Transition from conventional computational multibody dynamics approaches to machine learning based methods

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Dynamic simulations of flexible multibody systems, particularly those involving index 3 constraints, nonlinearities, or discontinuities, remain challenging. In practice, highly heterogeneous system setups, which typically include a mix of rigid and flexible bodies, finite element meshes with modal reduction, hydraulics, and control systems, integrated with external software components, preclude the straightforward application of state-of-the-art GPU acceleration techniques.

This talk commences with the open-source multibody dynamics simulator Exudyn, designed to manage such heterogeneity. While our system attempts to align with the capabilities of both open source and commercial software in the field, it also incorporates Lie-group integrators and automatic differentiation to maintain a lean code. We will discuss the system's design, its limitations, and the performance improvements achieved through traditional multi-threaded parallelization.

For further performance improvements, we have explored potential enhancements using machine learning methods aimed at replicating the input-output behavior of damped multibody systems without detailed knowledge of the states or initial conditions. We employ specially designed feed-forward neural networks, trained on randomized simulations within the expected range of inputs, to predict outputs with accuracy adequate for practical applications. An additional error estimator, trained across an extended range of inputs, helps to assess the reliability of these predictions. We will present results from several multibody models, demonstrating the accuracy of our predictions and estimators, as well as significant speed improvements over conventional simulations.

Looking ahead, we will discuss the potential for leveraging large language models to generate simulation models based solely on textual descriptions, allowing future engineers to abandon the usage of classical graphical user interfaces and struggles with solver settings.

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