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FROM SURROGATES TO AGENTS: ARTIFICIAL INTELLIGENCE IN SIMULATION-DRIVEN DESIGN FOR ADDITIVE MANUFACTURING

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ABSTRACT

The design freedom of Additive Manufacturing (AM), from topology-optimized components to lattice, auxetic and other architected metamaterials, creates design spaces far too large to explore with conventional simulation alone. High fidelity finite element and multiphysics analyses remain the reference for predicting the response of AM parts, yet their computational cost and the expert effort needed to set up, run and verify each model limit their use in large-scale design exploration and uncertainty studies. Artificial intelligence is changing this picture at two levels. Data-driven surrogate models, including graph neural networks operating directly on simulation meshes, neural operators and physics-informed networks, can approximate full-field simulation results at a fraction of the cost [1]. At the same time, AI agents based on large language models are beginning to automate the simulation workflow itself: generating geometries, preparing and meshing models, launching analyses, checking results and iterating on designs, increasingly within commercial simulation environments. This invited session brings together researchers from computational mechanics and artificial intelligence to discuss how these two levels can be combined into reliable simulation-driven design workflows for AM. Invited session topics include, but are not limited to: surrogate modelling of AM structures and processes, AI-assisted design and optimization of lattice, auxetic and architected metamaterials [2], automated and agentic simulation pipelines, large scale generation of simulation datasets for machine learning, verification, physical consistency and uncertainty quantification of AI generated results, and applications in impact protection, biomedical devices and lightweight structures. Particular emphasis is placed on reliability, when surrogate predictions and autonomously executed simulations can be trusted.

REFERENCES

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[2] Ntintakis I., Stavroulakis G.E., *Infill microstructures for additive manufacturing*, Applied Sciences, Vol. 12 (15), 7386, 2022.