TeraVoxel

Award No:
EIA-0079871

Project Title:
Development of the Distributed Teravoxel Data System: Acquisition, Networking, Archiving, Analysis, and Visualization

Investigators:
Paul E. Dimotakis (PI), Daniel I. Meiron, David B. Rutledge, David E. Breen (has left Caltech in the interim), and James C. Pool

Institution:

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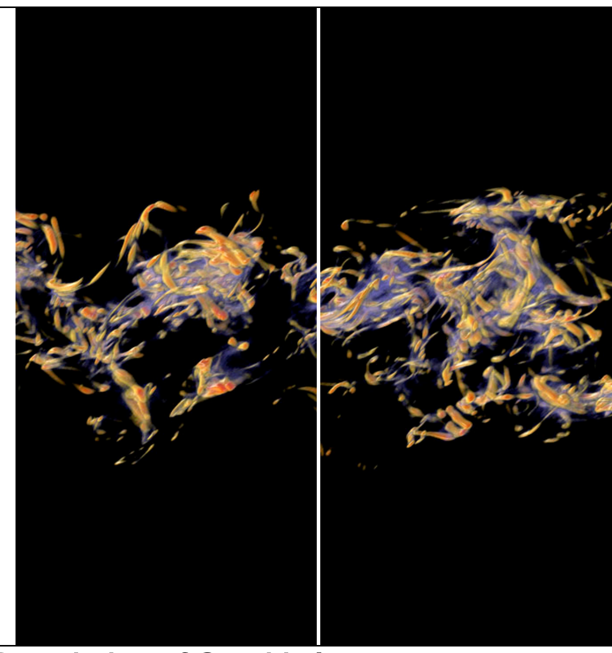
Pasadena, California 91125



Website:
http://www.cacr.caltech.edu/projects/teravoxel/

Description of Graphic Image:
Three-dimensional structure of a passive scalar contaminant field, from a point release, in homogeneous turbulence

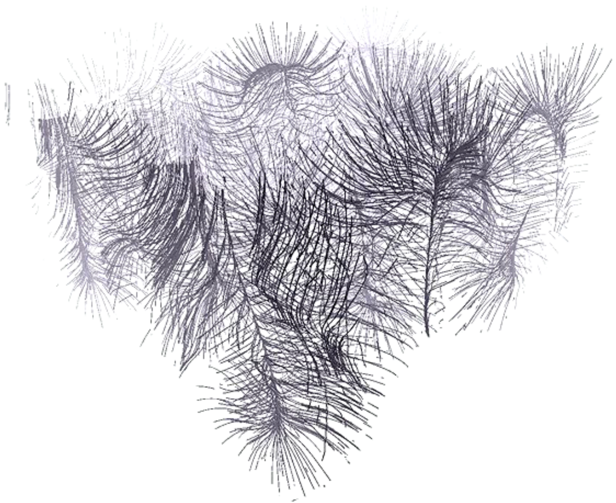
Project Description and Outcome *(Provide content for one or more of the following outcome goals)*

Ideas:
Infrastructure developments under the TeraVoxel project are enabling the data-acquisition, visualization, and analysis of the complex geometry of large, multi-dimensional data sets derived from both experiments and numerical simulations. The very large data rates required to acquire such data sets in the laboratory, the Terabyte-scale data volumes, and their complexity necessitated the development of unique instrumentation, data-acquisition and -storage, enhanced networking structures, new computer visualization hardware and software, and multi-processor data analysis and computation platforms. These developments were realized and funded in concert and collaboration with other projects at Caltech. The graphic above is a recent, preliminary result of volume rendering of scalar-field data measured using laser-induced fluorescence techniques and represents a first view of the three-dimensional dispersion of a passive contaminant in moderate Reynolds number, nearly homogeneous turbulence in water. The scalar-dispersion experiments were performed as part of a broad research effort on turbulent mixing, under support by the Air Force Office of Scientific Research.

Tools:
The TeraVoxel system, developed under CNS support, integrates multi-channel, parallel architecture high-speed laboratory data acquisition; a fast multi-channel fiber-optics relying on the CERN-defined S-link protocol to a "Datawulf" UNIX cluster, patterned after Caltech's original Beowulf design, supporting a high-speed/-volume parallel striped disk storage as well as first-stage data preprocessing; a specially developed volume-rendering cluster; interactive computer visualization hardware; and a shared fraction of a massively parallel (352 AMD Opteron cores) Shared Heterogeneous Cluster (SHC) developed with co-funding from TeraVoxel, DOE's Caltech ASC Center, the Numerical Relativity group in Physics, and Caltech's Center for Advanced Computing Research. The SHC, with an anticipated ~1 TFLOPS aggregate processing power will be coming on line in the next few weeks and will provide the necessary post-processing data-analysis capability, comprising the last stage in the original TeraVoxel project vision.

People:
The TeraVoxel project has brought together and supported scientists and engineers with a broad spectrum of talents and backgrounds. It is a collaboration between the science team, led by Paul Dimotakis (PI), Professor of Aeronautics and Applied Physics, and Dan Meiron (TeraVoxel Co-PI and ASC center PI), Professor of Applied and Computational Mathematics, and Computer Science, and the technology team in Caltech's Center for Advanced Computing Research (CACR) of computer, networking, data-storage, and computer-visualization researchers and engineers, led in the latter stages of the project by Mark Stalzer, CACR Director. Pending completion of the TeraVoxel infrastructure, response and assistance to science centers in other academic/research Divisions on campus, such as Physics and Astronomy (mitigation of atmospheric turbulence effects in ground-based astronomical observations), as well as Geology and Planetary Science (global 3D data sets of climatological importance over several years), will be realized.

Additional Graphic Image
You may insert a second graphic below with a description (photos, video, etc.) supporting one of your outcomes



Description of Graphic Image:
The graphics above derive from large-scale numerical simulations, computed as part of the Caltech ASC center program. The image on the left derives from a simulation of Rayleigh-Taylor instability flow (Cook & Dimotakis 2001, *J. Fluid Mech.*). The image on the right is from a numerical simulation by Ravi Samtaney (Princeton Plasma Physics Laboratory) of the interaction between a shock and a perturbed density interface (Richtmyer-Meshkov instability) in converging flow. The research leading to these results was performed under support by the DOE ASC center at Caltech (PI: D. Meiron). The computer visualizations are by Santiago Lombeyda of Caltech's CACR.