Dynamic Mechanical Properties of Additively Manufactured Lattice Structures

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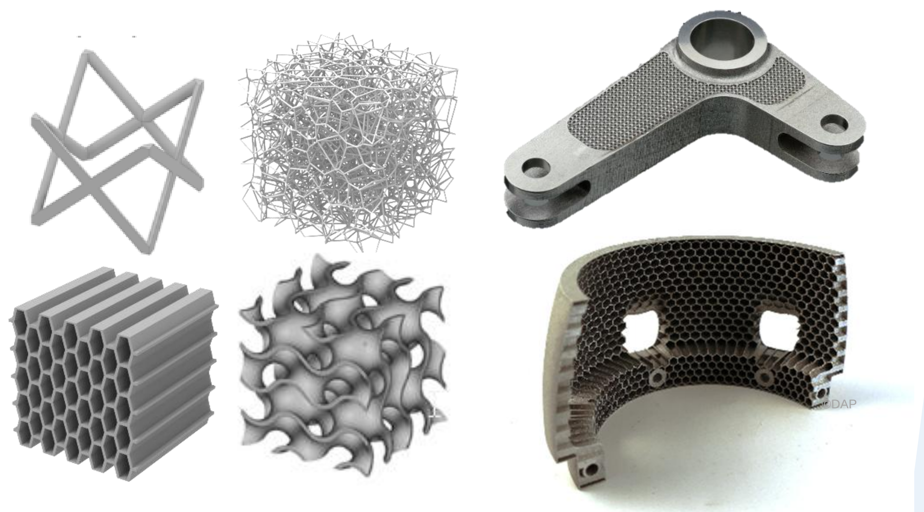
Introduction + Motivation

Diverse and **rapidly evolving** modeling approaches for Lattices in AM

Multi-scale interaction between parameters and dynamic properties

Lack of **standardized** metrics for validation and comparison

➔ Goal: Identification and evaluation of existing modeling techniques for dynamic mechanical properties of AM lattices



- **Effective mechanical properties** of AM produced lattice structures **are largely unknown**
- **Insufficient Qualification and reproducibility** of properties and are hindering the widespread commercial application of lattices

Motivation

- Influencing parameters for dynamic mechanical properties
- Various types of modeling techniques
- Identify the research gaps in current approaches

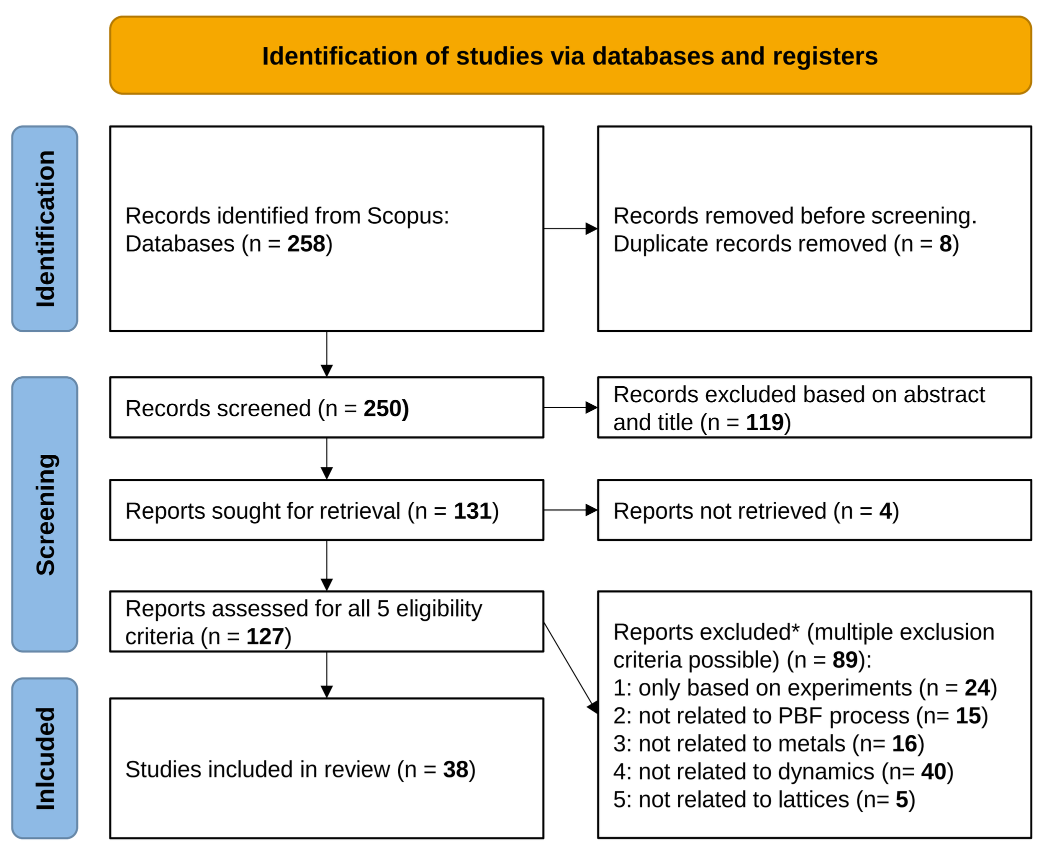
Approach

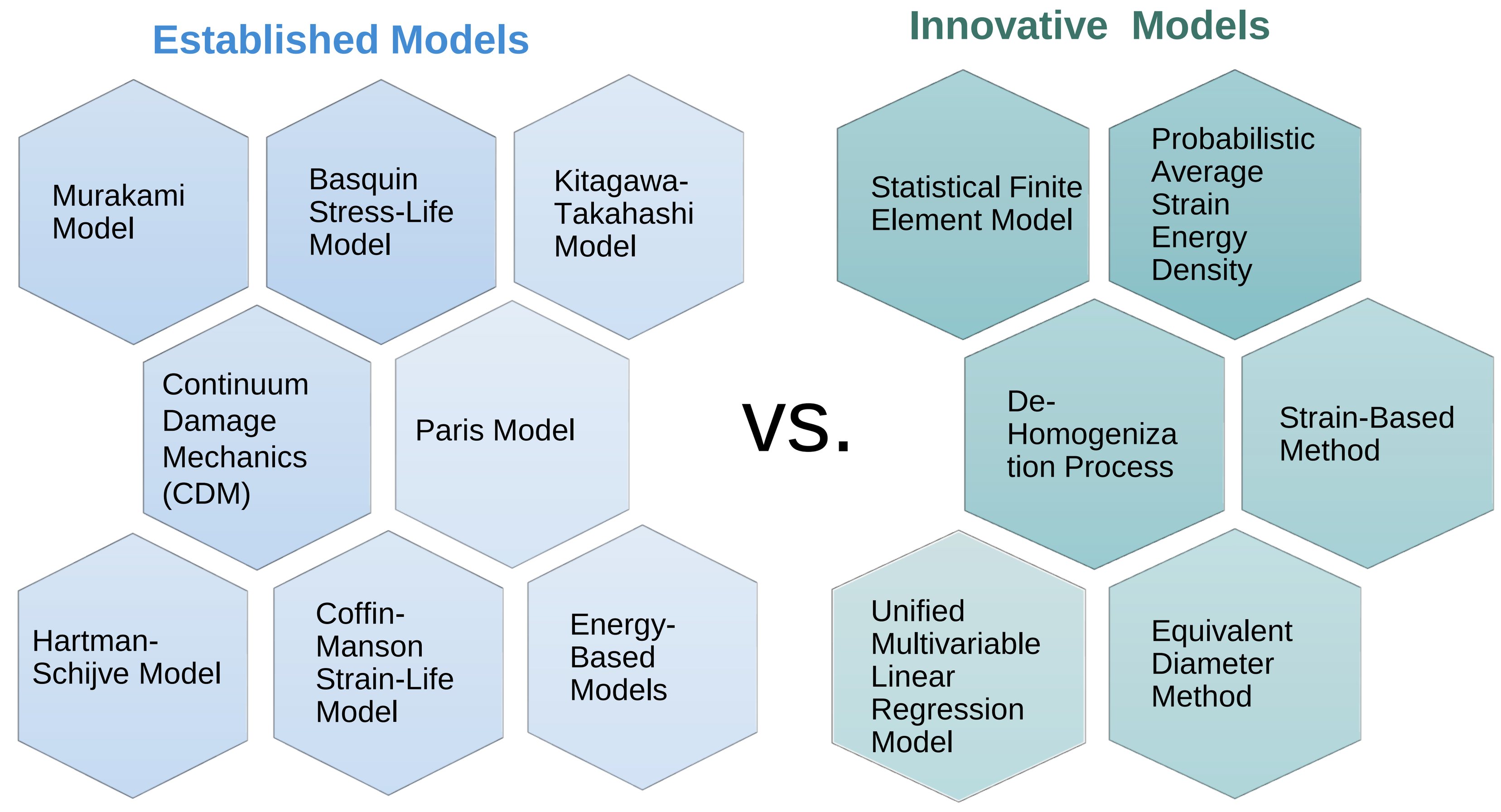
- Preview: Thematic + Bibliometric Analysis
- Implementation: PRISMA workflow.
- Evaluation and analysis: Correlation Matrix

In this paper, a systematic review of the dynamic mechanical properties of additively manufactured lattice structures was conducted. The review started with an initial identification of 3,929 records from databases, which were narrowed down through a systematic PRISMA workflow to 38 highly relevant studies. The analysis revealed that current models and methodologies for evaluating dynamic properties are limited to specific geometries, materials, or loading conditions. Additionally, there are significant trade-offs between accuracy, generalizability, and computational efficiency, with high demands for experimental validation. These findings highlight the pressing need for approaches that integrate additive manufacturing-specific characteristics, such as microstructural features (e.g., porosity, anisotropy), into predictive frameworks. Such integration would enable adaptive and hybrid models capable of addressing real-world dynamic applications.

Key Insights

- Modeling Quality Varies: Top studies use validated, AM-specific FEA models; simpler ones often miss key effects like anisotropy or defects.
- General vs. Specific Models: Broad models adapt across materials and geometries, while novel ones are often limited to niche cases.
- Computational Trade-offs: Accurate models are often slow; efficient ones lack detail. Some novel methods improve both.





Research Gaps

- AM-Specific Features Missing: Most models ignore critical factors like layer thickness and residual stress
- Scale Limitations: Current models rarely link microstructure to overall behavior—multiscale methods are needed.
- Standardization & AI Potential: Few standards exist; ML and open data can cut cost and boost model generalization.

Positive Correlation 1

	EC1	EC2	EC3	EC4	EC5
EC1	1,00	0,36	0,22	0,03	-0,18
EC2	0,36	1,00	-0,03	-0,31	0,32
EC3	0,22	-0,03	1,00	0,38	-0,17
EC4	0,03	-0,31	0,38	1,00	-0,15
EC5	-0,18	0,32	-0,17	-0,15	1,00

-1 Negative Correlation

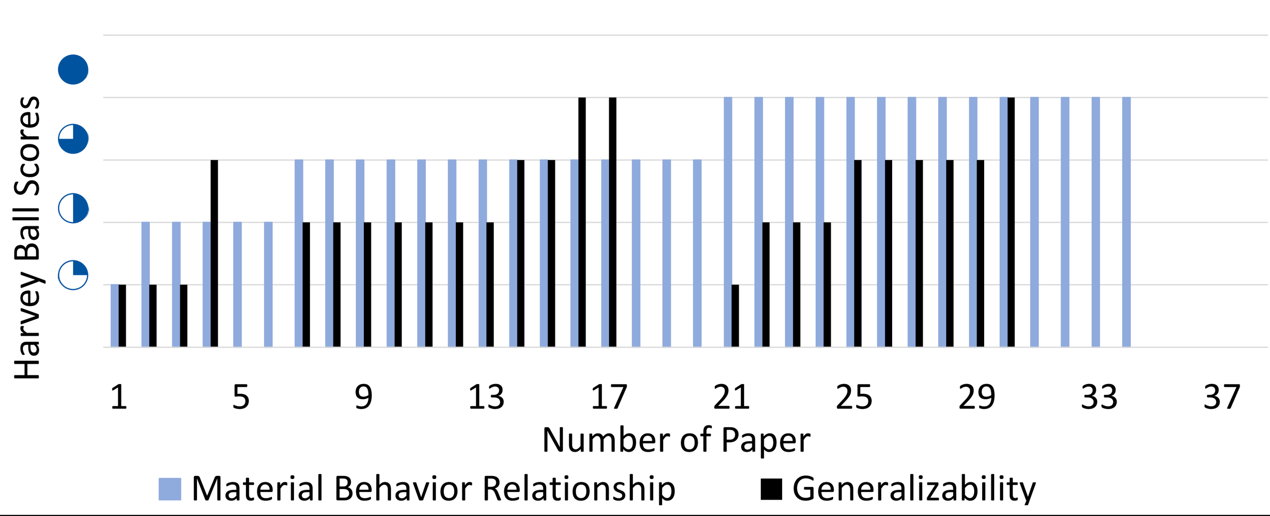
EC1 Quality of Numerical Analysis

EC2 Material Behavior Representation

EC3 Generalizability

EC4 Computational Efficiency

EC5 Novelty of Models



Observation

- Models are limited to specific condition or geometries.
- Trade-offs between accuracy, generalizability, and efficiency.
- High experimental validation demands

Future Work

- Significant AM-specific multi-scale approaches required
- Development of real-time adaptive and hybrid models
- Need for faster algorithms and ML integration

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[1] Henrik Kruse, Neha Kumari, Dr. Markus Sudmanns , Gustavo Melo, Prof. Dr.-Ing. Johannes Henrich Schleifenbaum "Dynamic Mechanical Properties of Additively Manufactured Lattice Structures: A Comprehensive Review", RTe Journal. 2025