Machine Learning for Electrical Machines Design and Modeling

Course Information & Syllabus & Fees

Course Information

Instructor: Tohid Sharifi
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Format: 10 sessions, 1.5 hours per session
Platform: Online via Google Meet
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Course Description

Is your design cycle slowed down by computationally expensive and time-consuming FEA simulations? This course provides the solution. We will teach you how to build and deploy powerful machine learning 'digital twins' that capture the complex physics of electrical machines and deliver performance predictions in seconds, not hours.

Benefits:

- You will gain the ability to rapidly analyze thousands of design variations, leading to deeper engineering insights and a more intuitive, agile workflow.
- By replacing simulation wait times with instantaneous feedback, you can focus on what truly matters: innovation and engineering excellence.
- Mastering this modeling capability is the critical first step, providing the foundation needed to unlock automated, multi-objective design optimization in the future.

Learning Objectives

Upon successful completion of this course, participants will be able to:

- **Formulate** raw engineering data from simulations/tests into structured datasets suitable for machine learning.
- **Analyze** raw engineering datasets to identify and handle outliers, noise, and other data quality issues.
- **Apply** data preprocessing techniques, such as normalization and feature scaling, to prepare robust datasets.
- **Implement** systematic feature selection strategies to identify the most influential design parameters.
- **Develop and train** artificial neural networks to predict the performance of electrical machines.
- **Validate** the accuracy and generalization capabilities of a trained model using cross-validation strategies.
- **Deploy** a finalized model as a high-speed 'digital twin' to perform parametric studies and performance analysis.
- **Articulate** the advantages and limitations of using data-driven models compared to traditional methods.

Prerequisites

This course is designed for engineers seeking to leverage data-driven methods. You should have:

- A basic understanding of electrical machine design concepts and analysis.
- Basic programming fundamentals in MATLAB. No prior experience in AI is necessary.

Required Materials

- **Software:** Installation of **MATLAB** (R2018a or later) and **Ansys Electronics Desktop** (version 2021 R1 or later) (Ansys Maxwell).
- **Course Files:** All datasets and scripts will be provided by the instructor.

Practical Application and Skill Development

This course is built around a hands-on, mentorship-driven approach. Your learning will be structured through:

- **Practical Exercises:** Throughout the course, we will use a **Synchronous Reluctance Motor (SynRM)** dataset as our benchmark. You will be given hands-on coding exercises to apply concepts from each session to this specific machine.
- **Capstone Project:** At the end of the course, you will undertake a comprehensive capstone project using a new, raw dataset for a **Permanent Magnet Synchronous Motor (PMSM)**. This will challenge you to apply the full workflow to a different type of machine, proving your comprehensive understanding.

By these activities, you will receive direct feedback and guidance from the instructor to enhance your capabilities.

Course Schedule

- **Session 1: Introduction to Machine Learning Modeling & MATLAB Setup**
  - *Goal:* Understand the "why" behind ML-driven engineering. Set up the MATLAB environment and introduce the course workflow.
- **Session 2: Dataset Creation from FEA Software**
  - *Goal:* Learn about data sampling methods (e.g., Latin Hypercube, full factorial) to design an effective parameter sweep in FEA software and export the results to create a structured dataset.
- **Session 3: The Engineering Dataset: Loading and Visualization**
  - *Goal:* Import the raw dataset into MATLAB. Perform initial exploratory data analysis and visualization to understand its characteristics.
- **Session 4: Data Preprocessing in Practice**
  - *Goal:* Apply essential data cleaning techniques, handle outliers, and implement normalization and scaling.
- **Session 5: Practical Feature Selection**
  - *Goal:* Understand and implement methods to identify the most influential design parameters, reducing model complexity.
- **Session 6: Neural Networks Part 1: Multi-Layer Perceptron (MLP)**
  - *Goal:* Learn the theory and practical application of MLPs for regression tasks. Build and configure an MLP model in MATLAB.
- **Session 7: Neural Networks Part 2: Radial Basis Function (RBF) Networks**
  - *Goal:* Explore RBF networks as a powerful neural network, Understand their strengths and build a model.
- **Session 8: Training and Validation: The Iterative Loop**
  - *Goal:* Master the process of training a model, using a validation set to monitor for overfitting and guide the training process.
- **Session 9: Model Evaluation and Cross-Validation**
  - *Goal:* Use robust methods for cross-validation and key performance metrics (RMSE, R-squared) to evaluate the final model's accuracy and generalization.
- **Session 10: Deploying Your Digital Twin & Course Conclusion**
  - *Goal:* Use the final, validated model as a high-speed "digital twin" for analysis. Review course concepts and discuss next steps.

Course Fee and Payment

The total fee for this comprehensive professional development course is **1200 €**.

The payment schedule is structured as follows:

- An initial payment of **600 €** is required to confirm enrollment before the course begins.
- The remaining balance of **600 €** is due after the completion of Session 5.