
Bibliography

- AKELEY, K. AND T. JERMOLUK (1988). "High-Performance Polygon Rendering", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 239-246.
- AKELEY, K. (1993). "RealityEngine Graphics", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 109-116.
- AMANATIDES, J. (1984). "Ray Tracing with Cones", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 129-135.
- AMBURN, P., E. GRANT AND T. WHITTED (1986). "Managing Geometric Complexity with Enhanced Procedural Models", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 189-196.
- ANJYO, K., Y. USAMI AND T. KURIHARA (1992). "A Simple Method for Extracting the Natural Beauty of Hair", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 111-120.
- APPLE COMPUTER, INC. (1985). *Inside Macintosh*, Volume 1, Addison-Wesley, Reading, MA.
- APPLE COMPUTER, INC. (1987). *Human Interface Guidelines: The Apple Desktop Interface*, Addison-Wesley, Reading, MA.
- ARVO, J. AND D. KIRK (1987). "Fast Ray Tracing by Ray Classification", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 55-64.
- ARVO, J. AND D. KIRK (1990). "Particle Transport and Image Synthesis", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 63-66.
- ARVO, J., ED. (1991). *Graphics Gems II*, Academic Press, Inc., San Diego, CA.
- ATHERTON, P R. (1983). "A Scan-Line Hidden Surface Removal Procedure for Constructive Solid Geometry", in proceedings of SIGGRAPH '83, *Computer Graphics*, 17(3), pp. 73-82.
- BARAFF, D. (1989). "Analytical Methods for Dynamic Simulation of Non-Penetrating Rigid Bodies", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 223-232.
- BARAFF, D. AND A. WITKIN (1992). "Dynamic Simulation of Non-Penetrating Flexible Bodies", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 303-308.
- BARKANS, A. C. (1990). "High-Speed, High-Quality, Antialiased Vector Generation", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 319-326.
- BARNESLEY, M. F., A. JACQUIN, F. MALASSENT, ET AL. (1988). "Harnessing Chaos for Image Synthesis", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 131-140.
- BARNESLEY, M. (1993). *Fractals Everywhere*, Second Edition, Academic Press, Inc., San Diego, CA.
- BARR, A. H. (1981). "Superquadrics and Angle-Preserving Transformations", *IEEE Computer Graphics and Applications*, 1(1), pp. 11-23.
- BARR, A. H. (1986). "Ray Tracing Deformed Surfaces", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 287-296.
- BARSKY, B. A. AND J. C. BEATTY (1983). "Local Control of Bias and Tension in Beta-Splines", *ACM Transactions on Graphics*, 2(2), pp. 109-134.
- BARSKY, B. A. (1984). "A Description and Evaluation of Various 3-D Models", *IEEE Computer Graphics and Applications*, 4(1), pp. 38-52.
- BARZEL, R. AND A. H. BARR (1988). "A Modeling System Based on Dynamic Constraints", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 179-188.
- BARZEL, R. (1992). *Physically-Based Modeling for Computer Graphics*, Academic Press, Inc., San Diego, CA.
- BAUM, D. R., S. MANN, K. P. SMITH, ET AL. (1991). "Making Radiosity Usable: Automatic Preprocessing and Meshing Techniques for the Generation of Accurate Radiosity Solutions", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 51-61.
- BECKER, S. C., W. A. BARRETT, AND D. R. OLSEN JR. (1991). "Interactive Measurement of Three-Dimensional Objects Using a Depth Buffer and Linear Probe", *ACM Transactions on Graphics*, 10(2), pp. 201-207.
- BECKER, B. G. AND N. L. MAX (1993). "Smooth Transitions between Bump-Rendering Algorithms", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 183-190.
- BEIER, T. AND S. NEELY (1992). "Feature-Based Image Metamorphosis", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 35-42.

- BERGMAN, L., H. FUCHS, E. GRANT, ET AL. (1986). "Image Rendering by Adaptive Refinement", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 29-38.
- BERGMAN, L. D., J. S. RICHARDSON, D. C. RICHARDSON, ET AL. (1993). "VIEW—an Exploratory Molecular Visualization System with User-Definable Interaction Sequences", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 117-126.
- BEZIER, P. (1972). *Numerical Control: Mathematics and Applications*, translated by A. R. Forrest and A. F. Parkhurst, John Wiley & Sons, London.
- BIER, E. A., S. A. MACKAY, D. A. STEWART, ET AL. (1986). "Snap-Dragging", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 241-248.
- BIER, E. A., M. C. STONE, K. PIER, ET AL. (1993). "Toolglass and Magic Lenses: The See-Through Interface", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 73-80.
- BISHOP, G. AND D. M. WIEMER (1986). "Fast Phong Shading", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 103-106.
- BLAKE, J. W. (1993). *PHIGS and PHIGS Plus*, Academic Press, London.
- BLESER, T. (1988). "TAE Plus Styleguide User Interface Description", NASA Goddard Space Flight Center, Greenbelt, MD.
- BLINN, J. F. AND M. E. NEWELL (1976). "Texture and Reflection in Computer-Generated Images", *CACM*, 19(10), pp. 542-547.
- BLINN, J. F. (1977). "Models of Light Reflection for Computer-Synthesized Pictures", *Computer Graphics*, 11(2), pp. 192-198.
- BLINN, J. F. AND M. E. NEWELL (1978). "Clipping Using Homogeneous Coordinates", *Computer Graphics*, 12(3), pp. 245-251.
- BLINN, J. F. (1978). "Simulation of Wrinkled Surfaces", *Computer Graphics*, 12(3), pp. 286-292.
- BLINN, J. F. (1982). "A Generalization of Algebraic Surface Drawing", *ACM Transactions on Graphics*, 1(3), pp. 235-256.
- BLINN, J. F. (1982). "Light Reflection Functions for Simulation of Clouds and Dusty Surfaces", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 21-29.
- BLINN, J. F. (1993). "A Trip Down the Graphics Pipeline: The Homogeneous Perspective Transform", *IEEE Computer Graphics and Applications*, 13(3), pp. 75-80.
- BLOOMENTHAL, J. (1985). "Modeling the Mighty Maple", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 305-312.
- BONO, P. R., J. L. ENCARNACAO, F. R. A. HOPGOOD, ET AL. (1982). "GKS: The First Graphics Standard", *IEEE Computer Graphics and Applications*, 2(5), pp. 9-23.
- BOOTH, K. S., M. P. BRYDEN, W. B. COWAN, ET AL. (1987). "On the Parameters of Human Visual Performance: An Investigation of the Benefits of Antialiasing", *IEEE Computer Graphics and Applications*, 7(9), pp. 34-41.
- BRESENHAM, J. E. (1965). "Algorithm for Computer Control of A Digital Plotter", *IBM Systems Journal*, 4(1), pp. 25-30.
- BRESENHAM, J. E. (1977). "A Linear Algorithm for Incremental Digital Display of Circular Arcs", *CACM*, 20(2), pp. 100-106.
- BROOKS, F. P., JR. (1986). "Walkthrough: A Dynamic Graphics System for Simulating Virtual Buildings", *Interactive 3D* 1986.
- BROOKS, F. P., JR. (1988). "Grasping Reality Through Illusion: Interactive Graphics Serving Science", *CHI '88*, pp. 1-11.
- BROOKS, J., P. FREDERICK, M. OUH-YOUNG, J. J. BATTER, ET AL. (1990). "Project GROPE - Haptic Display for Scientific Visualization", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), 24(4), pp. 177-185.
- BROWN, M. H. AND R. SEDGEWICK (1984). "A System for Algorithm Animation", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 177-186.
- BROWN, J. R. AND S. CUNNINGHAM (1989). *Programming the User Interface*, John Wiley & Sons, New York.
- BRUDERLIN, A. AND T. W. CALVERT (1989). "Goal-Directed, Dynamic Animation of Human Walking", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 233-242.
- BRUNET, P. AND I. NAVAZO (1990). "Solid Representation and Operation Using Extended Octrees", *ACM Transactions on Graphics*, 9(2), pp. 170-197.
- BRYSON, S. AND C. LEVIT (1992). "The Virtual Wind Tunnel", *IEEE Computer Graphics and Applications*, 12(4), pp. 25-34.
- BURT, P. J. AND E. H. ADELSON (1983). "A Multiresolution Spline with Application to Image Mosaics", *ACM Transactions on Graphics*, 2(4), pp. 217-236.
- BUXTON, W., M. R. LAMB, D. SHERMAN, ET AL. (1983). "Towards a Comprehensive User Interface Management System", in proceedings of SIGGRAPH '83, *Computer Graphics*, 17(3), pp. 35-42.
- BUXTON, W., R. HILL, AND P. ROWLEY (1985). "Issues and Techniques in Touch-Sensitive Tablet Input", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 215-224.
- CALVERT, T., A. BRUDERLIN, J. DILL, ET AL. (1993). "Desktop Animation of Multiple Human Figures", *IEEE Computer Graphics and Applications*, 13(3), pp. 18-26.
- CAMBELL, G., T. A. DEFANTI, J. FREDERIKSEN, ET AL. (1986). "Two Bit/Pixel Full-Color Encoding", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 215-224.
- CAMPBELL, III., A. T. AND D. S. FUSSELL (1990). "Adaptive Mesh Generation for Global Diffuse Illumination", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 155-164.
- CARD, S. K., J. D. MACKINLAY, AND G. G. ROBERTSON (1991). "The Information Visualizer, an Information Workspace", *CHI '91*, pp. 181-188.

- CARIGNAN, M., Y. YANG, N. M. THALMANN, ET AL. (1992). "Dressing Animated Synthetic Actors with Complex Deformable Clothes", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 99-104.
- CARLBOM, I., I. CHAKRAVARTY, AND D. VANDERSCHEL (1985). "A Hierarchical Data Structure for Representing the Spatial Decomposition of 3-D Objects", *IEEE Computer Graphics and Applications*, 5(4), pp. 24-31.
- CARPENTER, L. (1984). "The A-Buffer: An Antialiased Hidden-Surface Method", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 103-108.
- CARROLL, J. M. AND C. CARRITHERS (1984). "Training Wheels in a User Interface", *CACM*, 27(8), pp. 800-806.
- CASALE M. S. AND E. L. STANTON (1985). "An Overview of Analytic Solid Modeling", *IEEE Computer Graphics and Applications*, 5(2), pp. 45-56.
- CATMULL, E. (1975). "Computer Display of Curved Surfaces", in proceedings of the IEEE Conference on Computer Graphics, *Pattern Recognition and Data Structures*. Also in Freeman (1980), pp. 309-315.
- CATMULL, E. (1984). "An Analytic Visible Surface Algorithm for Independent Pixel Processing", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 109-115.
- CHAZELLE, B. AND J. INERPI (1984). "Triangulation and Shape Complexity", *ACM Transactions on Graphics*, 3(2), pp. 135-152.
- CHEN, M., S. J. MOUNTFORD, AND A. SELLEN (1988). "A Study in Interactive 3D Rotation Using 2D Control Devices", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 121-130.
- CHEN, S. E., H. E. RUSHMEIER, G. MILLER, ET AL. (1991). "A Progressive Multi-Pass Method for Global Illumination", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 165-174.
- CHIN, N. AND S. FEINER (1989). "Near Real-Time Shadow Generation Using BSP Trees", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 99-106.
- CHUANG, R. AND G. ENTIS (1983). "3-D Shaded Computer Animation—Step by Step", *IEEE Computer Graphics and Applications*, 3(3), pp. 18-25.
- CHUNG, J. C., ET AL. (1989). "Exploring Virtual Worlds with Head-Mounted Visual Displays", *Proceedings of SPIE Meeting on Non-Holographic True 3-Dimensional Display Technologies*, 1083, January 1989, pp. 15-20.
- CLARK, J. H. (1982). "The Geometry Engine: A VLSI Geometry System for Graphics", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 127-133.
- COHEN, M. F. AND D. P. GREENBERG (1985). "The Hemicube: A Radiosity Solution for Complex Environments", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 31-40.
- COHEN, M. F., S. E. CHEN, J. R. WALLACE, ET AL. (1988). "A Progressive Refinement Approach to Fast Radiosity Image Generation", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 75-84.
- COHEN, M. F. AND J. R. WALLACE (1993). *Radiosity and Realistic Image Synthesis*, Academic Press, Boston, MA.
- COOK, R. L. AND K. E. TORRANCE (1982). "A Reflectance Model for Computer Graphics", *ACM Transactions on Graphics*, 1(1), pp. 7-24.
- COOK, R. L., T. PORTER, AND L. CARPENTER (1984). "Distributed Ray Tracing", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 137-145.
- COOK, R. L. (1984). "Shade Trees", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 223-231.
- COOK, R. L. (1986). "Stochastic Sampling in Computer Graphics", *ACM Transactions on Graphics*, 6(1), pp. 51-72.
- COOK, R. L., L. CARPENTER, AND E. CATMULL (1987). "The Reyes Image Rendering Architecture", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 95-102.
- COQUILLART, S. AND P. JANCENE (1991). "Animated Free-Form Deformation: An Interactive Animation Technique", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 23-26.
- CROW, F. C. (1977). "The Aliasing Problem in Computer-Synthesized Shaded Images", *CACM*, 20(11), pp. 799-805.
- CROW, F. C. (1977). "Shadow Algorithms for Computer Graphics", in proceedings of SIGGRAPH '77, *Computer Graphics*, 11(2), pp. 242-248.
- CROW, F. C. (1978). "The Use of Grayscale for Improved Raster Display of Vectors and Characters", in proceedings of SIGGRAPH '78, *Computer Graphics*, 12(3), pp. 1-5.
- CROW, F. C. (1981). "A Comparison of Antialiasing Techniques", *IEEE Computer Graphics and Applications*, 1(1), pp. 40-49.
- CROW, F. C. (1982). "A More Flexible Image Generation Environment", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 9-18.
- CRUZ-NEIRA, C., D. J. SANDIN, AND T. A. DEFANTI (1993). "Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 135-142.
- CUNNINGHAM, S., N. K. CRAIGHILL, M. W. FONG, ET AL., ED. (1992). *Computer Graphics Using Object-Oriented Programming*, John Wiley & Sons, New York.
- CUTLER, E., D. GILLY, AND T O'REILLY, ED (1992). *The X Window System in a Nutshell*, Second Edition, O'Reilly & Assoc., Inc., Sebastopol, CA.
- CYRUS, M. AND J. BECK (1978). "Generalized Two- and Three-Dimensional Clipping", *Computers and Graphics*, 3(1), pp. 23-28.
- DAY, A. M. (1990). "The Implementation of an Algorithm to Find the Convex Hull of a Set of Three-Dimensional Points", *ACM Transactions on Graphics*, 9(1), pp. 105-132.
- DE REFFEY, P., C. EDELIN, J. FRANCON, ET AL. (1988). "Plant Models Faithful to Botanical Structure and Development", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 151-158.

- DEERING, M. (1992). "High Resolution Virtual Reality", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 195–202.
- DEERING, M. F. AND S. R. NELSON (1993). "Leo: A System for Cost-Effective 3D Shaded Graphics", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 101–108.
- DEMKO, S., L. HODGES, AND B. NAYLOR (1985). "Construction of Fractal Objects with Iterated Function Systems", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 271–278.
- DEPP, S. W. AND W. E. HOWARD (1993). "Flat-Panel Displays", *Scientific American*, 266(3), pp. 90–97.
- DEROSE, T. D. (1988). "Geometric Continuity, Shape Parameters, and Geometric Constructions for Catmull-Rom Splines", *ACM Transactions on Graphics*, 7(1), pp. 1–41.
- DIGITAL EQUIPMENT CORP. (1989). "Digital Equipment Corporation XUI Style Guide", Maynard, MA.
- DIPPE, M. AND J. SWENSEN (1984). "An Adaptive Subdivision Algorithm and Parallel Architecture for Realistic Image Synthesis", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 149–158.
- DOBKIN, D., L. GUIBAS, J. HERSHBERGER, ET AL. (1988). "An Efficient Algorithm for Finding the CSG Representation of a Simple Polygon", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 31–40.
- DOCTOR, I. J. AND J. G. TORBERG (1981). "Display Techniques for Octree-Encoded Objects", *IEEE Computer Graphics and Applications*, 1(3), pp. 29–38.
- DORSEY, J. O., F. X. SILLION, AND D. P. GREENBERG (1991). "Design and Simulation of Opera Lighting and Projection Effects", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 41–50.
- DREBIN, R. A., L. CARPENTER, AND P. HANRAHAN (1988). "Volume Rendering", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 65–74.
- DUFF, T. (1985). "Compositing 3D Rendered Images", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 41–44.
- DURRETT, H. J., ED. (1987). *Color and the Computer*, Academic Press, Boston.
- DUVANENKO, V. (1990). "Improved Line Segment Clipping", Dr. Dobb's Journal, July 1990.
- DYER, S. AND S. WHITMAN (1987). "A Vectorized Scan-Line Z-Buffer Rendering Algorithm", *IEEE Computer Graphics and Applications*, 7(7), pp. 34–45.
- DYER, S. (1990). "A Dataflow Toolkit for Visualization", *IEEE Computer Graphics and Applications*, 10(4), pp. 60–69.
- EARNshaw, R. A., ED. (1985). *Fundamental Algorithms for Computer Graphics*, Springer-Verlag, Berlin.
- EDELSBRUNNER, H. (1987). *Algorithms in Computational Geometry*, Springer-Verlag, Berlin.
- EDELSBRUNNER, H. AND E. P. MUCKE (1990). "Simulation of Simplicity: A Technique to Cope with Degenerate Cases in Geometric Algorithms", *ACM Transactions on Graphics*, 9(1), pp. 66–104.
- ELBER, G. AND E. COHEN (1990). "Hidden Curve Removal for Free Form Surfaces", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 95–104.
- ENDERLE, G., K. KANSY, AND G. PFAFF (1984). *Computer Graphics Programming: GKS—The Graphics Standard*, Springer-Verlag, Berlin.
- FARIN, G. (1988). *Curves and Surfaces for Computer Aided Geometric Design*, Academic Press, Boston, MA.
- FAROUKI, R. T. AND J. K. HINDS (1985). "A Hierarchy of Geometric Forms", *IEEE Computer Graphics and Applications*, 5(5), pp. 51–78.
- FEDER, J. (1988). *Fractals*, Plenum Press, New York.
- FEINER, S., S. NAGY, AND A. VAN DAM (1982). "An Experimental System for Creating and Presenting Interactive Graphical Documents", *ACM Transactions on Graphics*, 1(1), pp. 59–77.
- FERWERDA, J. A. AND D. P. GREENBERG (1988). "A Psychophysical Approach to Assessing the Quality of Anti-aliased Images", *IEEE Computer Graphics and Applications*, 8(5), pp. 85–95.
- FISHKIN, K. P. AND B. A. BARSKY (1984). "A Family of New Algorithms for Soft Filling", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 235–244.
- FUME, E. L. (1989). *The Mathematical Structure of Raster Graphics*, Academic Press, Boston.
- FOLEY, J. D., V. L. WALLACE, AND P. CHAN (1984). "The Human Factors of Computer Graphics Interaction Techniques", *IEEE Computer Graphics and Applications*, 4(11), pp. 13–48.
- FOLEY, J. D. (1987). "Interfaces for Advanced Computing", *Scientific American*, 257(4), pp. 126–135.
- FOLEY, J. D., A. VAN DAM, S. K. FEINER, ET AL. (1990). *Computer Graphics: Principles and Practice*, Addison-Wesley, Reading, MA.
- FOURNIER, A., D. FUSSEL, AND L. CARPENTER (1982). "Computer Rendering of Stochastic Models", *CACM*, 25(6), pp. 371–384.
- FOURNIER, A. AND D. Y. MONTUNO (1984). "Triangulating Simple Polygons and Equivalent Problems", *ACM Transactions on Graphics*, 3(2), pp. 153–174.
- FOURNIER, A. AND W. T. REEVES (1986). "A Simple Model of Ocean Waves", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 75–84.
- FOURNIER, A. AND D. FUSSELL (1988). "On the Power of the Frame Buffer", *ACM Transactions on Graphics*, 7(2), pp. 103–128.
- FOURNIER, A. AND E. FUME (1988). "Constant-Time Filtering with Space-Variant Kernels", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 229–238.
- FOWLER, D. R., H. MEINHARDT, AND P. PRUSINKIEWICZ (1992). "Modeling Seashells", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 379–387.
- FOX, D. AND M. WAITE (1984). *Computer Animation Primer*, McGraw-Hill, New York.
- FRANCIS, G. K. (1987). *A Topological Picturebook*, Springer-Verlag, New York.

- FRANKLIN, W. R. AND M. S. KANKANHALLI (1990). "Parallel Object-Space Hidden Surface Removal", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 87-94.
- FREEMAN, H. ED. (1980). *Tutorial and Selected readings in Interactive Computer Graphics*, IEEE Computer Society Press, Silver Springs, MD.
- FRENKEL, K. A. (1989). "Volume Rendering", *CACM*, 32(4), pp. 426-435.
- FRIEDEM, G., D. GORDON, AND R. A. REYNOLD (1985). "Back-to-Front Display of Voxel-Based Objects", *IEEE Computer Graphics and Applications*, 5(1), pp. 52-60.
- FRIEDHOFF, R. M. AND W BENZON (1989). *The Second Computer Revolution: Visualization*, Harry N. Abrams, Inc., New York.
- FUCHS, H., S. M. PIZER, E. R. HEINZ, S. H. BLOOMBERG, L. TSAI, AND D. C. STRICKLAND (1982). "Design of an Image Editing with a Space-Filling Three-Dimensional Display Based on a Standard Raster Graphics System", *Proceedings of SPIE*, 367, August 1982, pp. 117-127.
- FUCHS, H., J. POULTON, J. EYLES, ET AL. (1989). "Pixel-Planes 5: A Heterogeneous Multiprocessor Graphics System Using Processor-Enhanced Memories", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 79-88.
- FUJIMOTO, A. AND K. IWATA (1983). "Jag-Free Images on Raster Displays", *IEEE Computer Graphics and Applications*, 3(9), pp. 26-34.
- FUNKHOUSER, T. A. AND C. H. SEQUIN (1993). "Adaptive Display Algorithms for Interactive Frame Rates During Visualization Complex Virtual Environments", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 247-254.
- GALVEAN, T. A. AND J. F. HUGHES (1991). "Sculpting: An Interactive Volumetric Modeling Technique", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 267-274.
- GARDNER, G. Y. (1985). "Visual Simulation of Clouds", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 297-304.
- GASCUEL, M.-P. (1993). "An Implicit Formulation for Precise Contact Modeling between Flexible Solids", in proceedings of SIGGRAPH '93, *Computer Graphics*, pp. 313-320.
- GASKINS, T. (1992). *PHIGS Programming Manual*, O'Reilly & Associates, Sebastopol, CA.
- GHARACHORLOO, N., S. GUPTA, R. F. SPROULL, ET AL. (1989). "A Characterization of Ten Rasterization Algorithms", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 355-368.
- GIRARD, M. (1987). "Interactive Design of 3D Computer-Animated Legged Animal Motion", *IEEE Computer Graphics and Applications*, 7(6), pp. 39-51.
- GLASSNER, A. S. (1984). "Space Subdivision for Fast Ray Tracing", *IEFF Computer Graphics and Applications*, 4(10), pp. 15-22.
- GLASSNER, A. S. (1986). "Adaptive Precision in Texture Mapping", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 297-306.
- GLASSNER, A. S. (1988). "Spacetime Ray Tracing for Animation", *IEEE Computer Graphics and Applications*, 8(2), pp. 60-70.
- GLASSNER, A. S., ED. (1989). *An Introduction to Ray Tracing*, Academic Press, San Diego, CA.
- GLASSNER, A. S., ED. (1990). *Graphics Gems*, Academic Press, San Diego, CA.
- GLASSNER, A. S. (1992). "Geometric Substitution: A Tutorial", *IEEE Computer Graphics and Applications*, 12(1), pp. 22-36.
- GLASSNER, A. S. (1994). *Principles of Digital Image Synthesis*, Morgan-Kaufmann, Inc., New York.
- GLEICHER, M. AND A. WITKIN (1992). "Through-the-Lens Camera Control", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 331-340.
- GOLDSMITH, J. AND J. SALMON (1987). "Automatic Creation of Object Hierarchies for Ray Tracing", *IEEE Computer Graphics and Applications*, 7(5), pp. 14-20.
- GONZALEZ, R. C. AND P. WINTZ (1987). *Digital Image Processing*, Addison-Wesley, Reading, MA.
- GOOD, D. M., J. A. WHITESIDE, D. R. WIXON, AND S. J. JONES (1984). "Building A User-Derived Interface", *CACM*, 27(10), pp. 1032-1042.
- GOODMAN, T. AND R. SPENCE (1978). "The Effect of System Response Time on Interactive Computer-Aided Problem Solving", in proceedings of SIGGRAPH '78, *Computer Graphics*, 12(3), pp. 100-104.
- GORAL, C. M., K. E. TORRANCE, D. P. GREENBERG, ET AL. (1984). "Modeling the Interaction of Light Between Diffuse Surfaces", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 213-222.
- GORDON, D. AND S. CHEN (1991). "Front-to-Back Display of BSP Trees", *IEEE Computer Graphics and Applications*, 11(5), pp. 79-85.
- GORTLER, S. J., P. SCHRODER, M. F. COHEN, ET AL. (1993). "Wavelet Radiosity", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 221-230.
- GREEN, M. (1985). "The University of Alberta User Interface Management System", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 205-214.
- GREENE, N., M. KASS, AND G. MILLER (1993). "Hierarchical Z-Buffer Visibility", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 231-238.
- HAECKER, P. AND K. AKELLY (1990). "The Accumulation Buffer: Hardware Support for High-Quality Rendering", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 309-318.
- HAHN, J. K. (1988). "Realistic Animation of Rigid Bodies", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 299-308.
- HALL, R. A. AND D. P. GREENBERG (1983). "A Testbed for Realistic Image Synthesis", *IEEE Computer Graphics and Applications*, 3(8), pp. 10-20.
- HALL, R. (1989). *Illumination and Color in Computer Generated Imagery*, Springer-Verlag, New York.

- HANRAHAN, P. (1982). "Creating Volume Models from Edge-Vertex Graphs", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 77-84.
- HANRAHAN, P. AND J. LAWSON (1990). "A Language for Shading and Lighting Calculations", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 289-298.
- HART, J. C., D. J. SANDIN, AND L. H. KAUFFMAN (1989). "Ray Tracing Deterministic 3D Fractals", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 289-296.
- HART, J. C. AND T. A. DEFANTI (1991). "Efficient Antialiased Rendering of 3-D Linear Fractals", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 91-100.
- HE, X. D., P. O. HEYEN, R. L. PHILLIPS, ET AL. (1992). "A Fast and Accurate Light Reflection Model", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 253-254.
- HEARN, D. AND P. BAKER (1991). "Scientific Visualization: An Introduction", *Eurographics '91 Technical Report Series*, Tutorial Lecture 6.
- HECKBERT, P. (1982). "Color Image Quantization for Frame Buffer Display", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 297-307.
- HECKBERT, P. AND P. HANRAHAN (1984). "Beam Tracing Polygonal Objects", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 119-127.
- HOPGOOD, F. R. A., D. A. DUCE, J. R. GALLOP, ET AL. (1983) *Introduction to the Graphical Kernel System (GKS)*, Academic Press, London.
- HOPGOOD, F. R. A. AND D. A. DUCE (1991). *A Primer for PHIGS*, John Wiley & Sons, Chichester, England.
- HOPPE, H., T. DEROSE, T. McDONALD, ET AL. (1993). "Mesh Optimization", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 19-26.
- HOWARD, T. L. J., W. T. HEWITT, R. J. HUBBOLD, ET AL. (1991). *A Practical Introduction to PHIGS and PHIGS Plus*, Addison-Wesley, Wokingham, England.
- HUGHES, J. F. (1992). "Scheduled Fourier Volume Morphing", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 43-46.
- HUITRIC, H. AND M. NAHAS (1985). "B-Spline Surfaces: A Tool for Computer Painting", *IEEE Computer Graphics and Applications*, 5(3), pp. 39-47.
- IKEDO, T. (1984). "High-Speed Techniques for a 3-D Color Graphics Terminal", *IEEE Computer Graphics and Applications*, 4(5), pp. 46-58.
- IMMEL, D. S., M. F. COHEN, AND D. P. GREENBERG (1986). "A Radiosity Method for Non-Diffuse Environments", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 133-142.
- ISAACS, P. M. AND M. F. COHEN (1987). "Controlling Dynamic Simulation with Kinematic Constraints, Behavior Functions, and Inverse Dynamics", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 215-224.
- JARVIS, J. F., C. N. JUDICE, AND W. H. NINKE (1976). "A Survey of Techniques for the Image Display of Continuous Tone Pictures on Bilevel Displays", *Computer Graphics and Image Processing*, 5(1), pp. 13-40.
- JOHNSON, S. A. (1982). "Clinical Varifocal Mirror Display System at the University of Utah", *Proceedings of SPIE*, 367, August 1982, pp. 145-148.
- KAJIYA, J. T. (1983). "New Techniques for Ray Tracing Procedurally Defined Objects", *ACM Transactions on Graphics*, 2(3), pp. 161-181.
- KAJIYA, J. T. (1986). "The Rendering Equation", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 143-150.
- KAJIYA, J. T. AND T. L. KAY (1989). "Rendering Fur with Three-Dimensional Textures", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 271-280.
- KAPPEL, M. R. (1985). "An Ellipse-Drawing Algorithm for Faster Displays", in *Fundamental Algorithms for Computer Graphics*, Springer-Verlag, Berlin, pp. 257-280.
- KARASICK, M., D. LIEBER, AND L. R. NACKMAN (1991). "Efficient Delaunay Triangulation Using Rational Arithmetic", *ACM Transactions on Graphics*, 10(1), pp. 71-91.
- KASS, M. (1992). "CONDOR: Constraint-Based Dataflow", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 321-330.
- KASSON, J. M. AND W. PLOUFFE (1992). "An Analysis of Selected Computer Interchange Color Spaces", *ACM Transactions on Graphics*, 11(4), pp. 373-405.
- KAUFMAN, A. (1987). "Efficient Algorithms for 3D Scan-Conversion of Parametric Curves, Surfaces, and Volumes", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 171-179.
- KAWAGUCHI, Y. (1982). "A Morphological Study of the Form of Nature", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 223-232.
- KAY, T. L. AND J. T. KAJIYA (1986). "Ray Tracing Complex Scenes", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 269-278.
- KAY, D. C. AND J. R. LEVINE (1992). *Graphics File Formats*, Windcrest/McGraw-Hill, New York.
- KELLEY, A. D., M. C. MALIN, AND G. M. NIELSON (1988). "Terrain Simulation using a Model of Stream Erosion", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 263-268.
- KENT, J. R., W. E. CARLSON, AND R. E. PARENT (1992). "Shape Transformation for Polyhedral Objects", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 47-54.
- KIRK, D. AND J. ARVO (1991). "Unbiased Sampling Techniques for Image Synthesis", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 153-156.
- KIRK, D., ED. (1992). *Graphics Gems III*, Academic Press, San Diego, CA.
- KNUTH, D. E. (1987). "Digital Halftones by Dot Diffusion", *ACM Transactions on Graphics*, 6(4), pp. 245-273.
- KOCHANEK, D. H. U. AND R. H. BARTELS (1984). "Interpolating Splines with Local Tension, Continuity, and Bias Control", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 33-41.

- KOH, E.-K. AND D. HEARN (1992). "Fast Generation and Surface Structuring Methods for Terrain and Other Natural Phenomena", in proceedings of Eurographs '92 Computer Graphics Forum, 11(3), pp. C-169-180.
- KORIEN, J. U. AND N. I. BADLER (1982). "Techniques for Generating the Goal-Directed Motion of Articulated Structures", IEEE Computer Graphics and Applications, 2(9), pp. 71-81..
- KORIEN, J. U. AND N. I. BADLER (1983). "Temporal antialiasing in Computer-Generated Animation", in proceedings of SIGGRAPH '83, Computer Graphics, 17(3), pp. 377-388.
- LASSETER, J. (1987). "Principles of Traditional Animation Applied to 3D Computer Animation", in proceedings of SIGGRAPH '87, Computer Graphics, 21(4), pp. 35-44.
- LAUR, D. AND P. HANRAHAN (1991). "Hierarchical Splatting: A Progressive Refinement Algorithm for Volume Rendering", in proceedings of SIGGRAPH '91, Computer Graphics, 25(4), pp. 285-288.
- LAUREL, B. (1990). *The Art of Human-Computer Interface Design*, Addison-Wesley, Reading, MA.
- LEE, M. E., R. A. REDNER, AND S. P. USELTON (1985). "Statistically Optimized Sampling for Distributed Ray Tracing", in proceedings of SIGGRAPH '85, Computer Graphics, 19(3), pp. 61-68.
- LEVINTHAL, A. AND T. PORTER (1984). "CHAP — A SIMD Graphics Processor", in proceedings of SIGGRAPH '84, Computer Graphics, 18(3), pp. 77-82.
- LEVOY, M. (1988). "Display of Surfaces from Volume Data". IEEE Computer Graphics and Applications, 8(3), pp. 29-37
- LEVOY, M. (1990). "A Hybrid Ray Tracer for Rendering Polygon and Volume Data", IEEE Computer Graphics and Applications, 10(2), pp. 33-40.
- LEWIS, J.-P. (1989). "Algorithms for Solid Noise Synthesis", in proceedings of SIGGRAPH '89, Computer Graphics, 23(3), pp. 263-270.
- LIANG, Y.-D. AND B. A. BARSKY (1983). "An Analysis and Algorithm for Polygon Clipping" CACM, 26(11), pp. 868-877.
- LIANG, Y.-D. AND B. A. BARSKY (1984). "A New Concept and Method for Line Clipping", ACM Transactions on Graphics, 3(1), pp. 1-22.
- LIENT, S.-L., M. SHANTZ, AND V. PRATT (1987). "Adaptive Forward Differencing for Rendering Curves and Surfaces", in proceedings of SIGGRAPH '87, Computer Graphics, 21(4), pp. 111-118.
- LINDLEY, C. A. (1992). *Practical Ray Tracing in C*, John Wiley & Sons, New York.
- LISCHINSKI, D., F. TAMPIERI, AND D. P. GREENBERG (1993). "Combining Hierarchical Radiosity and Discontinuity Meshing", in proceedings of SIGGRAPH '93, Computer Graphics, pp. 199-208.
- LITWINOWICZ, P. C. (1991). "Inkwell: A 2 1/2-D Animation System", in proceedings of SIGGRAPH '91, Computer Graphics, 25(4), pp. 113-122.
- LODDING, K. N. (1983). "Iconic Interfacing", IEEE Computer Graphics and Applications, 3(2), pp. 11-20.
- LOKE, T.-S., D. TAN, H.-S. SEAH, ET AL. (1992). "Rendering Fireworks Displays", IEEE Computer Graphics and Applications, 12(3), pp. 33-43.
- LOOMIS, J., H. POIZNER, U. BELLUGI, ET AL. (1983). "Computer Graphic Modeling of American Sign Language", in proceedings of SIGGRAPH '83, Computer Graphics, 17(3), pp. 105-114.
- LORENSON, W. E. AND H. CLINE (1987). "Marching Cubes: A High-Resolution 3D Surface Construction Algorithm", in proceedings of SIGGRAPH '87, Computer Graphics, 21(4), pp. 163-169.
- MACKINLAY, J. D., S. K. CARD, AND G. G. ROBERTSON (1990). "Rapid Controlled Movement Through a Virtual 3D Workspace", SIGGRAPH 90, pp. 171-176.
- MACKINLAY, J. D., G. G. ROBERTSON, AND S. K. CARD (1991). "The Perspective Wall: Detail and Context Smoothly Integrated", CHI '91, pp. 173-179.
- MAGNENAT-THALMANN, N. AND D. THALMANN (1985). *Computer Animation: Theory and Practice*, Springer-Verlag, Tokyo.
- MAGNENAT-THALMANN, N. AND D. THALMANN (1987). *Image Synthesis*, Springer-Verlag, Tokyo.
- MAGNENAT-THALMANN, N. AND D. THALMANN (1991). "Complex Models for Animating Synthetic Actors", IEEE Computer Graphics and Applications, 11(5), pp. 32-45.
- MANDELBROT, B. B. (1977). *Fractals: Form, Chance, and Dimension*, Freeman Press, San Francisco.
- MANDELBROT, B. B. (1982). *The Fractal Geometry of Nature*, Freeman Press, New York.
- MANTYLA, M. (1988). *An Introduction to Solid Modeling*, Computer Science Press, Rockville, MD.
- MAX, N. L. AND D. M. LERNER (1985). "A Two-and-a-Half-D Motion Blur Algorithm", in proceedings of SIGGRAPH '85, Computer Graphics, 19(3), pp. 85-94.
- MAX, N. L. (1986). "Atmospheric Illumination and Shadows", in proceedings of SIGGRAPH '86, Computer Graphics, 20(4), pp. 117-124.
- MAX, N. L. (1990). "Cone-Spheres", in proceedings of SIGGRAPH '90, Computer Graphics, 24(4), pp. 59-62.
- METAXAS, D. AND D. TERZOPoulos (1992). "Dynamic Deformation of Solid Primitives with Constraints", in proceedings of SIGGRAPH '92, Computer Graphics, 26(2), pp. 309-312.
- MEYER, G. W., H. E. RUSHMEIER, M. F. COHEN, ET AL. (1986). "An Experimental Evaluation of Computer Graphics Imagery", ACM Transactions on Graphics, 6(1), pp. 30-50.
- MEYER, G. W. AND D. P. GREENBERG (1988). "Color-Defective Vision and Computer Graphics Displays", IEEE Computer Graphics and Applications, 8(5), pp. 28-40.
- MEYERS, D., S. SKINNER, AND K. SLOAN (1992). "Surfaces from Contours", ACM Transactions on Graphics, 11(3), pp. 228-258.
- MILLER, G. S. P. (1988). "The Motion Dynamics of Snakes and Worms", in proceedings of SIGGRAPH '88, Computer Graphics, 22(4), pp. 169-178.

- MILLER, J. V., D. E. BREEN, W. E. LORENSON, ET AL. (1991). "Geometrically Deformed Models: A Method for Extracting Closed Geometric Models from Volume Data", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 217-226.
- MITCHELL, D. P. (1991). "Spectrally Optimal Sampling for Distribution Ray Tracing", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 157-165.
- MITCHELL, D. P. AND P. HANRAHAN (1992). "Illumination from Curved Reflectors", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 283-291.
- MIYATA, K. (1990). "A Method of Generating Stone Wall Patterns", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 387-394.
- MOLNAR, S., J. EYLES, AND J. POULTON (1992). "PixelFlow: High-Speed Rendering Using Image Composition", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 231-240.
- MOON, F. C. (1992). *Chaotic and Fractal Dynamics*, John Wiley & Sons, New York.
- MOORE, M. AND J. WILHELMUS (1988). "Collision Detection and Response for Computer Animation", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 289-298.
- MORTENSON, M. E. (1985). *Geometric Modeling*, John Wiley & Sons, New York.
- MURAKI, S. (1991). "Volumetric Shape Description of Range Data Using the 'Blobby Model'", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 227-235.
- MUSGRAVE, F. K., C. E. KOLB, AND R. S. MACE (1989). "The Synthesis and Rendering of Eroded Fractal Terrains", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 41-50.
- MYERS, B. A. AND W. BUXTON (1986). "Creating High-Interactive and Graphical User Interfaces by Demonstration", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 249-258.
- NAYLOR, B., J. AMANATIDES, AND W. THIBAUT (1990). "Merging BSP Trees Yields Polyhedral Set Operations", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 115-124.
- NEWMAN, W. H. (1968). "A System for Interactive Graphical Programming", SJCC, Thompson Books, Washington, D. C., pp. 47-54.
- NEWMAN, W. H. AND R. F. SPROULL (1979). *Principles of Interactive Computer Graphics*, McGraw-Hill, New York.
- NGO, J. T. AND J. MARKS (1993). "Spacetime Constraints Revisited", in proceedings of SIGGRAPH '93, *Computer Graphics*, pp. 343-350.
- NICHOLL, T. M., D. T. LEE, AND R. A. NICHOLL (1987). "An Efficient New Algorithm for 2D Line Clipping: Its Development and Analysis", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 253-262.
- NIELSON, G. M., B. SHRIVER, AND L. ROSENBLUM, ED. (1990). *Visualization in Scientific Computing*, IEEE Computer Society Press, Los Alamitos, CA.
- NIELSON, G. M. (1993). "Scattered Data Modeling", *IEEE Computer Graphics and Applications*, 13(1), pp. 60-70.
- NISHIMURA, H. (1985). "Object Modeling by Distribution Function and a Method of Image Generation", *Journal Electronics Comm. Conf.* '85, J68(4), pp. 718-725.
- NISHITA, T. AND E. NAKAMAE (1986). "Continuous-Tone Representation of Three-Dimensional Objects Illuminated by Sky Light", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 125-132.
- NISHITA, T., T. SIRAI, K. TADAMURA, ET AL. (1993). "Display of the Earth Taking into Account Atmospheric Scattering", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 175-182.
- NORTON, A. (1982). "Generation and Display of Geometric Fractals in 3-D", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 61-67.
- NSF INVITATIONAL WORKSHOP (1992). "Research Directions in Virtual Environments", *Computer Graphics*, 26(3), pp. 153-177.
- OKABE, H., H. IMAOKA, T. TOMIHA, ET AL. (1992). "Three-Dimensional Apparel CAD System", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 105-110.
- OPENGL ARCHITECTURE REVIEW BOARD (1993). *OpenGL Programming Guide*, Addison-Wesley, Reading, MA.
- OPPENHEIMER, P. E. (1986). "Real-Time Design and Animation of Fractal Plants and Trees", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 55-64.
- OSF/MOTIF (1989). *OSF/Motif Style Guide*, Open Software Foundation, Prentice-Hall, Englewood Cliffs, NJ.
- PAINTER, J. AND K. SLOAN (1989). "Antialiased Ray Tracing by Adaptive Progressive Refinement", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 281-288.
- PANG, A. T. (1990). "Line-Drawing Algorithms for Parallel Machines", *IEEE Computer Graphics and Applications*, 10(5), pp. 54-59.
- PAVLIDIS, T. (1982). *Algorithms For Graphics and Image Processing*, Computer Science Press, Rockville, MD.
- PAVLIDIS, T. (1983). "Curve Fitting with Conic Splines", *ACM Transactions on Graphics*, 2(1), pp. 1-31.
- PEACHEY, D. R. (1986). "Modeling Waves and Surf", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 65-74.
- PEITGEN, H.-O. AND P. H. RICHTER (1986). *The Beauty of Fractals*, Springer-Verlag, Berlin.
- PEITGEN, H.-O. AND D. SAUPE, ED. (1988). *The Science of Fractal Images*, Springer-Verlag, Berlin.
- PENTLAND, A. AND J. WILLIAMS (1989). "Good Vibrations: Modal Dynamics for Graphics and Animation", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 215-222.
- PERLIN, K. AND E. M. HOFFERT (1989). "Hypertexture", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 253-262.
- PHILLIPS, R. L (1977). "A Query Language for a Network Data Base with Graphical Entities", in proceedings of SIGGRAPH '77, *Computer Graphics*, 11(2), pp. 179-185.

- PHONG, B. T. (1975). "Illumination for Computer-Generated Images", *CACM*, 18(6), pp. 311–317.
- PINEDA, J. (1988). "A Parallel Algorithm for Polygon Rasterization", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 17–20.
- PTTEWAY, M. L. V. AND D. J. WATKINSON (1980). "Bresenham's Algorithm with Gray Scale", *CACM*, 23(11), pp. 625–626.
- PLATT, J. C. AND A. H. BARR (1988). "Constraint Methods for Flexible Models", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 279–288.
- PORTER, T. AND T. DUFF (1984). "Compositing Digital Images", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 253–259.
- POTMESIL, M. AND I. CHAKRAVARTY (1982). "Synthetic Image Generation with a Lens and Aperture Camera Model" *ACM Transactions on Graphics*, 1(2), pp. 85–108.
- POTMESIL, M. AND I. CHAKRAVARTY (1983). "Modeling Motion Blur in Computer-Generated Images", in proceedings of SIGGRAPH '83, *Computer Graphics*, 17(3), pp. 389–399.
- POTMESIL, M. AND E. M. HOFFERT (1987). "FRAMES: Software Tools for Modeling, Rendering and Animation of 3D Scenes", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 85–93.
- POTMESIL, M. AND E. M. HOFFERT (1989). "The Pixel Machine: A Parallel Image Computer", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 69–78.
- PRATT, W. K. (1). *Digital Image Processing*, John Wiley & Sons, New York.
- PREFARATA, F. P. AND M. I. SHAMOS (1985). *Computational Geometry*, Springer-Verlag, New York.
- PRESS, W. H., S. A. TEUKOLSKY, W. T. VETTERLING, ET AL. (1992). *Numerical Recipes in C*, Cambridge University Press, Cambridge, England.
- PRUSINKIEWICZ, P., M. S. HAMMEL, AND E. MJOLSNESS (1993). "Animation of Plant Development", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 351–360.
- PRUYN, P. W. AND D. P. GREENBERG (1993). "Exploring 3D Computer Graphics in Cockpit Avionics", *IEEE Computer Graphics and Applications*, 13(3), pp. 28–35.
- QUEK, L.-H. AND D. HEARN (1988). "Efficient Space-Subdivision Methods in Ray-Tracing Algorithms", University of Illinois, Department of Computer Science Report UIUCDCS-R-88-1468.
- RAIBERT, M. H. AND J. K. HODGINS (1991). "Animation of Dynamic Legged Locomotion", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 349–358.
- REEVES, W. T. (1983). "Particle Systems: A Technique for Modeling a Class of Fuzzy Objects", *ACM Transactions on Graphics*, 2(2), pp. 91–108.
- REEVES, W. T. (1983). "Particle Systems—A Technique for Modeling a Class of Fuzzy Objects", in proceedings of SIGGRAPH '83, *Computer Graphics*, 17(3), pp. 359–376.
- REEVES, W. T. AND R. BLAU (1985). "Approximate and Probabilistic Algorithms for Shading and Rendering Structured Particle Systems", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 313–321.
- REEVES, W. T., D. H. SALESIN, AND R. L. COOK (1987). "Rendering Antialiased Shadows with Depth Maps", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 283–291.
- REQUICHA, A. A. G. AND J. R. ROSSIGNAC (1992). "Solid Modeling and Beyond", *IEEE Computer Graphics and Applications*, 12(5), pp. 31–44.
- REYNOLDS, C. W. (1982). "Computer Animation with Scripts and Actors", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 289–296.
- REYNOLDS, C. W. (1987). "Flocks, Herds, and Schools: A Distributed Behavioral Model", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 25–34.
- RIESENFELD, R. F. (1981). "Homogeneous Coordinates and Projective Planes in Computer Graphics", *IEEE Computer Graphics and Applications*, 1(1), pp. 50–55.
- ROBERTSON, P. K. (1988). "Visualizing Color Gamuts: A User Interface for the Effective Use of Perceptual Color Spaces in Data Displays", *IEEE Computer Graphics and Applications*, 8(5), pp. 50–64.
- ROBERTSON, G. G., J. D. MACKINLAY AND S. K. CARD (1991). "Cone Trees: Animated 3D Visualizations of Hierarchical Information", *CHI '91*, pp. 189–194.
- ROGERS, D. F. AND R. A. EARNSHAW, ED. (1987). *Techniques for Computer Graphics*, Springer-Verlag, New York.
- ROGERS, D. F. AND J. A. ADAMS (1990). *Mathematical Elements for Computer Graphics*, McGraw-Hill, New York.
- ROSENTHAL, D. S. H., ET AL. (1982). "The Detailed Semantics of Graphics Input Devices", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 33–38.
- RUBINE, D. (1991). "Specifying Gestures by Example", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 329–337.
- RUSHMEIER, H. AND K. TORRANCE (1987). "The Zonal Method for Calculating Light Intensities in the Presence of a Participating Medium", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 293–302.
- RUSHMEIER, H. E. AND K. E. TORRANCE (1990). "Extending the Radiosity Method to Include Specularly Reflecting and Translucent Materials", *ACM Transactions on Graphics*, 9(1), pp. 1–27.
- SABELLA, P. (1988). "A Rendering Algorithm for Visualizing 3D Scalar Fields", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 51–58.
- SABIN, M. A. (1985). "Contouring: The State of the Art", in *Fundamental Algorithms for Computer Graphics*, R. A. Earnshaw, ed, Springer-Verlag, Berlin, pp. 411–482.
- SALESIN, D. AND R. BARZEL (1993). "Adjustable Tools: An Object-Oriented Interaction Metaphor", *ACM Transactions on Graphics*, 12(1), pp. 103–107.
- SAMET, H. AND R. E. WEBBER (1985). "Sorting a Collection of Polygons using Quadtrees", *ACM Transactions on Graphics*, 4(3), pp. 182–222.

- SAMET, H. AND M. TAMMINEN (1985). "Bintrees, CSG Trees, and Time", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 121-130.
- SAMET, H. AND R. E. WEBBER (1988). "Hierarchical Data Structures and Algorithms for Computer Graphics: Part 1", *IEEE Computer Graphics and Applications*, 8(4), pp. 59-75.
- SAMET, H. AND R. E. WEBBER (1988). "Hierarchical Data Structures and Algorithms for Computer Graphics: Part 2", *IEEE Computer Graphics and Applications*, 8(3), pp. 48-68.
- SCHEIFLER, R. W. AND J. GETTYS (1986). "The X Window System", *ACM Transactions on Graphics*, 5(2), pp. 79-109.
- SCHOENEMAN, C., J. DORSEY, B. SMITS, ET AL. (1993). "Global Illumination", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 143-146.
- SCHRODER, P. AND P. HANRAHAN (1993). "On the Form Factor Between Two Polygons", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 163-164.
- SCHWARTZ, M. W., W. B. COWAN, AND J. C. BEATTY (1987). "An Experimental Comparison of RGB, YIQ, LAB, HSV, and Opponent Color Models", *ACM Transactions on Graphics*, 6(2), pp. 123-158.
- SEDERBERG, T. W. AND E. GREENWOOD (1992). "A Physically Based Approached to 2-D Shape Bending", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 25-34.
- SEDERBERG, T. W., P. GAO, G. WANG, ET AL. (1993). "2D Shape Blending: An Intrinsic Solution to the Vertex Path Problem", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 15-18.
- SEGAL, M. (1990). "Using Tolerances to Guarantee Valid Polyhedral Modeling Results", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 105-114.
- SEGAL, M., C. KOROBKIN, R. VAN WIDENFELT, ET AL. (1992). "Fast Shadows and Lighting Effects Using Texture Mapping", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 249-252.
- SEQUIN, C. H. AND E. K. SMYRL (1989). "Parameterized Ray Tracing", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 307-314.
- SHERR, S. (1993). *Electronic Displays*, John Wiley & Sons, New York.
- SHILLING, A. AND W. STRASSER (1993). "EXACT: Algorithm and Hardware Architecture for an Improved A-Buffer", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 85-92.
- SHIRLEY, P. (1990). "A Ray Tracing Method for Illumination Calculation in Diffuse-Specular Scenes", *Graphics Interface '90*, pp. 205-212.
- SHNEIDERMAN, B. (1986). *Designing the User Interface*, Addison-Wesley, Reading, MA.
- SHOEMAKE, K. (1985). "Animating Rotation with Quaternion Curves", in proceedings of SIGGRAPH '85, *Computer Graphics*, 19(3), pp. 245-254.
- SIBERT, J. L., W. D. HURLEY, AND T. W. BLESER (1986). "An Object-Oriented User Interface Management System", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 259-268.
- SILLION, F. X. AND C. PUECH (1989). "A General Two-Pass Method Integrating Specular and Diffuse Reflection", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 335-344.
- SILLION, F. X., J. R. ARVO, S. H. WESTIN, ET AL. (1991). "A Global Illumination Solution for General Reflectance Distributions", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 187-196.
- SIMS, K. (1990). "Particle Animation and Rendering Using Data Parallel Computation", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 405-413.
- SIMS, K. (1991). "Artificial Evolution for Computer Graphics", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 319-328.
- SINGH, B., J. C. BEATTY, K. S. BOOTH, ET AL. (1983). "A Graphics Editor for Benesh Movement Notation", in proceedings of SIGGRAPH '83, *Computer Graphics*, 17(3), pp. 51-62.
- SMITH, A. R. (1978). "Color Gamut Transform Pairs", *Computer Graphics*, 12(3), pp. 12-19.
- SMITH, A. R. (1979). "Tint Fill", *Computer Graphics*, 13(2), pp. 276-283.
- SMITH, A. R. (1984). "Plants, Fractals, and Formal Languages", in proceedings of SIGGRAPH '84, *Computer Graphics*, 18(3), pp. 1-10.
- SMITH, R. B. (1987). "Experiences with the Alternate Reality Kit: An Example of the Tension Between Literalism and Magic", *IEEE Computer Graphics and Applications*, 7(9), pp. 42-50.
- SMITH, A. R. (1987). "Planar 2-Pass Texture Mapping and Warping", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 263-272.
- SMITS, B. E., J. R. ARVO, AND D. H. SALESIN (1992). "An Importance-Driven Radiosity Algorithm", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 273-282.
- SNYDER, J. M. AND J. T. KAJIYA (1992). "Generative Modeling: A Symbolic System for Geometric Modeling", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 369-378.
- SNYDER, J. M., A. R. WOODBURY, K. FLEISCHER, ET AL. (1993). "Interval Method for Multi-Point Collisions between Time-Dependent Curved Surfaces", in proceedings of SIGGRAPH '93, *Computer Graphics*, pp. 321-334.
- SPROULL, R. F. AND I. E. SUTHERLAND (1968). "A Clipping Divider", AFIPS Fall Joint Computer Conference.
- STAM, J. AND E. FIUME (1993). "Turbulent Wind Fields for Gaseous Phenomena", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 369-376.
- STETTNER, A. AND D. P. GREENBERG (1989). "Computer Graphics Visualization for Acoustic Simulation", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 195-206.

- STRASSMANN, S. (1986). "Hairy Brushes", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 225-232.
- STRAUSS, P. S. AND R. CAREY (1992). "An Object-Oriented 3D Graphics Toolkit", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 341-349.
- SUNG, H. C. K., G. ROGERS, AND W. J. KÜBITZ (1990). "A Critical Evaluation of PEX", *IEEE Computer Graphics and Applications*, 10(6), pp. 65-75.
- SUTHERLAND, I. E. (1963). "Sketchpad: A Man-Machine Graphical Communication System", AFIPS Spring Joint Computer Conference, 23 pp. 329-346.
- SUTHERLAND, I. E., R. F. SPROULL, AND R. SCHUMACKER (1974). "A Characterization of Ten Hidden Surface Algorithms", *ACM Computing Surveys*, 6(1), pp. 1-55.
- SUTHERLAND, I. E. AND G. W. HODGMAN (1974). "Reentrant Polygon Clipping", *CACM*, 17(1), pp. 32-42.
- SWEZEY, R. W. AND E. G. DAVIS (1983). "A Case Study of Human Factors Guidelines in Computer Graphics", *IEEE Computer Graphics and Applications*, 3(8), pp. 21-30.
- TAKALA, T. AND J. HAHN (1992). "Sound Rendering", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 211-220.
- TANNAS, J., LAWRENCE E. ED. (1985). *Flat-Panel Displays and CRTs*, Van Nostrand Reinhold Company, New York.
- TELLER, S. AND P. HANRAHAN (1993). "Global Visibility Algorithms for Illumination Computations", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 239-246.
- TERZOPoulos, D., J. PLATT, A. H. BARR, ET AL. (1987). "Elastically Deformable Models", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 205-214.
- THALMANN, D. ED. (1990). *Scientific Visualization and Graphics Simulation*, John Wiley & Sons, Chichester, England.
- THIBAULT, W. C. AND B. F. NAYLOR (1987). "Set Operations on Polyhedra using Binary Space Partitioning Trees", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 153-162.
- TORBERG, J. G. (1987). "A Parallel Processor Architecture for Graphics Arithmetic Operations", in proceedings of SIGGRAPH '87, *Computer Graphics*, 21(4), pp. 197-204.
- TORRANCE, K. E. AND E. M. SPARROW (1967). "Theory for Off-Specular Reflection from Roughened Surfaces", *J. Optical Society of America*, 57(9), pp. 1105-1114.
- TRAVIS, D. (1991). *Effective Color Displays*, Academic Press, London.
- TUFT, E. R. (1983). *The Visual Display of Quantitative Information*, Graphics Press, Cheshire, CN.
- TUFT, E. R. (1990). *Envisioning Information*, Graphics Press, Cheshire, CN.
- TURKOWSKI, K. (1982). "Antialiasing Through the Use of Coordinate Transformations", *ACM Transactions on Graphics*, 1(3), pp. 215-234.
- UPSON, C. AND M. KEELER (1988). "VBUFFER: Visible Volume Rendering", in proceedings of SIGGRAPH '88, *Computer Graphics*, 22(4), pp. 59-64.
- UPSON, C., T. FAULHABER JR., D. KAMINS, ET AL. (1989). "The Application Visualization System: A Computational Environment for Scientific Visualization", *IEEE Computer Graphics and Applications*, 9(4), pp. 30-42.
- UPSTILL, S. (1990). *The RenderMan Companion*, Addison-Wesley, Reading, MA.
- VAN DE PANNE, M. AND E. FIUME (1993). "Sensor-Actuator Networks", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 335-342.
- VAN WIJK, J. J. (1991). "Spot Noise-Texture Synthesis for Data Visualization", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 309-318.
- VEENSTRA, J. AND N. AHUJA (1988). "Line Drawings of Octree-Represented Objects", *ACM Transactions on Graphics*, 7(1), pp. 61-75.
- VELHO, L. AND J. D. M. GOMES (1991). "Digital Halftoning with Space-Filling Curves", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 81-90.
- VON HERZEN, B., A. H. BARR, AND H. R. ZATZ (1990). "Geometric Collisions for Time-Dependent Parametric Surfaces", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 39-48.
- WALLACE, V. L. (1976). "The Semantics of Graphic Input Devices", in proceedings of SIGGRAPH '76, *Computer Graphics*, 10(1), pp. 61-65.
- WALLACE, J. R., K. A. ELMQUIST, AND E. A. HAINES (1989). "A Ray-Tracing Algorithm for Progressive Radiosity", in proceedings of SIGGRAPH '89, *Computer Graphics*, 23(3), pp. 315-324.
- WANGER, L. R., J. A. FERWERDA, AND D. P. GREENBERG (1992). "Perceiving Spatial Relationships in Computer-Generated Images", *IEEE Computer Graphics and Applications*, 12(3), pp. 44-58.
- WARE, C. (1988). "Color Sequences for Univariate Maps: Theory, Experiments, and Principles", *IEEE Computer Graphics and Applications*, 8(5), pp. 41-49.
- WARN, D. R. (1983). "Lighting Controls for Synthetic Images", in proceedings of SIGGRAPH '83, *Computer Graphics*, 17(3), pp. 13-21.
- WARNOCK, J. AND D. K. WYATT (1982). "A Device-Independent Graphics Imaging Model for Use with Raster Devices", in proceedings of SIGGRAPH '82, *Computer Graphics*, 16(3), pp. 313-319.
- WATT, A. (1989). *Fundamentals of Three-Dimensional Computer Graphics*, Addison-Wesley, Wokingham, England.
- WATT, M. (1990). "Light-Water Interaction Using Backward Beam Tracing", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 377-386.
- WATT, A. AND M. WATT (1992). *Advanced Animation and Rendering Techniques*, Addison-Wesley, Wokingham, England.
- WEGHORST, H., G. HOOPER, AND D. P. GREENBERG (1984). "Improved Computational Methods for Ray Tracing", *ACM Transactions on Graphics*, 3(1), pp. 52-69.
- WEIL, J. (1986). "The Synthesis of Cloth Objects", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 49-54.

- WEILER, K. AND P. ATHERTON (1977). "Hidden-Surface Removal Using Polygon Area Sorting", in proceedings of SIGGRAPH '77, *Computer Graphics*, 11(2), pp. 214-222.
- WEILER, K. (1980). "Polygon Comparison Using a Graph Representation", in proceedings of SIGGRAPH '80, *Computer Graphics*, 14(3), pp. 10-18.
- WESTIN, S. H., J. R. ARVO, AND K. E. TORRANCE (1992). "Predicting Reflectance Functions from Complex Surfaces", in proceedings of SIGGRAPH '92, *Computer Graphics*, 26(2), pp. 255-264.
- WESTOVER, L. (1990). "Footprint Evaluation for Volume Rendering", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 367-376.
- WHITTED, T. (1980). "An Improved Illumination Model for Shaded Display", CACM, 23(6), pp. 343-349.
- WHITTED, T. AND D. M. WEIMER (1982). "A Software Testbed for the Development of 3D Raster Graphics Systems", *ACM Transactions on Graphics*, 1(1), pp. 43-58.
- WHITTED, T. (1983). "Antialiased Line Drawing Using Brush Extrusion", in proceedings of SIGGRAPH '83, *Computer Graphics*, 17(3), pp. 151-156.
- WILHELM, J. (1987). "Toward Automatic Motion Control", *IEEE Computer Graphics and Applications*, 7(4), pp. 11-22.
- WILHELM, J. AND A. V. GELDER (1991). "A Coherent Projection Approach for Direct Volume Rendering", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 275-284.
- WILHELM, J. AND A. VAN GELDER (1992). "Octrees for Faster Isosurface Generation", *ACM Transactions on Graphics*, 11(3), pp. 201-227.
- WILLIAMS, L. (1990). "Performance-Driven Facial Animation", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 235-242.
- WILLIAMS, P. L. (1992). "Visibility Ordering Meshed Polyhedra", *ACM Transactions on Graphics*, 11(2), pp. 103-126.
- WITKIN, A. AND W. WELCH (1990). "Fast Animation and Control of Nonrigid Structures", in proceedings of SIGGRAPH '90, *Computer Graphics*, 24(4), pp. 243-252.
- WITKIN, A. AND M. KASS (1991). "Reaction-Diffusion Textures", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 299-308.
- WOLFRAM, S. (1991). *Mathematica*, Addison-Wesley, Reading, MA.
- WOO, A., P. POULIN, AND A. FOURNIER (1990). "A Survey of Shadow Algorithms", *IEEE Computer Graphics and Applications*, 10(6), pp. 13-32.
- WRIGHT, W. E. (1990). "Parallelization of Bresenham's Line and Circle Algorithms", *IEEE Computer Graphics and Applications*, 10(5), pp. 60-67.
- WU, X. (1991). "An Efficient Antialiasing Technique", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 143-152.
- WYSZECKI, G. AND W. S. STILES (1982). *Color Science*, John Wiley & Sons, New York.
- WYVILL, G., B. WYVILL, AND C. MCPHEETERS (1987). "Solid Texturing of Soft Objects", *IEEE Computer Graphics and Applications*, 7(12), pp. 20-26.
- YAEGER, L., C. UPSON, AND R. MYERS (1986). "Combining Physical and Visual Simulation: Creation of the Planet Jupiter for the Film "2010""", in proceedings of SIGGRAPH '86, *Computer Graphics*, 20(4), pp. 85-94.
- YAGEL, R., D. COHEN, AND A. KAUFMAN (1992). "Discrete Ray Tracing", *IEEE Computer Graphics and Applications*, 12(5), pp. 19-28.
- YAMAGUCHI, K., T. L. KUNII, AND FUJIMURA (1984). "Octree-Related Data Structures and Algorithms", *IEEE Computer Graphics and Applications*, 4(1), pp. 53-59.
- YOUNG, D. A. (1990). *The X Window System - Programming and Applications with Xt, OSF/Motif Edition*, Prentice-Hall, Englewood Cliffs, NJ.
- ZELEZNICK, R. C., D. B. CONNER, M. M. WLOKA, ET AL. (1991). "An Object-Oriented Framework for the Integration of Interactive Animation Techniques", in proceedings of SIGGRAPH '91, *Computer Graphics*, 25(4), pp. 105-112.
- ZELTZER, D. (1982). "Motor Control Techniques for Figure Animation", *IEEE Computer Graphics and Applications*, 2(9), pp. 53-60.
- ZHANG, Y. AND R. E. WEBBER (1993). "Space Diffusion: An Improved Parallel Halftoning Technique Using Space-Filling Curves", in proceedings of SIGGRAPH '93, *Computer Graphics Proceedings*, pp. 305-312.

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