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Physics-driven Digital Twin for Laser Powder Bed Fusion on GPUs

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Abstract:

The inherent strain method [1] is known and used for simulating - on a physical basis - deformation effects that occur in laser powder bed fusion (LPBF). The method is based on the idea of the inherent strain which is a black-box representation of strains caused by the process of metal printing inherent to the printer, printer settings and material used. This inherent strain can be generated from experimental data. Thus, a Digital Twin of the process combines data-driven and physics-driven aspects.

In this work, we present an implementation of the inherent strain method on graphics processing units (GPUs) that exploits the massive parallelism of the many GPU cores to speed up the simulations considerably – some results show up to two orders of magnitude speed-up compared to CPU-based implementations. Compared to GPU-based simulation with unstructured finite elements on tetrahedral meshes [2], our implementation leverages the characteristics of structured meshes in terms of indexing and compactness of the resulting stiffness matrix.

To simulate the deformations, the part is discretized in a set of regular finite elements (hexahedral elements of the same shape and size). The computation of the resulting deformation is parallelized in two ways: Firstly, each layer addition is simulated with a highly parallel finite element simulation. Secondly, each of these layer additions results in an increment of the total result. The calculations of the increments are independent from each other, thus, all increments can be computed in parallel.

References:

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