

RÉSUMÉ: ANDREW J. HANSON

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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)

Dissertation Title: "A Dual Resonance Model for Meson-Nucleon Scattering"

POSITIONS HELD

Indiana University, Professor Emeritus

Indiana University, Professor, July 1995 through June 2012.

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

Indiana University, Computer Science Dept., Chairman, July 2004 to June 2009.

Indiana University, Computer Science Dept., Director of Graduate Studies, July 1996 to June 2002.

Wolfson College, Cambridge University, UK. Sabbatical – Visiting Fellow, July 2010 to December 2010.

Computer Science and Engineering Department, California Institute of Technology, Pasadena, CA. Sabbatical – Moore Scholar, January 2010 to June 2010.

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

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

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 Theo-
retical 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

Pheng-Ann Heng (1992), Robert Cross (1995), JiYoung Chang (1995), Hui Ma
(1996), Kurt Zimmerman (1998), Eric Wernert (2000), Philip Chi-Wing Fu
(2003), Sidharth Thakur (2008), Hui Zhang (2008), Mitja Hmeljak (2010).

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. Applications of
haptic interfaces and multitouch interfaces such as iPhone environments for
scientific visualization, learning, and understanding.

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

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

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

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

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 kernel on CDC 1604 for the early PLATO automated teaching system; one of the first simultaneous asynchronous multi-user kernels ever implemented, in use for over 10 years.

HONORS AND AWARDS

2013 Distinguished Service Award. “In recognition of outstanding service and support for the Indiana University School of Informatics that furthers the development and excellence of the School and the field of informatics.” Award Ceremony 19 April 2013.

2012 JMGM Graphics Prize. Winner with co-author Sidharth Thakur of the 2012 *Journal of Molecular Graphics and Modelling* Graphics Prize, for the best graphics image of the year.

Moore Scholar. California Institute of Technology, January 2010 to June 2010.

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

GRANT ACTIVITY

“Visualizing Complex Projective Spaces,” FRSP internal IU award in collaboration with Prof. Ji-Ping Sha, Mathematics Department.

- “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.

SUMMARY OF MAJOR WORKS AND CONTRIBUTIONS

4Dice. iPhone/iPad/iPod-Touch application, exploiting multitouch technology to explore four-dimensional geometry (August 2011).

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.

DARPA/DMA Image Understanding Testbed project manager, 1980–1989.

Monograph in theoretical physics: *Gravitation, Gauge Theories and Differential Geometry*, T. Eguchi, P. Gilkey, and A.J. Hanson, Physics Reports, 1980.

Monograph in theoretical physics: *Constrained Hamiltonian Systems*, A.J. Hanson, T. Regge, and C. Teitelboim, Accademia Nazionale dei Lincei, 1976;

Holder of a share in the patent on the PLATO automated teaching system. For development of the original multi-user kernel (1961–1963).

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.

Graphics model provider: Provided the Calabi-Yau graphics models used by the graphics production team for the NOVA “Elegant Universe” series in November, 2003, Show Two and Show Three. The same graphics were reused on the cover of the corresponding article in *Scientific American*, November 2003.

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 Astronomical 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

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>. Formal publication information: Volume 44, Issue 6, June 2009, Pages 591-605

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.

Invited talk: Andrew J. Hanson, “The Challenge of Distinguishing Complexity from Art,” 2009 Gordon Research conference on Visualization in Science and Education, Oxford, UK, July 26-31 2009.

Alan Chu, Chi-Wing Fu, Andrew J. Hanson, and Pheng-Ann Heng, “GL4D: A GPU-based Architecture for Interactive 4D Visualization,” *IEEE Transactions on Visualization and Computer Graphics (TVCG)* (Proceedings of IEEE Visualization 2009), pages 1587–1594, vol. 15, no. 6, Nov./Dec. 2009.

Andrew J. Hanson and Ji-Ping Sha, “Exploring Visualization Methods for Complex Variables,” in *Scientific Visualization, Advanced Concepts*, ed. Hans Hagen. vol. 1, pp. 90–109 (2010).

Sidharth Thakur and Andrew J. Hanson, “A 3D Visualization of Multiple Time Series on Maps,” in Proceedings of 14th International Conference on Information Visualisation (IV10), 27-29 July 2010, London South Bank University (LSBU), London, UK, pages 336–343. (2010)

Session Chair “Information Visualisation: Application – II”; 14th International Conference on Information Visualisation (IV10), 27-29 July 2010, London South Bank University (LSBU), London, UK.

Invited talk: Andrew J. Hanson, “Fermat’s Last Theorem as a Visual Link from Superquadrics to String Theory,” CalTech Computer Science, 9 Feb 2010.

Invited talk: Andrew J. Hanson, “Fermat’s Last Theorem as a Visual Link from Superquadrics to String Theory,” CalTech Math Department Geometry Seminar, 9 April 2010.

Invited talk: Andrew J. Hanson, “The path from Super-Quadrics to Calabi-Yau Spaces via Fermat’s Last Theorem,” DAMTP Cambridge, UK, 29 November 2010.

H. Zhang, J. Weng, and Andrew J. Hanson, “A Pseudo-haptic Knot Diagram Interface,” Proc. SPIE 7868, Visualization and Data Analysis 2011 (Jan. 24, 2011, San Francisco, CA)

Invited talk: Andrew J. Hanson, “Visualizing the Path from Fermat’s Last Theorem to Calabi-Yau Spaces,” Indiana University, School of Informatics and Computing season opener colloquium, 2 September 2011. Posted on YouTube as <http://www.youtube.com/watch?v=Yz6gltKeoM8>

Xiaoqi Yan, Chi-Wing Fu, and Andrew J. Hanson, “Multitouching the Fourth Dimension,” IEEE Computer, Volume 45, Number 9, pp. 80–88 (September, 2012). DOI Bookmark: <http://doi.ieeecomputersociety.org/10.1109/MC.2012.77> (Journal version: <http://www.computer.org/csdl/mags/co/2012/09/mco2012090080-abs.html>)

Andrew J. Hanson and Sidharth Thakur, “Quaternion Maps of Global Protein Structure,” Journal of Molecular Graphics and Modelling, Volume 38, September 2012, Pages 256-278, ISSN 1093-3263, <http://dx.doi.org/10.1016/j.jmkgm.2012.06.004> (Alternate: <http://www.sciencedirect.com/science/article/pii/S1093326312000757>)

Course presented at Siggraph Asia, 2012: “Quaternion Applications.” These lectures were presented at Siggraph Asia 2012, 29 November in Singapore. New application topics included optimal, smoothly controllable tubing and tube texturing, quaternion protein maps, and how dual quaternions solve the century-old conundrum of how a quaternion acts on a vector.

Patricia L. Foster, Andrew J. Hanson, Heewook Lee, Ellen Popodi, and Haixu Tang. “On the Mutational Topology of the Bacterial Genome,” **G3: Genes, Genomes, Genetics**, Volume 3, no. 3, pp. 399–407 (March 2013). Pub Med link: <http://www.ncbi.nlm.nih.gov/pubmed/23450823>, DOI link: <http://dx.doi.org/10.1534/g3.112.005355>, Journal URL: <http://www.g3journal.org/content/3/3/399.abstract.html?etoc>.

Andrew J. Hanson, Gerardo Ortiz, Amr Sabry, and Yu-Tsung Tai. “Geometry of Discrete Quantum Computing,” *J. Phys. A: Math. Theor.* 46, no. 18, pp. 185301 (22 pages), 2013. (doi:10.1088/1751-8113/46/18/185301).

Invited Talk. Andrew J. Hanson, “Multitouching the Fourth Dimension,” ASIC 2013 (24–30 July 2013, Cortina d’Ampezzo, Italy).

Weiming Wang, Xiaoqi Yan, Chi-Wing Fu, Andrew J. Hanson, and Pheng-Ann Heng. “Interactive Exploration of 4D Geometry with Volumetric Halos.” In *Proceedings of Pacific Graphics 2013* (Singapore, October 7–9, 2013). DOI: 10.2312/PE.PG.PG2013short.001-006.

Andrew J. Hanson, Gerardo Ortiz, Amr Sabry, and Yu-Tsung Tai. “Discrete Quantum Theories,” *J. Phys. A: Math. Theor.* 47 (2014) 115305 (20pp) (March, 2014). <http://stacks.iop.org/1751-8121/47/115305>.

In press. Andrew J. Hanson, “Putting Science First: Distinguishing Visualizations from Pretty Pictures,” *IEEE Computer Graphics and Applications, Visualization Viewpoints* column, Theresa-Marie Rhyne, editor. To appear in July/August 2014.

April 8, 2014