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Title: The High Explosives & Affected Targets (HEAT) Dataset

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Web

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The High Explosives and Affected Targets (HEAT) Dataset

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Artificial Intelligence and Machine Learning (AI/ML) surrogate models offer a computationally efficient alternative to full-physics simulations, yet few existing datasets support model training, testing, and validation of the dynamics of high-explosive driven shocks through multiple materials. Shock propagation through materials is a computationally challenging problem because simulations must include material-specific equations of state (EOS) along with descriptions of other physical processes such as plastic deformation, phase change, damage processes, fluid instabilities, and multi-material interactions. Shocks are typically initiated by high-velocity impacts or explosive loading. The latter case necessitates the addition of models of reactive materials to represent high-explosive (HE) detonation.

To address the lack of an expansive dataset for multi-material shock propagation in the AI/ML community, we present the High-Explosives and Affected Targets (HEAT) Dataset. HEAT is a physics-rich collection of two-dimensional, cylindrically symmetric, simulations generated using an Eulerian, multi-material, shock-propagation code developed at Los Alamos National Laboratory. The dataset includes two partitions: (1) the expanding shock-cylinder (CYL) simulations, Figure 1, and (2) the Perturbed Layered Interface (PLI) simulations, Figure 2. Entries in both partitions consist of time series of arrays of thermodynamic fields (pressure, density, and temperature), kinematic fields (position and velocity), and additional fields that depend on thermodynamic and/or kinematic fields (e.g., material stress). Materials in the CYL partition include solids (Aluminum, Copper, depleted Uranium, Stainless Steel, Tantalum, and a generic polymer), a liquid (Water), gases (Air, Nitrogen), and a generic detonating material (HE). The PLI partition spans a highly varying geometry but consists of fixed materials across entries: Copper, Aluminum, stainless steel, generic polymer, and generic HE. HEAT captures critical phenomena such as momentum transfer, shock propagation, plastic deformation, and thermal effects, making HEAT a valuable benchmark for development of AI/ML emulation of multi-material shock propagation.

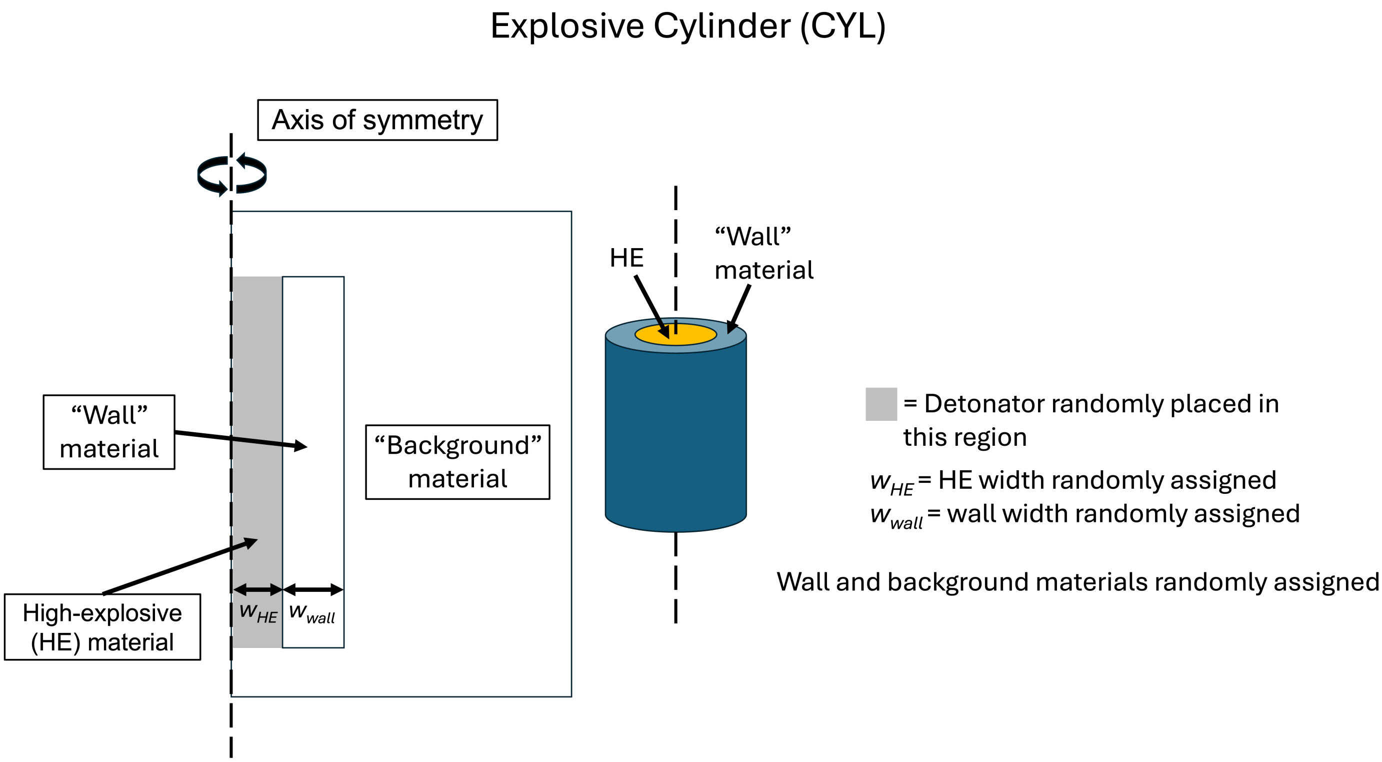

Figure 1: The shock-cylinder (CYL) partition of the HEAT dataset includes variations on the above schematic. A generic high-explosive (HE) material drives an expanding shock through a cylindrical wall which propagates into a background material. The wall and background materials are randomly sampled from a fixed set of material types. HE and wall thicknesses are also randomly chosen. This part of the dataset provides a strong basis for the study of AI/ML emulation of shocks.

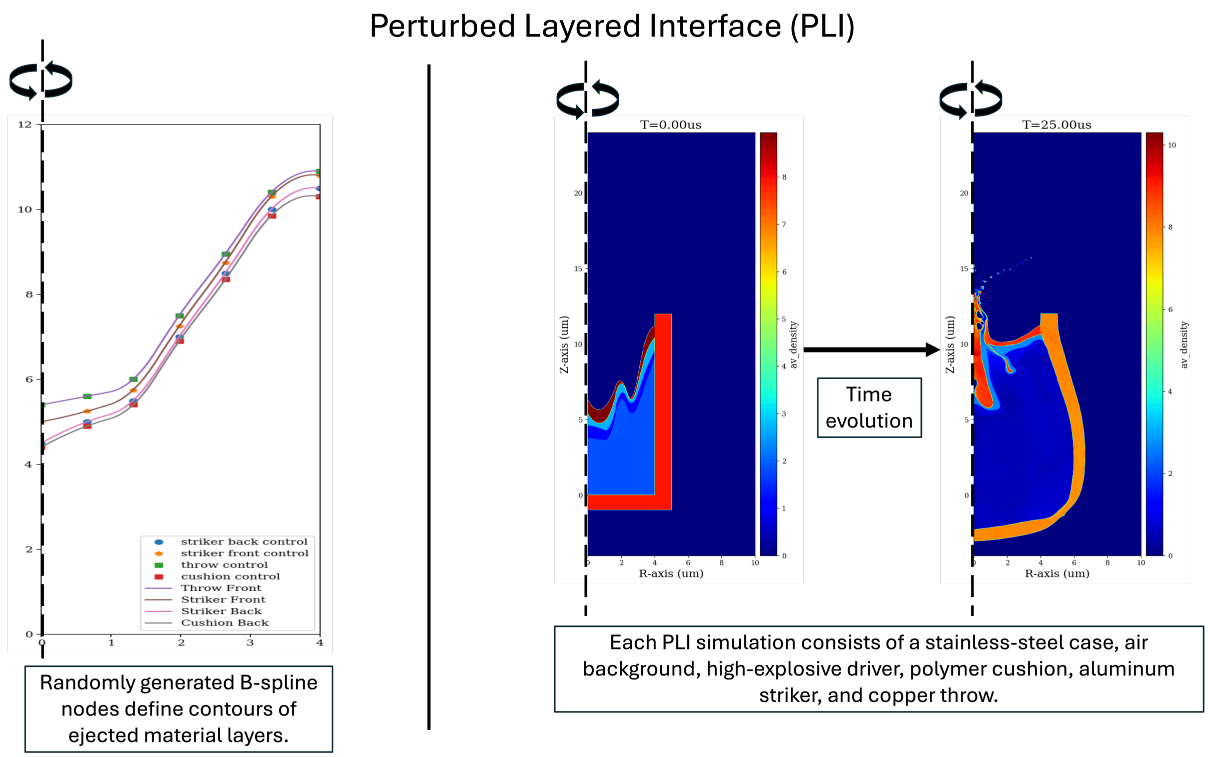

Figure 2: The Perturbed Layer Interface (PLI) partition of the HEAT dataset consists of cylindrically symmetric geometries in which three material layers with randomly prescribed contours are shocked by the detonation of a generic high-explosive charge. The shock energy is directed through the perturbed layers by a stainless steel case. Materials for all parts in these simulations are fixed while the large variations in geometry creates a diverse dataset to study AI/ML emulation of complex interaction between shocks in multiple materials.