AI & Data Centers Stage

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NUREMBERG, GERMANY

Toward an AI-Enhanced Simulation Pipeline for Power Converter Design

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Fraunhofer IISB

Messe Frankfurt Group

Fraunhofer IISB

Introduction

- Fraunhofer IISB is one of the leading European research institutions for **wide-bandgap semiconductors** and **power electronic systems.**
- Research for applications in semiconductor and electronics industry, electromobility, aerospace, and sustainable energy supply.
- Our activities cover the entire value chain – from semiconductor materials and processing technologies through packaging and module design to complex power electronic and energy systems.
- About 350 employees.
- At this years PCIM at Hall 6, booth 260

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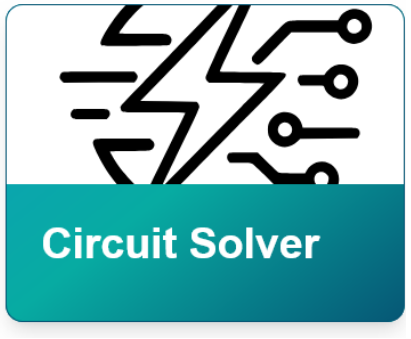
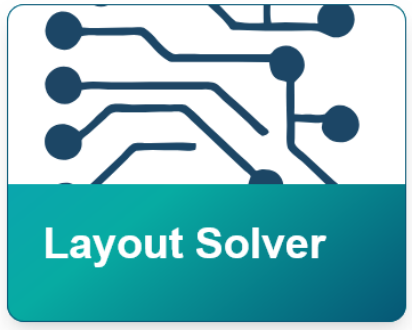
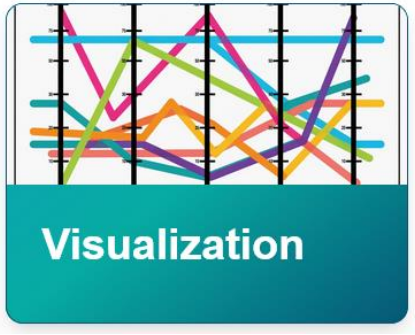
Simulation Pipeline for Power Converter Design

Overview

- Modern simulation pipelines consist of several steps which require different physical solvers







- Requirements for simulators and pipeline:
  - Fast and accurate
  - Good integration of the tools with one another
  - Cover every important metric of the design

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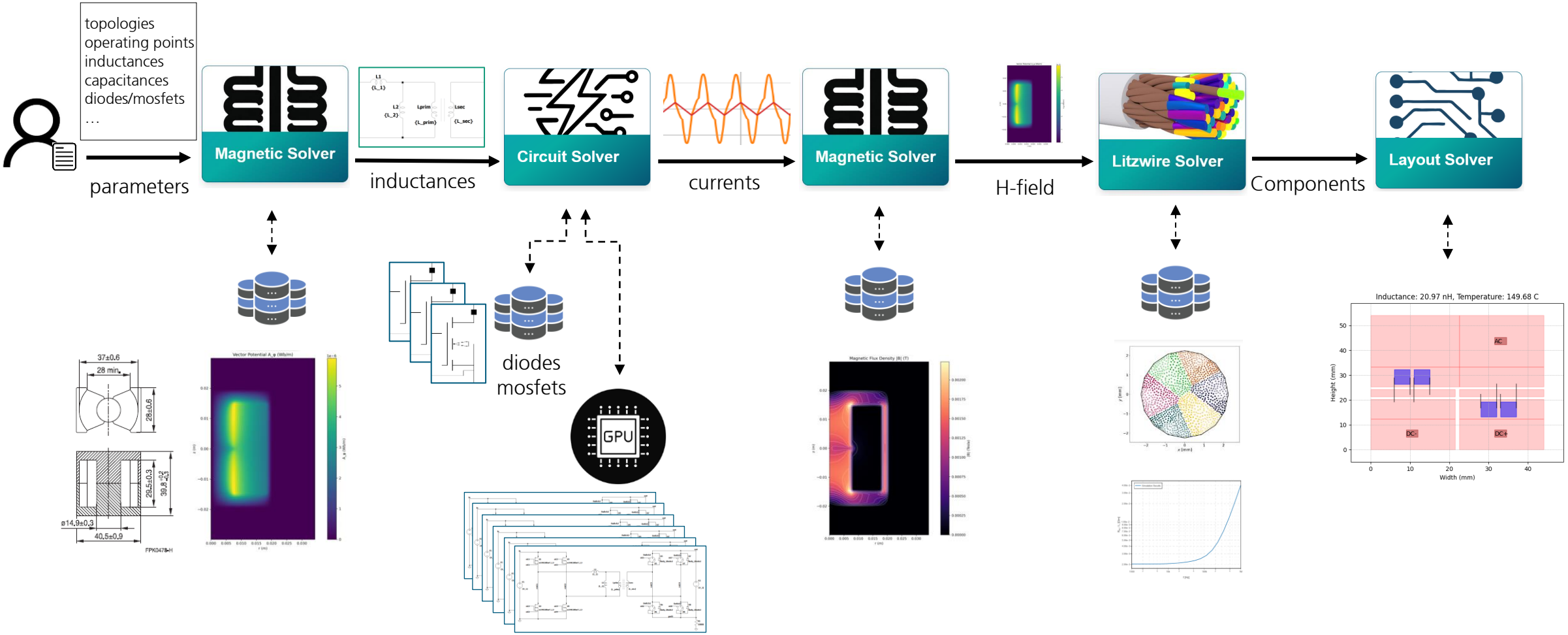
Simulation Pipeline for Power Converter Design

Workflow



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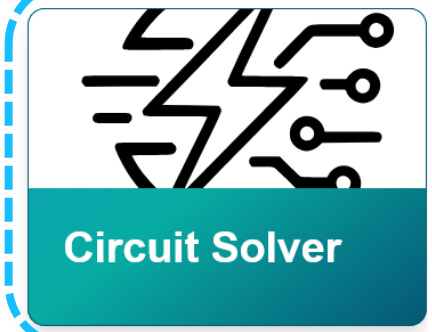
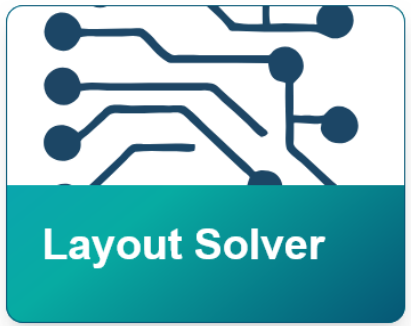
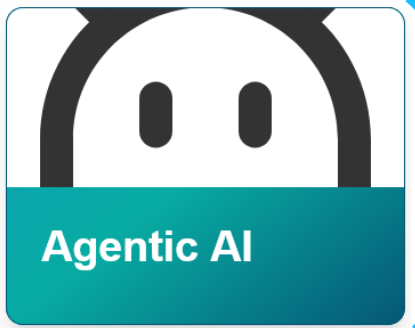
AI-Enhanced Simulation Pipeline for Power Converter Design

Overview

- AI can enhance simulation pipelines in three different ways:
  1. **AI acceleration for greater simulation speed**
  2. **AI optimization for better component design**
  3. **Agentic AI throughout the complete workflow**







1. AI acceleration for greater simulation speed:
Physics Informed Neural Networks

2. AI optimization for better component design:
Reinforcement Learning

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AI acceleration for greater simulation speed

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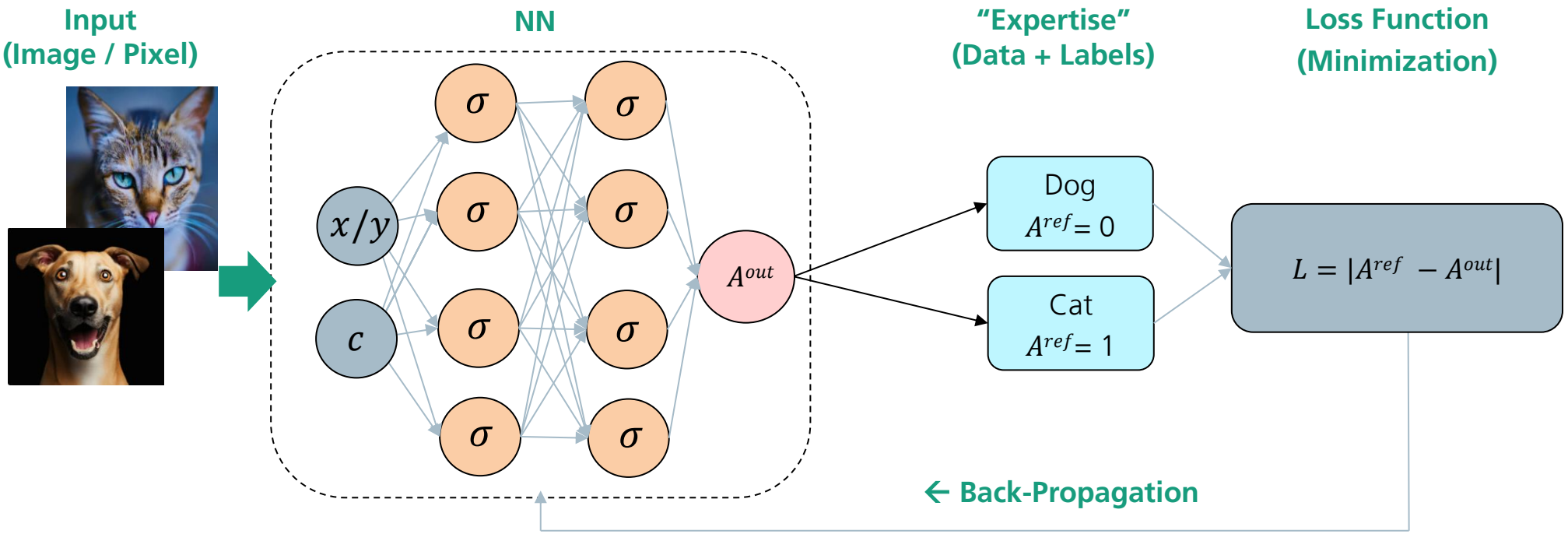
AI-Enhanced Simulation Pipeline for Power Converter Design

AI acceleration for greater simulation speed

Problem: Image recognition "dog or cat"
Solution: Supervised Learning



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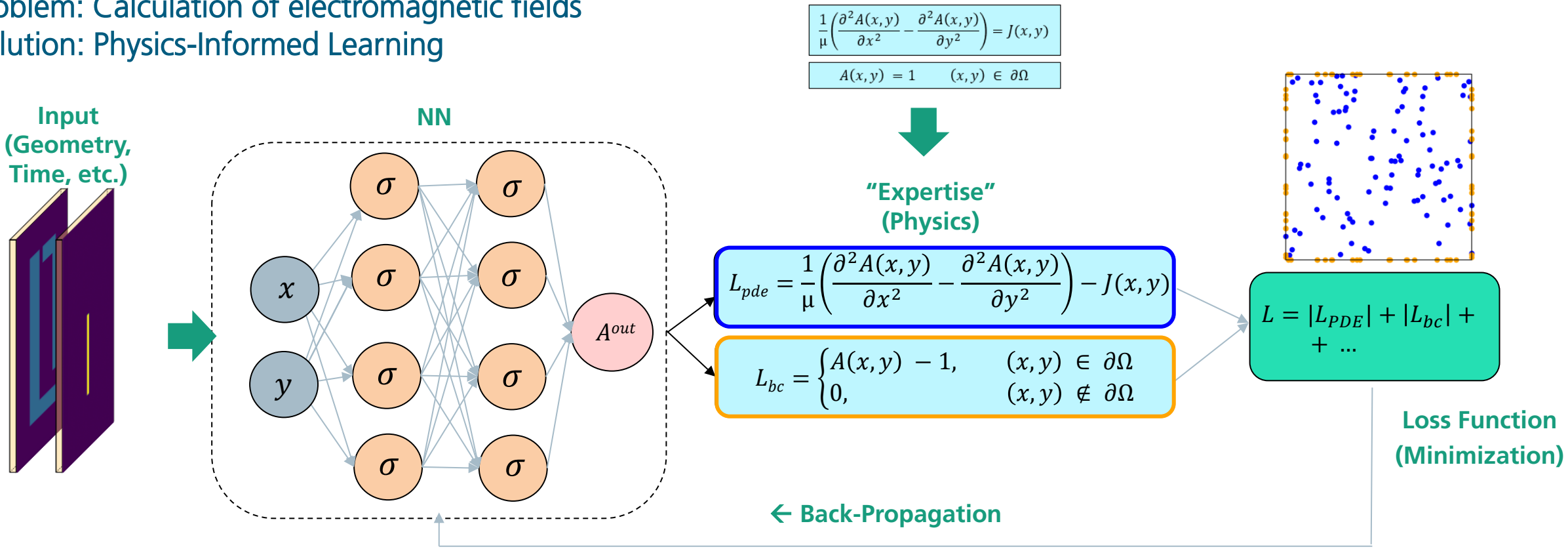
AI-Enhanced Simulation Pipeline for Power Converter Design

AI acceleration for greater simulation speed

Problem: Calculation of electromagnetic fields
Solution: Physics-Informed Learning



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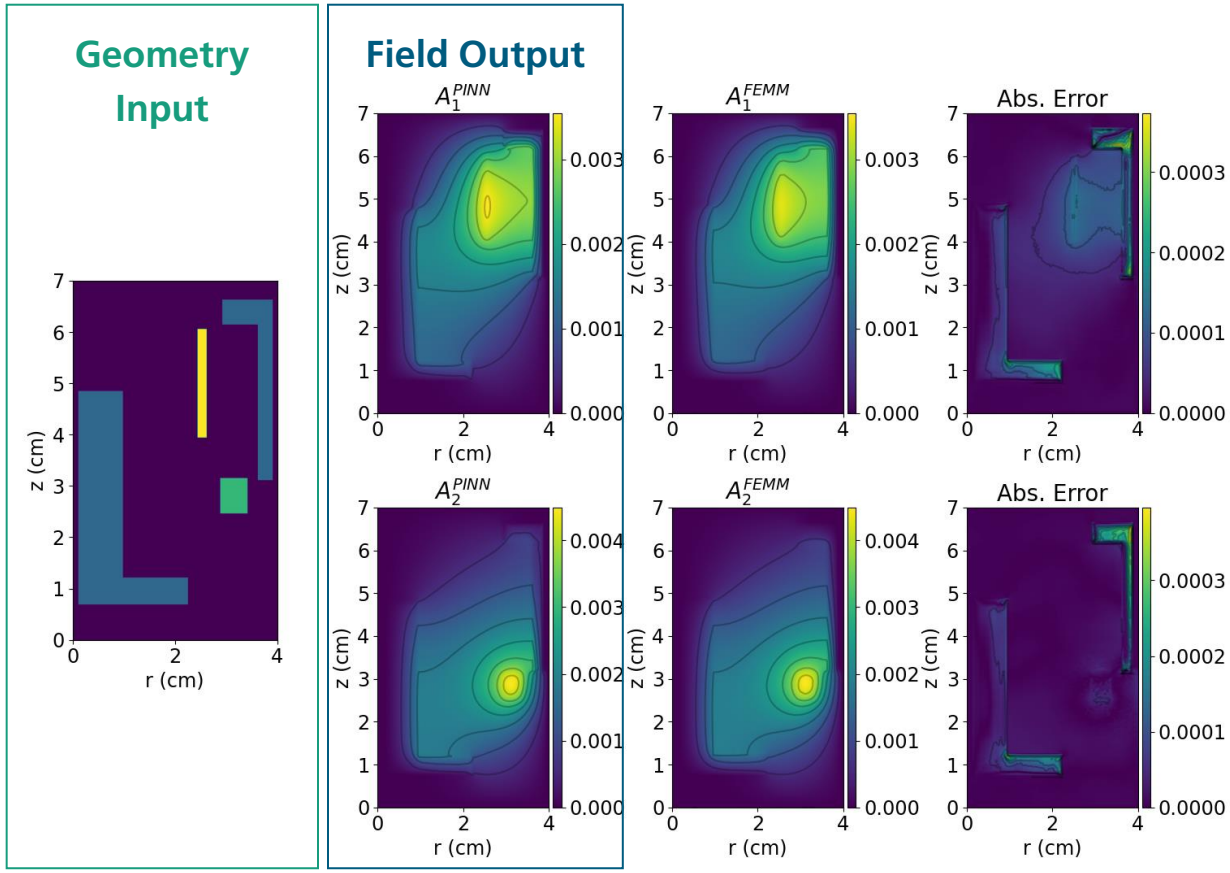
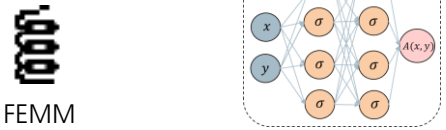
AI-Enhanced Simulation Pipeline for Power Converter Design

AI acceleration for greater simulation speed



The spatial magnetic vector potential is approximated and integrated.



	Reference Simulation	PINN
Setup	382 ms (geom., phy.)	0.06 ms (r,z, λ)
Solve / Predict	534 ms	0.4 ms
Total Inference	916 ms	0.5 ms

x 2000 faster

Simulations are faster via PINN compared to FEMM

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AI optimization for better component design

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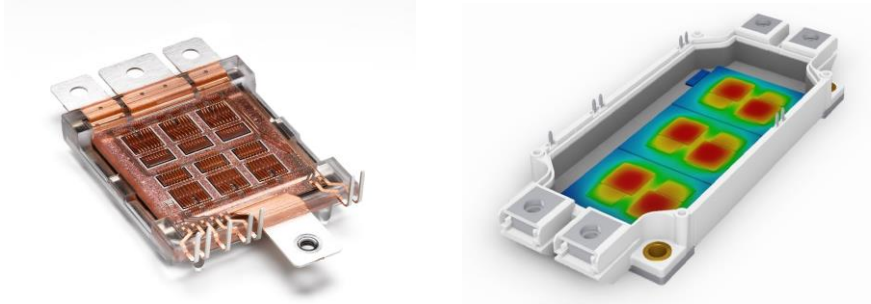
AI-Enhanced Simulation Pipeline for Power Converter Design

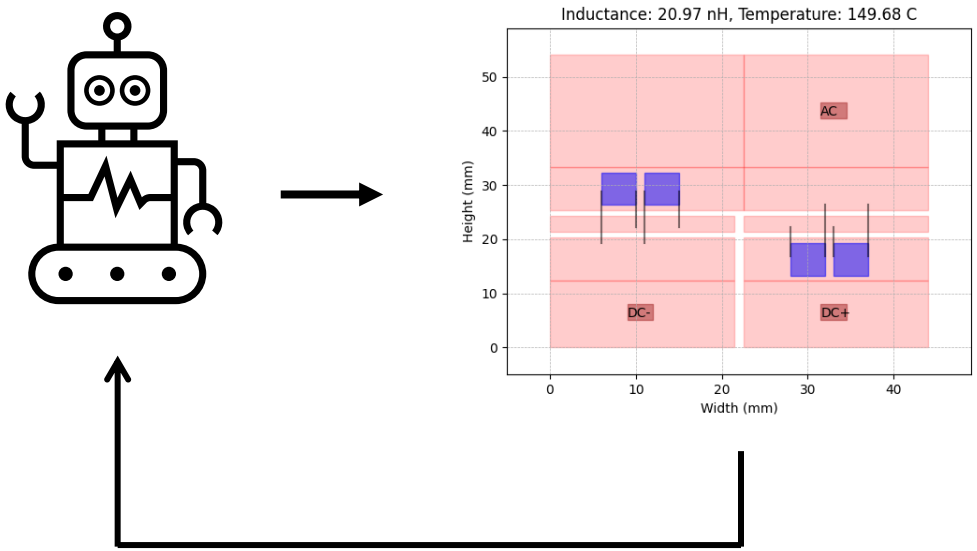
AI optimization for better component design

Layout Solver

- **Design of a half bridge:**
  - What is the optimal placement of components?
  - Can we automate this process?

- **Answer: Yes, we can train a RL agent to do this!**
  - When fast solvers are available, **Reinforcement Learning** can be used to optimize components
  - Optimize the placement of power modules w.r.t. maximum **junction temperature (T)** and **parasitic inductance (L)**





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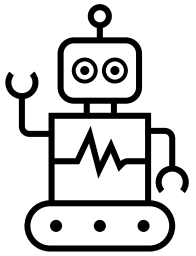
AI-Enhanced Simulation Pipeline for Power Converter Design

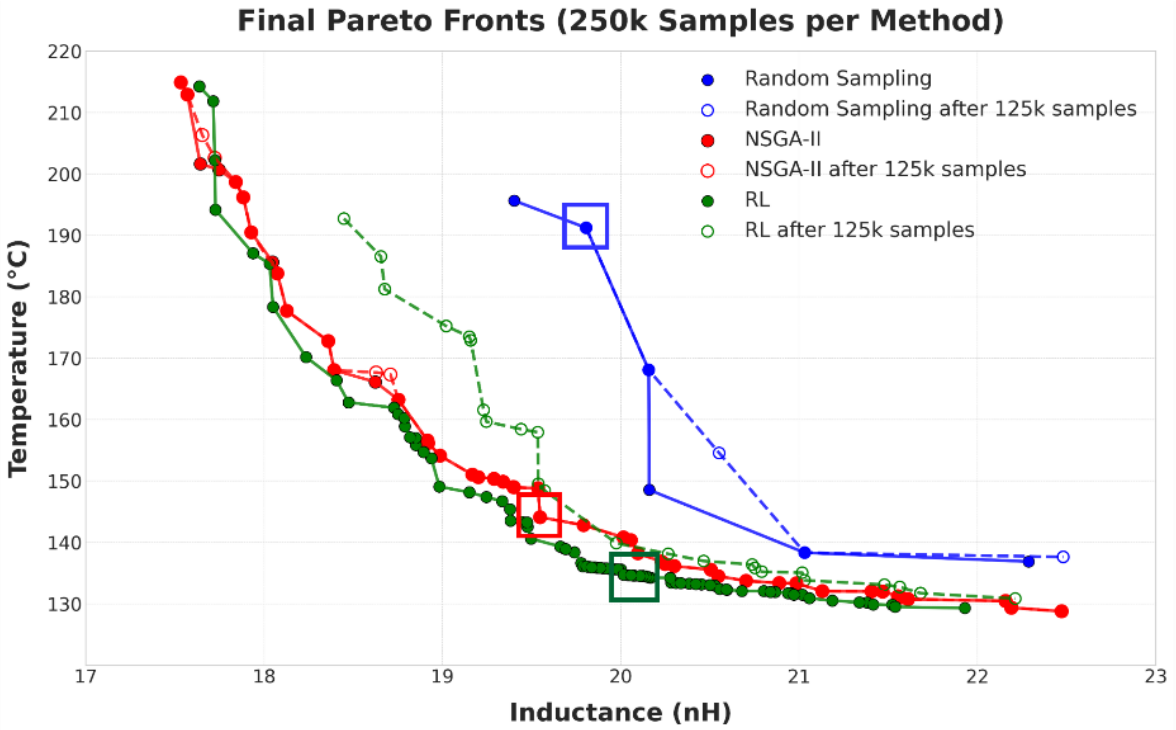
AI optimization for better component design

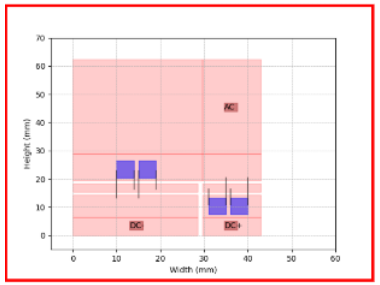
Layout Solver

Layout Optimization with Reinforcement Learning

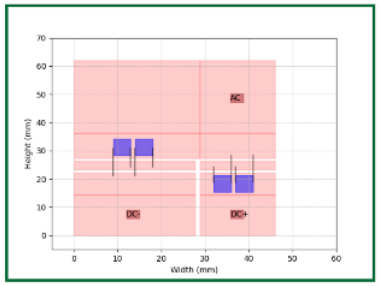


Reinforcement Learning

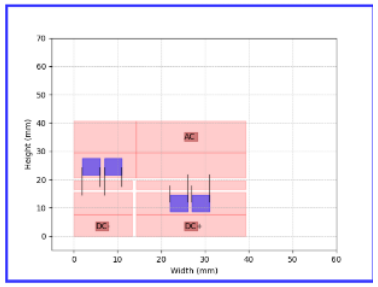




Layout A



Layout B



Layout C

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Agentic AI throughout the complete workflow

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AI-Enhanced Simulation Pipeline for Power Converter Design

Agentic AI throughout the complete workflow

Agentic AI

- How should Agentic AI be integrated in the development cycle?
  1. Chatbot assistant to engineer
  2. (Semi-)Autonomous researcher

1. Chatbot assistant to researcher

- LLM interacts with simulation tools via API requests
- Additional data via RAG/databases is available
- Interaction in the form of a chat
- Agent serves as a helpful executer rather than an autonomous researcher
- Mainly for the engineer's convenience

2. (Semi-)Autonomous researcher:

- LLM interacts with simulation tools directly
- Additional data as RAG/databases is available
- Additionally, the agent is given access to a workspace which already contains some analysis scripts and custom workflows
- Interaction in form of extensive task-descriptions
- Agent can work autonomously for hours/days
- Real impact

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AI-Enhanced Simulation Pipeline for Power Converter Design

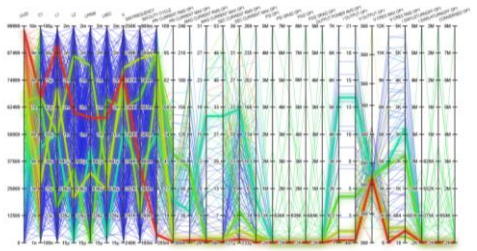
Agentic AI throughout the complete workflow

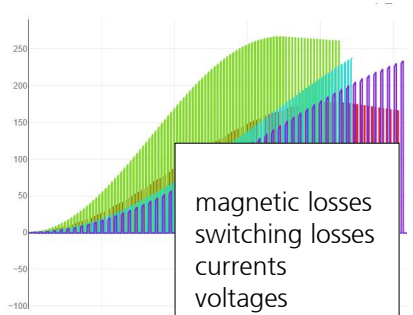
Agentic AI

Well defined extensive research tasks →

Set of solution candidates →

Report + Visualization





magnetic losses
switching losses
currents
voltages
measurements
…

Autonomous design of thousands of converters

Database
Previous Designs

API

- **Requirements for simulators and pipeline:**
  - Fast and accurate
  - Good integration of the tools with one another
  - Cover every important metric of the design

- Agent can interact with the simulation pipeline and create autonomously thousands of designs
- Agent can access a database of previous designs and benchmark against them
- Set of designs are chosen and reported to the engineers

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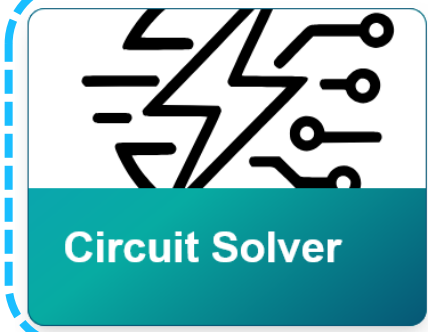

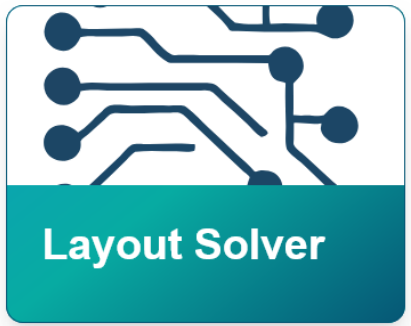

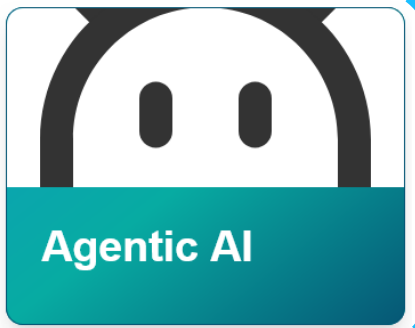

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Thank you for your attention!

I‘m pleased to answer your questions:
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