

# Christopher R. Wren, Ph.D.

**Home Address** 75 Hillsdale Road; Arlington MA, USA 02476;  
781.777.1555; c@drwren.com; <http://www.drwren.com/chris>

## Research and Technical Experience

### Senior Software Engineer

Google, Inc., Cambridge, MA, USA

Research Laboratory

2008 – *present*

Member of the Friend Connect team, developing social networking tools for the Internet.

### Principal Research Scientist

Mitsubishi Electric Research Laboratories, Cambridge, MA, USA

Research Laboratory

2001 – 2008

Invention of perceptual and context aware systems for human interface and automation. Actively involved in design and creation of novel perceptual technologies.

### Senior Perceptual Engineer

Perceptive Network Technologies, Inc., Waltham, MA, USA

2000 – 2001

Founding member of a perceptual sciences company dedicated to bringing context-aware communication technologies to the desktop, to help users manage converging information technologies.

### Research Assistant

Massachusetts Institute of Technology. Cambridge, MA, USA

Media Laboratory, Vision and Modeling Group

1994 – 2000

Created perceptual tool kits (Pfinder, STIVE, and Dyna) used internationally by many academic and research institutions. Extensive interaction with the media and research sponsors.

### Engineer and Dynamicist

Boston Dynamics Inc., Cambridge, MA, USA

1993 – 1994

Start-up engineering consultancy in dynamics, graphics, contact modeling, and animation, serving international clients in academics, research, industry, and the military.

## Education

**Doctor of Philosophy**, Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

Thesis Title: "Understanding Expressive Action."

Minor: "Stochastics, Dynamics, and Recursive Filtering."

**Master of Science**, Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science Thesis Title: "Pfinder: Real-Time Tracking of the Human Body"

**Bachelor of Science**, Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

Minor: Cognitive Psychology.

**Secondary Education** Western Reserve Academy, Hudson, OH, USA

## Highlights

### online video demonstrations:

<http://www.youtube.com/crwren>

### best paper award:

“Visualizing the History of Living Spaces” Yuri A. Ivanov, Christopher R. Wren, Alexander Sorokin, Ishwinder Kaur. IEEE Transactions on Visualization and Computer Graphics 13(6) pp 1153–1160. November 2007.

### best presentation award:

“SocialMotion: Measuring the Hidden Social Life of a Building” Christopher R. Wren, Yuri A. Ivanov, Ishwinder Kaur, Darren Leigh, Jonathan Westhues. Third International Symposium on Location- and Context-Awareness. September 2007. Oberpfaffenhofen, Germany.

### leadership role, major technical demonstraion:

“Buzz: Measuring and Visualizing Conference Crowds” Christopher R. Wren, Yuri A. Ivanov, Darren Leigh, Jonathan Westhues, Mariela Buchin, Tai-Peng Tian, and Pavan Turaga. ACM SIGGRAPH 2007 Emerging Technologies, San Diego, CA, USA. August 2007.

### best presentation award:

“Toward Scalable Activity Recognition for Sensor Networks” Christopher R. Wren and Emmanuel Munguia Tapia. Second International Workshop on Location- and Context-Awareness. 10-11 May 2006. Dublin, Ireland.

### book chapter:

“Perception for Human Motion Understanding,” Christopher R. Wren in “Innovations in Machine Intelligence & Robot Perception” Vol. 7. Patnaik, Jain, Tzafestas, and Banoore (Eds.) Springer. 2005, IX. pp. 265–324.

### founder of a perceptual sciences company:

Perceptive Network Technologies, Inc. Waltham, MA. 2000

### the “Minority Report interface”:

“Wearable City of News.” Flavia Sparacino, Steve Schwartz, Christopher R. Wren, Richard W. DeVaul, Glorianna Davenport, Alex P. Pentland. ACM SIGGRAPH 1999 Millennium Motel, Los Angeles, USA.

### over 1,000 citations according to Google Scholar:

“Pfinder: Real-Time Tracking of the Human Body.” Christopher R. Wren, Ali J. Azarbayejani, Trevor Darrell, and Alex P. Pentland. IEEE Trans. on Pattern Analysis and Machine Intelligence, 1997, 19(7), pp. 780-785.

### intellectual influence:

In graduate school I studied under Prof. Alex Pentland, inventor of *Eigenfaces* and one of the most widely cited authors in the field of computer vision, We worked together on five successful SIGGRAPH demonstrations.

### entrepreneurial influence:

I worked for two years under Prof. Marc Raibert, inventor of many running robots including Big Dog, and founder of Boston Dynamics, Inc. Marc taught me much about tiger-team engineering and rapid prototyping.

### human-centered design influence:

I worked four formative years under Dr. Richard A. Bolt, author of *The Human Interface* and founding member of the MIT Media Laboratory. I learned to love the *human* side of human-computer interface.

### Refereed Journal Papers and Chapters

"Visualizing the History of Living Spaces" Yuri A. Ivanov, Christopher R. Wren, Alexander Sorokin, Ishwinder Kaur. *IEEE Transactions on Visualization and Computer Graphics* 13(6) pp 1153–1160. November 2007.

"Functional Calibration for Pan-Tilt-Zoom Cameras in Hybrid Sensor Networks." Christopher R. Wren, Murat Erdem, Ali J. Azarbayejani. *ACM Multimedia Systems Journal*, Special Issue on Multimedia Surveillance Systems. Online October 9, 2006. (updated version of MERL TR2005-084)

"Similarity-based analysis for large networks of ultra-low resolution sensors." Christopher R. Wren, David Minnen, and Srinivas G. Rao *Pattern Recognition*, volume 39, issue 10, pp. 1918–1931. Special Issue on Similarity-Based Pattern Recognition. Elsevier. October 2006.

"Perception for Human Motion Understanding," Christopher R. Wren in "Innovations in Machine Intelligence & Robot Perception" Vol. 7. Patnaik, Jain, Tzafestas, and Banoore (Eds.) Springer. 2005, IX. pp. 265–324.

"Minimalism in Ubiquitous Interface Design", Christopher R. Wren and Carson J. Reynolds. *Personal and Ubiquitous Computing*, September 2004, 8(5), pp. 370-373.

"Perceptive Spaces for Performance and Entertainment: Untethered Interaction using Computer Vision and Audition." Christopher R. Wren, Flavia Sparacino, Ali J. Azarbayejani, Trevor J. Darrell, Thad E. Starner, Akira Kotani, Chloe M. Chao, Michal Hlavac, Kenneth B. Russell, Alex P. Pentland. *Applied Artificial Intelligence*, June 1997, 11(4), pp. 267-284.

"Pfinder: Real-Time Tracking of the Human Body." Christopher R. Wren, Ali J. Azarbayejani, Trevor Darrell, and Alex P. Pentland. *IEEE Trans. on Pattern Analysis and Machine Intelligence*, 1997, 19(7), pp. 780-785.

### Refereed and Invited Exhibitions

"Buzz: Measuring and Visualizing Conference Crowds" Christopher R. Wren, Yuri A. Ivanov, Darren Leigh, Jonathan Westhues, Mariela Buchin, Tai-Peng Tian, and Pavan Turaga. *ACM SIGGRAPH 2007 Emerging Technologies*, San Diego, CA, USA. August 2007.

"Ambient Intelligence for Better Buildings." Yuri Ivanov, Christopher Wren, Darren Leigh, Jonathan Westhues, Alexander Sorokin, Ishwinder Kaur. Demonstrations track of the 2006 Neural Information Processing Systems Conference, Vancouver, Canada, December 4, 2006.

"Ambient Intelligence for Better Buildings." Yuri Ivanov, Darren Leigh, Jonathan Westhues, Christopher R. Wren. *Mitsubishi Electric Internal Technology Roadshow*. Tokyo and Osaka, Japan. August 2006.

"Interacting With Projections Using iLamp Projectors." Paul Beardsley, Shane Booth, Clifton Forlines, Ramesh Raskar, Jeroen Van Baar and Christopher R. Wren. *ACM SIGGRAPH 2004 Emerging Technologies*, Los Angeles, CA, USA. August 2004.

"Wearable City of News." Flavia Sparacino, Steve Schwartz, Christopher R. Wren, Richard W. DeVaul, Gloriana Davenport, Alex P. Pentland. *ACM SIGGRAPH 1999 Millennium Motel*, Los Angeles, USA.

"Shall We Dance." Kazuyuki Ebihara, Jun Ohya, Thanarat Horprasert, Ismail Haritaoglu, David Harwood, Larry S. Davis, Christopher R. Wren, Alex P. Pentland. *ACM SIGGRAPH 1998 Enhanced Realities*, Orlando, FL, USA. July 1998

"Toco the Toucan." Deb Roy, Tony Jebara, Christopher R. Wren, William Tomlinson, Alex P. Pentland. *ACM SIGGRAPH 1997 Electric Garden*, Los Angeles, CA, USA. August 1997

"Smart Spaces." Ali J. Azarbayejani, Christopher R. Wren, Andrew Wilson, David Becker, Nuria Oliver, Deb Roy, Flavia Sparacino, Francois Berard, Alex P. Pentland. *ACM SIGGRAPH 1996 Digital Bayou*, New Orleans, LA, USA. August 1996

"Dreams and Illusions." Trevor Darrell, Bruce Blumberg, Michael P. Johnson, Christopher R. Wren, Pattie Maes, Alex P. Pentland. *ACM SIGGRAPH 1995*, Los Angeles, CA, USA. August 1995

"Trans-Atlantic SURVIVE." Thad Starner, Kenneth Russell, Christopher R. Wren, Martin R. Friedman, Alex P. Pentland. 1994 Schools Lecture, BT Laboratories, Martlesham, England, October 1994.

## Refereed Conference and Workshop Papers

“Pokey: Interaction through covert structured light.” Christopher R. Wren, Yuri Ivanov, Paul Beardsley, Biliana Kaneva, and Shoji Tanaka, Third IEEE International Workshop on Horizontal Interactive Human Computer Systems (TABLETOP). October 2008. Amsterdam.

“Ambient Intelligence as the Bridge to the Future of Pervasive Computing” Christopher R. Wren, Yuri A. Ivanov. Eighth International Conference on Automatic Face and Gesture Recognition. September 2008. Amsterdam.

“Soda Pop Zombies: Soft Drink Consumption and Motion” Daniel Wigdor, Yuri A. Ivanov, Christopher R. Wren. Proceedings of the 2007 ICMI Workshop on Massive Datasets. Nov. 2007. Nagoya, Japan.

“SocialMotion: Measuring the Hidden Social Life of a Building” Christopher R. Wren, Yuri A. Ivanov, Ishwinder Kaur, Darren Leigh, Jonathan Westhues. Third International Symposium on Location- and Context-Awareness. September 2007. Oberpfaffenhofen, Germany.

“Tracking People in Mixed Modality Systems” Yuri Ivanov, Alexander Sorokin, Christopher Wren, Ishwinder Kaur. Visual Communications and Image Processing 2007. February 2007. San Jose, California.

“Toward Scalable Activity Recognition for Sensor Networks” Christopher R. Wren and Emmanuel Munguia Tapia. Second International Workshop on Location- and Context-Awareness. 10-11 May 2006. Dublin, Ireland.

“Worse is Better for Ambient Sensing” Carson J. Reynolds and Christopher R. Wren. Pervasive 2006 Workshop on Privacy, Trust and Identity Issues for Ambient Intelligence. May 7th, 2006. Dublin, Ireland.

“Toward Spatial Queries for Spatial Surveillance Tasks” Christopher R. Wren and Yuri A. Ivanov. Pervasive 2006 Workshop on Pervasive Technology Applied Real-World Experiences with RFID and Sensor Networks. May 7, 2006. Dublin, Ireland.

“Automatic Pan-Tilt-Zoom Calibration in the Presence of Hybrid Sensor Networks”, Christopher R. Wren, Murat Erdem, Ali J. Azarbayejani, Third ACM International Workshop on Video Surveillance and Sensor Networks, Singapore, November 11, 2005.

“Change Detection by Frequency Decomposition: Wave-Back”, Fatih Porikli, Christopher R. Wren. Workshop on Image Analysis for Multimedia Interactive Services, April 2005.

“Large Networks of Ultra-low Resolution Sensors in Buildings”, Christopher R. Wren. International Conference on Integration of Knowledge Intensive Multi-Agent Systems, pp. 373-389, April 2005

“Waviz: Spectral Similarity for Object Detection” Christopher R. Wren, Fatih Porikli. IEEE International Workshop on Performance Evaluation of Tracking and Surveillance. Breckenridge, CO, USA. January 2005.

“Interactive Projection” Paul Beardsley, Shane Booth, Clifton Forlines, Ramesh Raskar, Jeroen Van Baar and Christopher R. Wren. ACM SIGGRAPH 2004, Emerging Technologies, Los Angeles, CA, USA. August 2004.

“Finding Temporal Patterns by Data Decomposition.” David C. Minnen and Christopher R. Wren. IEEE International Conference on Automatic Face and Gesture Recognition, Seoul, Korea, May 2004.

“Self-configuring, Lightweight Sensor Networks for Ubiquitous Computing.” Christopher R. Wren and Srinivasa Rao. International Conference on Ubiquitous Computing, pp. 205-206, Seattle, WA, USA, September 2003.

“Parsimony & Transparency in Ubiquitous Interface Design.” Christopher R. Wren and Carson J. Reynolds. International Conference on Ubiquitous Computing, pp. 31-33, Göteborg, Sweden, September 2002.

“Browsing 3-D spaces with 3-D vision: body-driven navigation through the Internet City” Flavia Sparacino, Christopher R. Wren, Ali J. Azarbayejani, Alex P. Pentland. Proceedings of 3DPVT: 1st International Symposium on 3D Data Processing Visualization and Transmission, Padova, Italy, June 19-21 2002.

“Volumetric Operations with Surface Margins.” Christopher R. Wren, Yuri A. Ivanov. IEEE Computer Vision and Pattern Recognition Technical Sketches, Kauai, HI, December 2001.

“Combining Audio and Video in Perceptive Spaces.” Christopher R. Wren, Sumit Basu, Flavia Sparacino, Alex P. Pentland. First International Workshop on Managing Interaction, Dublin, Ireland, December 1999.

“Understanding Purposeful Human Motion.” Christopher R. Wren and Alex P. Pentland. 1999 IEEE International Workshop on Modeling People, Kerkyra, Greece, September 20, 1999

“City of News.” Flavia Sparacino, Richard DeVaul, Christopher R. Wren, Ronald MacNeil, Gloriana Davenport, Alex P. Pentland. SIGGRAPH 1999, Visual Proceedings, Los Angeles, CA, USA, August 8-13, 1999.

“Augmented Performance in Dance and Theater.” Flavia Sparacino, Christopher R. Wren, Glorianna Davenport, Alex P. Pentland. International Dance and Technology, Arizona State University, Feb. 25-28, 1999.

“Digital Circus: a computer-vision based interactive Virtual Studio.” Flavia Sparacino, Christopher R. Wren, Glorianna Davenport, Alex P. Pentland IMAGINA, Monte Carlo, Monaco, January 18-20 1999.

“Real-time 3D Motion Capture.” Thanarat Horprasert, Ismail Haritaoglu, David Harwood, Larry S. Davis, Christopher R. Wren, Alex P. Pentland. Workshop on Perceptual User Interfaces, San Francisco, CA, USA, November 4-6, 1998

“Dynamic Modeling of Human Motion.” Christopher R. Wren and Alex P. Pentland. Proceedings of the Third IEEE International Conference on Automatic Face and Gesture Recognition, Nara, Japan, April 14-16, 1998

“Perceptive Spaces: Learning Dynamic Models of Human Behavior.” Christopher R. Wren, Sumit Basu, Alex P. Pentland. Workshop on Perceptual User Interfaces, Banff, Canada, October 19-21, 1997

“Improvisational Theater Space.” Flavia Sparacino, Kristin Hall, Christopher R. Wren, Glorianna Davenport, and Alex P. Pentland. The Sixth Biennial Symposium for Arts and Technology, Connecticut College, New London, CT, USA, February 27 - March 2, 1997.

“Pfinder: Real-Time Tracking of the Human Body.” Christopher R. Wren, Ali J. Azarbayejani, Trevor Darrell, and Alex P. Pentland. Second IEEE International Conference on Automatic Face and Gesture Recognition, Killington, VT, USA, October 1996.

“Real-time 3-D Tracking of the Human Body.” Ali J. Azarbayejani, Christopher R. Wren, Alex P. Pentland. Proceedings of IMAGE'COM 96, Bordeaux, France, May 1996

“HyperPlex: a World of 3D Interactive Digital Movies.” Flavia Sparacino, Christopher R. Wren, Alex P. Pentland, Glorianna Davenport. Proc. of IJCAI'95 Workshop on Entertainment and AI/Alife. Montreal, Canada. pp. 77-81. August 1995.

### **Lectures, Workshops, and Tutorials**

“Ambient Intelligence for Better Buildings” tutorial at the Third International Conference on Intelligent Sensors, Sensor Networks and Information Processing. Melbourne, Australia, December 2007.

“Sensor Networks for Better Buildings” Google TechTalks, Mountain View CA, February 2007.

“Using sensor networks for action recognition” NIPS 2005 Workshop on Recognition and Discovery of Activities and Interactions. Whistler, BC, Canada, December 2005.

“Activity Mining in Sensor Networks.” NIPS 2004 Workshop on Activity Recognition and Discovery. Whistler, BC, Canada, December 2004.

## Patents and Patent Applications

*Patents may also have been filed in Japan or Europe.*

U.S. Patent 7,415,164: "Spectral Similarity for Object Detection."

U.S. Patent 7,359,836: "Scalable Activity Recognition for Sensor Networks."

U.S. Patent 7,302,369: "Traffic and Geometry Modeling with Sensor Networks."

U.S. Patent 7,242,421: "Establishing a communications link by sensing perceptual presence."

U.S. Patent 6,911,995: "Depth Segmentation with Virtual Surface Margins."

U.S. Patent 6,680,745: "Videoconferencing method with tracking of face and dynamic bandwidth allocation."

U.S. Patent Application: "Determining Geometries of Scenes"

U.S. Patent Application: "Probabilistic Graphs on Surveillance Data"

U.S. Patent Application: "Tracking and Identifying Objects in Environments."

U.S. Patent Application: "Method For Processing Queries For Surveillance Tasks"

U.S. Patent Application: "Composite Surveillance Camera System."

U.S. Patent Application: "Context Aware Surveillance System Using a Hybrid Sensor Network."

U.S. Patent Application: "Efficient Hierarchical Decomposition of Temporal Patterns."

U.S. Patent Application: "Extending face recognition systems to multi-view images and audio."