A new efficient approach for 3D hydrodynamics simulation

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A new efficient approach for 3D hydrodynamics simulation

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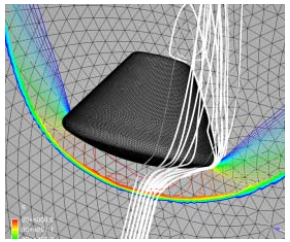
BACKGROUND & MOTIVATION

Current high-fidelity 3D simulation tools are limited by accuracy, performance, and setup time

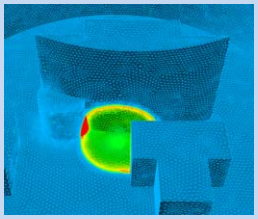
- Tedious problem definition
- 2D algorithms often do not scale to 3D
- Poor accuracy requires intractable levels of mesh resolution
- Legacy tools not easily ported to advanced computer architectures



INNOVATION

Tetrahedral grids allow rapid setup of complex geometries and support accurate and robust numerical algorithms

- New mathematical approaches overcome historical accuracy issues
- Algorithms are designed for 3D performance on advanced architectures from the beginning
- Commodity software can be used for problem definition

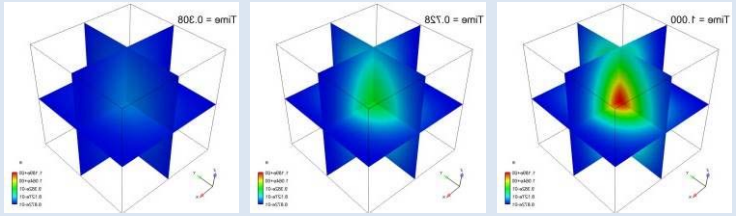


DESCRIPTION

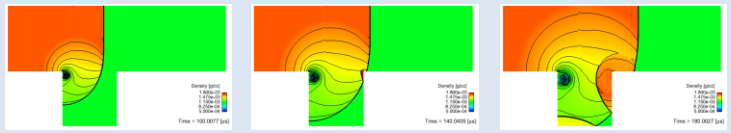
LANL's CHICOMA code solves the compressible hydrodynamic equations on moving tetrahedral grids.

- Hydrodynamic equations can be solved in Lagrangian, Eulerian, and Arbitrary Lagrangian-Eulerian reference frames
- The equations are solved using a finite element method coupled to approximate Riemann solvers
- The methods have been extensively verified against relevant analytical solutions

CHICOMA is 10^3-10^4 times faster than current production codes for the same level of accuracy!



Verification example: Analytical test problem involving nonlinear energy growth, similar to fusion ignition in an ICF capsule



Validation example: Interaction of a shock wave with a square cavity

Key reference: *J. Waltz et al, Computers & Fluids 92:172-187 (2014)*

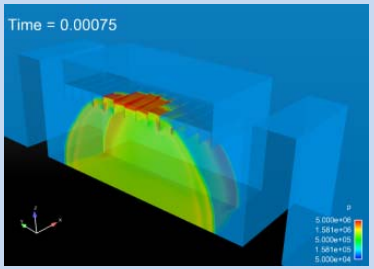
TRL 3: An early prototype of the capability is in the final testing and validation stages

ANTICIPATED IMPACT

Performance gains of 10^3-10^4 over current tools have the potential to change the class of simulations that can be run:

Orders-of-magnitude savings across the workflow:

- Setup
- Simulation
- Analysis



Simulations that were previously too expensive (in CPU time) are now possible

PATH FORWARD

Validation of methods against realistic applications of interest

- Further validate physics
- Tailor physics to individual programs:
  - Advanced Simulation and Computing
  - Joint Munitions Program
  - NNSA Emergency Response

Potential End Users:

- Scientists and engineers who require large-scale, high fidelity modeling of complex physical systems

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