Vadim Shapiro

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Formal Education

1991	Ph.D.	Mechanical Engineering	Cornell University
1989	M.S.	Mechanical Engineering	Cornell University
1983	M.S.	Computer Science	University of California, Los Angeles
1981	B.A.	Mathematics	New York University
1981	B.A.	Computer Science	New York University

Positions Held

2007 - present	*Bernard A. & Frances M. Weideman Professor of Mechanical Engineering* *Professor of Computer Sciences,* University of Wisconsin-Madison
2004 - present	*Founder and CTO* Intact Solutions, LLC, Madison, WI
2003 - 2007	*Professor* Mechanical Engineering & Computer Sciences, University of Wisconsin-Madison
2000 - 2003	*Associate Professor* Mechanical Engineering & Computer Sciences, University of Wisconsin-Madison
1994 - 2000	*Assistant Professor* Mechanical Engineering & Computer Sciences, University of Wisconsin-Madison
1992-1994	*Staff Research Engineer* Analytic Process Department, General Motors R&D Center, Warren, MI
1991-1992	*Research Associate* Computer Science Department, Cornell University, Ithaca, NY
1986-1990	*General Motors Fellow* Sibley School of Mechanical Engineering, Cornell University, Ithaca, NY
1983-1986	*Research Scientist, Senior Research Scientist* Computer Science Department, General Motors Research, Warren, MI

Visiting Positions

2007 - 2009	*Visiting Professor* University of California, Berkeley
2000 - 2001	*Visiting Professor* Dipartamento di Informatica e Automazione, Universita Roma Tre, Italy
2001 (summer)	*Senior Visitor* Applied Mathematics and Theoretical Physics, University of Cambridge, UK
1998 (summer)	*EPSRC Visiting Fellow* Applied Mathematics and Theoretical Physics, University of Cambridge, UK
1993 (winter)	*Invited Lecturer* Institute for Pure and Applied Mathematics (IMPA), Rio de Janeiro, Brazil

Recognitions and Awards

- Bernard A. & Frances M. Wiedeman Endowed Chair, 2007
- Fellow of ASME, 2007
- The Most Cited Paper Award, 2007, Computer Aided Geometric Design journal
- Best Paper Award, 32th ASME Design Automation Conference, Conference, September 2006 (out of 119 accepted papers).
- Best Paper Award, 15th International Conference on Design Theory and Methodology (ASME Design Engineering Conferences), September 2003 (out of 56 accepted papers).
- Best Paper Award, Fifth ACM Symposium on Solid Modeling and Applications, June 1999
- National Science Foundation CAREER Award 1995-99
- General Motors Fellow 1986-90
- Fellow of UCLA School of Engineering and Applied Science 1981-82
- Phi Beta Kappa 1981
- Pi Mu Epsilon 1981, Honorary Mathematical Fraternity
- New York University Founders Day Award 1981

Patents

1. V. Shapiro, I. Tsukanov, "Meshfree Method and System for Modeling and Analysis," *United States Patent 6,718,291,* April 6, 2004.
2. V. Shapiro, H. T. Ilies, "Methods and Apparata for Shaping Moving Geometric Shapes," *United States Patent 6,044,306,* March 28, 2000.
3. D. L. Vossler, V. Shapiro, "System and methods for converting boundary representations to Constructive Solid Geometry representations for three-dimensional solid object modeling," *United States Patent 5,537,519*, July 16, 1996.

Service

Editorial Responsibilities

- *Graphical Models,* Associate Editor, 2010 – present.
- *ASME/ACM Journal Of Computing and Information Science in Engineering* (JCISE), Associate Editor, 2003 – present.
- *International Journal of Computational Geometry and Applications* (IJCGA), Associate Editor, 2004 – present.
- *Computer-Aided Design*, Editor, 2004 – present
- *International Journal of Shape Modeling,* Member of Editorial Board, 2001 – present.
- *Computer-Aided Design*, guest editor, 1999, 2003, 2004.

Other Professional Activities

- Organizer, Minisymposium on Topologically Robust Computations, 2009 SIAM/ACM Joint Conference on Geometric and Physical Modeling, San Francisco, CA, October 2009.
- ACM SIGGRAPH Symposium on Solid & Physical Modeling; program committee 1997, 1999, 2001, 2004, 2006, 2007, 2009, 2010; General Co-Chair in 2002 (Saarbrucken, Germany), Program Co-Chair in 2003 (Seattle, WA) and 2005 (MIT, Cambridge, MA).
- Invited member of EPSRC Peer Review College, UK, 2006 – present.
- Organizer, Workshop on Shape and Topology Optimization: From Theory to Practice, 2006 ASME Design Technical Conferences, Philadelphia, PA, September 10, 2006.
- Invited reviewer for Italian Ministry for Education University and Research (MIUR), 2003 – present.
- Solid Modeling Association, (founding) member of the Executive Committee, 2001–2005; also responsible for maintaining community website www.solidmodeling.org
- ECCOMAS Thematic Conference on Meshless Methods, Lisbon, July 11-14, 2005; scientific committee.
- SIAM Conference on Geometric Design, Seattle, WA, November 2003. Organizer of Minisymposium on *Engineering Challenges in Geometric Modeling.*
- Shape Modeling International; program committee 1997, 1999, 2001, 2002, 2004.
- Geometric Modeling and Processing; program committee 2000, 2002, 2004.
- Tools and Methods of Competitive Engineering; program committee 1998, 2000, 2002, 2004
- IFIP WG5.2 Workshop on Geometric Modeling: Fundamentals and Applications; program committee 2000, 2002.

- 12th Conference on Design Tools and Methods in Industrial Engineering, Rimini, Italy, September 5-7,2001; program committee.
- SIAM conference on Geometric Design, Nov. 2-5 1999, Albuquerque, NM
  Organizer of Minisymposium "Advances in solid modeling."
- Constructive Solid Geometry; program committee 1996, 1998, Winchester, U.K.
- Thirteenth Annual ACM Symposium on Computational Geometry, June 4–6, 1997, Nice, France; program committee
- Second SIAM Conference on Geometric Design, Tempe, AZ (November 1991)
  Organized Minisymposium "Advances in Constructive Representations."
- Member of ASME, ACM, SIAM

External examiner for international candidates:

- Franco Millichio, PhD 2007, University of Rome, 2007
- Tang Shaohui, Ph.D. 2007, Nanyang Technological University, Singapore,
- Juan Ruiz de Miras, Ph.D. 2001, University of Granada, Spain
- Richard Egli, Ph.D. 2000, University of Montreal, Canada
- Antonio Aguilera, Ph.D. 1998, Universitat Politecnica de Catalunya, Barcelona, Spain

UW-Madison Activities

- UW-Madison campus committees
  - Conflict of Interests Committee, 2002 – 2005
  - Hilldale Research Fellowship Committee, 2002–2004
  - Mathematics and Computation in Engineering Executive Committee 1995–2000
  - Wendt Library Committee, 1995 – 1999
- ME Department Committees:
  - Faculty Search & Hiring, 1998 – 2006 (Chair, 2003-2005)
  - Merit Review Committee, 2001 – 2003
  - Curriculum Committee, 2005 – present
  - Junior Faculty Mentoring Committees, 2001 – present

Research Publications

Archival Journal Publications

1. A. DiCarlo, F. Milicchio, A. Paoluzzi, and V. Shapiro "Chain-Based Representations for Solid and Physical Modeling," *IEEE Transactions on Automation Science and Engineering,* Vol 6 (2009), Issue 3, pages 454–467.

2. J. Chen, M. Freytag, V. Shapiro, "Shape Sensitivity of Constructive Representations", *Computer Aided Geometric Design,* Vol 25, Issue 7, pages 470–488, October 2008.

3. F. Milicchio, A. DiCarlo, A. Paoluzzi, V. Shapiro, "A Codimension-Zero Approach to Discretizing and Solving Field Problems," *Advanced Engineering Informatics,* Vol 22 (2008), pages 172–185.

4. A. Biswas, J. Fenves, V. Shapiro and R. Sriram, "Representation of Heterogeneous Material Properties in Core Product Model," *Engineering with Computers,* Vol. 24 (2008), pages 43–58.

5. V. Shapiro, "Semi-Analytic Geometry with R-functions," *ACTA Numerica,* Volume 16, May 2007, pages 239 – 303 (invited paper).

6. I. Tsukanov, V. Shapiro, "Adaptive multiresolution refinement with distance fields," *International Journal of Numerical Methods in Engineering,* Vol. 72 (2007), No. 11, pages 1355–1386.

7. J. Chen, V. Shapiro, K. Suresh, and I. Tsukanov, "Shape Optimization with Topological Changes and Parametric Control," *International Journal of Numerical Methods in Engineering,* Volume 71 (2007), No. 3, pages 313-346.

8. J. Qi, V. Shapiro and N. F. Stewart, "Single-set and class-of-sets semantics for geometric models," *Computer Aided Design,* Volume 38 (2006), pages 1088-1098.

9. J.Qi, V. Shapiro, "Topological Model of Tolerant Solid Modeling," *Computer Aided Design,* Vol.38, No. 4, April 2006.

10. J.Qi, V. Shapiro, "Geometric Interoperability with ϵ-solidity," *Transactions of ASME, Journal of Computing and Information Science in Engineering,* Vol. 6, No. 3, September 2006.

11. M. Freytag, V. Shapiro, and I. Tsukanov, "Field Modeling with Sampled Distances," *Computer Aided Design,* Volume 38, Issue 2, February 2006, Pages 87-100.

12. I. Tsukanov, V. Shapiro, "Meshfree Modeling and Analysis of Physical Fields in Heterogeneous Media," *Journal of Advances in Computational Mathematics,* Volume 23 (2005), Number 1-2, pp. 95-124, 2005.

13. H. Ilies, V. Shapiro, "Equivalence Classes for Shape Synthesis of Moving Mechanical Parts," *Transactions of ASME, Journal of Computing and Information Science in Engineering,* Vol. 4, No. 3, March 2004, pp 20-27.

14. A. Biswas, V. Shapiro and I. Tsukanov, "Heterogeneous Material Modeling with Distance Fields," *Computer-Aided Geometric Design,* Volume 21 (2004), Number 3, pp. 215–242.

15. V. Ramaswamy, V. Shapiro, "Combinatorial Laws for Physically Meaningful Design," *Transactions of ASME, Journal of Computing and Information Science in Engineering,* Vol. 4, No. 3, March 2004, pp 3-10. (Preliminary version won the best paper award at the ASME 15th International Conference on Design Theory and Methodology, September 2-6, 2003 Chicago, Illinois.)

16. A. Biswas, V. Shapiro, "Approximate Distance Fields with Non-Vanishing Gradients," *Graphical Models,* Vol. 66, Issue 3, May 2004, pp 133-159.

17. I. Tsukanov, V. Shapiro, S. Zhang, "A Meshfree Method for Incompressible Fluid Dynamics Problems," *International Journal of Numerical Methods in Engineering,* Vol. 58, No. 1, 2003, pp. 127-158.

18. S. Raghothama, V. Shapiro, "Topological Framework for Part Families," *Transactions of ASME, Journal of Computing and Information Science in Engineering,* Volume 2 (2002), No. 4, pp. 246–255.

19. I. Tsukanov and V. Shapiro, "The Architecture of SAGE – A Meshfree System Based on RFM," *Engineering with Computers,* Volume 18 (2002), No. 4, pp. 295–311.

20. H. Ilies and V. Shapiro, "A Class of Forms From Function: The Case of Parts Moving in Contact," *Research in Engineering Design,* Volume 13 (2002), No. 3, pp. 157–166.

21. E. O. Mihal, V.L. Rvachev, T.I. Sheyko, I.G. Tsukanov, V. Shapiro, "Physical Fields with geometric singularities," *Radioelectronics and informatics,* No. 3, 2002, pp. 19–25 (in Russian).

22. V. Shapiro, "A Convex Deficiency Tree Algorithm for Curved Polygons," *Internal Journal of Computational Geometry and Applications*, Vol. 11, No. 2, 2001, pp. 215–238.

23. V. Rvachev, T. Sheiko, V. Shapiro, I. Tsukanov, "Transfinite Interpolation over Implicitly Defined Sets" *Computer-Aided Geometric Design,* Vol. 18, No. 4, 2001, pp. 195–220.

24. H. Ilies and V. Shapiro, "On Shaping with Motion," *ASME Transactions, Journal of Mechanical Design,* vol. 122, no. 4, December 2000, pp. 567–574.

25. J. A. Chard and V. Shapiro, "A Multivector Data Structure for Differential Forms and Equations," *IMACS Transactions, Mathematics and Computers in Simulation,* 54 (2000), pp. 33–64.

26. S. Raghothama, V. Shapiro, "Consistent Updates in Dual Representation Systems," *Computer-Aided Design,* Vol. 32, 2000, pages 463–477. (This paper was also presented and won the Best Paper Award at the *Fifth ACM Symposium on Solid Modeling and Applications,* Ann Arbor, MI, June 1999.)

27. V. Shapiro, I. Tsukanov, "Meshfree Simulation of Deforming Domains," *Computer Aided Design,* Vol. 31, No. 7, 1999, pages 459–471.

28. V. Rvachev, T. Sheiko, V. Shapiro, I. Tsukanov, "On Completeness of RFM Solution Structures," *Computational Mechanics* Vol. 25, 2000, pages 305–316. (Special issue on Meshfree Methods).

29. H. Ilies, V. Shapiro, "The Dual of Sweep," *Computer Aided Design,* Vol. 31, No. 3, March 1999, pages 185–201.

30. V. Rvachev, T. Sheiko, V. Shapiro, "Application of the Method of R-functions to Integration of DIfferential Equations with Partial Derivatives," *Cybernetics and Systems Analysis,* Vol. 25, No. 1, 1999.

31. S. Raghothama, V. Shapiro, "Boundary Representation Deformation in Parametric Solid Modeling," *ACM Transactions on Computer Graphics*, Vol. 17, No. 4 (Oct. 1998), Pages 259–286.

32. V. L. Rvachev, T. I. Sheiko, V. Shapiro, "Generalized Interpolation Formulae of Lagarange-Hermite on arbitrary loci," Journal of Mechanical Engineering, National Academy of Science of Ukraine, Vol. 1, No. 3-4, 1998, page 150–166. In Russian.

33. V. L. Rvachev, T. I. Sheiko, V. Shapiro, "R-functions Method in Boundary Value Problems with Geometrical and Physical Symmetry," *Mathematical Methods and Physicomechanical Fields,* Vol. 41, No. 1, 1998. In Russian.

34. V. Shapiro, "Well-formed set representations of solids," *International Journal on Computational Geometry and Applications,* Vol. 9, No. 2 (1999), pages 125 – 150.

35. V. Rvachev, T. Sheiko, V. Shapiro, J. Uicker, "Implicit Function Modeling of Solidification in Metal Casting," *ASME Transactions, Journal of Mechanical Design*, Volume 119, Number 4, December 1997, pp. 466–473.

36. V. Shapiro, "Maintenance of geometric representations through space decompositions," *International Journal on Computational Geometry and Applications,* Vol. 7, No. 4(1997), pp. 383–418.

37. V. V. Veretelnik, V. L. Rvachev, A. N. Shevchenko, T. I. Sheiko, J. J. Uicker, V. Shapiro, "Modeling of metal solidification in complex geometric shapes," *Electro-Magnetic Waves,* No. 8, August 1996. In Russian.

38. V. Shapiro, "Real functions for representation of rigid solids," *Computer-Aided Geometric Design,* Vol. 11, No. 2, 1994.

39. R. S. Palmer, V, Shapiro, "Chain models of physical behavior for engineering analysis and design," *Research in Engineering Design,* Vol.5, No. 3, 1994, invited paper for the special issue *Advances in Representations and Reasoning for Mechanical CAD*.

40. T. Peters, D. Rosen, V. Shapiro, "A topological model of limitations in design for manufacturing," *Research in Engineering Design,* Vol. 6, No. 4, 1994.

41. V. Shapiro, D. L. Vossler, "Separation for boundary to CSG conversion," *ACM Transactions on Graphics,* January 1993.

42. V. Shapiro, D. L. Vossler, "Efficient CSG representations of two-dimensional solids," *Transactions of ASME, Journal of Mechanical Design,* Vol. 113, No. 3, September 1991, pp. 292–305.

43. V. Shapiro, D. L. Vossler, "Construction and optimization of CSG representations," special issue of *Computer-Aided Design "Beyond Solid Modelling",* Vol. 23, No. 1, pp. 4–20, January/February 1991.

44. V. Shapiro, H. Voelcker, "On the role of geometry in mechanical design," *Research in Engineering Design,* Vol.1, No. 1, pp. 69–73, 1989.

45. A. Morgan, V. Shapiro, "Box-bisection for solving second-degree systems and the problem of clustering," *ACM Transactions on Mathematical Software,* Vol.13 (1987), No.2, pp. 152–167.

Chapters and volumes

46. Jiaqin Chen, Vadim Shapiro, "Optimization of Continuous Heterogeneous Models," *Heterogeneous Object Modelling and Applications, Lecture Notes in Computer Science,* Volume 4889, pages 193–213, Springer Berlin, 2008.

47. L. Kobbelt, V. Shapiro, editors, Proceedings of *2005 ACM Symposium on Solid and Physical Modeling,* MIT, Cambridge, MA, June 2005.

48. G. Elber, V. Shapiro, guest editors, *Solid Modeling and Applications,* special issue of *Computer-Aided Design,* Volume 36, Issue 11, September 2004.

49. G. Elber, V. Shapiro, guest editors, *Solid Modeling and Applications,* special issue of *Journal of Computing and Information Science in Engineering,* Vol. 3, No. 4, December 2003.

50. G. Elber, V. Shapiro, editors, Proceedings of *Eighth ACM Symposium on Solid Modeling and Applications,* Seattle, WA, June, 2003.

51. A. Pasko, V. Shapiro, guest editors *Heterogeneous object models and their applications,* special issue of *Computer-Aided Design,* 2004.

52. V. Shapiro, "Solid Modeling," *Handbook of Computer Aided Geometric Design,* (G. Farin, J. Hoschek, M.-S. Kim, eds.), pp. 473 – 518, Elsevier Science Publishers, 2002.

53. G. Jared, V. Shapiro, *Geometric Languages and Interfaces,* special issue of *Computer Aided Design,* Volume 31, 1999.

54. Jonas Gomes, Christopher Hoffmann, Vadim Shapiro, and Luiz Velho, *Modeling in Computer Graphics,* SIGGRAPH'93 Course Notes #40, SIGGRAPH-ACM publication, 1993.

55. R.B. Tilove, M.S. Pickett, V. Shapiro, "RoboTeach: an off-line robot programming system based on GMSolid," *Solid Modeling by Computers: From Theory to Applications,* (Mary S. Pickett and John W. Boyse Editors), pp. 159-180, Plenum Press, 1984.

Refereed conference proceedings and books

56. S. Nelaturi, V. Shapiro, "Configuration Products in Geometric Modeling," *ACM Symposium on Solid and Physical Modeling,* San Francisco, CA, October 2009.

57. A.DiCarlo, F. Milicchio, A. Paoluzzi, V. Shapiro, "Discrete Physics using Metrized Chains," *ACM Symposium on Solid and Physical Modeling,* San Francisco, CA, October 2009.

58. B. Luft, V. Shapiro, I. Tsukanov, "Geometrically Adaptive Numerical Integration," *ACM Symposium on Solid and Physical Modeling,* Stony Brook, NY, June 2008.

59. S. Nelaturi, A. Abhyankar, V. Shapiro, and R. Tilove, "Feasible Spaces in Weld Gun Selection," *IEEE Conference on Automation Science and Engineering,* Washington, DC, 2008.

60. M. Freytag, V. Shapiro, I. Tsukanov, "Acquiring the physics of artifacts," paper DETC2007-35701, in *Proceedings of the ASME 2007 Computers and Information in Engineering Conference IDETC/CIE 2007,* September 4-7, 2007, Las Vegas, USA.

61. J. Chen, M. Freytag, V. Shapiro, "Shape Sensitivity of Constructive Representations", *Proceedings of 2007 ACM Symposium on Solid and Physical Modeling,* June 4–6, 2007, Beijing, China.

62. A. Di Carlo, F. Milicchio, A. Paoluzzi and V. Shapiro, "Solid and Physical Modeling with Chain Complexes," *Proceedings of 2007 ACM Symposium on Solid and Physical Modeling, June 4–6, 2007, Beijing, China.*

63. V. Shapiro, "Homotopy conditions for tolerant geometric queries," *Reliable Implementation of Real Number Algorithms: Theory and Practice,* Dagstuhl Seminar, January 2006, *Lecture Notes in Computer Science, Volume 5045,* pages 162–180, Springer Berlin, 2008.

64. J. Chen, V. Shapiro, K. Suresh, and I. Tsukanov, "Shape Optimization with Topological Changes and Parametric Control," *ASME paper DETC2006-99612, Proceedings of the ASME 2006 International Design Engineering Technical Conferences,* September 10-13, 2006, Philadelphia, PA. **Best Paper Award**.

65. J. Qi and V. Shapiro, "Epsilon-Regular Sets and Intervals," *Proceedings of IEEE International Conference on Shape Modeling and Applications,* 15-17 June 2005, MIT, Cambridge, MA.

66. M. Freytag and V. Shapiro, "B-rep SE: Simplicially Enhanced Boundary Representation," *Proceedings of the Ninth ACM Symposium on Solid Modeling and Applications,* Genova, Italy, June 2004, pp 157-168.

67. V. Ramaswamy, V. Shapiro, "Combinatorial Laws for Physically Meaningful Design," ASME paper DETC2003/DTM-48654, *Proceedings of 15th International Conference on Design Theory and Methodology,* September 2-6, 2003 Chicago, Illinois. **Best Paper Award**.

68. H. Ilies, V. Shapiro, "On the Synthesis of Functionally Equivalent Mechanical Designs" *Workshop on Computational Synthesis, 2003 AAAI Spring Symposium series,* March 24-26, 2003, Stanford University, Palo Alto, California.

69. S. Raghothama, V. Shapiro, "Topological Framework for Part Families," *Proceedings of the 7th ACM Symposium on Solid Modeling and Applications,* Saarbrucken, Germany, June 17–21, 2002.

70. A. Biswas, V. Shapiro and I. Tsukanov, Heterogeneous Material Modeling with Distance Fields, *13th Solid Freeform Fabrication Symposium,* Austin, TX, August 5-7, 2002.

71. H. Ilies and V. Shapiro, "A Class of Forms From Function: The Case of Parts Moving in Contact," *Research in Engineering Design,* Vol. 13, No. 3, 2002, pp. 157-166 (a preliminary version appeared as Technical Paper DETC2001/DTM-21704, *Proceedings of 2001 ASME Conference on Design Theory and Methodology,* Pittsburgh, PA, USA, September 912, 2001.

72. I. Tsukanov, V. Shapiro, C. Rutland, S. Zhang, "Solution of the incompressible fluid dynamics problem via the R-function meshfree method," *First M.I.T. Conference on Computational Fluid and Solid Mechanics,* June 12 - 15, 2001 Cambridge, MA.

73. S. Raghothama, V. Shapiro, "Models and Representations for Part Families," *From Geometric Modeling to Shape Modeling* (U. Cugini and M. Wozny, Editors), Kluwer Academic, 2002; proceedings of the *IFIP WG5.2 Workshop on Geometric Modeling,* Parma, Italy, October 2000.

74. V. Shapiro, I. Tsukanov, "Meshfree Automation of Engineering Analysis," *From Geometric Modeling to Shape Modeling* (U. Cugini and M. Wozny, Editors), Kluwer Academic, 2002; proceedings of the *IFIP WG5.2 Workshop on Geometric Modeling,* Parma, Italy, October 2000.

75. S. Raghothama, V. Shapiro, "Consistent Updates in Dual Representation Systems," *Proceedings of the Fifth ACM Symposium on Solid Modeling and Applications,* Ann Arbor, MI, June 1999. **The Best Paper Award.** Also invited paper for the special issue of *Computer-Aided Design.*

76. V. Shapiro, I. Tsukanov "Implicit Functions with Guaranteed Differential Properties," *Proceedings of the Fifth ACM Symposium on Solid Modeling and Applications,* Ann Arbor, MI, June 1999.

77. S. Raghothama, V. Shapiro, "Necessary Conditions for Boundary Representation Variance," *Proceedings of the Thirteenth ACM Symposium on Computational Geometry,* June 4–6, 1997, Nice, France.

78. H. Ilies, V. Shapiro, "`UNSWEEP`: Formulation and Computational Properties," *Proceedings of the Fourth ACM Symposium on Solid Modeling and Applications,* Atlanta, GA, May 1997.

79. H. Ilies, V. Shapiro, "An Approach to Systematic Part Design," *Product Modeling for Computer Integrated Design and Manufacture,* , edited by M. J. Pratt, R. D. Sriram, M.J. Wozny, Chapman and Hall, 1997. (Proceedings of the Fifth IFIP WG 5.2 Workshop on Geometric Modeling in Computer Aided Design, Airlie, Virginia, May 19–23, 1996.)

80. V. Shapiro, D. L. Vossler, "What is a parametric family of solids?" *Proceedings of the Third ACM/IEEE Symposium on Solid Modeling and Applications,* Salt Lake City, Utah, May 17-19, 1995.

81. R. B. Tilove, V. Shapiro, M. S. Pickett, "Modeling and analysis of robot work cells in RoboTeach," *Proceedings of Symposium on Computer-Aided Manufacturing and Robotics,* ASME Winter Annual Meeting, pp. 33-52, New Orleans, Louisiana, December 9-14, 1984.