Visualization and Analysis of Flow Data at the University of California Mechanical and Aerospace Engineering Department

"PV-WAVE not only saves graduate students time by quickly producing high-quality figures from flow data, it actually helps students make new discoveries through visual data analysis. This facilitation of the discovery process is invaluable for their studies and research."

– Dr. Haris Catrakis
Associate Professor
University of California - Irvine

Quick Facts

• Students in the Mechanical and Aerospace Engineering department needed visualization capabilities to help in their fluid mechanics research
• Understanding of how fluids move and the forces on them can be applied to multiple disciplines that are impacted by flows
• PV-WAVE is a valuable tool for students by helping them create images from flow data and analyze the data to make new discoveries

The Problem

Students and researchers in the Mechanical and Aerospace Engineering department at the University of California, Irvine do work in a variety of areas, including continuum mechanics, power, propulsion and environment, micro/nanomechanics and systems design. One area of focus for the Department is fluid mechanics – how fluids move and the forces on them. Research and advances in fluid mechanics can be applied to scientific disciplines such as aerospace and oceanography as well as other disciplines where understanding of flows is valuable such as traffic management or stock market modeling.

Graduate students in PhD- and Masters-level programs in the Department do research to advance their knowledge and studies and need tools to help them visualize and analyze flow data.

The Solution

Dr. Haris Catrakis, Associate Professor in the Mechanical and Aerospace Engineering department selected PV-WAVE from Visual Numerics as a visual data analysis tool for his students. “I used PV-WAVE as a graduate student and liked the speed at which the product lets you visualize and analyze image data. I knew that it would be a valuable tool for students here at UC-Irvine,” said Dr. Catrakis.

Today, students use PV-WAVE in a Windows environment for a variety of research. An example of a final product from PV-WAVE is the flow data image shown in Figure 1. This flow image was produced using PV-WAVE applied to experimentally recorded flow data by the Ph.D. students of Professor Catrakis. The experimental data consisted of three-dimensional space-time high-resolution measurements of the mixed-fluid concentration resulting from fluid mixing and turbulence in liquid jets.
KEY BENEFITS

• Saves research time by quickly creating high-quality images

• Helps students better model, analyze and visualize complex flow systems

• Facilitates new discoveries through visual data analysis

PV-WAVE had a central role in the discovery process because PV-WAVE enabled a fast and insightful visualization of a database with size of about 1 GB. Using the unique visualization features of PV-WAVE, namely the ability to show transparently superpositions of about 1,000 image slices from the GB-sized database, PV-WAVE enabled students to visualize simultaneously the multiscale dynamics of the outer interface separating pure fluid from mixed fluid. The main discovery from this analysis was that there is a large region inside the interface (the white region inside the blue interface) which contains mixed fluid rather than pure fluid. This discovery revealed that the mechanism by which fluid mixing occurs in turbulence is by the action of the large-scale dynamics on the small-scale motions near the outer part of the turbulent flow rather than in its interior.

This new mechanism is important in various applications and has already found broad use in engineering applications involving turbulence, mixing, and flow control. In addition, the basic discovery has a broad impact on a wide range of other scientific and engineering problems, such as atmospheric dynamics, propulsion devices, ocean mixing, as well as astrophysical turbulence in galaxies and in the universe.

Return on Investment

By enabling the exploration of physical and mathematical models of turbulence, PV-WAVE helps students better model, analyze and visualize these complex systems.

PV-WAVE helps students focus on their PhD dissertations and Master research. “Using PV-WAVE to create images saves considerable time because it is so easy to use and quick to produce high-quality results,” said Dr. Catrakis. “More important, it is priceless in the ability it gives students to easily analyze data and make new discoveries,” he added.

For more information on research being done by Dr. Catrakis and his department on turbulence and the dynamics of flows, visit http://catrakis.net/.