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Peer Review

Review of: "Data-Driven, Parameterized Reduced-order Models for Predicting Distortion in Metal 3D Printing"

Iason Sideris[1]

1. Swiss Federal Institute of Technology, Zurich, Switzerland

This article develops a reduced order model (ROM) based on proper orthogonal decomposition (POD) and Gaussian process regression (GPR) from simulation data, then compares that model's performance with the original simulations and a graph convolutional network (GCN). My main comments are:

· Reduced Order Modeling Background

Reduced order modeling is a well-established field with prior applications in metal additive manufacturing. Methods such as balanced truncation and moment matching have been widely studied and applied to the topic. It would strengthen the introduction to include background on these approaches. Moreover, the authors are not the first to use GPR in this context; more references to previous work would help position the paper.

· Organization and Clarity

The methods section includes extensive implementation details that might fit better in the results section. Further, there is ambiguity in the physical representation of some variables (e.g., μ), which needs clarification.

· Limitations of POD

POD is snapshot-based and part-specific, meaning it would have to be repeated for every new part. This involves a potentially large data acquisition cost, especially with simulations that last around 2 hours each. Given that a full FEM model capturing the system dynamics is already available, it may be more efficient to consider methods like balanced truncation or moment matching, which are known to

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extract ROMs directly from these dynamics—and these have been applied before in metal additive manufacturing. Clarification on the novelty of the proposed approach would be beneficial.

· **Graph Convolutional Network Considerations**

There is insufficient evidence that the GCN architecture cannot perform better. One could explore reducing the latent dimension, adjusting the encoder size, or increasing regularization to see if these changes yield improvements.

Overall, the article seems to have a somewhat narrow scope and could benefit from a more comprehensive literature review. Additionally, it would be helpful if there were more context provided regarding the significance of the findings, as well as stronger evidence to support the claims made.

Declarations

Potential competing interests: No potential competing interests to declare.