TRANSFORMERS MAGAZINE'S
INDUSTRY NAVIGATOR

INVESTMENTS, ARTIFICIAL INTELLIGENCE AND SUSTAINABILITY

CONFERENCE 2024

A digital twin perspective on AI-driven winding fault analysis in transformers

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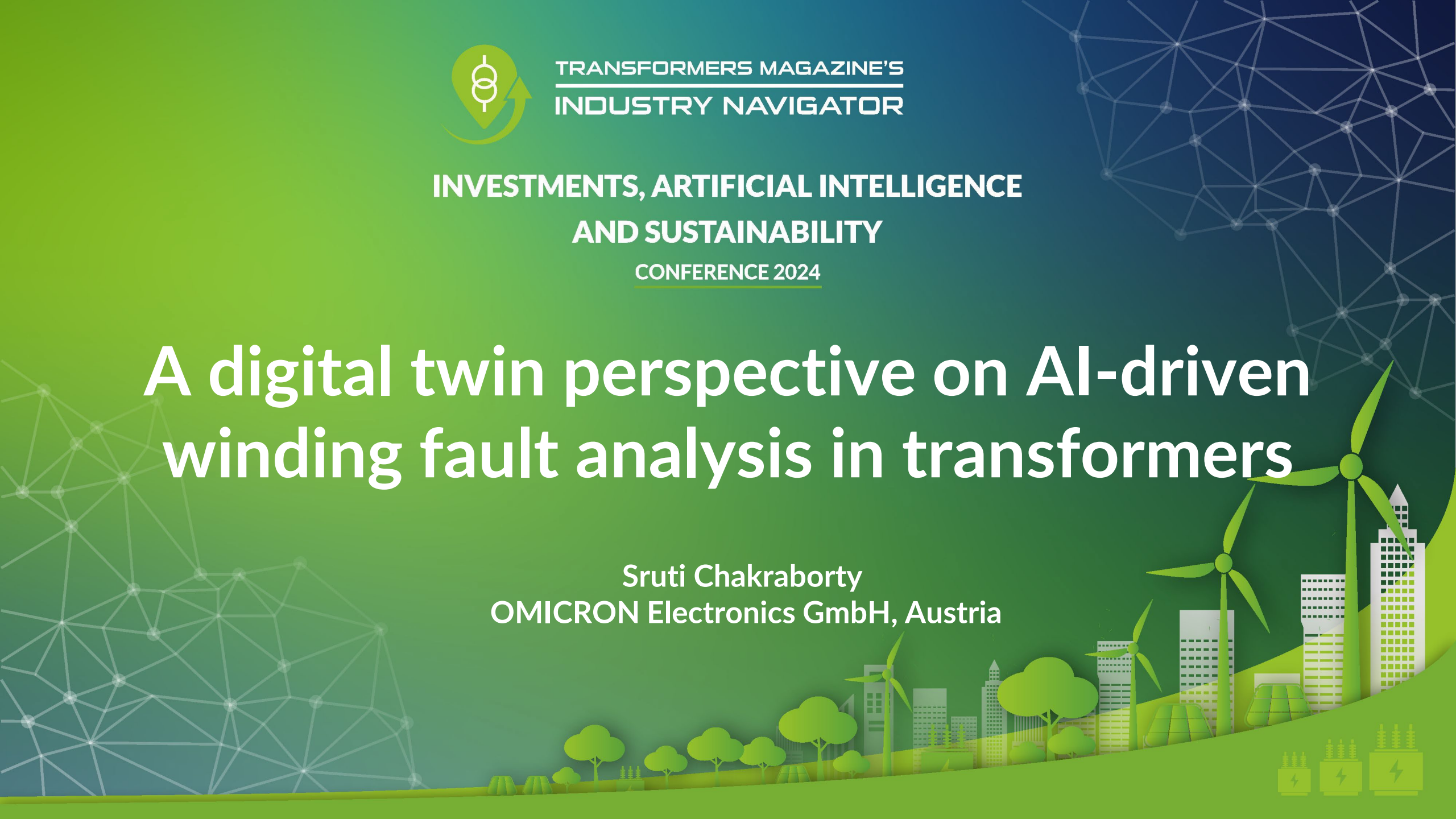
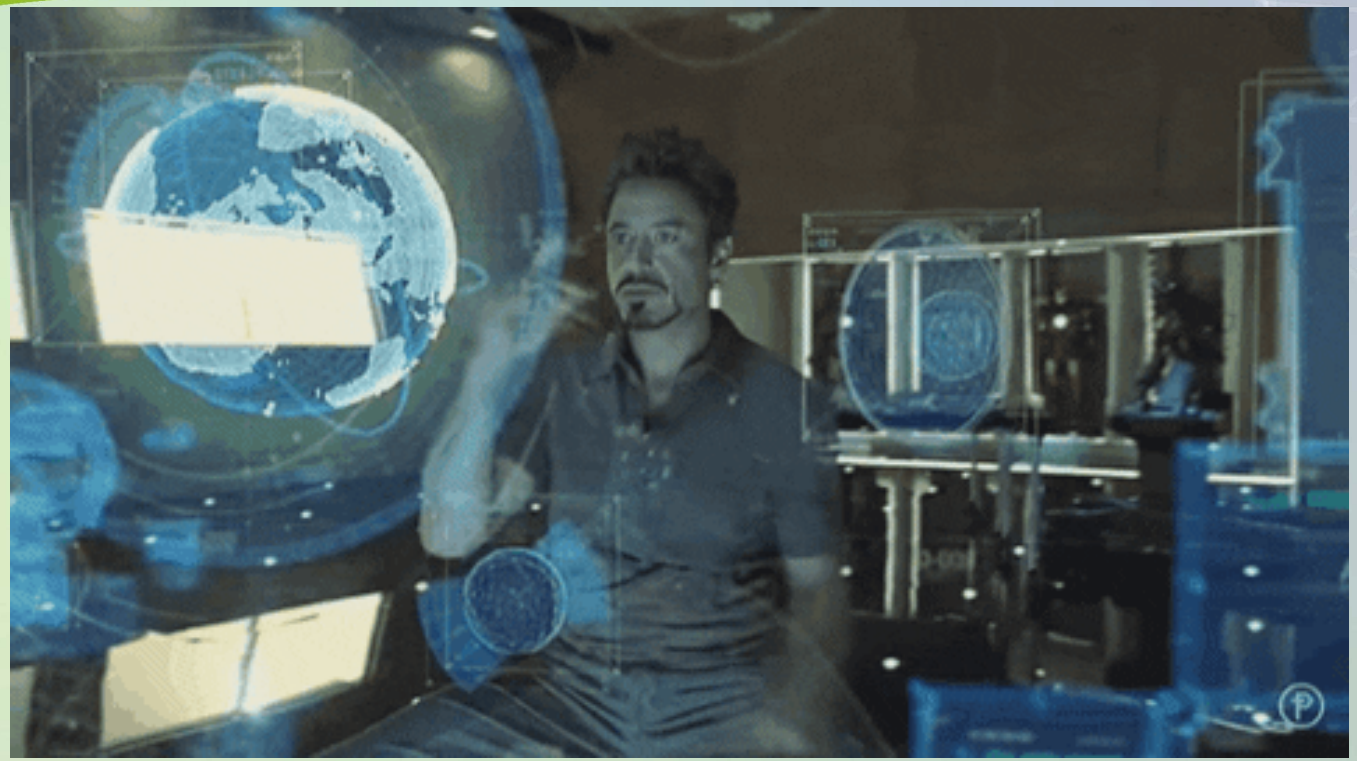
OMICRON Electronics GmbH, Austria





*"Humans are too **optimistic**, and we tend to only look at data that **confirms** what we were thinking. I believe that that artificial intelligence can help us in that area."*

About the use of AI in digital twins

Dr. Michael Grieves' interview to ASME in 2021

Sruti Chakraborty
Product manager
Omicron Electronics GmbH

Agenda

- Digital twins vs Simulations
- Winding fault analysis in transformers
- The AI approach
- Where does OMICRON stand in this journey?

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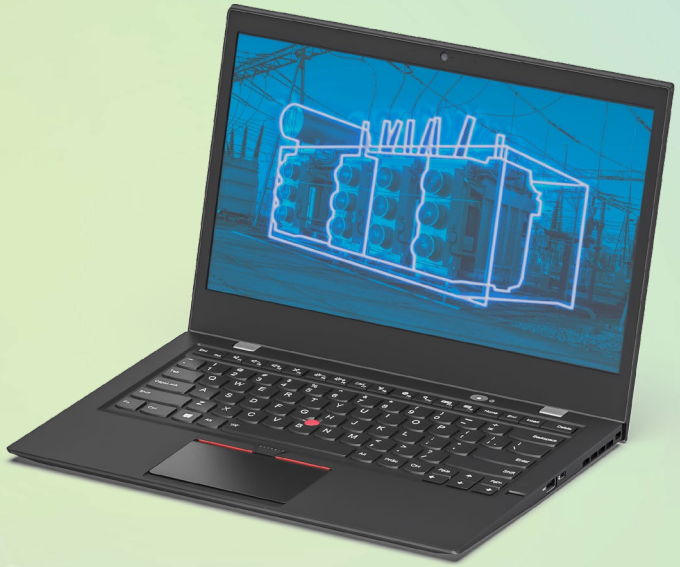
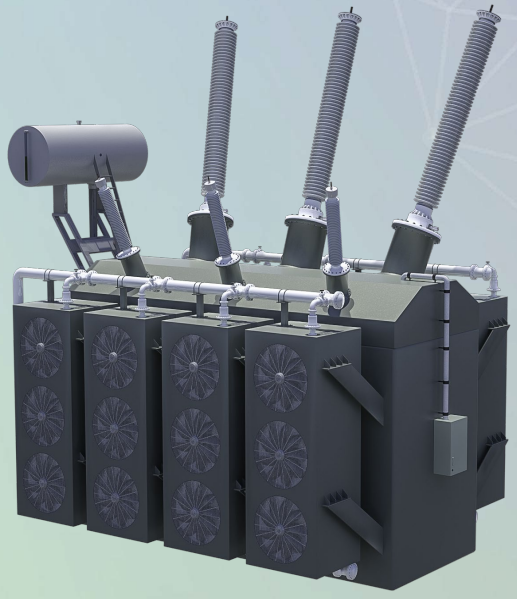
Digital twins vs Simulations

Digital twins vs Simulations





	Purpose	Data	Outcome	Flexibility	Adaptability
Digital twins	Real-time monitoring	Real-time	Present & future	Higher	Investigator
Computer aided simulations	Testing	Static & historically available	Strictly immediate	Lower	Implementer

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Digital twins for fault analysis

Storage

Processing

Modelling

Optimize

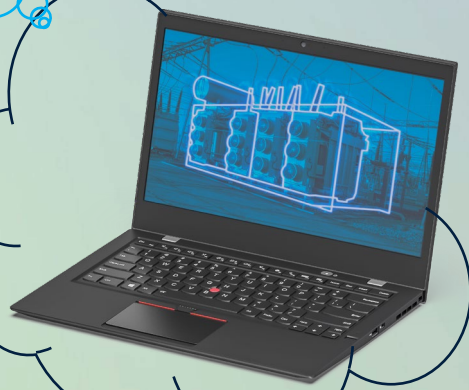
Predict

Collect

Analyse

Simulate

Visualize



Data transmission layer

Data-driven decision

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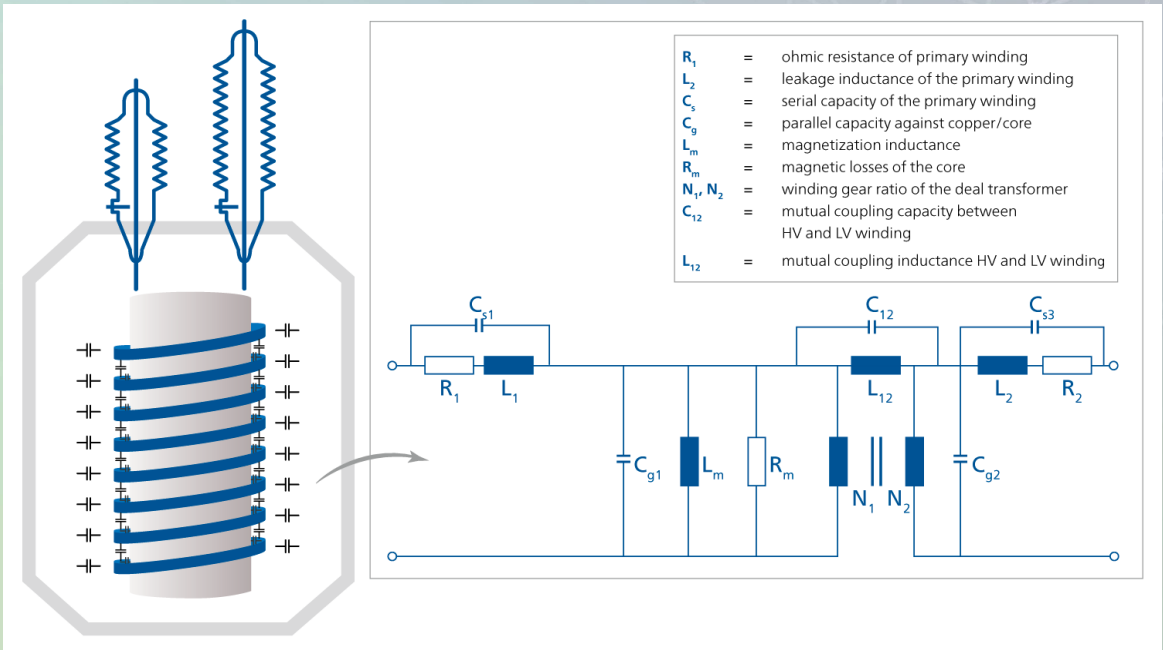
Sweep frequency response analysis (SFRA)

- For testing mechanical integrity
- Ideal for anomaly detection
- Popular routine test for utilities
- Non-invasive at low voltages
- Sensitive to winding deformations



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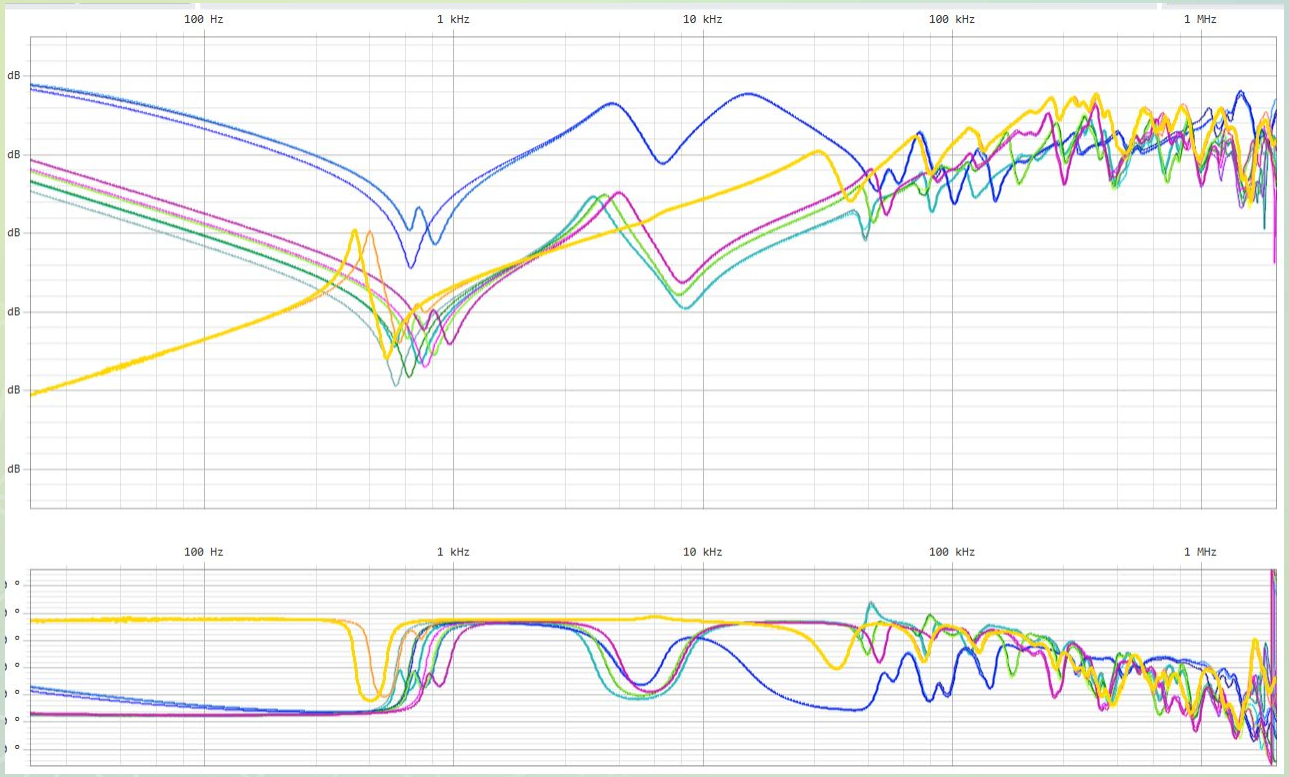
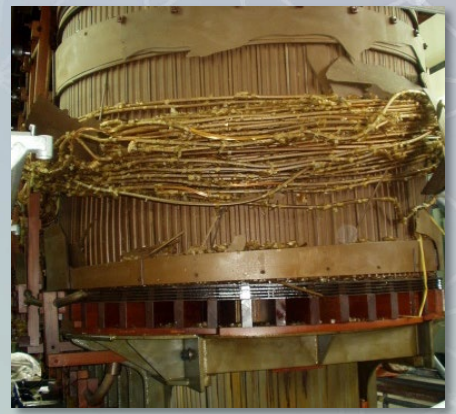
The Analysis in SFRA



Deformed core



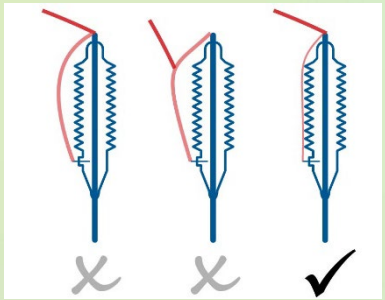
Collapsed tap winding

Damaged main winding

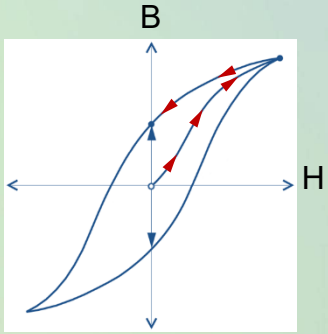
Displaced internal connections

Factors affecting reproducibility

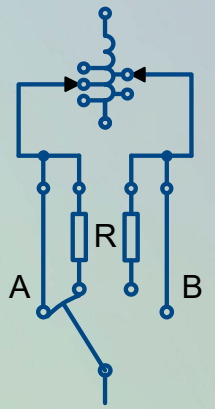
Connection mistakes



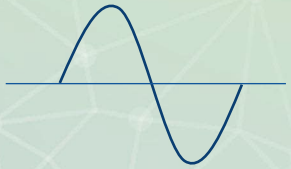
Residual magnetism



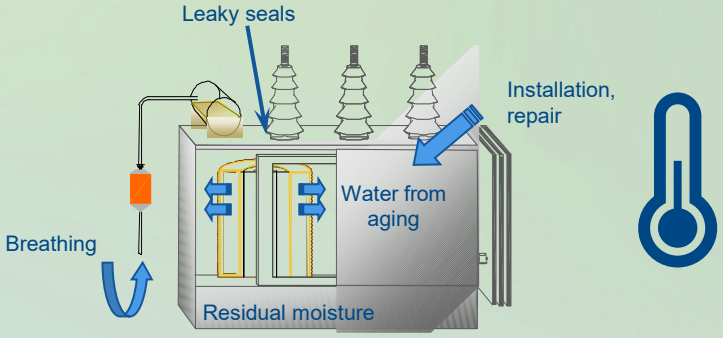
Tap changer position



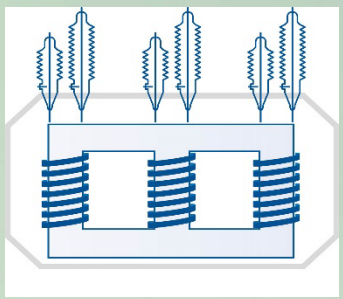
Amplitude of source voltage



Temperature and moisture



Injection path



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Merging AI and SFRA for transformers

- Improving asset **reliability** and **efficiency** through condition assessment
- Improving anomaly detection **accuracy**
  - Fault identification
  - Fault classification
- Automating and optimizing **predictivity**
  - The model itself is important, but using more data significantly enhances prediction outcomes.
  - AI's potential lies not only in the model but also in the data it processes.

FRA interpretation

Data quality

Data availability

Model adoption rate

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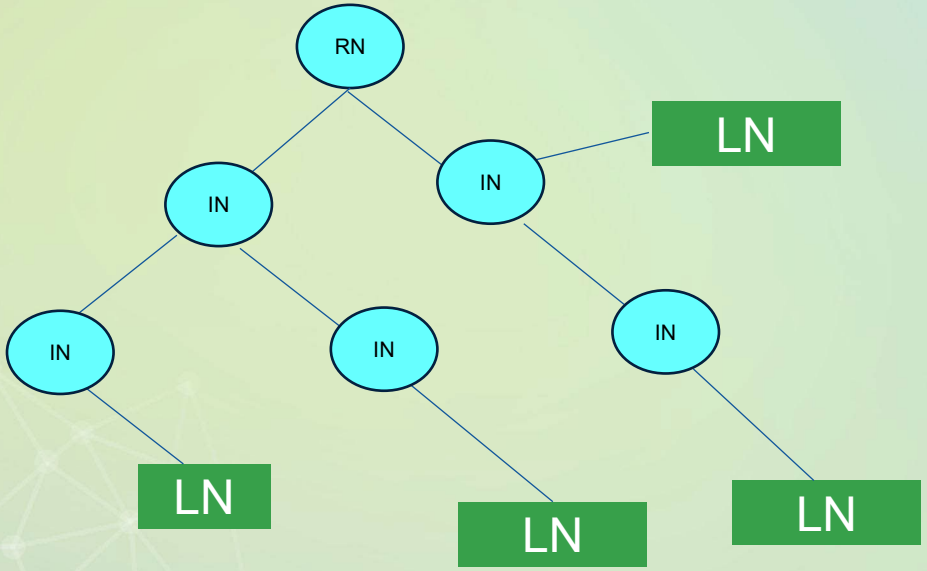
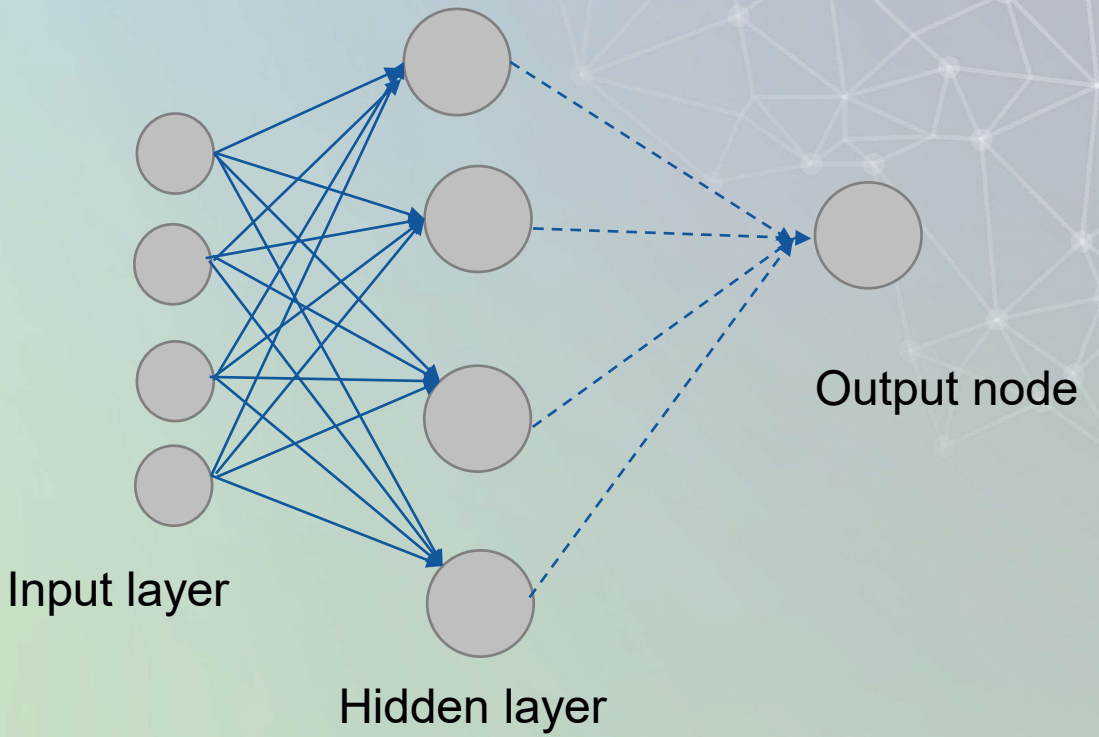
Merging AI and SFRA for transformers





- Decision trees can help to
  - interpret FR traces
  - classify failure modes
  - enact risk predictions

- Neural networks can
  - improve high-frequency models
  - diagnose faults
  - detect failure in internal winding insulation

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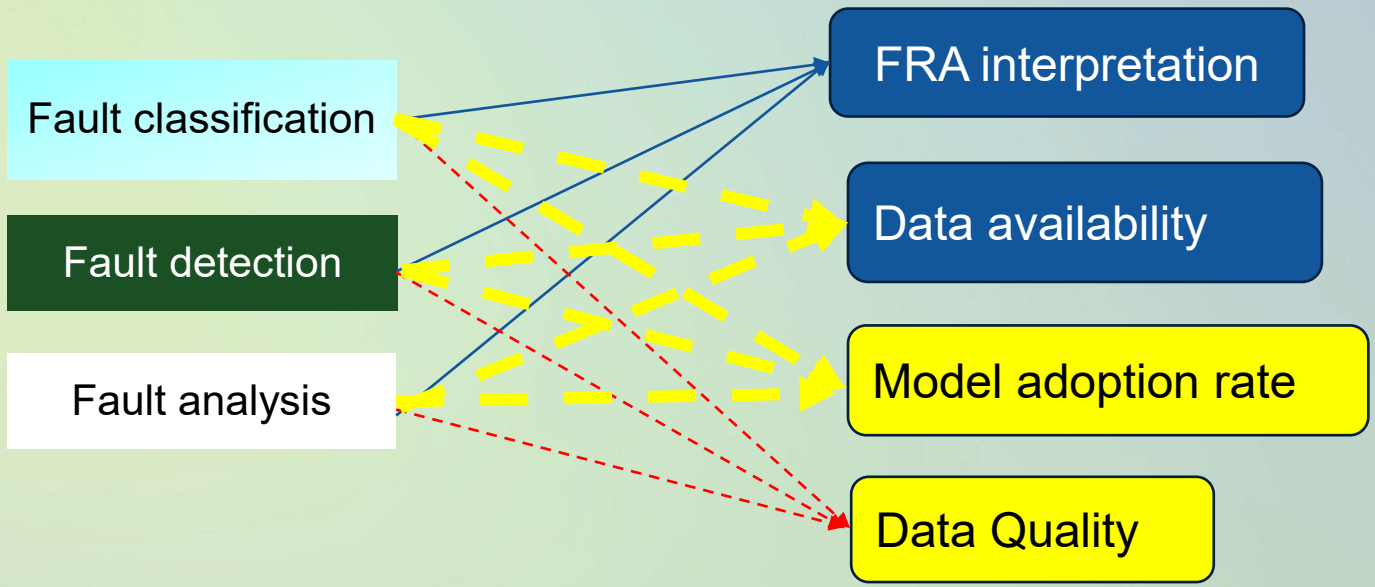
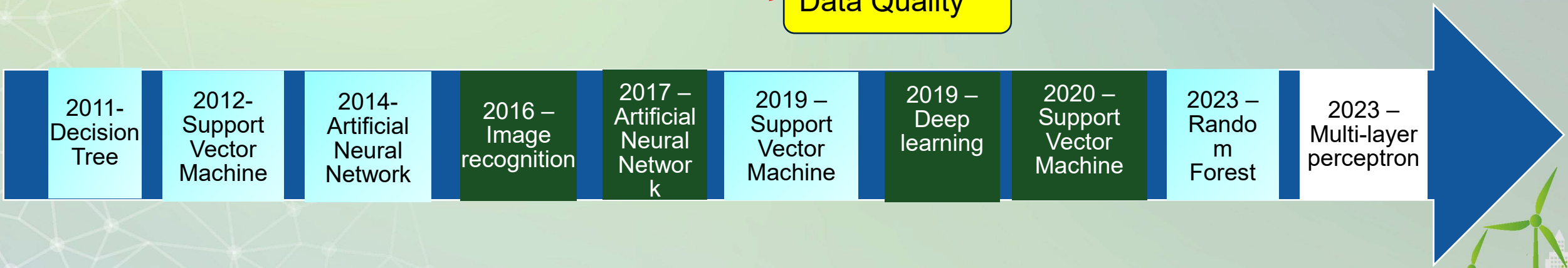
Merging AI and SFRA for transformers





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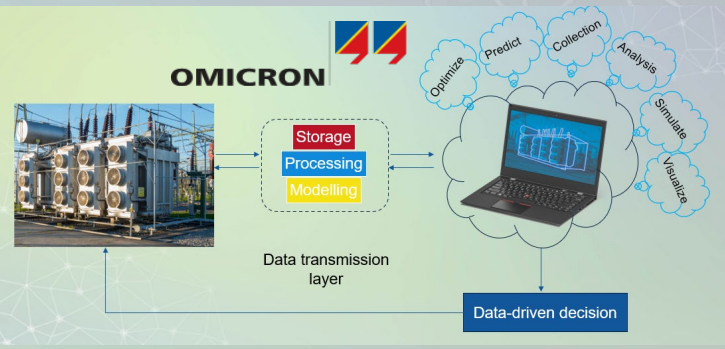
Challenges in AI-adoption for SFRA

- SFRA side
  - Existing practices are based on visual comparison
  - Bias risk
  - Lack of standardization in result analysis
    - CIGRE TB by WG A2.53 **could not make recommendations** for quantitative assessment methodology with defined criteria and thresholds.
  - Not a fleet solution
  - Limited dependability
  - Frequency modelling parameters are seldom known
- AI-Side
  - Reproducibility
  - Reliability
  - Explainability
  - Data availability
  - Data quality



Conclusions

- Improved predictive analysis of assets
- Offer real-time insights
- Maximize resource efficiency
- Lower carbon footprint
- Long term cost-savings

Thank you very much for your attention!

Emotions are energy. Our energy moves.

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