# Octane: GPU-accelerated Deflagration Simulation for Engineering Applications

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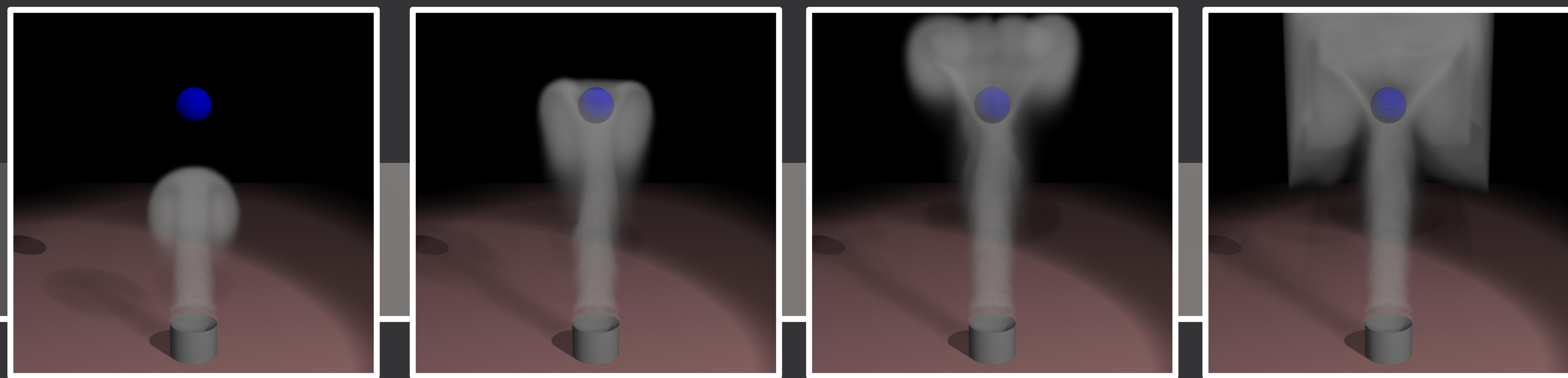
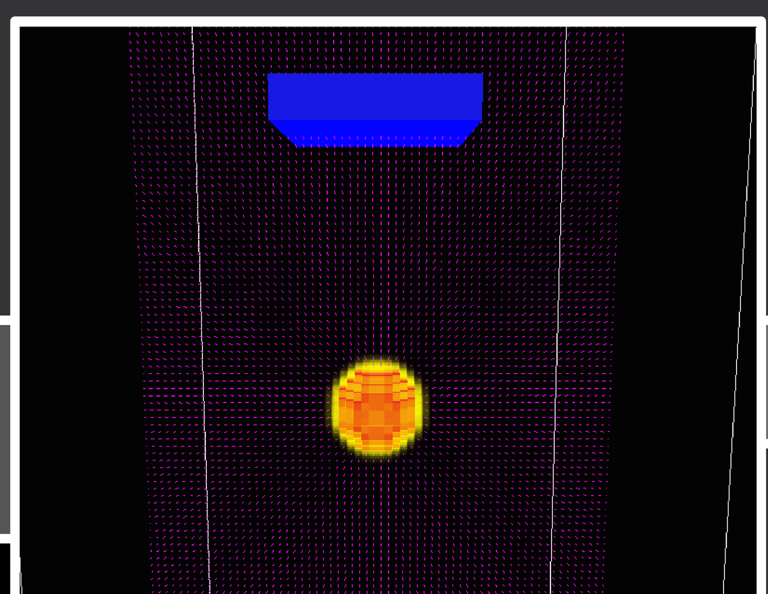


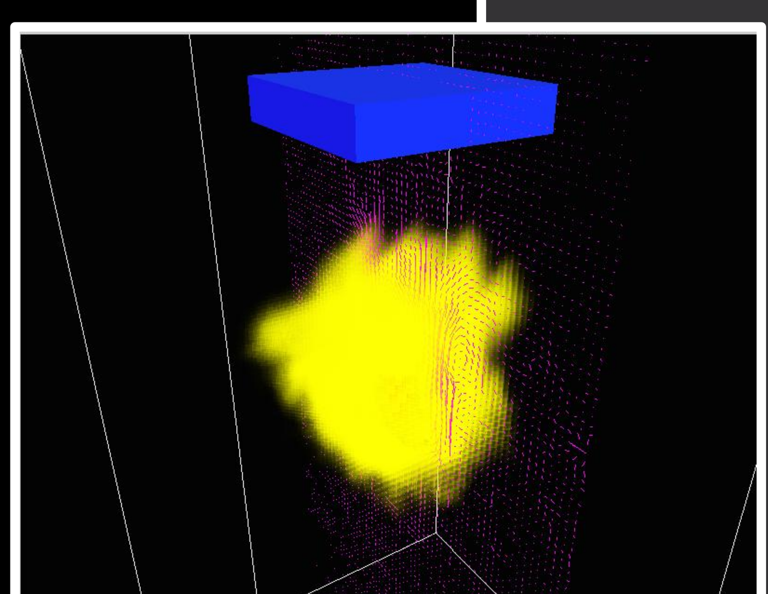
## Overview

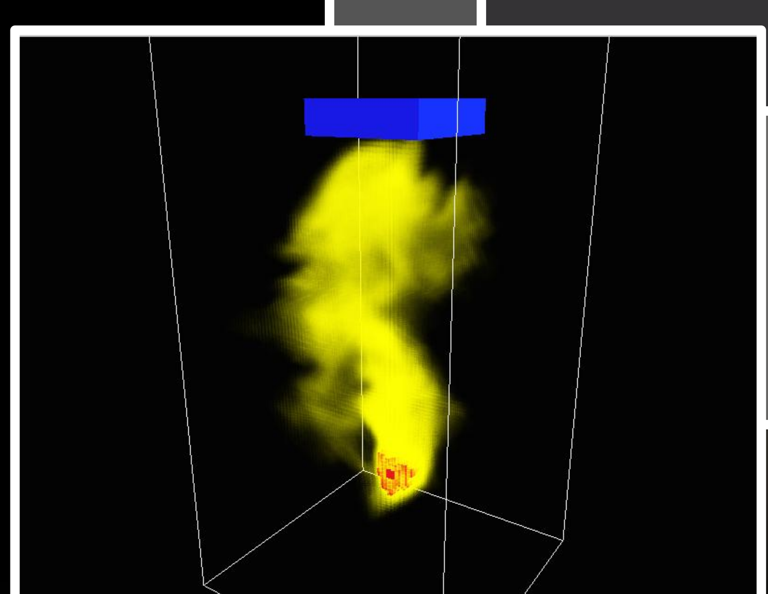
The simulation of fluid phenomena is an area of interest for both computer graphics and engineering disciplines. Visually plausible fluid simulations are often employed in special effects for the film and video game industries, while physically accurate simulations are important for engineering applications like aircraft tests or combustion simulations.

Fluid simulations using the incompressible Navier-Stokes equations are expensive, both because of a time step restriction based on the CFL condition and because a large linear system must be solved at each time step. Because the requirements of physical accuracy are less stringent for graphics applications than they are in computational fluid dynamics, graphics researchers have developed a number of techniques that accept some loss of accuracy in favor of increased simulation speed.



Octane is a system that is part of an ongoing project within the CUDA Research Center at SURVICE Engineering to use graphics techniques to solve engineering simulation problems. In particular, Octane provides a CUDA-based GPU implementation of cutting edge techniques in graphics research to approximate the behavior of subsonic combustions.

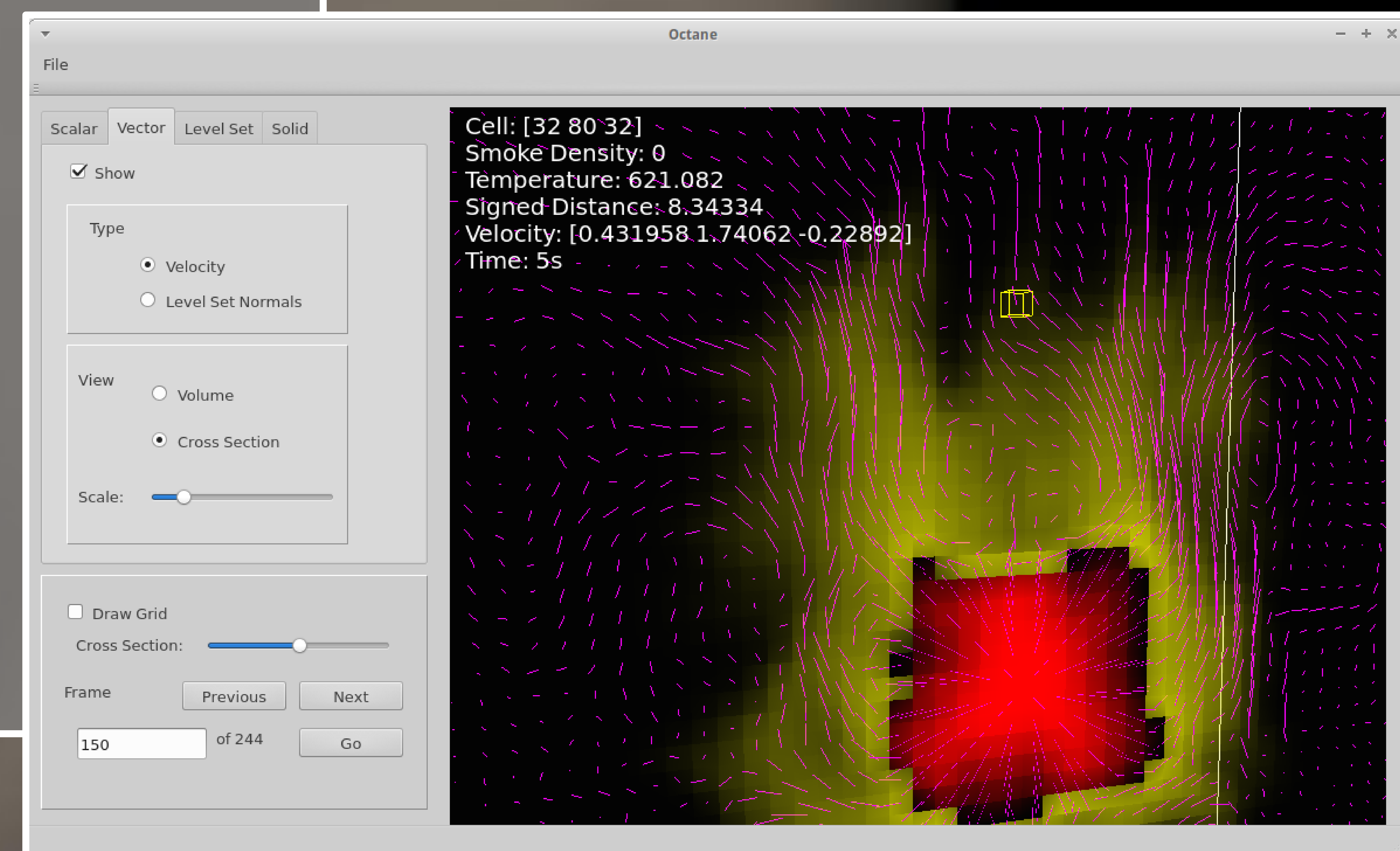


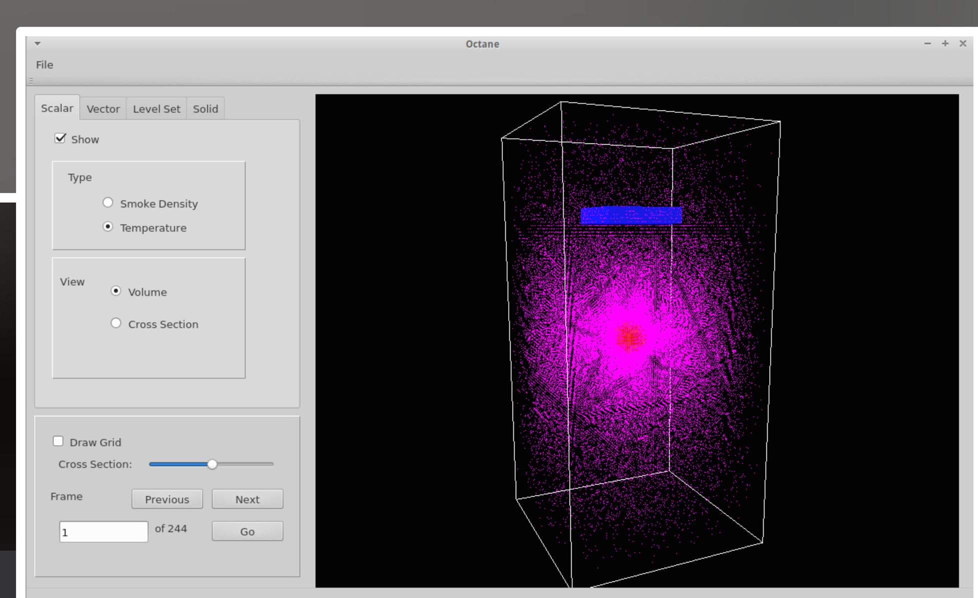


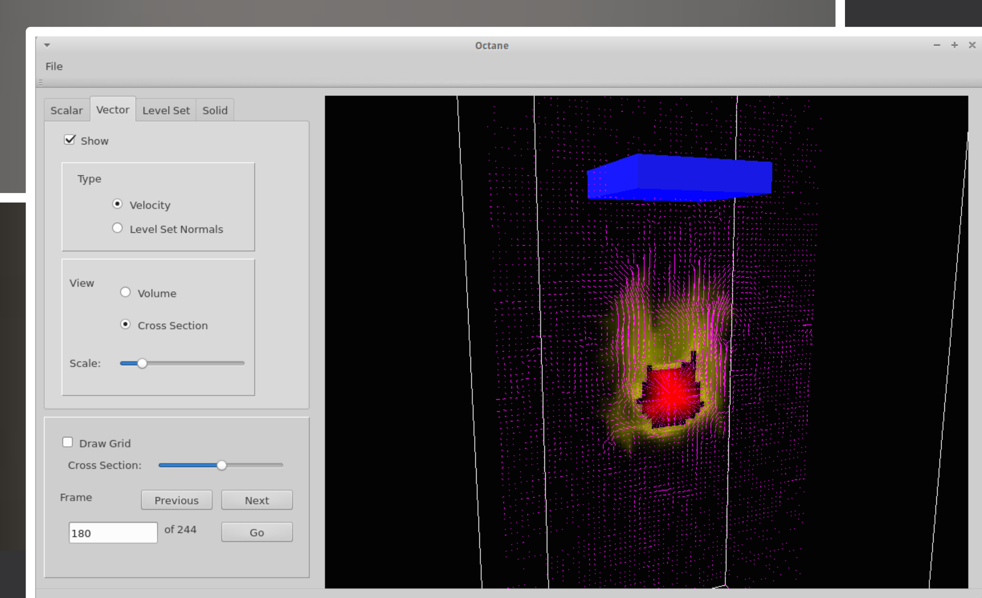
## Methodology

The Octane system solves the incompressible Navier-Stokes equations on a uniform grid using a MAC grid discretization. Advection is performed using the Semi-Lagrangian advection scheme. Buoyancy force is calculated based on a temperature field. A vorticity confinement force [1] is used to add vortical detail back into simulations that lose small scale fluid motion due to their grid resolution. The projection step is performed by solving for pressures using the CUSP linear algebra library.

Combustion is simulated using the thin flame model [2]. A level set is used to represent the inside region of unreacted fuel and the outside region of reacted gas. A discontinuous jump in pressure occurs across the zero isocontour of the level set, while the fluid remains incompressible elsewhere in the domain.





## Initial Results & Future Work

Octane has demonstrated initial results for subsonic combustions using the thin flame model in two- and three-dimensional simulations. The core fluid solver has been developed in parallel with a YAML-based specification for initial conditions and a Qt front-end for data visualization.

As an ongoing project, future goals include further acceleration of the system's fluid solver using the GPU, increased flexibility in users' ability to specify initial conditions, and improved tools to visualize and interpret simulation results.

**References**

[1] R. Fedkiw, J. Stam, and H. Jensen. Visual Simulation of Smoke. In Proc. of ACM SIGGRAPH 2001, pages 15–22, 2001.

[2] D. Nguyen, R. Fedkiw, and H. Jensen. Physically Based Modeling and Animation of Fire. ACM Trans. Graph. (SIGGRAPH Proc.), 21:721–728, 2002.

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For more information on Octane and other projects at SURVICE Engineering, please visit http://www.survice.com