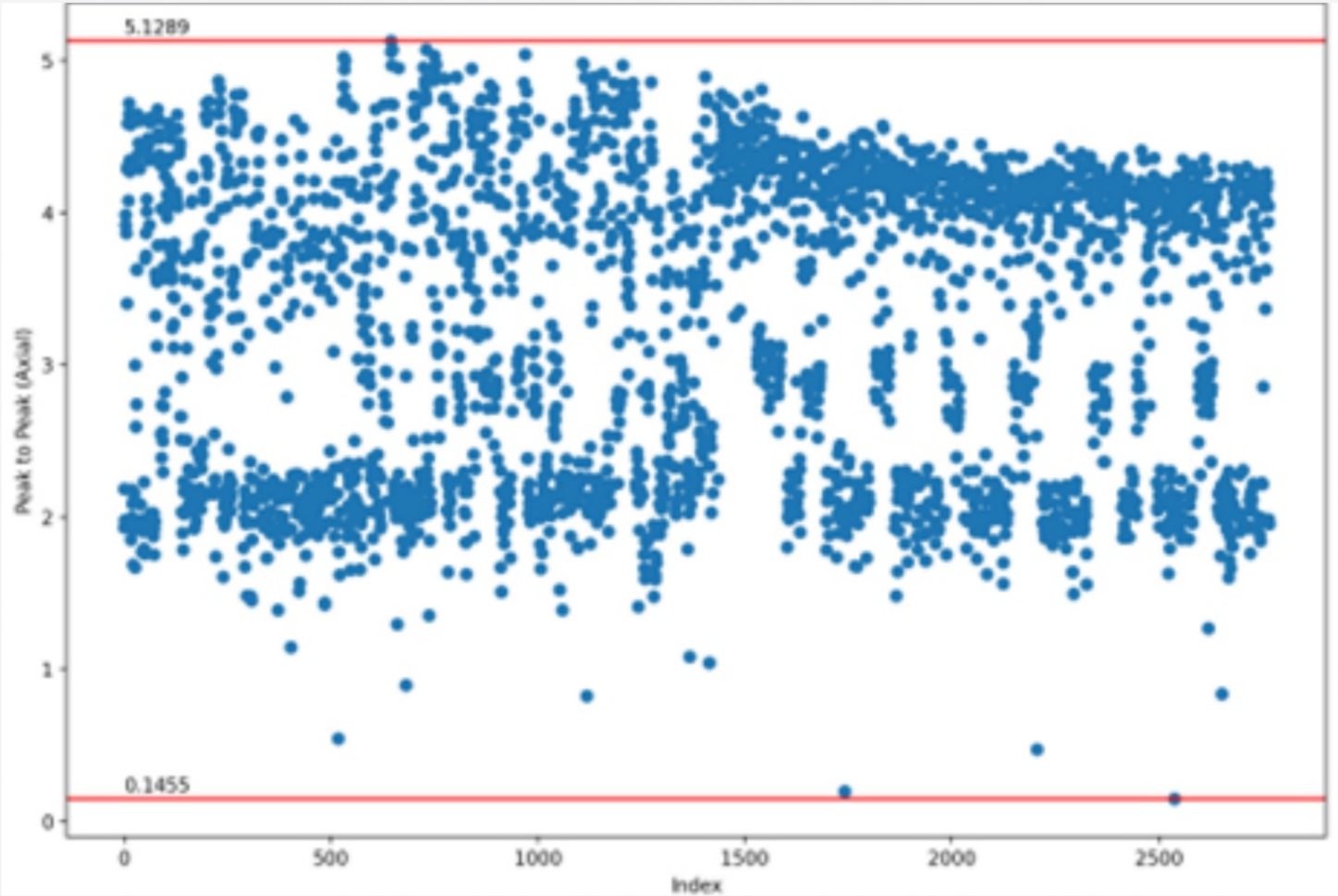


Sliding Window Technique

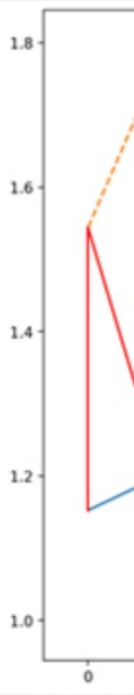


Deep learning

Prediction Algorithms



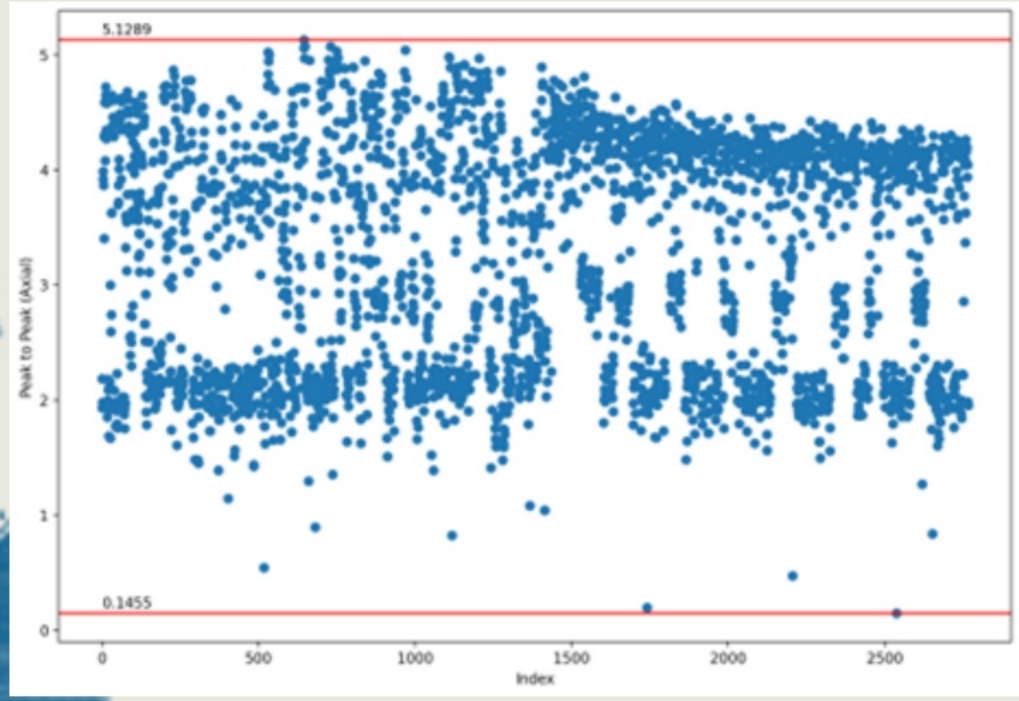
Peak-to-peak analysis



Peak-to-peak analysis

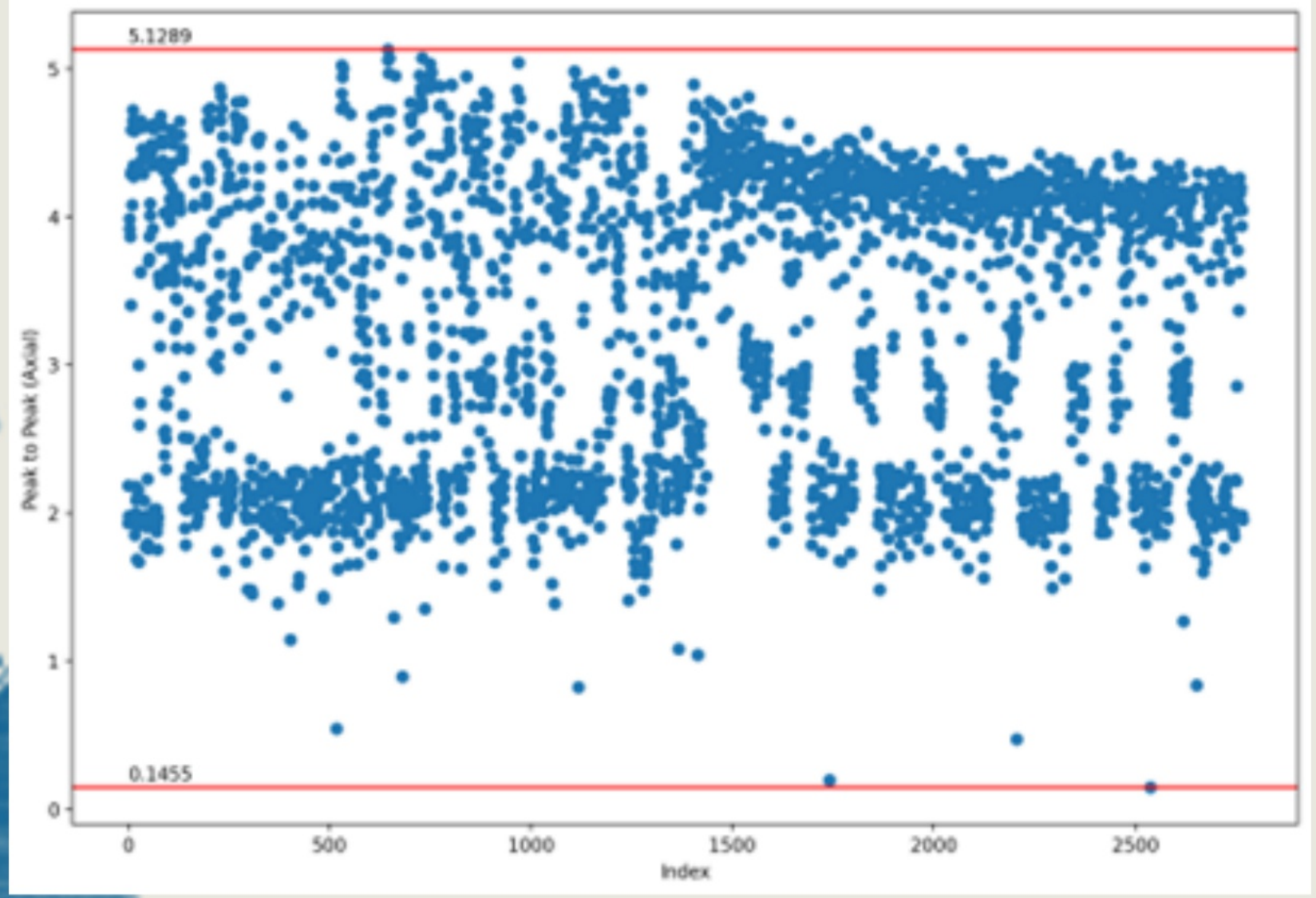
Minimal variance in the peak-to-peak values in vibration could provide clear demarcation from faulty motors

(Del Rossr et al., 2021)



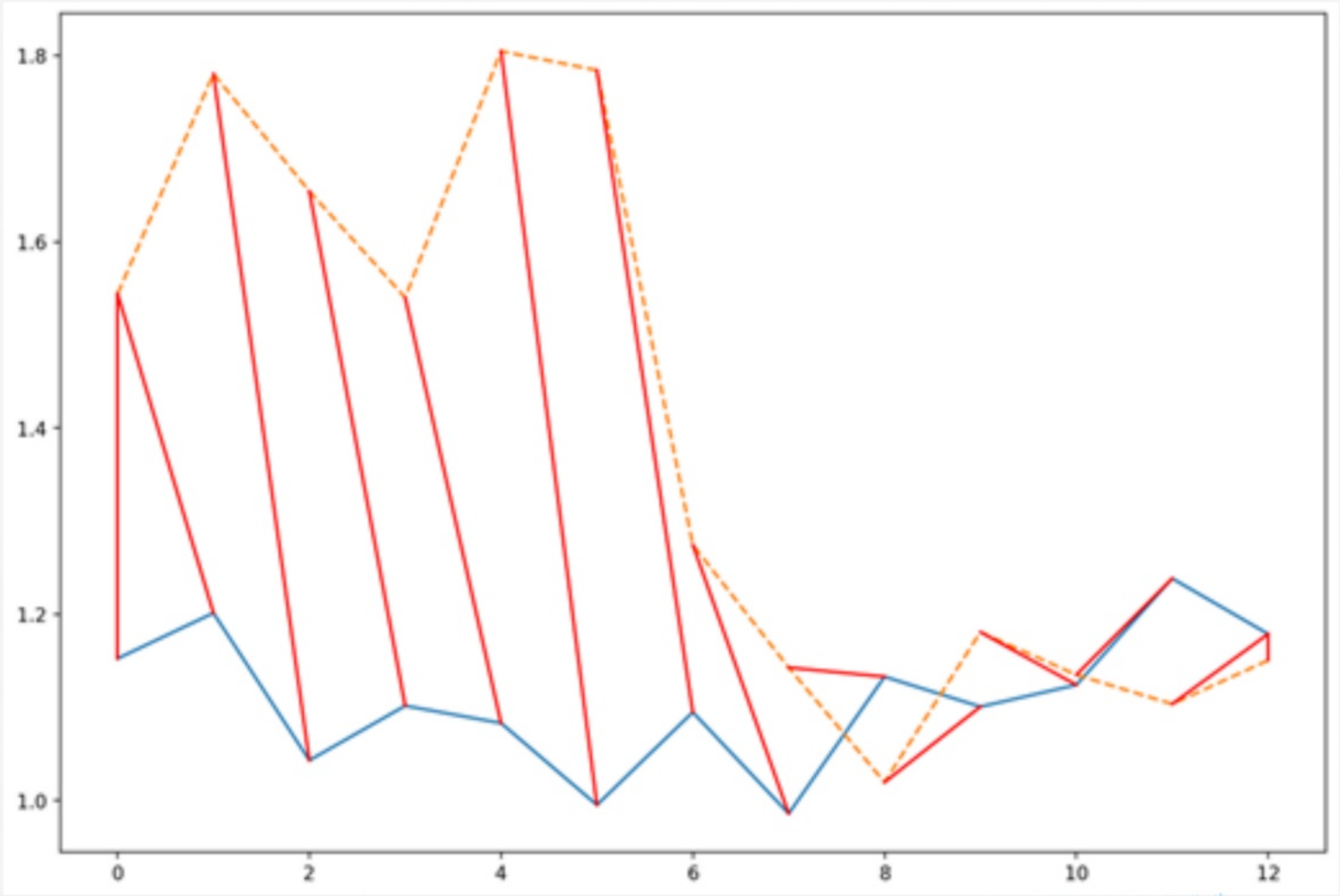
Thresholds set at
$0.1455 < x < 5.1289$

2021)

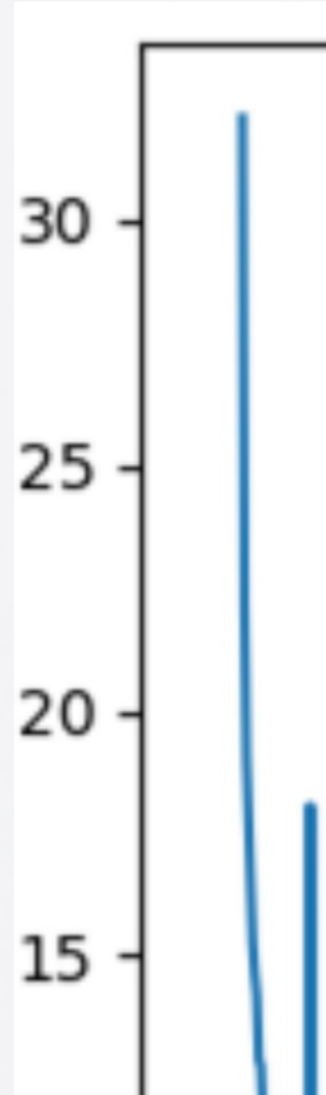


Thresholds set at

$0.1455 < x < 5.1289$



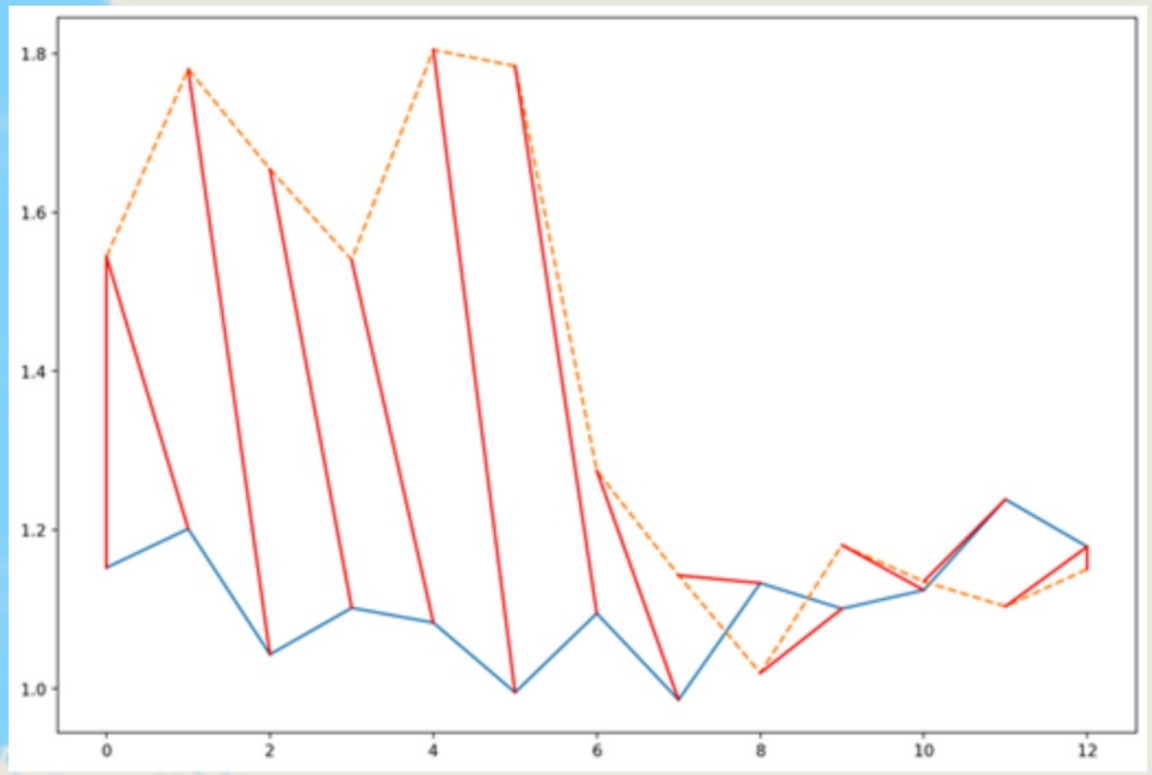
Sliding Window Technique



Sliding Window Technique

- Aim to identifying recurring patterns
  (Bagheri 2018 as cited in Ainarappan et al., 2023)

- Dynamic Time Warping
  - Calculating the distance between two windows



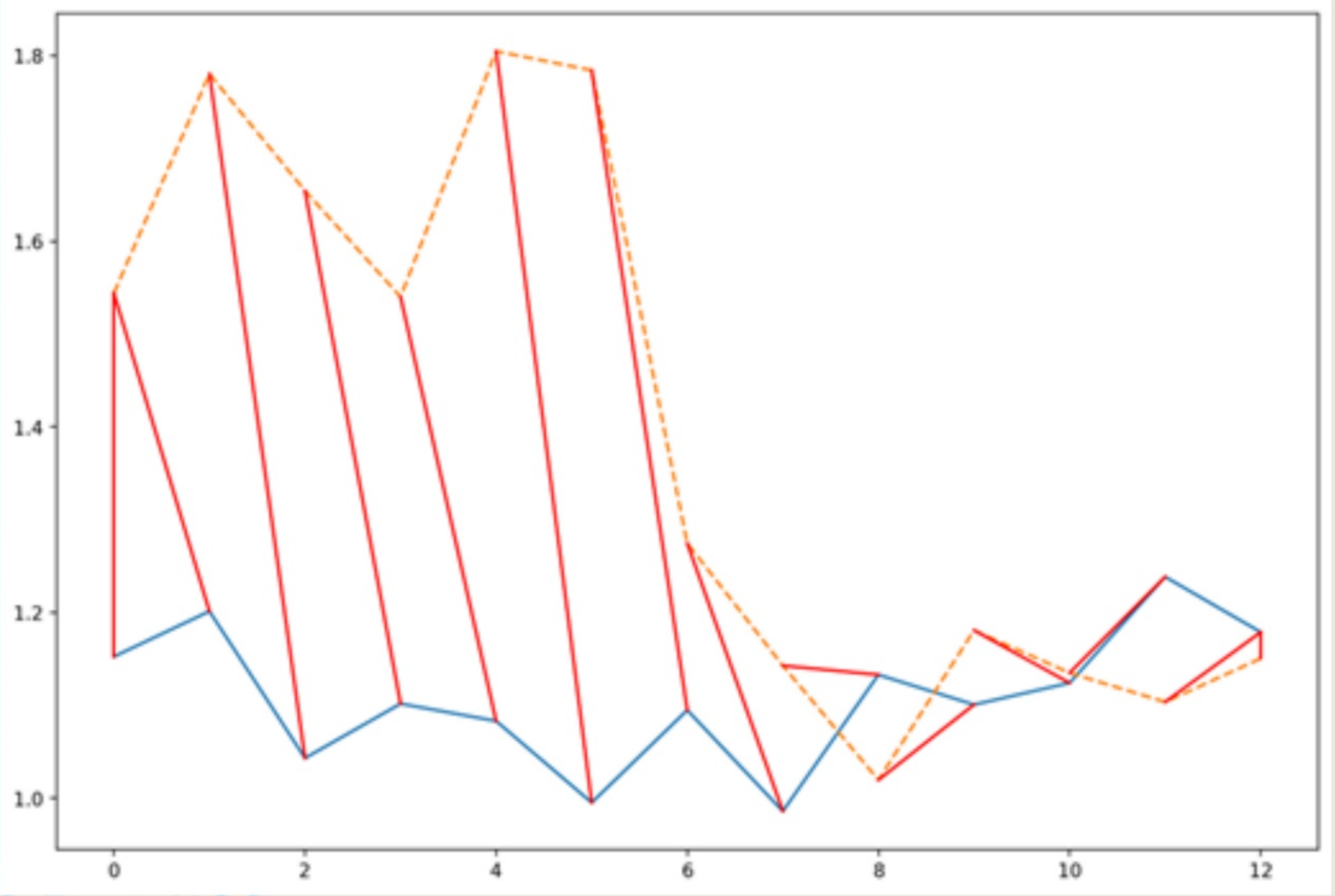
DTW between Rows 1 to 13 and Rows 675 to 687

DTW Distance of 0.10225

rns

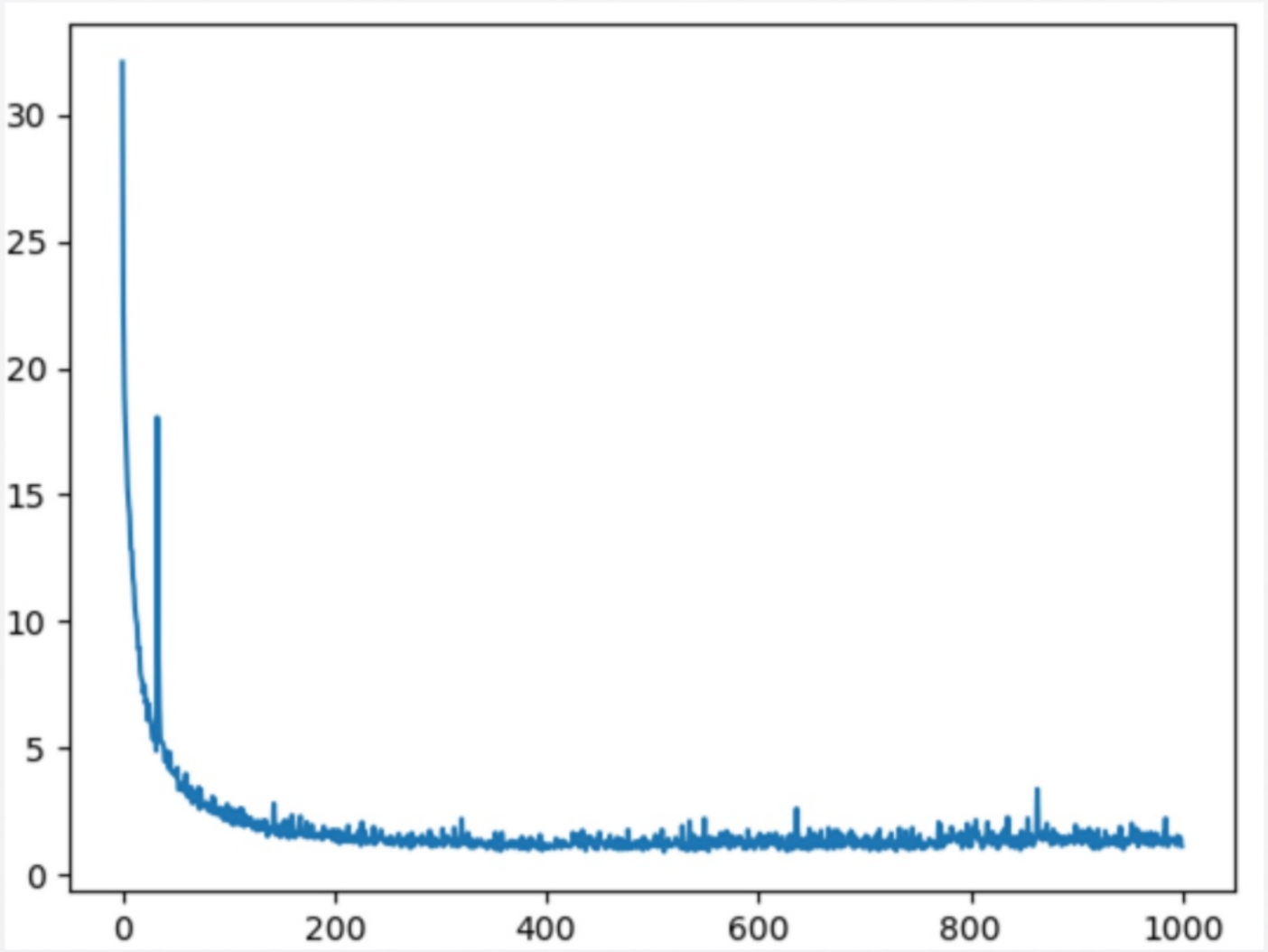
et al., 2023)

een two



DTW between Rows 1 to 13 and Rows 675 to 687

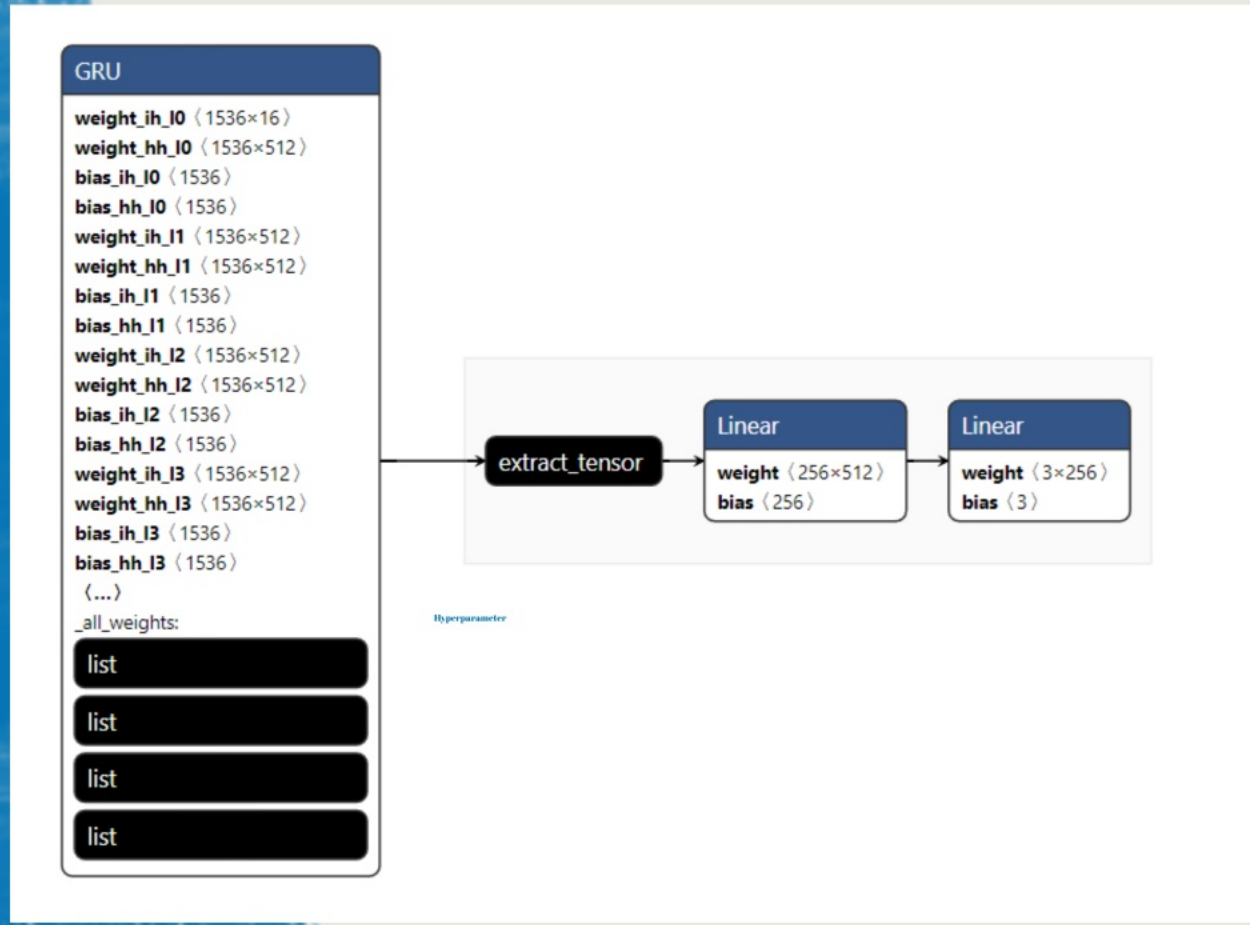
DTW Distance of 0.10225



Deep learning

Deep learning

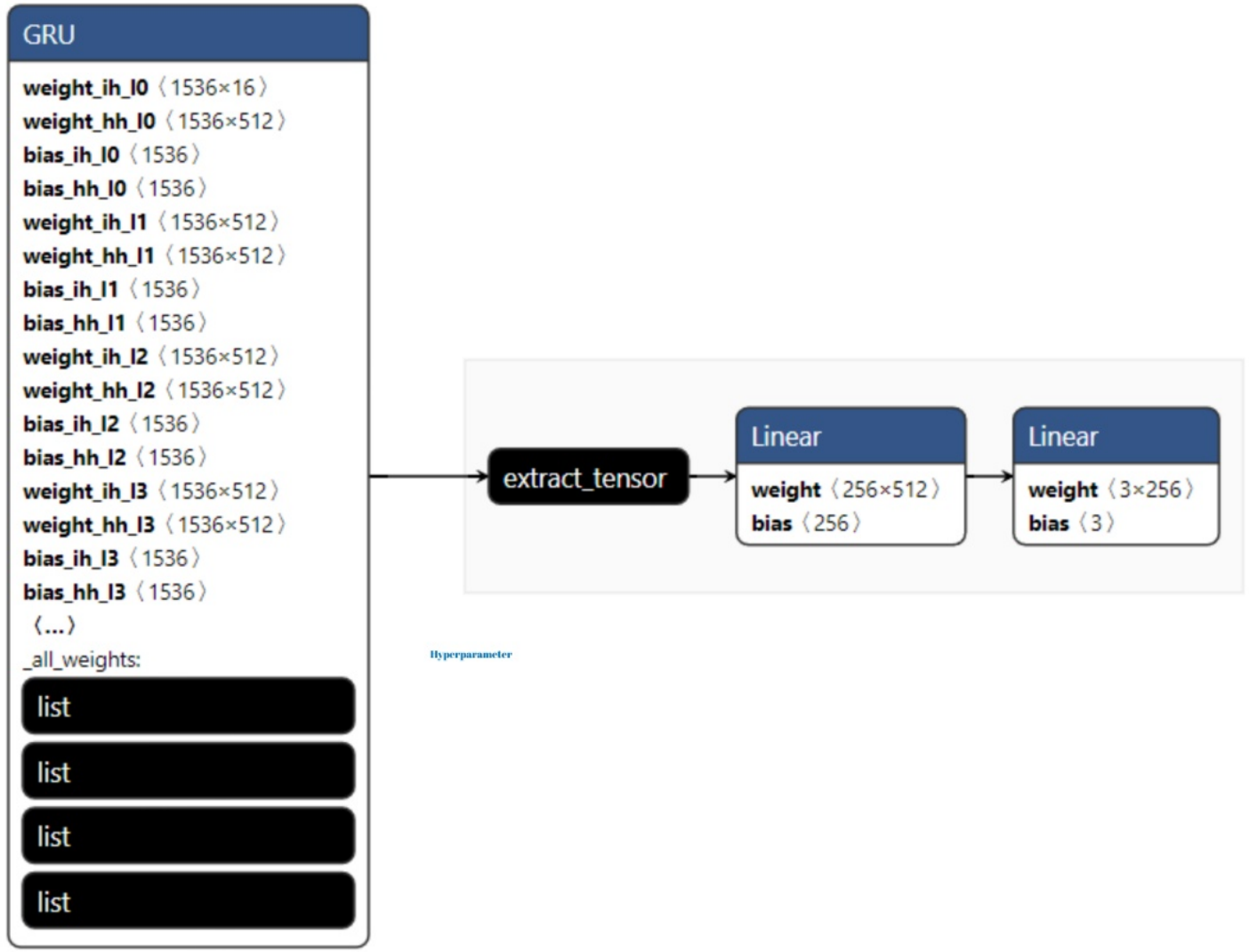
Recurrent neural network model with Gated Recurrent Unit architecture (GRU)



4-fold GRU layer

dropout rate of 0.1

del with
cture (GRU)

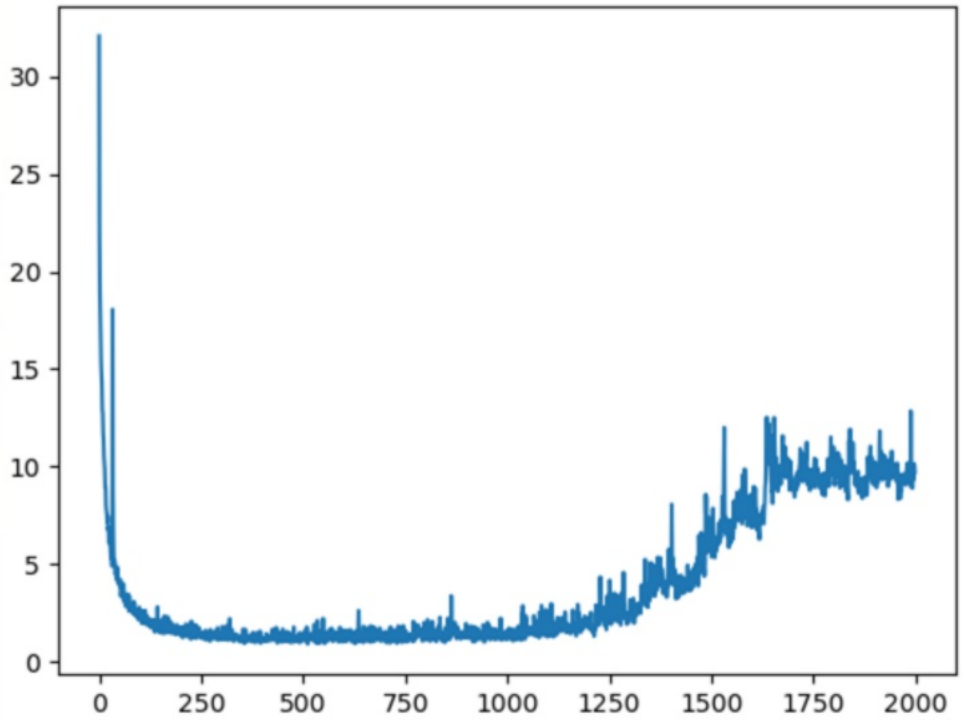


4-fold GRU layer
dropout rate of 0.1

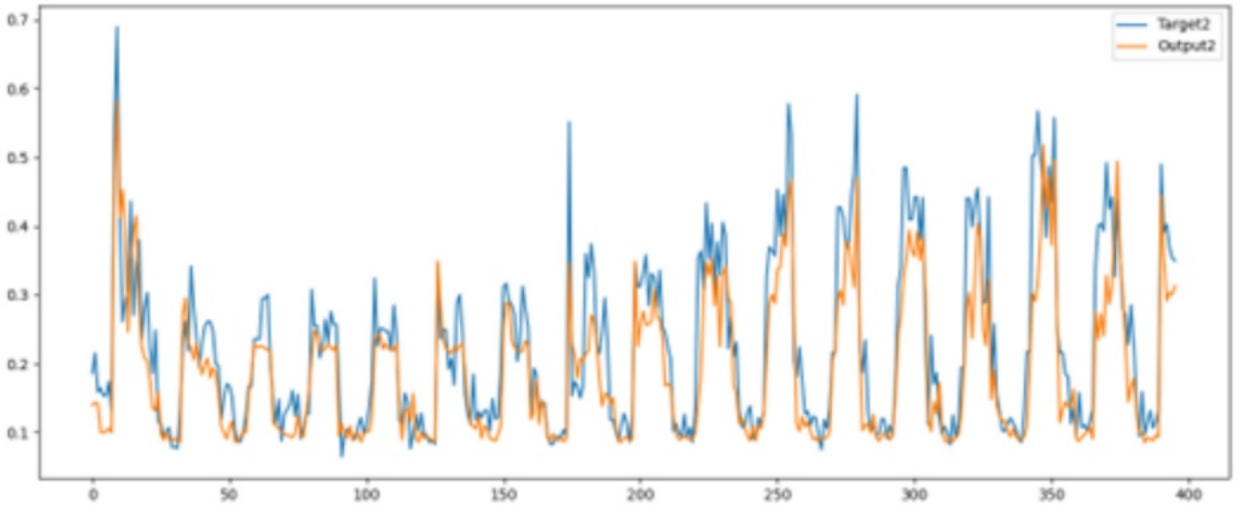
Hyperparameter

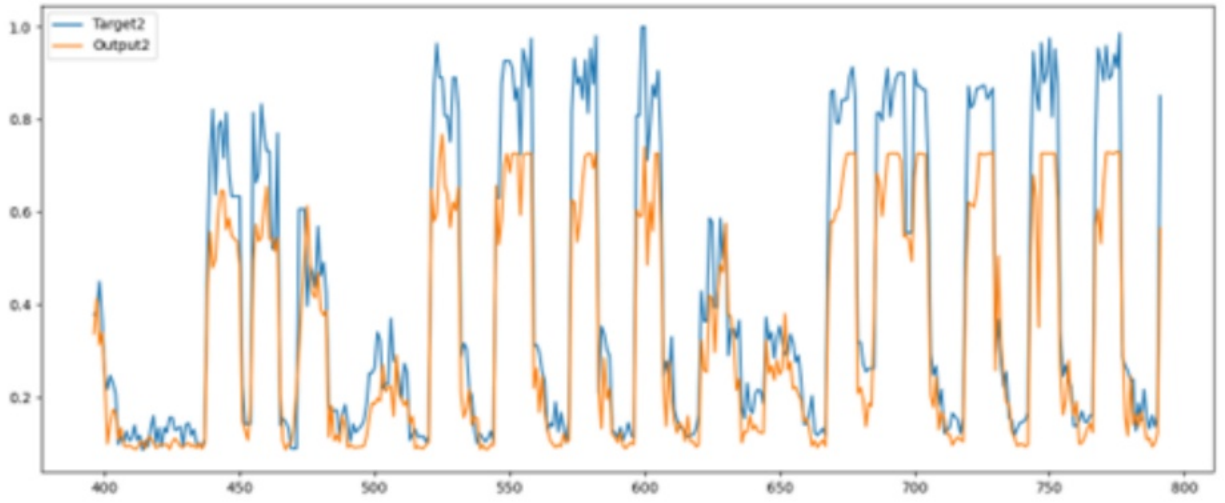
- Adam optimizer
- Mean Square Error Loss function
- loss of best model: 0.901

- Overfiting happened after 1250 of epochs



Model evaluation





loss of best model: 0.901

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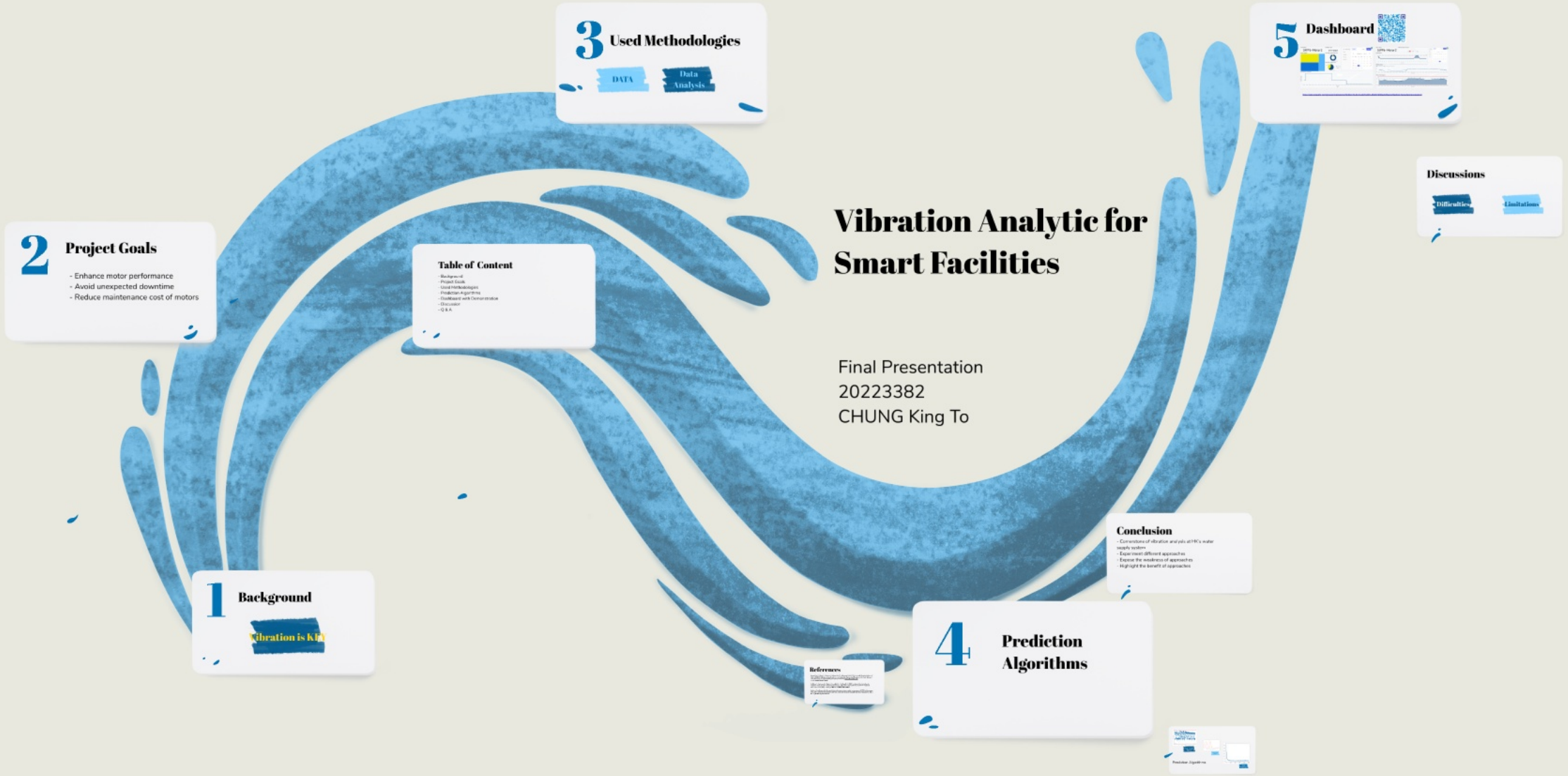
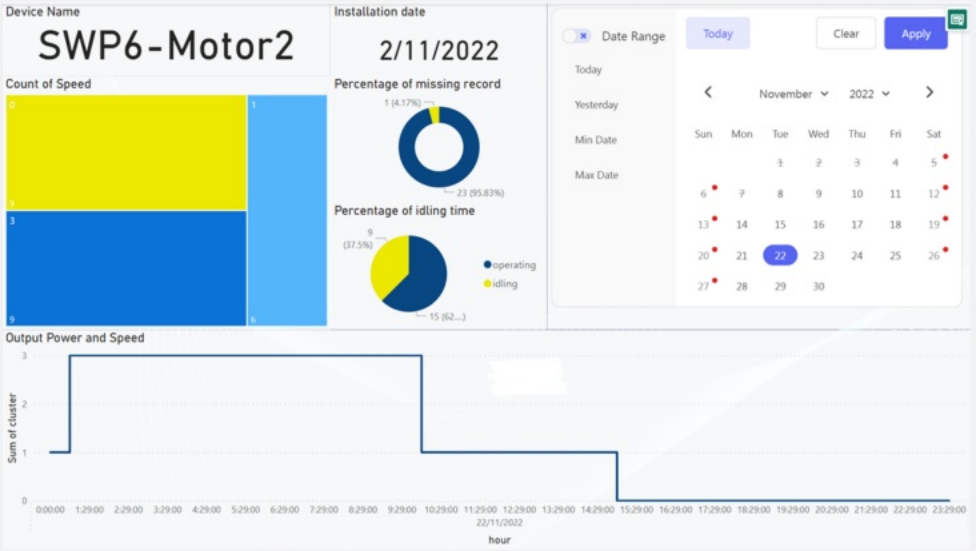


5 Dashboard



https://app.powerbi.com/groups/me/reports/7d82c172-6cc3-4470-80fc-d52074f83a24/ReportSection?experience=power-bi

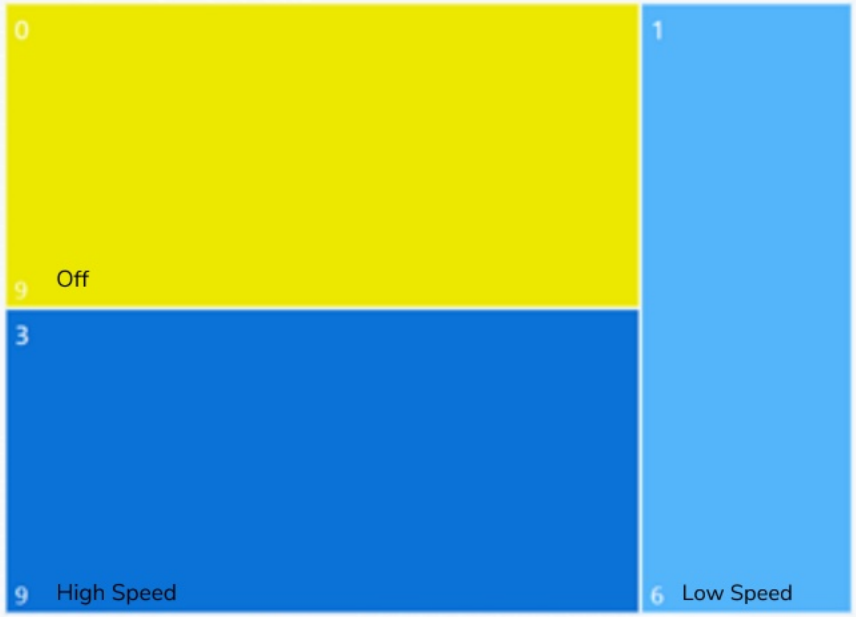
Device Name

SWP6-Motor2

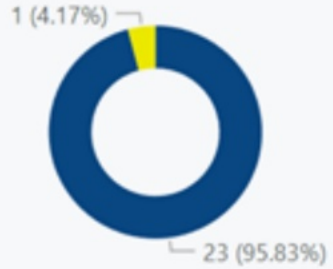
Installation date

2/11/2022

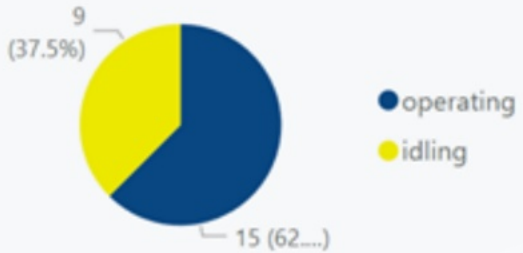
Count of Speed

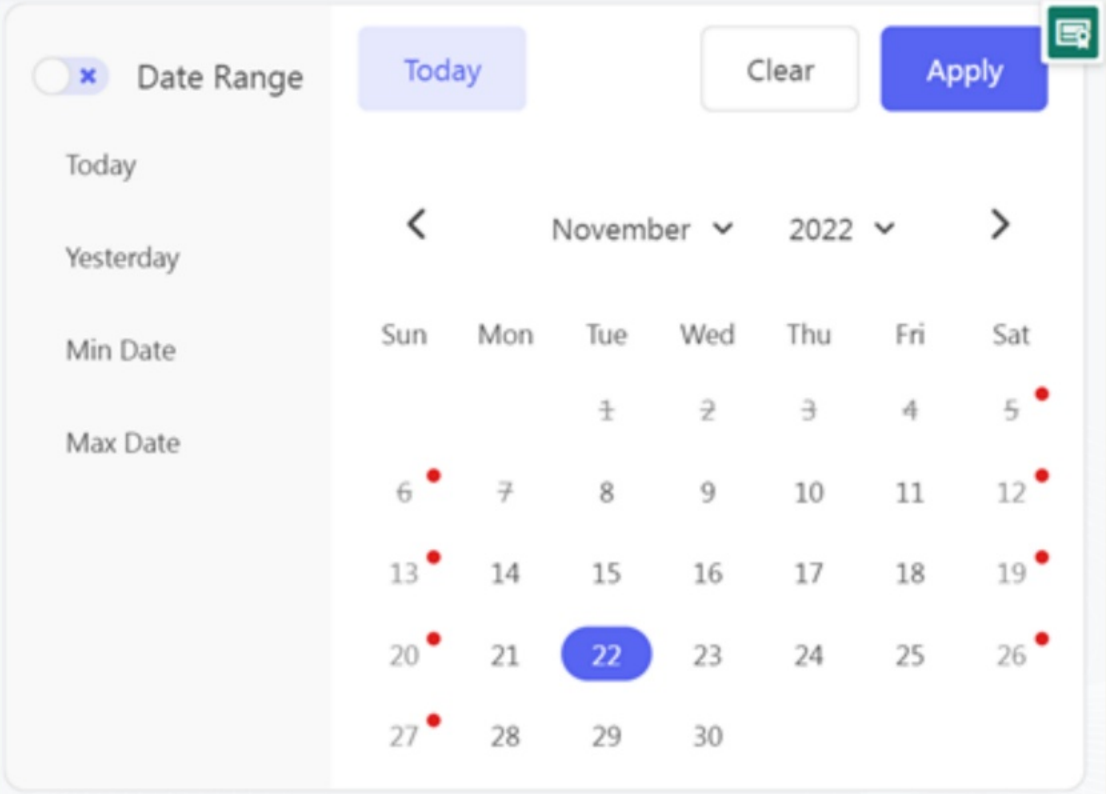


Percentage of missing record

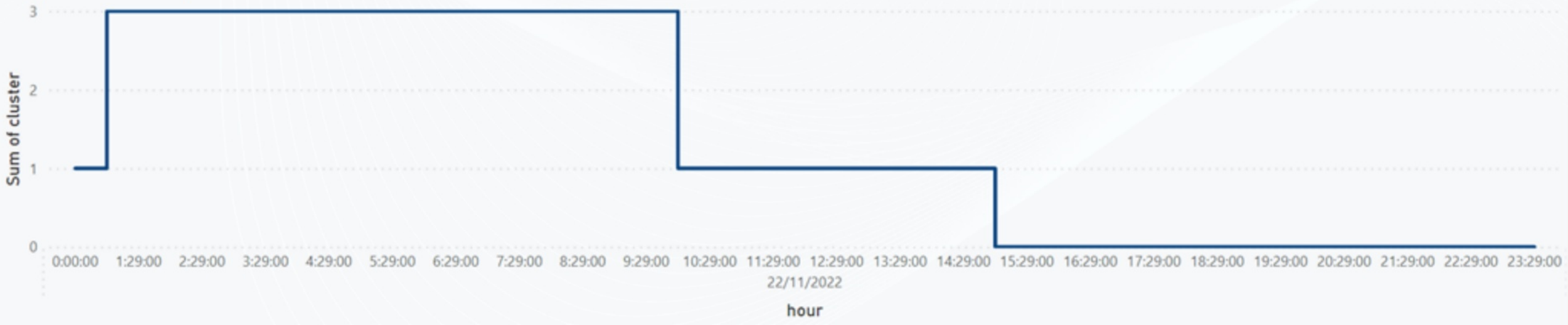


Percentage of idling time





Output Power and Speed



Device Name

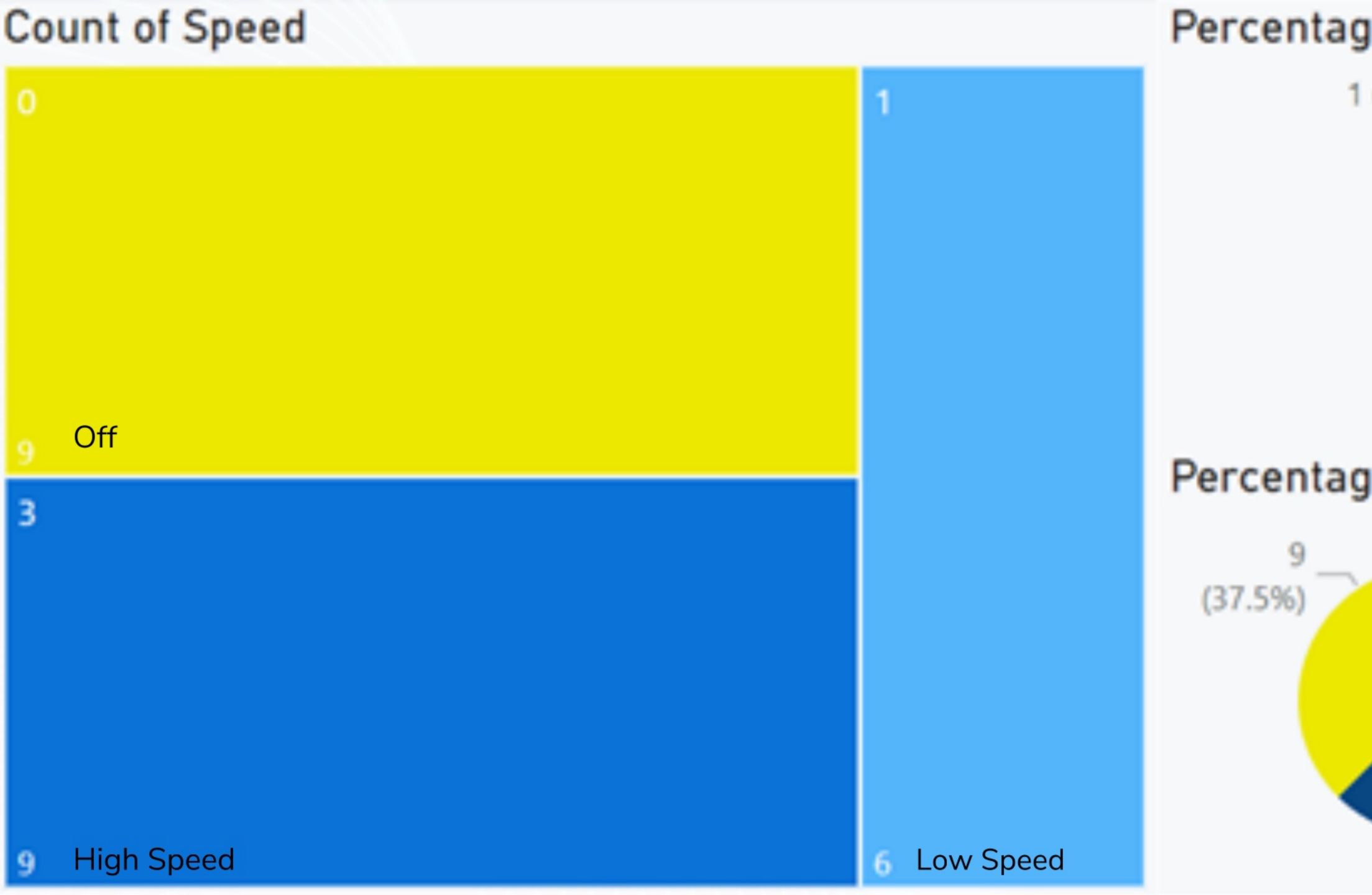
SWP6-Motor2

Count of Speed

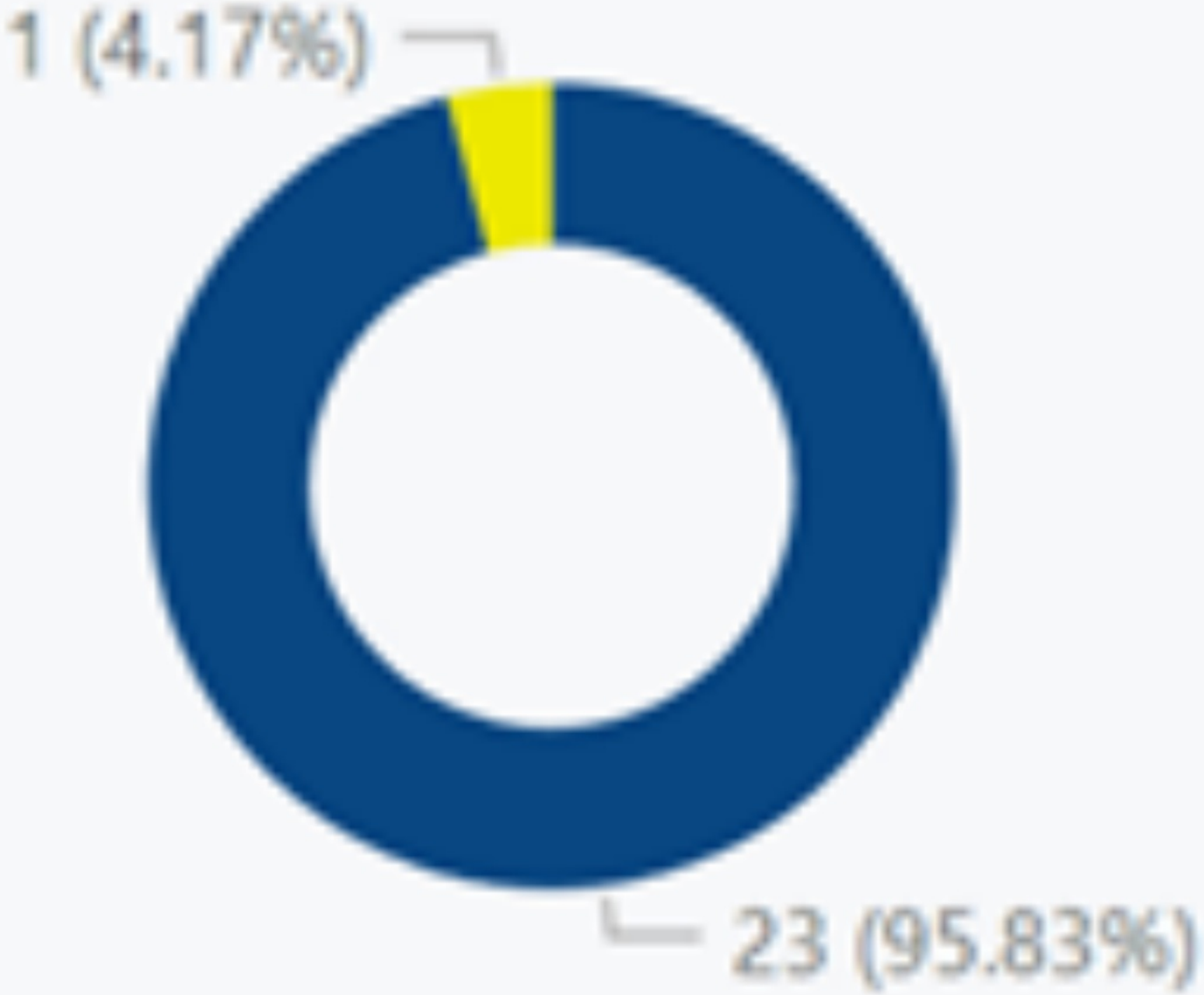
Installation date

2/11/2022

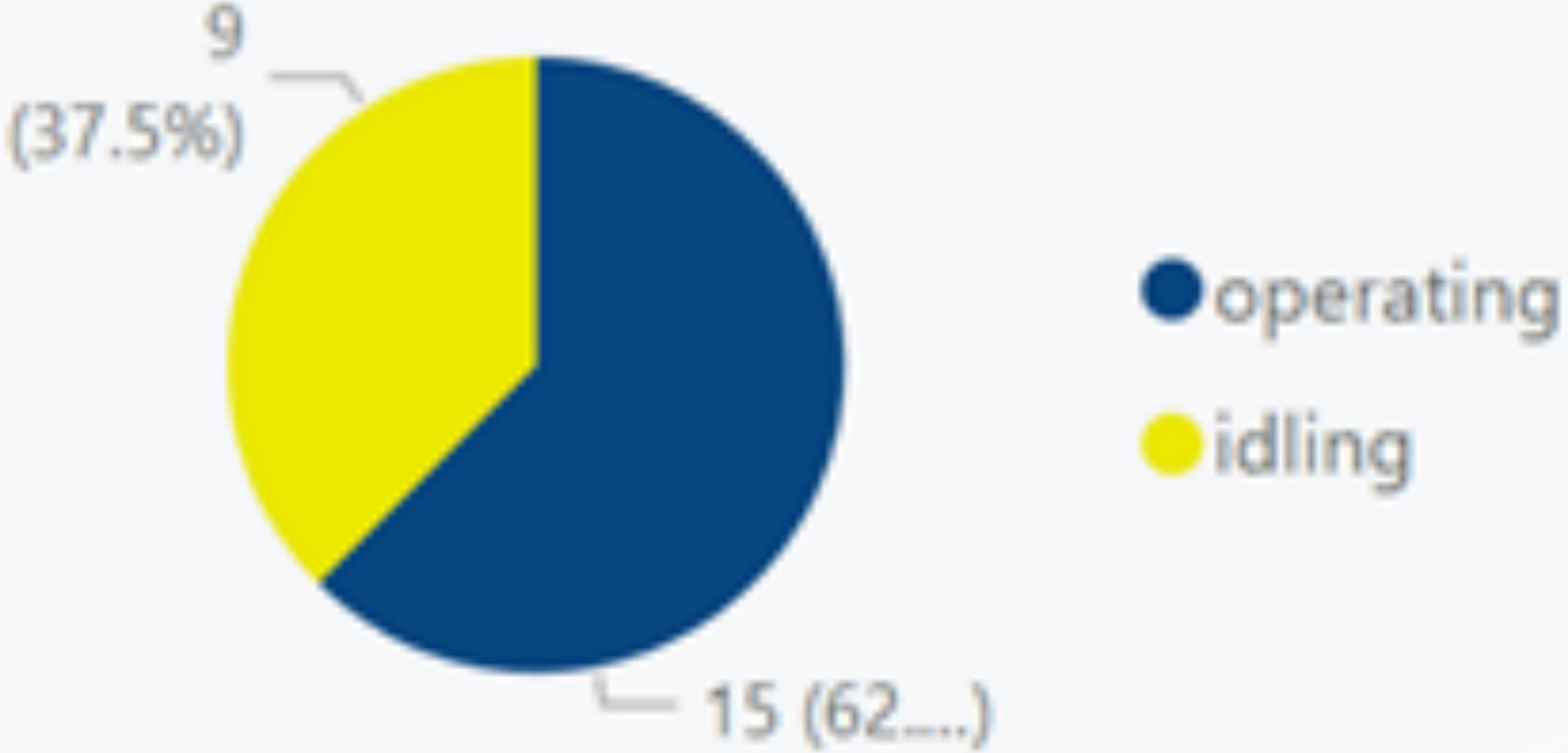
Percentage of missing record


Count of Speed
0
9
Off
3
9
High Speed
1
6
Low Speed
Percentag
1
Percentag
9
(37.5%)

Percentage of missing record



Percentage of idling time



22

ecord

(95.83%)

e

operating

idling

Date Range

Today

Yesterday

Min Date

Max Date

Today

Clear

Apply

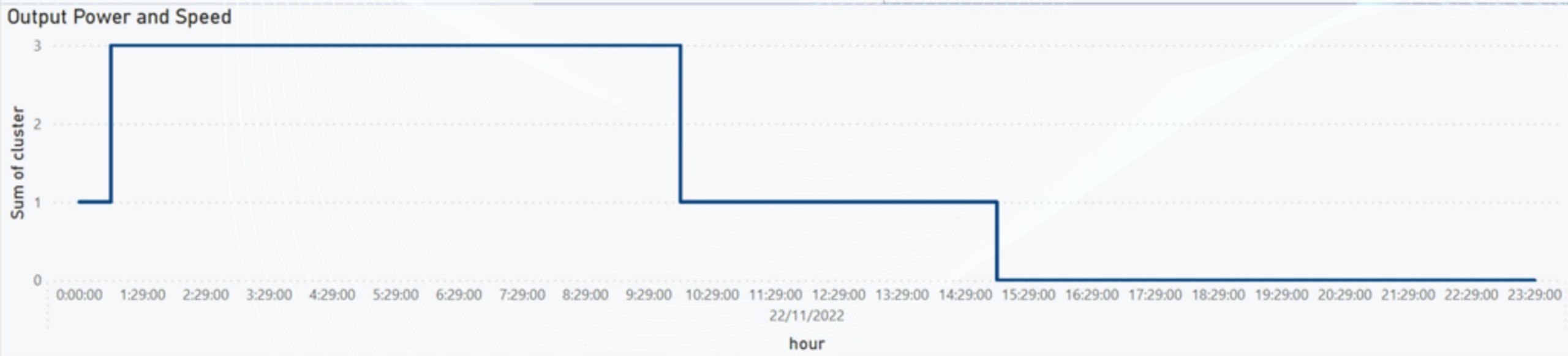
November

2022

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Max Date

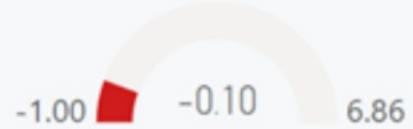
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			



Device Name

SWP6-Motor2

DTW in between 24 hours



Date Range

Today | Clear | Apply

Today

Yesterday

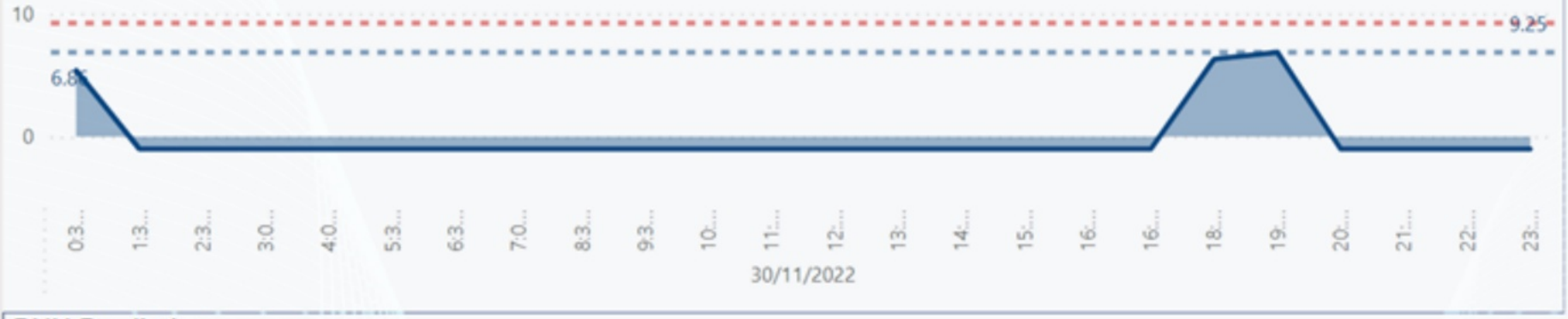
Min Date

Max Date

November 2022

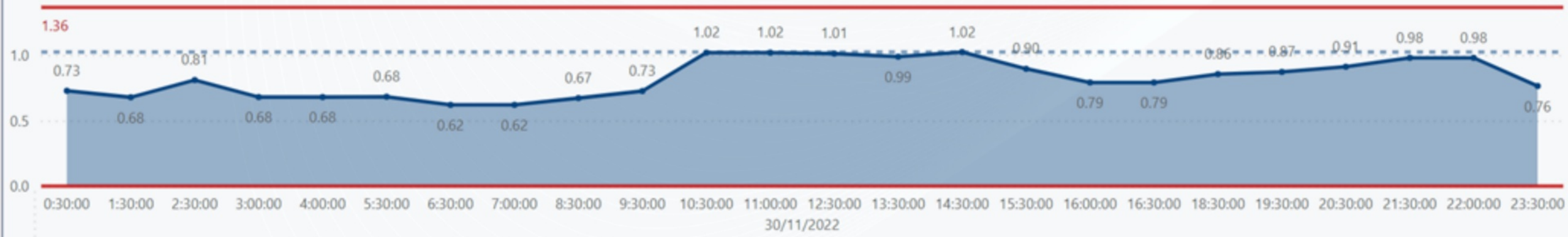
Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

DTW analysis

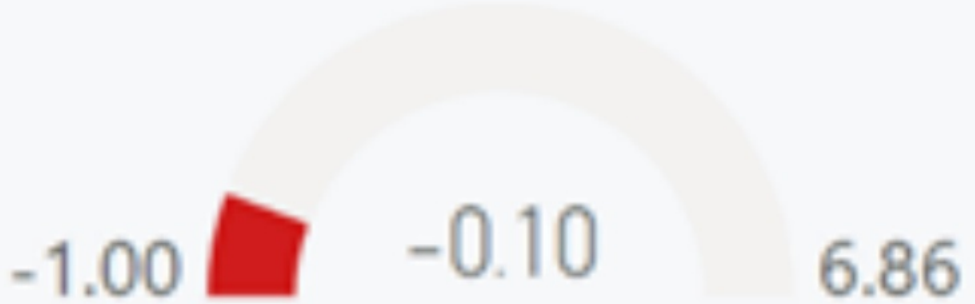


RNN Prediction

Peak to Peak analysis



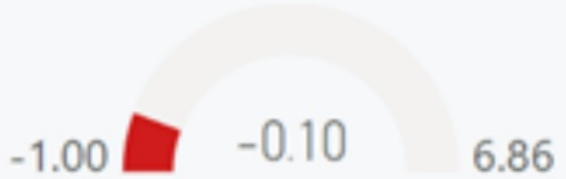
DTW in between 24 hours



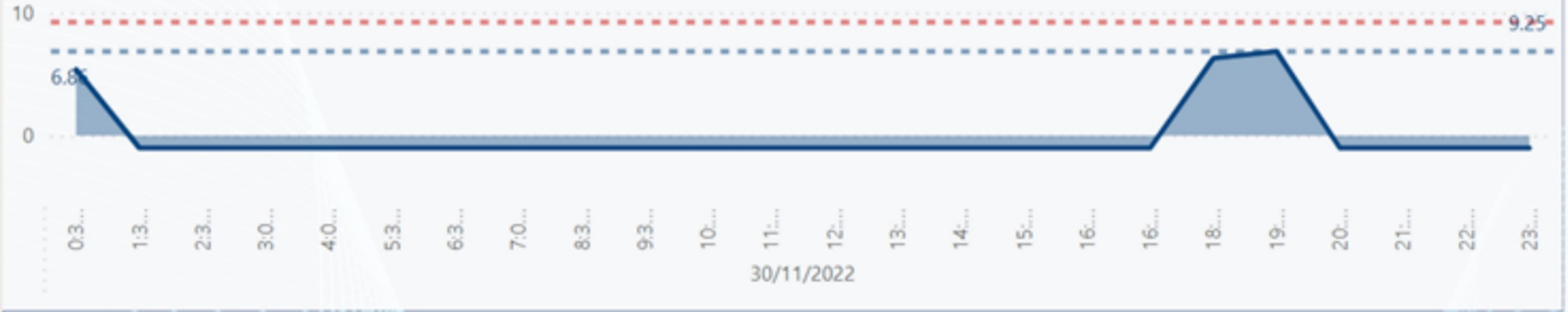
Device Name

SWP6-Motor2

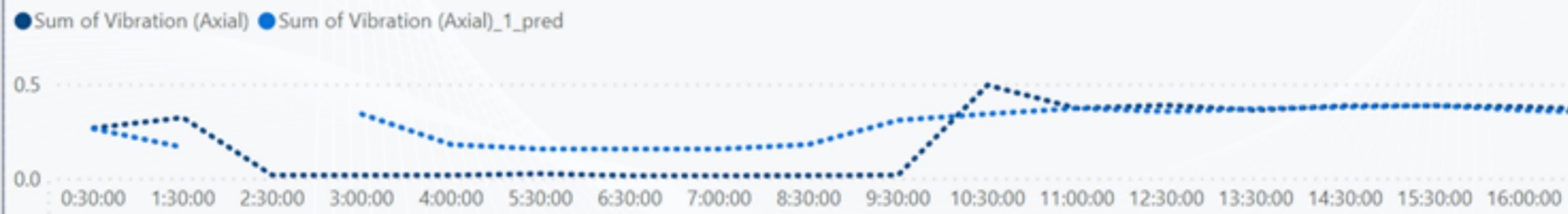
DTW in between 24 hours



DTW analysis



RNN Prediction



SWP6-Motor2

Date Range

Today

Yesterday

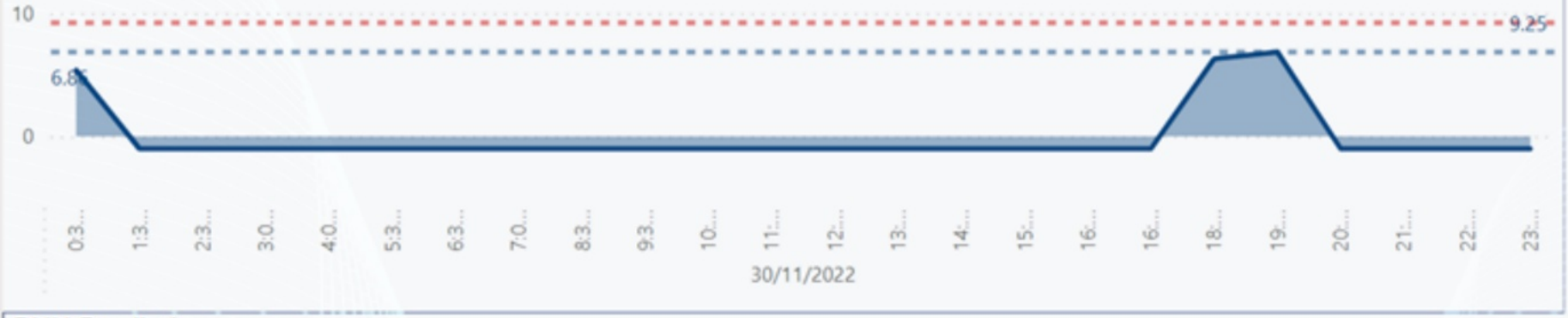
Min Date

Max Date

November 2022

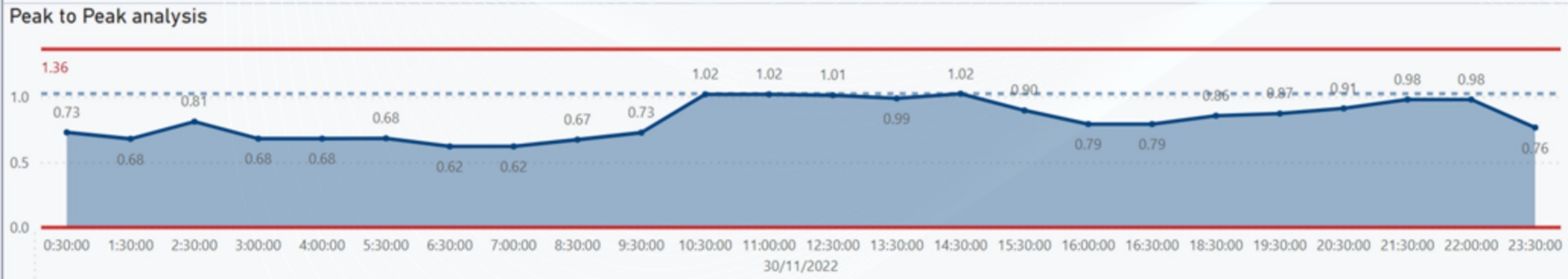
Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

DTW analysis

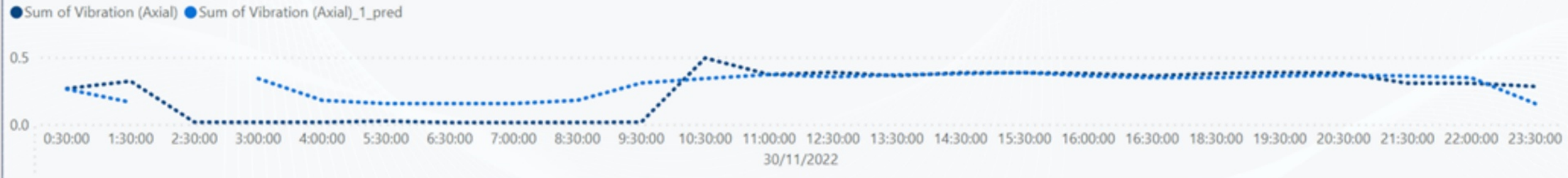


RNN Prediction

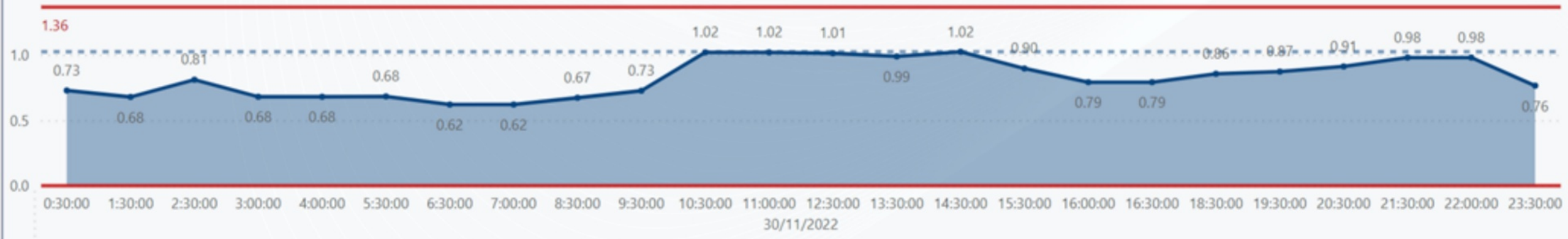
Peak to Peak analysis



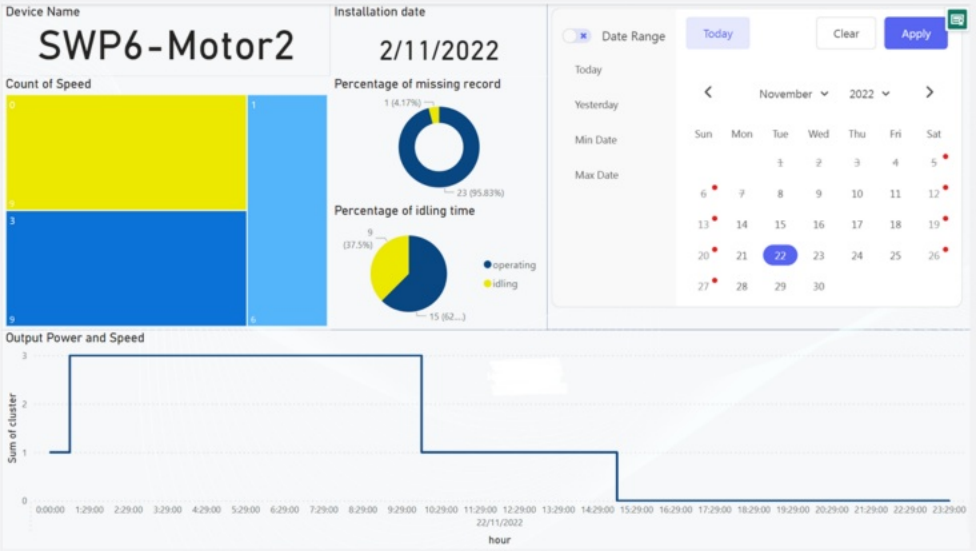
RNN Prediction



Peak to Peak analysis



5 Dashboard



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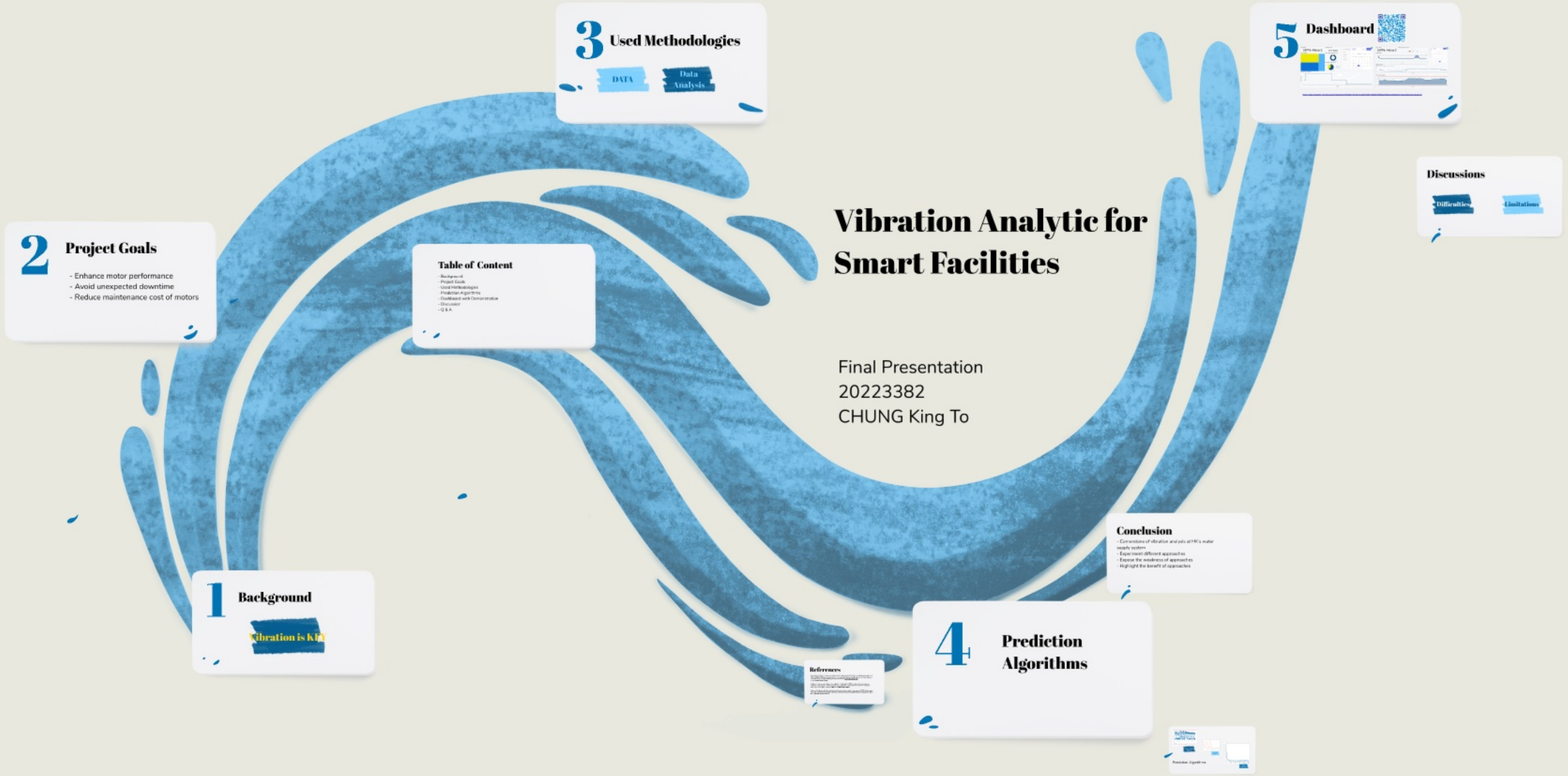

Discussions

Difficulties

Limitations

Difficulties

- High percentage of missing value and idling record

- Hardware limitation

- Lack of enough samples for training RNN model

Limitations

- Insensitive for Peak-to-peak value

- Long reaction time with high computational demand for DTW Technique

- High barrier for non-expert user

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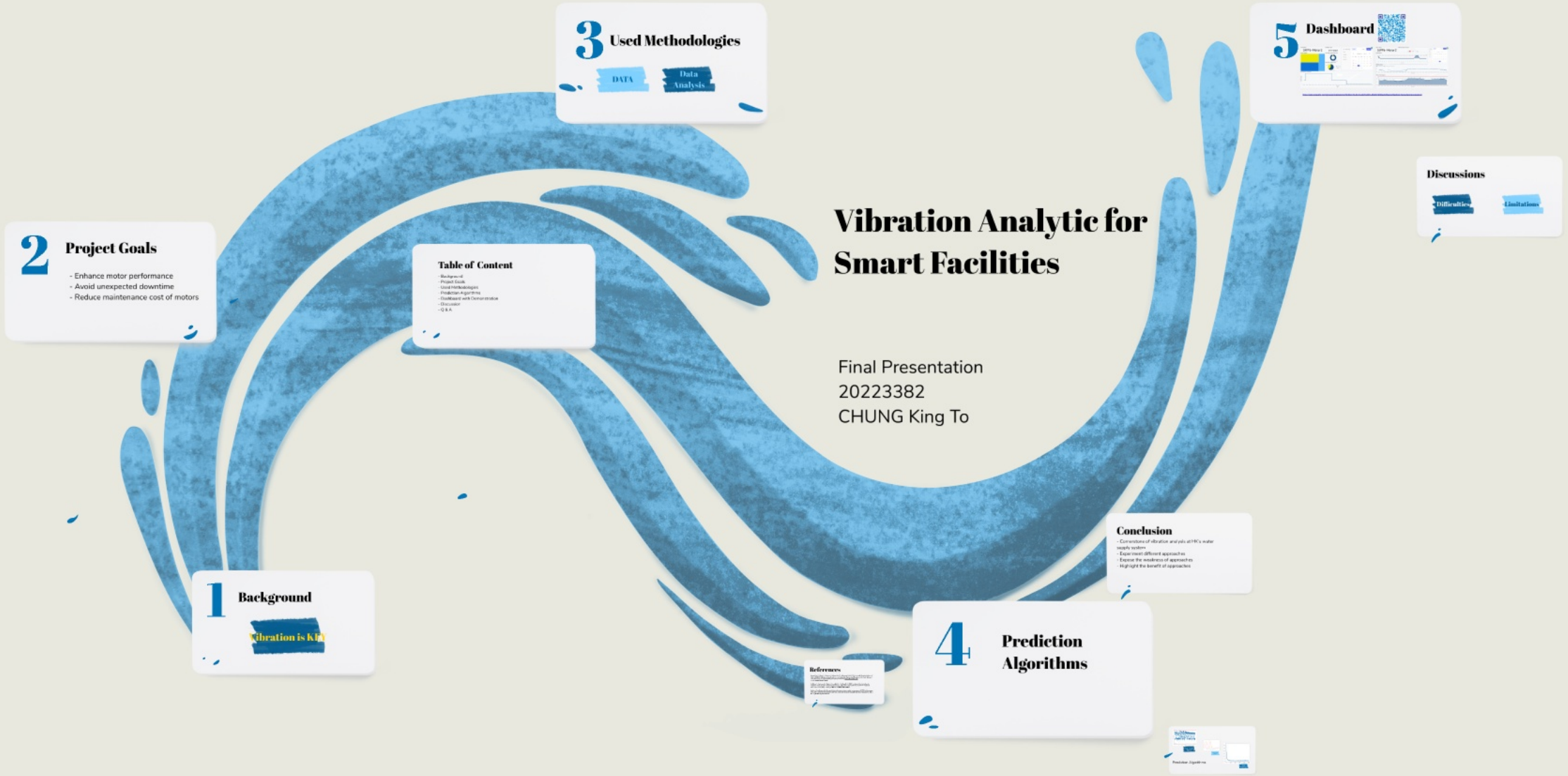

Conclusion

- Cornerstone of vibration analysis at HK's water supply system
- Experiment different approaches
- Expose the weakness of approaches
- Highlight the benefit of approaches

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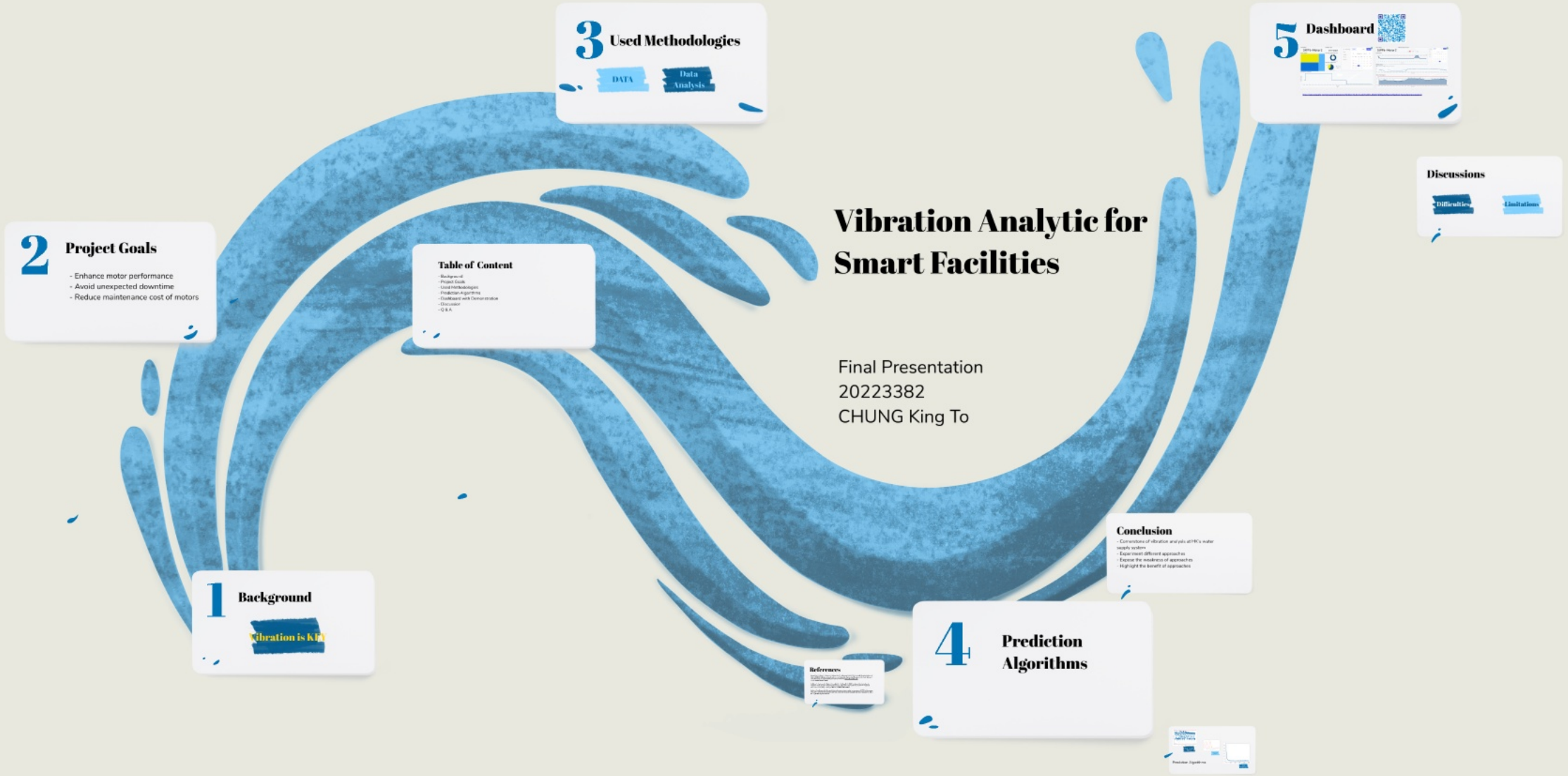

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