

Deep Co-design: Streamlining the Electro-Thermal Design Process for Future Automation

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INTRODUCTION

- Design teams are increasingly facing complex problems necessitating highly-integrated and interdisciplinary collaboration
 - Example: thermal solutions for power electronics needed to meet the demand for electric vehicles (EVs) and consumer electronics
- Electro-thermal practitioners have employed a “co-design” approach [1]
- Traditional co-design falls short of the ideals of simultaneous collaboration and rich communication between disciplines

OBJECTIVE

Draw on collaboration principles from design and systems engineering to propose a new concurrent design framework:

"Deep Co-design"

	Traditional Co-design	Deep Co-design
Nature of Collaboration	<p>Collaboration happens sequentially [2]</p> <ul style="list-style-type: none"> Infrequent sharing of domain information Sequential optimization of sub-systems Freezing of design architecture of one domain to inform the other 	<p>Collaboration happens simultaneously</p> <ul style="list-style-type: none"> Frequent sharing of domain information Concurrent optimization of sub-systems Co-development of design architectures
Fidelity of Domain Models	<p>Low fidelity models</p> <ul style="list-style-type: none"> Geometric constraints imposed [3] Late iterations cause high costs [4] 	<p>High fidelity models</p> <ul style="list-style-type: none"> No geometric constraints Integrated models reduce costly iterations

RESULTS

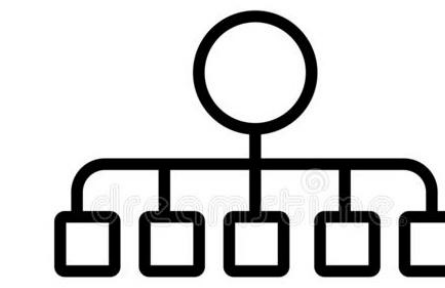
Traditional Co-design

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Electrical	Electrical specifications determined	1														
	Analytical calculations of electrical system	2	•													
	Simplified electrical models to determined system losses	3		•												
	Designing of printed circuit board (PCB)	4			•											
	Determine distribution of components on the PCB	5				•										
Thermal	Select appropriate thermal management system	6					•									
	Generate CAD of system architecture	7						•								
	Import CAD into Spaceclaim, design modeler, or COMSOL	8							•							
	Generate computational fluid dynamics (CFD) ready CAD	9								•						
	Import electrical CAD into thermal model	10									•					
	Multi-physics simulation setup	11										•				
	Solve simulation	12											•			
	Post process and evaluate results	13												•		
Build	Fabricate system and test	14													•	

Deep Co-design

		1	2	3	4	5	6	7	8	9	10	11	12
Integrated Electro-thermal	Electrical specifications with consultation	1											
	Construct numerical model of electrical system and assess preliminary results	2	•										
	Designing of printed circuit board (PCB)	3		•									
	Design thermal management system	4			•								
	Generate optimized thermal design in 2D	5				•							
	Generate CAD of system architecture in 3D	6					•						
	Conduct 3D high-fidelity simulation of thermal design and assess results of simulation	7						•					
	Incorporate high-fidelity thermal model into electrical model	8							•				
	Solve electro-thermal simulation until the desired design criterion is met	9								•			
	Post process and evaluate results	10									•		
	Parallel electrical and thermal system build	11										•	
	Test system, validate simulations	12											•

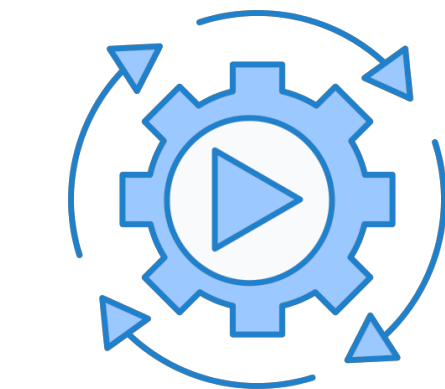
FUTURE AUTOMATION



Categorize the integrated (electro-thermal) design tasks into the five design stages



Identify the role/contribution of designers and computational supports in each category



Select, develop and implement apt automation method to further reduce time-to-develop at the category/task-level

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