Enhancing Biomechanical Impact Simulations through Physics-Informed Neural Networks

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Traditional biomechanical impact simulations, often relying on the Finite Element Method (FEM), face limitations in computational efficiency, parameter tuning complexity, and ability to extract data-driven insights. Physics-Informed Neural Networks (PINNs) emerge as a transformative approach to address these challenges and usher in a new era of advanced simulation techniques in computational biomechanics.

PINNs, seamlessly integrating physics principles into neural network architectures, provide a powerful tool for enhancing biomechanical impact simulations. By leveraging neural networks' ability to approximate complex relationships and learn from data, we can achieve significant improvements in several key areas:

- Computational Efficiency: PINNs significantly reduce computational time by approximating intricate biomechanical relationships, eliminating the need for extensive FEM simulations.
- Model Calibration and Optimization: PINNs expedite parameter tuning in biomechanical models, streamlining the calibration process and enhancing model accuracy.
- Data-Driven Insights: Neural networks' pattern recognition capabilities enable us to uncover hidden patterns and relationships within biomechanical datasets, leading to deeper understanding of biological structures and behaviors.
- Real-Time Decision Support: PINNs enable real-time predictions during simulations, enabling rapid decision-making in dynamic scenarios where timely responses are crucial.
- Integration with Finite Element Models: Hybrid approaches combining PINNs with FEM can synergistically enhance simulation accuracy and efficiency.