CSE 5194.02 (Approved): Scientific Visualization

Course Description
Principles of scientific data analysis and visualization, including advanced rendering, geometric, topological, and statistical methods.

Transcript Abbreviation: Sci. Visualization
Grading Plan: Letter Grade
Course Deliveries: Classroom
Course Levels: Undergrad, Graduate
Student Ranks: Senior, Masters, Doctoral
Course Offerings: Spring
Flex Scheduled Course: Never
Course Frequency: Every Year
Course Length: 14 Week
Credits: 3.0
Repeatable: No
Time Distribution: 3.0 hr Lec
Expected out-of-class hours per week: 6.0
Graded Component: Lecture
Credit by Examination: No
Admission Condition: No
Off Campus: Never
Campus Locations: Columbus
Prerequisites and Co-requisites: Prereq: MATH 2174, 2568, 4568, or 5520H; and CSE 3541, 5542, or 5544; or grad standing
Exclusions: Cross-Listings:

Course Rationale: Piloting a new course on scientific visualization.

The course is required for this unit's degrees, majors, and/or minors: No
The course is a GEC: No
The course is an elective (for this or other units) or is a service course for other units: Yes

Subject/CIP Code: 14.0901
Subsidy Level: Doctoral Course

Programs

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>BS CSE</td>
<td>BS Computer Science and Engineering</td>
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<tr>
<td>MS CSE</td>
<td>MS Computer Science and Engineering</td>
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<td>PhD CSE</td>
<td>PhD Computer Science and Engineering</td>
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</table>

Course Goals

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<tr>
<th>Description</th>
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<tbody>
<tr>
<td>Master fundamental theories and techniques for handling (input, output, and transformation of) scientific data sets.</td>
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<tr>
<td>Be familiar with state of the art visualization and analysis algorithms for scientific data sets.</td>
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<td>Be competent with developing customized data transformation and visualization techniques for domain specific scientific data.</td>
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<td>Be competent with using publicly available software libraries for scientific data visualization and analysis.</td>
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Course Topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Lec</th>
<th>Rec</th>
<th>Lab</th>
<th>Cli</th>
<th>IS</th>
<th>Sem</th>
<th>FE</th>
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<tbody>
<tr>
<td>Course overview and mathematical foundations.</td>
<td>3.0</td>
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<tr>
<td>Scientific data models and scientific visualization software.</td>
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<tr>
<td>Scalar data visualization I: basic visualization techniques, isosurface (marching cubes), isosurface topology, efficient isosurface search algorithms.</td>
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<td>Scalar data visualization II: direct volume rendering optical model, discrete approximation, transfer function design.</td>
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<td>Scalar data visualization III: topological methods.</td>
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<td>Vector data visualization I: basic visualization techniques, numerical integration and particle tracing.</td>
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<td>Vector data visualization II: stream function and stream surface, flow texture synthesis.</td>
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<td>Vector data visualization III: vector field topology.</td>
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<td>Unstructured and scattered data visualization techniques.</td>
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<td>Large data visualization I: parallel algorithms (volume rendering, image compositing, particle tracing).</td>
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<td>Large data visualization II: statistics based data reduction, scientific data compression.</td>
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<td>Machine learning for scientific visualization</td>
<td>1.5</td>
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<td>Visualization software</td>
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<td>Visualization applications: case studies</td>
<td>1.0</td>
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Representative Assignments

Lab 1: Use Paraview/VTK for visualizing benchmark scientific data
Lab 2: Implementation of Isosurface surface extraction using Marching Cubes
Lab 3: Implementation of direct volume rendering volume rendering
Lab 4: Implementation of streamlines, pathlines, and streaklines for vector field data

Grades

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Four lab assignments.</td>
<td>60%</td>
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<tr>
<td>Midterm</td>
<td>15%</td>
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<tr>
<td>Final project</td>
<td>25%</td>
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Representative Textbooks and Other Course Materials

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
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<tbody>
<tr>
<td><em>The Visualization Handbook</em></td>
<td>Charles D. Hansen and Christopher R. Johnson</td>
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<tr>
<td><em>The Visualization Toolkit, 4th edition</em></td>
<td>Bill Schroeder, Ken Martin, and Bill Lorensen</td>
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### ABET-EAC Criterion 3 Outcomes

<table>
<thead>
<tr>
<th>Course Contribution</th>
<th>College Outcome</th>
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<tbody>
<tr>
<td>**</td>
<td>1 an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics - pre-2019 EAC SLOs (a) and (e); (k) is implied</td>
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<td>**</td>
<td>2 an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors - pre-2019 EAC SLO (c); (k) is implied</td>
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<td>**</td>
<td>3 an ability to communicate effectively with a range of audiences - pre-2019 EAC SLO (g)</td>
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<td>*</td>
<td>4 an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts - pre-2019 EAC SLOs (f) (h) and (j)</td>
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<td>5 an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives - pre-2019 EAC SLO (d)</td>
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<td>**</td>
<td>6 an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions - pre-2019 EAC SLO (b); (k) is implied</td>
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<td>***</td>
<td>7 an ability to acquire and apply new knowledge as needed, using appropriate learning strategies - pre-2019 EAC SLO (i)</td>
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### ABET CAC Criterion 3 Outcomes

<table>
<thead>
<tr>
<th>Course Contribution</th>
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<tr>
<td>**</td>
<td>CAC 1 analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions</td>
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<td>***</td>
<td>CAC 2 design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the programs discipline</td>
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<tr>
<td>**</td>
<td>CAC 3 communicate effectively in a variety of professional contexts</td>
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<td>*</td>
<td>CAC 4 recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles</td>
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<td>*</td>
<td>CAC 5 function effectively as a member or leader of a team engaged in activities appropriate to the programs discipline</td>
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<tr>
<td>***</td>
<td>CAC 6 apply computer science theory and software development fundamentals to produce computing-based solutions</td>
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</tbody>
</table>

Prepared by: Mircea-Radu Teodorescu