Science-based simulations on present GPUs and future extensions

We develop technologies for supporting finite element simulations on multicore streaming processors. The upward trends in graphics processor (GPU) performance are impressive, even relative to progressively more powerful, conventional CPUs. The SCI Institute leverages its considerable track record and expertise in scientific computing on GPUs to pursue the development of new technologies and algorithms for finite element simulations on GPU clusters. Thus work takes place in the context of the NVIDIA Center of Excellence at the University of Utah and the SCI Institute.

Extending Uintah

Uintah is a parallel software environment for solving large-scale computational mechanics and fluid dynamics systems, and has particular strengths when dealing with systems that require large deformations, fire simulation, and fluid-structure interactions. Uintah’s general-purpose, fluid-structure interaction code has been used to characterize a wide array of physical systems and processes encompassing a wide range of time and length scales. Scientific problem-solving environment to simulate large multi-scale, multi-physics science-based energy systems.

The broad applicability of Uintah makes it suitable for a range of energy problems such as flow through micro and nano-scale porous media as well as combustion examples related to flares, boilers and fires. The aim of the Uintah work is to show that Uintah may be used to solve challenging energy-related problems on large scale high-performance computers such as the Jaguar XT5 and the new Titan XK6 at Oak Ridge National Laboratory.

Large-scale visualization techniques for science-based energy system simulation applications

One of the greatest scientific and engineering challenges of the twenty-first century is to understand and make effective use of this growing body of information. The SCI Institute is an international leader in visualization, leveraging and expanding our expertise in large-scale visualization research and development toward the seamless integration of high-end visualization techniques with simulation results of energy systems.

Provenance enabling Uintah:

With large computational simulations there is substantial uncertainty inherent in any prediction of science-based systems. A number of factors contribute to uncertainty, including experimental measurements, mathematical formulation, and the way different processes are coupled together in the numerical approach for simulation. Tracking of and analysis of this uncertainty is critical to any work that will truly impact the creation of future energy systems.

Visualization of Geologic Materials - Volume rendering of CT X-Ray data from a large rock sample, complex fracturing test conducted by TerraTek, under deep earth stress conditions. The created fracture (visualized in red) interacts with a large Calcite mineral inclusion (shown in gold). This image allows visualization of the fracture resistance provided by the Calcite inclusion. The fracture width is about 1 mm and the inclusion is 30-50 mm in dimension. (The X-Ray voxel size is 1.00 mm by 0.17 mm by 0.17 mm.)

Future Directions:

Unconventional and Renewable Energy Research Utilizing Advanced Computer Simulations