Blue Waters Virtual Course

High Performance Visualization for Large-Scale Scientific Data Analytics
Spring 2015

Instructor: Prof. Han-Wei Shen, Department of Computer Science and Engineering, The Ohio State University

Course Aim: This semester-long course is offered to students who are interested in learning how to use visualization for analyzing scientific data sets. This course will also be of interest to students who are considering scientific visualization as a research topic for their advanced studies.

Expected student background: The desired audience will be graduate students who are majoring in computer science, or areas related to computational sciences. Students are expected to be able to program in C /C++ or Python. Prior experience in parallel programming is a plus but not required.

Textbooks (not required)

- Visualization Toolkit: An Object-Oriented Approach to 3D Graphics, 4th Edition, Schroeder, Martin, Lorensen
- The Visualization Handbook: Hansen, Johnson
- High Performance Visualization: Enabling Extreme-Scale Scientific Insight, Bethel, Childs, Hansen

Grading:
Homwork: 75 %
Take home midterm exam: 10 %
Final project: 15 %

Course Topics:

- Scientific data model and file formats
- Basic data plotting and visualization
- Visualization software (ParaView and VTK)
- Visualization algorithms: volume rendering, isosurface, flow visualization
- Strategies for handling large data
- Parallel visualization algorithms
- Large data analysis and visualization approaches

Tentative schedule:

- Week 1:
  - –Overview of scientific data visualization
  - –Scientific data model

- Week 2:
  - –Scientific data file formats (VTK, NetCDF, Plot3D)
  - –Data processing and plotting using Python
- Week 3:
  - –Basic visualization techniques
  - –Visualization software: ParaView

- Week 4
  - –Visualization pipeline
  - –Programming visualization using VTK: C++ or Python
- Week 5/6
  - –Visualization algorithm I: volume rendering
    - Optical Model
    - Ray casting
    - Advanced topics in volume rendering
- Week 6/7
  - –Visualization algorithm II: isosurface
    - Marching Cubes
    - Analysis of isosurfaces (topology, geometry, and advanced search algorithms)

- Week 8/9
  - –Visualization algorithm III: flow visualization
    - Particle tracing and numerical integration
    - Flow texture generation
    - Advanced flow analysis
- Week 9/10
  - –Strategies for handling large data sets
    - Level of detail
    - Data partitioning and distribution
    - Out-of-core processing
    - Parallel computation
    - Query-driven demand processing
- Week 10/11
  - –Large scale data visualization using ParaView
  - –Parallel visualization algorithm I
    - Overview of MPI
    - Parallel volume rendering and image composition
- Week 11/12
  - –Parallel visualization algorithm II
    - Parallel flow visualization algorithms
    - Parallel streamline, stream surface generation
- Week 12/13:
  - –Advanced visualization topics:
    - Time-varying visualization
    - Query driven visualization

•Week 13/14:
  –Advanced visualization topics:
    Distributional and information-theoretical based approaches
•Week 14/15:
    Student project presentations and highlights

About the course instructor:

Han-Wei Shen is a full professor in the Department of Computer Science and Engineering at the Ohio State University. He has worked in the area of scientific visualization for more than 2 decades. His research is primarily focused on parallel visualization, flow visualization, time-varying visualization, and isosurface and volume rendering. His research has been supported by many federal HPC and Data Analytics programs, including DOE's SciDAC II, SciDAC III, Exascale Computing, and NSF's Big Data research initiatives. He has won NSF's CAREER award and DOE's Early Career Principle Investigator award for his visualization research. He has also won the Outstanding Teaching Award twice from the Department of Computer Science and Engineering OSU, and Ruth and Joel Spira Outstanding Teaching Award. He was a program chair for IEEE Visualization 2008 and 2009, a program chair for IEEE Pacific Visualization 2009 and 2010, and is a paper chair for IEEE Scientific Visualization conference 2013 and 2014.