2ⁿᵈ IEEE International Challenge in Design Methods for Power Electronics

2025 IEEE Power Electronics Society

MagNet Challenge 2

"From Steady-State to Transient Models!"

Tutorial Session 6, Oct. 30ᵗʰ, 2025

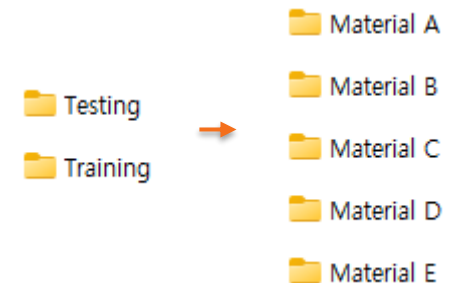**Hyukjae Kwon, Shukai Wang, Haoran Li, Thomas Guillod, Minjie Chen, Charles R. Sullivan**

Agenda

- **Webinar 1 – Data and Neural Network Methods**
  - May 16th Friday, 9 AM EST

- **Webinar 2 – Analytical Methods (by Dr. Thomas Guillid)**
  - May 23rd, Friday, 9 AM EST

- **Webinar 3 – Model Testing and Evaluation Rules**
  - May 30th, Friday, 9 AM EST

- **Webinar 4 – Brainstorm and Q&A**
  - June 6th, Friday, 9 AM EST

- **Webinar 5 – Pre-Evaluation Rules**
  - Sept 12th, 10 AM EST

- **Webinar 6 – Evaluation Datasets**
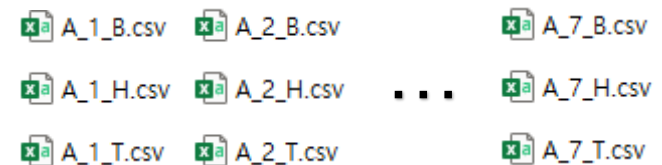 - Oct 30th, 10 AM EST

Final Evaluation Dataset

- **5 new materials** will be provided,

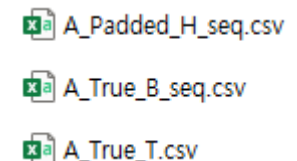 labeled **A – E** (anonymous for fair evaluation)

- **Training data** includes 3 kinds of CSV files:

  - ✓ **B** (T): Magnetic flux density sequences
  - ✓ **H** (A/m): Magnetic field strength sequences
  - ✓ **T** (℃): Temperature

- **Testing data** includes 3 CSV files:

  - ✓ **B** (T): B input segments for prediction
  - ✓ **H_padded** (A/m): H_{past} input segments for prediction
  - ✓ **T** (℃): Temperature

Evaluation Data Format

Temp ▮

■ Input (Known values)

■ Output (Unknown values)

Frequency
- 50 kHz
- 80 kHz
- 125 kHz
- 200 kHz
- 320 kHz
- 500 kHz
- 800 kHz

1,000 Steps

$B(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

$H(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

90% unknown

$B(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

$H(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

50% unknown

~ 1,000 total segments per material

$B(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

$H(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

10% unknown

Temperature
- 25 ℃
- 50 ℃
- 70 ℃

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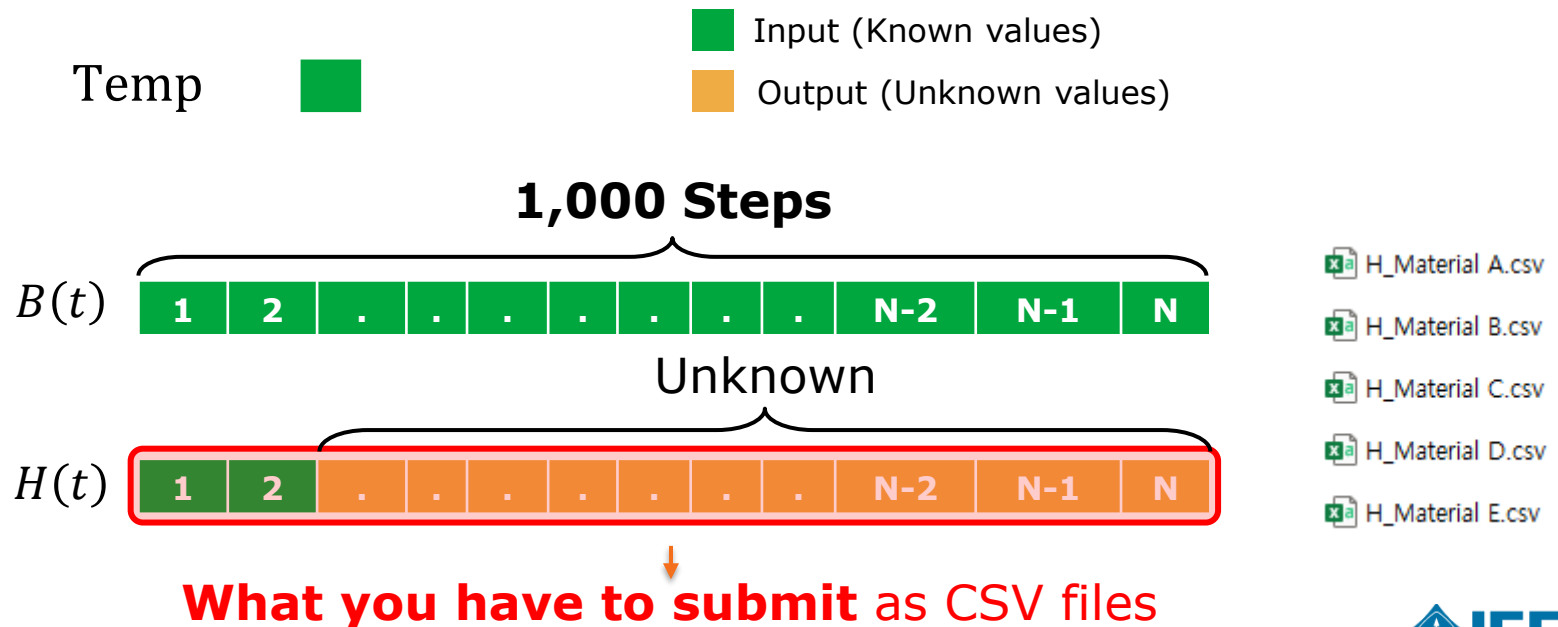Advancing Technology for Humanity

Evaluation Data Submission

❖ **Objective**

- Fill the unknown part of each H(t) sequence using your model's prediction

❖ **Submission Rules**

- **Order must match** the provided sequence order exactly

- Submit the **entire H(t) sequence** (both known and unknown part)

- Example:

Temp ■ ■ Input (Known values)

■ Output (Unknown values)

1,000 Steps

$B(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

Unknown

$H(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

H_Material A.csv
H_Material B.csv
H_Material C.csv
H_Material D.csv
H_Material E.csv

What you have to submit as CSV files

Evaluation Data Submission

❖ **Example**

- Fill **all NaN values** in <Material>_Padded_H_seq.csv for all the data points.
- Save and submit the predicted H sequences with the following file name format: H_<Material>.csv.

Padded H(t)

A_Padded_H_seq.csv

Predicted H(t)

H_Material A.csv

Submit the entire 1,000 Steps

Evaluation Criteria

- 1. Sequence Relative Error:

Prediction

Provided

$$\text{Err}_{seq} = \frac{RMS(H_{pred} - H_{meas})}{RMS(H_{meas})} \times 100\%$$

  – How well the predicted sequence fits the characteristic response of the input data.

- 2. Normalized Energy Relative Error:

Provided or calculate

$$\text{Err}_{ene} = \frac{\int_{t_1}^{t_2} \frac{dB}{dt} \cdot H_{pred}(t)dt - \int_{t_1}^{t_2} \frac{dB}{dt} \cdot H_{meas}(t)dt}{\int_{t_0}^{t_3} \frac{dB}{dt} \cdot H_{meas}(t)dt} \times 100\%$$

Prediction

Provided (core loss)

  – t_0: start of full sequence, t_3: end of full sequence
  – t_1: start of test segment, t_2: end of test segment
  – How does the **core loss error of predicted segment** compare to the **total core loss** of the entire sequence?

Data Provided

- The **number of sequences** of each materials is provided in the following table:

	Tiny data Challenge	Frequency Challenge	No past H data Challenge	Flux density Challenge	Special material Challenge
Number of Sequences	**Material A**	**Material B**	**Material C**	**Material D**	**Material E**
Training Sequences	105	6,758	8,158	9,536	6,901
Testing Sequences	1,260 out of 12,405	963 out of 2,656	1,119 out of 5,439	1,242 out of 6,357	1,089 out of 4,601

- The **training and testing sequences** are **selected differently** for each materials for the purpose of the Magnet Challenge 2.
- **Training and testing sequences** will be released on **Nov. 15th**.
- The **complete dataset** will be released after the MagNet challenge 2 is completed.

Evaluation Data Format

❖ **Material C** − No past H data challenge

Temp ⬛

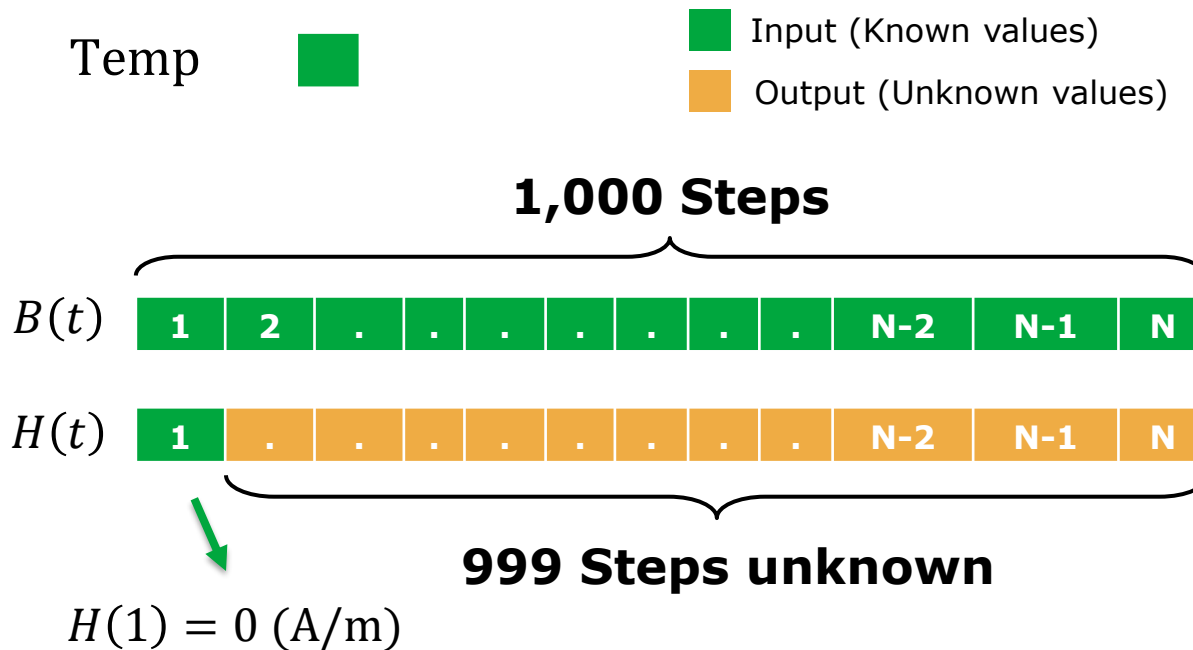🟩 Input (Known values)

🟧 Output (Unknown values)

1,000 Steps

$B(t)$ | 1 | 2 | . | . | . | . | . | . | . | N-2 | N-1 | N |

$H(t)$ | 1 | . | . | . | . | . | . | . | . | N-2 | N-1 | N |

999 Steps unknown

$H(1) = 0$ (A/m)

Frequency
- 50 kHz
- 80 kHz
- 125 kHz
- 200 kHz
- 320 kHz
- 500 kHz
- 800 kHz

Temperature
- 25 ℃
- 50 ℃
- 70 ℃

- Only the **initial value** of H is provided (0 A/m).

- No previous H sequence data is given, **unlike the other materials**.

- Teams may assume **all past of H(t)** before the starting point are also 0 A/m.
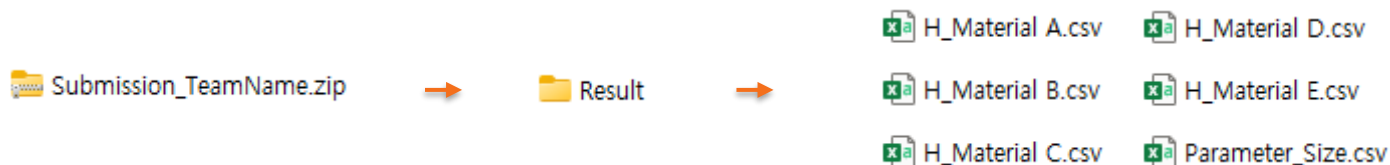
Result Submission

- Please follow the steps below to ensure a smooth and accurate evaluation:

  ➢ **Rename** the main folder with your **team's name** (e.g., the name of the university)

  ➢ Put all the **output CSV files** inside the subfolder named "**Result**".

  ❖ In a **Parameter_Size.csv** file, clearly indicate **the number of parameters** in your model for **each materials (A – E)**. The table below shows an example:

	Material A	Material B	Material C	Material D	Material E
Number of Parmaters	13,782	19,451	10,237	16,894	10,237

- Function to **count parameters** in a **Pytorch** model

```python
def count_parameters(model):
    """Returns the number of trainable parameters in the model."""
    return sum(p.numel() for p in model.parameters() if p.requires_grad)
```

  ➢ (Jan. 15th) **Compress the entire folder as a ZIP file** for submission.

Submission_TeamName.zip → Result →
H_Material A.csv   H_Material D.csv
H_Material B.csv   H_Material E.csv
H_Material C.csv   Parameter_Size.csv

  ➢ (Jan. 31st) Submit **4-page final report (.pdf)**.   TeamName_MagNetX Report.pdf

Conclusion

- **November 15th, 2025** – Release of final evaluation data
    1) Download the new **training and testing datasets** from the following link for the **five additional materials (A – E)**
        - MagNet Challenge GitHub: https://github.com/minjiechen/magnetchallenge-2
          Or MagNetX GitHub: https://github.com/PaulShuk/MagNetX
    2) Use the training data **to train, tune, and refine** your model or algorithm.
    3) Predict the **energy loss** for the provided segments and **future H sequences**, filing all **NaN values** in Material_Padded_H_seq.csv for all the data points.

2. Final Model

- **January 15th, 2026** – Final model and results submission
    1) Submit **prediction results** as **five separate CSV files** (one for each material) with the number of parameters for each material.
    2) Submit all required files to **pelsmagnet@gmail.com**

3. Final Report

- **January 31st, 2026** – Final report submission
    1) Include a **4-page report (IEEE TPEL format, PDF)** briefly describing your key methods and concepts.
- **February 2026** – Submit trained models for validation and ranking