NSF/CCLI: Data Visualization: An Interdisciplinary Approach to Reducing the Cognitive Load When Extracting Meaning from Large Data Sets

Investigators
- Dr. David J. Russomanno, PI
  Electrical and Computer Engineering
drussomanno@memphis.edu
- Dr. Don Franceschetti, Co-PI
  Physics
dfrancesche@memphis.edu
- Dr. Amy de Jongh-Curry, Co-PI
  Biomedical Engineering
  adjongh@memphis.edu
- Ms. Anna Lambert, Co-PI
  Civil Engineering/Educational Psychology
  anna1231@aol.com

Other Personnel
- Ms. Omoju Thomas
  Ph.D. Graduate Student in EECE
  oathomas@memphis.edu
- Mr. Barry J. McCrory
  Physics teacher in the Memphis City Schools (MCS)
  mccroryb@k12tn.net
- Ms. Trish Phillips
  Physics teacher in the Memphis City Schools (MCS)
  JstbPtrcP@netscape.net

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Curriculum
- National: 56% of undergraduate students have no community-based project experience
- U of M: 72% did not participate in a community-based project experience
- Need: interdisciplinary Data Viz course with a community-based project experience
- Not a replacement for traditional capstone design in engineering or computer science curricula

Learning Objectives
- Increase undergraduate and high-school students’ comprehension of data-intensive phenomena by reducing the cognitive load required when extracting meaning from multi-dimensional data.
- Increase undergraduates’ ability to implement a custom visualization application based on a set of user-defined requirements.
- Infuse undergraduates into civic engagement by having them work on interdisciplinary teams, which include high-school teachers, to implement and subsequently extend and maintain a repository of contextually-relevant, visualization applications to support inquiry-based learning opportunities for high school students.
- Increase awareness and readiness of high-school teachers to integrate custom, visualization tools into their own classrooms by linking tools developed by undergraduates at The University of Memphis to relevant experiments and studies which could be conducted within the teachers’ pedagogical activities.

Adaptation/Integration Sources
- An undergraduate computational science across the curriculum (CSAC) program funded by the NSF, Battelle Memorial Institute, and W. M. Keck Foundation and directed by Capital University
- Graduate computational science visualization modules developed by The University of Edinburgh
- Professional workshop materials developed by The University of Groningen
- Other good sources: U. of Illinois, Gettysburg College

A&I Approach
- A set of modules for integrating visualization techniques into a CSAC program, which were originally developed using several software tools and languages, will be adapted for engineering and science majors using a single, integrated visualization development platform (VTK).
Why Visualization Toolkit (VTK)?

• Students will not only acquire understanding of basic visualization techniques, but also gain competency using a unified, software development platform to create/modify/test algorithms and build custom applications.

Intellectual Merit

• Facilitates participants’ comprehension/experience of scientific/engineering development from two perspectives: (1) as learners exploring and developing hypotheses about data-intensive domains; (2) and as developers of state-of-the-art applications that link university-level topics to high-school level content.

Broader Impact

• It is proposed that as our high-school teacher participants use new tools (whose design they influenced) they will instill in their students and colleagues an enthusiasm and a sense of participation and confidence in approaching data-intensive, scientific and engineering topics, as well as an awareness of the university as a member of the community.

Example Application:

Visualize 3D finite element torso model used to simulate defibrillation field quantities such as voltage, potential, gradient, and current density.

Example assignment teaming a biomedical engineering, electrical engineering and a computer science major.

Collaborator and Application(s) Disciplines

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<tr>
<th>Disciplines</th>
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<tbody>
<tr>
<td>Biomedical Engineering</td>
<td>John Hochstein, Professor, Visualization of general thermodynamics and fluid flow problems</td>
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<tr>
<td>Civil Engineering</td>
<td>Barry J. McCrory†, Memphis City Schools Math and Physics Teacher, using computer modeling and visualization in the K-12 classroom</td>
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<tr>
<td>Computer Science</td>
<td>Olfa Nasraoui, Assistant Professor, U. of Louisville, Web data visualization</td>
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<tr>
<td>Engineering Education</td>
<td>John Franceschetti*, Professor, Visualization in chemistry and physics</td>
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<td>Electrical Engineering</td>
<td>John Haddock, Professor, Visualization in mathematics</td>
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<td>Industrial Engineering</td>
<td>Michael Racer, Associate Professor, Network optimization and capacity assignment visualization</td>
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<td>Mathematics</td>
<td>Shahram Pezeshk, Professor, Visualization of earthquake and structures data</td>
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<td>Mechanical Engineering</td>
<td>Hichem Frigui, Assistant Professor, U. of Louisville, Content-based image retrieval visualization</td>
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<tr>
<td>Mechanical Engineering</td>
<td>Carl Halford, Professor, Visualization of electromagnetic phenomena, optics, sensors, and cellular telephony/wireless networks</td>
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<td>Physics and Chemistry</td>
<td>Anna Phillips*, Educational Psychologist, Pedagogy, assessment of course outcomes, evaluation of visualization technology efficacy in the classroom</td>
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<td>David J. Russomanno*, Associate Professor, Software Engineering for custom visualization applications, visualization in software analysis and design</td>
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* denotes PI or CO-PIs, † denotes consultant, others are volunteers.