

RÉSUMÉ: ANDREW J. HANSON

Professor and Chair
Department of Computer Science, Indiana University, Bloomington

ACADEMIC BACKGROUND

B.S. cum laude, Chemistry and Physics (1966), Harvard College

Ph.D., Theoretical Physics (1971), Massachusetts Institute of Technology

PH.D. ADVISOR

Kerson Huang (Massachusetts Institute of Technology)

POSITIONS HELD

Indiana University, Chairman of Computer Science, July 2004 to present.

Indiana University, Professor, July 1995 to present.

CVLAB Computer Vision Laboratory, EPFL (Ecole Polytechnique Fédérale Lausanne), Sabbatical – Visiting Professor, Fall 2002.

iMAGIS/IMAG Computer Graphics Research Laboratory, University of Grenoble, Grenoble, France, Sabbatical – Visiting Scientist, July 1995 to July 1996.

Indiana University, Associate Professor, September 1989 to June 1995.

CERN (European Organization for Nuclear Research), Geneva, Switzerland, Scientific Associate, Spring 1992.

SRI International, Senior Computer Scientist in Artificial Intelligence Center, October 1980 to September 1989.

Technology Development of California, Project Scientist working in design of computer-based cartographic systems for NOAA/NOS, under the auspices of NASA-Ames research center. January 1979 to September 1980.

Lawrence Berkeley Laboratory, Postdoctoral Research Associate in Theoretical Physics, September 1976 to December 1978.

Stanford Linear Accelerator Center, Postdoctoral Research Associate in Theoretical Physics, June 1974 to August 1976.

Cornell University, Postdoctoral Research Associate in Theoretical Physics, September 1973 to May 1974.

Institute for Advanced Study, Princeton, Postdoctoral Research Associate in Theoretical Physics, September 1971 to August 1973; (National Science Foundation Postdoctoral Fellow).

PH.D. ADVISEES

Completed Degrees: Pheng Heng (1992), Robert Cross (1995), JiYoung Chang (1995), Hui Ma (1996), Eric Wernert (2000), Philip Chi-Wing Fu (2003), Sidharth Thakur (2008), Hui Zhang (2008).

Current Students: Yinggang Li, Mitja Hmeljak.

PROFESSIONAL INTERESTS

Artificial intelligence, with emphasis on model-driven machine vision, information-theoretic optimization, and uncertain reasoning.

Visualization of scientific problems using computer graphics techniques, with emphasis on mathematical objects in higher dimensions. Possible uses of haptic interfaces for such applications.

Computer graphics methods, including interactive techniques and fundamental problems of modeling and control.

Cognitive factors involved in learning spatial intuition and perception of unphysical dimensions using computer-based interaction.

User Interfaces for virtual reality applications, including constrained navigation methods for desktop interactive 3D systems as well as immersive environments.

Computer-based “automated research assistants” to aid in the conceptualization and solution of scientific research problems, with an emphasis on mathematics and physics.

PROFESSIONAL EXPERIENCE AND AWARDS

“Exploring New Geometry by Touching, Seeing, and Feeling,” NSF, 9/01/2004 – 8/30/2009. \$215,195.

“Visualizing Complex Projective Spaces and their Applications,” NSF, 7/01/2002 – 6/30/2007. \$256,101.

“Virtual Planetarium Design,” Silicon Graphics Inc. (SGI), 1/03 – 12/05. \$106,000.

“Journey of the Sun – A Virtual Reality Simulation: Data-Constrained Modeling and Visualization of Interstellar Matter in our Galaxy,” P.C. Frisch and A.J. Hanson, NASA Applied Systems Research grant, collaboration with the University of Chicago, 8/03 – 7/04. \$40,000.

“Journey of the Sun – A Virtual Reality Simulation: Data-Constrained Modeling and Visualization of Interstellar Matter in our Galaxy,” P.C. Frisch, A.J. Hanson, and D.G. York. NASA Applied Systems Research grant, collaboration with the University of Chicago, 5/02 – 4/03. \$37,000.

“The Journey of the Sun — A Virtual Reality Simulation,” P.C. Frisch, A.J. Hanson, and D.G. York. NASA Applied Systems Research grant, collaboration with the University of Chicago, 2/99 – 1/02. \$347,000.

“A Graphics Studio and Lab for Arts and Sciences,” with Randall Bramley, Peter Shirley, et al., IU Office of Information Technologies 7/95 –6/98. \$300,000

“Computer Graphics Lab for Interdisciplinary Research and Training Consortium,” with Randall Bramley, Robert Shakespeare, et al., IU Office of Information Technologies 7/95 –6/96.

Participant in “An Infrastructure for Conceptualization and Visualization,” D. Wise, principal investigator, an NSF Institutional Infrastructure grant, 7/1/93 – 6/30/98, NSF CDA 93-03189.

Principal investigator on NSF research project, “Interactive Mathematical Visualization,” August 1992 – January 1995.

Principal investigator on NSF research instrumentation grant, Spring 1993.

Received award of CERN (European Organization for Nuclear Research) Scientific Associateship, consisting of a full fellowship to work with the Computers and Networks division at CERN on problems involving interactive graphics visualization systems for High Energy Physics. Spring 1992.

Principal investigator on NSF-funded joint research project with Stanford University Psychology Department, “Teaching and Learning of Spatial Intuition: Collaborative Research,” February 1986 – November 1988.

Principal investigator on USAETL-funded research project, “Research in Expert Interactive Cartographic Systems,” May 1985 – July 1986.

Principal Investigator and Project Manager for installation of IU Testbed system at USAETL, July 1982 – June 1985.

Project coordinator for the SRI DARPA/DMA Image Understanding Testbed effort, 1980 – 1989.

Extensive research experience in theoretical elementary particle physics and mathematical physics, including making computer-animated films to demonstrate physical phenomena, and analyzing numerous physical problems using computer methods.

Designed interactive graphics hardware and software for applications in interactive cartographic editing.

Developed system software for the early PLATO automated teaching system.

SUMMARY OF MAJOR WORKS AND CONTRIBUTIONS

Visualizing Quaternions, book published by Morgan-Kaufmann/Elsevier, 2006.

Produced and directed, “Solar Journey,” 20:00 minute computer animation, DVD published by Finley-Holiday Films, 2006.

Contributor to “Visualization in Scientific Computing,” a report to the National Science Foundation by the Panel on Graphics, Image Processing and Workstations.

Research publications in theoretical physics, including two monographs: *Constrained Hamiltonian Systems*, A.J. Hanson, T. Regge, and C. Teitelboim, Accademia Nazionale dei Lincei, 1976; *Gravitation, Gauge Theories and Differential Geometry*, T. Eguchi, P. Gilkey, and A.J. Hanson, Physics Reports, 1980.

Shared with T. Eguchi the Second Place award for the Gravity Research Foundation essay competition in 1979.

DARPA/DMA Image Understanding Testbed project manager.

Holder of a share in the patent on the PLATO automated teaching system.

PROFESSIONAL ASSOCIATIONS

American Association for Artificial Intelligence
American Mathematical Society
American Physical Society (Division of Particles and Fields)
Association for Computing Machinery (SIGGRAPH)
IEEE Computer Society
Sigma Xi

PUBLICATIONS AND PRESENTATIONS
ANDREW J. HANSON

- P.K. Chapman and A.J. Hanson “An Eotvos Experiment in Earth Orbit,” Proc. Conf. on Expt’al Tests of Grav. Theories, p. 228. Ed. R.W. Davies, J.P.L. Pub., Pasadena, CA (1971).
- A.J. Hanson, “Dual N-Point Functions in PGL (N-2, C)-Invariant Formalism,” Phys. Rev. **D5**, pp. 1948–1956 (1972).
- S. Fubini, A.J. Hanson, and R. Jackiw, “New Approach to Field Theory,” Phys. Rev. **D7**, pp. 1733–1760 (1973).
- A.J. Hanson and T. Regge, “The Relativistic Spherical Top,” Annals of Physics (NY), **87**, pp. 498–566 (1974).
- P. Goddard, A.J. Hanson, and G. Ponzano, “The Quantization of a Massless Relativistic String in a Time-Like Gauge,” Nucl. Phys., **B89**, pp. 76–92 (1975).
- A.J. Hanson, T. Regge, and C. Teitelboim, **Constrained Hamiltonian Systems**, Contributi del Centro Linceo Interdisc. di Scienze Matem. e loro Applic., No. 22, Accademia Nazionale dei Lincei, Rome, 135 pages (1976).
- I. Bars and A.J. Hanson, “Quarks at the Ends of the String,” Phys. Rev. **D13**, pp. 1744–1760 (1976).
- W.A. Bardeen, I. Bars, A.J. Hanson, and R.D. Peccei, “Study of the Longitudinal Kink Modes of the String,” Phys. Rev. **D13**, pp. 2364–2382 (1976).
- W.A. Bardeen, I. Bars, A.J. Hanson, and R.D. Peccei, “Quantum Poincare Covariance of the Two-Dimensional String,” Phys. Rev. **D14**, pp. 2193–2196 (1976).
- A.J. Hanson, R.D. Peccei, and M.K. Prasad, “Two Dimensional SU(N) Gauge Theory, Strings and Wings: Comparative Analysis of Meson Spectra and Covariance,” Nucl. Phys. **B121**, pp. 477–504 (1977); SLAC-PUB-1816 (September 1976).
- A.J. Hanson and M.K. Prasad, “Consistency of SU(N) Gauge Theory in Two Euclidean Dimensions,” Phys. Rev. **D15**, pp. 3765–3767 (1977).
- T. Eguchi, P.B. Gilkey, A.J. Hanson, “Topological Invariants and Absence of Axial Anomaly for a Euclidean Taub-NUT Metric,” Phys. Rev. **D17**, pp. 423–427 (1978).

- T. Eguchi and A.J. Hanson, "Asymptotically Flat Self-Dual Solutions to Euclidean Gravity," *Physics Letters* **74B**, pp. 249–251 (1978).
- A.J. Hanson and H. Romer, "Gravitational Instanton Contribution to Spin 3/2 Axial Anomaly," *Physics Letters* **80B**, pp. 58–60 (1978).
- A.J. Hanson and T. Regge, "Torsion and Quantum Gravity," in **Group Theoretical Physics: Proceedings of the Int. Col. and Integrative Conf. on Group Theory and Mathematical Physics held in Austin, Tex., Sept. 11–16, 1978**. Edited by W. Beiglbock, A. Bohm, and E. Takasugi. *Lecture Notes in Physics* **94**, pp. 354–361 (Springer-Verlag, Berlin, 1979).
- A.J. Hanson, "Gravitational Instantons," Invited paper at the 1979 Meeting of the American Physical Society, Washington D.C., 23–26 April (1979).
- T. Eguchi and A.J. Hanson, "Self-Dual Solutions to Euclidean Gravity," *Ann. Phys. (N.Y.)*, **120**, pp. 82–106 (1979).
- T. Eguchi and A.J. Hanson, "Gravitational Instantons," *Journal of General Relativity and Gravitation*, **11**, pp. 315–320 (1979). Second prize essay in the 1979 Gravity Research Foundation Competition.
- T. Eguchi, P.B. Gilkey, and A.J. Hanson, "Gravitation, Gauge Theories and Differential Geometry," *Physics Reports*, **66**, No. 6, pp. 213–393 (December 1980).
- M.A. Fischler and A.J. Hanson, "The SRI Image Understanding Program," *Proceedings of the DARPA Image Understanding Workshop*, pp. 223–235 (April 1981).
- A.J. Hanson and M.A. Fischler, "The DARPA/DMA Image Understanding Testbed," *Proceedings of the DARPA Image Understanding Workshop*, pp. 342–351 (September 1982).
- A.J. Hanson, "Overview of the Image Understanding Testbed," SRI Technical Note 311 (October 1983)
- A.J. Hanson, "The DARPA/DMA Image Understanding Testbed User's Manual," SRI Technical Note 277 (January 1984)
- A.J. Hanson, "The DARPA/DMA Image Understanding Testbed System Manager's Manual," SRI Technical Note 299 (January 1984, revised December 1985)
- A.J. Hanson, "Vision, perception and imagery" — Session Summary. (Session organizer and chairperson.) *Proceedings of the ACM Annual Conference (San Francisco, Calif., Oct. 8-10)*. pp. 228–229, (ACM, New York, 1984).

- P. Fua and A.J. Hanson, "Locating Cultural Regions in Aerial Imagery Using Geometric Cues," Proceedings of the DARPA Image Understanding Workshop, pp. 271–278 (December 1985).
- P. Fua and A.J. Hanson, "Using Generic Geometric Knowledge to Delineate Cultural Objects in Aerial Imagery," SRI Technical Note 378 (March 1986).
- P. Fua and A.J. Hanson, "Resegmentation Using Generic Shape: Locating General Cultural Objects," Pattern Recognition Letters **5**, pp. 243–252 (1987).
- P. Fua and A.J. Hanson, "Using Generic Geometric Models for Intelligent Shape Extraction," Proceedings of the Image Understanding Workshop, pp. 227–233 (February 1987).
- A.J. Hanson, A.P. Pentland, and L.H. Quam, "Design of a Prototype Interactive Cartographic Display and Analysis Environment," Proceedings of the Image Understanding Workshop, pp. 475–482 (February 1987).
- P. Fua and A.J. Hanson, "Using Generic Geometric Models for Intelligent Shape Extraction," Proceedings of the AAAI Sixth National Conference on Artificial Intelligence, pp. 706–711 (July 1987).
- Contributor to Panel Report.* B.H. McCormick, T.A. DeFanti, and M.D. Brown, Eds., "Visualization in Scientific Computing," a report to the National Science Foundation by the Panel on Graphics, Image Processing and Workstations; Computer Graphics **21**, No. 6 (Nov. 1987).
- A.J. Hanson, Producer, Videotape of SRI Perception Group research entitled "Cartographic Modeling System," selected for inclusion in the SIGGRAPH Video Review Issue 29, *Visualization Systems* (1987).
- A.J. Hanson, "Hyperquadrics: Smoothly Deformable Shapes with Convex Polyhedral Bounds," Computer Vision, Graphics and Image Processing **44**, 191–210 (1988).
- N.R. Corby, J.L. Mundy, P.A. Vrobel, A.J. Hanson, L.H. Quam, G.B. Smith, and T.M. Strat, "PACE — An Environment for Intelligence Analysis," in Proceedings of the Image Understanding Workshop, Boston, MA, pp. 342–350 (April 6–8, 1988).
- P. Fua and A.J. Hanson, "Extracting Generic Shapes Using Model-Driven Optimization," in Proceedings of the Image Understanding Workshop, Boston, MA, pp. 994–1004 (April 6–8, 1988).
- A.J. Hanson and L. Quam, "Overview of the SRI Cartographic Modeling Environment," in Proceedings of the Image Understanding Workshop, Boston, MA, pp. 576–582 (April 6–8, 1988).

- A.J. Hanson and L. Quam, "A Cartographic Visualization Environment," in Proceedings of the Military Computing Conference, Anaheim, CA, pp. 233–240 (May 3–5, 1988).
- H.A. Cunningham, M. Pavel, and A.J. Hanson, "Using Mental Models in a Visual-Motor Adaptation Task," talk presented at the 1988 meeting of the Psychonomic Society, Chicago, Illinois.
- A.J. Hanson, "Discovering Hyperquadrics," 5:00 minutes, videotape included in first annual report for NSF grant IST-8511751 (1987). Shown at the Workshop on Differential Geometry, Calculus of Variations, and Computer Graphics (Mathematical Sciences Research Institute, Berkeley, CA, May 23–25, 1988).
- A.J. Hanson, "Discovering Hyperquadrics," talk presented at the Workshop on Differential Geometry, Calculus of Variations, and Computer Graphics (Mathematical Sciences Research Institute, Berkeley, CA, May 23–25, 1988).
- A.J. Hanson, M. Pavel, and H. Cunningham, "Spatial Intuition," 24 minutes, videotape included in final report for NSF grant IST-8511751 (November, 1988).
- P. Fua and A.J. Hanson, "Objective Functions for Feature Discrimination: Theory," in Proceedings of the Image Understanding Workshop, Palo Alto, CA, May 23–26, 1989, pp. 443–460 (Morgan Kaufmann, 1989).
- P. Fua and A.J. Hanson, "Objective Functions for Feature Discrimination: Applications to Semiautomated and Automated Feature Extraction," in Proceedings of the Image Understanding Workshop, Palo Alto, CA, May 23–26, 1989, pp. 676–694 (Morgan Kaufmann, 1989).
- P. Fua and A.J. Hanson, "Objective Functions for Feature Discrimination," in Proceedings of the Eleventh International Joint Conference on Artificial Intelligence, 20–25 August 1989, Detroit, MI; pp. 1596–1602 (Morgan Kaufmann, 1989).
- A.J. Hanson, Producer, Videotape of SRI Perception Group research entitled "Progress in Image Understanding," selected for inclusion in Eleventh International Joint Conference on Artificial Intelligence, 1989, Videotape Program (videotape published and distributed as a supplement to the conference proceedings by Morgan Kaufmann, 1989).
- Invited talk.* "An Optimization Framework for Feature Extraction," Stanford Symposium on "Applications of the Minimal Description Length Principle," March 28, 1990.

- Invited talk.* “Visualizing Homogeneous Equations in CP²,” Colloquium on Computer Graphics in Pure Mathematics, Iowa City, Iowa, May 17–19, 1990.
- A.J. Hanson, “Amplitude-Based Approach to Evidence Accumulation,” in Proceedings of the Sixth Conference on *Uncertainty in Artificial Intelligence*, pp. 405–414; republished in *Uncertainty in Artificial Intelligence 6*, P. Bonissone and M. Henrion (eds.), Machine Intelligence and Pattern Recognition, Volume 12, (Elsevier, North Holland, 1991).
- P. Fua and A.J. Hanson, “An Optimization Framework for Feature Extraction,” *Machine Vision and Applications* **4** pp. 59–87 (1991).
- Refereed Conference Exhibition.* A.J. Hanson (Author and Director), P.A. Heng and B.C. Kaplan (Animators), videotape entitled “Visualizing Fermat’s Last Theorem,” in Siggraph Video Review 61, Scene 4. Presented in the Animation Screening Room at *SIGGRAPH 90*, Dallas, Texas, August 8–10, 1990.
- A.J. Hanson, P.A. Heng, and B.C. Kaplan, “Techniques for Visualizing Fermat’s Last Theorem: A Case Study,” in Proceedings of *Visualization 90*, San Francisco, October 23–26, 1990, pp. 97–106 (IEEE Computer Society Press, 1990).
- Invited Conference Exhibition.* A.J. Hanson (Author and Director), P.A. Heng and B.C. Kaplan (Animators), videotape entitled “Visualizing Fermat’s Last Theorem,” presented in the Visualization Theatre at *SUPERCOMPUTING 90*, New York City, November 12–16, 1990.
- A.J. Hanson, “Implicit Functions for Modeling Arbitrary Deformable Shapes,” Indiana University Computer Science Department Technical Report 320 (1990).
- P. Suetens, P. Fua, and A.J. Hanson, “Computational Strategies for Object Recognition,” *ACM Computing Surveys*, **24**, No. 1, pp. 5–61 (1992).
- A.J. Hanson and P.A. Heng, “Visualizing the Fourth Dimension Using Geometry and Light,” chosen for inclusion in the Video Proceedings of *Visualization ’91*, San Diego, CA, Oct 22–25, 1991.
- A.J. Hanson and P.A. Heng, “Visualizing the Fourth Dimension Using Geometry and Light,” in the Proceedings of *Visualization ’91*, San Diego, CA, Oct 22–25, pp. 321–328 (1991).
- Book Chapter.* A.J. Hanson, “The Rolling Ball,” in *Graphics Gems III*, ed. David Kirk, pp. 51–60 (Academic Press, San Diego, 1992).

A.J. Hanson and P.A. Heng, “Illuminating the Fourth Dimension,” *Computer Graphics and Applications*, **12**, No. 4, pp. 54–62 (July, 1992).

Refereed Conference Exhibition. A.J. Hanson (Author and Co-Director) and P.A. Heng (Co-Director), videotape entitled “FourSight,” presented in the Animation Screening Room at *SIGGRAPH 92*, Chicago, Illinois, July 28–31, 1992. Published in *Siggraph Video Review* 85, scene 11.

Refereed Conference Graphic Publication. A.J. Hanson and P.A. Heng, “Fermat’s Surfaces,” 35mm slide images included in the conference Technical Slide Set Vol. **27**, No. 1, of *SIGGRAPH 92*, Chicago, Illinois, July 28–31, 1992.

Invited plenary conference talk. A.J. Hanson, “Seeing the Right Picture: Graphics and Visualization for High Energy Physics,” invited plenary talk. In *Proceedings of the International Conference on Computing in High Energy Physics (CHEP92)*, Annecy, France, 21–25 September 1992; Ed. Verkerk and Wojcik; pp. 90–95 (CERN 92-07, December 1992).

“Visualizing Surfaces in 4D,” invited talk at the Workshop on Visualization of Geometric Structures, held at the Mathematical Sciences Research Institute (MSRI), Berkeley, CA, 12–16 October 1992.

A.J. Hanson and P.A. Heng, “Four-Dimensional Views of 3D Scalar Fields,” in *Proceedings of Visualization ’92*, Boston, MA, Oct 21–23, 1992, pp. 84–91 (IEEE Computer Society Press, Los Alamitos, CA, 1992).

Refereed Videotape. A.J. Hanson (Director and Producer), videotape entitled “knot⁴,” exhibited in Small Animation Theater of *SIGGRAPH 93*, Anaheim, CA, August 1–8, 1993. Published in *Siggraph Video Review* **93**, Scene 1 (1993).

Book Chapter. A.J. Hanson, “Geometry for N -dimensional Graphics,” in *Graphics Gems IV*, ed. by Paul Heckbert, pp. 149–170 (AP Professional, Cambridge MA, 1994).

A.J. Hanson and R.A. Cross, “Interactive Visualization Methods for Four Dimensions,” in *Proceedings of Visualization ’93*, San Jose, CA, Oct 25–29, 1993, pp. 196–203 (IEEE Computer Society Press, Los Alamitos, CA, 1993).

Refereed Conference Videotape. A.J. Hanson and R.A. Cross, “Interactive Visualization Methods for Four Dimensions,” in *Video Proceedings of Visualization ’93*, San Jose, CA, Oct 25–29, 1993, (IEEE Computer Society Press, Los Alamitos, CA, 1993).

- Invited Videotape Exhibition.* A.J. Hanson (Director and Producer), videotape entitled “knot⁴,” presented on Japanese television, fall, 1993.
- Invited Videotape Exhibition.* A.J. Hanson (Director and Producer), videotape entitled “knot⁴,” presented at The International Joint Mathematics Meeting Heidelberg, Germany, October 1-3, 1993, a joint conference of the American and European mathematical societies.
- Invited Videotape Exhibition.* A.J. Hanson (Director and Producer), videotape entitled “knot⁴,” presented at Supercomputing ’93 Conference, November 15–19, 1993, Portland, Oregon.
- A.J. Hanson, T. Munzner, and G. Francis, “Interactive Methods for Visualizable Geometry,” *IEEE Computer* **27**, No. 7, pp. 73–83 (IEEE Computer Society Press, Los Alamitos, CA, July, 1994).
See <http://www.geom.umn.edu/~munzner/ieee94/ieee/ieee.html>.
- H. Ma and A.J. Hanson, “MeshView,” an interactive 4D geometry viewer software system. Available by anonymous ftp from `geom.umn.edu`. Version 1.0 designed and released in June 1994.
- R.A. Cross and A.J. Hanson, “Virtual Reality Performance for Virtual Geometry,” in *IEEE Visualization ’94*, Arlington, VA, Oct 19–21, 1994. pp. 156–163 (IEEE Computer Society Press, Los Alamitos, CA, 1994).
- A.J. Hanson and H. Ma, “Visualizing Flow with Quaternion Frames,” in *IEEE Visualization ’94*, Arlington, VA, Oct 19–21, 1994. pp. 108–115 (IEEE Computer Society Press, Los Alamitos, CA, 1994).
- Refereed Conference Videotape.* A.J. Hanson and H. Ma, “Visualizing Flow with Quaternion Frames,” in Video Proceedings of *IEEE Visualization ’94*, Arlington, VA, Oct 19–21, 1994. (IEEE Computer Society Press, Los Alamitos, CA, 1994).
- Refereed Conference Videotape.* R.A. Cross and A.J. Hanson, “Virtual Reality Performance for Virtual Geometry,” in Video Proceedings of *IEEE Visualization ’94*, Arlington, VA, Oct 19–21, 1994. (IEEE Computer Society Press, Los Alamitos, CA, 1994).
- Invited Conference Talk* A.J. Hanson, “Approaches to Simulating 4D Worlds,” invited talk at AMS “Minneapolis Mathfest” Meeting, August 15–17 1994, Minneapolis, Minnesota, in session “Computer Graphics as a Research Tool in Geometry and Topology” organized by Dennis Roseman.
- Ji-Young Chang and A.J. Hanson, “Virtual Line Segment-Based Hough Transform,” in Proceedings of 12th International Conference on Pattern Recognition, pp. 57–62, Vol. I, Jerusalem, Israel, October 9–13, 1994.

- Invited paper.* A.J. Hanson, “A Construction for Computer Visualization of Certain Complex Curves,” in “Computers and Mathematics” column, ed. Keith Devlin, of *Notices of the American Mathematical Society*, **41**, No. 9, pp. 1156–1163 (American Math. Soc., Providence, November/December, 1994).
- Book Chapter.* A.J. Hanson, “Rotations for N -dimensional Graphics,” in *Graphics Gems V*, ed. by Alan Paeth, pp. 55–64 (AP Professional, Cambridge MA, 1995). Previously published as Indiana University Computer Science Department Technical Report 406.
- A.J. Hanson, “Quaternion Frenet Frames: Making Optimal Tubes and Ribbons from Curves.” Indiana University Computer Science Department Technical Report 407 (June 1994).
- Refereed Graphics Demonstration* R.A. Cross and A.J. Hanson, “Knotted Spheres in the Fourth Dimension,” Virtual Reality Room (VROOM demonstration, Siggraph 94 *Visual Proceedings*, Computer Graphics, Annual Conference Series, 1994, ACM SIGGRAPH, p. 235 (1994).
- Invited, Refereed Paper:* A.J. Hanson and H. Ma, “Quaternion Frame Approach to Streamline Visualization,” in *IEEE Transactions on Visualization and Computer Graphics* **1**, No. 2, pp. 164–174 (June, 1995).
- A.J. Hanson and H. Ma, “Parallel Transport Approach to Curve Framing,” Indiana University Technical Report 425 (January, 1995).
- Refereed Videotape.* A.J. Hanson (Director and Producer), videotape entitled “4Dice,” (1:00 minute) presented in Computer Animation Festival, of *SIGGRAPH 95*, Los Angeles, CA, August 6–11, 1995. In Siggraph Video Review **114**, Scene 14 (1995).
- A.J. Hanson and H. Ma, “Space Walking,” in Proceedings of *IEEE Visualization '95*, Atlanta, GA, Oct 19–21, 1995. pp. 126–133 (IEEE Computer Society Press, Los Alamitos, CA, 1995).
- Conference Videotape:* H. Ma and A.J. Hanson, “Space Walking,” animation in Video Proceedings of *IEEE Visualization '95*, Atlanta, GA, Oct 19–21, 1995. (IEEE Computer Society Press, Los Alamitos, CA, 1995).
- Book Review.* Reviewed *Scientific Visualization: Advances and Challenges*, edited by L. Rosenblum; in *IEEE Computation Science and Engineering*, Winter issue, pp. 87–88 (1995).
- Invited Conference Talk* A.J. Hanson, “Exploiting Quaternion Frames in Geometry,” invited talk at *Software and Mathematical Visualization Workshop* 24–28 June 1996, Princeton University, Princeton, NJ.

Invited Panelist. IEEE Visualization '96 Panelist: "Mathematical Visualization: Standing at the Crossroads." Voted "Best Panel of Conference."

Invited Conference Talk A.J. Hanson, "Visualization of Manifolds in Four-Dimensions," at workshop entitled *Issues in the Computation of Bifurcations and Singularities in Dynamical Systems*, October 16–20, 1996, at the Geometry Center, Minneapolis, MN.

A.J. Hanson and E. Wernert, "Constrained 3D Navigation with 2D Controllers," in Proceedings of *IEEE Visualization '97*, Phoenix, AZ, Oct 22–24, 1997. pp. 175–182 (IEEE Computer Society Press, 1997). Also available as IUCS Technical Report 479.

A.J. Hanson and E.A. Wernert, "Constrained Navigation," computer animation in Video Proceedings of *IEEE Visualization '97*, Phoenix, AZ, Oct 22–24, 1997. (IEEE Computer Society Press, 1997).

Course given at Siggraph '98: A.J. Hanson, "Computer Graphics beyond the Third Dimension."

Course given at IEEE Visualization '98: H. Hagen, A.J. Hanson, and G. Scheuermann, "Clifford Algebra, Quaternions and their Applications in Visualization."

A.J. Hanson, "Constrained Optimal Framings of Curves and Surfaces using Quaternion Gauss Maps," in Proceedings of IEEE Visualization '98, pp. 375–382, 1998.

A.J. Hanson and E. Wernert, "Image-Based Rendering with Occlusions via Cubist Images." in Proceedings of IEEE Visualization '98, pp. 327–334, 1998.

A.J. Hanson and E. Wernert, "Image-Based Rendering with Occlusions via Cubist Images." computer animation in Video Proceedings of IEEE Visualization '98, 1998.

A.J. Hanson, "Quaternion Gauss Maps and Optimal Framings of Curves and Surfaces," Indiana University Computer Science Department Technical Report 518 (October, 1998).

Course given at Siggraph '99: A.J. Hanson, "Visualizing Quaternions."

A.J. Hanson, S. Hughes, and E. Wernert, "Constrained Navigation Environments," in *Scientific Visualization: Dagstuhl '97 Proceedings*, Hans Hagen, Gregory M. Nielson, and Frits Post editors; pp. 95–104 IEEE Computer Society Press, Los Alamitos, CA, 2000.

E.A. Wernert and A.J. Hanson, "A Framework for Assisted Exploration with Collaboration," in Proceedings of IEEE Visualization '99, pp. 241–248, 1999.

E.A. Wernert and A.J. Hanson, "Tethering and reattachment in collaborative virtual environments," in Proceedings of Virtual Reality 2000, p. 292. IEEE Computer Society Press, 2000.

Andrew J. Hanson, Chi-Wing Fu, and Eric A. Wernert, "Very Large Scale Visualization Methods for Astrophysical Data." in "Data Visualization 2000," Proceedings of the Joint EUROGRAPHICS and IEEE TCVG Symposium on Visualization, May 29-31, 2000, Amsterdam, the Netherlands, pp. 115–124, Springer-Verlag, 2000.

Course presented at Siggraph 2000: A.J. Hanson, "Visualizing Quaternions."

Animation presented at the Siggraph 2000 Electronic Theater: Andrew J. Hanson and Philip C.W. Fu. Cosmic clock. Siggraph Video Review, vol. 134, scene 5, 2000. 3:35 minute refereed video animation: Observing the Universe using the finite speed of light to place measured objects in their correct temporal context.

Course presented at Siggraph 2001: A.J. Hanson, "Visualizing Quaternions."

Course presented at Siggraph 2001: A.J. Hanson and D. Weiskopf, "Visualizing Relativity."

Video presentations. A.J. Hanson and C.W. Fu, "Solar Journey," 4:00 minute video animation representing a tour of the interstellar neighborhood of our Sun within the Milky Way.

L. Herda, R. Urtasun, A. Hanson, and P. Fua. "Automatic Determination of Shoulder Joint Limits using Quaternion Field Boundaries." In *Proceedings of 5th International Conference on Automated Face and Gesture Recognition*, Washington, D.C., May 2002; pages 95–100, IEEE Computer Society, 2002.

P.C. Frisch and A.J. Hanson, "The Solar Journey: Modeling Features of the Local Bubble and Galactic Environment of the Sun," Poster 11.04, 199th meeting of the American Astronomical Society (AAS), Washington DC, January 2002.

Invited talk, refereed paper: Andrew J. Hanson, Chi-Wing Fu, and Eric A. Wernert, "Visualizing Cosmological Time," pp. 423–438, in *Data visualization: the State of the Art*, eds.: Post, Frits H.; Nielson, Gregory M.; Bonneau,

Georges-Pierre. Boston, Kluwer Academic Publishers, 2003. (Kluwer international series in engineering and computer science : 713). ISBN 1-4020-7259-7 *Proceedings of the Dagstuhl Scientific Visualization Seminar*, May 2000.

L. Herda and R. Urtasun and A. Hanson and P. Fua, “Automatic Determination of Shoulder Joint Limits using Experimentally Determined Quaternion Field Boundaries,” *International Journal on Robotics Research*. pp. 419–434, Volume 22, Issue 6, 1 June 2003.

Invited talk, refereed paper: Andrew J. Hanson and Chi-Wing Fu, “Approaches to Interactive Visualization of Large-scale Dynamic Astrophysical Environments,” in Gerald Farin, Bernd Hamann, and Hans Hagen (editors), *Proceedings of NSF/DoE Lake Tahoe Workshop on Hierarchical Approximation and Geometrical Methods for Scientific Visualization*, October 2000, Tahoe City, CA, pp. 119–142, Springer-Verlag, Berlin, 2003.

Andrew J. Hanson, Chi-Wing Fu, and Priscilla C. Frisch, “Constraint-Based Astronomic Modeling Tools,” in *Geometric Modeling for Scientific Visualization*, edited by Guido Brunnett, Bernd Hamann, and Heinrich Mueller. pp. 437–452, Springer-Verlag, 2003.

Invited presentation. “Exploring the Visualization of Calabi-Yau Spaces,” presented at Dagstuhl Seminar 03231: *Scientific Visualization: Extracting Information and Knowledge from Scientific Data Sets*; Schloss Dagstuhl, Wadern, Germany, 31 May - 6 June, 2003.

Chi-Wing Fu, Tien-Tsin Wong, Wai-Shun Tong, Chi-Keung Tang, and Andrew J. Hanson, “Binary-Space-Partitioned images for Resolving Image-Based Visibility.” *IEEE Transactions on Visualization and Computer Graphics*, vol 10, no 1, pp. 58–71, Jan–Feb 2004.

Book Chapter. Andrew J. Hanson and Philip Chi-Wing Fu, “Applications of MDL to Selected Families of Models,” in *Advances in Minimum Description Length: Theory and Applications*, Ch. 5, pp. 125–150. Edited by Peter D. Grünwald, In Jae Myung, and Mark A. Pitt. MIT Press, Cambridge, MA, 2005. ISBN 0-262-07262-9.

Invited talk.

“Touching the Fourth Dimension.” Invited speaker for the *Conference on 4-Dimensional Worlds*, Feb 25–26, 2005, sponsored by the Institute for Mathematical Behavioral Sciences, University of California at Irvine.

Course presented at Siggraph 2005: “Visualizing Quaternions.”

Andrew J. Hanson and Hui Zhang, “Multimodal Exploration of the Fourth Dimension,” in Proceedings of IEEE Visualization 2005, pp. 263–270, IEEE Computer Society Press, 2005.

Animation accompanying Visualization 2005 paper: “Touching the 4D Torus,” in DVD Proceedings of IEEE Visualization 2005.

Marcus Magnor, Kristian Hildebrand, Andrei Lintu, and Andrew J. Hanson, “Reflection Nebula Visualization.” in Proceedings of IEEE Visualization 2005, pp. 255–262, IEEE Computer Society Press, 2005.

Winner of \$1000 cash Honorable Mention prize in 2005 SensAble 3D Touch Developer Challenge.

Hui Zhang, Sidharth Thakur, and Andrew J. Hanson. *KnotExplore*, a system for sketching, manipulating, and exploring topological knots and links embedded in 3D. (The 2005 SensAble Technologies corporation 3D Touch Developer Challenge haptic interface competition resulted in prizes awarded to 1st, 2nd, 3rd, and five Honorable Mention contestants).

Video Production. A.J. Hanson, director, “Solar Journey,” 20:00 minute computer animation designed for classroom and planetarium pedagogical use. A tour of the interstellar neighborhood of our Sun within the Milky Way, a fly-in to the Black Hole at the center of the galaxy, and a tour of Andromeda and the Large Magellanic Cloud. Finley-Holiday Films, 2006.

Book Andrew J. Hanson, *Visualizing Quaternions*, Morgan-Kaufmann/Elsevier, 2006. (ISBN 10: 0-12-088400-3)

Andrew J. Hanson and Ji-Ping Sha, “A Contour Integral Representation for the Dual Five-Point Function and a Symmetry of the Genus Four Surface in R^6 ,” *Journal of Physics A: Mathematics and General*, 39, pp. 2509–2537, 2006.

Andrew J. Hanson, Priscilla C. Frisch, Chi-Wing Fu, and Yinggang Li, “Galactic Center Fly-In.” Refereed presentation and exhibition of 4-minute animation centered on the black hole at the galactic center. Presentation 160.05 at the 207th meeting of the American Astronomical Society, 8-12 January 2006, Washington, DC. One of 9 selections chosen by the referees from 46 submitted animations.

Chi-Wing Fu, Andrew J. Hanson, and Eric A. Wernert, “Navigation Techniques for Large-Scale Astronomical Exploration.” In Proceedings of *Visualization and Data Analysis 2006* (VDA 2006), January 15–19, 2006, San Jose Convention Center. SPIE vol. 6060, pages 6060:0K-1–6060:0K-10, 2006.

Sidharth Thakur, Andrew J. Hanson, and Geoffrey P. Bingham, “Active visualization methods enable perception of structure and motion in higher dimensional spaces: Comparing active vs. passive perception of the rigidity of 3D and 4d objects,” *Journal of Vision*, Vol. 6, No. 6, pp. 864–864, June, 2006.

Yinggang Li, Chi-Wing Fu, and Andrew J. Hanson, “Scalable WIM: Effective Exploration in Large-scale Astrophysical Environments,” *IEEE Transactions on Visualization and Computer Graphics (TVCG) (Proceedings of IEEE Visualization 2006)*, pages 1005-1011, vol. 12, no. 5, Sep.-Oct. 2006.

Hui Zhang and Andrew J. Hanson, “Physically Interacting with Four Dimensions,” *Advances in Visual Computing, Proceedings of ISVC 2006, Lake Tahoe, NV, Nov 6–8. pages 232–242, 2006 (Springer).*

S. Thakur, A.J. Hanson, and G.P. Bingham, “Active visualization methods enable perception of structure from motion in higher dimensional spaces: Comparing active and passive perception of the rigidity of 3D and 4D objects,” *Journal of Vision*, Vol. 6, No. 4, p. 864a, 2006.

Chi-Wing Fu and Andrew J. Hanson, “A Transparently Scalable Visualization Architecture for Exploring the Universe.” *IEEE Transactions on Visualization and Computer Graphics*, Vol. 13, No. 1, January/February 2007, pp.108-121.

Course presented at Siggraph 2007: “Visualizing Quaternions.”

Hongwei Li, Chi-Wing Fu, Yinggang Li, and Andrew J. Hanson, “Visualizing Large-Scale Uncertainty in Astrophysical Data,” *IEEE Transactions on Visualization and Computer Graphics (TVCG) (Proceedings of IEEE Visualization 2007)*, pages 1640–1647, vol. 13, no. 6, Nov./Dec. 2007.

Hui Zhang and Andrew J. Hanson, “Shadow-Driven 4D Haptic Visualization,” *IEEE Transactions on Visualization and Computer Graphics (TVCG) (Proceedings of IEEE Visualization 2007)*, pages 1688–1695, vol. 13, no. 6, Nov./Dec. 2007.

Hui Zhang, Sidharth Thakur, and Andrew J. Hanson, “Haptic Exploration of Mathematical Knots.” *Advances in Visual Computing, Proceedings of ISVC 2007, Lake Tahoe, NV, Nov 26-28. pages 745–756, 2007 (Springer).*

Sidharth Thakur and Andrew J. Hanson, “A Framework for Exploring High-Dimensional Geometry.” *Advances in Visual Computing, Proceedings of ISVC 2007, Lake Tahoe, NV, Nov 26-28, pages 804–815, 2007 (Springer).*

Film Production.

“The PolarGrid Project: Understanding Global climate change,” a 6.5 minute

film created for the National Science Foundation at the request of NSF Program Director Rita Rodriguez. I conceived the design, wrote the script, participated in the production and editing of the film with Dave Rust's team in the IU office of marketing and communications, and narrated the initial version that was widely distributed by IU and NSF. A final version replaced my narration, using the same script, by the voice of a professional actress from New York City. Final release: June, 2008. See http://www.iuinfo.indiana.edu/bem/productions/polargrid/PolarGrid_Video.html

Submitted, under review.

Andrew J. Hanson and Ji-Ping Sha, "Exploring Visualization Methods for Complex Variables." submitted to proceedings of Dagstuhl 2005–2007 Visualization Workshop.

Hongwei Li, Chi-Wing Fu, and Andrew J. Hanson, "Visualizing Multiwavelength Astrophysical Data," IEEE Transactions on Visualization and Computer Graphics (TVCG) (Proceedings of IEEE Visualization 2008), pages 1555-1562, vol. 14, no. 6, Nov./Dec. 2008.

Andrew J. Hanson and Ji-Ping Sha, "A Tessellation for Fermat Surfaces in CP³." (<http://arxiv.org/abs/0804.3218>), Journal of Symbolic Computation, 15 pages, September 2008. Journal DOI link: <http://dx.doi.org/10.1016/j.jsc.2008.09.002>.

invited talk: Andrew J. Hanson, "Experiencing the Fourth Dimension," abstract # 1047-00-116, p. 61, 1047th Meeting of the American Mathematical Society, UIUC, Urbana, Illinois, March 27-29, 2009.

submitted: Alan Chu, Chi-Wing Fu, Andrew J. Hanson, and Pheng Ann Heng, "4DGPU: A Framework for Interactive Four-Dimensional Visualization," IEEE Transactions on Visualization and Computer Graphics (TVCG) (Proceedings of IEEE Visualization 2009), pages xxxx–xxxx, vol. xx, no. x, Nov./Dec. 2009.

April 15, 2009