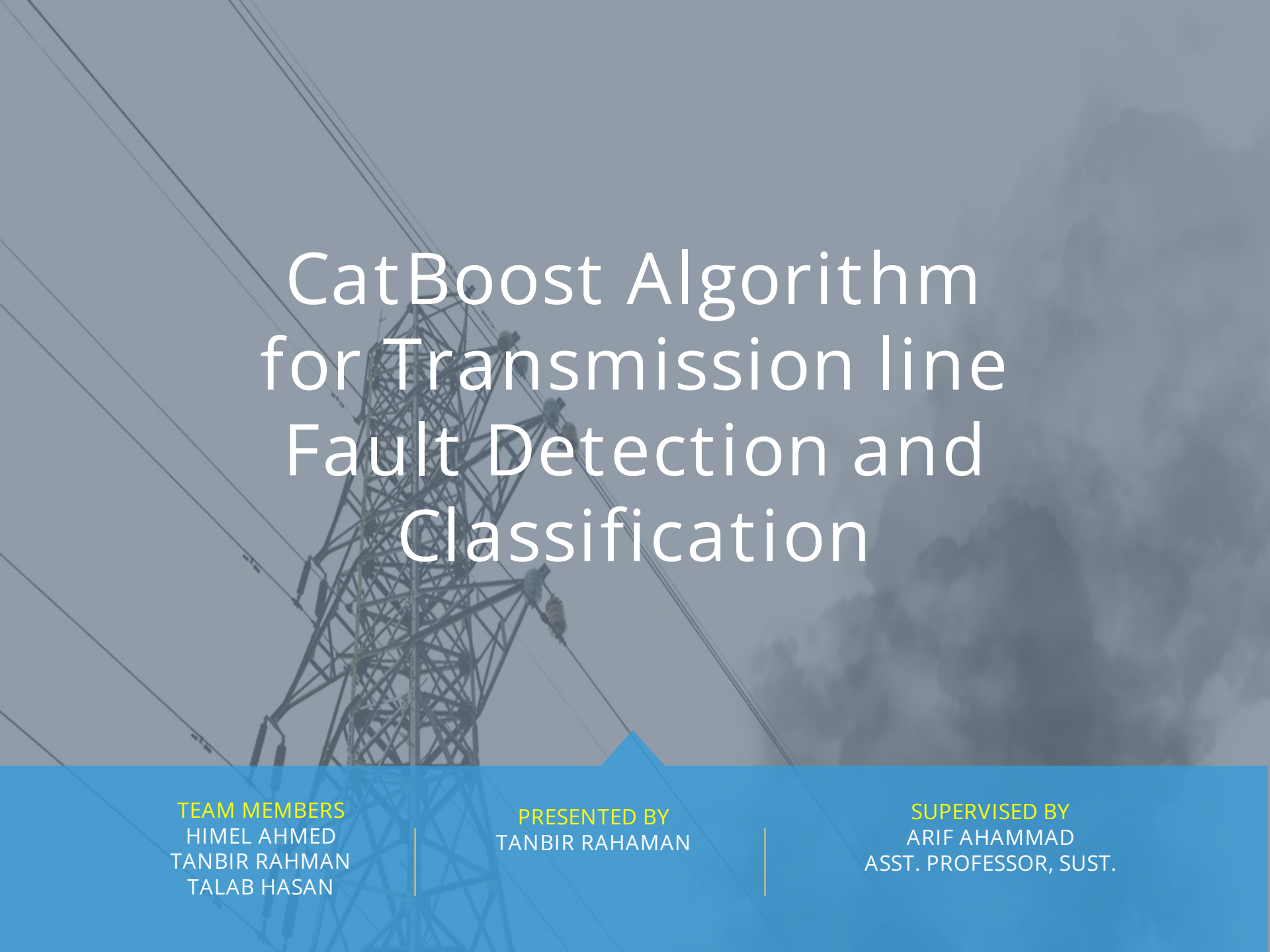

# CatBoost Algorithm for Transmission line Fault Detection and Classification


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# Thesis Outline

# Introduction

Typical fault detection procedure-

01
Needs long time

02
Hampers reliability

03
Create instability, discontinuity

Consequences,

01
Transmission & distribution loss 8.31%

02
Frequent power outages

03
Hampers businesses & discourages foreign investment

# Introduction

Machine learning procedure-

01

Needs short time

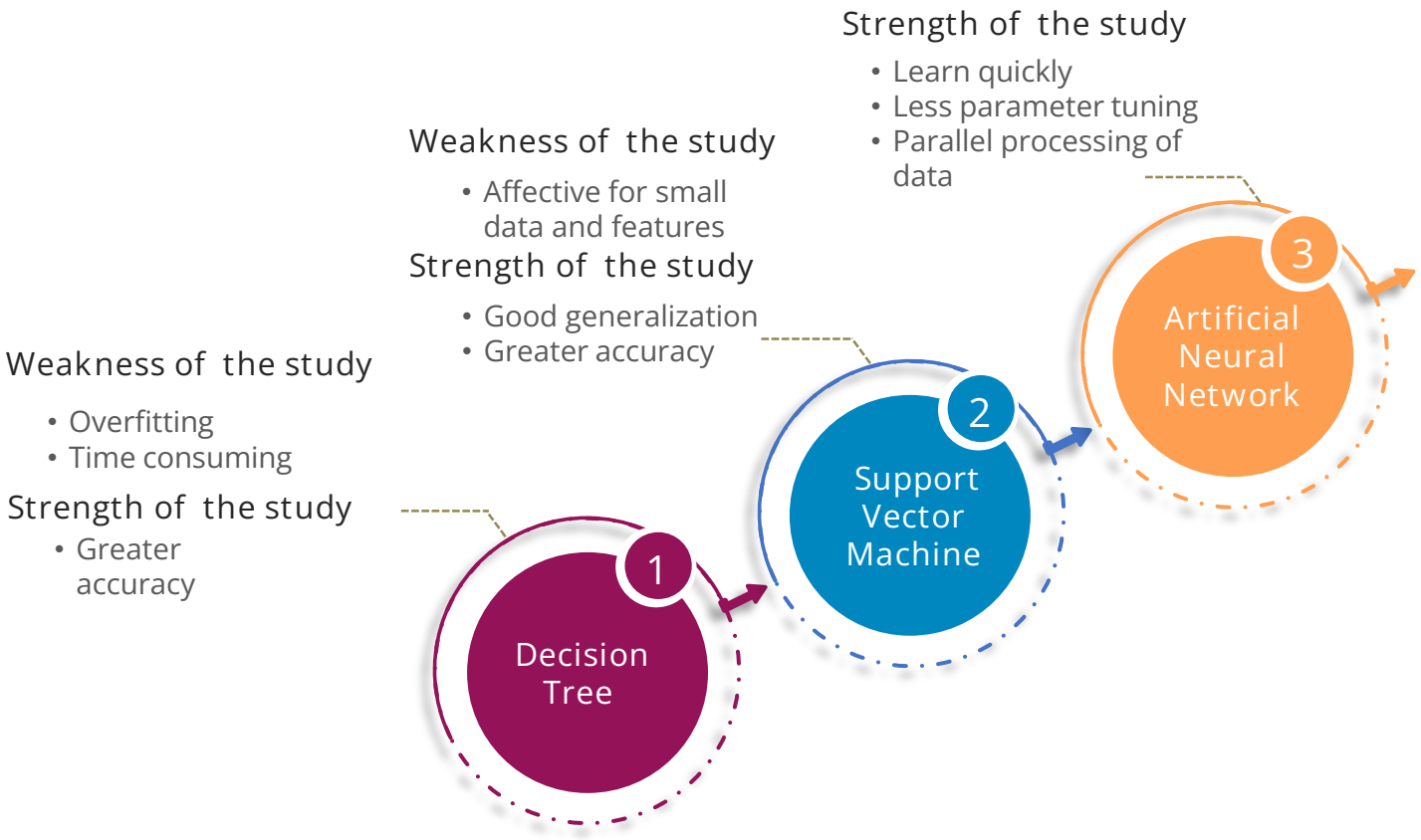
02

Increases reliability

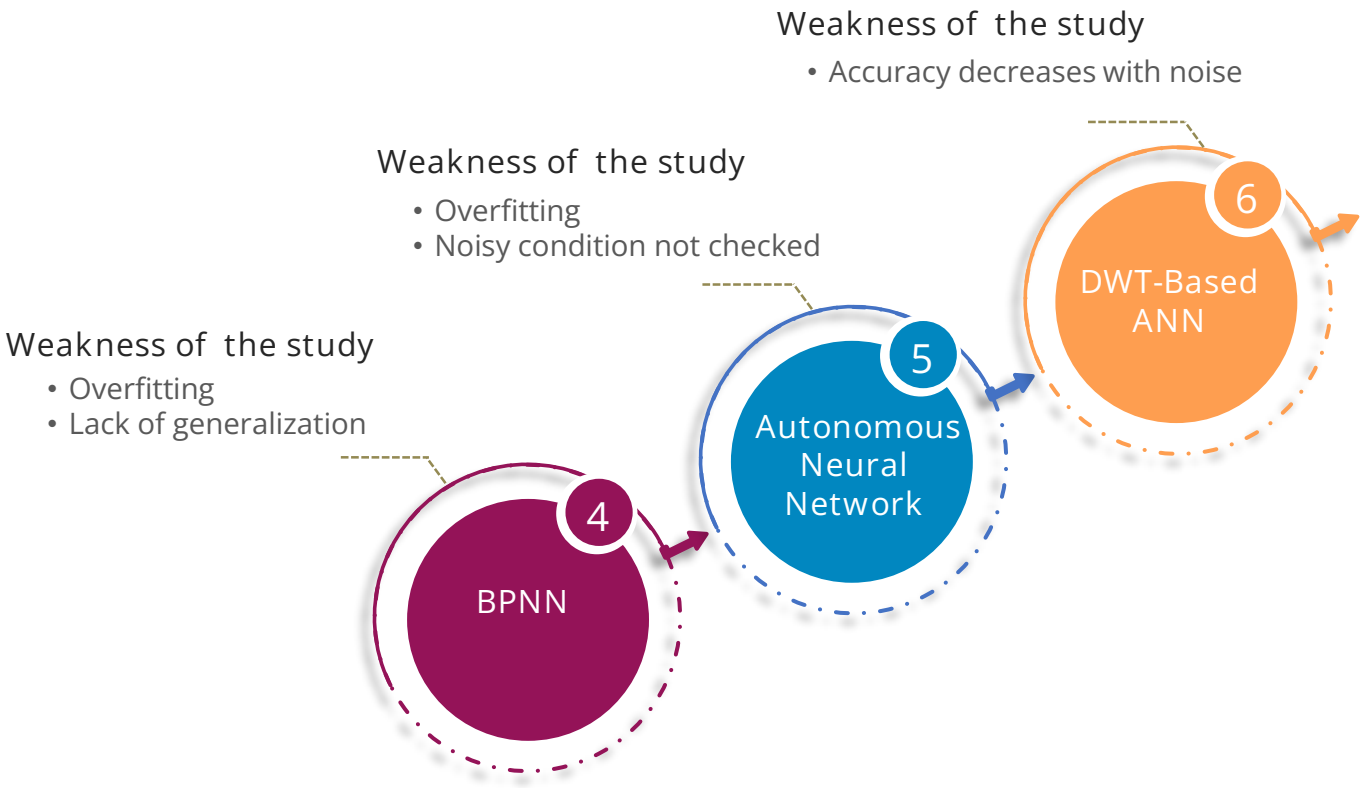
03

Provide stability, continuity

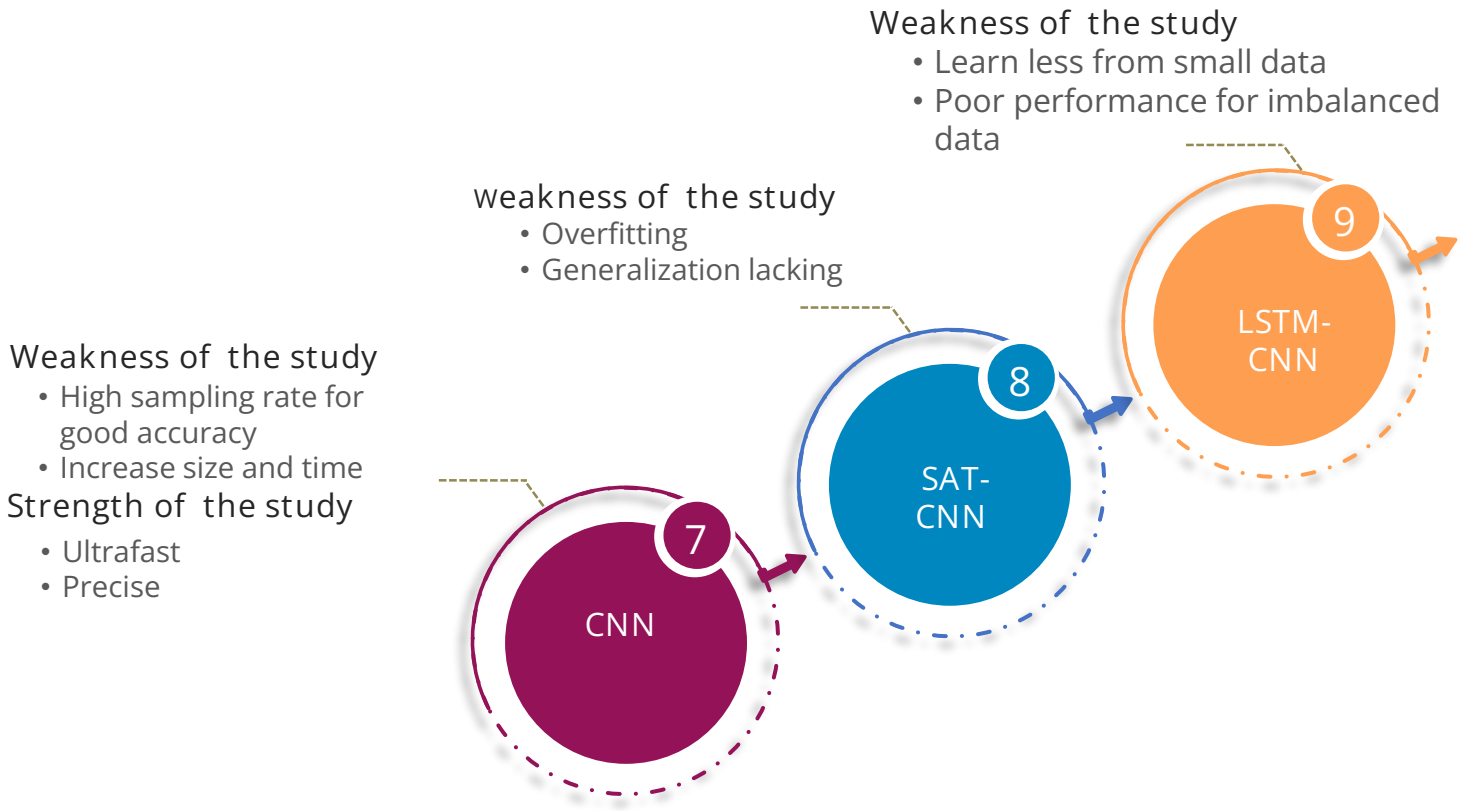
# Literature Review



# Literature Review



# Literature Review



# Major Drawbacks Based on Literature

01 Overfitting

02 Accuracy decreases with noise

03 Less performance in data varieties

04 Less learning for small data

05 Implicit pre-processing of data

# Hypothesis
(Proposed model)

01 Overfitting detector

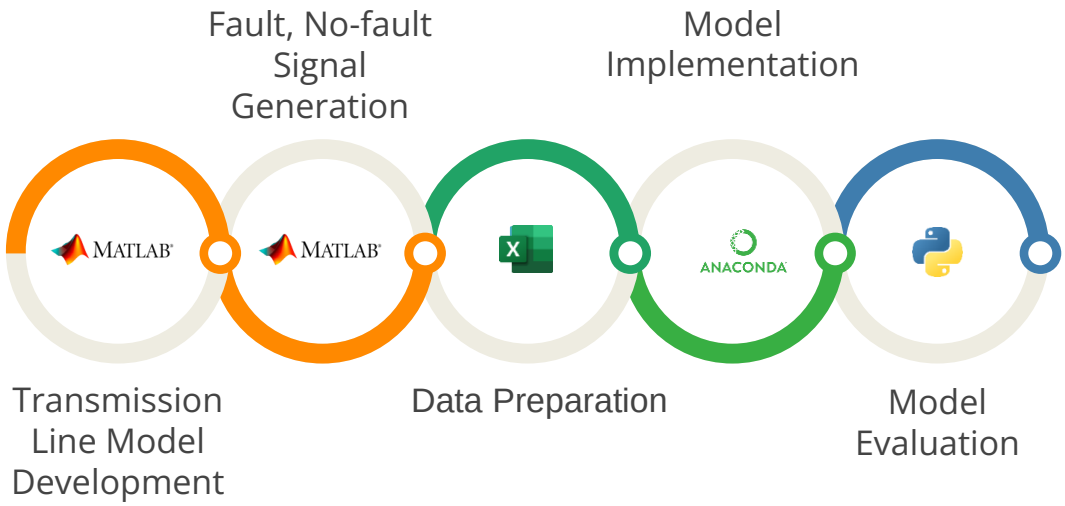
02 Maintains accuracy with noise

03 Good performance in data varieties

04 Good learning for small and big data

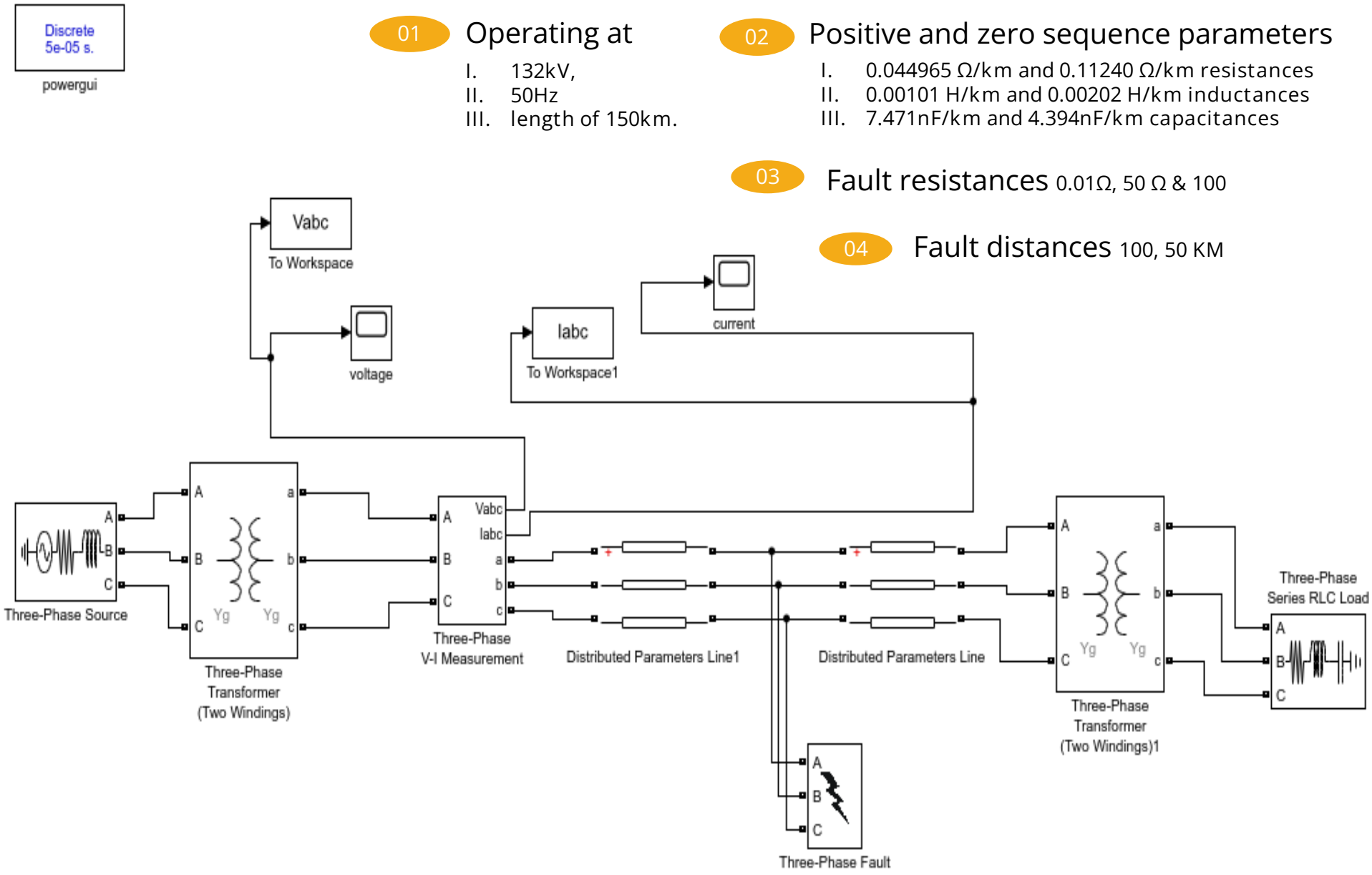
05 Explicit pre-processing of data

# Methodology



# Transmission Line Model Development

01




01 Operating at

I. 132kV,
II. 50Hz
III. length of 150km.

02 Positive and zero sequence parameters

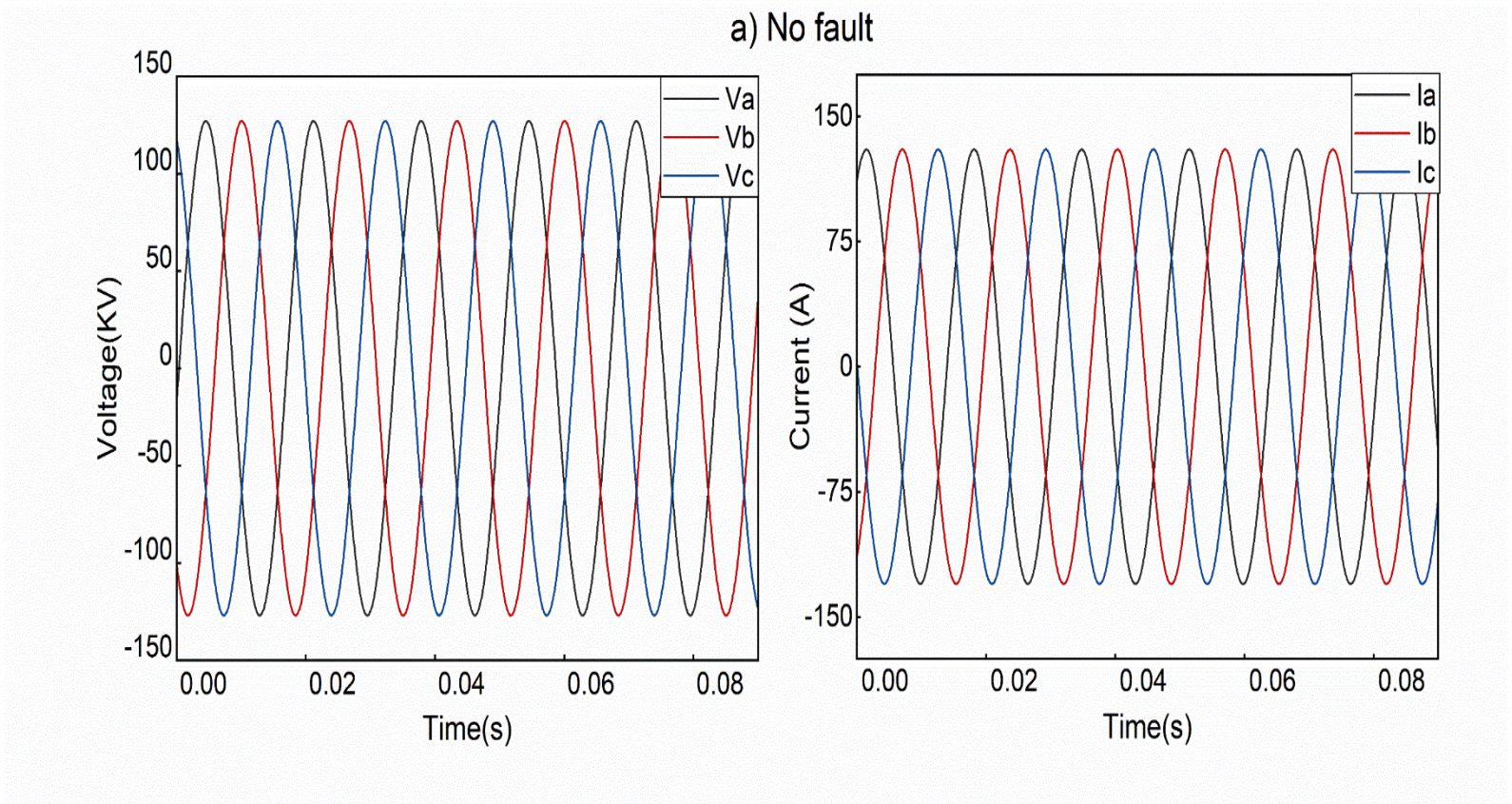
I. 0.044965 Ω/km and 0.11240 Ω/km resistances
II. 0.00101 H/km and 0.00202 H/km inductances
III. 7.471nF/km and 4.394nF/km capacitances

03 Fault resistances 0.01Ω, 50 Ω & 100

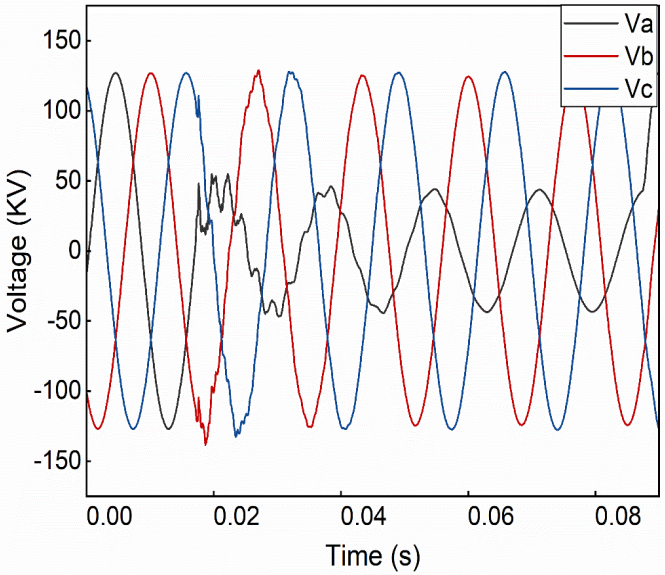
04 Fault distances 100, 50 KM

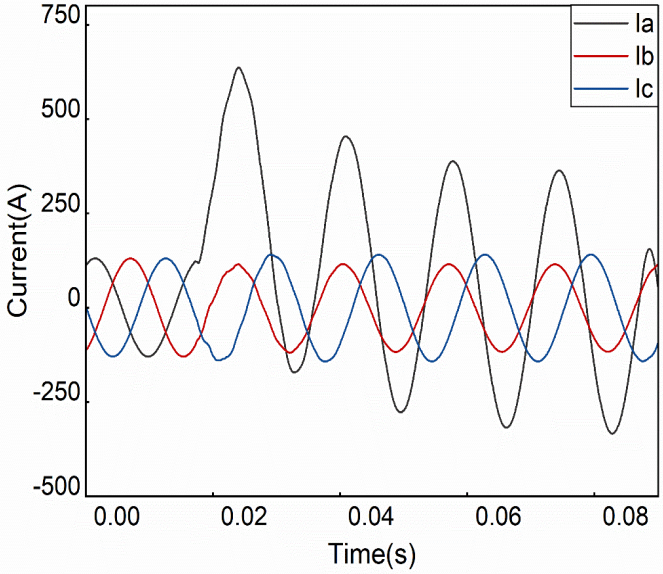
# Fault, No-fault Signal Generation

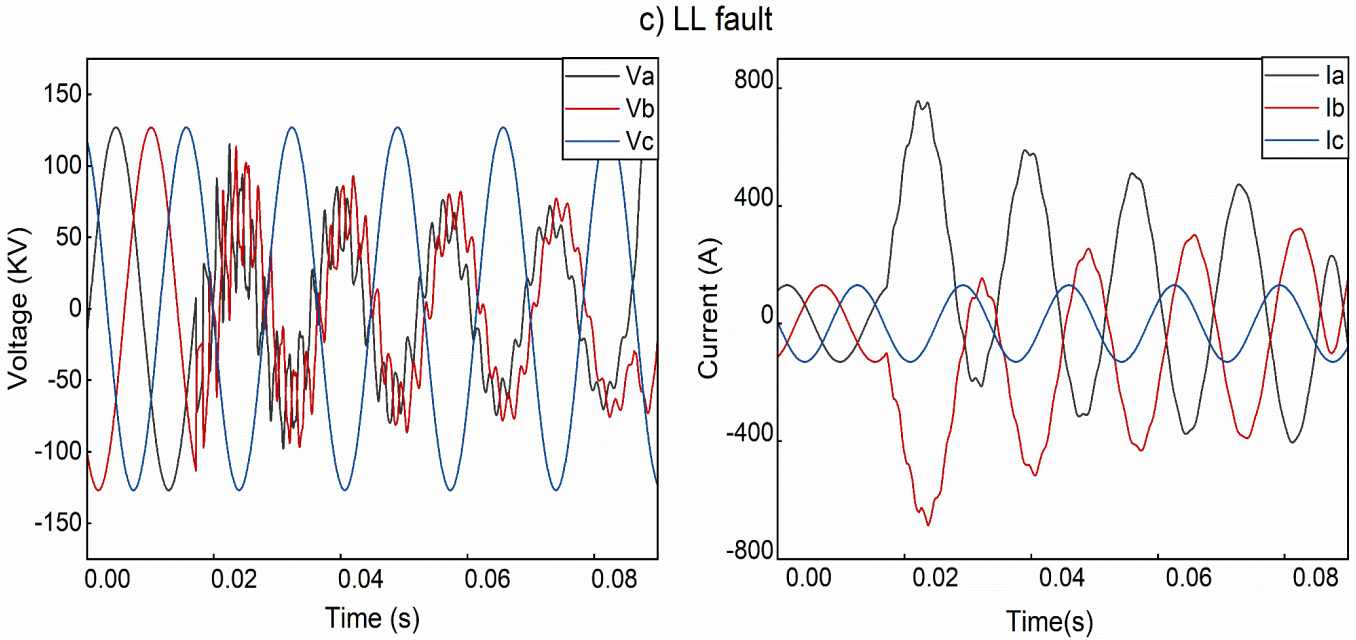
02


a) No fault
150
100
50
0
-50
-100
-150
Voltage(KV)
Va
Vb
Vc
0.00
0.02
0.04
0.06
0.08
Time(s)
150
75
0
-75
-150
Current (A)
Ia
Ib
Ic
0.00
0.02
0.04
0.06
0.08
Time(s)

b) LG fault


Va
Vb
Vc
150
100
50
0
-50
-100
-150
Voltage (KV)
0.00
0.02
0.04
0.06
0.08
Time (s)

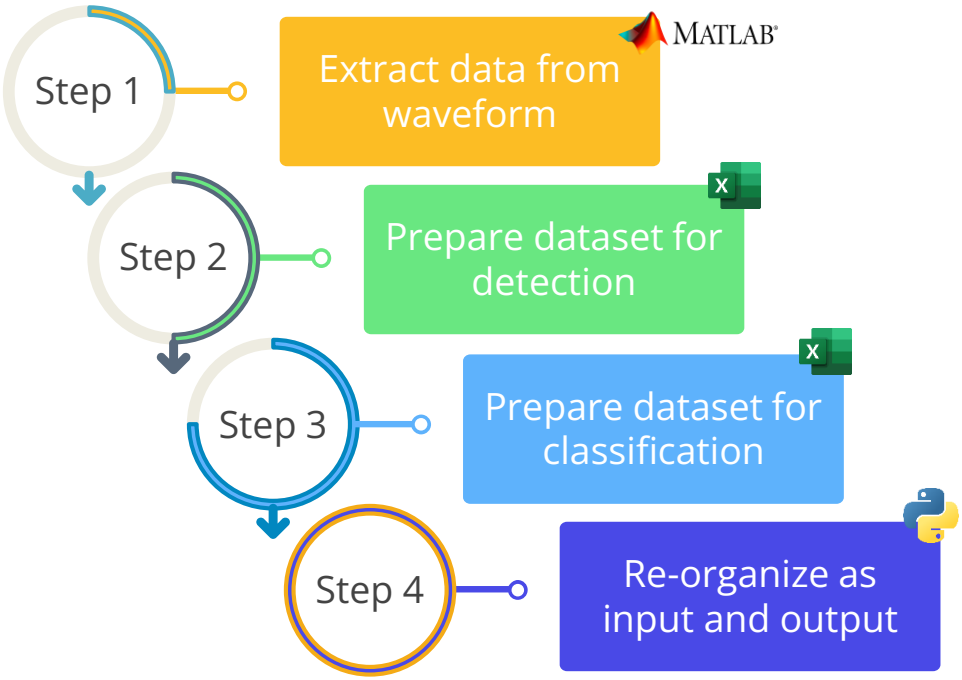

Ia
Ib
Ic
750
500
250
0
-250
-500
Current(A)
0.00
0.02
0.04
0.06
0.08
Time(s)


c) LL fault
Va
Vb
Vc
Voltage (KV)
150
100
50
0
-50
-100
-150
0.00
0.02
0.04
0.06
0.08
Time (s)
Ia
Ib
Ic
Current (A)
800
400
0
-400
-800
0.00
0.02
0.04
0.06
0.08
Time(s)

# Data Preparation

03

✓ Sampling frequency 12khz



## Detection dataset

Input

| Va | Vb | Vc | Ia | Ib | Ic | OUTPUT |
|---|---|---|---|---|---|---|
| 49.17 | - 125.96 | 76.79 | 130.1718 | -67.1407 | -63.0311 | 0 |
| 53.55 | - 126.47 | 72.92 | 130.1688 | -62.8889 | -67.2798 | 0 |
| 55.71 | - 126.66 | 70.95 | 130.0978 | -60.7291 | -69.3687 | 0 |
| 14.24 | - 125.99 | 76.76 | 135.0093 | -71.3579 | -67.2375 | 1 |
| 17.88 | - 122.97 | 76.44 | 142.1678 | -67.5876 | -71.9696 | 1 |
| 15.78 | - 123.58 | 74.05 | 146.0309 | -65.7525 | -74.3848 | 1 |

No fault

Fault

# Classification dataset

Input

Output

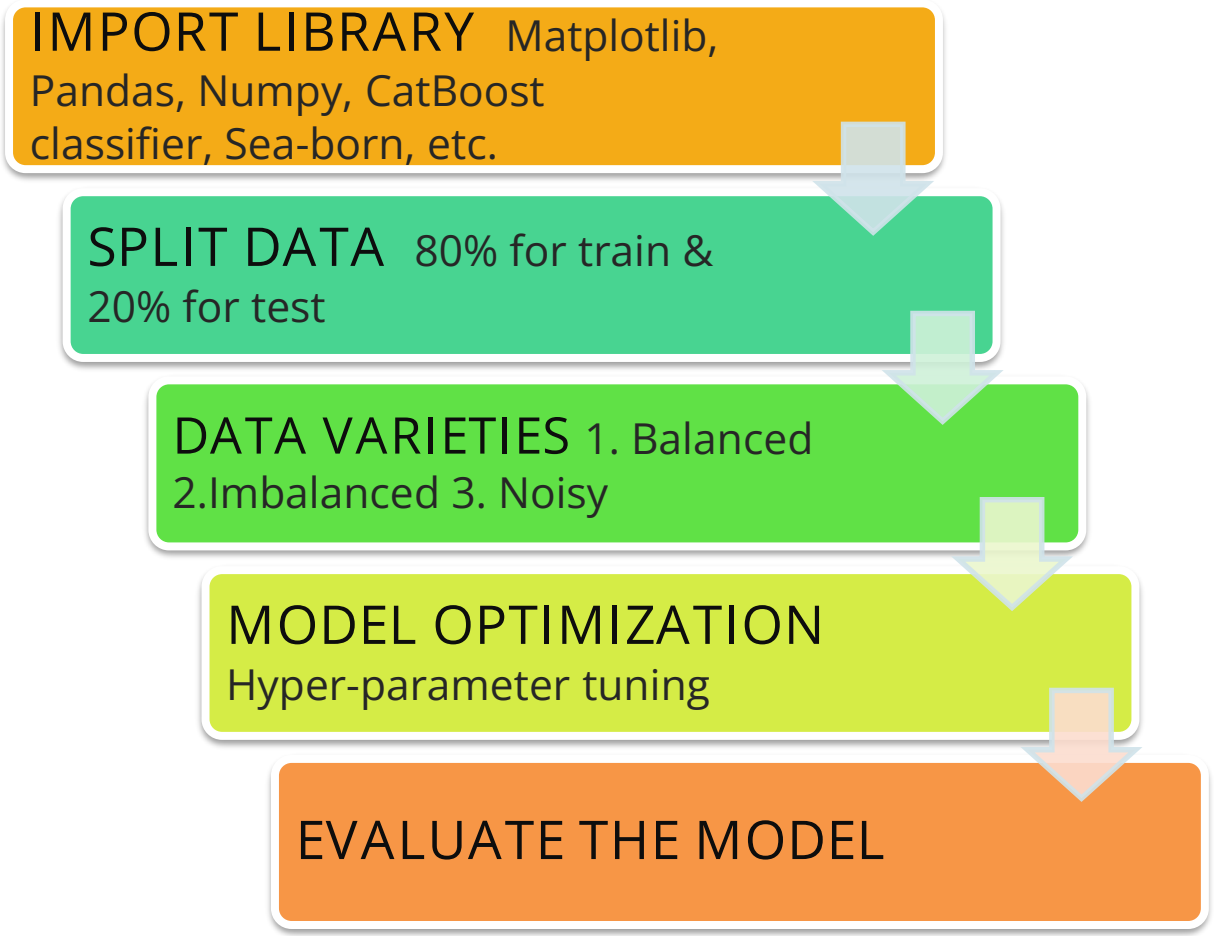
| | Va | Vb | Vc | Ia | Ib | Ic | A | B | C | G | faultType |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 49170.90541 | -125961.168300 | 76790.262910 | 130.171817 | -67.140715 | -63.031102 | 0 | 0 | 0 | 0 | 0000 |
| **1** | 53547.88759 | -126472.806200 | 72924.918580 | 130.168754 | -62.888916 | -67.279838 | 0 | 0 | 0 | 0 | 0000 |
| **2** | 55708.23313 | -126661.265900 | 70953.032720 | 130.097849 | -60.729111 | -69.368738 | 0 | 0 | 0 | 0 | 0000 |
| **3** | 59968.79332 | -126903.134700 | 66934.341370 | 129.817420 | -56.345527 | -73.471893 | 0 | 0 | 0 | 0 | 0000 |
| **4** | 64144.14075 | -126964.684200 | 62820.543410 | 129.352520 | -51.881845 | -77.470675 | 0 | 0 | 0 | 0 | 0000 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **2495** | -14967.52182 | 27368.963230 | -12401.441410 | 484.939112 | -88.531589 | -396.407523 | 1 | 1 | 1 | 0 | 1110 |
| **2496** | -17222.85093 | 18231.551560 | -1008.700629 | 477.660245 | -70.840372 | -406.819873 | 1 | 1 | 1 | 0 | 1110 |
| **2497** | -18100.79030 | 14054.227380 | 4046.562918 | 473.898117 | -61.327590 | -412.570527 | 1 | 1 | 1 | 0 | 1110 |
| **2498** | -19444.64246 | 6202.593350 | 13242.049110 | 466.062186 | -41.094758 | -424.967429 | 1 | 1 | 1 | 0 | 1110 |
| **2499** | -20291.56226 | -1070.148109 | 21361.710360 | 457.737625 | -19.381800 | -438.355825 | 1 | 1 | 1 | 0 | 1110 |

| Categorical representation | Fault type(output) |
|---|---|
| 0000 | No fault |
| 1001 | LG fault |
| 1100 | LL fault |
| 1101 | LLG fault |
| 1110 | LLL fault |

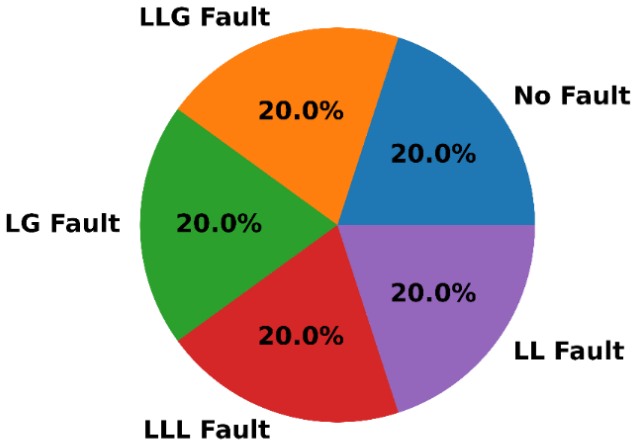
# Model Implementation

04

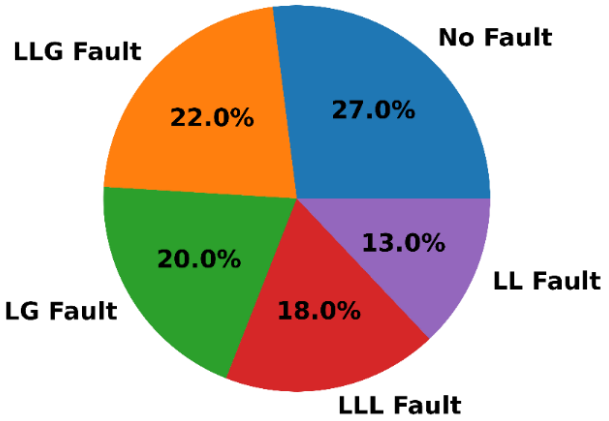
Tools
1. Python
2. Anaconda
3. Jupiter notebook



# Data state variation

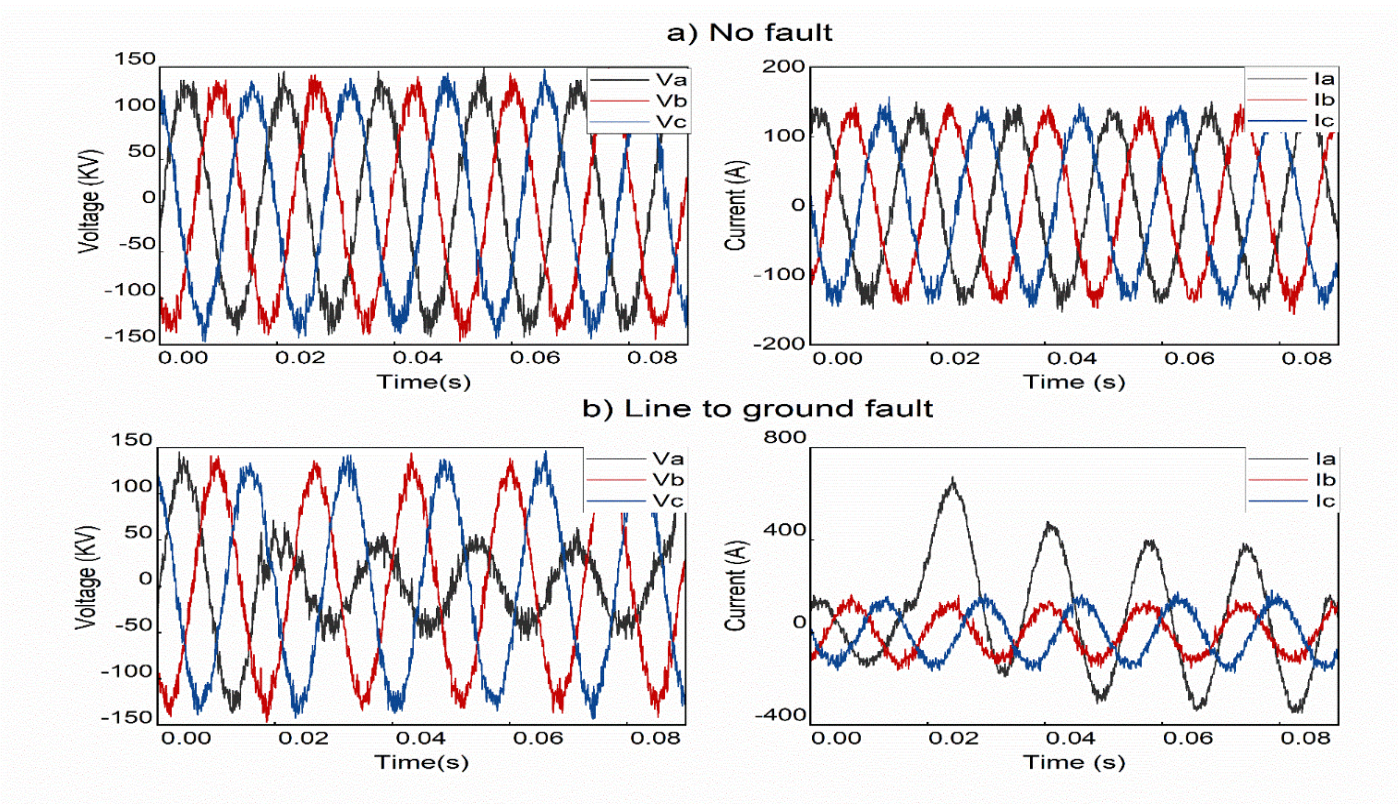



a) Balanced condition



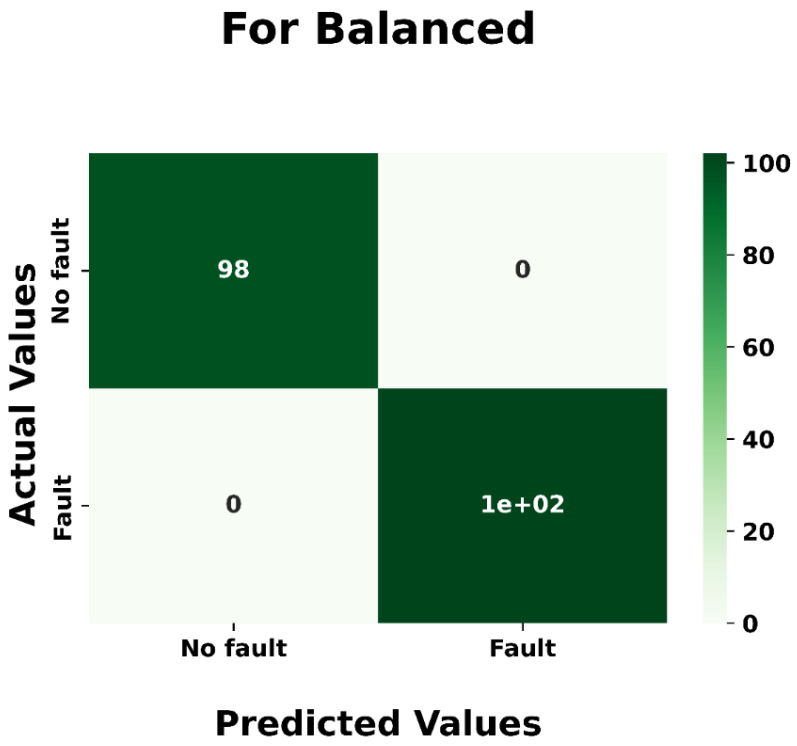

b) Imbalanced condition

- ✓ Additive White Gaussian Noise
- ✓ 37,20 dB SNR

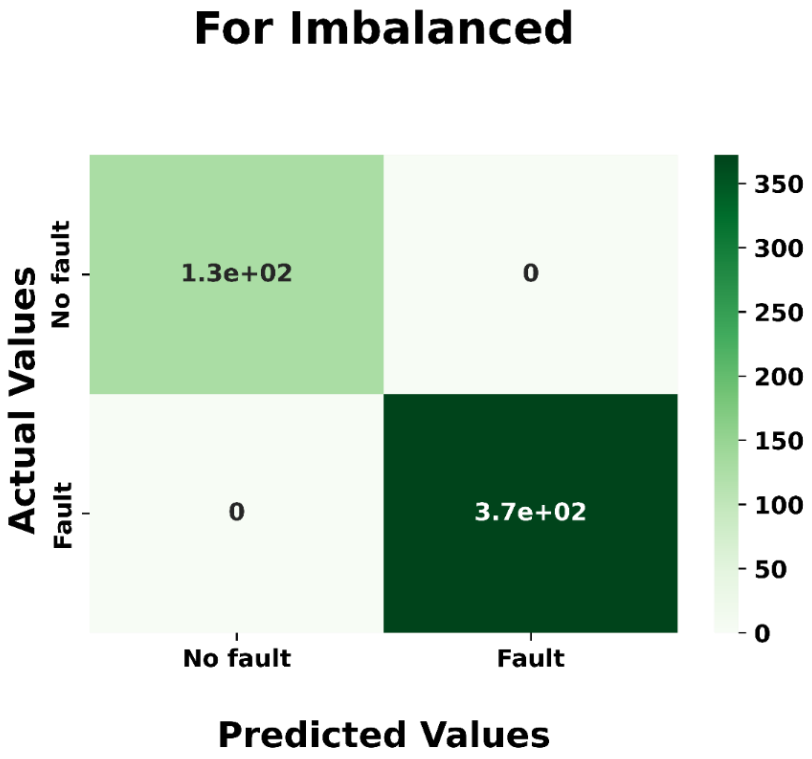



Sample waveform for noisy condition data collection

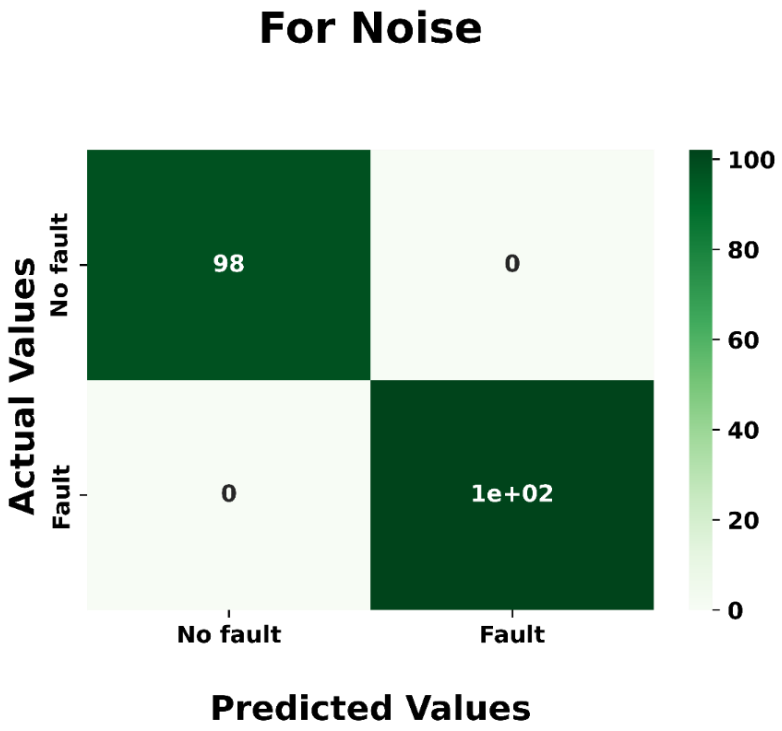
# Results (Detection)



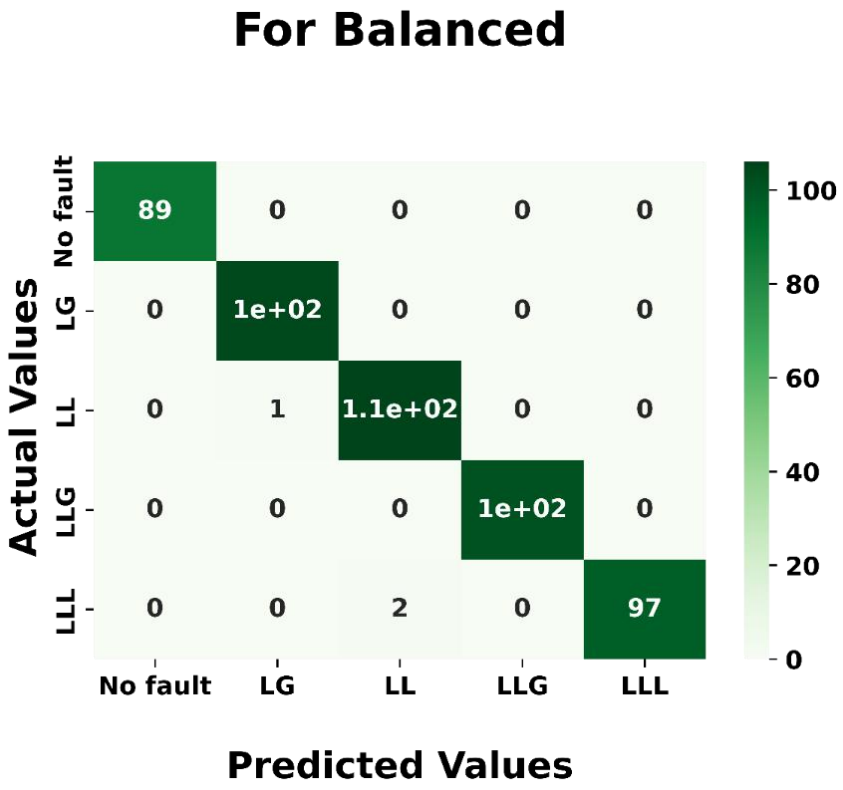
# Results (Detection)



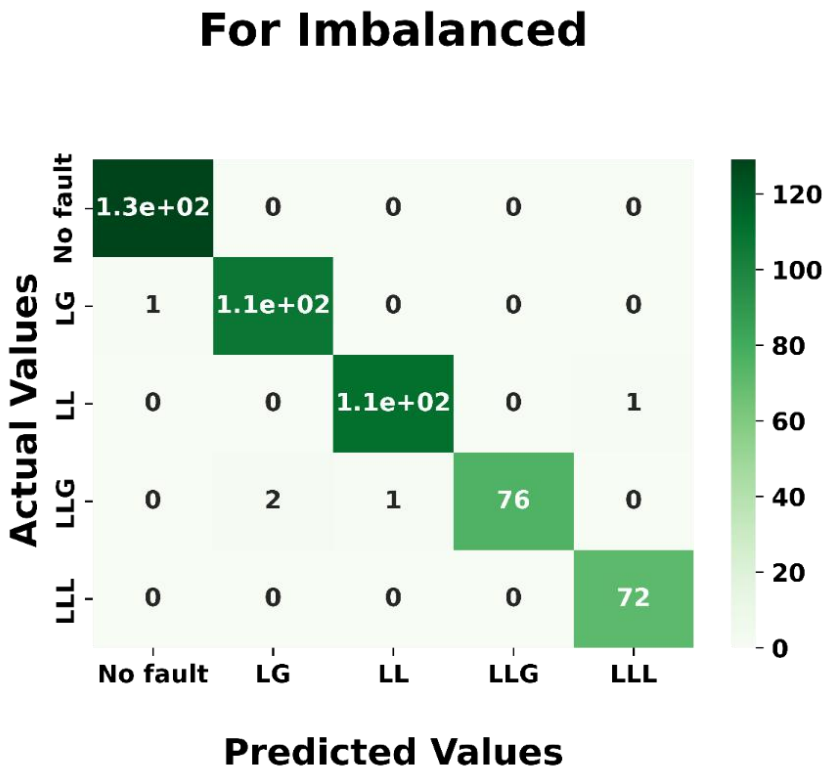
# Results (Detection)



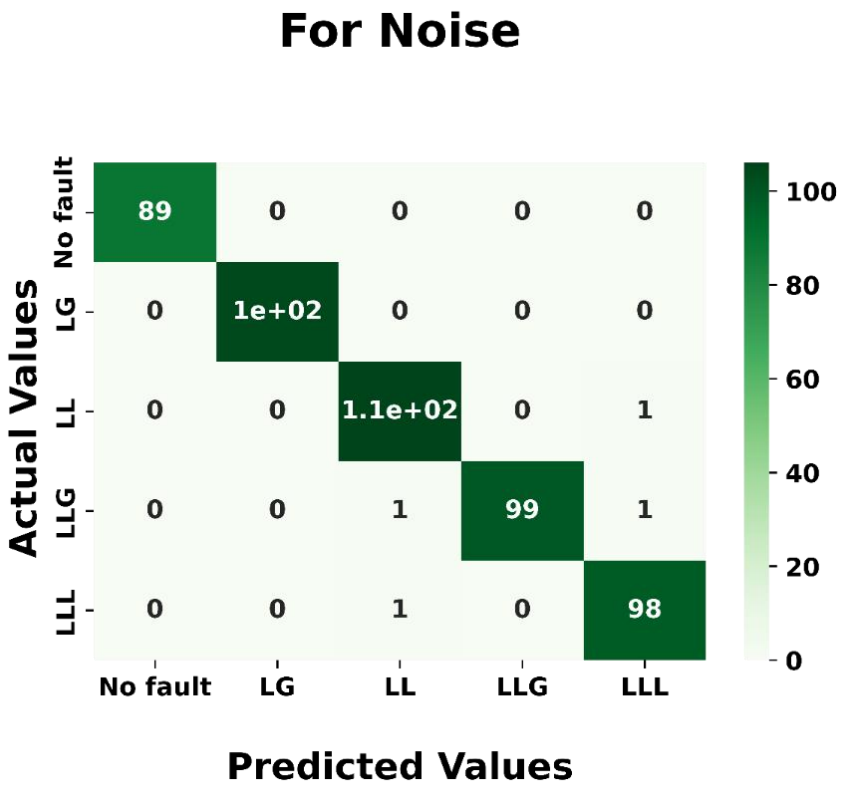
# Results (Classification)



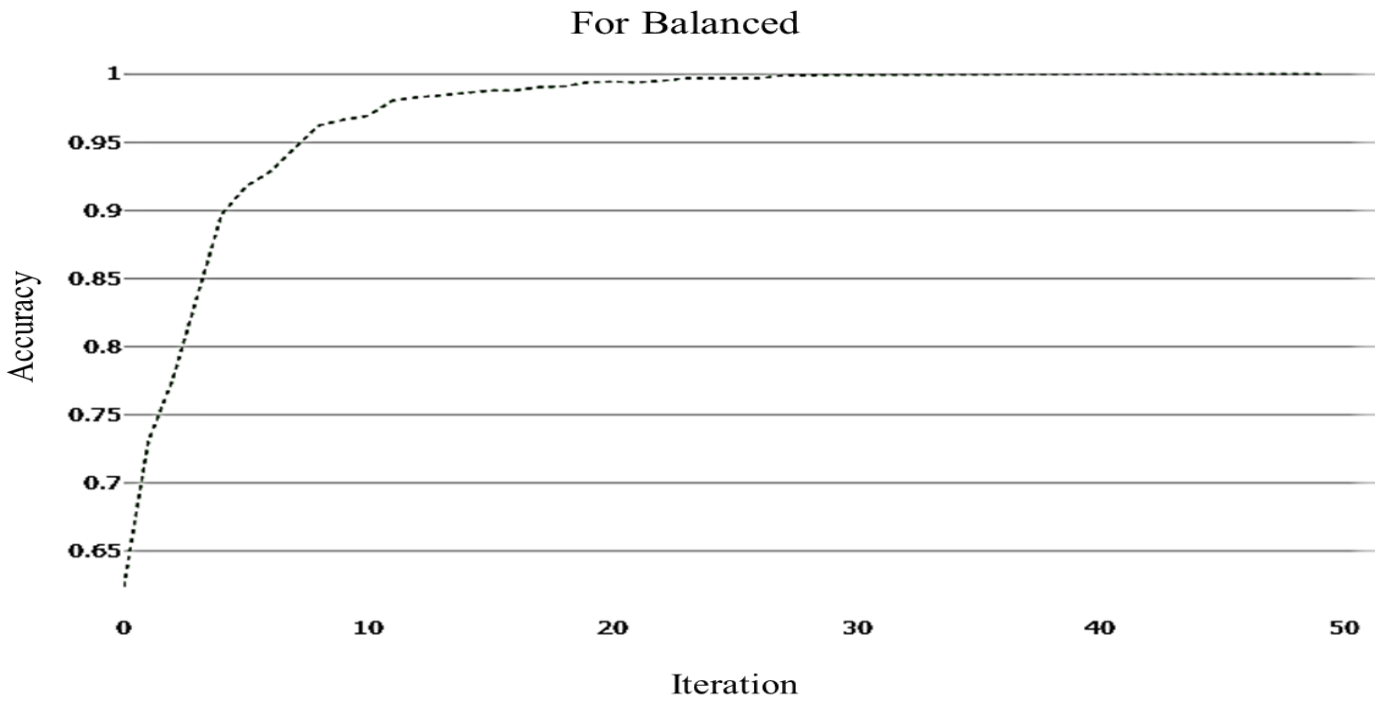
# Results Classification



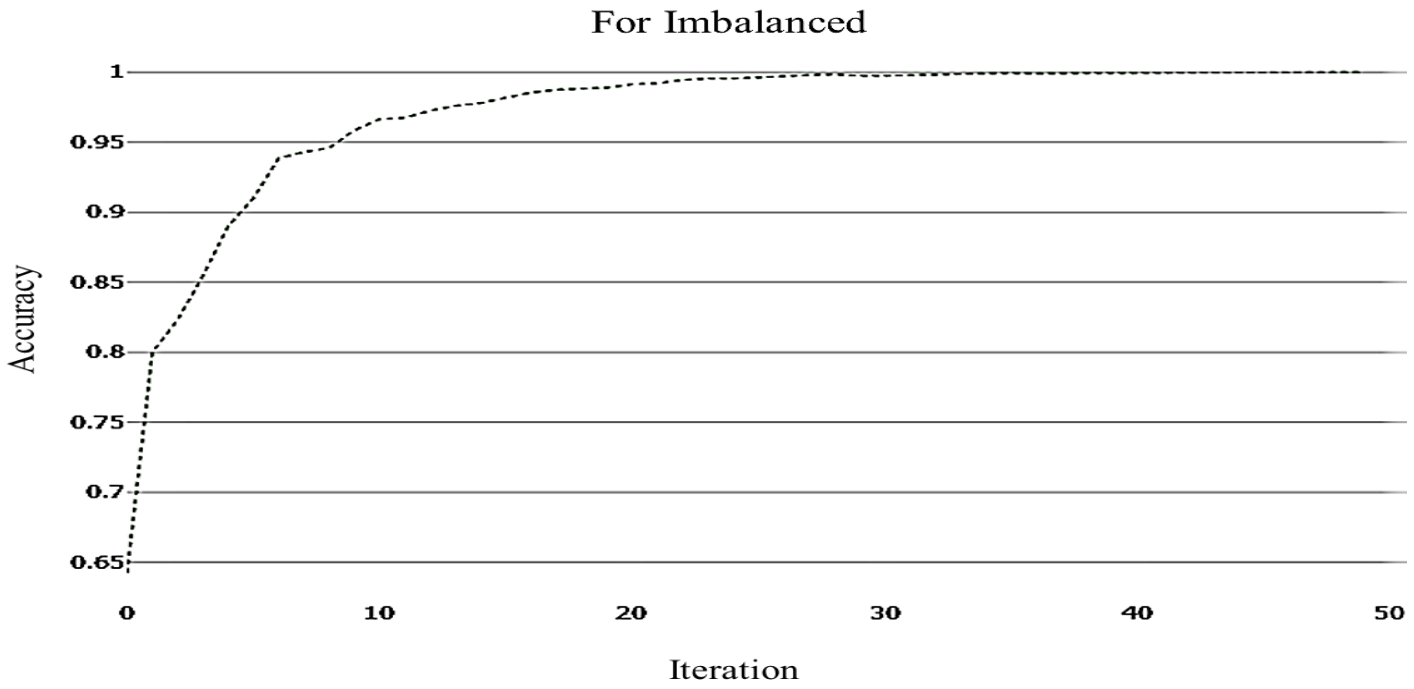
# Results Classification



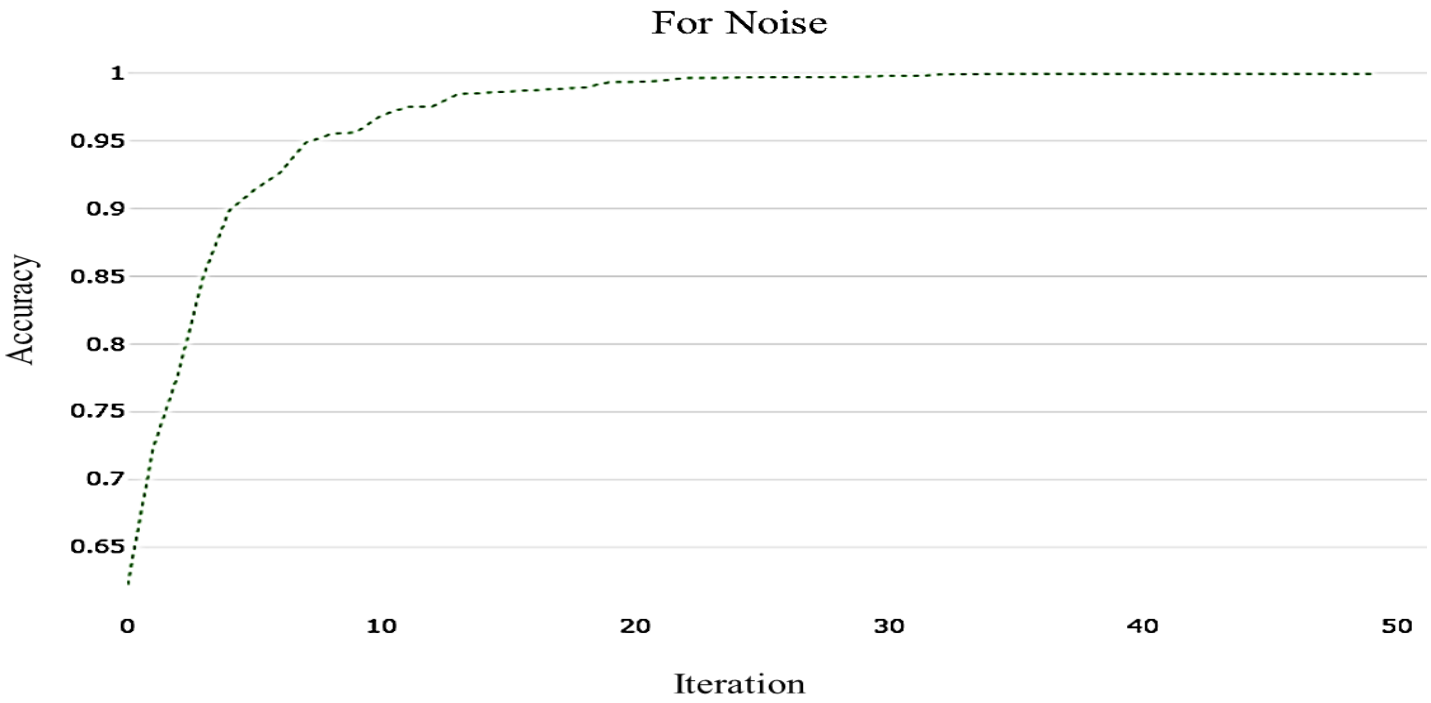
# Results (Classification)



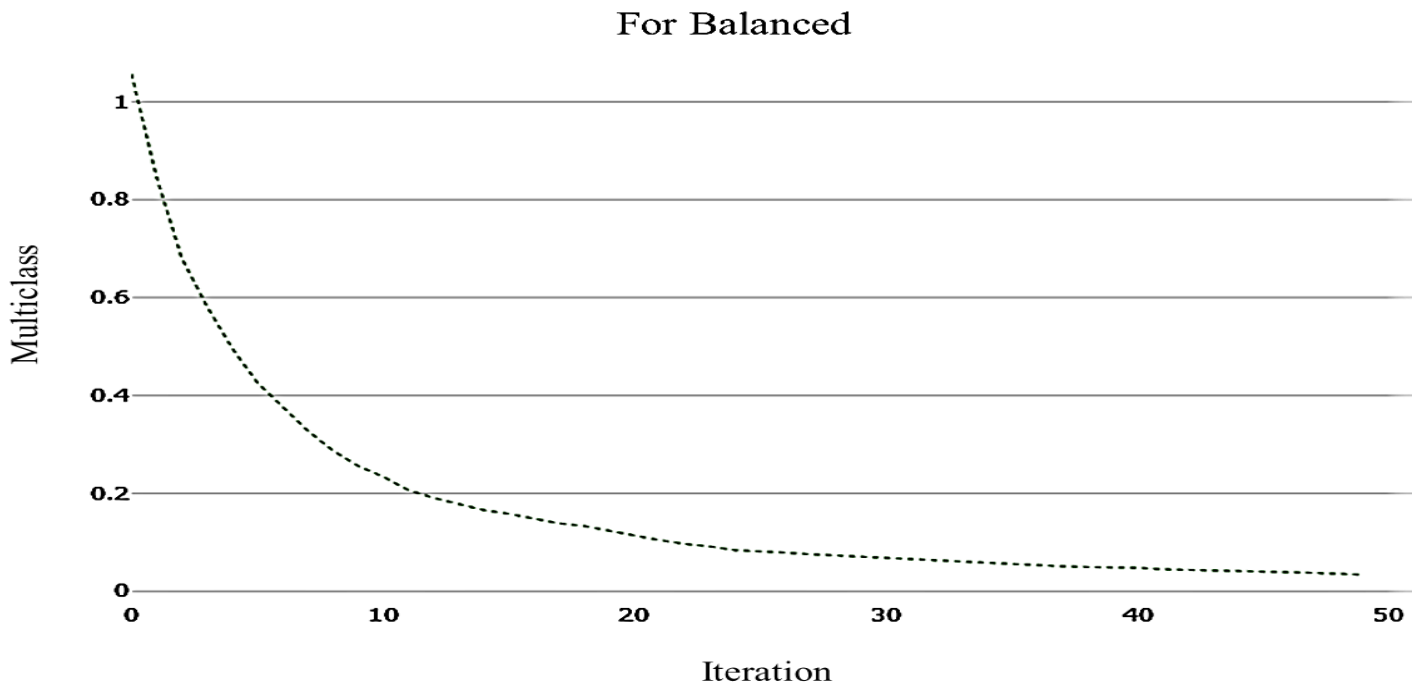
# Results Classification



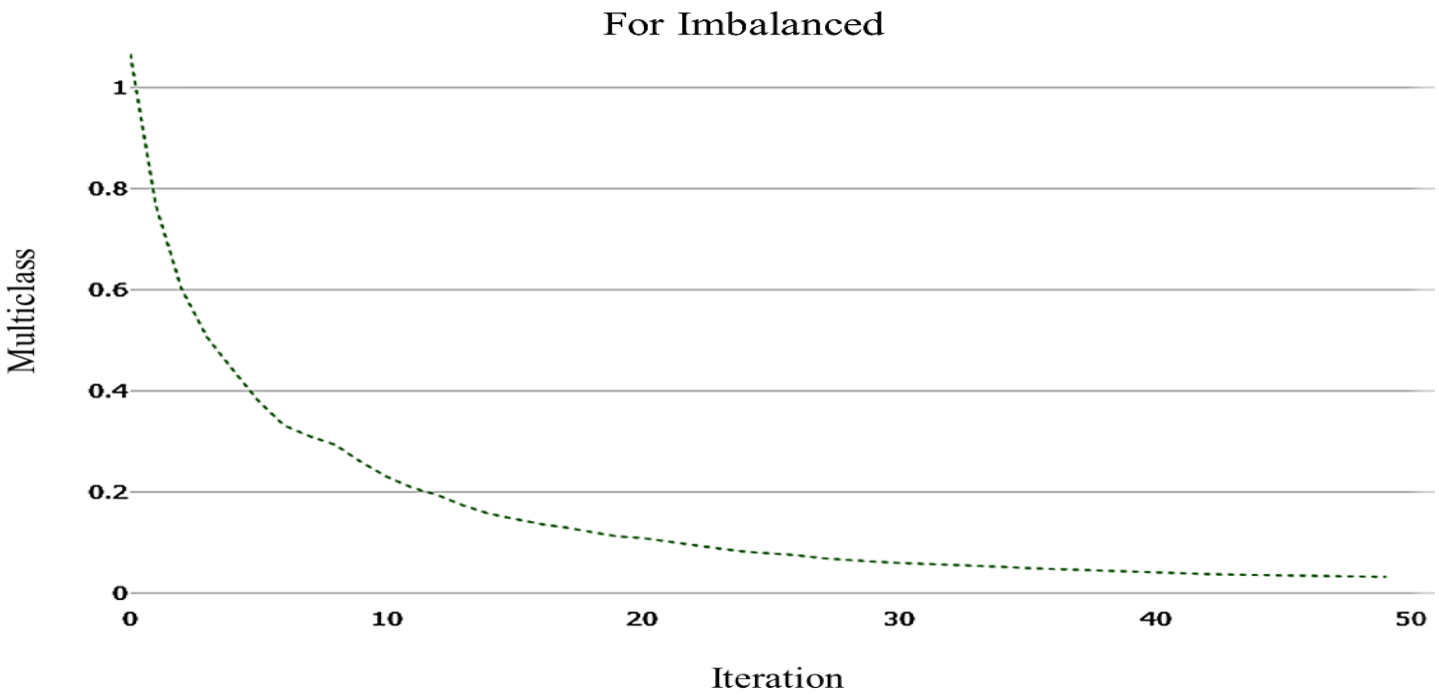
# Results Classification



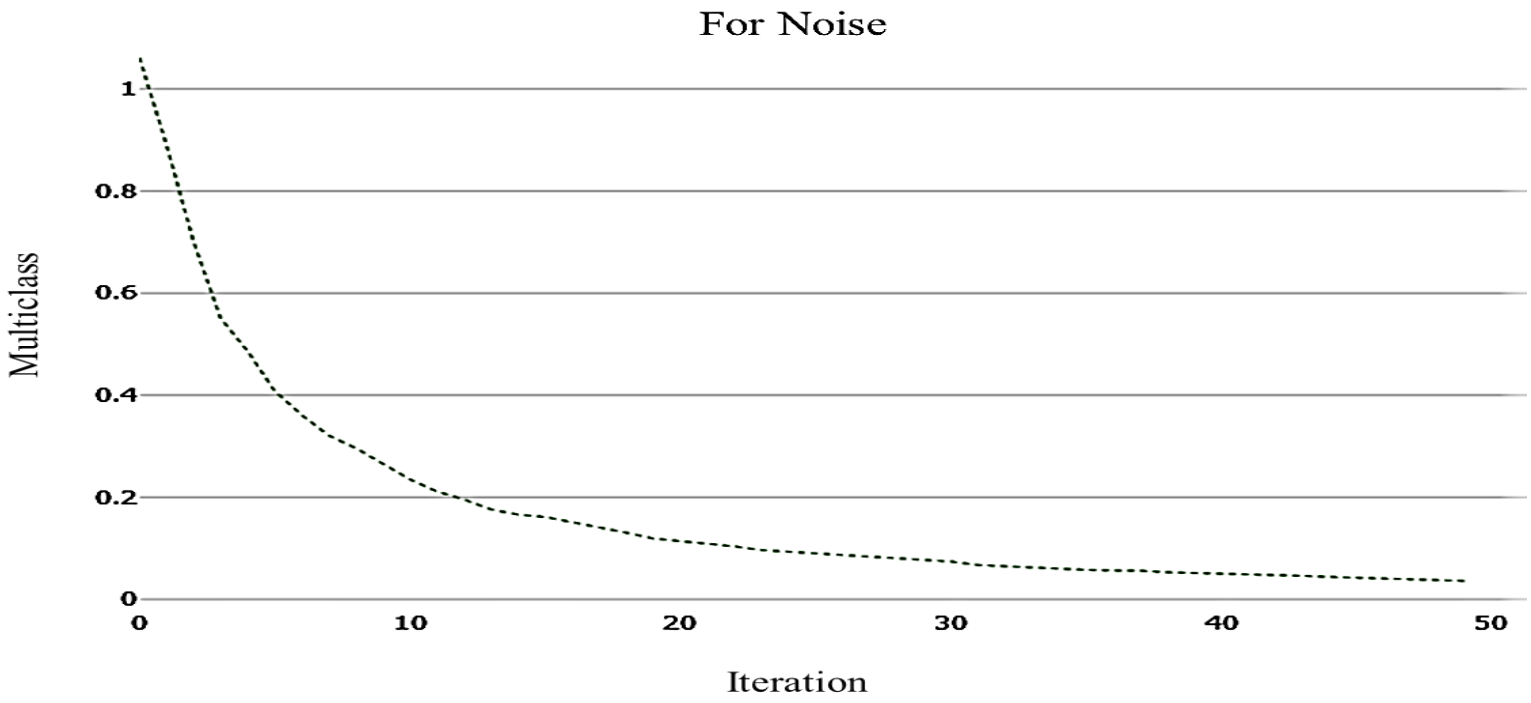
# Results Classification



# Results Classification



# Results Classification



# Discussion

01

Well-fitted

02

Good performance metrics

03

Maintains accuracy

Table 1: Performance measurement metrics

| Task | Data type | Precision | Recall | F1 | Accuracy |
|---|---|---|---|---|---|
| Detection | Balanced | 1 | 1 | 1 | 1 |
| | Noise | 1 | 1 | 1 | 1 |
| | Imbalanced | 1 | 1 | 1 | 1 |
| Classification | Balanced | 0.99 | 0.99 | 0.99 | 0.99 |
| | Noise | 0.99 | 0.99 | 0.99 | 0.99 |
| | Imbalanced | 0.99 | 0.99 | 0.99 | 0.99 |

Table 2: Comparison with some reviewed literature

| Method | Input | Data Size | Noise Immunity | Accuracy | Operating condition Variation | Data Variation Check |
|---|---|---|---|---|---|---|
| DWT-ANN | Current | 48,396 | Yes, but impact on accuracy | 99.3% | Fault resistance are 0, 20 Ω, 100 Ω and 1000 Ω | Not mentioned |
| SAT-CNN | Voltage and Current | 228,690 | 97% accuracy at 10 dB SNR | 99.58% | Not mentioned | Not mentioned |
| BPNN | Voltage and Current | 1188 | Not mentioned | 97.3% | Not mentioned | Not mentioned |
| **Proposed CatBoost Classifier** | **Voltage and Current** | **2500** | **99% accuracy at 20, 37 dB SNR** | **99%** | **Fault resistance are 0.01, 0.01, 50, 100 ohm, Fault distance are 50,100 Km** | **99% accuracy** |

- Abdullah, A. Ultrafast Transmission Line Fault Detection Using a DWT-Based ANN. *IEEE Trans. on Ind. Applicat.* 2018, *54*, pp. 1182–1193.

- Fahim, S.R.; Sarker, Md.R.I.; Arifuzzaman, Md.; Hosen, Md.S.; Sarker, S.K.; Das, S.K. A Novel Approach to Fault Diagnosis of High Voltage Transmission Line - A Self Attentive Convolutional Neural Network Model. In Proceedings of the 2020 IEEE Region 10 Symposium (TENSYMP); IEEE: Dhaka, Bangladesh, 2020; pp. 1329–1332.

- Jamil, M.; Sharma, S.K.; Singh, R. Fault Detection and Classification in Electrical Power Transmission System Using Artificial Neural Network. *SpringerPlus* 2015, *4*, 334.

# Conclusions

01 No explicit data processing

02 High time performance

03 100% accuracy in detection

04 99% in classification

05 Maintains accuracy in data varieties

06 Resilient towards operating conditions

# Future Research

01 More optimized by real-world applications

02 Design protective system based on ML

03 Advanced computation technology

Questions?

Thank You!