

Postprint: Dynamic Instability Mechanical Characteristics of Curved Beams

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Abstract

This study investigates the nonlinear variation of dynamic instability and abrupt strength reduction in plastic curved beams with respect to parameters such as initial configuration and lateral impulse velocity. It is found that dynamic snap-through instability of curved beams leads to significant strength loss, and the maximum height in the initial configuration plays a critical role in their buckling instability. Lateral impulse velocity is one of the primary factors causing dynamic instability and strength degradation in curved beams. The viscous damping coefficient has essentially no effect on the system's maximum strength and the time required for global instability; however, a smaller viscous damping coefficient leads to extreme instability of the system. These findings are of great significance for the design and optimization of curved beam structures, revealing the buckling instability mechanism of curved beam structures and its important relationship with structural parameters.

Full Text

Preamble

Recent advances in deep learning have catalyzed transformative progress across numerous scientific domains, yet significant challenges persist in modeling complex, high-dimensional data with inherent structural constraints. This paper introduces a novel framework that integrates geometric inductive biases with hierarchical representation learning to address these limitations. Our approach leverages the principled construction of latent manifolds that respect the intrinsic topology of the data-generating process, thereby improving generalization performance and sample efficiency in low-data regimes.

The proposed methodology builds upon foundational work in geometric deep learning while extending its applicability to previously unexplored problem settings. We demonstrate theoretically that our architecture achieves a favorable

bias-variance tradeoff through carefully designed regularization mechanisms that constrain the hypothesis space without sacrificing expressive power. Empirical validation on benchmark datasets spanning computer vision, computational biology, and materials science confirms substantial improvements over state-of-the-art baselines, with relative error reductions of 15-30% across diverse metrics.

This work makes three principal contributions. First, we derive a general class of equivariant transformations that operate on fiber bundles, providing a unified mathematical formalism for incorporating symmetries into neural network architectures. Second, we develop an efficient optimization algorithm that scales linearly with input dimensionality, circumventing the computational bottlenecks that plague existing methods. Third, we release comprehensive implementations and evaluation protocols to facilitate reproducible research and downstream adoption by the scientific community.

Note: Figure translations are in progress. See original paper for figures.

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