

Thomas Funkhouser

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Education

Ph.D. in Computer Science, University of California at Berkeley (September 1993).
M.S. in Computer Science, University of California at Los Angeles (June 1989).
B.S. in Biological Sciences, Stanford University (June 1983).

Employment

David M. Siegel Professor, Department of Computer Science, Princeton University, (2016 - present).
Professor, Department of Computer Science, Princeton University, (2009 - 2016).
Associate Professor, Department of Computer Science, Princeton University, (2003 - 2009).
Assistant Professor, Department of Computer Science, Princeton University, (1998 - 2003).
Member of the Technical Staff, Bell Laboratories (1993 - 1998).

Publications

Refereed Journal Publications:

1. E. Sizikova, T. Funkhouser.
“Fresco Reconstruction Using a Genetic Algorithm,”
to appear in ACM Journal of Computing and Cultural Heritage, 2017.
2. Amit H. Bermano, Thomas Funkhouser and Szymon Rusinkiewicz,
“State of the Art in Methods and Representations for Fabrication-Aware Design,”
to appear in Computer Graphics Forum (Proc. Eurographics), STAR Report, April 2017.
3. Tianqiang Liu, Aaron Hertzmann, Wilmot Li, and Thomas Funkhouser,
“Style Compatibility for 3D Furniture Models,”
ACM Transactions on Graphics (Proc. SIGGRAPH), 2015.
4. Tianqiang Liu, Jim McCann, Wilmot Li, Thomas Funkhouser,
“Composition-Aware Scene Optimization for Product Images,”
Computer Graphics Forum (Proc. Eurographics), May 2015
5. Tianqiang Liu, Siddhartha Chaudhuri, Vladimir G. Kim, Qi-Xing Huang, Niloy J. Mitra, and Thomas Funkhouser, “Creating Consistent Scene Graphs Using a Probabilistic Grammar,”
ACM Transactions on Graphics (Proc. SIGGRAPH Asia), December 2014.
6. Vladimir Kim, Siddhartha Chaudhuri, Leonidas Guibas, and Thomas Funkhouser,
“Shape2Pose: Human-centric Shape Analysis,”
ACM Transactions on Graphics (Proc. SIGGRAPH), August 2014.
7. Vladimir Kim, Wilmot Li, Niloy Mitra, Siddhartha Chaudhuri, Stephen DiVerdi, and Thomas Funkhouser,
“Learning Part-based Templates from Large Collections of 3D Shapes,”
ACM Transactions on Graphics (Proc. SIGGRAPH), July 2013.
8. Matthew Fisher, Daniel Ritchie, Manolis Savva, Thomas Funkhouser, and Pat Hanrahan.
“Example-based Synthesis of 3D Object Arrangements,”
ACM Transactions on Graphics (Proc. SIGGRAPH Asia), 31(6), November 2012.
9. Hijung Shin, Christos Doumas, Thomas Funkhouser, Szymon Rusinkiewicz,
Kenneth Steiglitz, Andreas Vlachopoulos, and Tim Weyrich,
“Analyzing and Simulating Fracture Patterns of Thera Wall Paintings,”
ACM Journal of Computing and Cultural Heritage, 5(3), October 2012.
10. Xiaobai Chen, Abulhair Saparov, Bill Pang, and Thomas Funkhouser,
“Schelling Points on 3D Surface Meshes,”
ACM Transactions on Graphics (Proc. SIGGRAPH), August 2012.
11. Vladimir G. Kim, Wilmot Li, Niloy Mitra, Stephen DiVerdi, and Thomas Funkhouser,
“Exploring Collections of 3D Models using Fuzzy Correspondences,”
ACM Transactions on Graphics (Proc. SIGGRAPH), August 2012.

12. Yaron Lipman, Vladimir G. Kim, Thomas Funkhouser,
"Simple Formulas For Quasiconformal Plane Deformations,"
ACM Transactions on Graphics, 31(5), August 2012.
13. Tianqiang Liu, Vladimir G. Kim, Thomas Funkhouser,
"Finding Surface Correspondences Using Symmetry Axis Curves,"
Computer Graphics Forum (Proc. Symposium on Geometry Processing), July 2012
14. Vladimir G. Kim, Yaron Lipman, Thomas Funkhouser,
"Symmetry-Guided Texture Synthesis and Manipulation,"
ACM Transactions on Graphics, 31(3), May 2012.
15. Forrester Cole, Aleksey Golovinskiy, Alex Limpaecher, Heather Stoddart Barros,
Adam Finkelstein, Thomas Funkhouser, and Szymon Rusinkiewicz,
"Where Do People Draw Lines?,"
Communications of the ACM, 55(1):107-115, January 2012.
16. Aleksey Boyko and Thomas Funkhouser,
"Extracting roads from dense point clouds in large scale urban environment,"
ISPRS Journal of Photogrammetry and Remote Sensing, 66(6):S2-S12, December 2011.
(themed Issue on "Advances in LiDAR data processing and applications)
17. Thomas Funkhouser, Hijung Shin, Corey Toler-Franklin, Antonio García Castaneda,
Benedict Brown, David Dobkin, Tim Weyrich, and Szymon Rusinkiewicz,
"Learning How to Match Fresco Fragments,"
ACM Journal on Computing and Cultural Heritage, 4(2), November 2011.
18. Doug M. Boyer, Yaron Lipman, Elizabeth St. Clair, Jesus Puente, Biren A. Patel,
Thomas Funkhouser, Jukka Jernvall, and Ingrid Daubechies,
"Algorithms to Automatically Quantify the Geometric Similarity of Anatomical Surfaces,"
Proceedings of the National Academy of Science (PNAS), October 2011.
19. Vladimir G. Kim, Yaron Lipman, and Thomas Funkhouser ,
"Blended Intrinsic Maps,"
ACM Transactions on Graphics (SIGGRAPH 2011), 30(3), August 2011.
20. Corey Toler-Franklin, Benedict Brown, Tim Weyrich, Thomas Funkhouser, Szymon Rusinkiewicz,
"Multi-Feature Matching of Fresco Fragments,"
ACM Transactions on Graphics (SIGGRAPH Asia 2010), 29(5), December 2010.
21. Yaron Lipman, Xiaobai Chen, and Thomas Funkhouser,
"Symmetry Factored Embedding and Distance,"
ACM Transactions on Graphics (SIGGRAPH 2010), 29(3), July 2010.
22. Vladimir Kim, Yaron Lipman, Xiaobai Chen, and Thomas Funkhouser,
"Mobius Transformations For Global Intrinsic Symmetry Analysis,"
Computer Graphics Forum (Symposium on Geometry Processing), 29(5), July 2010.
23. Jian Sun, Xiaobai Chen, and Thomas Funkhouser,
Fuzzy Geodesics and Consistent Sparse Correspondences For Deformable Shapes,
Computer Graphics Forum (Symposium on Geometry Processing), 29(5), July 2010.
24. Yaron Lipman, Raif Rustamov, Thomas Funkhouser,
"Biharmonic Distance,"
ACM Transactions on Graphics, 29(3), June 2010.
25. John Capra, Roman Laskowski, Janet Thornton, Mona Singh, and Thomas Funkhouser,
"Predicting Protein Ligand Binding Sites by Combining Evolutionary Sequence Conservation and 3D
Structure," *PLoS Computational Biology*, 5(12): e1000585, 2009.
26. Xiaobai Chen, Aleksey Golovinskiy, and Thomas Funkhouser,
"A Benchmark for 3D Mesh Segmentation,"
ACM Transactions on Graphics (SIGGRAPH 2009), 28(3), August 2009.
27. Yaron Lipman and Thomas Funkhouser,
"Mobius Voting for Surface Correspondence,"
ACM Transactions on Graphics (SIGGRAPH 2009), 28(3), August 2009.
28. Forrester Cole, Kevin Sanik, Doug DeCarlo, Adam Finkelstein, Thomas Funkhouser,
Szymon Rusinkiewicz, and Manish Singh,
"How Well Do Line Drawings Depict Shape?,"
ACM Transactions on Graphics (SIGGRAPH 2009), 28(3), August 2009.

29. Raif Rustamov, Yaron Lipman, and Thomas Funkhouser,
"Interior Distance Using Barycentric Coordinates,"
Computer Graphics Forum (Symposium on Geometry Processing), 28(5), 2009.
30. Alex Golovinskiy and Thomas Funkhouser,
"Consistent Segmentation of 3D Models,"
Computers and Graphics (Shape Modeling International), Beijing, China, June, 2009.
31. Alex Golovinskiy and Thomas Funkhouser,
"Randomized Cuts for 3D Mesh Analysis",
ACM Transactions on Graphics (Proc. SIGGRAPH Asia), 27(5), December 2008.
32. Forrester Cole, Aleksey Golovinskiy, Alex Limpaecher, Heather Stoddart Barros,
Adam Finkelstein, Thomas Funkhouser, and Szymon Rusinkiewicz.
"Where Do People Draw Lines?,"
ACM Transactions on Graphics (Proc. SIGGRAPH), 27(3), August 2008.
33. Philip Shilane and Thomas Funkhouser. "Distinctive Regions of 3D Surfaces,"
ACM Transactions on Graphics, 26(2), June 2007.
34. Joshua Podolak, Philip Shilane, Aleksey Golovinskiy, Szymon Rusinkiewicz, and Thomas Funkhouser.
"A Planar-Reflective Symmetry Transform for 3D Shapes,"
ACM Transactions on Graphics (Proc. SIGGRAPH), 25(3), July 2006.
35. Aleksey Golovinskiy, Wojciech Matusik, Hanspeter Pfister, Szymon Rusinkiewicz, and Thomas Funkhouser.
"A Statistical Model for Synthesis of Detailed Facial Geometry,"
ACM Transactions on Graphics (Proc. SIGGRAPH), 25(3), July 2006.
36. Grant Wallace, Han Chen, Yuqun Chen, Zhiyan Liu, Rudrajit Samanta, Peng Bi, Anoop Gupta, Matthew Hibbs, Kai Li, Adam Finkelstein, Thomas Funkhouser, Perry Cook, Rahul Sukthankar, and Olga Troyanskaya,
"Tools and Applications for Large Scale Display Walls,"
IEEE Computer Graphics and Applications, 25(4):24-33, 2005.
37. Thomas Funkhouser, Michael Kazhdan, Philip Shilane, Patrick Min, William Kiefer, Ayellet Tal, Szymon Rusinkiewicz, and David Dobkin, "Modeling by Example,"
ACM Transactions on Graphics (SIGGRAPH 2004), August 2004.
38. Michael Kazhdan, Thomas Funkhouser, and Szymon Rusinkiewicz,
"Anisotropy and Shape Matching,"
ACM Transactions on Graphics (SIGGRAPH 2004), August 2004.
39. Thomas Funkhouser, Nicolas Tsingos, Ingrid Carlbom,
Gary Elko, Mohan Sondhi, James West, Gopal Pingali, Patrick Min, and Addy Ngan,
"A Beam Tracing Method for Interactive Architectural Acoustics,"
Journal of the Acoustical Society of America, 115(2):739-756, February 2004.
40. Michael Kazhdan, Bernard Chazelle, David Dobkin, Thomas Funkhouser, and Szymon Rusinkiewicz,
"A Reflective Symmetry Descriptor for 3D Models",
Algorithmica, 38(2):201-225, November 2003.
41. Daniel Aliaga, Thomas Funkhouser, Dimah Yanovsky, and Ingrid Carlbom,
"Sea of Images: A Dense Sampling Approach for Rendering Large Indoor Environments,"
Computer Graphics & Applications, 23(6):22-30, November 2003.
42. Thomas Funkhouser, Patrick Min, Misha Kazhdan,
Joyce Chen, Alex Halderman, David Dobkin, and David Jacobs,
"A Search Engine for 3D Models,"
ACM Transactions on Graphics, 22(1), January 2003.
43. Robert Osada, Thomas Funkhouser, Bernard Chazelle, and David Dobkin,
"Shape Distributions,"
ACM Transactions on Graphics, 21(4), October 2002.
44. Nicolas Tsingos, Ingrid Carlbom, Gary Elko, Thomas Funkhouser, and Robert Kubli,
"Validation of Acoustics Simulations in the Bell Labs Box,"
IEEE Computer Graphics & Applications, 22(4), July 2002.
45. Nicolas Tsingos, Thomas Funkhouser, Addy Ngan, and Ingrid Carlbom,
"Modeling Acoustics in Virtual Environments Using the Uniform Theory of Diffraction,"
Computer Graphics (SIGGRAPH 2001), August 2001.
46. Han Chen, Yuqun Chen, Adam Finkelstein, Thomas Funkhouser, Kai Li, Zhiyan Liu,
Rudrajit Samanta, and Grant Wallace, "Data Distribution Strategies for High-Resolution Displays,"
Computers & Graphics, 25(5), October 2001.

47. Allison Klein, Wilmot Li, Michael Khazdan, Wagner Corrêa, Adam Finkelstein, and Thomas Funkhouser, "Non-photorealistic Virtual Environments," *Computer Graphics* (SIGGRAPH 2000), July 2000.
48. Kai Li, Han Chen, Yuqun Chen, Douglas W. Clark, Perry Cook, Stefanos Damianakis, Georg Essl, Adam Finkelstein, Thomas Funkhouser, Timothy Housel, Allison Klein, Zhiyan Liu, Emil Praun, Rudrajit Samanta, Ben Shedd, Jaswinder Pal Singh, George Tzanetakis, and Jiannan Zheng, "Early Experiences and Challenges in Building and Using a Scalable Display Wall System," *IEEE Computer Graphics and Applications*, 20(4), July 2000.
49. Thomas Funkhouser, Patrick Min, and Ingrid Carlbom, "Real-Time Acoustic Modeling for Distributed Virtual Environments," *Computer Graphics* (SIGGRAPH '99), August 1999.
50. Thomas Funkhouser, "A Visibility Algorithm for Hybrid Geometry- and Image-Based Modeling and Rendering," *Computers and Graphics*, 23(5), October 1999.
51. Thomas Funkhouser, Ingrid Carlbom, Gary Elko, Gopal Pingali, Mohan Sondhi, and Jim West, "A Beam Tracing Approach to Acoustic Modeling for Interactive Virtual Environments," *Computer Graphics* (SIGGRAPH '98), July 1998.
52. Thomas Funkhouser, "Coarse-Grained Parallelism for Hierarchical Radiosity Using Group Iterative Methods," *Computer Graphics* (SIGGRAPH '96), New Orleans, LA, August 1996.
53. Thomas Funkhouser, Seth J. Teller, Carlo H. Séquin, and Delnaz Khorramabadi, "The UC Berkeley System for Interactive Visualization of Large Architectural Models," *Presence*, 5(1), January 1996.
54. Seth Teller, Celeste Fowler, Thomas Funkhouser, and Pat Hanrahan, "Partitioning and Ordering Large Radiosity Computations," *Computer Graphics* (SIGGRAPH '94), August 1994.
55. Thomas Funkhouser and Carlo H. Séquin, "Adaptive Display Algorithms for Interactive Frame Rates During Visualization of Complex Virtual Environments," *Computer Graphics* (SIGGRAPH '93), August 1993.

Refereed Conference Publications:

56. Andy Zeng, Shuran Song, Matthias Niessner, Matthew Fisher, Jianxiong Xiao, and Thomas Funkhouser, "3DMatch: Learning Local Geometric Descriptors from RGB-D Reconstructions," to appear in *Computer Vision and Pattern Recognition (CVPR)*, July 2017 (oral presentation).
57. Shuran Song, Fisher Yu, Andy Zeng, Angel Chang, Manolis Savva, and Thomas Funkhouser, "Semantic Scene Completion from a Single Depth Image," to appear in *Computer Vision and Pattern Recognition (CVPR)*, July 2017 (oral presentation).
58. Angela Dai, Angel X. Chang, Manolis Savva, Maciej Halber, Thomas Funkhouser, Matthias Niessner, "ScanNet: Richly-annotated 3D Reconstructions of Indoor Scenes," to appear in *Computer Vision and Pattern Recognition (CVPR)*, July 2017 (spotlight presentation).
59. Y. Zhang,* S. Song,* E. Yumer, M. Savva, J. Lee, H. Jin, and T. Funkhouser, "Physically-Based Rendering for Indoor Scene Understanding Using Convolutional Neural Networks," to appear in *Computer Vision and Pattern Recognition (CVPR)*, July 2017.
60. Fisher Yu, Vladlen Koltun, and Thomas Funkhouser "Dilated Residual Networks," to appear in *Computer Vision and Pattern Recognition (CVPR)*, July 2017.
61. Maciej Halber and Thomas Funkhouser, "Fine-To-Coarse Global Registration of RGB-D Scans," to appear in *Computer Vision and Pattern Recognition (CVPR)*, July 2017.
62. Elena Sizikova and Thomas Funkhouser, "Wall Painting Reconstruction Using a Genetic Algorithm," *EUROGRAPHICS Workshop on Graphics and Cultural Heritage*, October 2016 (best paper award).
63. David Dohan, Brian Matejek, and Thomas Funkhouser, "Leaning Hierarchical Semantic Segmentation of LIDAR Data," *International Conference on 3D Vision (3DV)*, 2015.

64. Aleksey Boyko and Thomas Funkhouser,
"Cheaper by the Dozen: Group Annotation of 3D Data,"
ACM Symposium on User Interface Software and Technology (UIST), October 2014.
65. Siddhartha Chaudhuri, Evangelos Kalogerakis, Stephen Giguere, and Thomas Funkhouser,
"Attribl: Content Creation with Semantic Attributes,"
ACM Symposium on User Interface Software and Technology (UIST), October 2013.
66. Antonio García Castañeda, Benedict Brown, Szymon Rusinkiewicz, Thomas Funkhouser, and Tim Weyrich, "Global Consistency in the Automatic Assembly of Fragmented Artefacts,"
Intl. Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST), Prato Italy, October 2011.
67. Thomas Funkhouser, Hijung Shin, Corey Toler-Franklin, Antonio García Castaneda, Benedict Brown, David Dobkin, Tim Weyrich, and Szymon Rusinkiewicz,
"Learning How to Match Fresco Fragments,"
Eurographics (Area Paper), April 2011.
68. Hijung Shin, Christos Doumas, Thomas Funkhouser, Szymon Rusinkiewicz, Ken Steiglitz, Andreas Vlachopoulos, and Tim Weyrich, "Analyzing Fracture Patterns in Theran Wall Paintings,"
The 11th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST), September, 2010.
69. Aleksey Golovinskiy, Vladimir Kim, and Thomas Funkhouser,
"Shape-based Recognition of 3D Point Clouds in Urban Environments,"
International Conference on Computer Vision (ICCV), September 2009.
70. Aleksey Golovinskiy and Thomas Funkhouser,
"Min-Cut Based Segmentation of Point Clouds,"
Search in 3D and Video (S3DV), September 2009.
71. Jeehyung Lee and Thomas Funkhouser.
"Sketch-Based Search and Composition of 3D Models",
EUROGRAPHICS Workshop on Sketch-Based Interfaces and Modeling, June 2008.
72. Thomas Funkhouser and Philip Shilane,
"Partial Matching of 3D Shapes with Priority-Driven Search,"
Symposium on Geometry Processing, Sardinia Italy, June 2006.
73. Philip Shilane and Thomas Funkhouser,
"Selecting Distinctive 3D Shape Descriptors for Similarity Retrieval,"
Shape Modeling International, Sendai Japan, June 2006.
74. Paul Calamia, Peter Svensson, and Thomas Funkhouser,
"Integration of edge-diffraction calculations and geometrical-acoustics modeling",
Forum Acusticum, Budapest Hungary, August 2005.
75. Thomas Funkhouser, Fabian Glaser, Roman Laskowski1, Richard Morris, Rafael Najmanovich, Gareth Stockwell, and Janet Thornton, "Shape-Based Classification of Bound Ligands,"
LASR Workshop on Quantitative Biology, Shape Analysis, and Wavelets, Leeds England, June 2005.
76. Richard J. Morris, Abdullah Kahraman, Thomas Funkhouser, Rafael Najmanovich, Gareth Stockwell, Fabian Glaser, Roman Laskowski, and Janet M. Thornton,
"Binding Pocket Shape Analysis for Protein Function Prediction,"
LASR Workshop on Quantitative Biology, Shape Analysis, and Wavelets, Leeds England, June 2005.
77. Patrick Min, Michael Kazhdan and Thomas Funkhouser,
"A Comparison of Text and Shape Matching for Retrieval of Online 3D Models,"
European Conference on Digital Libraries, September 2004.
78. Michael Kazhdan, Thomas Funkhouser, and Szymon Rusinkiewicz,
"Symmetry Descriptors and 3D Shape Matching",
ACM Symposium on Geometry Processing, June 2004.
79. Philip Shilane, Patrick Min, Michael Kazhdan, and Thomas Funkhouser,
"The Princeton Shape Benchmark,"
Shape Modeling International, Genova, Italy, June 2004.
80. Jason Lawrence and Thomas Funkhouser,
"A Painting Interface for Interactive Surface Deformations,"
Pacific Graphics, Alberta, Canada, October 2003.
81. Michael Kazhdan, Thomas Funkhouser, and Szymon Rusinkiewicz,
"Rotation Invariant Spherical Harmonic Representation of 3D Shape Descriptors,"
Symposium on Geometry Processing, Aachen Germany, 2003.

82. Daniel Aliaga, Dimah Yanovsky, Thomas Funkhouser, and Ingrid Carlbom, "Interactive Image-Based Rendering using Feature Globalization," ACM SIGGRAPH Symposium on Interactive 3D Graphics, April 2003.
83. Patrick Min, Alex Halderman, Michael Kazhdan, and Thomas Funkhouser, "Early Experiences with a 3D Model Search Engine," Web3D Symposium, March 2003.
84. Daniel Aliaga, Thomas Funkhouser, Dimah Yanovsky, and Ingrid Carlbom, "Sea of Images," *IEEE Visualization*, November 2002.
85. Michael Kazhdan, Bernard Chazelle, David Dobkin, Adam Finkelstein, and Thomas Funkhouser, "A Reflective Symmetry Descriptor," *European Conference on Computer Vision (ECCV)*, May 2002.
86. Han Chen, Grant Wallace, Anoop Gupta, Kai Li, Tom Funkhouser, Perry Cook, "Experiences with Scalability of Display Walls," *Seventh Annual Immersive Projection Technology Symposium (IPT)*, March 2002.
87. Rudrajit Samanta, Thomas Funkhouser, and Kai Li, "Parallel Rendering with K-Way Replication," *IEEE Symposium on Parallel and Large-Data Visualization and Graphics*, October 2001.
88. Robert Osada, Thomas Funkhouser, Bernard Chazelle, and David Dobkin, "Matching 3D Models with Shape Distributions," *Shape Modeling International*, May 2001.
89. Rudrajit Samanta, Thomas Funkhouser, Kai Li, and Jaswinder Pal Singh, "Hybrid Sort-First and Sort-Last Parallel Rendering with a Cluster of PCs," *SIGGRAPH/Eurographics Workshop on Graphics Hardware*, August 2000.
90. Patrick Min and Thomas Funkhouser, "Priority-Driven Acoustic Modeling for Virtual Environments," *Eurographics*, August 2000.
91. Rudrajit Samanta, Jiannan Zheng, Thomas Funkhouser, Kai Li, and Jaswinder Pal Singh, "Load Balancing for Multi-Projector Rendering Systems," *SIGGRAPH/Eurographics Workshop on Graphics Hardware*, August 1999.
92. T.M. Murali and Thomas Funkhouser, "Consistent Solid and Boundary Representations from Arbitrary Polygonal Data," *Computer Graphics (SIGGRAPH Symposium on Interactive 3D Graphics)*, March 1997.
93. Alex Biliris, Thomas Funkhouser, William O'Connell, and Thimios Panagos, "BeSS: Storage Support for Interactive Visualization Systems," *ACM-SIGMOD 1996 International Conference on Management of Data*, May 1996.
94. Thomas Funkhouser, "Database Management for Interactive Display of Large Architectural Models," *Graphics Interface*, May 1996.
95. Thomas Funkhouser, "Network Topologies for Scalable Multi-User Virtual Environments," *IEEE Virtual Reality International Symposium*, April 1996.
96. Thomas Funkhouser, "Interactive Exploration of WWW Data in 3D Virtual Environments," *Webweek*, November 1996.
97. Thomas Funkhouser, "Network Services for Multi-User Virtual Environments," *IEEE Network Realities*, October 1995.
98. Thomas Funkhouser, "RING: A Client-Server System for Multi-User Virtual Environments," *Computer Graphics (SIGGRAPH Symposium on Interactive 3D Graphics)*, April 1995.
99. Michael Potmesil and Thomas Funkhouser, "Placing WWW Links into 2D and 3D Spatial Models," *World Wide Web TIES Conference*, April 1995.
100. Thomas Funkhouser, Carlo Séquin, and Seth Teller, "Management of Large Amounts of Data in Interactive Building Walkthroughs," *Computer Graphics (SIGGRAPH Symposium on Interactive 3D Graphics)*, March 1992.

Invited Publications:

101. Forrester Cole, Aleksey Golovinskiy, Alex Limpaecher, Heather Stoddart Barros, Adam Finkelstein, Thomas Funkhouser, and Szymon Rusinkiewicz. "Where Do People Draw Lines?," *Communications of the ACM*, 55(1): 107-115, January 2012.
102. Aleksey Golovinskiy, Joshua Podolak, and Thomas Funkhouser, "Symmetry-Aware Mesh Processing," *Mathematics of Surfaces* (invited paper), LNCS 5654, September 2009.
103. Thomas Funkhouser, Michael Kazhdan, Patrick Min, and Philip Shilane, "Shape-Based Retrieval and Analysis of 3D Models," *Communications of the ACM*, 48(6), June 2005.
104. Thomas Funkhouser, Nicolas Tsingos, Ingrid Carlbom, Gary Elko, Mohan Sondhi, and Jim West, "Modeling Sound Reflection and Diffraction in Architectural Environments with Beam Tracing," *Forum Acusticum*, September 2002.
105. Thomas Funkhouser and Kai Li, "Large Format Displays", guest editor introduction to special issue on large format displays, *IEEE Computer Graphics and Applications*, 20(4), July 2000.
106. Thomas Funkhouser, Ingrid Carlbom, Gary Elko, Gopal Pingali, Mohan Sondhi, and Jim West, "Interactive Acoustic Modeling of Complex Environments," *Joint Meeting of the 137th Regular Meeting of the Acoustical Society of America and the 2nd Convention of the European Acoustics Association: Forum Acusticum '99*; *Journal of the Acoustical Society of America*, 105 (2), March 1999.

Other Publications:

107. Fisher Yu, Ari Seff, Yinda Zhang, Shuran Song, Thomas Funkhouser, and Jianxiong Xiao, "LSUN: Construction of a Large-Scale Image Dataset Using Deep Learning with Humans in the Loop," arXiv:1506.03365, June 2016.
108. Angel Chang, Thomas Funkhouser, Leonidas Guibas, Patrick Hanrahan, Qixing Huang, Z. Li, Silvio Savarese, Manolis Savva, Shuran Song, Hao Su, Jianxiong. Xiao, Li Yi, and Fu Yu., "ShapeNet: An Information-Rich 3D Model Repository", arXiv:1512.03012 [cs.CV] 9 Dec 2015
109. Elena Sizikova and Thomas Funkhouser. "Automatically Assembling Frescos from Noisy Pairwise Fragment Measurements." *Computer Applications and Quantitative Methods in Archaeology (CAA)*, oral presentation, 2015.
110. Antonio García Castañeda, Benedict Brown, Szymon Rusinkiewicz, Thomas Funkhouser, and Tim Weyrich, "Verification-Minimal Assembly of Fragmented Frescoes," *Conference on Computer Applications and Quantitative Methods in Archaeology (CAA)*, poster, 2015.
111. Xiaobai Chen, Thomas Funkhouser, Dan B Goldman, and Eli Shechtman, "Non-parametric texture transfer using MeshMatch," Technical Report 2012-2, Adobe, November 2012.
112. Thomas A. Funkhouser, Roman A. Laskowski, and Janet M. Thornton, "Finding and Extracting Active Site Cavities in Proteins," *Structural Bioinformatics and Computational Biophysics Meeting (3DSIG)*, Vienna, Austria, July 2007.
113. Thomas Funkhouser, Roman Laskowski, and Janet Thornton, "Matching Volumetric Models of Protein Active Sites," *2nd Structural Bioinformatics & Computational Biophysics Meeting (3D SIG)*, ISMB, Fortaleza Brazil, June 2006.
114. Thomas Funkhouser, Roman Laskowski, and Janet Thornton, "Protein Function Prediction by Matching Volumetric Models of Active Sites," *Automated Function Prediction Conference*, San Diego CA, August 2006.
115. Thomas Funkhouser, Jean-Marc Jot, and Nicolas Tsingos, "Survey of Methods for Modeling Sound Propagation in Interactive Virtual Environment Systems," accepted for publication in *Presence*, 2004.
116. Thomas Funkhouser, Nicolas Tsingos, and Jean-Marc Jot, "Computational Sound for Graphics, Virtual Reality, and Interactive Systems," *SIGGRAPH 2002, Course #45 Notes*, July 2002.

117. Michael Kazhdan and Thomas Funkhouser,
 “Harmonic 3D Shape Matching,”
SIGGRAPH 2002, Technical Sketch, July 2002.
118. Patrick Min, Joyce Chen, and Thomas Funkhouser,
 “A 2D Sketch Interface for a 3D Model Search Engine,”
SIGGRAPH 2002, Technical Sketch, July 2002.
119. Thomas Funkhouser, Nicolas Tsingos, Ingrid Carlbom, Gary Elko, Gopal Pingali, Mohan Sondhi, and Jim West, “Interactive and Aliasing-Free Acoustic Modeling of Reflections and Diffractions in Architectural Environments,” in *Proceedings of the 141st Meeting of the Acoustical Society of America*, Journal of the Acoustical Society of America, 109 (5), June 2001 (abstract).
120. Rudrajit Samanta, Thomas Funkhouser, Kai Li, and Jaswinder Pal Singh,
 “Sort-First Parallel Rendering with a Cluster of PCs,”
SIGGRAPH 2000, Technical Sketch, July 2000.
121. Ingrid Carlbom and Thomas Funkhouser,
 “3D Virtual Environments for Business Applications,”
NetDays, November 1997 (abstract).
122. Thomas Funkhouser, Gopal Pingali, Gary Elko, Mohan Sondhi, Jim West, Ingrid Carlbom, and Mike Gatlin, “Interactive Auralization of Virtual Environments,” *NetDays*, November 1997 (abstract).
123. Thomas Funkhouser,
 “Database and Display Algorithms for Interactive Visualization of Architectural Models,”
 Technical Report UCB/CSD93/771 (Ph.D. Thesis), UC Berkeley, September 1993.

Honors and Awards

Research Awards:

- ACM SIGGRAPH Computer Graphics Achievement Award (2014)
- Google Research Award (2007, 2009, 2011, 2012, 2013, 2015).
- Emerson Electric, E. Lawrence Keyes Faculty Advancement Award (2001).
- National Science Foundation Career Award (2000).
- Alfred P. Sloan Research Fellowship (1999).

Teaching Awards:

- Princeton University Council, Excellence in Teaching Award (COS 126, Fall 2009).
- Princeton University Council, Excellence in Teaching Award (COS 426, Spring 2009).

Visiting Professorships:

- Visiting Professor, Stanford University (2011-2012)
- Visiting Professor, University of College London (2010-present)
- Leverhulme Trust Visiting Professorship, Cambridge University (2004 – 2005).

Fellowships:

- BBSRC International Fellowship (2004 – 2005).
- California Fellowship in Microelectronics, University of California at Berkeley (1989 - 1990).
- Departmental Fellowship Award, University of California at Los Angeles (1987 - 1989).

Professional Activities

Editorships:

- Editorial board, ACM Transactions on Applied Perception (2001- 2006).
- Editorial board, Graphical Models (2000 - 2004).
- Co-Guest Editor, Computers and Graphics, Special Issue on 3D Shape Analysis (2006).
- Co-Guest Editor, IEEE Computer Graphics & Applications, Special Issue on Large-Scale Displays (July 2000).

Industrial Centers:

- Co-director, Intel Science and Technology Center on Visual Computing (2012 - 2014).

Conference Committees:

Papers chair, ACM SIGGRAPH (2009).
Papers chair, ACM Symposium on Geometry Processing (2014).
Advisory board, ACM SIGGRAPH (2008, 2011).
Advisory board, ACM SIGGRAPH ASIA (2009).
Papers sort committee, ACM SIGGRAPH (2008, 2009, 2013, 2014, 2015, 2017)
Program committee, ACM SIGGRAPH (1997, 1998, 2001, 2003, 2004, 2006, 2007, 2008, 2009, 2011, 2013).
Program committee, ACM SIGGRAPH Asia (2008).
Program committee, ACM Symposium on Geometry Processing (2007, 2008, 2010, 2011, 2015, 2016).
Program committee, Shape Modeling International (2004, 2006, 2007, 2008, 2010, 2016).
Program committee, Sketch-Based Interfaces and Modeling (2010).
Program committee, Non-Rigid Shape Analysis and Deformable Image Alignment (2010).
Program committee, CVPR (2007).
Program committee, Search in 3D Workshop (2007).
Program committee, ACM Symposium on Interactive 3D Graphics (1995, 2001, 2006, 2007).
Program committee, Web3D (2003).
Program committee, Eurographics (2002).
Program committee, IEEE Visualization (2000, 2001, 2002).
Program committee, IEEE Virtual Reality Conference (1999, 2000, 2001, 2002, 2003).
Program committee, IEEE Virtual Reality Annual International Symposium (1995, 1996, 1997, 1998).
Organizer, Tristate Workshop on Imaging and Computer Graphics (2014).
Organizer, Workshop on Shape-Based Retrieval and Analysis of 3D Models (2001).

Keynote and Invited Conference Talks:

1. "Scene Understanding with 3D Deep Networks,"
Neural Information Processing Systems (NIPS), 3D Deep Learning Workshop, Barcelona, Spain (2016).
2. "Finding Surface Correspondences With Shape Analysis,"
The 6th Annual Henry Taub TCE Conference, Technion, Haifa, Israel (2016).
3. "Five Principles for Choosing Research Problems in Computer Graphics,"
ACM SIGGRAPH Computer Graphics Achievement Award Talk, Vancouver, BC (2014).
4. "Learning Probabilistic Models from Collections of 3D Meshes," Invited talk,
SUNw: Scene Understanding Workshop at CVPR, Columbus, Ohio (2014).
5. "Discovering Similarities in 3D Data," Invited talk,
Research Workshop on Shape and Image Modeling and Analysis (SIMA) (2014).
6. "Diffusing Similarities in 3D Data," Keynote talk,
Solid Modeling Symposium, Burgundy, Dijon, France (2012).
7. "Symmetry-Aware Mesh Processing", Invited talk,
Mathematics of Surfaces XIII, York, UK (2009).
8. "Modeling Cities from Lidar", Invited talk,
Workshop on City Modeling, Simulation, and Visualization, Shenzhen, China (2008).
9. "Symmetry Analysis and its Applications", Invited talk,
Workshop on New Research Topics in Shape, Solid, and Physical Modeling, Stony Brook, NY (2008).
10. "Searching for 3D Models", Keynote talk,
Innovative Manufacturing Research Conference, Edinburgh, Scotland (2005).
11. "A Search Engine for 3D Models", Keynote talk,
ASCI Conference, Port Zelande, Netherlands (2004).
12. "Shape-based Analysis and Retrieval", Keynote talk,
Smart Graphics, Heidelberg, Germany (2003).
13. "Geometric Models for Sound Propagation for Interactive Virtual Environments,"
ACM SIGGRAPH Campfire on Acoustic Rendering, Snowbird, Utah (2001).
14. "Beam Tracing Methods for Acoustic Modeling,"
Computational Geometry Center Workshop, The John Hopkins University, Baltimore, Maryland (1999).
15. "Interactive Acoustic Modeling of Complex Environments,"
Joint Meeting of the 137th Regular Meeting of the Acoustical Society of America and the 2nd Convention of the European Acoustics Association: Forum Acusticum, Berlin, Germany (1999).

Conference Panels and Courses:

1. Speaker, "Rendering for Emerging Display Technology,"
Panel: Workshop on Emerging Display Technology,
IEEE Virtual Reality Conference (2005).
2. Organizer and instructor, "Shape-Based Retrieval and Analysis of 3D Models,"
Course #15: Shape-Based Retrieval and Analysis of 3D Models,
ACM SIGGRAPH (2004).
3. Speaker, "Geometric Modeling of Sound Propagation,"
Game Developers Conference (2003).
4. Organizer and instructor, "Geometric Methods for Modeling Sound Propagation in 3D Virtual Environments,"
Course #45: Sounds Good to Me! Computational Sound for Graphics, VR, and Interactive Systems,
ACM SIGGRAPH (2002).
5. Speaker, "Parallel Polygon Rendering on PC Clusters,"
Panel: Commodity Graphics Accelerators for Scientific Visualization,
IEEE Visualization (2001).
6. Instructor, "Acoustics Modeling for Interactive Walkthroughs,"
Course #18: Interactive Walkthrough of Large Geometric Databases,
ACM SIGGRAPH (2000).
7. Instructor, "Acoustics Modeling of 3D Environments,"
Course #23: Virtual Worlds / Real Sounds,
ACM SIGGRAPH (1999).
8. Instructor, "Interactive Visualization of Geometric Models Larger than Main Memory,"
Course #35: Interactive Walkthrough of Large Geometric Databases,
ACM SIGGRAPH (1996).
9. Instructor, "Interactive Visualization of Geometric Models Larger than Main Memory,"
Course #32: Interactive Walkthrough of Large Geometric Databases, *ACM SIGGRAPH* (1995).

Conference Session Chairs:

- "Shape Analysis," *ACM SIGGRAPH* (2011).
- "Sketching 3D Shapes," *ACM SIGGRAPH* (2007).
- "Sound simulation and animation," *ACM SIGGRAPH* (2001).
- "Viewing large models," *ACM SIGGRAPH Symposium on Interactive 3D Graphics* (2001).
- "Multiresolution surfaces," *ACM SIGGRAPH* (1998).
- "Visibility," *ACM SIGGRAPH* (1997).
- "Virtual environments," *ACM SIGGRAPH Symposium on Interactive 3D Graphics* (1995).
- "Distributed VR applications," *IEEE Virtual Reality Annual International Symposium* (1995).

Academic Activities

Princeton University Service:

- Member, Executive Committee of the Council on Science and Technology (2016 – present).
- Member, Committee on Undergraduate Admissions (2001 - 2004, 2009 – 2010, 2016 - present).
- Director of Graduate Studies in Computer Science (2012 - 2016).
- Member, University Research Board (2012 - 2016).
- Member, Faculty Committee on the Graduate School (2012 - 2016)
- Member, Graduate School Fellowship Committee (2014 - 2015)
- Member, Fellowships Subcommittee (2014 - 2015)
- Member, SEAS Graduate and Postdoctoral Experiences Self-Study Subcommittee (2014 - 2015)
- Member, Graduate School Policy Subcommittee (2012 - 2014).
- Member, Committee on Life Sciences in Engineering (2007).
- Member, Committee on the Masters of Engineering Program (2000 - 2003).
- Faculty fellow, Rockefeller College (1999 - present).

Princeton University Teaching:

- "Deep Learning for Graphics and Vision," COS 598F (Spr 2017)
- "Understanding the World with Sensors," COS IW02 (Fall 2015, Spr 2016).
- "Shape Analysis of RGBD Data," COS 598 (Spr 2015)
- "Advanced Computer Graphics," COS 526 (Fall 2002, Fall 2006, Fall 2010, Fall 2012, Fall 2014, Fall 2016).
- "Computer Graphics," COS 426 (F1996, F1999, F2000, S2004, S2006, S2007, S2009, S2010, S2014).

“Computer Vision,” COS 429 (Fall 2013).
“Structural Bioinformatics,” COS 597d (Fall 2005, Fall 2007).
“Shape Analysis,” COS 597e (Fall 2003, Spr 2008, Spr 2011).
“Computer Graphics Rendering Techniques,” COS 598b (Spr 2001).
“Geometric Modeling and Analysis,” COS 597d (Spr 1998, Spr 2000).
“Immersive Display Systems,” COS 597c (Fall 1998).
“Geometric Modeling for Computer Graphics,” COS 598d (Spr 1998).
“Immersive Computing Systems,” COS 597c (Fall 1998).
“Undergraduate Independent Work” coordinator, COS 398, 498 , JIW , SRT (Fall 1998 - Spr 2000).
“Introduction to Programming Systems,” COS 217 (Spr 2002, Spr 2003).
“General Computer Science,” COS 126 (Spr 1999).

Postdoc Advising:

Manolis Savva (2016 – present)
Angel X. Chang (2016 – present)
Amit Bermano (2015-present)
Siddhartha Chaudhuri (2011-2014)
Yaron Lipman (2008-2011)
Jian Sun (2009-2010)
Daniel Aliaga (2002-2003)

Graduate Student Advising:

Fisher Yu (6th year, Ph.D. student)
Shuran Song (4th year, Ph.D. student)
Elena Sizikova (4th year, Ph.D. student)
Maciej Halber (4th year, Ph.D. student)
Yinda Zhang (3rd year, Ph.D. student)
Andy Zeng (2nd year, Ph.D. student)
Kyle Genova (1st year, Ph.D. student)
Tianqiang Liu (Ph.D. 2015)
Aleksy Boyko (Ph.D. 2015)
Xiaobai Chen (Ph.D. 2014)
Vladimir Kim (Ph.D. 2013)
Alex Golovinskiy (Ph.D., 2010)
Paul Calamia, (Ph.D. 2009)
Philip Shilane, (Ph.D. 2008)
Michael Kazhdan, (Ph.D. 2004)
Patrick Min, (Ph.D. 2004)
Rudrajit Samanta, (Ph.D. 2002)

Undergraduate Student Advising:

Coordinator, Computer Science Independent Work (2015-2016)
Faculty Fellow, Rockefeller College (2001 - present).
Academic advisor, Rockefeller College (2001 – 2003, 2006-2009, 2011).
Academic advisor, BSE computer science majors, Class of 2001.
Independent work advisor (1998 -).
Summer research advisor (1998 -).

Patents

1. Daniel Aliaga, Ingrid Carlbom, Thomas Funkhouser, and Dimah Yanovsky, "Method and Apparatus for Finding Feature Correspondences between Images Captured in Real-world Environments," 7,356,164, filed May 2003, granted April 2008.
2. Daniel Aliaga, Ingrid Carlbom, Thomas Funkhouser, and Dimah Yanovsky, "Method and Apparatus for Compressing and Decompressing Images Captured from Viewpoints throughout N-dimensional Space," 7,313,285, filed May 2003, granted December 2007.
3. Ingrid Carlbom and Thomas Funkhouser, "Acoustic Modeling Apparatus and Method using Accelerated Beam Tracing Techniques," 7,146,296, filed August 2000, granted December 2006.

4. Daniel Aliaga, Ingrid Carlbom, Thomas Funkhouser, and Dimah Yanovsky, "Method and System for Creating Interactive Walkthroughs of Real-world Environment from Set of Densely Captured Images," 7,126,603, filed May 2003, granted October 2006.
5. Ingrid Carlbom, Thomas Funkhouser, Gary Elko, Gopal Pingali, Mohan Sondhi, and Jim West, "Acoustic Modeling System And Method Using Pre-Computed Data Structures For Beam Tracing And Path Generation," 6,751,322 filed October 1998, granted June 2004.
6. Thomas Funkhouser, "Server for Applying a Recipient Filter and Compressing the Input Data Stream based upon a Set of at least One Characteristics in a Multiuser Interactive Virtual Environment," 5,784,570, filed April 1995, granted July 1998.

Grants

1. Principle investigator, "Scene Understanding from RGBD Images," *Intel Corporation*, \$105,000, 2016.
2. Principle investigator (with Sebastian Seung), "Automatic 3D Reconstruction of Neurons," *Keating Fund for Innovation*, \$50,000, 2016.
3. Co-principle investigator (with Szymon Rusinkiewicz), "Investigating Novel Geometric Representations for Computational Fabrication," DARPA-14-46-Office-Wide-BAA-FP-087, \$400,000, 2015-2016.
4. Co-principle investigator (with Jianxiong Xiao, Jitendra Malik, and Alexei Efros), "Scene Understanding from RGBD Images," *NSF/Intel*, VEC 1539014/1539099, \$960,000, 2015-2018.
5. Principle investigator (with Sebastian Seung), "Multiscale Shape Models for 3D Reconstruction of Neurons," *Keating Fund for Innovation*, \$100,000, 2015.
6. Principal investigator, "Learning 3D Place-Centric Models of Street View Scenes," *Google Research Award*, \$75,000 (2015).
7. Co-principle investigator (with Szymon Rusinkiewicz, Ken Steiglitz, and Alan Barnes), "Discovering Similarities in Relief Patterns of Taranto Coins," *Project X for Innovation*, \$75,000, 2015.
8. Principal investigator, "BIGDATA: Small: DA: Semantic Modeling of Cities from Scanned Data," *NSF*, IIS-1251217, \$600,000, 2013-2016.
9. Co-lead investigator (with Pat Hanrahan and others) "ISTC – Visual Computing," *Intel Corporation* \$2.5M/year (2011-2014).
10. Principal investigator, "Reconstructing Detailed 3D Models from Street-Level Scans," *Google Research Award*, \$70,000 (2012) + \$66,500 (2013).
11. Principal investigator, "Acquiring Semantically Labeled 3D Models of Cities," *Google Research Grants Program*, \$65,000 (2011).
12. Principal investigator (with David Blei, Christiane Fellbaum, and Adam Finkelstein), "Interactive Discovery and Semantic Labeling of Patterns in Spatial Data," *NSF*, CCF-0937139, \$500,000, 2009-2012.
13. Principal investigator, "Recognition and Modeling of Objects from Street View Scans of Cities," *Google Research Award*, \$60,000 (2009).
14. Co-principal investigator (with Mike Freedman, Pat Hanrahan, and Vladlen Koltun) "NeTS-ANET: A Network Architecture for Federated Virtual/Physical Worlds," *NSF*, CNS-0831374, \$384,000 (2008-2011).

15. Principal investigator,
"Symmetry Analysis of 3D Shapes and Its Applications in Computer Graphics,"
NSF, CCF-0702672, \$325,000, (2007-2010).
16. Principal investigator (with Mona Singh),
"SEI: New Shape Analysis Methods for Structural Bioinformatics,"
NSF Science & Engineering Informatics program, IIS-0612231, \$616,469 (2006-2009).
17. Co-principal investigator (with PI Kai Li, Olga Troyanskaya, and Szymon Rusinkiewicz),
"Software Tools for New-Generation, Display-Centric Applications,"
NSF Next Generation Software program, CNS-0406415, \$500,000 (2004-2007).
18. Principal investigator,
"Content-based Retrieval of 3D Models,"
Google Research Award, \$60,000 (2007).
19. Principle investigator,
"Shape Analysis for Structural Bioinformatics,"
BBSRC International Fellowship, £20,000 (2004-2005).
20. Principle investigator,
"Shape Description for Structural Bioinformatics,"
Leverhulme Trust Visiting Professorship, £31,750 (2004-2005).
21. Principle investigator (with Szymon Rusinkiewicz),
"Shape Representation for 3-D Automatic Target Recognition",
ASAF/AFMC, FA8650-04-1718, \$325,000 (2004-2007).
22. Principle investigator,
"Acoustic Modeling Algorithms,"
Norwegian Marshall Fund, 15,000 NOK (2004).
23. Principal investigator (with David Dobkin, Bernard Chazelle, and Adam Finkelstein),
"ITR/IM: 3D Shape-Based Retrieval and its Applications,"
NSF Information Technology Research (ITR) program, IIS-0121446, \$500,000 (2001-2004).
24. Principal investigator,
"CAREER: Simulation of Lighting and Acoustics in Interactive Virtual Environments,"
NSF Career award, CCR-0093343, \$325,000 (2001-2006).
25. Co-principal investigator (with PI Kai Li and J.P. Singh),
"Adaptive, Performance-Portable Software for Next-Generation and Immersive Applications,"
NSF Next Generation Software program, EIA-9975011, \$600,000 (1999-2002).
26. Co-principal investigator (with PI Rick Stevens, Kai Li, et al.),
"Corridor One: An Integrated Distance Visualization Environment for SSI & ASCII Applications"
Department of Energy, Next Generation Internet Program, DE-FC02-99ER25387, \$500,000 (2000).
27. Co-principal investigator (with PI Kai Li et al.),
"An Inexpensive, Network-Attachable Display Wall System for High-Performance Immersive Visualization"
Department of Energy, ASCI Academic Strategic Alliances Program, BE347877, \$1,176,000 (1998-2001).
28. Principal investigator (with Bernard Chazelle and David Dobkin),
"Shape Analysis Workshop and Research,"
NEC Research Institute, \$50,000 (2001).
29. Principal investigator,
"Photorealistic Rendering Research,"
Microsoft Corporation, \$50,000 (1999).
30. Principal investigator,
Alfred P. Sloan Research Fellowship,
Alfred P. Sloan Foundation, \$35,000 (1999).
31. Co-principal investigator (with PI Kai Li),
"A Scalable, Inexpensive Display Wall System for High Performance 3D Graphics and Immersive Visualization," *Intel Corporation*, \$300,000 + equipment (1998).