

AI for Power Electronics Design: From Smart Algorithms to Intelligent Systems

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AI & PE Design at a Glance

2

Smart Algorithms for PE Design

3

Intelligent Systems

4

Conclusions and Prospects

1.1 The role of Power Electronics (PE)

Power Electronics (PE) is the key to energy conversion and control.

The application fields of PE



Photovoltaic power



Wind power



HVDC



Electrified railway



Energy storage



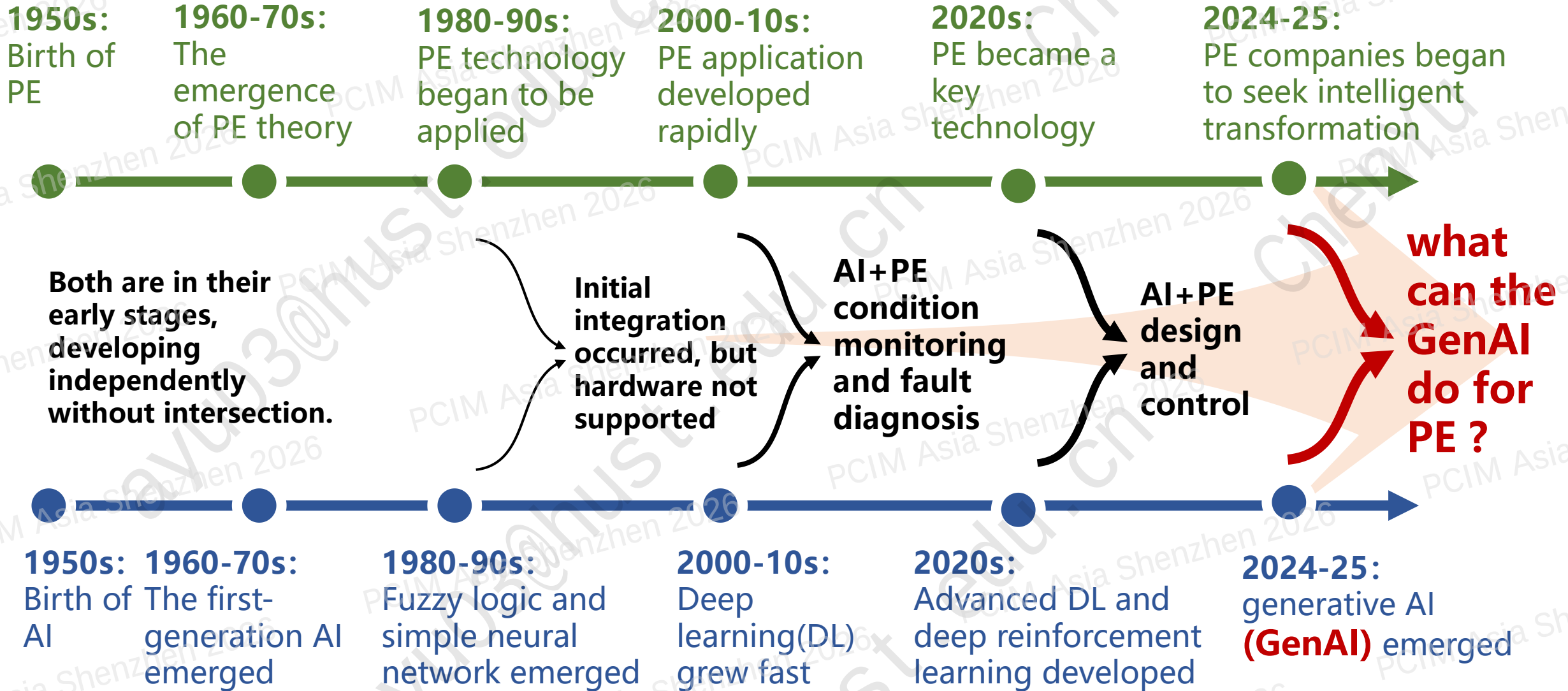
Electric vehicles



Server cluster

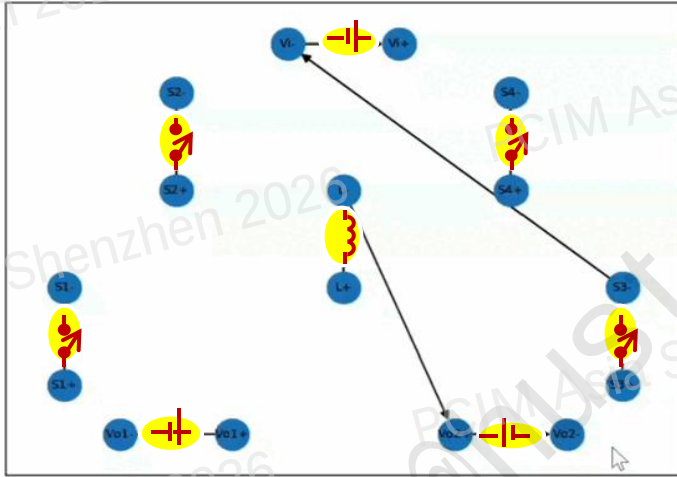
1.2 Integration between AI and PE

For a long time, we have wanted to combine AI with PE in many ways



1.3 My AI+PE perspective

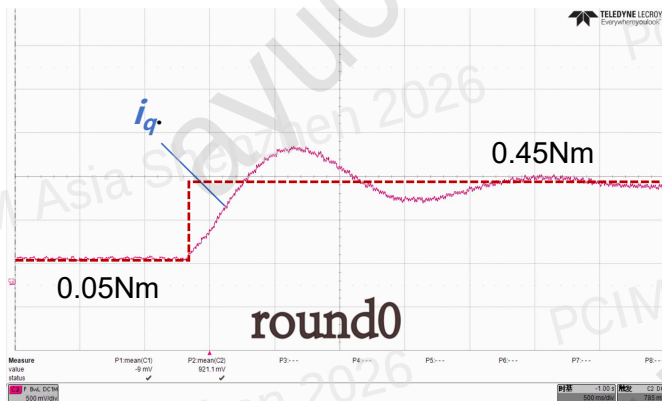
I have been working on AI and power electronics for a long time.



AI for topology deduction



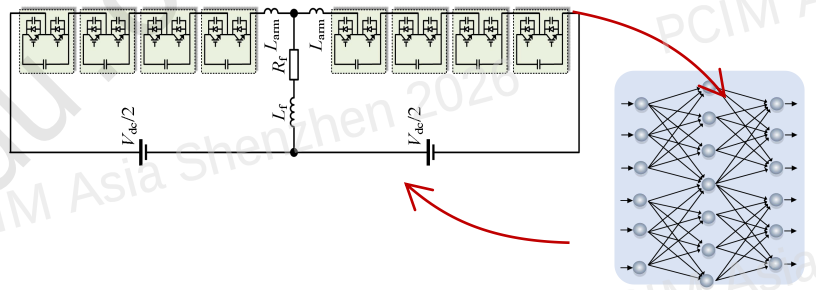
AI for layout and routing



AI for waveform control



AI for state monitoring



Control a converter from zero

1.4 Scope of this report

AI for Power Electronics Design

Topology
Deduction

Parameter
Calculation

Modulation Desgin

PE PCB
layout & routing

Circuit modeling

controller design

- **Task characteristics:**
non-real-time
- **Current goal:**
AI can free engineers from repetitive work
- **Final goal:**
AI creates actual results that are better than what humans can achieve

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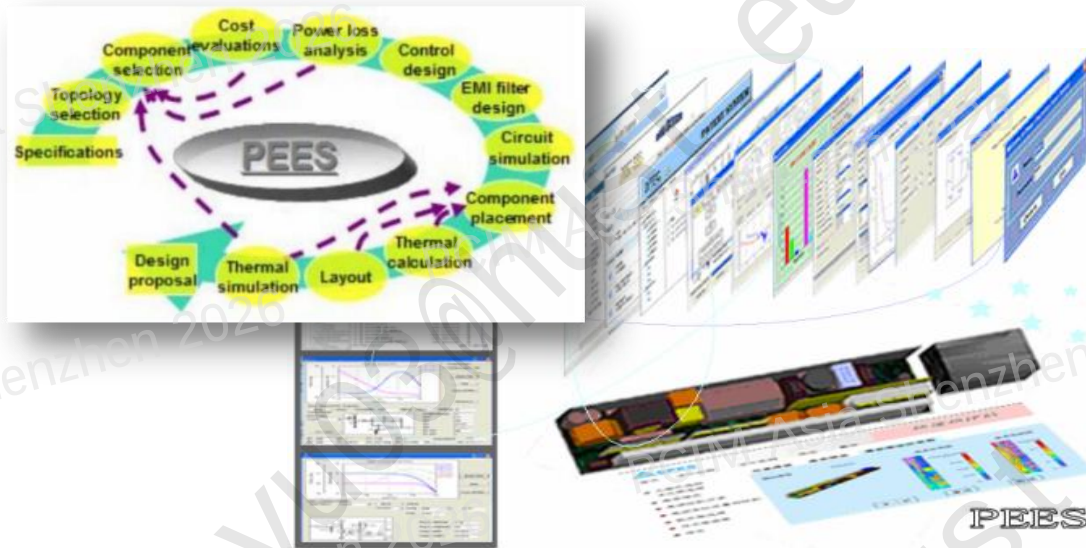
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Conclusions and Prospects

2.1 Traditional AI and PE design

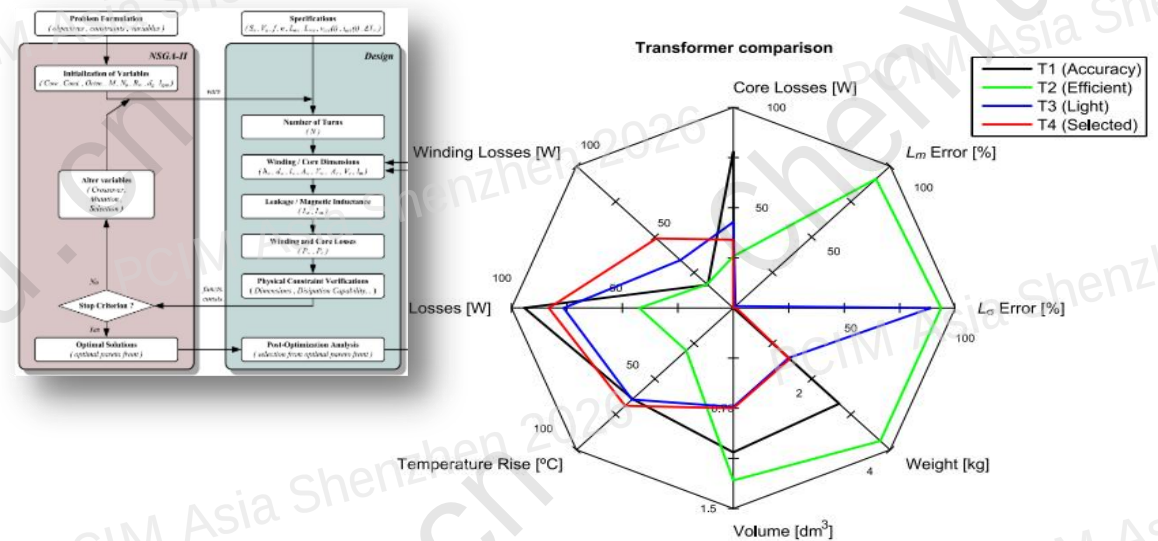
Expert systems and heuristic algorithms were the earliest smart algorithms applied to PE design.

Delta' s PE design expert system



“ W. Li and J. Ying, "Design and analysis artificial intelligence (AI) research for power supply — power electronics expert system (PEES)," 2008 Twenty-Third Annual IEEE Applied Power Electronics Conference and Exposition, Austin, TX, USA, 2008, pp. 2009-2015.

Genetic algorithm for Core Design



“ A. Garcia-Bediaga, I. Villar, A. Rujas, L. Mir and A. Rufer, "Multiobjective Optimization of Medium-Frequency Transformers for Isolated Soft-Switching Converters Using a Genetic Algorithm," in IEEE Transactions on Power Electronics, vol. 32, no. 4, pp. 2995-3006, April 2017.

So, from today's point of view, these algorithms are no longer smart.
A smart algorithm must learn from data

2.2 Deep learning and PE design

Deep learning provides a powerful tool for learning from data.

Step 1

Deep Neural Network (DNN)

Feature recognition (CNN, Graph convolution, Transformer, ...)

Output fitting (Full connect NN)

Step 2

Input 1
Input 2
.....
Input n

Out 1
Out 2
.....
Out n

Label 1
Label 2
.....
Label n

Back-propagation

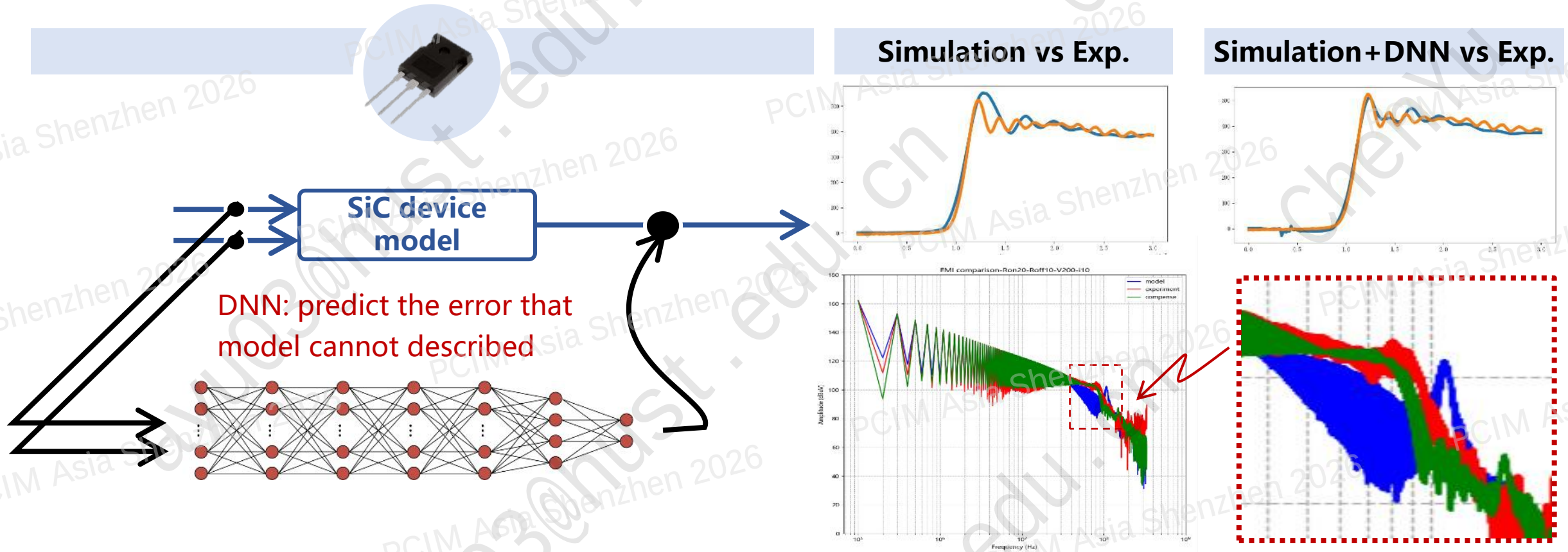
adjusts weights to drive the output ever closer to the label

Step 3

We only need to feed the data to a deep learning model, and then get the results we want.

2.2 Deep learning and PE design

In PE design, DL can be used for modeling tasks. For example, we can use DL to learn the deviation between simulation and experiment.

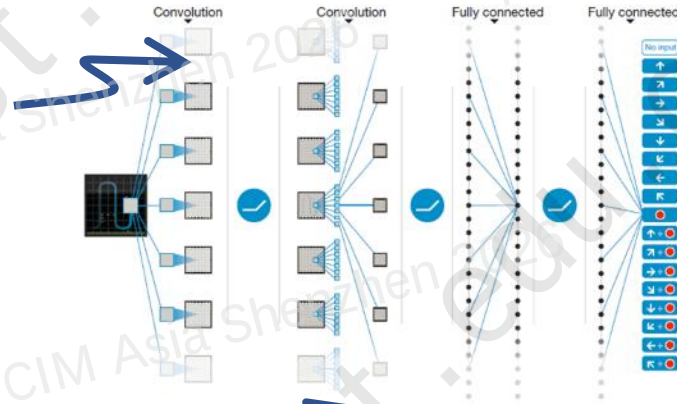


DL requires a lot of data collected by humans.
Can an algorithm collect data and learn from data on its own?

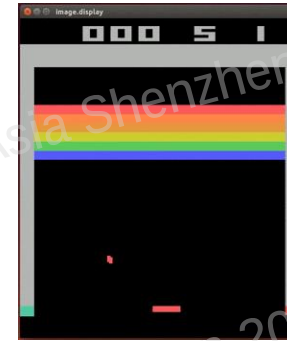
2.3 Deep reinforcement learning (DRL) and PE design

In 2015, DeepMind published a paper in Nature, using DRL to let a deep neural network learn to play games on its own.

Step 1: feeds raw game frames directly into the DNN



Step 2: The DNN's outputs: direct control the game



Step 3: train the DNN with reward feedback to improve gameplay (Reinforcement-learning)

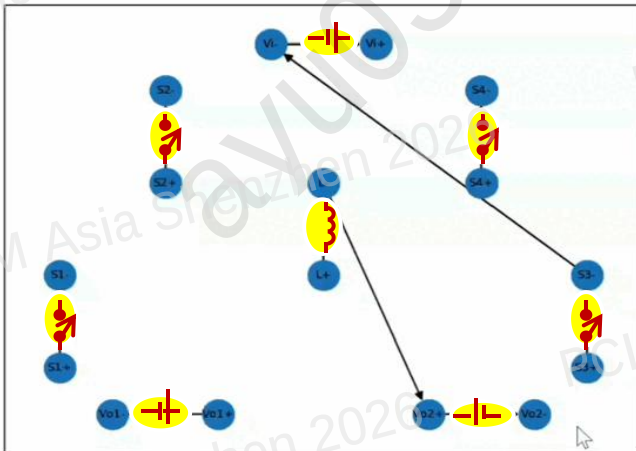
With DRL, the algorithm has become much smarter, because it can explore like a human

2.3 Deep reinforcement learning (DRL) and PE design

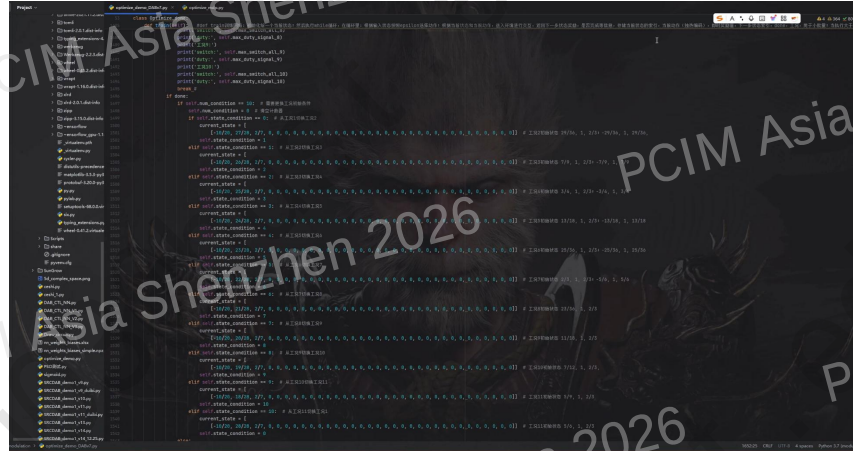
Inspired by this work, many PE design problems can be solved by DRL.



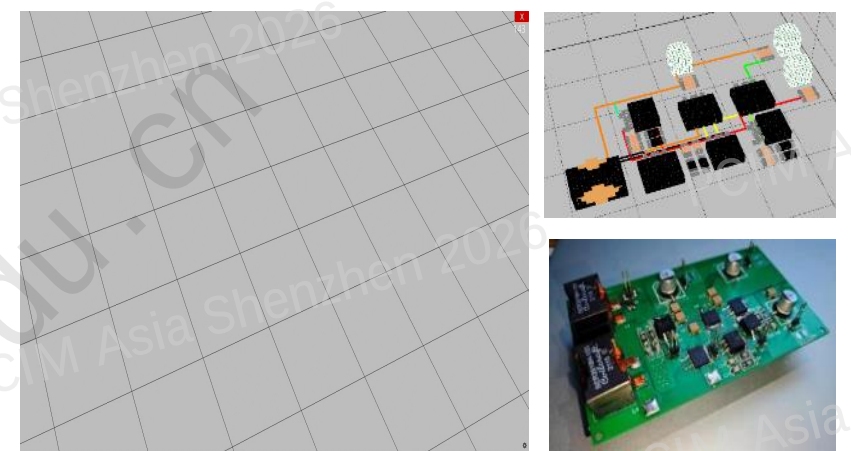
DRL for Topology Deduction



DRL for Modulation Design

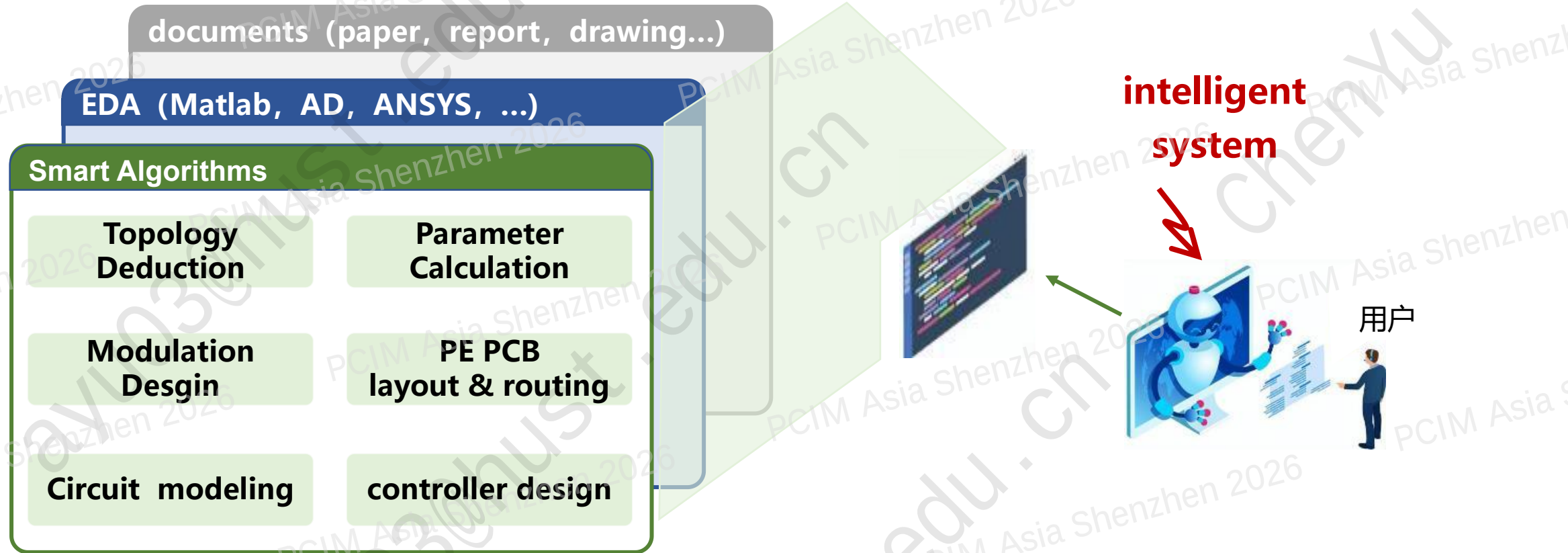


DRL for Simple PCB Design



2.4 What New trends ?

So far, a lot of smart algorithms have been developed for different PE design tasks. However, **a real design project** is much complicated.



We need a powerful intelligent system

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Smart Algorithms for PE Design

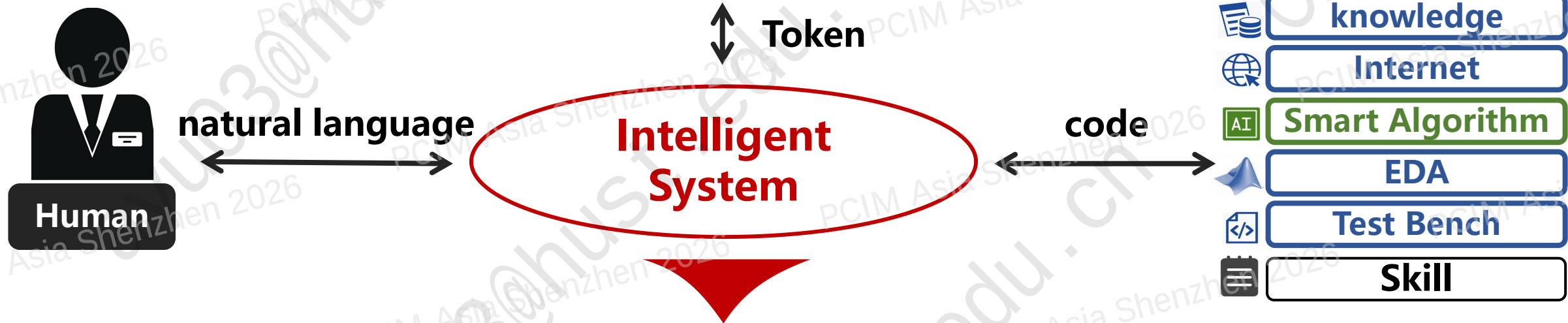
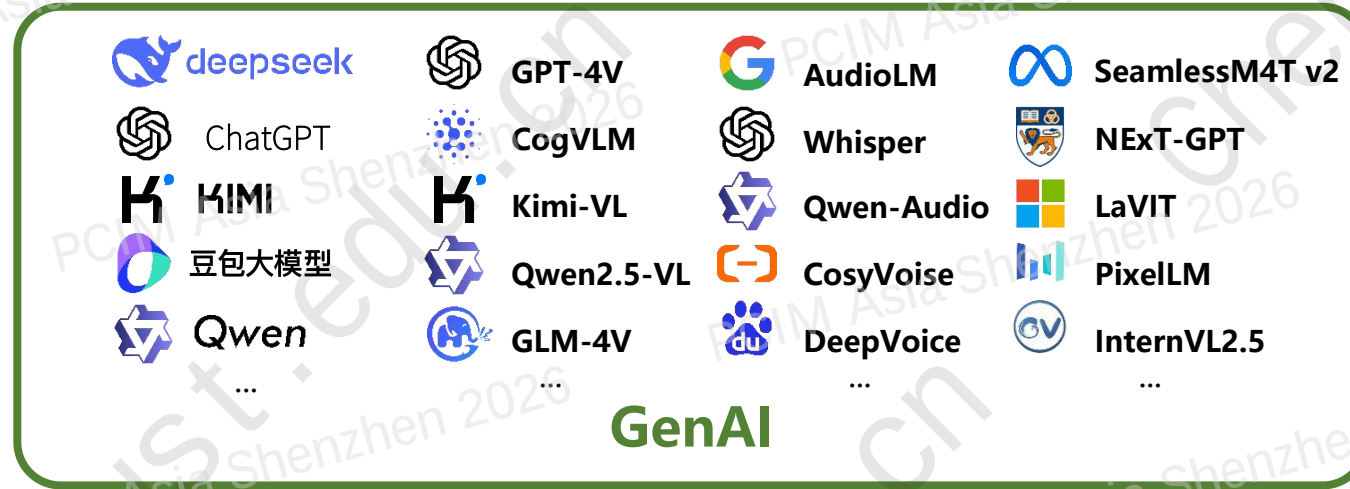
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Conclusions and Prospects

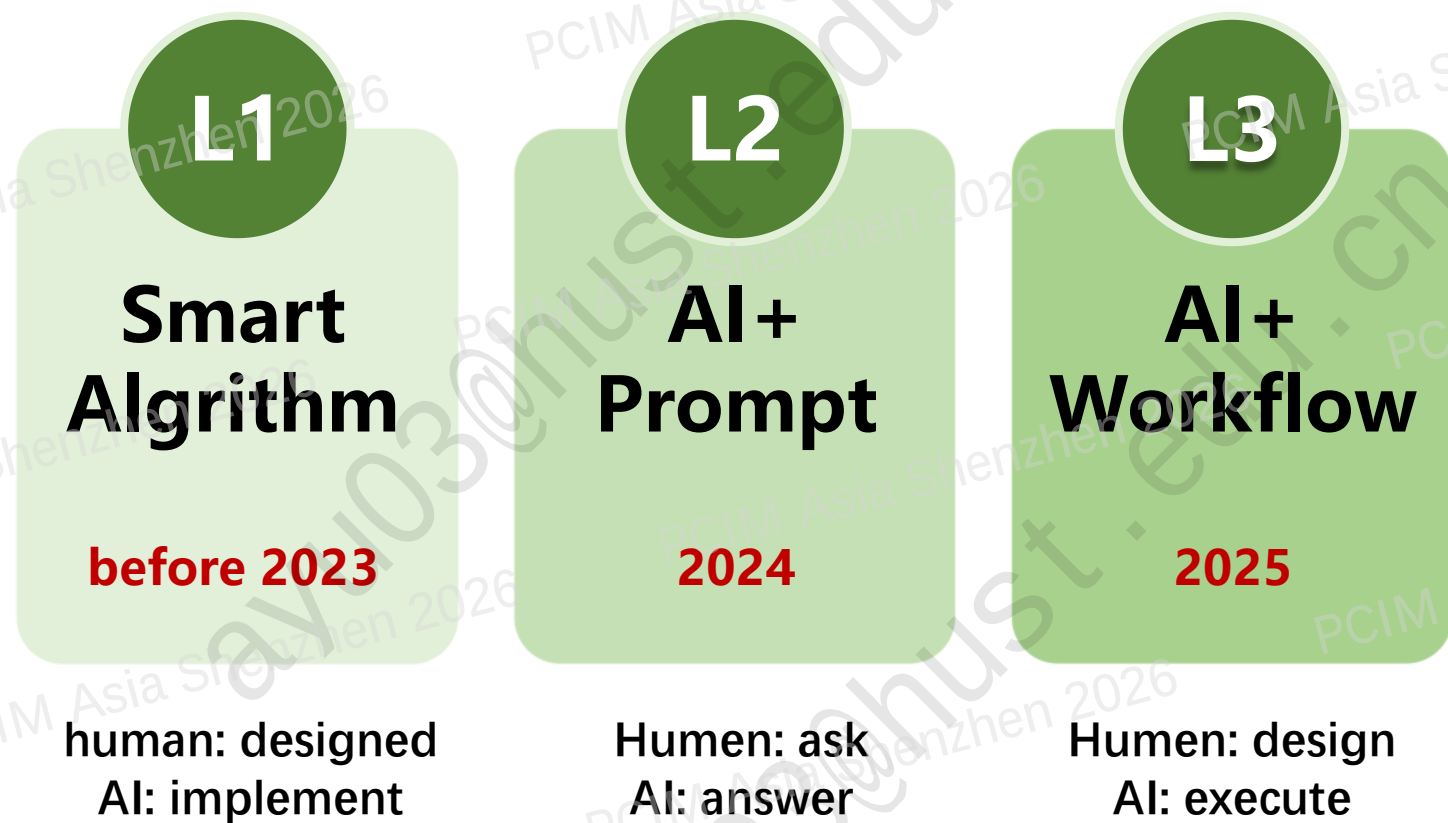
3.1 Emerging paradigm



I think we should harness **human intelligence, AI, and all the tools** to create a powerful intelligent system for PE design

3.2 Technology roadmap

We are already on our way from smart algorithms toward intelligent systems.



3.3 Cutting-edge progress

In 2025, I led an AI+PE competition. One of the challenges was to **develop an AI-based design tool for power electronics.**



第11届高校电力电子应用设计大赛
The 11th University Power Electronics Application Design Competition

高校电力电子应用设计大赛

电力电子领域全国水平最高的大学生竞赛

参赛报名



竞赛3：第十一届高校电力电子应用设计大赛—“台达杯”AI应用竞赛

主办单位：中国电源学会、中国电源学会科技竞赛工作委员会

承办单位：华中科技大学

冠名合作伙伴：台达电子企业管理（上海）有限公司

联合合作伙伴：湖南艾华集团股份有限公司、苏州镓创晶合科技有限公司

本竞赛旨在探索人工智能（Artificial Intelligence, AI）在电力电子领域的创新应用，如AI在电力电子设计、控制、运维等领域的应用，基于AI的项目规划管理，AI与领域知识融合方法等。鼓励大学生关注AI前沿，鼓励创新，鼓励开源，以促进“AI+电力电子”实际落地和产业升级

3.3 Cutting-edge progress

AI is used to drive a simulation software.



Delta Cup award-winning entry

- Zhengzhou University
- <https://gitlink.org.cn/hanjuebeauty/LLAMAPICE.git>

Reduce the output ripple of the circuit

3.3 Cutting-edge progress

AI is used to generate the circuit schematics.

Design a totem-pole PFC circuit with an input voltage of 265 VAC, a nominal output voltage of 400 VDC, and a rated power of 3.3 kW.

Delta Cup award-winning entry

- Tsinghua University
- <https://github.com/Neo-Skywalker/PEBot>



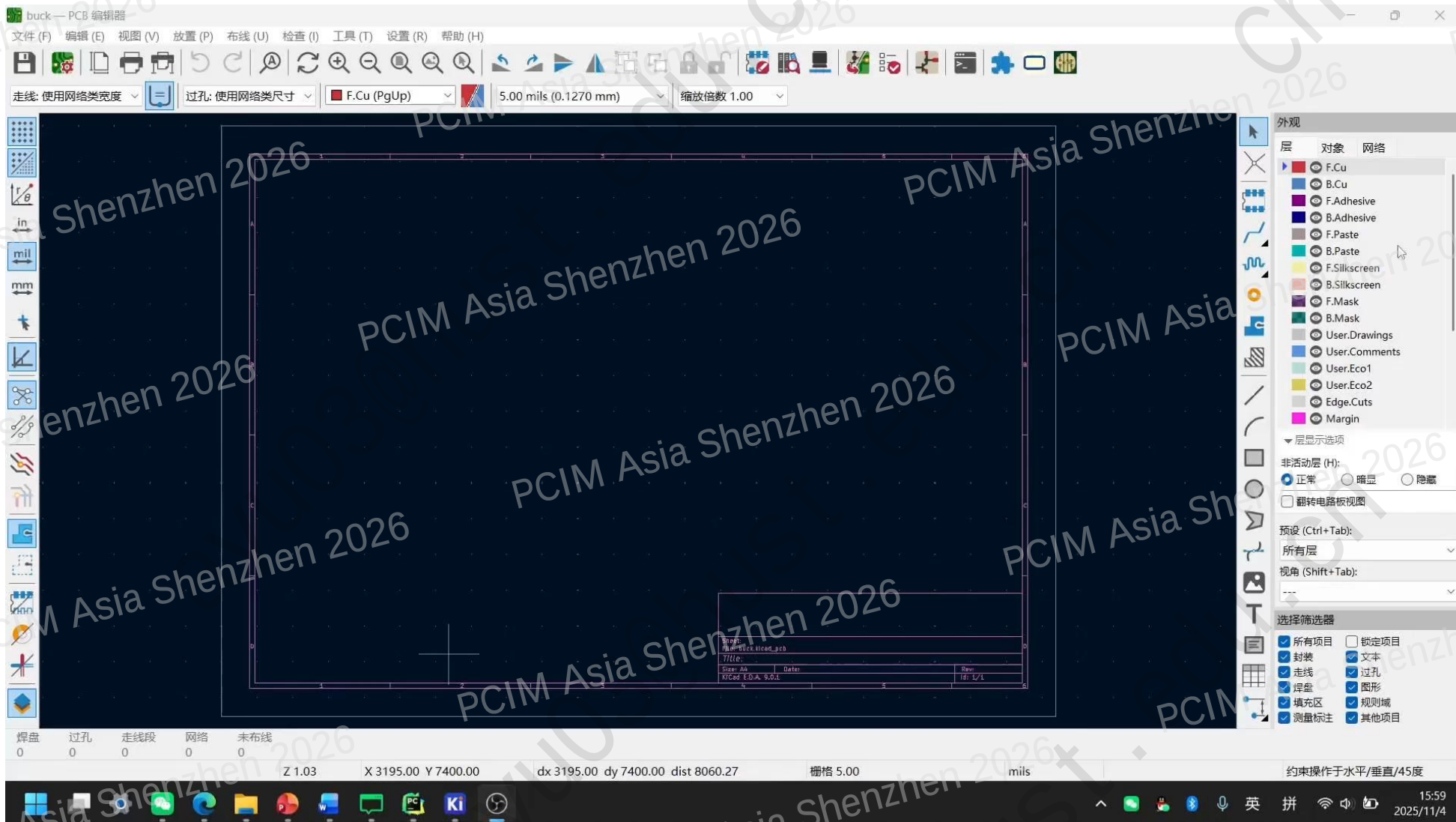
要求设计一款图腾柱PFC电路

3.3 Cutting-edge progress

AI is treated as an assistant for PCB Design.

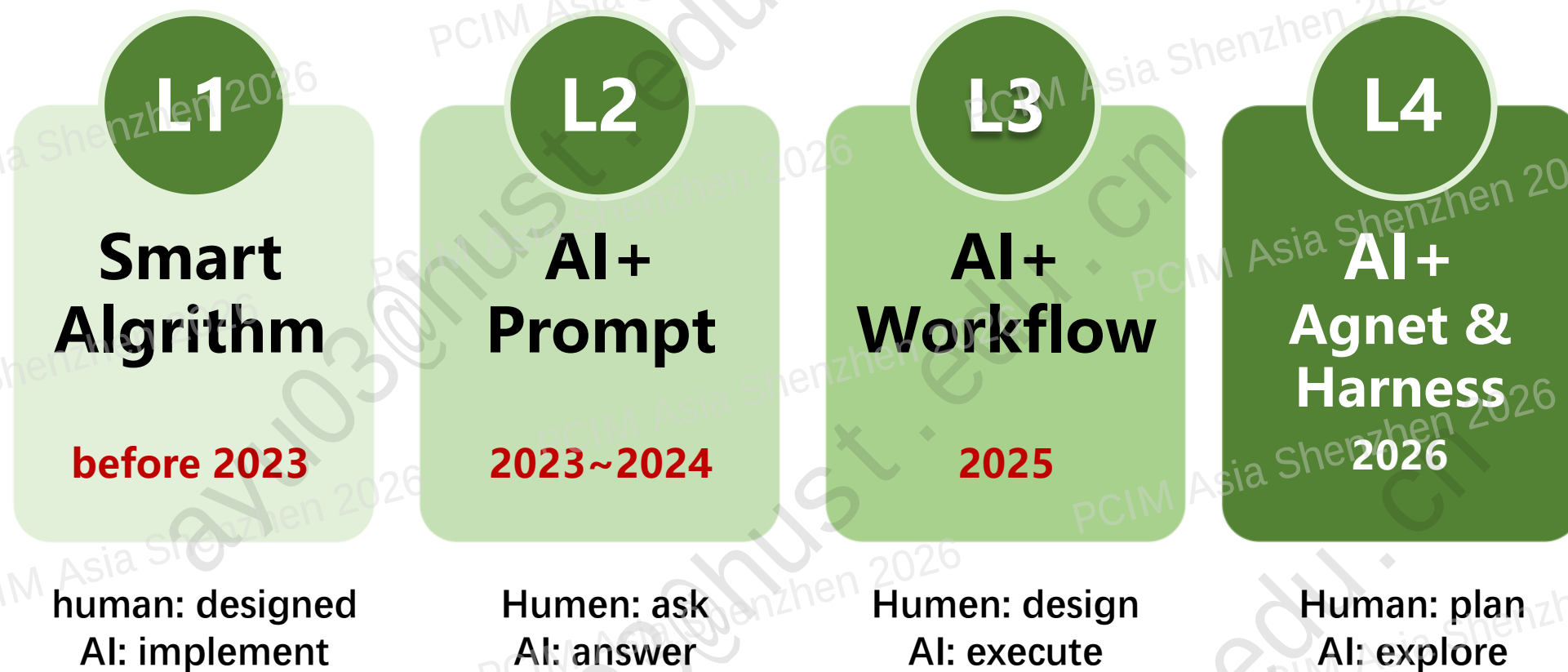
Delta Cup award-winning entry

- South China University of Technology
- LLM-Assisted PCB Design
- <https://github.com/SenwangYu/SCUT-Assistant>



3.4 PE Harness

And AI technology never stops. In 2026, the intelligent system means **Agent and Harness engineering**.



3.4 PE Agent

Human plan, AI design: a micro-power buck converter design within 30 min.

Design Mission

- Design a micropower buck converter with the following specifications:
- Input voltage: 5V
- Output voltage: 3.3V
- Rated load current: 2A
- Output voltage ripple: $\leq 1\%$ of rated output voltage
- Inductor current ripple: $\leq 20\%$ of rated current
- Voltage overshoot during startup: $\leq 4V$

MISSION1: read datasheet

MISSION2: mode analysis

MISSIONx: xxx

The screenshot displays the PEagent AI design interface. On the left is a sidebar with icons for '记录' (Record), 'Agent', '工具' (Tools), '知识库' (Knowledge Base), '发布' (Publish), and '学习' (Learn). The main area is titled '@调度专家 设计...' and contains a text input field '请输入您的设计需求'. Below this, a chat window shows a conversation with 'Doctor-chen'. The chat content includes a detailed design mission for a micro-power buck converter, specifying input/output voltages, current, ripple, and overshoot. It lists five tasks: 1. Find TP5562219 datasheet; 2. Perform mode analysis; 3. Calculate component parameters; 4. Build a state-space average model; 5. Design a PID controller. The right sidebar shows a '任务规划' (Task Planning) section with a checklist: '开始' (Start), '初始化' (Initialize), '模板选择' (Template Selection), '需求确认' (Requirement Confirmation), '摘要检查' (Summary Check), '异步存储' (Asynchronous Storage), '目录生成' (Table of Contents Generation), '目录检查' (Table of Contents Check), '自主规划' (Autonomous Planning), '调用智能体' (Call Agent), '摘要更新' (Summary Update), '任务跳转' (Task Jump), and '结束' (End).

设计一个微功率buck电路，它的输入是5V，输出是3.3V，额定负载电流是2A。输出电压纹波不要超过额定电压的1%，电感电流纹波不能超过额定电流的20%。电路启动时的电压超调量不能超过4V。

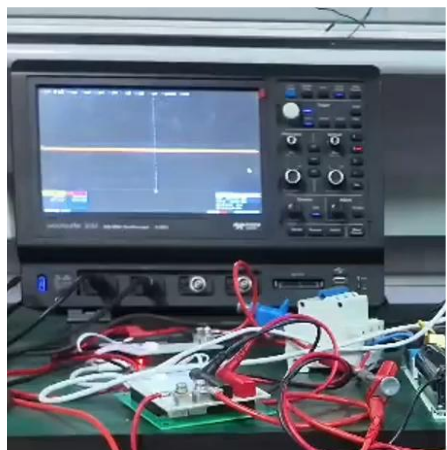
要求使用TP5562219芯片为核心来构建该buck电路。需要完成的设计任务有：

- # 1，上网查找TP5562219信息
 - 查找TP5562219的介绍，确认它的工作模式、控制特性、开关频率等信息，为后续电路设计提供基础
 - 给出1份查询报告
- # 2，给出buck电路的工作模式分析，给出buck电路的基本工作过程
 - 给出电路的模式分析，以及关键的方程式，便于后续计算做参考
 - 给出1份设计报告
- # 3，给出buck电路中电感、电容的参数计算书
 - 需要计算的元件参数有：输入电容值，输出滤波电感值，输出滤波电容值
 - 充分考虑工程设计中的设计裕量，允许实际取值大于计算结果
 - 给出1份计算书
- # 4，按最终确认的元件选择结果，调用“仿真建模专家-电路仿真-Python”做一个buck电路的状态空间平均模型
 - 要使用最终确认的元件参数值，需要“状态空间平均模型”
 - 因为进行的是开环仿真，因此即使仿真指标不满足设计要求，也不需要修改参数。将指标记录下来即可
 - 生成1份仿真报告
- # 5，调用“PEagent-仿真建模专家-控制仿真-Python”智能体，为buck电路设计一个PID控制器
 - 调节Kp, Ki, Kd三个控制器参数，直到控制效果达到设计要求
 - 生成1份控制参数设计报告

内容由人工智能模型生成，请仔细甄别

3.4 PE Agent

Humans plan, AI executes: call the genetic algorithm, ANSYS software and use the test bench and scope.

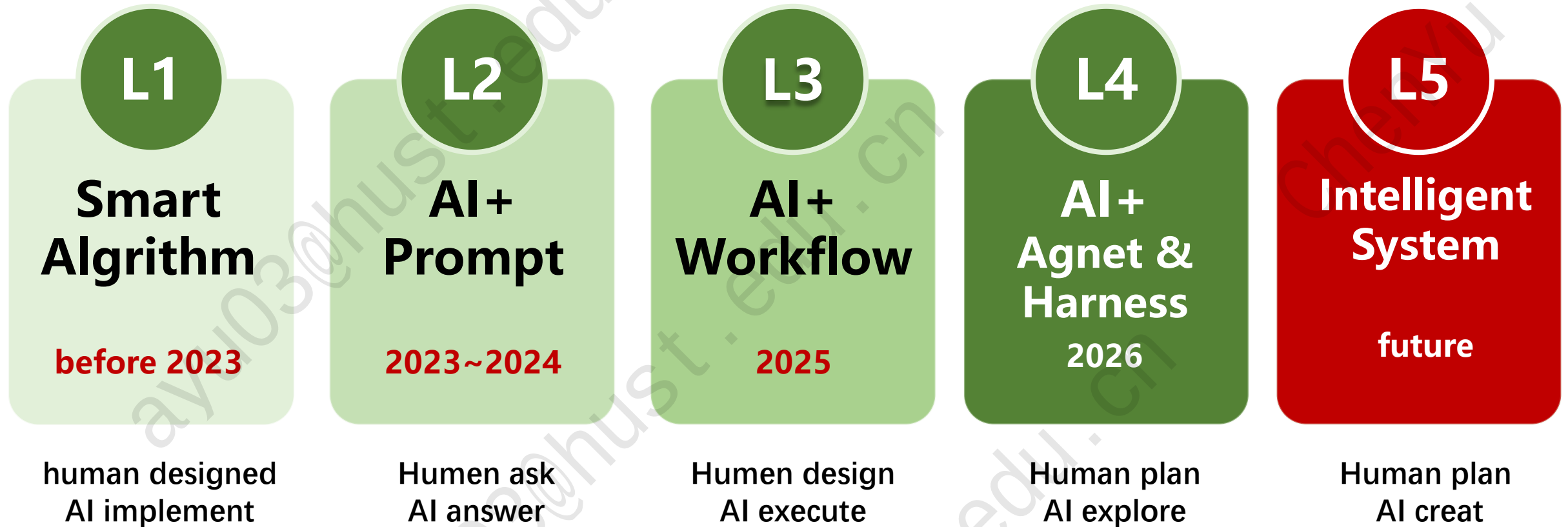


环节1：电感参数设计

00:01 / 120:00 结束录制

3.5 What is the next ?

The next-generation form of intelligent systems and what it can do for power electronics design are very exciting.



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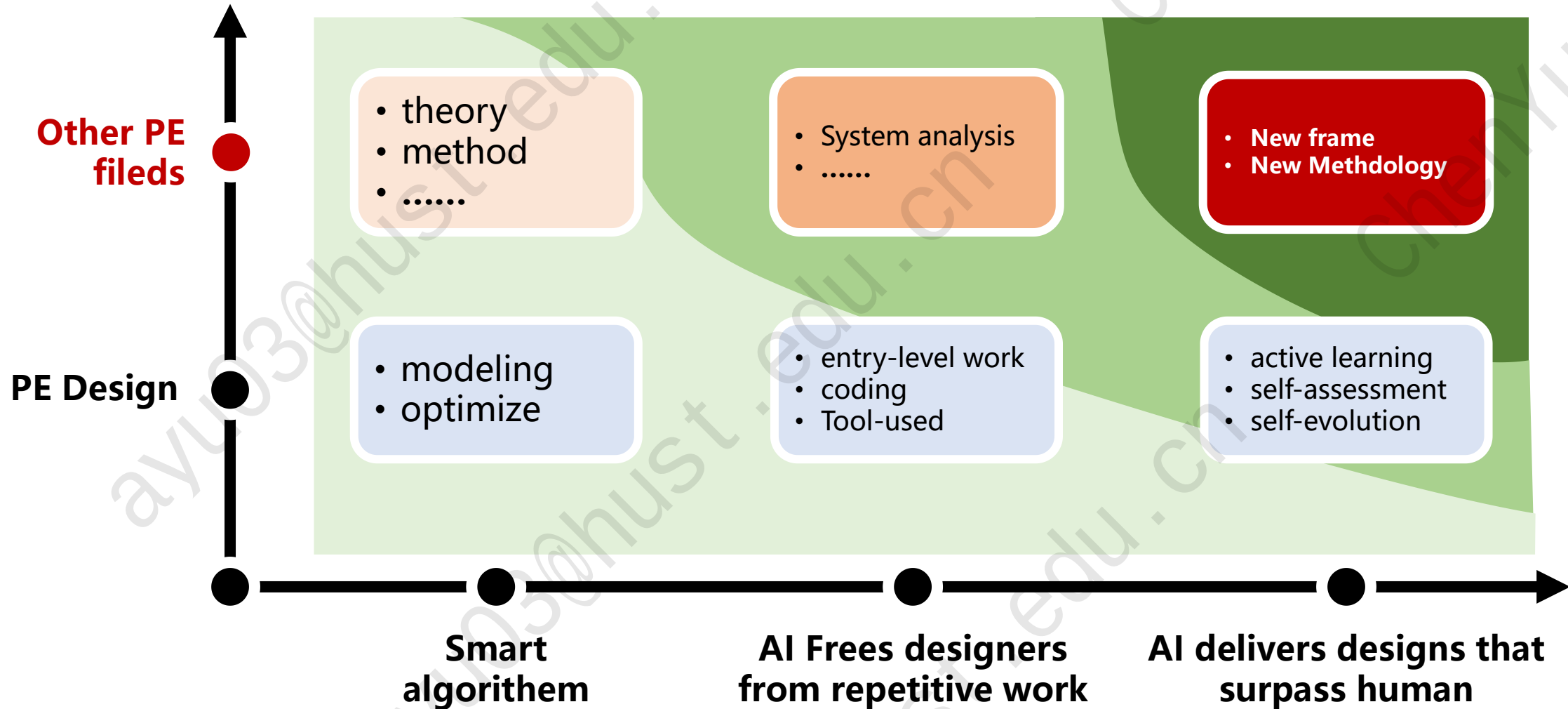
Intelligent Systems

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Conclusions and Prospects

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Smart algorithms to intelligent systems, the tempting future.



Thank you for listening