

CLIFFORD ALAN SHAFFER

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Date and place of birth: August 15, 1959, Baltimore, Maryland.

Education:

- BS in Computer Science: University of Maryland, College Park, 1980.
- MS in Computer Science: University of Maryland, College Park, 1982.
- PhD in Computer Science: University of Maryland, College Park, 1986.

Dissertation Title: Application of Alternative Quadtree Representations

Advisor: Hanan Samet

Professional positions held:

Associate Department Head for Graduate Studies (7/17 – present)
Department of Computer Science, Virginia Polytechnic Institute & State University.

Professor (6/08 – present)
Department of Computer Science, Virginia Polytechnic Institute & State University.
Interdisciplinary Program in Genetics, Bioinformatics, and Computational Biology, 7/04 – present.

W.S. “Pete” White Chair for Innovation in Engineering Education (6/16 – 6/18)
Department of Computer Science, Virginia Polytechnic Institute & State University.

Associate Professor (8/93 – 6/08)
Department of Computer Science, Virginia Polytechnic Institute & State University.

Assistant Professor (9/87 – 8/93)
Department of Computer Science, Virginia Polytechnic Institute & State University.

Summer Faculty Fellow (5/90 – 8/90)
NASA/Goddard Space Flight Center, Greenbelt, Maryland.

Research Associate (8/86 – 8/87)
Center for Automation Research, University of Maryland.

Publications

Books:

1. C.A. Shaffer, *Data Structures and Algorithm Analysis in Java: Third Edition*, Dover Publications, Mineola, NY, 2011.
2. C.A. Shaffer, *Data Structures and Algorithm Analysis in C++: Third Edition*, Dover Publications, Mineola, NY, 2011.
3. SHAFFER, C. A. *A Practical Introduction to Data Structures and Algorithm Analysis*, 2nd ed. Prentice Hall PTR, Upper Saddle River, NJ, USA, 2000.

4. SHAFFER, C. A. *A Practical Introduction to Data Structures and Algorithms Analysis, Java Edition*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA, 1998.
5. SHAFFER, C. A. *A Practical Introduction to Data Structures and Algorithm Analysis*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA, 1997.
6. C.A. Shaffer, Instructor's manual for *A Practical Introduction to Data Structures and Algorithm Analysis*, Prentice Hall, Upper Saddle River, NJ, 1997.

Journal publications:

1. Hamouda S, Edwards SH, Elmongui HG, Ernst JV, Shaffer CA. RecurTutor: An Interactive Tutorial for Learning Recursion, to appear in *ACM Transactions on Computing Education*.
2. M. Chen, B. Amos, L.T. Watson, J.J. Tyson, Y. Cao, C.A. Shaffer, M. Trosset, C. Oguz, G. Kakoti, Quasi-Newton Stochastic Optimization Algorithm for Parameter Estimation of a Stochastic Model of the Budding Yeast Cell Cycle, to appear in *IEEE/ACM Transactions on Computational Biology and Bioinformatics*, 2018.
3. T.C. Jones Jr., S. Hoops, L.T. Watson, A. Palmisano, J.J. Tyson, and C.A. Shaffer, JigCell Model Connector: Building Large Molecular Network Models from Components, *Simulation* 94, 11(2018), 993-1008.
4. KOH, K. H., FOUH, E., FARGHALLY, M. F., SHAHIN, H., AND SHAFFER, C. A. Experience: Learner analytics data quality for an etextbook system. *J. Data and Information Quality* 9, 2 (Jan. 2018), 10:1–10:10
5. A.C. Bart, J. Tibau, D.G. Kafura, C.A. Shaffer, and E. Tilevich, Design and Evaluation of a Block-based Environment with a Data Science Context, to appear in *IEEE Transactions on Emerging Topics in Computing*. DOI: <https://doi.org/10.1109/TETC.2017.2729585>.
6. S. Hamouda, S.H. Edwards, H.G. ElMongui, J.V. Ernst, and C.A. Shaffer. A Basic Recursion Concept Inventory. *Computer Science Education* 27, 2(December 2017), 121–148.
7. BART, A. C., TIBAU, J., TILEVICH, E., SHAFFER, C. A., AND KAFURA, D. BlockPy: An open access data-science environment for introductory programmers. *Computer* 50, 5 (May 2017), 18–26.
8. BART, A. C., WHITCOMB, R., KAFURA, D., SHAFFER, C. A., AND TILEVICH, E. Computing with CORGIS: Diverse, real-world datasets for introductory computing. *ACM Inroads* 8, 2 (Mar. 2017), 66–72.
9. V. Karavirta and C.A. Shaffer, Creating Engaging Online Learning Material with the JSAV JavaScript Algorithm Visualization Library, *IEEE Transactions on Learning Technologies* 9, 2(April–June 2016), 171–183.
10. S. Hamouda and C.A. Shaffer, Crib Sheets and Exam Performance in a Data Structures Course, *Computer Science Education* 26, 1(February 2016), 1–26.
11. PALMISANO, A., HOOPS, S., WATSON, L. T., JONES, T. C., TYSON, J. J., AND SHAFFER, C. A. Jigcell run manager (jc-rm): a tool for managing large sets of biochemical model parametrizations. *BMC Systems Biology* 9, 1 (Dec 2015), 95.
12. AHN, T.-H., SANDU, A., WATSON, L. T., SHAFFER, C. A., CAO, Y., AND BAUMANN, W. T. A framework to analyze the performance of load balancing schemes for ensembles of stochastic simulations. *International Journal of Parallel Programming* 43, 4 (Aug. 2015), 597–630.

13. FOUH, E., BREAKIRON, D. A., HAMOUDA, S., FARGHALLY, M. F., AND SHAFFER, C. A. Exploring students learning behavior with an interactive eTextbook in computer science courses. *Computers in Human Behavior* 41, C (Dec. 2014), 478–485.
14. C.A. Shaffer, Grand challenges in digital education, *Frontiers in ICT* 1, 5(2014). DOI: 10.3389/fict.2014.00005
15. E. Fouh, V. Karavirta, D.A. Breakiron, S. Hamouda, S. Hall, T.L. Naps, and C.A. Shaffer, Design and Architecture of an Interactive eTextbook – the OpenDSA System, *Science of Computer Programming* 88, *Special Issue on Software Development Concerns in the e-Learning Domain*, 1(August 2014), 22–40.
16. M.L. Cooper, C.A. Shaffer, S.H. Edwards, and S.P. Ponce, Open source software and the algorithm visualization community, *Science of Computer Programming* 88, *Special Issue on Software Development Concerns in the e-Learning Domain*, 1(August 2014), 82–91.
17. PALMISANO, A., HOOPS, S., WATSON, L. T., JONES JR, T. C., TYSON, J. J., AND SHAFFER, C. A. Multistate model builder (msmb): a flexible editor for compact biochemical models. *BMC Systems Biology* 8, 1 (Apr 2014), 42.
18. A. Verstak, N. Ramakrishnan, L.T. Watson, J. He, C.A. Shaffer, and A.Y. Grama, Using Hierarchical Data Mining to Characterize Performance of Wireless System Configurations, *Advances in Engineering Software* 65, November 2013, 66–77.
19. E. Fouh, M. Akbar, and C.A. Shaffer, The Role of Visualization in Computer Science Education, *Computers in the Schools* 29, Issue 1-2, 2012, 95–117.
20. Z. Liu, Y. Pu, C.A. Shaffer, S. Hoops, J.J. Tyson, and Y. Cao, Hybrid Modeling and Simulation of Stochastic Effect on Progression through the Eukaryotic Cell Cycle, *Journal of Chemical Physics* 136, 3(January) 2012.
21. SHAFFER, C. A., COOPER, M. L., ALON, A. J. D., AKBAR, M., STEWART, M., PONCE, S., AND EDWARDS, S. H. Algorithm visualization: The state of the field. *ACM Transactions on Computing Education* 10, 3 (Aug. 2010), 9:1–9:22.
22. RANDHAWA, R., SHAFFER, C. A., AND TYSON, J. Model composition for macromolecular regulatory networks. *IEEE/ACM Transactions on Computational Biology and Bioinformatics* 7, 2 (Apr. 2010), 278–287.
23. T.-H. Ahn, L.T. Watson, Y. Cao, C.A. Shaffer, and W.T. Baumann, Cell Cycle Modeling for Budding Yeast with Stochastic Simulation Algorithms, *Computer Modeling in Engineering and Sciences* 51, 1(2009), 27–52.
24. RANDHAWA, R., SHAFFER, C. A., AND TYSON, J. J. Model aggregation: A building-block approach to creating large macromolecular regulatory networks. *Bioinformatics* 25, 24 (Dec. 2009), 3289–3295.
25. PANNING, T. D., WATSON, L. T., ALLEN, N. A., CHEN, K. C., SHAFFER, C. A., AND TYSON, J. J. Deterministic parallel global parameter estimation for a model of the budding yeast cell cycle. *Journal of Global Optimization* 40, 4 (Apr. 2008), 719–738.
26. MISHRA, D., SHAFFER, C. A., RAMAKRISHNAN, N., WATSON, L. T., BAE, K. K., HE, J., VERSTAK, A. A., AND TRANTER, W. H. S⁴W: A problem-solving environment for wireless system design. *Software-Practice & Experience* 37, 14 (Nov. 2007), 1539–1558.
27. PANNING, T. D., WATSON, L. T., SHAFFER, C. A., AND TYSON, J. J. A mathematical programming formulation for the budding yeast cell cycle. *Simulation* 83, 7 (July 2007), 497–514.

28. L. Thomas, C.A. Shaffer, L. Mili, and E. Thomas, Automated Detection of Severe Surface Defects on Barked Hardwood Logs, *Forest Product Journal* 57, 4(April 2007), 50–56.
29. L. Thomas, L. Mili, E. Thomas, and C.A. Shaffer, Defect Detection on Hardwood Logs Using Laser Scanning, *Wood and Fiber Science* 38, 4(October, 2006), 682–695.
30. SHAFFER, C. A. Experiences teaching a graduate research methods course. *SIGCSE Bulletin* 38, 2 (June 2006), 97–101.
31. VASS, M. T., SHAFFER, C. A., RAMAKRISHNAN, N., WATSON, L. T., AND TYSON, J. J. The JigCell Model Builder: A spreadsheet interface for creating biochemical reaction network models. *IEEE/ACM Transactions on Computational Biology and Bioinformatics* 3, 2 (Apr. 2006), 155–164.
32. N.A. Allen, K.C. Chen, C.A. Shaffer, J.J. Tyson, and L.T. Watson, Computer Evaluation of Network Dynamics Models with Application to Cell Cycle Control in Budding Yeast, *IEE Proceedings – Systems Biology* 153, 1(Jan 2006), 13–21.
33. J. He, A. Verstak, L. T. Watson, C. A. Stinson, N. Ramakrishnan, C. A. Shaffer, T. S. Rappaport, C. R. Anderson, K. Bae, J. Jiang, and W. H. Tranter, Globally Optimal Transmitter Placement for Indoor Wireless Communication Systems, *IEEE Transactions on Wireless Communications* 3, 6(Nov 2004) 1906–1911.
34. VASS, M., ALLEN, N., SHAFFER, C. A., RAMAKRISHNAN, N., WATSON, L. T., AND TYSON, J. J. The JigCell Model Builder and Run Manager. *Bioinformatics* 20, 18 (Dec. 2004), 3680–3681.
35. SKIDMORE, R. R., VERSTAK, A., RAMAKRISHNAN, N., RAPPAPORT, T. S., WATSON, L. T., HE, J., VARADARAJAN, S., SHAFFER, C. A., CHEN, J., BAE, K. K., JIANG, J., AND TRANTER, W. H. Towards integrated PSEs for wireless communications: Experiences with the S⁴W and SitePlanner projects. *SIGMOBILE Mob. Comput. Commun. Rev.* 8, 2 (Apr. 2004), 20–34.
36. N.A. Allen, L. Calzone, K.C. Chen, A. Ciliberto, N. Ramakrishnan, C.A. Shaffer, J.C. Sible, J.J. Tyson, M.T. Vass, L.T. Watson, and J.W. Zwolak, Modeling Regulatory Networks at Virginia Tech, *OMICS, A Journal of Integrative Biology* 7, 3(2003), 285–299.
37. N.A. Allen, C.A. Shaffer, M.T. Vass, N. Ramakrishnan, and L.T. Watson, Improving the Development Process for Eukaryotic Cell Cycle Models with a Modeling support environment, *Simulation* 79, 12(Dec 2003), 674–688.
38. E.J. Rubin, C.A. Shaffer, N. Ramakrishnan, L.T. Watson, R. Dymond, D. Kibler, R. Dietz, J. Chanat, V. Lohani, D. Bosch, and C. Speir, From Landscapes to Waterscapes: A PSE for Landuse Change Analysis, *Engineering with Computers* 19, 1(July 2003), 9–25.
39. VERSTAK, A., RAMAKRISHNAN, N., WATSON, L. T., HE, J., SHAFFER, C. A., BAE, K. K., JIANG, J., TRANTER, W. H., AND RAPPAPORT, T. S. BSML: A binding schema markup language for data interchange in problem solving environments. *Scientific Programming* 11, 3 (Aug. 2003), 199–224.
40. HE, J., WATSON, L. T., RAMAKRISHNAN, N., SHAFFER, C. A., VERSTAK, A., JIANG, J., BAE, K., AND TRANTER, W. H. Dynamic data structures for a direct search algorithm. *Computational Optimization and Applications* 23, 1 (Oct. 2002), 5–25.
41. L.T. Watson, V.K. Lohani, D.F. Kibler, R.L. Dymond, N. Ramakrishnan, and C.A. Shaffer, Integrated Computing Environments for Watershed Management, *ASCE Journal of Computing in Civil Engineering* 16, 4(October 2002), 259–268.
42. N. Ramakrishnan, L.T. Watson, D.G. Kafura, C.J. Ribbens, and C.A. Shaffer, Programming Environments for Multidisciplinary Grid Communities, *Concurrency and Computation: Practice and Experience*, 13–15(Nov–Dec 2002), 1241–1273.

43. BEGOLE, J., SMITH, R. B., STRUBLE, C. A., AND SHAFFER, C. A. Resource sharing for replicated synchronous groupware. *IEEE/ACM Transactions on Networking* 9, 6 (Dec. 2001), 833–843.
44. GOEL, A., BAKER, C. A., SHAFFER, C. A., GROSSMAN, B., WATSON, L. T., HAFTKA, R. T., AND MASON, W. H. VizCraft: A problem-solving environment for aircraft configuration design. *Computing in Science and Engineering* 3, 1 (Jan. 2001), 56–66.
45. BEGOLE, J., ROSSON, M. B., AND SHAFFER, C. A. Flexible collaboration transparency: Supporting worker independence in replicated application-sharing systems. *ACM Transactions on Computer-Human Interaction* 6, 2 (June 1999), 95–132.
46. S.H Edwards and C.A. Shaffer, An Analysis of a Course-Oriented Electronic Mailing List, *Computer Science Education* 9, 1(April 1999), 8–22.
A. Goel, C. Phanouriou, F. A. Kamke, C. J. Ribbens, C. A. Shaffer, and L. T. Watson, WBCSim: A Prototype Problem Solving Environment for Wood-Based Composites Simulations, *Engineering with Computers* 15, 2(1999), 198–210.
47. J. Begole, P.L. Isenhour, and C.A. Shaffer, Can You Share JavaBeans?, *Dr. Dobb's Journal*, 300(June 1999), 121–122, (also, Computer Science TR 98-13, Virginia Tech, 1998).
48. BEGOLE, J., STRUBLE, C. A., AND SHAFFER, C. A. Leveraging java applets: Toward collaboration transparency in java. *IEEE Internet Computing* 1, 2 (Mar. 1997), 57–64.
49. PEMMARAJU, S. V., AND SHAFFER, C. A. Analysis of the worst case space complexity of a pr quadtree. *Information Processing Letters* 49, 5 (Mar. 1994), 263–267,
50. L.W. Carstensen, Jr., C.A. Shaffer, R.W. Morrill and E.A. Fox, **GeoSim**: A GIS-Based Simulation Laboratory for Introductory Geography, *Journal of Geography* 92, 5(Sep/Oct 1993), 217–222.
51. C.A. Shaffer, R. Juvvadi, and L.S. Heath, A Generalized Comparison of Quadtree and Bintree Storage Requirements, *Image and Vision Computing* 11, 7(September 1993), 402–412 (also, Computer Science TR 89-23, Virginia Tech, Jun 1989).
52. SHAFFER, C. A. Real-time robot arm collision detection for telerobotics. *Computers and Electrical Engineering* 17, 3 (July 1991), 205–215.
53. C.A. Shaffer, Real-Time Robot Arm Collision Detection for Telerobotics, *Journal of Computer & Electrical Engineering* 17, 3(1991), 205–215.
54. SHAFFER, C. A., AND STOUT, Q. F. Linear time distance transforms for quadtrees. *CVGIP: Image Understanding* 54, 2 (July 1991), 215–223.
55. LATTANZI, M. R., AND SHAFFER, C. A. An optimal boundary to quadtree conversion algorithm. *CVGIP: Image Understanding* 53, 3 (Apr. 1991), 303–312.
56. D.N. Oskard, T.-H. Hong, and C.A. Shaffer, Real-Time Algorithms and Data Structures for Underwater Mapping, *IEEE Transactions on Systems, Man, and Cybernetics* 20, 6(Nov/Dec 1990), 1469–1475.
57. C.A. Shaffer, H. Samet, and R.C. Nelson, QUILT: A Geographic Information System Based on Quadtrees, *International Journal of Geographic Information Systems* 4, 2(Aug, 1990), 103–131, (also Computer Science TR-1885, University of Maryland, Jul 1987).
58. C.-H. Ang, H. Samet, and C.A. Shaffer, A New Region Expansion for Quadtrees, *IEEE Transactions on Pattern Analysis and Machine Intelligence* 12, 7(Jul, 1990), 682–686.
59. SHAFFER, C. A., AND SAMET, H. Set operations for unaligned linear quadtrees. *Comput. Vision Graph. Image Process.* 50, 1 (Apr. 1990), 29–49.

60. SHAFFER, C. A., AND SAMET, H. Algorithm to expand regions represented by linear quadtrees. *Image and Vision Computing* 6, 3 (Aug. 1988), 162–168.
61. SHAFFER, C. A. A formula for computing the number of quadtree node fragments created by a shift. *Pattern Recogn. Lett.* 7, 1 (Apr. 1988), 45–49.
62. SAMET, H., SHAFFER, C. A., NELSON, R. C., HUANG, Y. G., AND ROSENFELD, A. Recent developments in linear quadtree-based geographic information systems. *Image and Vision Computing* 5, 3 (Aug. 1987), 187–197.
63. SAMET, H., SHAFFER, C. A., AND WEBBER, R. E. Digitizing the plane with cells of nonuniform size. *Information Processing Letters* 24, 6 (Apr. 1987), 369–375.
64. SHAFFER, C. A., AND SAMET, H. Optimal quadtree construction algorithms. *Computer Vision, Graphics, and Image Processing* 37, 3 (Mar. 1987), 402–419.
65. SAMET, H., AND SHAFFER, C. A. A model for the analysis of neighbor finding in pointer-based quadtrees. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 7, 6 (June 1985), 717–720.
66. H. Samet, A. Rosenfeld, C.A. Shaffer, and R.E. Webber, A Geographic Information System Using Quadtrees, *Pattern Recognition* 17, 6(Nov/Dec 1984), 647–656.
67. H. Samet, A. Rosenfeld, C.A. Shaffer, and R.E. Webber, Quadtree Region Representation in Cartography: Experimental Results, *IEEE Transactions on Systems, Man, and Cybernetics* 13, 6(Nov/Dec 1983), 1148–1154.

Book chapters:

1. E. Fouh, S. Hamouda, M.F. Farghally, and C.A. Shaffer, Automating Learner Feedback in an eTextbook for Data Structures and Algorithms Courses, in *Challenges in ICT Education: Formative Assessment, Learning Data Analytics and Gamification*, Santi Caballé and Robert Clarisó, eds., Elsevier, 2016, 135–165.
2. M. Akbar and C.A. Shaffer, Social Networks in Digital Libraries, in *Digital Libraries Applications: CBIR, Education, Social Networks, eScience/Simulation, and GIS*, E.A. Fox and J.P. Leidig, eds., Morgan & Claypool, 2014, 45–62. DOI: 10.2200/S00565ED1V01Y201401ICR032
3. Clifford A. Shaffer, Jason W. Zwolak, Ranjit Randhawa, and John J. Tyson Modeling Molecular Regulatory Networks with JigCell and PET, in *Systems Biology 500*, Ivan Maly, ed., Humana Press, 2009, 81–111.
4. KOENEMANN, J., CARROLL, J. M., SHAFFER, C. A., ROSSON, M. B., AND ABRAMS, M. Designing collaborative applications for classroom use: The LiNC project. In *The Design of Children's Technology*, A. Druin, Ed. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 1998, ch. Designing Collaborative Applications for Classroom Use: The LiNC Project, pp. 99–122.
5. C.A. Shaffer, Data representations for Geographic Information Systems, in *Annual Review of Information Science and Technology* 27, (Martha E. Williams, Ed.), American Society for Information Science, Medford, NJ, 1992, 135–172.
6. SHAFFER, C. A., AND FEUSTEL, C. D. Exact computation of 2-d intersections. In *Graphics Gems III*, D. Kirk, Ed. Academic Press Professional, Inc., San Diego, CA, USA, 1992, ch. Exact Computation of 2-D Intersections, pp. 188–192.

7. C.A. Shaffer, Getting Around on a Sphere, in *Graphics Gems II*, (J. Arvo, Ed.), Academic Press, San Diego, CA, 1991.
8. SHAFFER, C. A. Fast circle-rectangle intersection checking. In *Graphics Gems*, A. S. Glassner, Ed. Academic Press Professional, Inc., San Diego, CA, USA, 1990, ch. Fast Circle-rectangle Intersection Checking, pp. 51–53.
9. SHAFFER, C. A. Bit interleaving for quad or octrees. In *Graphics Gems*, A. S. Glassner, Ed. Academic Press Professional, Inc., San Diego, CA, USA, 1990, ch. Bit Interleaving for Quad or Octrees, pp. 443–447.
10. SAMET, H., SHAFFER, C. A., AND WEBBER, R. E. Using linear quadtrees to store vector data. In *Proceedings of a Workshop (Eurographics Seminars on Data Structures for Raster Graphics)* (New York, NY, USA, 1986), Springer-Verlag New York, Inc., pp. 91–123.

Invited conference papers:

1. LIU, Z., MOBASSERA, U. J., SHAFFER, C. A., WATSON, L. T., AND CAO, Y. Multistate modeling and simulation for regulatory networks. In *Proceedings of the Winter Simulation Conference* (Dec. 2010), WSC '10, Winter Simulation Conference, pp. 631–642.
2. SHAFFER, C. A., RANDHAWA, R., AND TYSON, J. J. The role of composition and aggregation in modeling macromolecular regulatory networks. In *Proceedings of the 38th Conference on Winter Simulation* (Dec. 2006), WSC '06, Winter Simulation Conference, pp. 1628–1636.
3. SAURO, H. M., HAREL, D., KWIATKOWSKA, M., SHAFFER, C. A., UHRMACHER, A. M., HUCKA, M., MENDES, P., STRÖMBACK, L., AND TYSON, J. J. Challenges for modeling and simulation methods in systems biology. In *Proceedings of the 38th Conference on Winter Simulation* (Dec. 2006), WSC '06, Winter Simulation Conference, pp. 1720–1730.
4. E.A. Fox, N.D. Barnette, C.A. Shaffer, L. Heath, W. Wake, L.T. Nowell, J.A.N. Lee, D. Hix and H.R. Hartson, Progress in Interactive Learning with a Digital Library in Computer Science, in *Proceedings ED-MEDIA 95, World Conf. on Educational Multimedia and Hypermedia*, June 17–21, 1995, Graz, Austria.
5. C.A. Shaffer, Indexing Methods for Area of Interest Retrieval from World Scale GIS, *Proceedings of the International Colloquium on Digital Maps in Geosciences*, Wuerzburg, West Germany, Sep 1989, in *Geologisches Jahrbuch A 122*, 1992, 101–107.
6. C.A. Shaffer, An Empirical Comparison of Vectors, Rasters, and Quadtrees for Representing Geographic Data, *Proceedings of the International Colloquium on the Construction and Display of Geoscientific Maps Derived from Databases*, Dinkelsbuehl, West Germany, Dec 1986, in *Geologisches Jahrbuch A 104*, (1988), 99–115.
7. H. Samet, C.A. Shaffer, R.C. Nelson, Y.-G. Huang, K. Fujimura, and A. Rosenfeld, Hierarchical Data Structures for Geographic Information, *Proceedings of the International Colloquium on the Construction and Display of Geoscientific Maps Derived from Databases*, Dinkelsbuehl, West Germany, Dec 1986, in *Geologisches Jahrbuch A 104*, (1988), 97–98.

Conference papers:

1. KAZEROUNI, A. M., EDWARDS, S. H., AND SHAFFER, C. A. Quantifying incremental development practices and their relationship to procrastination. In *Proceedings of the 2017 ACM Conference on International Computing Education Research* (New York, NY, USA, Aug. 2017), ICER '17, ACM, pp. 191–199.

2. KAZEROUNI, A. M., EDWARDS, S. H., HALL, T. S., AND SHAFFER, C. A. DevEventTracker: Tracking development events to assess incremental development and procrastination. In *Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education* (New York, NY, USA, June 2017), ITiCSE '17, ACM, pp. 104–109.
3. FARGHALLY, M. F., KOH, K. H., SHAHIN, H., AND SHAFFER, C. A. Evaluating the effectiveness of algorithm analysis visualizations. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2017), SIGCSE '17, ACM, pp. 201–206. (Designated an Exemplary Research Paper)
4. BART, A. C., WHITCOMB, R., KAFURA, D., SHAFFER, C. A., AND TILEVICH, E. Computing with CORGIS: Diverse, real-world datasets for introductory computing. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2017), SIGCSE '17, ACM, pp. 57–62. (Winner, Best Research Paper Award)
5. FARGHALLY, M. F., KOH, K. H., ERNST, J. V., AND SHAFFER, C. A. Towards a concept inventory for algorithm analysis topics. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2017), SIGCSE '17, ACM, pp. 207–212.
6. A.C. Bart, J. Tibau, E. Tilevich, C.A. Shaffer, and D.G. Kafura, Implementing an Open-Access, Data Science Programming Environment for Learners, in *Proceedings of the 40th IEEE Annual Computer Software and Applications Conference (COMPSAC 2016)*, Atlanta, GA, June 2016, 728–737.
7. E. Fouh, M.F. Farghally, S. Hamouda, K.H. Koh, and C.A. Shaffer, Investigating Difficult Topics in a Data Structures Course Using Item Response Theory and Logged Data Analysis, in *Proceedings of the 9th International Conference on Educational Data Mining (EDM 2016)*, Raleigh, NC, June 2016, 370–375.
8. BART, A. C., AND SHAFFER, C. A. Instructional design is to teaching as software engineering is to programming. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education* (New York, NY, USA, Mar. 2016), SIGCSE '16, ACM, pp. 240–241.
9. MARTIN, J., EDWARDS, S. H., AND SHAFFER, C. A. The effects of procrastination interventions on programming project success. In *Proceedings of the Eleventh Annual International Conference on International Computing Education Research* (New York, NY, USA, July 2015), ICER '15, ACM, pp. 3–11.
10. EDWARDS, S. H., MARTIN, J., AND SHAFFER, C. A. Examining classroom interventions to reduce procrastination. In *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education* (New York, NY, USA, July 2015), ITiCSE '15, ACM, pp. 254–259.
11. KIRKPATRICK, M. S., CUNY, J. E., GUZDIAL, M., HOLLAND-MINKLEY, A., AND SHAFFER, C. A. Best practices for IRB approval: Four perspectives. In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2015), SIGCSE '15, ACM, pp. 267–268.
12. HAZZAN, O., AND SHAFFER, C. A. Big data in computer science education research. In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2015), SIGCSE '15, ACM, pp. 591–592.
13. C.A. Shaffer, E. Fouh, S. Hamouda, and M.F. Farghally, OpenDSA: Experiences using an Interactive eTextbook to Teach Data Structures and Algorithms, *Proceedings of Conference on Higher Education pedagogy*, Blacksburg, VA, February 2015, 85–86.
14. AKBAR, M., SHAFFER, C. A., FAN, W., AND FOX, E. A. Recommendation based on deduced social networks in an educational digital library. In *Proceedings of the 14th ACM/IEEE-CS Joint Conference on Digital Libraries* (Piscataway, NJ, USA, Sept. 2014), JCDL '14, IEEE Press, pp. 29–38.

15. BART, A. C., TILEVICH, E., HALL, S., ALLEVATO, T., AND SHAFFER, C. A. Transforming introductory computer science projects via real-time web data. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2014), SIGCSE '14, ACM, pp. 289–294.
16. KARAVIRTA, V., AND SHAFFER, C. A. JSAV: The JavaScript Algorithm Visualization Library. In *Proceedings of the 18th ACM Conference on Innovation and Technology in Computer Science Education* (New York, NY, USA, Mar. 2013), ITiCSE '13, ACM, pp. 159–164.
17. KORHONEN, A., NAPS, T., BOISVERT, C., CRESCENZI, P., KARAVIRTA, V., MANNILA, L., MILLER, B., MORRISON, B., RODGER, S. H., ROSS, R., AND SHAFFER, C. A. Requirements and design strategies for open source interactive computer science eBooks. In *Proceedings of the ITiCSE Working Group Reports Conference on Innovation and Technology in Computer Science Education-working Group Reports* (New York, NY, USA, June 2013), ITiCSE -WGR '13, ACM, pp. 53–72.
18. S. Hall, E. Fouh, D. Breakiron, M. Elshehaly, and C.A. Shaffer, Evaluating Online Tutorials for Data Structures and Algorithms Courses, *Proceedings of the 2013 ASEE Annual Conference & Exposition*, Atlanta, GA, June 2013, Paper #5951.
19. GEHRINGER, E. F., GOLUB, B. L., COHEN, R., ARNOW, D. M., AND SHAFFER, C. A. Panel: Textbook pricing, present and future. In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2013), SIGCSE '13, ACM, pp. 633–634.
20. M. Akbar, C.A. Shaffer, and E.A. Fox, “Deduced social networks for an educational digital library” in *Proceedings of the 12th ACM/IEEE-CS Joint Conference on Digital Libraries, JCDL '12*, Washington, DC, June 2012, 43–46
21. C.A. Shaffer, V. Karavirta, A. Korhonen and T.L. Naps, “OpenDSA: Beginning a Community Hyper-textbook Project” in *Proceedings of 11th Koli Calling International Conference on Computing Education Research*, Koli National Park, Finland, November 17-20, 2011, 112–117.
22. AKBAR, M., FAN, W., SHAFFER, C. A., CHEN, Y., CASSEL, L., DELCAMBRE, L., GARCIA, D. D., HISLOP, G. W., SHIPMAN, F., FURUTA, R., CARPENTER, B. S., HSIEH, H., SIEGFRIED, B., AND FOX, E. A. Digital library 2.0 for educational resources. In *Proceedings of the 15th International Conference on Theory and Practice of Digital Libraries: Research and Advanced Technology for Digital Libraries* (Berlin, Heidelberg, Sept. 2011), TPD'11, Springer-Verlag, pp. 89–100.
23. C.A. Shaffer, T.L. Naps, and E. Fouh, “Truly Interactive Textbooks for Computer Science Education” in *Proceedings of the Sixth Program Visualization Workshop*, Darmstadt, Germany, June 30, 2011, 97–103.
24. SHAFFER, C. A., AND EDWARDS, S. H. Scheduling and student performance. In *Proceedings of the 16th Annual Joint Conference on Innovation and Technology in Computer Science Education* (New York, NY, USA, June 2011), ITiCSE '11, ACM, pp. 331–331.
25. AKBAR, M., FAN, W., CASSEL, L., DELCAMBRE, L., SHAFFER, C. A., FOX, E. A., AND CHEN, Y. How educators find educational resources online. In *Proceedings of the 16th Annual Joint Conference on Innovation and Technology in Computer Science Education* (New York, NY, USA, 2011), ITiCSE '11, ACM, pp. 367–367.
26. SHAFFER, C. A., AKBAR, M., ALON, A. J. D., STEWART, M., AND EDWARDS, S. H. Getting algorithm visualizations into the classroom. In *Proceedings of the 42nd ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2011), SIGCSE '11, ACM, pp. 129–134.

27. FOX, E. A., CHEN, Y., AKBAR, M., SHAFFER, C. A., EDWARDS, S. H., BRUSILOVSKY, P., GARCIA, D., DELCAMBRE, L., DECKER, F., ARCHER, D., FURUTA, R., SHIPMAN, F., CARPENTER, S., AND CASSEL, L. Ensemble PDP-8: Eight principles for distributed portals. In *Proceedings of the 10th Annual Joint Conference on Digital Libraries* (New York, NY, USA, 2010), JCDL '10, ACM, pp. 341–344.
28. SHAFFER, C. A., NAPS, T. L., RODGER, S. H., AND EDWARDS, S. H. Building an online educational community for algorithm visualization. In *Proceedings of the 41st ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2010), SIGCSE '10, ACM, pp. 475–476.
29. AHN, T.-H., WANG, P., WATSON, L. T., CAO, Y., SHAFFER, C. A., AND BAUMANN, W. T. Stochastic cell cycle modeling for budding yeast. In *Proceedings of the 2009 Spring Simulation Multiconference* (San Diego, CA, USA, Mar. 2009), SpringSim '09, Society for Computer Simulation International, pp. 113:1–113:6.
30. WANG, P., RANDHAWA, R., SHAFFER, C. A., CAO, Y., AND BAUMANN, W. T. Converting macromolecular regulatory models from deterministic to stochastic formulation. In *Proceedings of the 2008 Spring Simulation Multiconference* (San Diego, CA, USA, Apr. 2008), SpringSim '08, Society for Computer Simulation International, pp. 385–392.
31. E. Thomas, L. Thomas, and C.A. Shaffer, Defect detection on hardwood logs using high resolution laser scan data, in *Proceedings of the 15th International Symposium on Non-Destructive Testing of Wood*, Duluth, MN, September 2007, 163–167.
32. RANDHAWA, R., SHAFFER, C. A., AND TYSON, J. J. Fusing and composing macromolecular regulatory network models. In *Proceedings of the 2007 Spring Simulation Multiconference - Volume 2* (San Diego, CA, USA, Mar. 2007), SpringSim '07, Society for Computer Simulation International, pp. 337–344.
33. SHAFFER, C. A., COOPER, M., AND EDWARDS, S. H. Algorithm visualization: A report on the state of the field. In *Proceedings of the 38th SIGCSE Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2007), SIGCSE '07, ACM, pp. 150–154.
34. E. Thomas, L. Thomas, C.A. Shaffer and L. Mili, Using External High-Resolution Log Scanning to Determine Internal Defect Characteristics, in *Proceedings of the 15th Central Hardwood Forestry Conference*, Knoxville, TN, February 2006, 497–505.
35. T.D. Panning, L.T. Watson, N.A. Allen, C.A. Shaffer, and J.J. Tyson, Deterministic Global Parameter Estimation for a Budding Yeast Model, in *Proceedings of the 2006 High Performance Computing Symposium (HPC'06)*, Huntsville, AL, 2006, 195–201.
36. ALLEN, N. A., SHAFFER, C. A., AND WATSON, L. T. Building modeling tools that support verification, validation, and testing for the domain expert. In *Proceedings of the 37th Conference on Winter Simulation* (Dec. 2005), WSC '05, Winter Simulation Conference, pp. 419–426.
37. L. Thomas, L. Mili, C.A. Shaffer, and E. Thomas, Defect Detection on Hardwood Logs Using High Resolution Three-dimensional Laser Scan Data, in *IEEE International Conference on Image Processing, ICIP*, Singapore, October 24–27, 2004, 243–246.
38. J. He, M. Sosonkina, C.A. Shaffer, J.J. Tyson, L.T. Watson, and J.W. Zwolak, A Hierarchical Parallel Scheme for a Global Search Algorithm, in *Proceedings of the 2004 High Performance Computing Symposium (HPC'04)*, J. Meyer (ed.), Society for Modeling and Simulation International, San Diego, CA, 2004, 43–50.
39. J. He, M. Sosonkina, C.A. Shaffer, J.J. Tyson, L.T. Watson, and J.W. Zwolak, A Hierarchical Parallel Scheme for Global Parameter Estimation in Systems Biology, in *Proceedings of the 18th International Parallel & Distributed Processing Symposium*, CD-ROM, IEEE Computer Soc., Los Alamitos, CA, 2004, 9 pages.

40. SHAFFER, C. A. Buffer pools and file processing projects for an undergraduate data structures course. In *Proceedings of the 35th SIGCSE Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2004), SIGCSE '04, ACM, pp. 175–178.
41. SARAIYA, P., SHAFFER, C. A., MCCRICKARD, D. S., AND NORTH, C. Effective features of algorithm visualizations. In *Proceedings of the 35th SIGCSE Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2004), SIGCSE '04, ACM, pp. 382–386.
42. ALLEN, N. A., SHAFFER, C. A., VASS, M. T., RAMAKRISHNAN, N., AND WATSON, L. T. Improving the development process for eukaryotic cell cycle models with a modeling support environment. In *Proceedings of the 35th Conference on Winter Simulation: Driving Innovation* (Dec. 2003), WSC '03, Winter Simulation Conference, pp. 782–790.
43. E. Thomas, L. Thomas, L. Mili, R. Ehrich, A.L. Abott, and C. Shaffer, Primary Detection of Hardwood Log Defects Using Laser Surface Scanning, *Proceedings of Machine Vision Applications in Industrial Inspection XI*, SPIE Volume 5011, Santa Clara, CA, January 2003, 39–48.
44. VASS, M., CARROLL, J. M., AND SHAFFER, C. A. Supporting creativity in problem solving environments. In *Proceedings of the 4th Conference on Creativity & Cognition* (New York, NY, USA, Oct. 2002), C&C '02, ACM, pp. 31–37.
45. C. R. Anderson, T. S. Rappaport, K. Bae, A. Verstak, N. Ramakrishnan, W. H. Tranter, C. A. Shaffer, and L. T. Watson, In-Building Wideband Multipath Characteristics at 2.5 & 60 GHz, in *Proceedings of IEEE Vehicular Technology Fall Conference*, Vancouver, Canada, 2002, 97–101.
46. K. K. Bae, J. Jiang, W. H. Tranter, C. R. Anderson, T. S. Rappaport, J. He, A. Verstak, L. T. Watson, N. Ramakrishnan, and C. A. Shaffer, WCDMA STTD Performance Analysis with Transmitter Location Optimization in Indoor Systems Using Ray-Tracing Technique, in *Proceedings of IEEE 2002 Radio and Wireless Conference*, Boston, MA, 2002, 123–127.
47. V. Colaso, A. Kamal, P. Saraiya, C. North, D.S. McCrickard, and C.A. Shaffer, Learning and Retention in Data Structures: A Comparison of Visualization, Text, and Combined Methods, in *Proceedings of the World Conference on Educational Multimedia/Hypermedia and Educational Telecommunications (ED-MEDIA 2002)*, Denver CO, June 2002, 332–333.
48. VERSTAK, A., HE, J., WATSON, L. T., RAMAKRISHNAN, N., SHAFFER, C. A., RAPPAPORT, T. S., ANDERSON, C., BAE, K., JIANG, J., AND TRANTER, W. H. S⁴W: Globally optimized design of wireless communications systems. In *Proceedings of the 16th International Parallel and Distributed Processing Symposium* (Washington, DC, USA, Apr. 2002), IPDPS '02, IEEE Computer Society, pp. 292–.
49. J. He, A. Verstak, L. T. Watson, T. S. Rappaport, C. R. Anderson, N. Ramakrishnan, C. A. Shaffer, W. H. Tranter, K. Bae, and J. Jiang, Global Optimization of Transmitter Placement in Wireless Communication Systems, in *Proceedings of the 2002 High Performance Computing Symposium (HPC'02)*, A. Tentner (ed.), Soc. for Modeling and Simulation Internat., San Diego, CA, 2002, 328–333.
50. A. Verstak, M. Vass, N. Ramakrishnan, C.A. Shaffer, L.T. Watson, K.K. Bae, J. Jiang, W.H. Tranter, and T.S. Rappaport, Lightweight Data Management for Compositional Modeling in Problem Solving Environments, in *Proceedings of the 2001 High Performance Computing Symposium (HPC'01)*, A. Tentner (ed.), Soc. for Modeling and Simulation Internat., San Diego, CA, 2001, 148–153.
51. C. A. Shaffer, N. Ramakrishnan, L. T. Watson, R. Dymond, and V. Lohani, The Role of Problem Solving Environments in Watershed Assessment, in *Proceedings of the Integrated Decision-Making for Watershed Management Symposium: Processes and Tools*, Virginia Water Resources Research Center, Blacksburg, VA, VWRRC P7–2001, 2001, 677–690.

52. E. J. Rubin, R. Dietz, J. Chanat, C. Speir, R. Dymond, V. Lohani, D. Kibler, D. Bosch, C. A. Shaffer, N. Ramakrishnan, and L. T. Watson, From Landscapes to Waterscapes: A PSE for Landuse Change Analysis, in *Proc. Integrated Decision-Making for Watershed Management Symposium: Processes and Tools*, Virginia Water Resources Research Center, Blacksburg, VA, VWRRC P7-2001, 2001, 643-659.
53. E.J. Rubin, R. Dietz, S. Lingam, J. Chanat, C. Speir, R. Dymond, V. Lohani, D. Kibler, D. Bosch, C.A. Shaffer, N. Ramakrishnan, and L.T. Watson, From Landscapes to Waterscapes: A PSE for Landuse Change Analysis, in *Proceedings of the 16th IMACS World Congress*, Special Session on 'PSEs for Scientific Computing,' Lausanne Switzerland, M. Deville and R. Owens (eds.), CD-ROM, August 2000, 6 pages.
54. C. A. Shaffer, L. T. Watson, D. G. Kafura, and N. Ramakrishnan, Features of Problem Solving Environments for Computational Science, in *Proceedings of the 2000 High Performance Computing Symposium (HPC'00)*, A. Tentner (Ed.), Society for Computer Simulation International, San Diego, CA, 2000, 242-247.
55. GOEL, A., BAKER, C., SHAFFER, C. A., GROSSMAN, B., HAFTKA, R. T., MASON, W. H., AND WATSON, L. T. Vizcraft (case study): A multidimensional visualization tool for aircraft configuration design. In *Proceedings of the Conference on Visualization '99: Celebrating Ten Years* (Los Alamitos, CA, USA, 1999), VIS '99, IEEE Computer Society Press, pp. 425-428.
56. C.A. Shaffer, L.T. Watson, and D.G. Kafura, Component Frameworks for Problem Solving Environments in Computational Science, in *Proceedings of the 1st Symposium on Reusable Architectures and Components for Developing Distributed Information Systems (RACDIS'99)*, Orlando, FL, August 1999, 653-656.
57. BEGOLE, J. B., ROSSON, M. B., AND SHAFFER, C. A. Supporting worker independence in collaboration transparency. In *Proceedings of the 11th Annual ACM Symposium on User Interface Software and Technology* (New York, NY, USA, Nov. 1998), UIST '98, ACM, pp. 133-142.
58. SHAFFER, C. A., KNILL, D. L., AND WATSON, L. T. Visualization for multiparameter aircraft designs. In *Proceedings of the Conference on Visualization '98* (Los Alamitos, CA, USA, Oct. 1998), VIS '98, IEEE Computer Society Press, pp. 491-494.
59. P.L. Isenhour, J. Begole, W.S. Heagy, and C.A. Shaffer, **Sieve**: A Java-Based Collaborative Visualization Environment, *Late Breaking Hot Topics Proceedings, IEEE Visualization'97*, Phoenix, AZ, October 1997, 13-16.
60. BEGOLE, J., STRUBLE, C. A., SHAFFER, C. A., AND SMITH, R. B. Transparent sharing of java applets: A replicated approach. In *Proceedings of the 10th Annual ACM Symposium on User Interface Software and Technology* (New York, NY, USA, Oct. 1997), UIST '97, ACM, pp. 55-64.
61. C.A. Shaffer, L.S. Heath, J.M. Nielsen and J. Yang, SWAN: A Student-Controllable Data Structure Visualization System, *Proceedings of ED-MEDIA 96*, Boston MA, June 1996, 632-637.
62. SHAFFER, C. A., HEATH, L. S., AND YANG, J. Using the swan data structure visualization system for computer science education. In *Proceedings of the Twenty-seventh SIGCSE Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 1996), SIGCSE '96, ACM, pp. 140-144.
63. YANG, J., SHAFFER, C. A., AND HEATH, L. S. SWAN: A data structure visualization system. In *Proceedings of the Symposium on Graph Drawing* (London, UK, UK, Sept. 1996), GD '95, Springer-Verlag, pp. 520-523.
64. J.S. Bright, C.A. Shaffer, P.S. Nagarkatti and M. Nagarkatti, Computer Simulation of the Immune System, in *Proceedings of the Fourteenth Annual Seminar of Cancer Researchers in Virginia*, Blacksburg, VA, March 1994, 17.

65. C.A. Shaffer, J.M.A. Begole, L.W. Carstensen, Jr., R.W. Morrill and E.A. Fox, **GeoSim: A GIS-Based Simulation Laboratory for Introductory Geography**, *Proceedings of the 1994 ADCIS Conference*, Nashville, TN, February 1994.
66. SHAFFER, C. A., AND BROWN, P. R. A paging scheme for pointer-based quadtrees. In *Proceedings of the Third International Symposium on Advances in Spatial Databases* (London, UK, UK, June 1993), SSD '93, Springer-Verlag, pp. 89–104.
67. C.A. Shaffer and M.T. Ursekar, Large Scale Editing and Vector to Raster Conversion Via Quadtree Spatial Indexing, *Proceedings of the 5th International Symposium on Spatial Data Handling*, Charleston, SC, August 1992, 505–513.
68. SHAFFER, C. A. A full resolution elevation representation requiring three bits per pixel. In *Proceedings of the First Symposium on Design and Implementation of Large Spatial Databases* (New York, NY, USA, 1990), SSD '90, Springer-Verlag New York, Inc., pp. 45–64.
69. D.N. Oskard, T.-H. Hong, and C.A. Shaffer, Real-Time Algorithms and Data Structures for Underwater Mapping, *SPIE Symposium on Sensor Fusion: Spatial Reasoning and Scene Interpretation*, Cambridge MA, Nov 1988.
70. C.-H. Ang, H. Samet, and C.A. Shaffer, Fast Region Expansion for Quadtrees, *Proceedings of the Third International Symposium on Spatial Data Handling*, Sydney, Australia, Aug 1988, 19–38.
71. C.A. Shaffer and H. Samet, An Optimal Quadtree Construction Algorithm, *Proceedings of the Eighth International Conference on Pattern Recognition*, Paris, France, Oct, 1986, 317–319.
72. H. Samet, C.A. Shaffer, R.C. Nelson, Y.G. Huang, K. Fujimura, and A. Rosenfeld, Recent Developments in Quadtree-Based Geographic Information Systems, *Proceedings of the Second International Symposium on Spatial Data Handling*, Seattle, Jul 1986, 15–32, (see also Geographic Information Systems Workshop, Springfield, Virginia, Dec 1985).
73. H. Samet, C.A. Shaffer, and R.E. Webber, The Segment Quadtree: A Linear Quadtree-Based Representation for Linear Features, *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'85)*, San Francisco, Jun 1985, 385–389.
74. H. Samet, A. Rosenfeld, C.A. Shaffer, and R.E. Webber, Use of Hierarchical Data Structures in Geographical Information Systems, *Proceedings of the International Symposium on Spatial Data Handling*, Zurich, Aug 1984, 392–411.
75. H. Samet, A. Rosenfeld, C.A. Shaffer, and R.E. Webber, Processing Geographic Data with Quadtrees, *Proceedings of the Seventh International Conference on Pattern Recognition*, Montreal, Aug 1984, 212–215.
76. H. Samet, A. Rosenfeld, C.A. Shaffer, and R.E. Webber, A Quadtree-Based Geographical Information System, *Proceedings of the Third Scandinavian Conference on Image Analysis*, Copenhagen, Jul 1983, 231–236.

Poster papers and abstracts:

1. FARGHALLY, M. F., FOUH, E., HAMOUDA, S., KOH, K. H., AND SHAFFER, C. A. Visualizing algorithm analysis topics. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education* (New York, NY, USA, Mar. 2016), SIGCSE '16, ACM, pp. 687–687.
2. S. Hamouda, N.D. Barnette, E. Fouh, M.F. Farghally, H.G. Elmongui, and C.A. Shaffer, Developing a Concept Inventory to Enhance Teaching of Recursion, *Proceedings of Conference on Higher Education pedagogy*, Blacksburg, VA, February 2015, 208.

3. M.F. Farghally, E. Fouh, S. Hamouda, and C.A. Shaffer, Conveying Algorithm Analysis Concepts Through Visualization, *Proceedings of Conference on Higher Education pedagogy*, Blacksburg, VA, February 2015, 206.
4. E. Fouh, S. Hamouda, M.F. Farghally, and C.A. Shaffer Using an Interactive eTextbook to Teach Data Structures and Algorithms: Findings from Using the OpenDSA System in CS2 and CS3 Course, *Proceedings of Conference on Higher Education pedagogy*, Blacksburg, VA, February 2015, 235.
5. N. Maji and C.A. Shaffer Visualizing NP Complete Proofs and Reductions in OpenDSA, *Proceedings of Conference on Higher Education pedagogy*, Blacksburg, VA, February 2015, 236.
6. A.C. Bart, J. Riddle, O. Saleem, B. Chowdhury, E. Tilevich, C.A. Shaffer, and D.G. Kafura Motivating Students with Big Data: CORGIS and MUSIC, presented at *SPLASH-E 2014*, Portland, OR, October 2014.
7. BREAKIRON, D. A., FOUH, E., HAMOUDA, S., AND SHAFFER, C. A. Analysis of interaction logs for online tutorials. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2014), SIGCSE '14, ACM, pp. 709–709.
8. A.C. Bart, E. Tilevich, C.A. Shaffer, T. Allevato, S. Hall, Using Real-Time Web Data to Enrich Introductory Computer Science Projects, presented at *Splash-E '13*, Indianapolis, Indiana, October, 2013.
9. FOUH, E., BREAKIRON, D., ELSHEHALY, M., HALL, T. S., KARAVIRTA, V., AND SHAFFER, C. A. OpenDSA: Using an active etextbook to teach data structures and algorithms (abstract only). In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education* (New York, NY, USA, Mar. 2013), SIGCSE '13, ACM, pp. 734–734.
10. M. Akbar and C.A. Shaffer, “User type clustering to refine search and browse for educational resources”, poster abstract in *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education*, SIGCSE 2012, Raleigh, NC, March 2012, 666. Student research competition 2nd place winner.
11. C.A. Shaffer, “Active eTextbooks for CS: what should they be?”, Birds-of-a-Feather session abstract in *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education*, SIGCSE 2012, Raleigh, NC, March 2012, 680.
12. E. Fouh, M. Sun, and C.A. Shaffer, “OpenDSA: a creative commons active-ebook”, poster abstract in *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education*, SIGCSE 2012, Raleigh, NC, March 2012, 721.
13. M. Akbar, A.J. Alon, M. Stewart, C.A. Shaffer, S.H. Edwards, “AlgoViz Portal: Lowering the Barriers for Entry into an Online Educational Community,” poster presented at 2010 Conference on Higher Education Pedagogy, Blacksburg VA, February 2010.
14. M. Akbar, Y. Chen, M. Stewart, E.A. Fox, C.A. Shaffer, S.H. Edwards, P. Fan, “Ensemble: Enriching Communities and Collections to Support Education in Computing,” Poster presented at 2010 Conference on Higher Education Pedagogy, Blacksburg VA, February 2010.
15. M. Akbar, A.J. Alon, M. Stewart, C.A. Shaffer, S.H. Edwards, “Building an Online Educational Community,” poster presented at 2010 Conference on Higher Education Pedagogy, Blacksburg VA, February 2010.
16. C.A. Shaffer, S.H. Edwards, and M. Akbar, “The AlgoViz Portal: Lowering the Barriers for Entry into an Online Educational Community,” poster presented at NSF NSDL PIs meeting, November 2009.

17. C.A. Shaffer, M. Agarwal, A. Kumar, and S.H. Edwards, Going Beyond Algorithm Visualization to Algorithm Exploration, *39th ACM Technical Symposium on Computer Science Education (SIGCSE 2008)*, Portland OR, March 2008.
18. L. Thomas, E. Thomas, and C. Shaffer, Algorithm for Automated Detection of Surface Defects on Hardwood Logs, *Forest Products Society, 61st International Convention*, Knoxville, TN, June 2007.
19. R. Randhawa, C.A. Shaffer, and J.J. Tyson, Composition and Aggregation for Biological Pathway Modeling, *The Seventh International Conference on Systems Biology*, Yokohama, Japan, October, 2006, poster FI66.
20. BROWN, P. R., SHAFFER, C. A., AND WEBBER, R. E. A paging scheme for pointer-based quadtrees (abstract only). In *Proceedings of the 19th Annual Conference on Computer Science* (New York, NY, USA, Mar. 1991), CSC '91, ACM, pp. 687–.
21. C.A. Shaffer, V. Miranda, J.J.C. Wang, S. Kriss, L.W. Carstensen, Jr., R.W. Morrill, and E.A. Fox, Computerized Simulations for Introductory Geography Instruction, in *Proceedings of Application of Geographic Information Systems, Simulation Models, and Knowledge-based Systems for Landuse Management*, Blacksburg, VA, Nov 12–14, 1990, 479–480.
22. SHAFFER, C. A., AND HERB, G. M. A real-time robot collision avoidance system (abstract). In *Proceedings of the 1990 ACM Annual Conference on Cooperation* (New York, NY, USA, Feb. 1990), CSC '90, ACM, pp. 441–.
23. H. Samet, A. Rosenfeld, C.A. Shaffer, and R.E. Webber, Quadtree Region Representation in Cartography: Experimental Results, *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'83)*, Washington D.C., Jun 1983, 176–177.

Videos:

1. A.J. Alon, M. Stewart, M. Akbar, C.A. Shaffer, “Issues in Algorithm Visualization”, video presented as part of the video program for *41st ACM Technical Symposium on Computer Science Education (SIGCSE'10)*, March 11-13, 2010.

Conference Tutorials:

1. E. Tilevich, C.A. Shaffer, and A.C. Bart, Creating Stimulating, Relevant, and Manageable Introductory Computer Science Projects That Utilize Real-time Web-based Data, Workshop presentation, *Proceedings of the 45th ACM Technical Symposium on Computer Science Education (SIGCSE '14)*, Atlanta, GA, March 2014, 743–743.
2. C.A. Shaffer, T.L. Naps, S.H. Rodger, S.H. Edwards, “How to Use Algorithm Visualizations in Your Class,” Workshop presentation, *42nd ACM Technical Symposium on Computer Science Education (SIGCSE'11)*, Dallas TX, March 9, 2011.
3. C.A. Shaffer, Efficient Algorithms for Quadtree-Based Geographic Informations Systems in *Quadtrees and Octree Methods*, SIGGRAPH '87 course notes No. 18, Anaheim, Jul 1987.
4. C.A. Shaffer, H. Samet, R.E. Webber, R.C. Nelson, Y-G. Huang, and A. Rosenfeld, An Implementation for a Geographic Information System Based on Quadtrees in *Quadtrees, Octrees and Related Hierarchical Data Structures*, SIGGRAPH '85 course notes No. 25, San Francisco, Jul 1985.

Edited Collections:

1. G.A. Wainer, C.A. Shaffer, R.M. McGraw, M.J. Chinni, *Proceedings of the 2009 Spring Simulation Multiconference, SpringSim 2009*, San Diego, California, USA, March 22-27, 2009 SCS/ACM 2009.
2. SHAFFER, C. A. Dissertation abstracts in computer graphics. *ACM SIGGRAPH Computer Graphics* 27, 2 (Sept. 1993), 86–98.
3. C.A. Shaffer, Dissertation Abstracts in Computer Graphics, *Computer Graphics* 26, 1(January 1992), 76–96.

Software manuals:

1. HINES, D. T., BEGOLE, J. M., KLIPSCH, C. A., AND SHAFFER, C. A. The geosim interface library (gil): Programmer’s manual, version1.0.1. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1994.
2. JUN, Y., SHAFFER, C. A., AND HEATH, L. S. The swan user’s manual, version 1.1. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1995.

Unrefereed papers and reports:

1. M. Abrams, D. Allison, D. Kafura, C. Ribbens, M.B. Rosson, C. Shaffer, and L. Watson, *PSE Research at Virginia Tech: An Overview*, Computer Science TR 98-21, Virginia Tech, Aug 1998.
2. J.B. Begole and C.A. Shaffer, *Flexible Collaboration Transparency*, Computer Science TR 98-11, Virginia Tech, Apr 1998.
3. J.B. Begole and C.A. Shaffer, *Internet Based Real-Time Multiuser Simulation: Ppong*, Computer Science TR 97-01, Virginia Tech, Feb 1997.
4. J.B. Begole, C.A. Struble, and C.A. Shaffer, *Collaboration Transparency in Java through Event Broadcasting*, Computer Science TR 97-02, Virginia Tech, Feb 1997.
5. J.M.A. Begole, C.A. Shaffer and M. Lattanzi, The **Project GeoSim** Graphical User Interface, *Proceedings of the 23rd Virginia Computer User’s Conference*, Oct 1993, 17–28.
6. T.L. Ryan and C.A. Shaffer, Device Independent Perspective Volume Rendering Using Octrees, Computer Science TR 92-05, Virginia Tech, Feb 1992.
7. PEMMARAJU, S. V., AND SHAFFER, C. A. Analysis of the worst case space complexity of a pr quadtree. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1992.
8. SHAFFER, C. A., AND FEUSTEL, C. D. A representation and algorithm for exact computation of cascaded polygon intersections with fixed storage requirements. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1991.
9. SHAFFER, C. A., CARSTENSEN, L. W., MIRANDA, V. F., KRISS, S. A., MORRILL, R. W., AND FOX, E. A. Project geosim: The first two modules. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1991.
10. SHAFFER, C. A., AND HERB, G. M. A real time robot arm collision detection system. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1990.
11. C.A. Shaffer and D.B. Boldery, The Elevation Pyramid, Computer Science TR 90-29, Virginia Tech, 1990.
12. SHAFFER, C. A., AND STOUT, Q. F. Linear time distance transforms for quadtrees. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1989.

13. SHAFFER, C. A., JUVVADI, R., AND HEATH, L. S. A generalized comparison of quadtree and bintree storage requirements. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1989.
14. LATTANZI, M., AND SHAFFER, C. A. An optimal boundary to quadtree conversion algorithm. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1989.
15. G.B. Terrell and C.A. Shaffer, A “C” Programming Language Software Tutor, *Proceedings of the 19th Virginia Computer User’s Conference*, Blacksburg VA, Sep 1989, 60–68.
16. D.B. Boldery and C.A. Shaffer, Spatial Data Generation through Interpolation, *Proceedings of the 19th Virginia Computer User’s Conference*, Blacksburg VA, Sep 1989, 69–77.
17. G.M. Herb and C.A. Shaffer, A Real Time Robot Collision Avoidance Safety System, *Proceedings of the 19th Virginia Computer User’s Conference*, Blacksburg VA, Sep 1989, 84–93.
18. SHAFFER, C. A., AND SAMET, H. Set operations for unaligned linear quadtrees. Tech. rep., Virginia Polytechnic Institute & State University, Blacksburg, VA, USA, 1988.
19. C.A. Shaffer and H. Samet, An in-Core Hierarchical Data Structure Organization for a Geographic Database, Computer Science TR-1886, University of Maryland, Jul 1987.
20. C.A. Shaffer, Application of Alternative Quadtree Representations, Ph.D. Dissertation, Computer Science Department, University of Maryland, College Park MD, 1986 (also Computer Science TR-1672, University of Maryland, Jun 1986).
21. H. Samet, A. Rosenfeld, C. A. Shaffer, R. C. Nelson, Y.-G. Huang, K. Fujimura, Application of Hierarchical Data Structures to Geographic Information Systems: Phase IV Computer Science TR-1578, University of Maryland, Dec 1985
22. H. Samet, A. Rosenfeld, C.A. Shaffer, R.C. Nelson, and Y-G. Huang, Application of Hierarchical Data Structures to Geographic Information Systems: Phase III, Computer Science TR-1457, University of Maryland, Nov 1984.
23. A. Rosenfeld, H. Samet, C.A. Shaffer, and R.E. Webber, Application of Hierarchical Data Structures to Geographic Information Systems: Phase II, Computer Science TR-1327, University of Maryland, Sep 1983.
24. C.A. Shaffer, QED: A Quadtree Editor, Masters Scholarly Paper, CSC-400, Computer Science Department, University of Maryland, 1982.
25. A. Rosenfeld, H. Samet, C.A. Shaffer, and R.E. Webber, Application of Hierarchical Data Structures to Geographic Information Systems, Computer Science TR-1197, University of Maryland, Jun, 1982.

Academic awards

June 2017 – Winner of Virginia Tech 2017 Scholarship of Teaching and Learning Award.

April 2017 – Winner of Virginia Tech XCalibur Award for integrating technology in teaching and learning.

March 2017 – Winner of Best Research Paper at SIGCSE 2017: A.C. Bart, R. Whitcomb, D. Kafura, C.A. Shaffer, and E. Tilevich, Computing with CORGIS: Diverse, Real-world Datasets for Introductory Computing, in *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE 2017)*, Seattle, WA, March 2017, 57–62.

March 2017 – Paper designated an Exemplary Research Paper at SIGCSE 2017: M.F. Farghally, K.H. Koh, H. Shahin, and C.A. Shaffer, Evaluating the Effectiveness of Algorithm Analysis Visualizations, in *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE 2017)*, Seattle, WA, March 2017, 201–206.

June 2016 to June 2018 – W.S. “Pete” White Chair for Innovation in Engineering Education.

December 2015 – ACM Distinguished Educator.

April 2015 – Dean’s Award for Excellence in Teaching.

1994 *Journal of Geography* award for best article related to teaching in a University or College.

September, 1994 – Undergraduate Computational Science Award, AMES Laboratory for **Project GeoSim**.

Professional activities, non-local presentations, meetings, and workshops:

March 2015 – A.C. Bart, E. Tilevich, and C.A. Shaffer, Creating Stimulating, Relevant, and Manageable Introductory Computer Science Projects that Utilize Real-Time, Large, Web-Based Datasets, Workshop presentation, *Proceedings of the 46th ACM Technical Symposium on Computer Science Education (SIGCSE 2015)*, Kansas City, MO.

March 2014 – E. Tilevich, C.A. Shaffer, and A.C. Bart, Creating Stimulating, Relevant, and Manageable Introductory Computer Science Projects That Utilize Real-time Web-based Data, Workshop presentation, *Proceedings of the 45th ACM Technical Symposium on Computer Science Education (SIGCSE 2014)*, Atlanta, GA.

May 30, 2011 – C.A. Shaffer, “How Can We Teach Problem Solving?,” keynote presentation to *Finnish Computer Science Days*, Aalto University, Finland.

May 25, 2011 – C.A. Shaffer, “How Can We Teach Problem Solving?,” keynote presentation to *Second Nordic Network of Engineering Education Research Seminar*, Mustio Manor, Finland.

March, 2011 – C.A. Shaffer, T.L. Naps, S.H. Rodger, and S.H. Edwards, “How to Use Algorithm Visualizations in Your Class,” Workshop presentation, *42nd ACM Technical Symposium on Computer Science Education (SIGCSE 2011)*, Dallas, TX.

item March, 2009 – C.A. Shaffer, T. Naps, and S.H. Edwards, “Building a Community for Algorithm Visualization”, Birds-of-a-Feather session, *40th ACM Technical Symposium on Computer Science Education (SIGCSE 2009)*.

March, 2008 – C.A. Shaffer, T. Naps, and S.H. Edwards, “Algorithm Visualization” Birds-of-a-Feather session, *39th ACM Technical Symposium on Computer Science Education (SIGCSE 2008)*.

June, 2006 – “Modeling the Cell Cycle with JigCell and DARPA’s BioSPICE Software”, presented at *Pathway Databases and Modeling Tools*, Princeton University, <http://www.cs.princeton.edu/picasso/prime/pdmt.php>.

June, 2005 – L. Thomas, E. Thomas, L. Mili, and C.A. Shaffer, “Locating Exterior Defects on Hardwood Logs Using High Resolution Laser Scanning,” presented at the *59th International Forest Products Society Convention*, Quebec City, Canada (presented by L. Thomas).

May, 2005 – “Beyond SBML,” presented at the 3rd Annual Systems Biology Markup Language Hackathon, Tokyo, Japan.

May, 2005 – DARPA BioSPICE PI Meeting, Washington DC.

March, 2005 – C.A. Shaffer, T. Panning, and R. Randhawa, “JigCell,” a presentation and software demonstration at the *3rd Symposium on Computational Cell Biology*, Lenox Massachusetts.

October, 2004 – DARPA BioSPICE PI Meeting, Washington DC.

May, 2003 – DARPA BioSPICE PI Meeting, Ft. Lauderdale, FL.

April 2003 – “The DARPA BioSPICE Project,” Virginia Biotechnology Institute Seminar Series, Blacksburg VA.

February, 2003 – DARPA BioSPICE PI Workshop, College Park, MD.

April, 2003 – “User Interface Paradigms for Describing Pathway Models,” presented at Formal Languages for Biological Processes, Cold Spring Harbor Lab.

November 2002 – DARPA BioSPICE PI Workshop, San Diego, CA.

September 2002 – DARPA BioSPICE Model Definition Workshop, Boston, MA.

August, 2002 – DARPA BioSPICE PI sub-group coordination meeting, Philadelphia, PA.

May, 2002 – DARPA BioSPICE PI Workshop, Washington, DC.

April, 2002 – Session chair and presenter, 22nd Annual Seminar of Cancer Researchers in Virginia, “BioSPICE and Problem-Solving Environments for Systems Biology,” Blacksburg, VA.

November 2001 – DARPA BioSPICE PI Workshop, Monterey, CA.

January, 2001 – Session chair, Integrated Decision-Making for Watershed Management Symposium: Processes and Tools, Chevy Chase, MD.

May, 1998 – Participant, NSF Invitational Workshop on Distributed Information, Computation, and Process Management for Scientific and Engineering Environments, presented position paper “Collaborative Problem Solving Environments.”

September, 1995 – Participant, NSF CISE/EHR Workshop on a Computer Science Research Agenda for Educational Technology.

July, 1991 – Lecture: A real-time robot collision avoidance safety system, University of Iceland, Reykjavik, Iceland.

August, 1990 – Workshop participant: “Data Structures and Access Software for Scientific Visualization” at SIGGRAPH’90, Dallas TX, August 6–7, 1990.

September, 1989 – Invited lecture: Indexing methods for area of interest retrieval from world scale GIS, *International Colloquium on Digital Maps in Geosciences*, Wuerzburg, West Germany, September 1989.

July, 1987 – Course Speaker, SIGGRAPH ’87: *Quadtrees and Octree Methods*

December, 1986 – Invited lecture: A Comparison of Vectors, Rasters, and Quadtrees for Representing Geographic Data, *International Colloquium on the Construction and Display of Geoscientific Maps Derived from Databases*, Dinkelsbuehl, West Germany, December 1986.

October, 1986 – Invited lecture: Hierarchical Rectangle Representations, CNR, Genova, Italy.

July, 1985 – Course Speaker, SIGGRAPH ’85: *Quadtrees, Octrees and Related Hierarchical Data Structures*

March, 1985 – Invited lecture: A Quadtree-based Geographic Information System, IIMAS-UNAM, Mexico City

Research Grants:

2017-2020 C.A. Shaffer, S.H. Edwards, P. Brusilovsky (UPitt), K. Koedinger (CMU) “BCC-EHR: Collaborative Research: Community-building and Infrastructure Design for Data-Intensive Research in Computer Science Education”, National Science Foundation DLR-1740765, \$268,941 (Virginia Tech share).

2016-2018 C.A. Shaffer, “Pete White Professorship”, Virginia Tech, \$52,000.

2016-2019 D.G. Kafura, C.A. Shaffer, E. Tilevich, K.S. Cennamo, and J.V. Ernst, “IUSE: A Scaffolded Data-Centric Approach to Improved Learning of Introductory Computing Concepts”, National Science Foundation DUE-1624320, \$594,314.

2015-2017 C.A. Shaffer, J.V. Ernst, S.Rodger (Duke), T.L. Naps (U. Wisconsin–Oshkosh) “Collaborative Research: Assessing and Expanding the Impact of OpenDSA, an Open Source, Interactive eTextbook for Data Structures and Algorithms”, National Science Foundation DUE-1432008, \$998,402 (\$716,000 Virginia Tech share).

2014-2015 D.G. Kafura, E. Tilevich, and C.A. Shaffer, “TUES: EAGER: Scaffolding Big Data for Authentic Learning of Computing”, National Science Foundation DUE-1444094, \$97,658.

2013-2015 S.H. Edwards and C.A. Shaffer, “Classroom Interventions to Reduce Procrastination”, National Science Foundation DUE-1245334, \$199,986.

2013-2014 S. Puntambekar (U. Wisconsin–Madison), N. Narayanan (Auburn U.), and C.A. Shaffer, “EAGER: SAVI: Dynamic Digital Text: An Innovation in STEM Education”, National Science Foundation IIS-1258471, \$247,933 (\$67,208 VT share).

2012-2014 C.A. Shaffer, T.S. Hall, T.L. Naps (U. Wisconsin–Oshkosh), and R. Baraniuk (Rice U.), “Integrating the eTextbook: Truly Interactive Textbooks for Computer Science Education”, National Science Foundation DUE-1139861, \$200,000 (\$125,000 VT share).

2012-2014 E. Tilevich and C.A. Shaffer, “Transforming Introductory Computer Science Projects via Real-TimeWeb Data”, National Science Foundation DUE-1140318, \$199,987.

2011-2013 D.G. Tatar, S. Harrison, D.G. Kafura, M.A. Perez-Quinonez, and C.A. Shaffer, “Planning Grant: Integrating Computational Thinking into Middle School Curriculum”, National Science Foundation, CNS-1132227, \$199,998.

2010-2014 J.J. Tyson, W. Baumann, J. Peccoud, S. Hoops, Y. Cao, and C.A. Shaffer, “Stochastic Models of Cell Cycle Regulation in Eukaryotes,” National Institutes of Health, 2-R01-GM078989-05, \$1,986,688.

2010-2011 C.A. Shaffer and S.H. Edwards, “The AlgoViz Portal: Lowering the Barriers for Entry into an Online Educational Community” National Science Foundation NSDL program, DUE-0937863, \$149,999.

2009–2010 C.A. Shaffer and S.H. Edwards, “Building a Community and Establishing Best Practices in Algorithm Visualization through the AlgoViz Wiki,” National Science Foundation CCLI program, DUE-0836940, \$149,206.

2009–2010 C.A. Shaffer and S.H. Edwards, “AlgoViz Project Steering Committee” National Science Foundation, DUE-0946644, \$8,500.

2009 C.A. Shaffer, "TCNP Driving Biological Problem: Year 4 Renewal: Using Composition to Integrate a Cell Cycle Model with Morphological Checkpoints," University of Connecticut, \$20,925.

2008–2009 C.A. Shaffer and S.H. Edwards, "Steering Committee Workshop to Build a Community for Algorithm Visualization" National Science Foundation, DUE-0839837, \$8,500.

2008 C.A. Shaffer, "TCNP Driving Biological Problems: Using Composition to Integrate a Cell Cycle Model with Morphological Checkpoints," University of Connecticut, \$17,738.

2006–2010 J.J. Tyson, W.T. Baumann, Y. Cao, M.R. Paul, A. Sandu, C.A. Shaffer, and L.T. Watson, "Stochastic Models of Cell Cycle Regulation in Eukaryotes," National Institute of General Medical Sciences, 1-R01-GM078989-01, \$1,437,504.

2006–2007 C.A. Shaffer, "Refinement and Analysis of Log Surface Defect Detection Methods Using High-Resolution Laser Scanning," Wood Education and Resource Center, USDA Forest Service, \$50,000.

2001–2006 J.J. Tyson, B. Novak, F.R. Cross, M.D. Mendenhall, J.C. Sible, K.C. Chen, C.A. Shaffer, L.T. Watson, and N. Ramakrishnan, "The Eukaryotic Cell Cycle as a Test Case for Modeling Cellular Regulation in a Collaborative PSE," Defense Advanced Research Projects Agency: \$2,442,399.

2001–2003 J.J. Tyson, L.T. Watson, J. Sible, K. Chen, C.A. Shaffer, N. Ramakrishnan, and P. Mendes, "Problem Solving Environment for Modeling the Cell Cycle," National Institute of General Medical Sciences, R01-GM64339-01, \$211,038.

2001–2002 J.J. Tyson, C.A. Shaffer, J.C. Sible, N. Ramakrishnan, L.T. Watson, and D.G. Kafura, "Biocomplexity Incubation Activity: A Collaborative PSE for Computational Modeling of Eukaryotic Cell Cycle Controls," NSF: \$99,965, MCB-0083315.

2001–2005 C.A. Shaffer and R. Ehrich, "Detection of Surface Defects on Barked Hardwood Stems and Logs," USDA Forest Service, \$54,378.

2000–2001 C.A. Shaffer, "Virginia Tech Computer Science Department Support for ADOPTTECH STTR Phase II Proposal," ADOPTTECH Corp: \$53,374.

1999–2002 T.S. Rappaport, C.A. Shaffer, W. Tranter, L.T. Watson, N. Ramakrishnan, and D.G. Kafura, "A Collaborative Problem Solving Environment for Modeling of Broadband Wireless Communications Systems": NSF, \$1,000,000.

1999 D. Bosch, L.T. Watson, N. Ramakrishnan, C.A. Shaffer, R. Dymond, D. Kibler, and D. Orth, "Toward Leadership in Problem Solving Environments for Ecosystem Assessment, Mangement and Policy": APIRES/Virginia Tech, \$48,600.

1997 F.A. Kamke, L.T. Watson, C.J. Ribbens, D.C.S. Allison, M. Abrams, D. Kafura, M.B. Rosson, and C.A. Shaffer, "Towards Leadership in Problem Solving Environments for Science, Engineering, and Manufacturing": ASPIRES/Virginia Tech, \$20,000.

1996–1999 C.A. Shaffer, J.B. Campbell, J.M Carroll, N. Hauenstein, and B. Hertel, "Integrating Statistics and Models across the Social Sciences Curricula": FIPSE, \$277,801, P116A50674.

1996–1998 J.M. Carroll, C.A. Shaffer, M.B. Rosson and J. Burton, "Leveraging Networks for Collaborative Education in the Blacksburg Electronic Village": NSF NIE program, \$1,117,128. RED-9554206

1996 R.D. Kriz, M. Abrams, Y.J. Beliveau, D.R. Bevan, J.M. Carroll, W.A. Curtin, R.W. Ehrich, D. Farkas, D.S. Hix, B.M. Kleiner, C.A. Shaffer, R.C. Williges, "Acquisition of a CAVE(tm)*: Breaking Research and Educational Barriers by Developing and Evaluating 3D Visualization Tools with CAVE* Technology": NSF-ARI Equipment Acquisition Grant, \$890,000.

1995–1996 C.A. Shaffer and N.D. Barnette, “The GeoSim Interface Library for Introductory Programming Courses”: NSF Course and Curriculum Development program, \$19,768.DUE-9455403.

1993–1995 E.A. Fox, J.A.N. Lee, H. Rex Hartson, C.A. Shaffer and N.D. Barnette, “Interactive Learning with a Digital Library in Computer Science”: NSF Educational Infrastructure grant, \$449,088, EIA-9312611.

1992–1995 C.A. Shaffer, L.W. Carstensen, Jr., R.W. Morrill and E.A. Fox, “**GeoSim**: A GIS-Based Simulation Laboratory for Introductory Geography”: NSF, \$107,940, USE-9155943; FIPSE, \$149,571, P116B20130.

1992 A.L. Abbot, C.A. Shaffer and J.W. Roach, “Real-Time Planning and Control for Cooperative Manipulators in the Virginia Tech AI/Robotics Laboratory”: NSF equipment grant, \$36,000.

1990 C.A. Shaffer, NASA/ASEE Summer Faculty Fellowship Program participant at Goddard SFC, Greenbelt MD, \$10,000.

1989 C.A. Shaffer, SIGGRAPH Conference Grant for Educators, estimated value: \$1,000.

1989–1990 C.A. Shaffer, “Hierarchical Data Structures for Robot Collision Avoidance”: NASA Goddard, \$27,500.

1989–1990 C.A. Shaffer, L.W. Carstensen, Jr., J.B. Campbell and E.A. Fox, “A Prototype Geographic Information System for Personal Workstations”: General Dynamics \$43,000; Virginia Center for Innovative Technology \$33,890.

1988–1989 C.A. Shaffer, Matching Grants award from Virginia Tech: \$1000.

1987–1989 C.A. Shaffer, Small Grants Pilot Project award from the College of Arts and Sciences, Virginia Tech: \$2400.

Major research projects:

2011-present: Principle Investigator for the OpenDSA project to develop an open-source active eTextbook for algorithms and data structures courses. See <http://algoviz.org/OpenDSA>.

2006–present: Principle Investigator for the AlgoViz project to develop a community of users and developers of algorithm visualization in computer science education. This includes development of the AlgoViz Portal (<http://algoviz.org>).

2004–2006: Principal Investigator for an investigation of log surface defect detection methods using high-resolution laser scanning.

2001–present: Co-Principal Investigator for the JigCell project, a problem-solving environment for biochemical pathway analysis. With support from DARPA, NSF, and NIH, this is a major multidisciplinary project involving faculty from Biology and Computer Science. My major role is as system architect, primarily for developing user interfaces and visualizations for the system, and overseeing general software development and system integration.

1999–2004: Co-Principal Investigator for the NSF-supported “A Collaborative Problem Solving Environment for Modeling of Broadband Wireless Communications Systems.”

1999–2001: Co-Principal Investigator for Virginia Tech ASPIRES project to develop a Problem Solving Environment for watershed assessment.

1996–1999: Principal Investigator for FIPSE-supported “Integrating Statistics and Models across the Social Sciences Curricula.” This project integrates statistical processing with large databases and tutorials to teach Social Sciences students basic statistics and data visualization.

1996–1998: Co-Principal Investigator for NSF-supported “Leveraging Networks for Collaborative Education in the Blacksburg Electronic Village.” University researchers are working with the local county K12 school system to build a “virtual school” over the internet. Stressing collaborative, interactive courseware and a shared environment, our goal is to allow students from both rural and suburban schools to work together.

1990–1996: Project director for Project GeoSim, a series of software modules that apply geographic information systems and simulation to introductory geography education. This software simulates of various geographic and economic processes, such as migration and population dynamics.

1989–90: Principal Investigator for projects aimed at applying sophisticated GIS techniques to personal workstations. Primary contributions of this project include the elevation pyramid, a method for compressing DEMs by up to 5:1 with little or no loss of accuracy. Supported by General Dynamics Electronics Division and the Virginia Center for Innovative Technology.

1989–1990: Principal Investigator for a real-time robot arm collision avoidance safety system. Supported by NASA/Goddard SFC.

1986–1987: Initial designer for the Combat Information Processor mapping system for Harry Diamond U.S. Army Laboratory.

1986: Designed and implemented the low-level mapping system used on the NBS (now NIST) Autonomous Underwater Vehicle project.

1980–1987: Designer and chief implementor for the **QUILT** project, the first Geographic Information System based on advanced hierarchical data structures.

PhD Students Graduated:

Mohammed F. Farghally, *Visualizing Algorithm Analysis Topics*, November 2016.

Sally Hamouda, *Enhancing Learning of Recursion*, December, 2015.

Eric Fouh, *Building and Evaluating a Learning Environment for Algorithm and Data Structure Courses*, May, 2015.

Monika Akbar, *Integrating Community with Collections in Educational Digital Libraries*, December, 2013.

Ranjit Randhawa, *Composition and Aggregation in Modeling Macromolecular Regulatory Networks*, April, 2008.

Liya Thomas, *Automated Detection of Surface Defects on Barked Hardwood Logs and Stems Using 3-D Laser Scanned Data*, September, 2006.

Nicholas A. Allen, *Computational Software for Building Biochemical Reaction Network Models with Differential Equations*, November, 2005.

James M.A. Begole, *Flexible Collaboration Transparency: Supporting Worker Independence in Repliated Application-Sharing Systems*, December, 1998.

MS Students Graduated:

Mark Lattanzi (1989), Dave B. Boldery (1990), Gregory M. Herb (1990), Matt Zukoski (1990), Sheryl Kriss (1991), Vincent Miranda (1991), Mahesh Ursekar (1991), Timothy Ryan (1992), Patrick R. Brown (1992), Tungsheng Yu (1992), Colin Klipsh (1993), Nirupama Thiruvengadam (1993), James M.A. “Bo” Begole (1994), Jun Yang (1995), David Hines (1996) John Raley (1996), Philip L. Isenhour (1998), Amit Goel (1999), Ali Ashgar Zafer (2001), Purvi Saraiya (2002), Dhananjay Mishra (2004), Matthew L. Cooper (2007), A.J. Alon (2010), U.J. Mobassera (2011), Gayathri Subramanian (2012), Daniel A. Breakiron (2013), Ann M. Paul (2013), Nabanita Maji (2015), Hosam Shahin (2017).

Courses taught:

CS1206 Operating Systems Tools II (freshman CS majors – created new course).

CS1705 Introduction to Programming (freshman CS major first course – including partial revision of course material for semester system; as part of undergraduate curriculum committee, instituted major revision of first year major’s course content).

CS2104 Problem Solving in Computer Science (undergraduate introductory course in problem solving; created and piloted course).

CS3114 (previously, CS2606, CS2604, and CS3301) Data Structures (undergraduate – complete revision of course material for semester system; wrote textbook; most faculty at Virginia Tech teaching this course since 1988 have used my textbook, course notes, and overheads).

CS4104 Data and Algorithm Analysis (undergraduate – developed new course notes).

CS4204 Introductory Computer Graphics (undergraduate – developed new course notes).

CS4944 Advanced UNIX Topics (undergraduate seminar – developed course).

CS5014 Research Methods in Computer Science (graduate – developed new course notes).

CS5034 Models of Computation (graduate – developed course).

CS5114 Theory of Algorithms (graduate – complete revision of course material).

CS5362 Spatial Data Structures and Algorithms (graduate seminar – developed course).

CS6104 Advanced Computer Graphics (graduate seminar – developed course).

CS6604 Advanced Computer Graphics and Computational Geometry (graduate seminar – codeveloped course).

CS6604 Algorithm Visualization (graduate seminar – developed course).

CS6604 Reinventing CS Education through the eTextbook (graduate seminar – developed course).

CS6604 Designing and Implementing Online Education Systems (graduate seminar – developed course).

CS6704 Design Patterns and Component Frameworks (graduate seminar – developed course).

Educational writings:

“Minimalist UNIX” – an introductory guide to UNIX, used in our introductory courses.

“Your Guide to GNU” – an introductory guide to EMACS and GNU software.

“Elements of Programming Style” – departmental programming style guidelines, used in all programming classes.

“Keeping Your Password Safe: A User’s Introduction to Computer Security” – departmental security guidelines used in all introductory classes, including lecture notes for one hour lecture one basic computer security issues.

Professional service:

2017: Member, Associate Program Chair Committee for ITiCSE 2017.

March, 2016: Member, external departmental review panel, Computer Science Department, University at Albany, SUNY.

2014-present: Specialty Chief Editor for Digital Education, *Frontiers in ICT*.

2008-present: Associate editor, *Simulation: Transactions of the Society for Modeling and Simulation International*.

2012-present: Member of the Editorial Board, *Computational Biology Journal*.

2005–present: Member, Editorial Review Board, AACE Journal of Interactive Learning Research (JILR).

2006–present: Member, Editorial Review Board, AACE Journal of Computers in Mathematics and Science Teaching (JCMST).

2005-present: Member, Virginia State University’s Computer Science Advisory Board.

2015: Member, SPLASH-E 2015 Program Committee

2015: Member of International Program Committee, 5th International Conference on Simulation and Modeling Methodologies, Technologies and Applications - SIMULTECH 2015

March 2009: Vice General Chair, 2009 Spring Simulation Multiconference (SpringSim’09), San Diego, CA.

April 2008: Program Chair, 2008 High Performance Computing & Simulation Symposium (HPCS), Ottawa, Canada.

March 2007: Program Co-chair for the 2007 Symposium on High Performance Computing (HPC 2007), Norfolk VA.

2010, 2009, 2007, 2005, 2004, 1997, 1994, 1993: Member, NSF program review panels.

2002, 2001, 1999, 1998, 1994: Reviewer, FIPSE Comprehensive Program.

1996, 1997: Judge for ThinkQuest student WWW site competition.

1991–1995: Coordinator, ACM SIGGRAPH Computer Graphics Thesis Abstracts Project.

1992: Member, Department of Energy panel for reviewing DOE National Labs projects in Robotics for nuclear waste cleanup.

1989: Scientist partner for the Bell Atlantic-AAAS Institute for Middle School Science and Technology Teachers

Referee/Reviewer (within past 5 years): *ACM SIGCSE 2011, 2012, 2013, 2014, 2015, 2016, 2017, ACM ITiCSE 2015, 2016, 2017, SIMULTECH 2017, IEEE Transactions on Industrial Informatics, Learning and Individual Differences: Journal of Psychology and Education, 4th International Joint Conference on Computational Sciences and Optimization (CSO 2011), Winter Simulation Conference 2010, AACE Journal of Computers in Mathematics and Science Teaching (JCMST), AACE Journal of Interactive Learning Research (JILR), ACM Transactions on Visualization and Computer Graphics, ACM Transactions on Computing Education, Bioinformatics BMC Bioinformatics, Routledge Publishing, Journal of Computational Chemistry, IEEE Transactions on Learning Technologies, Journal of Theoretical Biology, IET Systems Biology, ASEE Computers in Education Journal Acta Cybernetica International Journal of STEM Education*

Professional Societies: Distinguished Educator of ACM. Senior Member of IEEE, IEEE Computer Society. Member of ACM SIGCSE. Member of ASEE.

University and departmental service

2017 to present – Associate Department Head for Graduate Studies
2016 to 2017 – Chair, Department of Computer Science Graduate Admissions Committee
2016 to 2017 – Chair, Department of Computer Science Collegiate Faculty Search Committee
2015 – Chair, Department of Computer Science Faculty Search Committee
2014 – Member, Department of Computer Science Faculty Search Committee
2013 to 2014 – Member, Department of Computer Science Personnel Committee
2010 to 2012 – Chair, Department of Computer Science Personnel Committee
2008 to 2010 – Member, Department of Computer Science Personnel Committee
2007 to 2010 – Member, University Commission on Graduate Studies and Policies (Vice Chair, 2007-2008)
2008 to 2009 – Member, Degree Requirements, Standards, Criteria and Academic Policies Committee (DRSCAP)
2007 to 2008 – Chair, University Graduate Curriculum Committee
2005 to 2007 – Member, University Faculty Leadership Development Academy Committee
2003 to 2006 – Representative, College of Engineering Executive Committee
1998 to 2006 – Chair, Department of Computer Science Graduate Program Committee
2004 to 2006 – Member, College of Engineering Graduate Curriculum Committee
1990 to 1992; 2006 to 2009 – Member, Department of Computer Science Undergraduate Program Committee
1997 to 2000 – University Faculty Senate (Secretary/Treasurer 1998 to 1999)
1997 to 2000 – University Transportation and Parking Committee (Chair 1997–1998)
1996 to 1998 – Member of four Departmental Faculty Search Committees
1997 to 1998 – Member, Department of Computer Science Graduate Admissions Committee
1996 Member, Departmental M.S. Orals Defense Committee

1995 to 1996 – Chair, Departmental M.S. Orals Defense Committee

1992 to 1995; 1997 to 1998 – Member, Department of Computer Science Graduate Program Committee

1992 to 1993 – Chair, Departmental Ph.D. Qualifier Committee

1992 – Chair, Computer Science Department Security Taskforce

1989 to 1990 – Member, Departmental Undergraduate PC Taskforce

1988 to 1990 – Cosponsor of graduate student seminar in computer graphics and computational geometry.

1987 to 1990 – Member, Departmental Computer Resources Committee

1987 – Member, Departmental Undergraduate PC Selection Committee

Current research interests:

Computational Biology and Bioinformatics, Problem Solving Environments, Digital Education, Algorithm Visualization, Visualization, Hierarchical Data Structures, Geographic Information Systems, Computer Graphics, Algorithm Design and Analysis, Data Structures.