Scientific Information Visualization

CSC 7443, Spring 2011

9:10 am to 10:30 am, Tuesday and Thursday

104 Audubon Hall

Bijaya Bahadur Karki

Course Description

Catalog:

Study computer visualization principles, techniques and tools used for explaining and understanding information; includes visualization algorithms, techniques, and applications

Objectives:

Study visualization principles and algorithms to explore, transform and view data/information as computer graphs or images to gain understanding and insight into the data/information

Understand/develop/apply a wide range of visualization methods (tools) to visualize a variety of datasets (from medical, to geological, to biological, to financial from simulations, experiments and other sources).

Course Materials: Books

- OpenGL Programming Guide: The official Guide to Learning OpenGL, Version 2.1, Red Book 6th Edition by Shreiner, Woo, Neider and Davis, 2008 or older Editions
  www.opengl.org
- OpenGL A Primer, 3rd Edition by E. Angel, 2005
- The Visualization Handbook, C.D. Hansen and C.R. Johnson, Elsevier, 2005
- Computer Visualization: Graphics techniques for Scientific and Engineering Analysis by R. S. Gallagher, 1994
- The Visualization Toolkit: An object-oriented approach to 3D graphics by W. Schroeder et al., 1997
- Information Visualization by R. Spence, 2001

Course Materials (Contd.)

- Lecture notes
  - Posted on
    moodle.lsu.edu
    www.csc.lsu.edu/~karki
- Research papers
  - Distributed/referred during class
  - Student presentation
- Web sources
  - Referenced in lecture notes

Prerequisite

- CSC 7300 or equivalent
- Consent of instructor
  - Computer graphics
  - Programming in C/C++
  - Algebra, Calculus

Grading Policy

- Grading Items:
  - Homework assignment: 20 %
  - Paper presentation: 10 %
  - Project/programming: 15 %
  - Midterm exam (option of makeup exam): 25 %
  - Final exam: 30 %

- Grading Scale:
  - A = 90 % or more
  - B = 78 % to 89 %
  - C = 65 % to 77 %
  - D = 50 % to 64 %
  - F = below 50 %

Rules/Regulations

- Class attendance is highly encouraged.
- Late submissions of homework/programming assignments will be penalized.
- Academic dishonesty will be treated seriously.
  - Need to work independently.

Contact Information and Office Hours

- Office
  - 283 Coates Hall, Department of Computer Science
- Email
  - karki@csc.lsu.edu
- Phone
  - 578-3197

- Regular office hours
  - 1 pm to 3 pm (Monday and Wednesday)
- Special office hours
  - Any time by appointment

Course Outline: Major Topics

- General introduction
- Computer graphics for visualization
- Scientific visualization
- Information visualization
- Virtual reality

General Introduction

- Definition and concept of visualization
- Visualization types and applications
- Visualization issues
- Available programs and APIs

Computer Graphics for Visualization

- OpenGL
- Drawing geometric objects
- Viewing
- Color
- Lighting
- Special topics

Scientific Visualization

- Isosurface rendering
- Volume rendering
- Vector and tensor visualization
- Software- and hardware-based approaches
- Large-scale data visualization
- Case studies

Information Visualization

- Internal models
- Data representation
- Interaction and exploration
- Presentation
- Connectivity

Virtual Reality

- CAVE, ImmersaDesk, CAVE library
- Virtual reality modeling language (VRML)
- Learning about Louisiana Immersive Technologies Enterprise (LITE)

Sample Questions: Set 1

Answer "True" or "False" to the following statements:

- The OpenGL's color state remains unaffected by a `glColor()` call within a display list.
- A vertex shader program allows the user to manipulate the processing of fragments.
- In the splatting algorithm, the weight of the contribution of each data sample to each pixel is determined by the value of the footprint function.
- When a non-regular grid is mapped to a regular grid, rays cast from the image plane remain as straight lines in the computational space.
- Bifocal display is one case of focus+context approach.

Set 2

Short-answer questions:

- How does OpenGL support hidden-surface removal? State it's two advantages.
- Give four specific examples of datasets, state their data types and give one visualization technique for each dataset.
- How do you determine the nature of the critical points in a vector field? Elaborate your answer with different cases.
- Describe the basics steps in the operation of the shear-warp factorization-based volume rendering. Is this algorithm suitable for parallel implementation? Justify your answer.
- What is Star Coordinates plot? Display the two six-dimensional data of A(2,3,5,1,4,6) and B(6,4,3,6,8,0) using this plot.

Set 3

Questions-based on papers presented by students in the class:

- How does the curvature-based transfer function differ from the conventional transfer function in terms of definition and usefulness?
- Describe two types of ambiguities you can find in the Marching Cubes' based isosurface extraction with examples. How can you avoid the ambiguity?
- What is the major approximation that the near-phong quality quadratic shading makes to speed up shading?
- What is the microarray data? In the directed graph representation of the data, what do the nodes and arrows represent?
- What is the problem with parallel coordinates for large-scale multivariate data? How do you overcome it?

Set 4

- Solve the following ray-casting problem.

The scalar values at eight vertices of the voxel of unit length (**a=1**) are

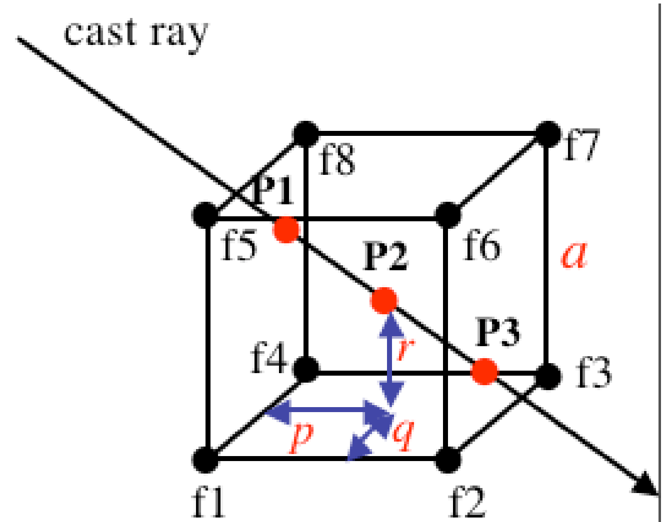
f1=5.0, f2=5.1, f3=5.2, f4=4.6

f5=4.9, f6=5.1, f7=5.3, f8=4.7

The ray is sampled at three points

P1(0.2,0.3,0.8), P2(0.5,0.5,0.5), P3(0.8,0.7,0.2)

Color and opacity of the cast ray before it hits **P1** is (0,0,0,0)



Using the given transfer function, compute the color of the ray after it leaves **P3** by compositing from back-to-front order