

77th IIW

**Annual Assembly and
International Conference**
on Welding and Joining

7-12 July 2024
Rhodes, Greece



AI-Driven Simulation of Overlay Welding for Active Exploration Of Weld Distortion Scenarios On Cloud-Based Digital Twins

ENTEKNOGRATE

ENGINEERING SIMULATION LABORATORY

SMART SYSTEM VS. ADVANCED SYSTEM

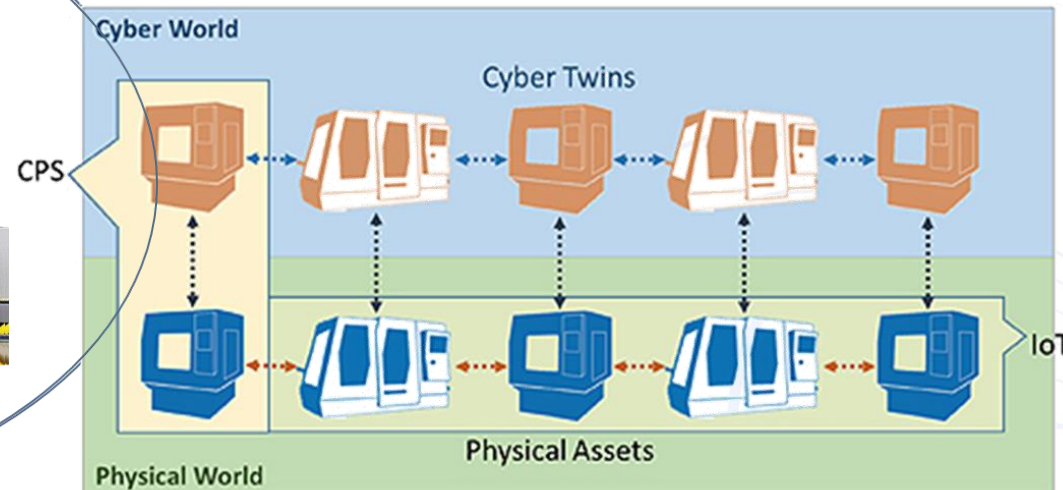
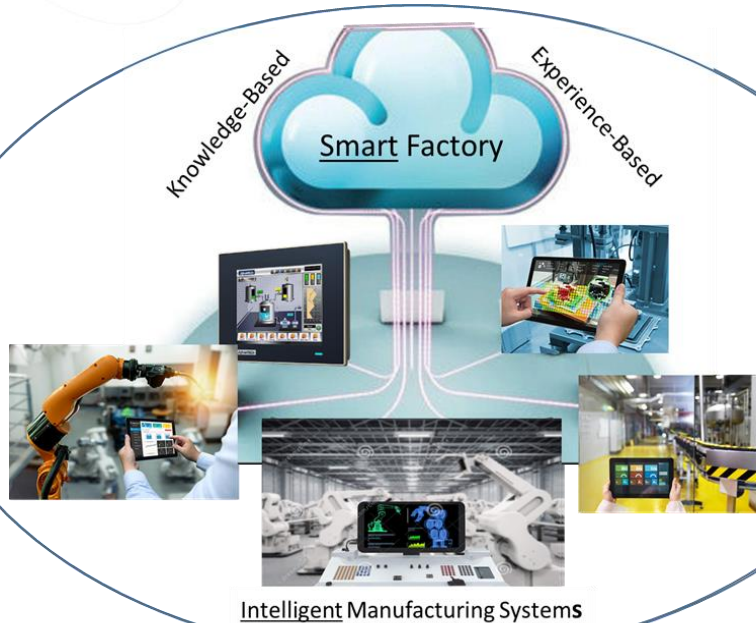
The smart factory represents a leap forward from self-contained automation to fully connected and intelligent manufacturing systems with learning capability over time.



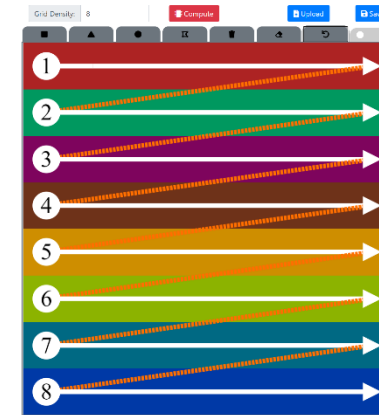
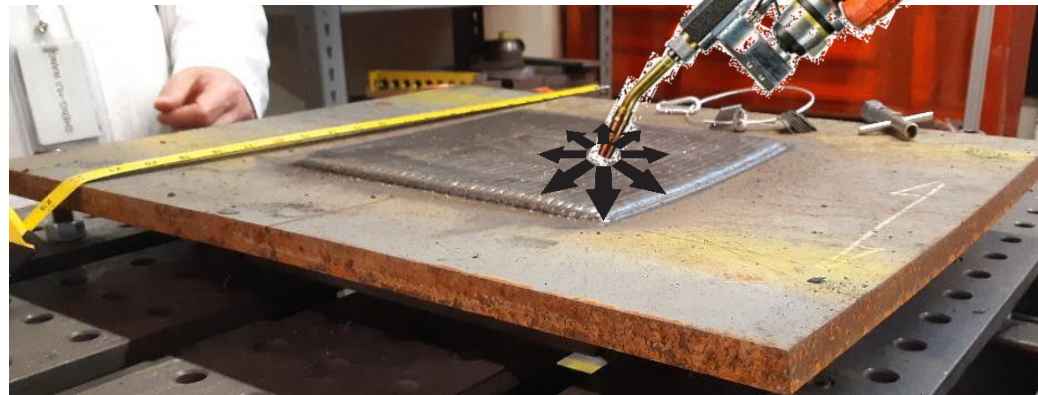
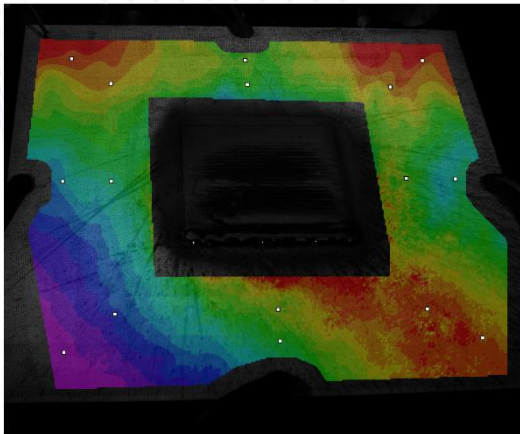
CYBER PHYSICAL SYSTEM

The smart factory represents a leap forward from self-contained automation to fully connected and intelligent manufacturing systems with learning capability over time.

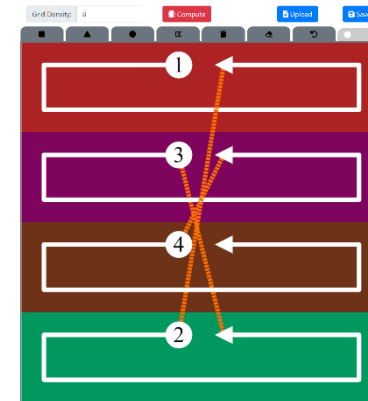
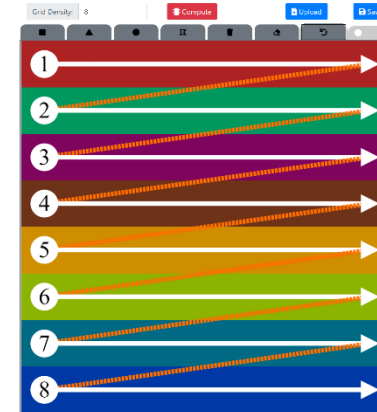
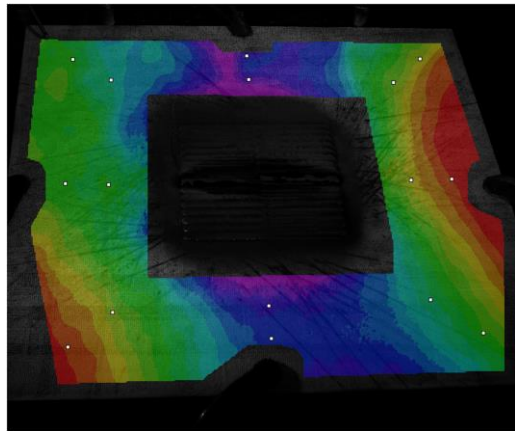
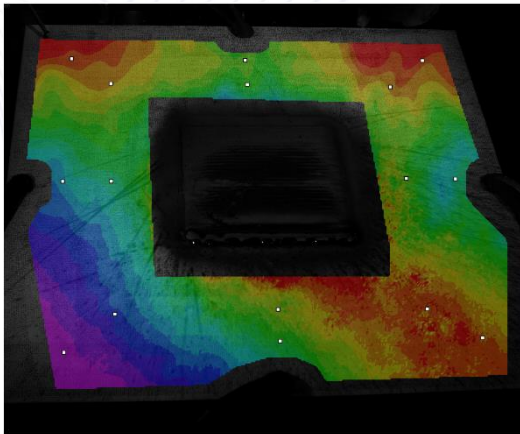
Cyber-Physical Sys. (CPS) ↳ Cyber-Manufacturing



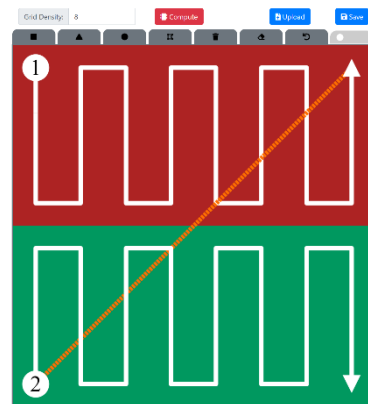
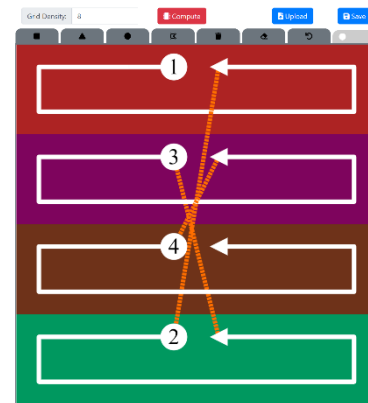
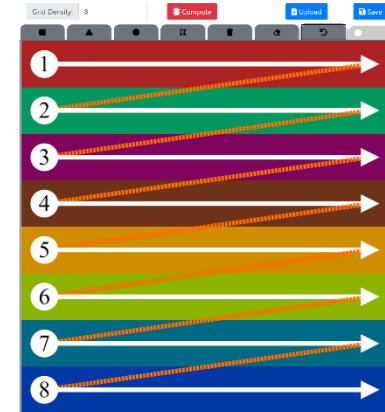
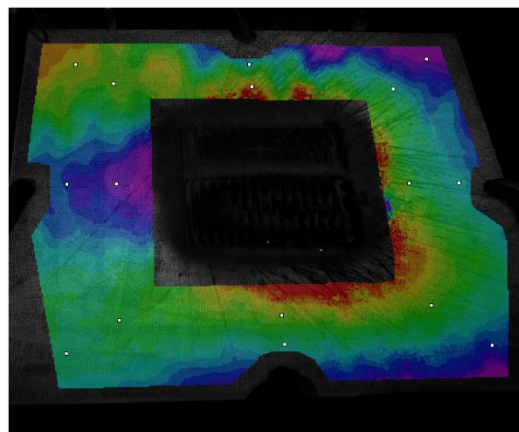
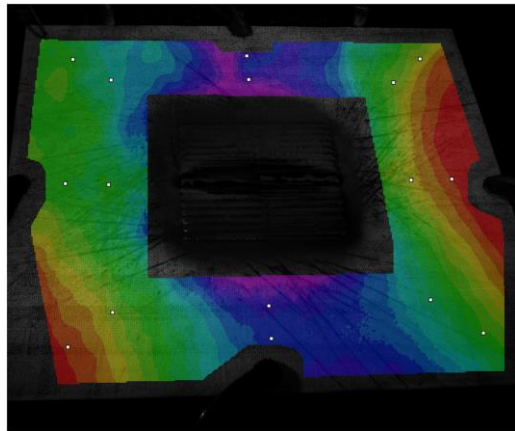
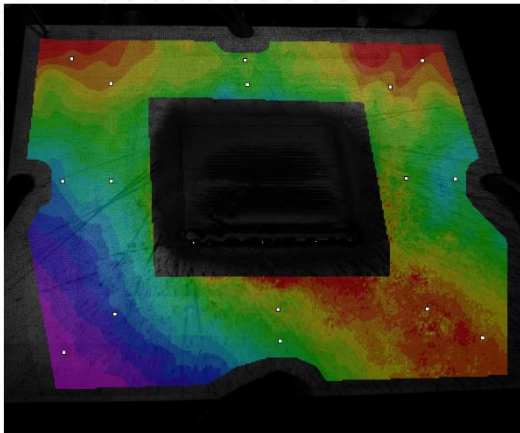
OVERLAY METAL DEPOSITION



OVERLAY METAL DEPOSITION

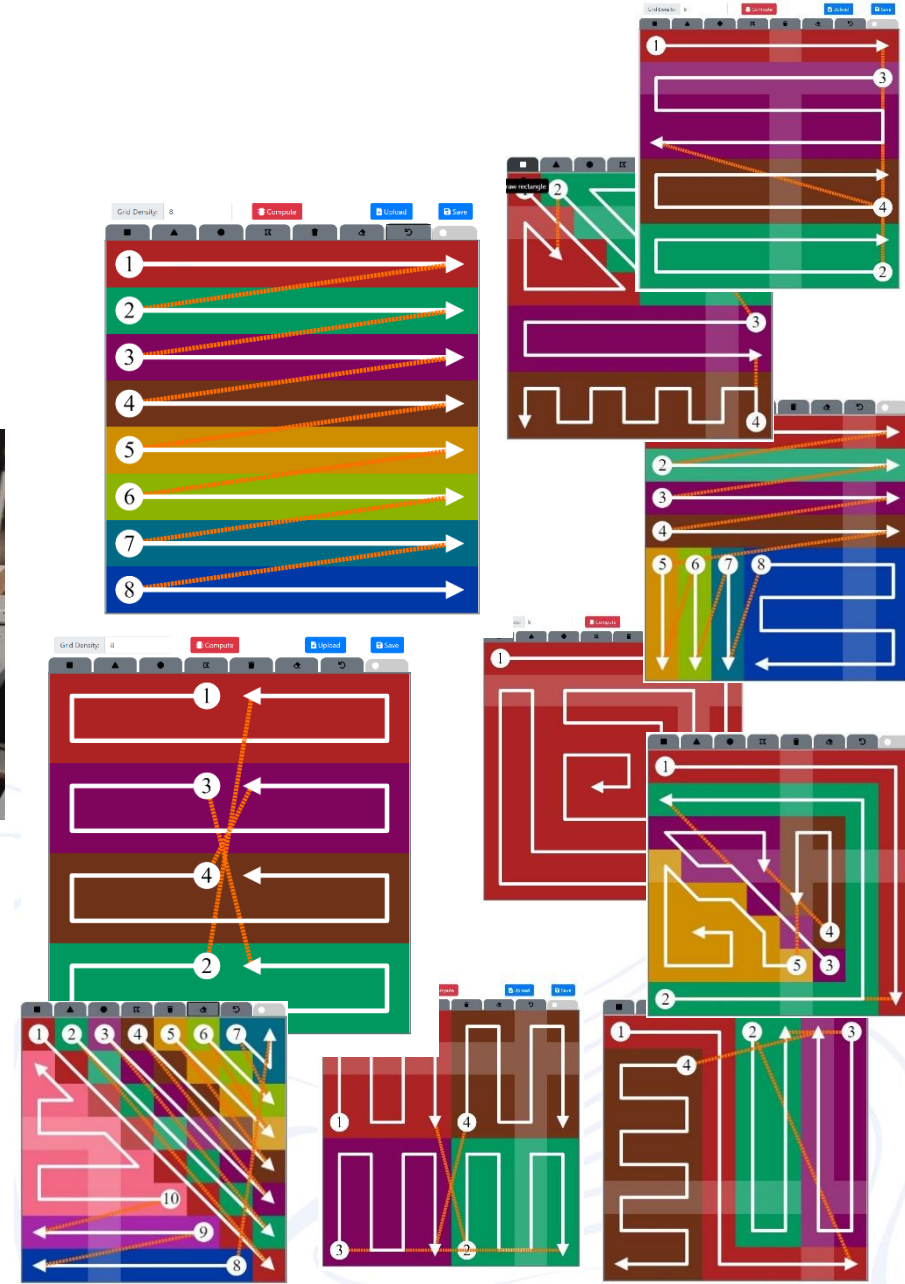
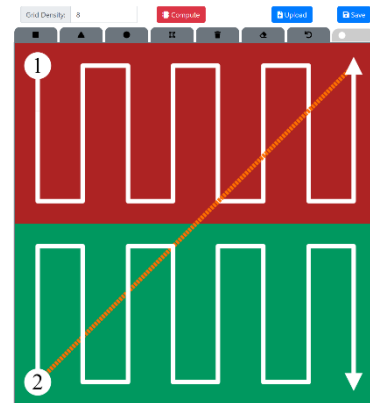
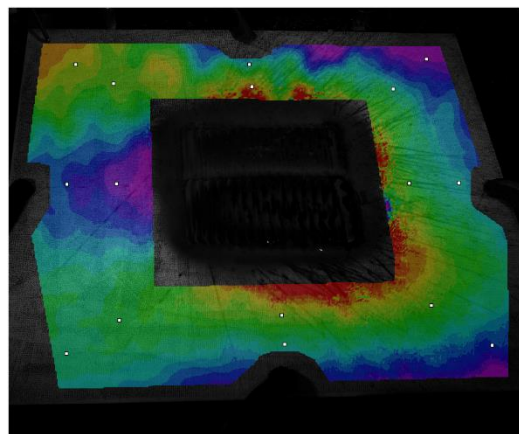
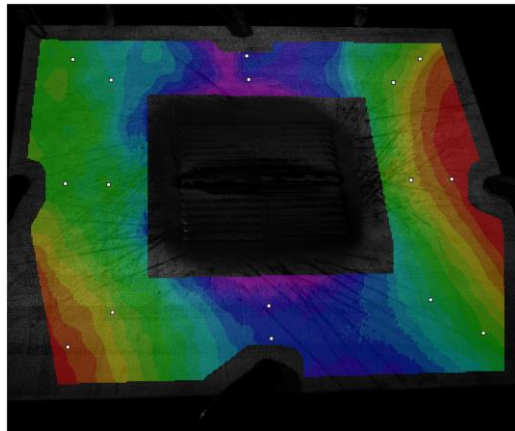
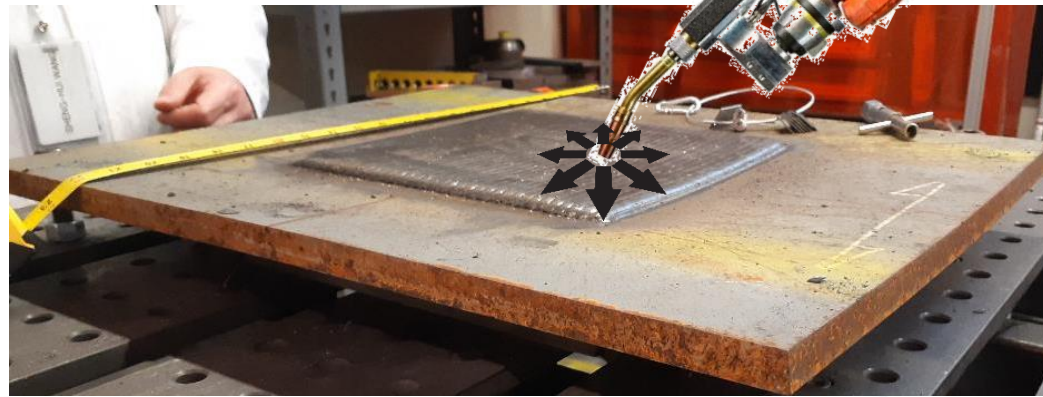
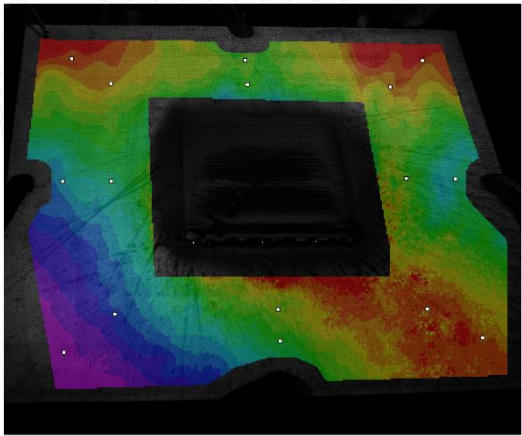


OVERLAY METAL DEPOSITION

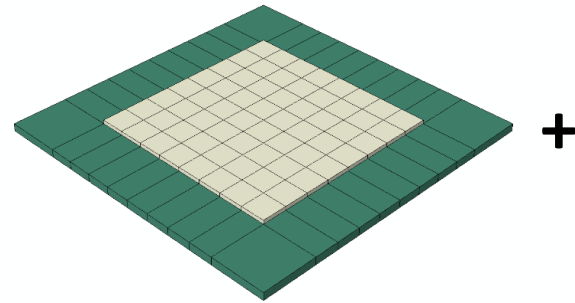


OVERLAY METAL DEPOSITION

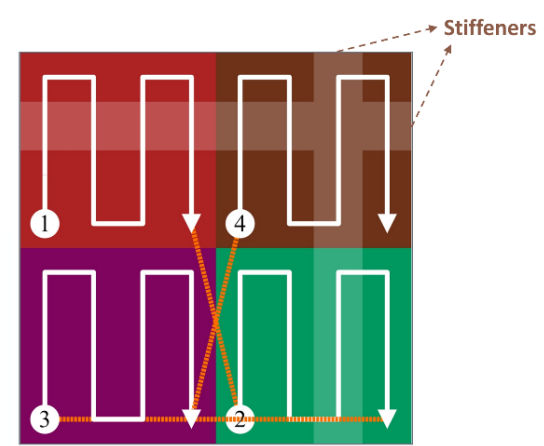
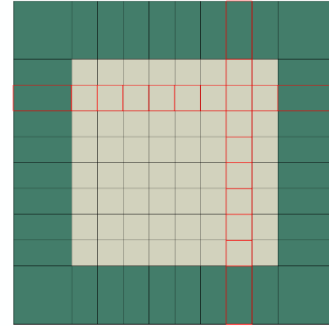
Combinatorial Optimization With Endless Possibilities



CONSTRUCTING A CYBER TWIN



+



Deposition Pattern
Stiffener Pattern

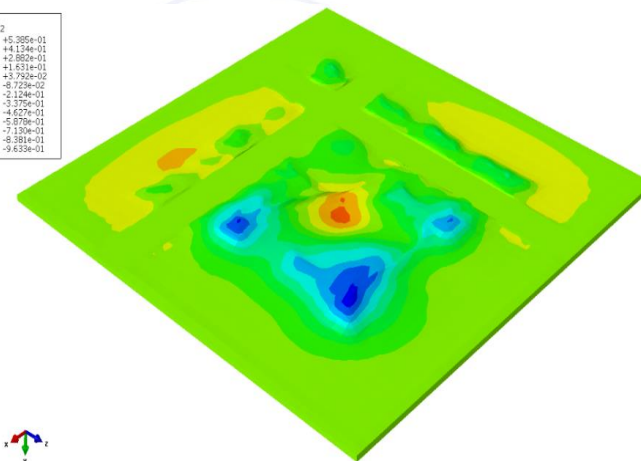
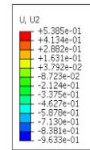
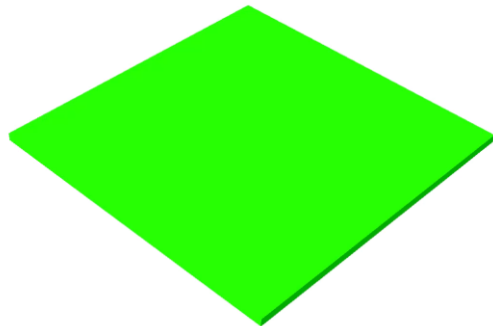
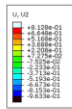
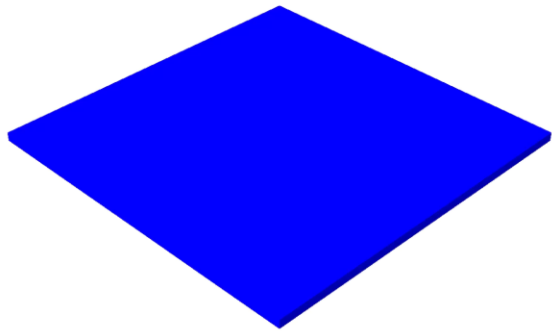
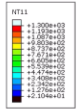


**PDE-Driven
Cyber Twin**

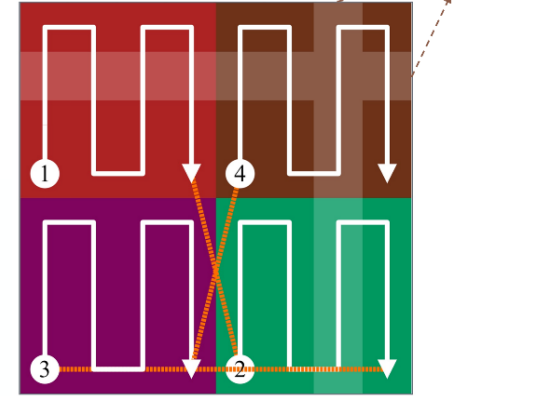
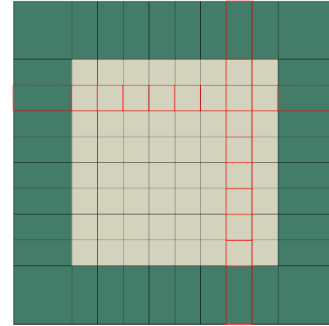
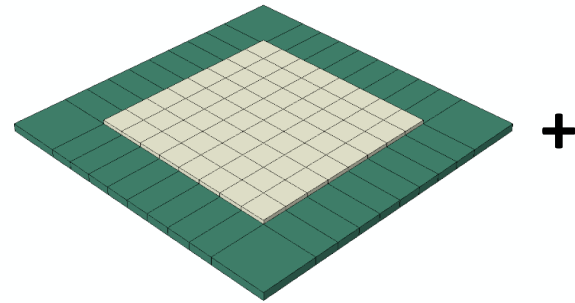


Displacement
 $X_1, X_2, X_3, \dots, X_n$
 $Y_1, Y_2, Y_3, \dots, Y_n$
 $Z_1, Z_2, Z_3, \dots, Z_n$

Response time = 8 hours



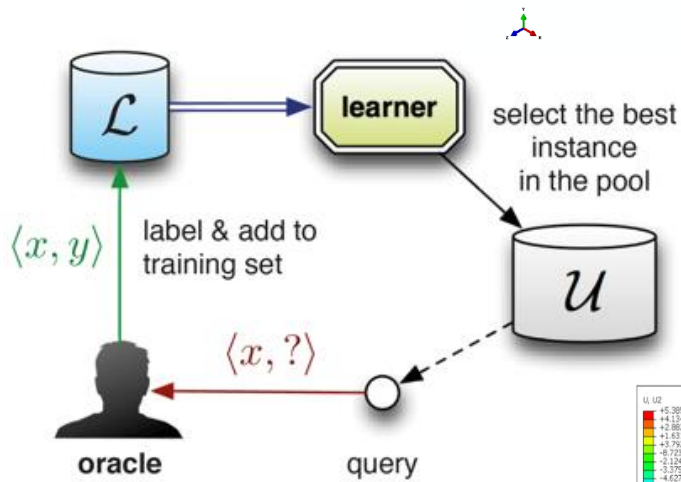
RESPONSIVE CYBER TWIN



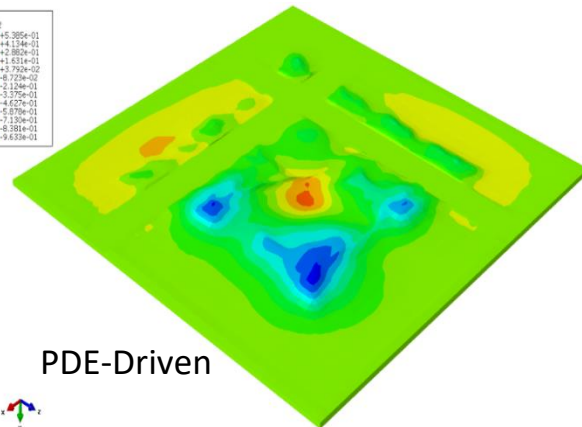
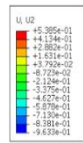
Deposition Pattern
Stiffener Pattern



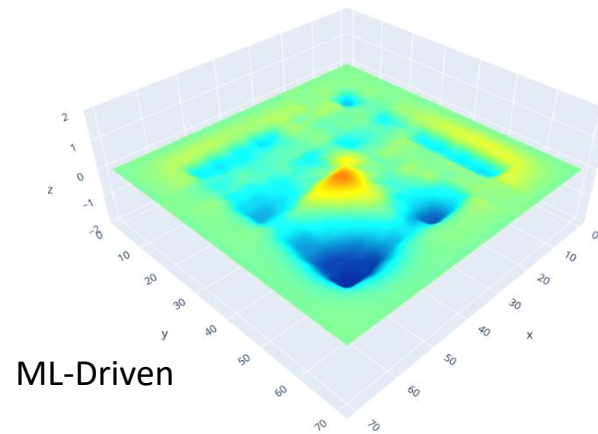
Displacement
 $X_1, X_2, X_3, \dots, X_n$
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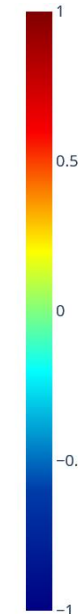
Response time = 1 sec



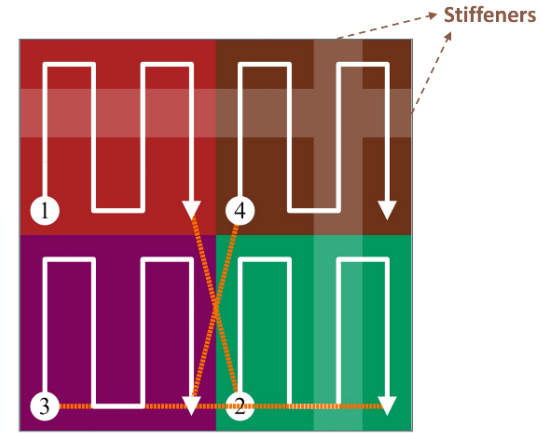
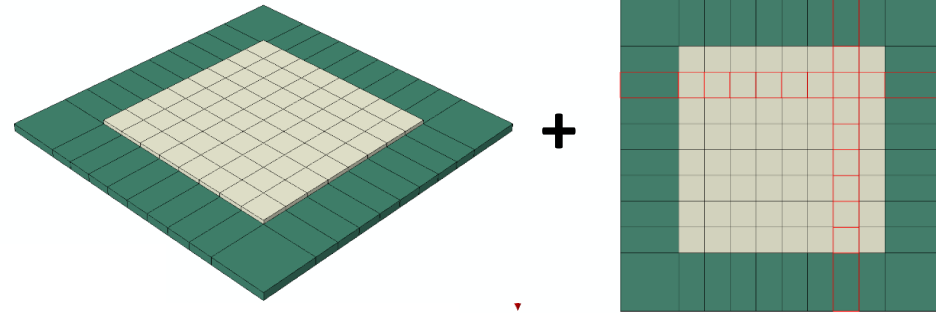
PDE-Driven



ML-Driven



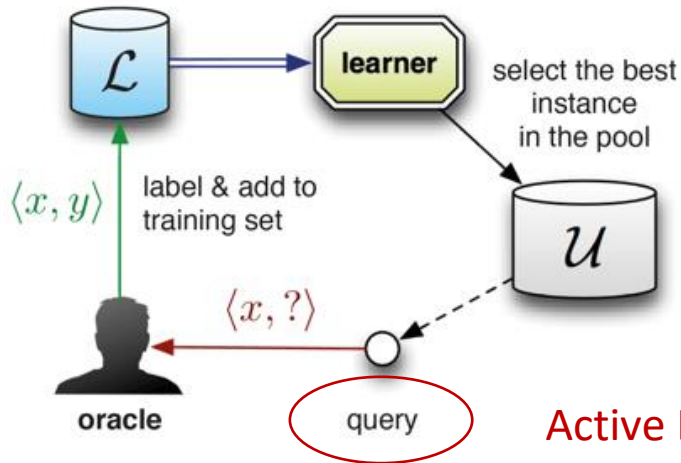
RESPONSIVE CYBER TWIN



Deposition Pattern
Stiffener Pattern



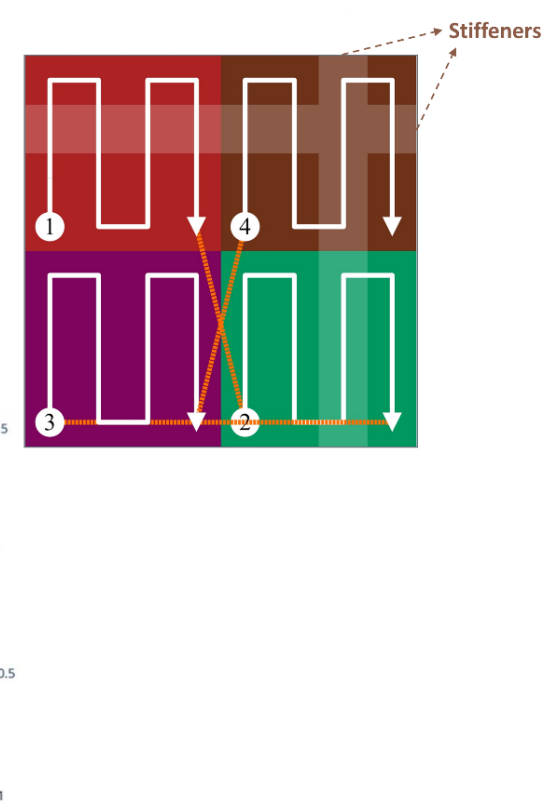
Displacement
 $X_1, X_2, X_3, \dots, X_n$
 $Y_1, Y_2, Y_3, \dots, Y_n$
 $Z_1, Z_2, Z_3, \dots, Z_n$



Active Learning – QBC

- 410 iterative queries
- 20 hypotheses
- Disagreement by variance

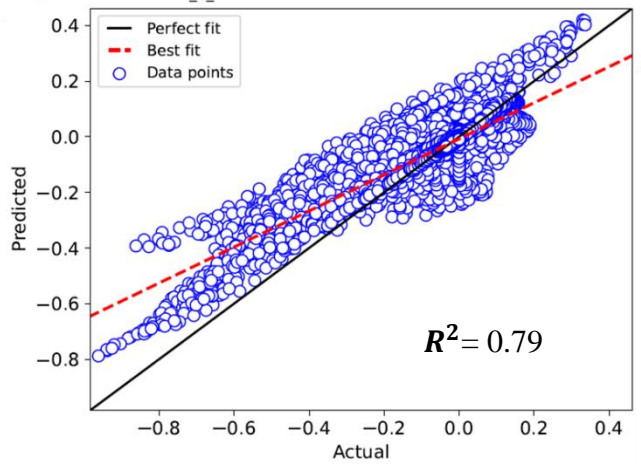
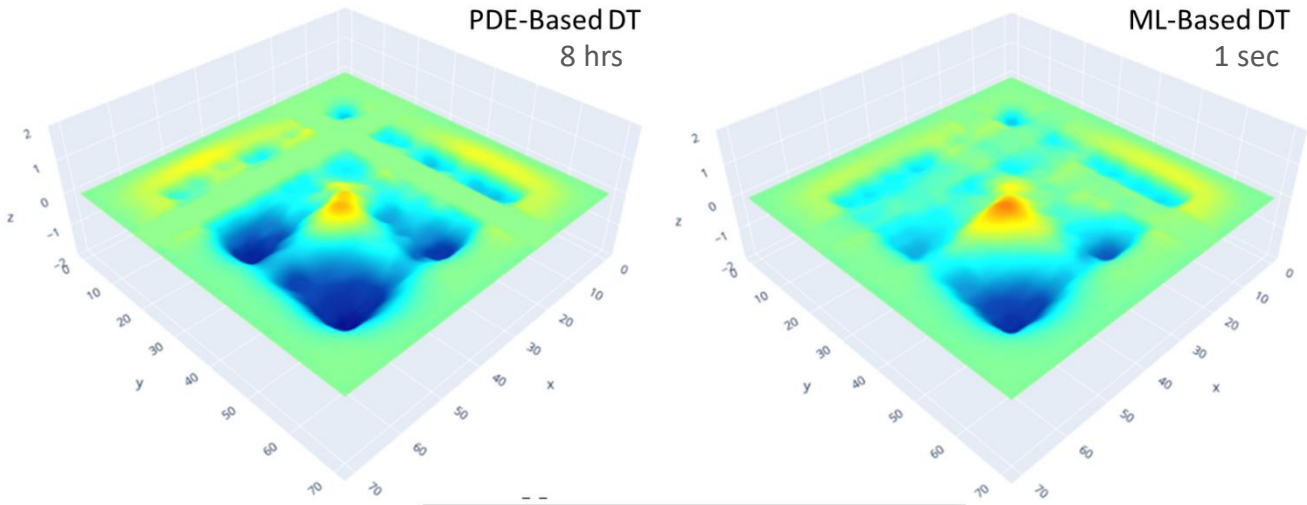
VALIDATION OF CYBER TWIN



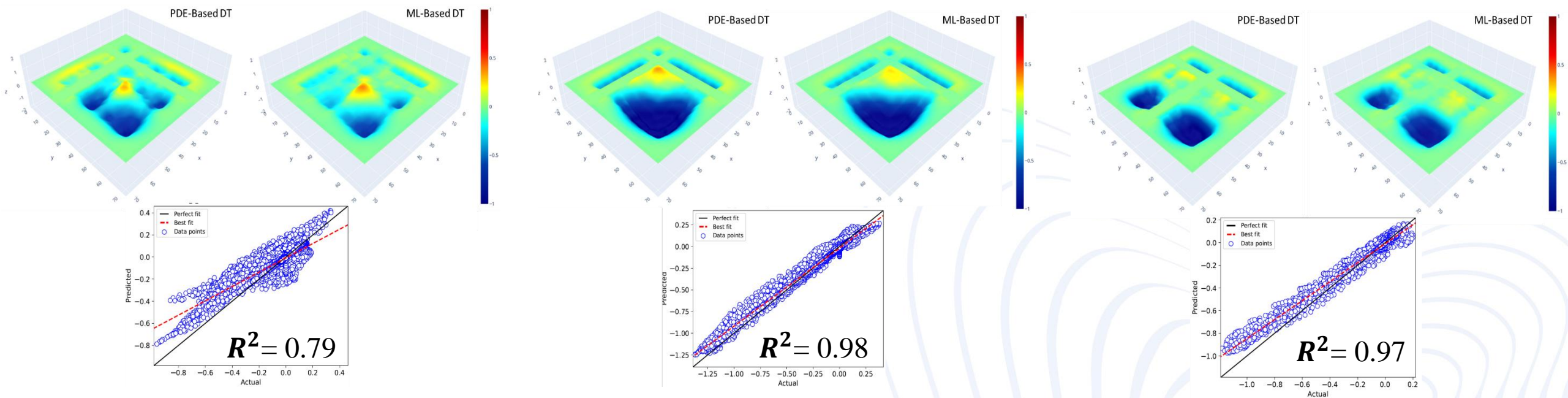
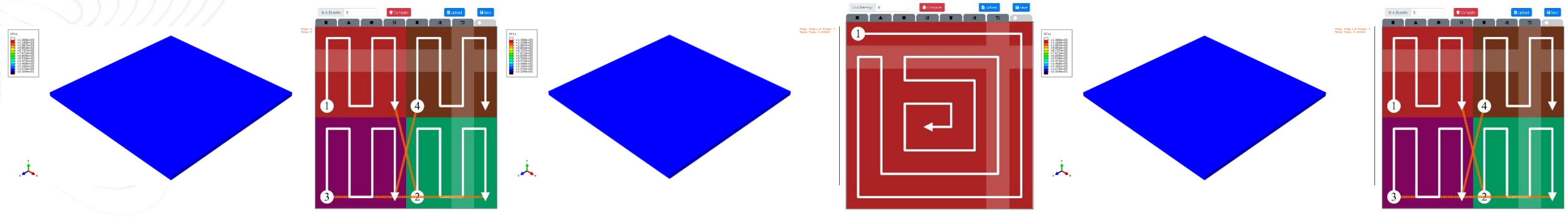
Deposition Pattern
Stiffener Pattern



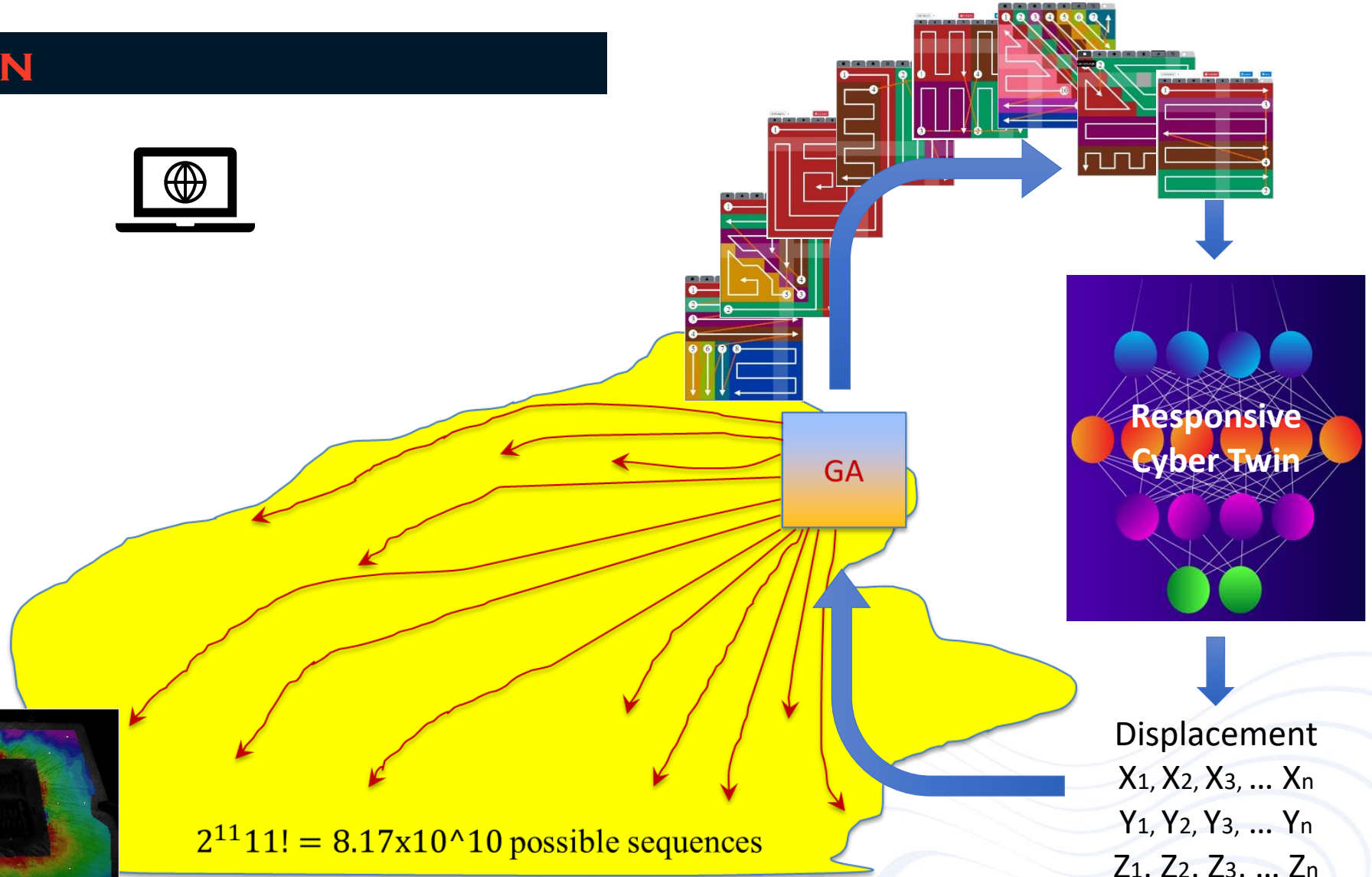
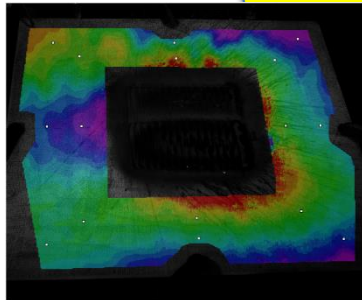
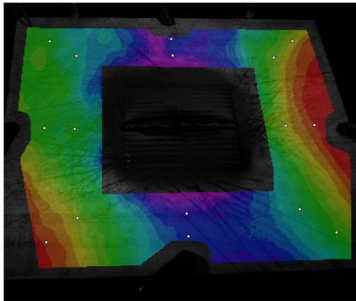
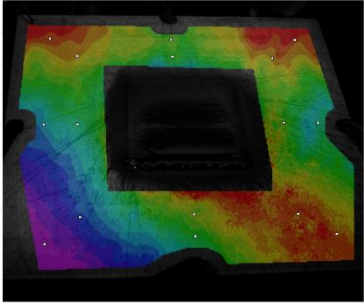
Displacement
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 $Y_1, Y_2, Y_3, \dots, Y_n$
 $Z_1, Z_2, Z_3, \dots, Z_n$



RESPONSIVE CYBER TWIN



DESIGN EXPLORATION



CYBER –TWIN ESSENTIALS (MFG)

Active Learning

to explore large design spaces with limited data (not typical big data mining)

Quick Learning

to enable interactive and iterative navigation and response time (not conventional FEA simulations)

Architecture of Smarting

Smart systems are not explicit programming, they are architected to learn continually (autonomous vs. smart machine)

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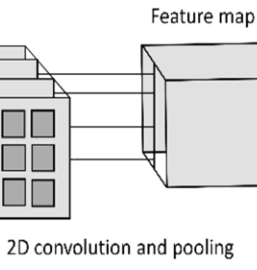
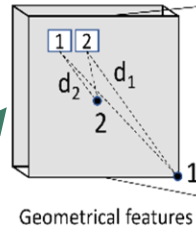
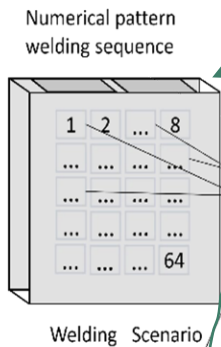
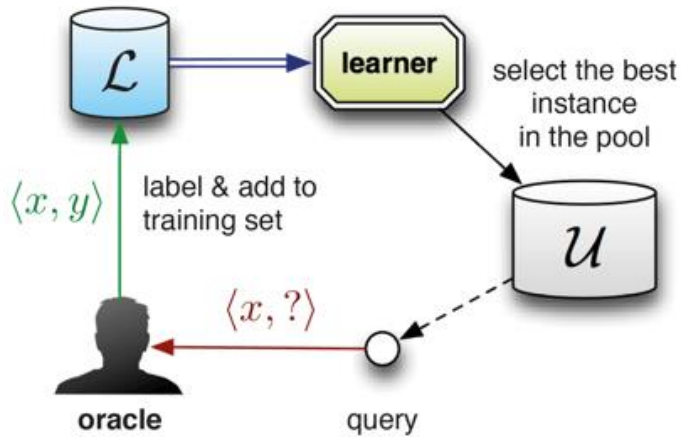
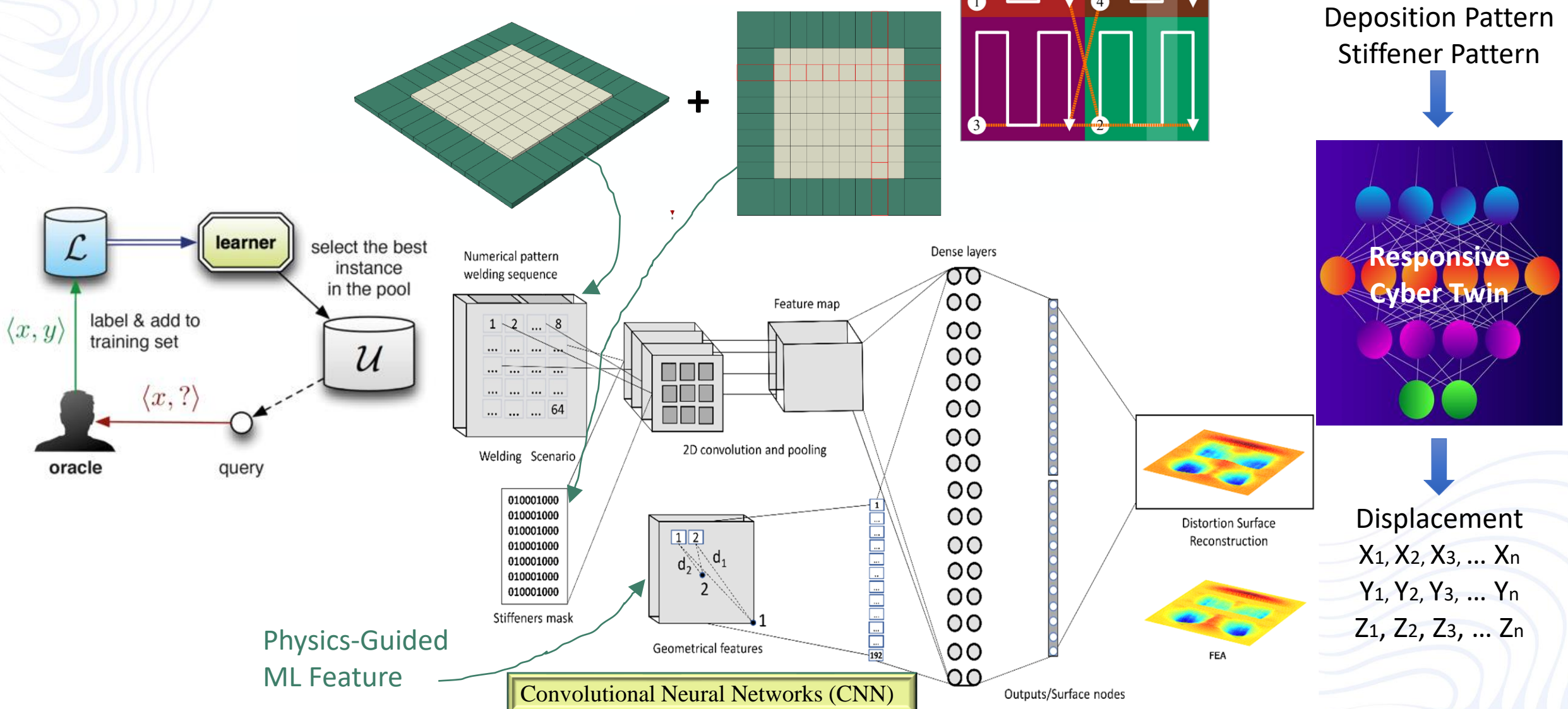
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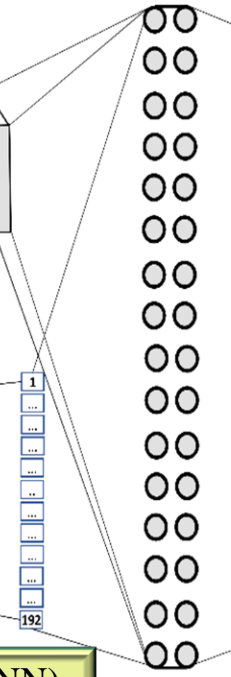
Smart systems are not explicit programming, they are architected to learn continually (autonomous vs. smart machine)



RESPONSIVE CYBER TWIN



Dense layers



Outputs/Surface nodes

