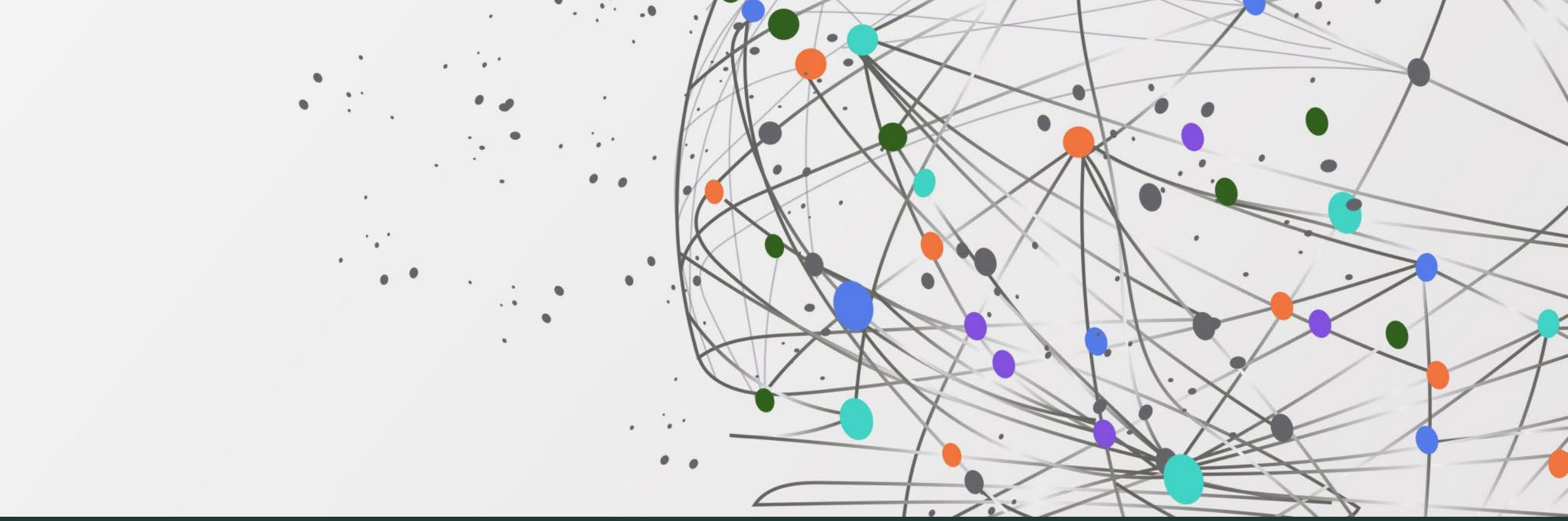
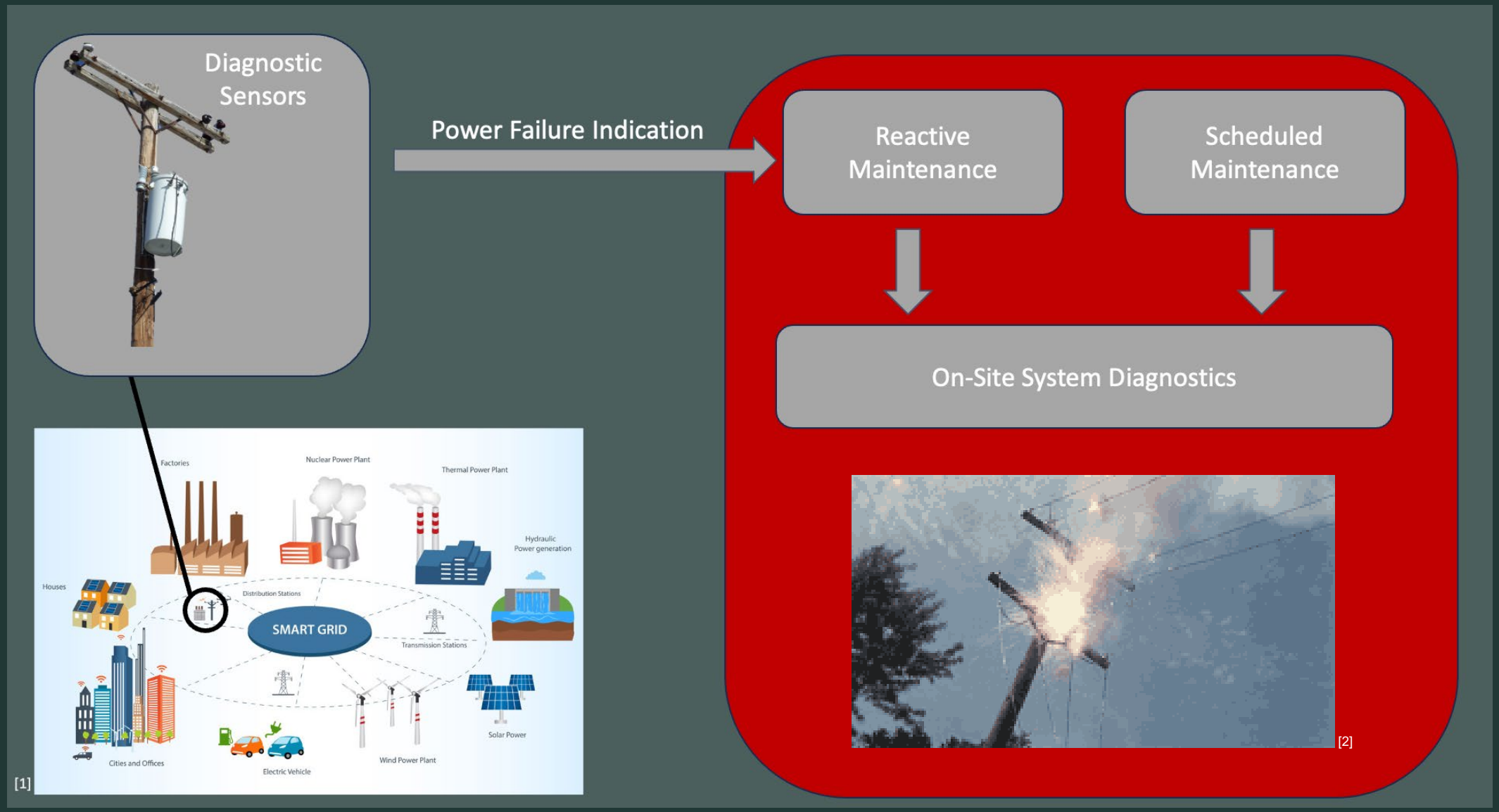


GPT -like Attention Mechanisms for Power Transformer Condition Monitoring and Prognostics

Mentor: Yufei Tang, Ph.D.

Raul Mendy, Aira Torres, Joseph Accurso

Research Objectives



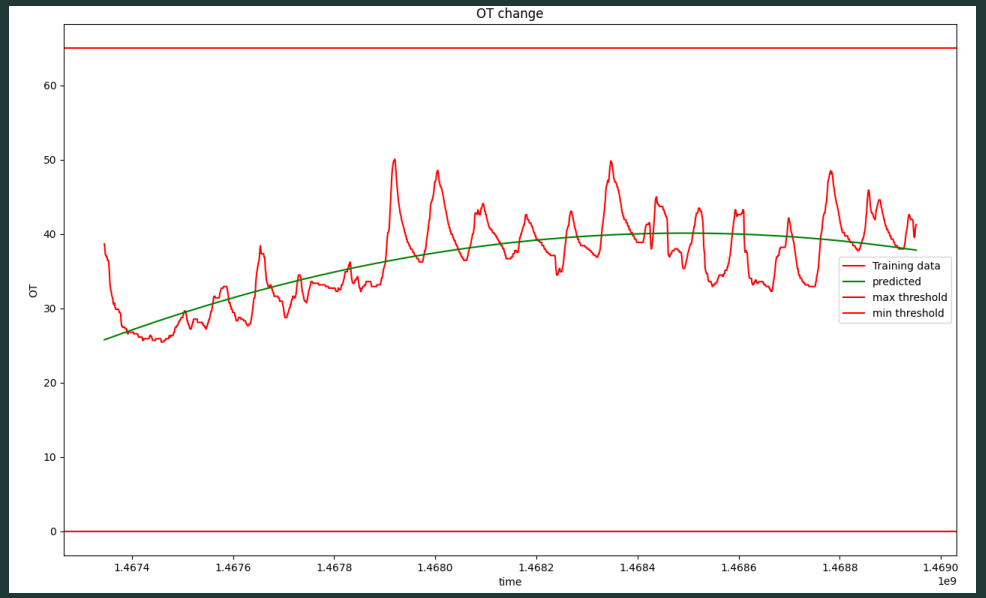
REMAINING USEFUL LIFE MODEL

Remaining Useful Life

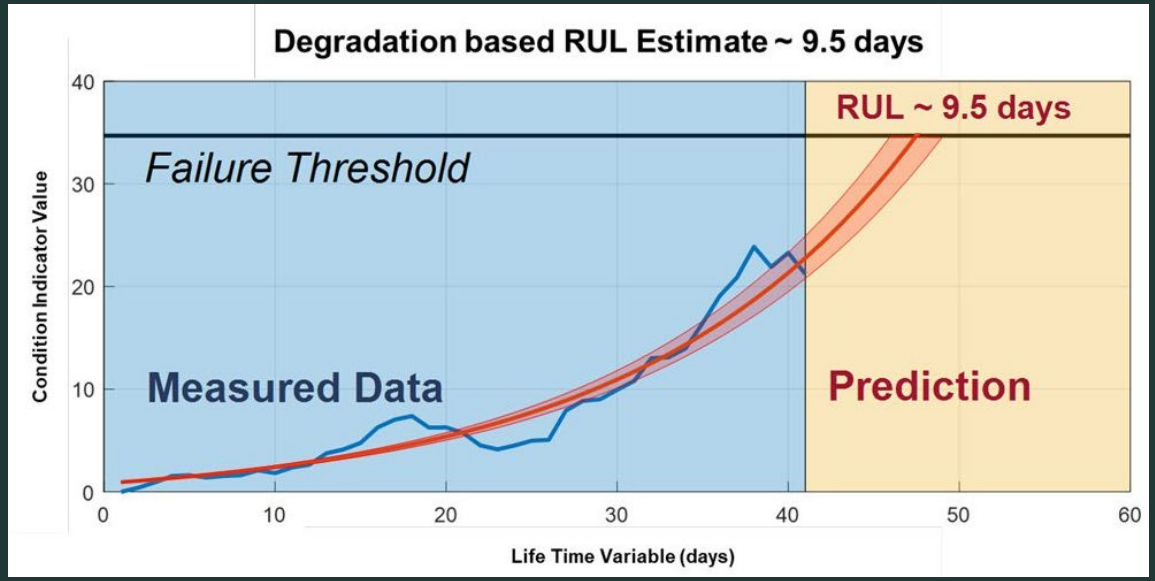
- ETTm1 & ETTm2
- 2 power transformers
- Change in oil temp for 2 years
- Degradation-based RUL model
- Min and max threshold values
- Estimates # of days until maintenance is required

Machine Learning Model:

- Polynomial Regression



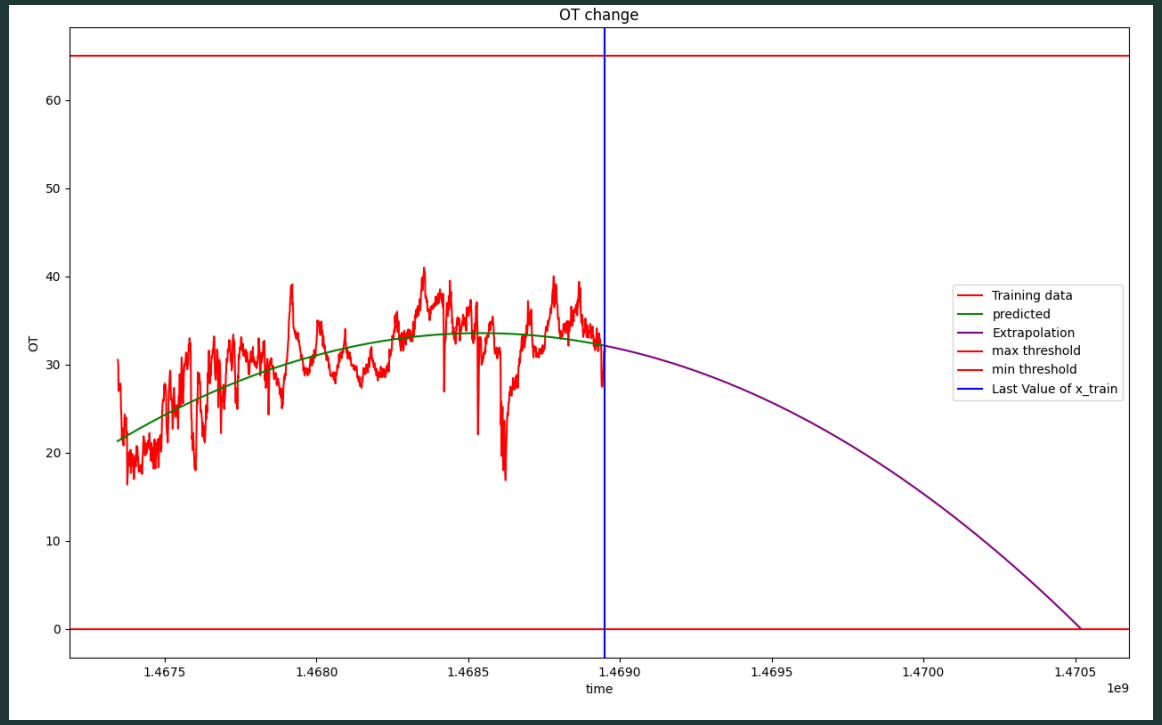
ETTm2:MONTH 1



Remaining Useful Life Results

Case 1: Decreasing prediction line

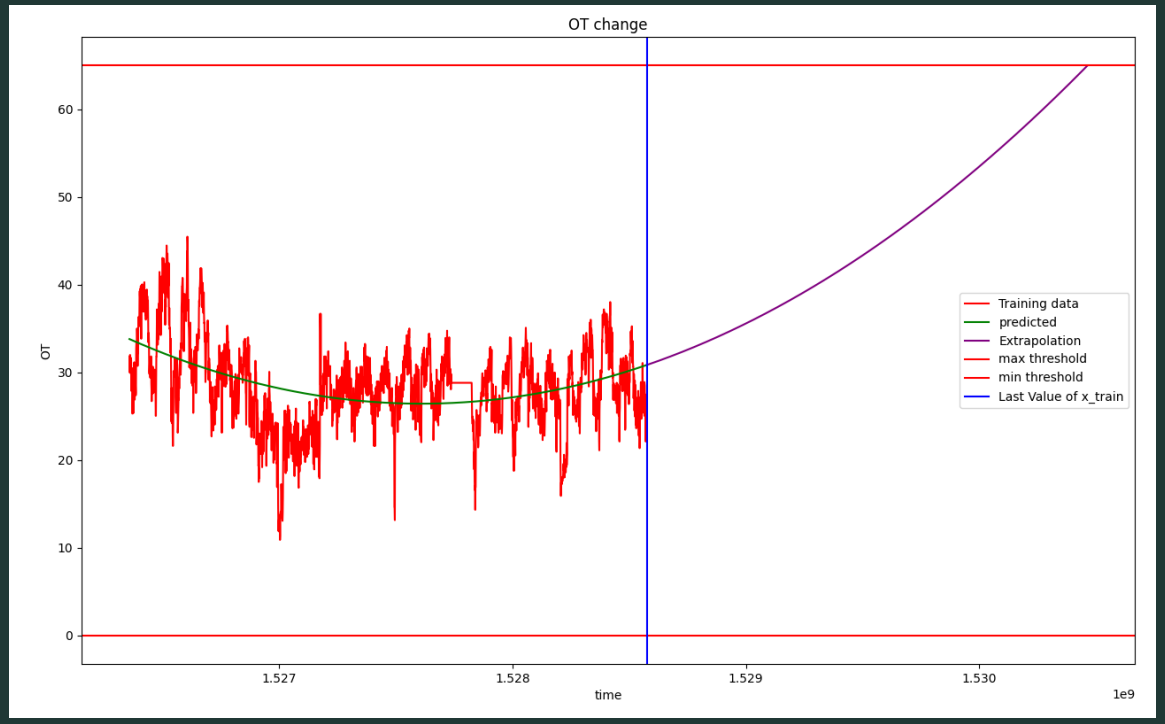
Month 1: M1 dataset



RUL = 18 DAYS

Case 2: Increasing prediction line

Month 24: M2 dataset



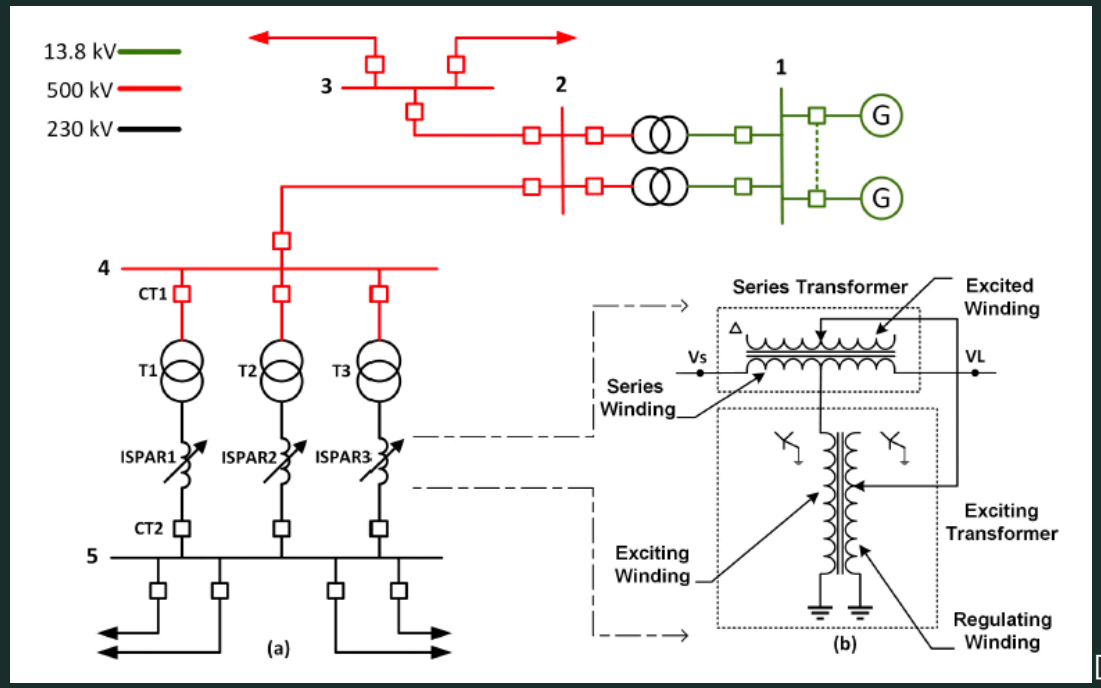
RUL = 22 DAYS

MULTI -CLASS CLASSIFICATION MODEL

Fault Classification Dataset

- Text File Format
- ~110,000 Simulated Examples
- 45 Fault Classes
- 3 Phases
- 726 Measurements per Phase

- Normalized to ~390,000 Examples
- ~850,000,000 Total Measurements



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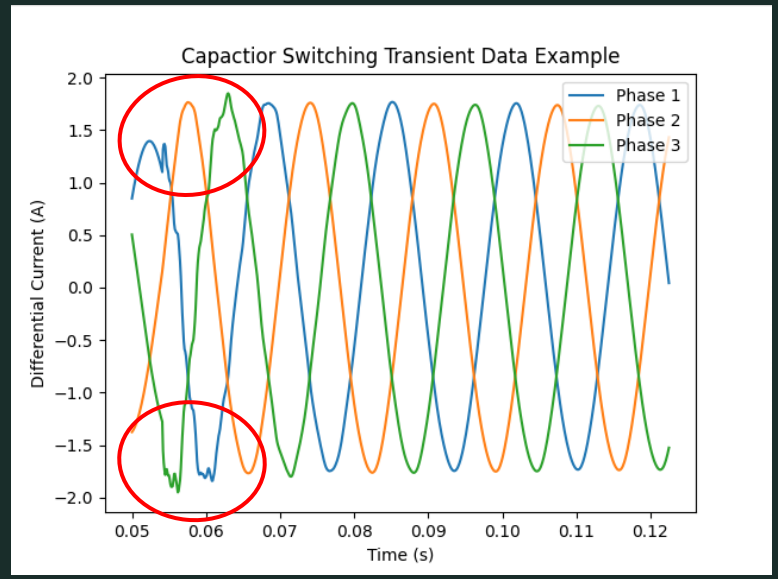
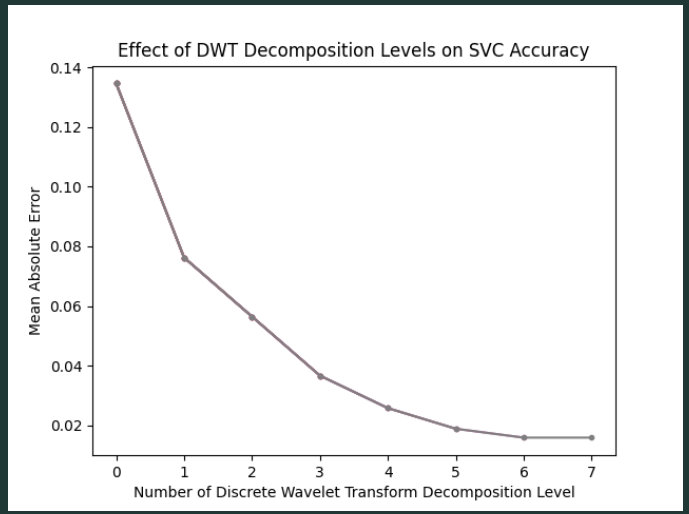
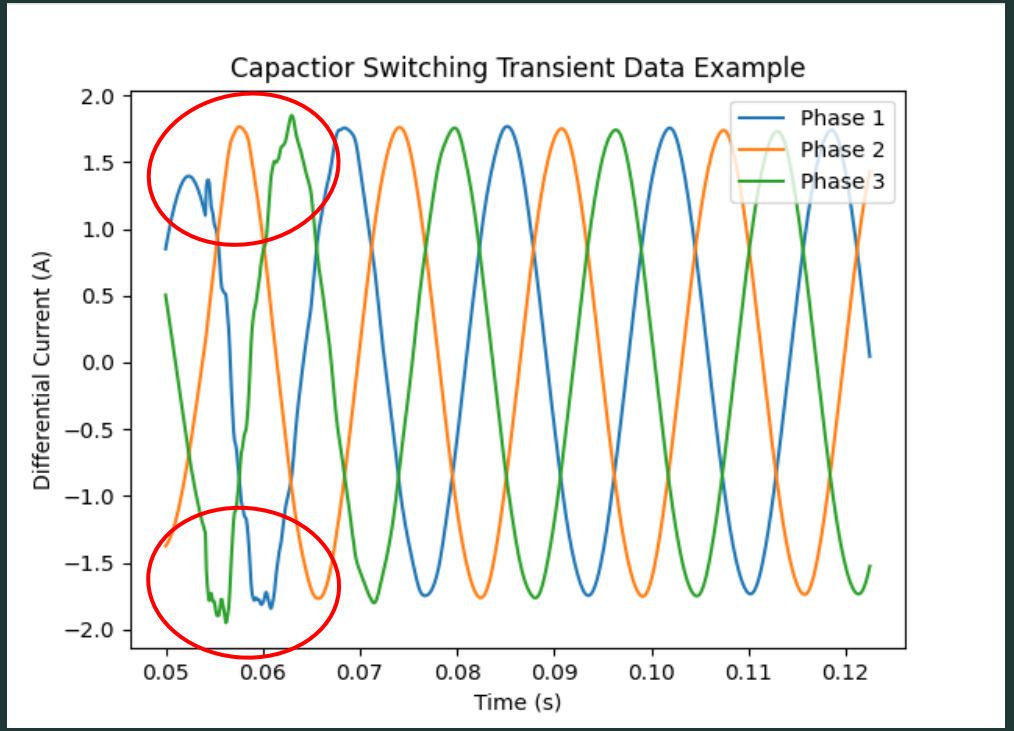


Fault Classification
Using Machine Learning

- Discrete Wavelet Transform Decomposition
  - Daubechies 2 Wavelet
  - 3 – 5 Decomposition Levels
- Random Forest
- Gradient Boost
- Support Vector Machine





Fault Classification
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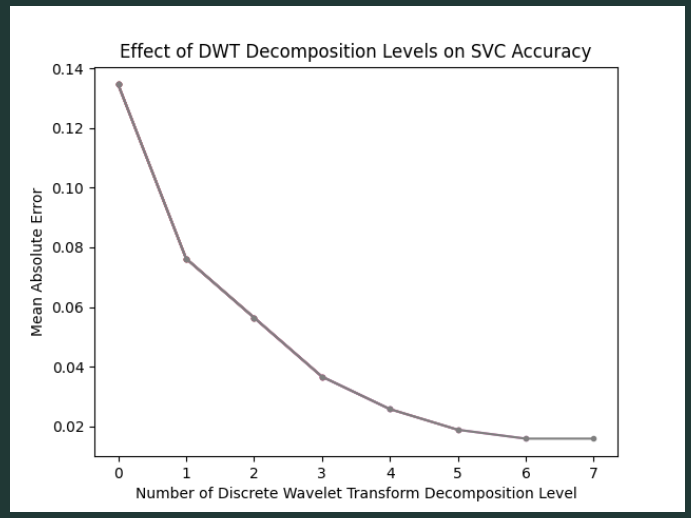
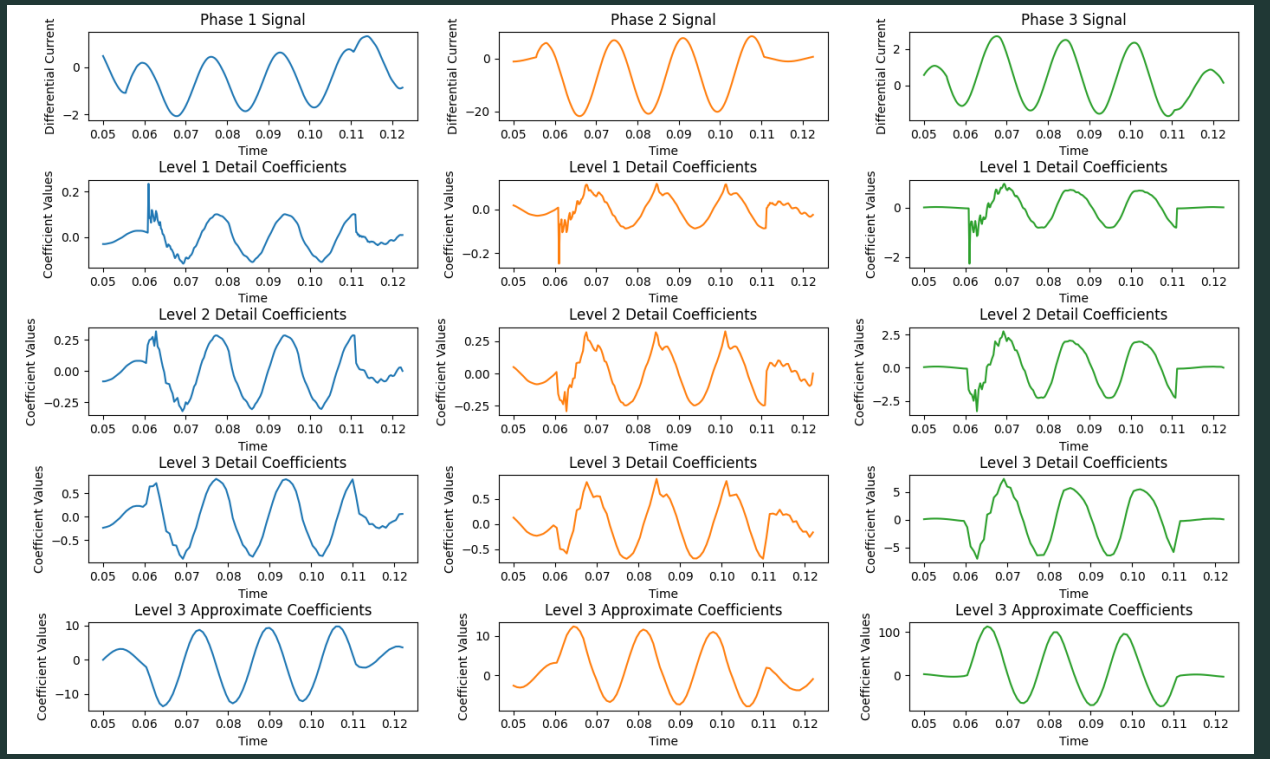
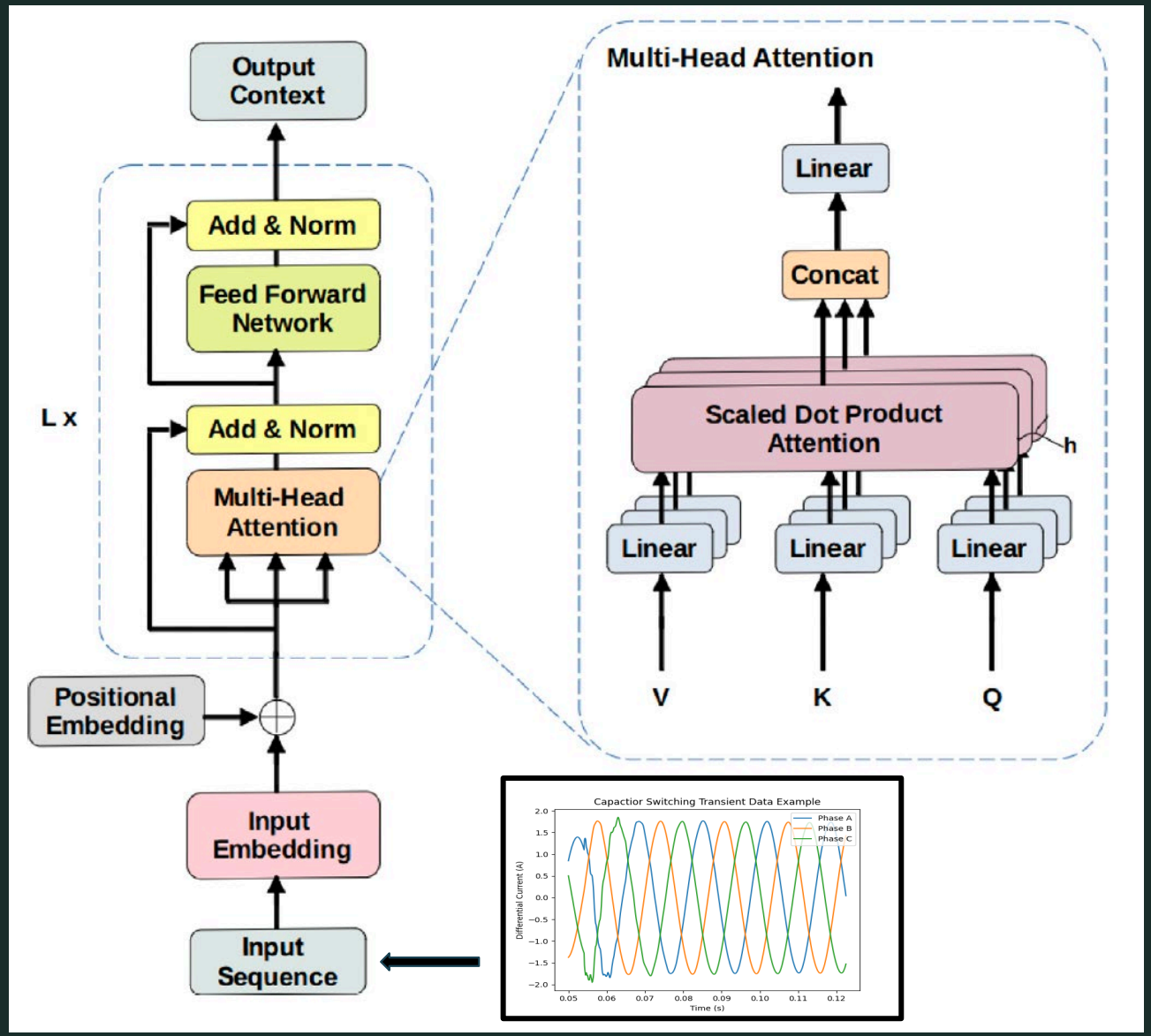




Fault Classification Using the Transformer Architecture

- Foundational architecture of Chat-GPT
- Signal analysis within positional context
- Multi-head attention mechanism
- No need for time-consuming DWT decomposition-based feature extraction



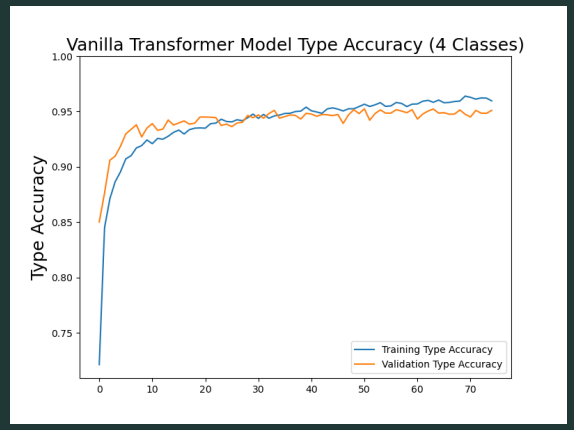
Fault Classification Results

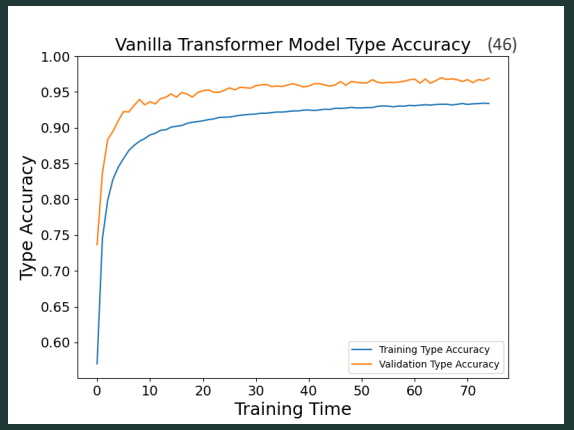
Machine Learning Models

Model Type	# Classes	Accuracy	Training Time
Random Forest	2	92%	7 minutes
Gradient Boost	2	91%	20 minutes
SVC	2	98%	5 minutes
SVC	4	92%	2 hours

Transformer Architecture

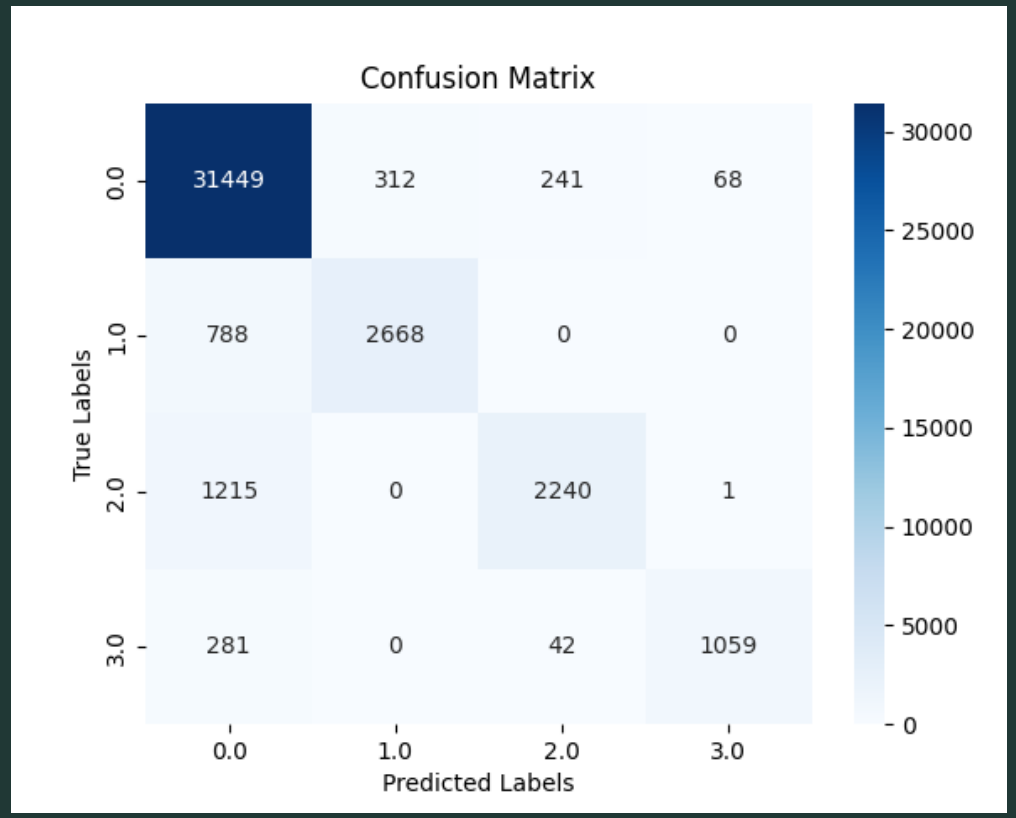
Model Type	# Classes	Accuracy	Training Time
Transformer Arch.	4	95%	30 minutes
Transformer Arch.	46	97%	5 hours



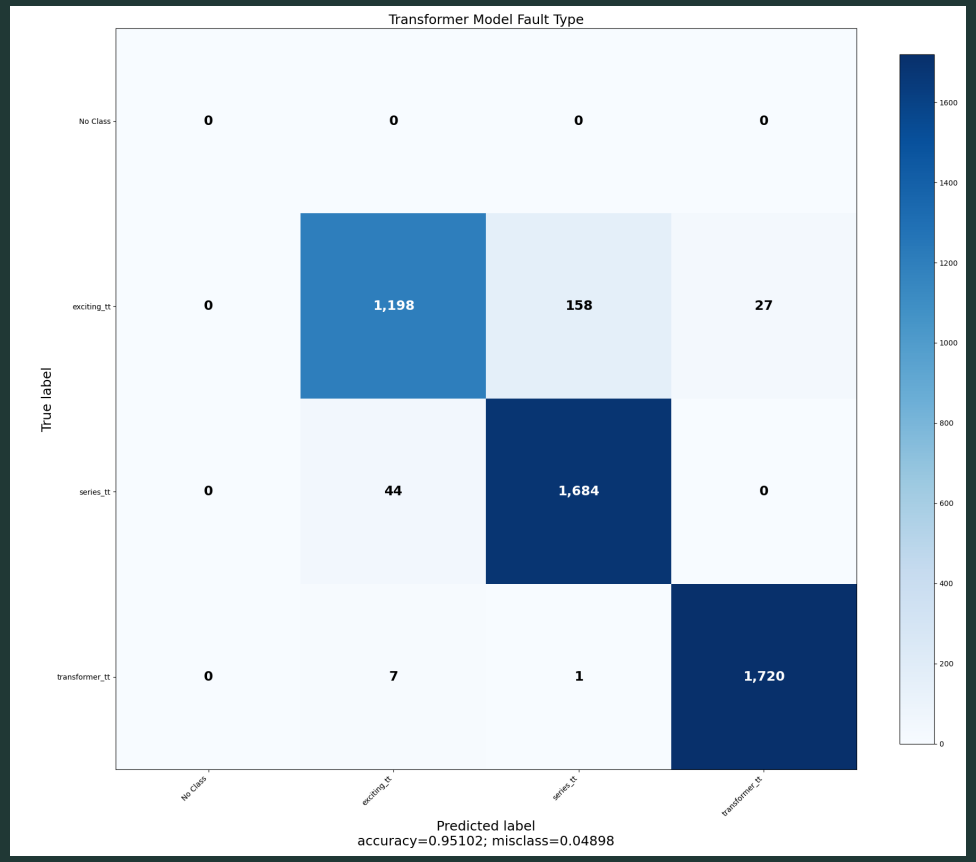


Confusion Matrices

Support Vector Classification

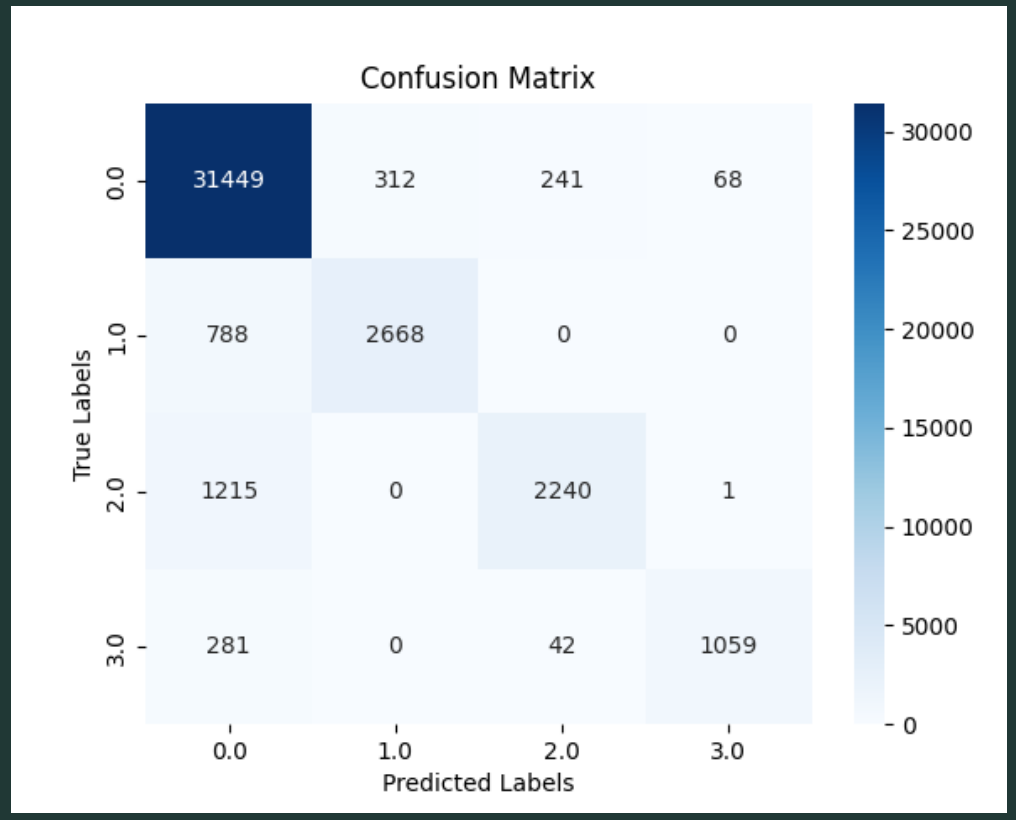


Transformer Architecture

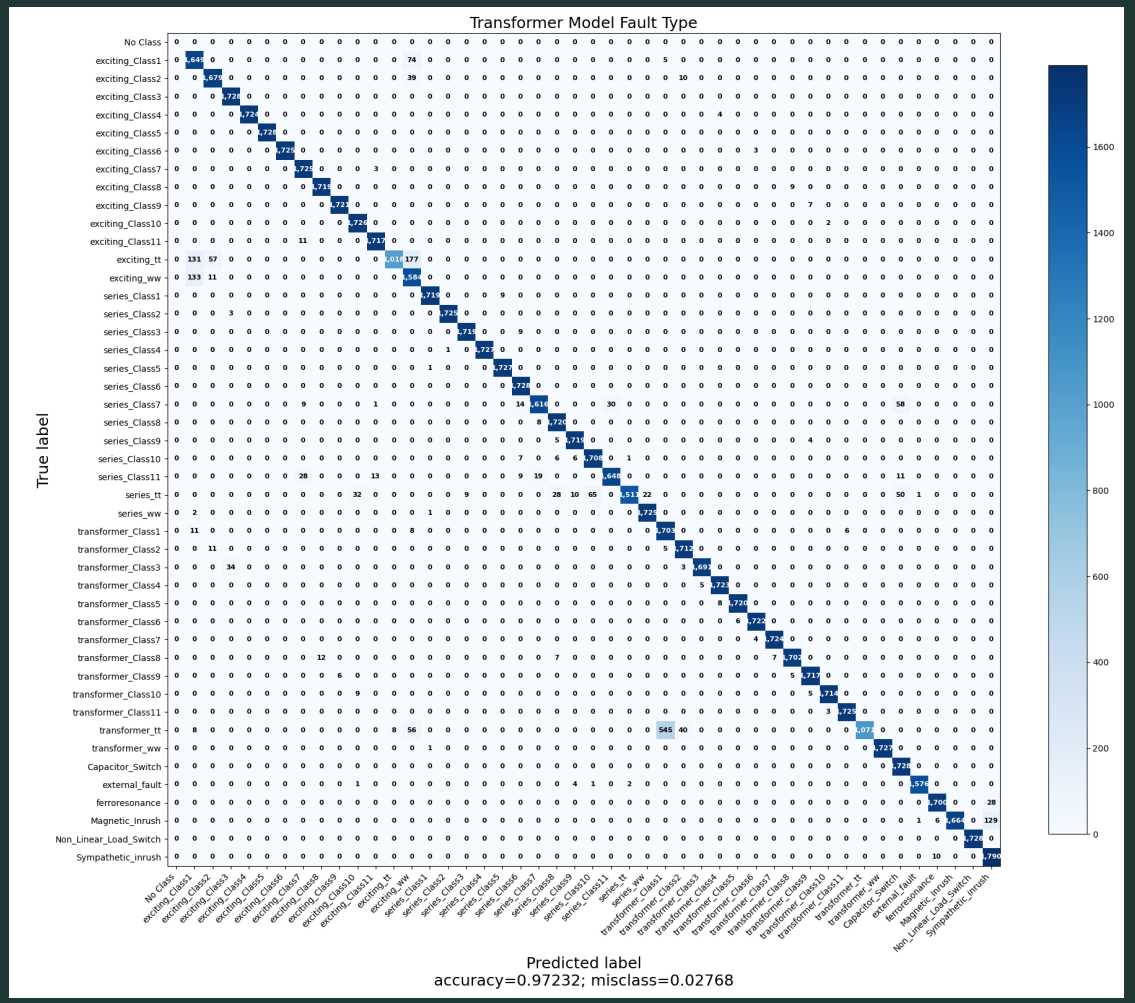


Confusion Matrices

Support Vector Classification



Transformer Architecture



FULL SYSTEM INTEGRATION

Diagnostic Sensors

Anomalous Three-Phase Signal

Fault Classification Model

Oil Temperature

Remaining Useful Life (RUL) Estimation Model

Historical Database

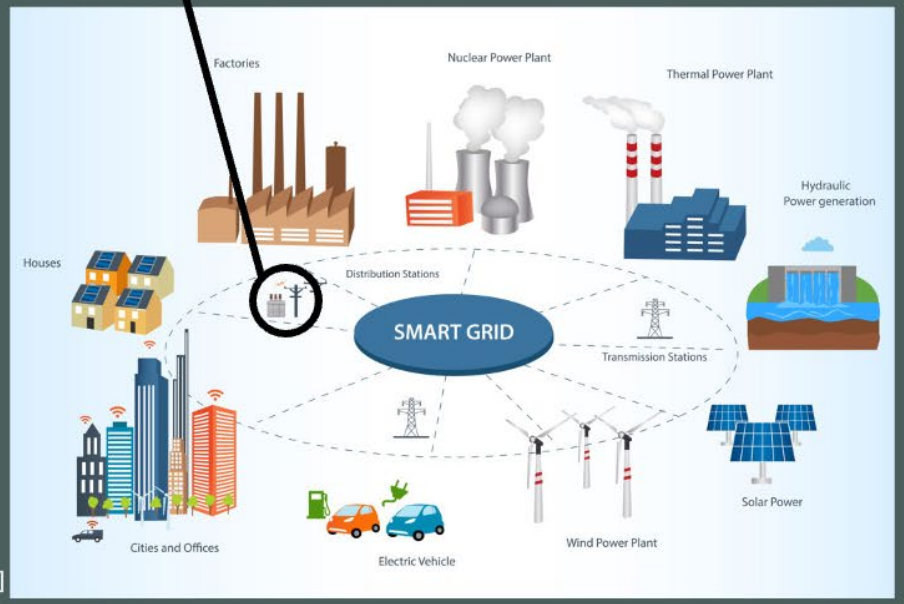
User Query

Natural Language Processor
+
Graphical User Interface

Natural Language Response

Diagnostic Information

Prognostic Estimation



[1]

DEMONSTRATION

tk

FPL CHATBOT

Send

Clear Screen

Next Steps

FPL Data

- Duplicate results with real smart grid data
- Use continuous data sources

Anomalous Three-Phase Signal

Oil Temp

Fault Classification Model

Remaining Useful Life (RUL) Estimation Model

Historical Database

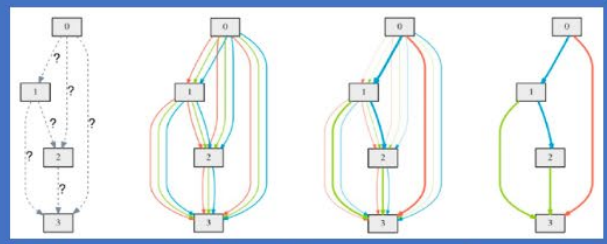
User Query

Natural Language Processor + Graphical User Interface

Natural Language Response

Diagnostic Information

Prognostic Estimation



Differential Architecture Search (DARTS) Transformer

Dynamically constructs the most optimal transformer architecture

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