

# Dennis W. Strelow

## Curriculum Vitae, Fall 2015

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### SUMMARY AND OBJECTIVE

I have more than 20 years of training and experience in software and computer vision, and practical experience in massively parallel computing, machine learning, and optimization. I have a Ph.D. in computer science from Carnegie Mellon, where my thesis was on visual odometry; and have been a software engineer for almost 10 years at Google, where I've split my time equally between products and research.

I'm looking to:

- Reach the public by building end user apps, production servers, or the data those serve. "Launch is my religion" is coarse way to phrase this but probably says it the best.
- Make a measurable impact: happier users, more users, more revenue.
- Make major contributions to computer science, including computer vision, machine learning, and optimization.
- I'm a veteran engineer and extremely team focused, and an explicit leadership role would be a good next opportunity for me.

### EXPERIENCE IN BRIEF

- Spring 2006 - Present: Software engineer, senior software engineer, Google
- Spring 2005 – Spring 2006: Senior research scientist, Honeywell Advanced Technology Laboratory
- Fall 1998 – Fall 2004: Ph.D. in Computer Science, Carnegie Mellon University
- Summer 2001 – Summer 2004: NASA Graduate Student Research Fellowship (GSRP) fellowship recipient
- Fall 1996 - Summer 1998: Software engineer, K<sup>2</sup>T Inc.
- Fall 1994 - Summer 1996: M.S. in computer science, University of Illinois at Urbana-Champaign

- Spring 1996 - Summer 1996: Research assistant, National Center for Supercomputing Applications
- Summer 1995: Graduate research assistant, Los Alamos National Laboratory
- Summer 1994: Summer research assistant, National Solar Observatory
- Fall 1990 - Spring 1994: B.S. in computer science and mathematics, University of Wisconsin-Madison
- Summer 1993: NSF Research Experience for Undergraduates student, University of Nebraska-Lincoln

## RESEARCH, EDUCATION, AND EMPLOYMENT

Spring 2006 - Present

**Google**, Mountain View, California

I was a Software Engineer from 2006 to 2010, and have been a Senior Software Engineer since 2010. As a senior engineer, I've earned "exceeds expectations" or "strongly exceeds expectations" performance ratings in every evaluation during the last 4+ years.

*Google Research, "embedded" with Google Geo, Summer 2012 - Present*

For the last 3 years, I've worked for Google Research, but have been "embedded" with Google Geo, the organization responsible for Maps and Street View. I worked for 18 months with a team merging high-resolution Street View images and lidar geometry into lower-resolution 3D models created using stereo from aerial images. My work with this project included automatic "ultra-wide baseline matching" between aerial and Street View images, propagating the public's requests to take down Street View images to our models, and tree detection in Street View images.

More recently, I've worked on several user-facing projects including indoor Street View; Planets, which lets you travel to Mars and the Moon inside Google Maps; and other projects that aren't yet public.

*Google Research, research in learning and optimization, Summer 2007 - Spring 2012*

I worked for 5 years in Google Research's Machine Perception team, researching machine learning and optimization. I worked on machine learning for image classification, which ultimately resulted in new ultra-fast visual features that improved Google's Image Safe Search.

But, the high point from this period is my General Wiberg algorithm, which minimizes common "chicken-and-egg" functions better than the standard approach, expectation-maximization. General Wiberg applies to many general problems including least squares, L1 (robust) minimization, maximum likelihood estimation, and max margin problems; and we've applied the algorithm to bundle adjustment, projective bundle adjustment, Poisson non-negative matrix factorization, and multiple instance learning.

Work from this period was published in top conferences in vision and learning, CVPR, ECCV, ICCV, and NIPS. My original paper on General Wiberg was accepted as a CVPR oral (2.5% acceptance rate), and the last word on general Wiberg paper has just been accepted to the top vision journal, IEEE PAMI.

*Google Image Search, Spring 2006 - Summer 2007*

I worked for 1.5 years on the Image Search team, working on the feature that became Image Search's "Find Similar Images." I built our real-time development demo using Google's parallel infrastructure; and improved the visual features used by the image similarity metric. I also developed the core image class used by Image Search and many other teams.

Spring 2005 to Spring 2006

**Honeywell Advanced Technology Laboratory**, Minneapolis, Minnesota

I was a research scientist at Honeywell's Advanced Technology Laboratory in the Integrated Security Technology (IST) section, which emphasized computer vision for video surveillance. My projects at Honeywell included the development of an algorithm for propagating the detail from one dataset to a second, degraded dataset of a different modality. Potential applications of this method include improving the resolution of CT scans using MRI scans, and improving the resolution of terrain elevation data using aerial photos. Beside my work in the IST section, I worked with the laboratory's navigation and control section on vision-aided navigation for unmanned air vehicles; and on visual odometry for ground vehicles.

Fall 1998 to Fall 2004

**Carnegie Mellon University**, Pittsburgh, Pennsylvania

I earned a Ph.D. from Carnegie Mellon's Computer Science Department, where my advisor was Dr. Sanjiv Singh. My thesis research focused on making image-based, six degree of freedom motion estimation robust for autonomous vehicle and modeling applications. Specifically, my research investigated the fusion of image measurements and measurements from inexpensive inertial sensors for motion estimation; the potential advantages of omnidirectional cameras for motion estimation; robust image feature tracking; and mechanisms for automatically closing the loop in motion estimation from long image sequences. This work was partially supported by a NASA Graduate Student Researcher Program (GSRP) fellowship from Summer 2001 to Summer 2004.

Fall 1996 to Summer 1998

**K<sup>2</sup>T, Inc.**, Pittsburgh, Pennsylvania

Before coming to Carnegie Mellon as a student I was a software engineer in the visual modeling group at CMU spin-off K<sup>2</sup>T, Inc. (K<sup>2</sup>T is now Quantapoint, Inc.) My work at K<sup>2</sup>T included the commercialization of Carnegie Mellon's factorization algorithms for three-dimensional modeling from video and the development of algorithms for modeling architecture from still photos.

Fall 1994 to Summer 1996

**University of Illinois at Urbana-Champaign**, Urbana-Champaign, Illinois

I earned an M.S. from the University of Illinois Department of Computer Science. My thesis research was performed with the biological imaging group at the National Center for Supercomputing Applications (NCSA). This research developed a new algorithm for constructing polyhedral surface models from volumetric data (e.g., cortex models from MRI data) and the visualization and manipulation of these models in NCSA's CAVE virtual reality environment.

Summer 1995

**Los Alamos National Laboratory**, Los Alamos, New Mexico

As a graduate research assistant with the image analysis group, I focused on document and medical image analysis. Among other algorithms, this work resulted in a robust method for delineating rib cage volumes in computed tomography (CT) images.

Summer 1994

**National Solar Observatory**, Sunspot, New Mexico

As a research assistant at the observatory, I developed algorithms for automatically tracking erratic sunspot motion in solar images and for measuring the intensity of solar flares.

Fall 1990 to Spring 1994

**University of Wisconsin-Madison**, Madison, Wisconsin

I earned a B.S. in computer science and mathematics from the University of Wisconsin. My advanced courses in computer science included artificial intelligence, compilers, computer architecture, and theoretical computer science. In mathematics my advanced courses included numerical analysis, numerical linear algebra, advanced calculus, differential equations, abstract algebra, and symbolic logic.

Summer 1993

**University of Nebraska-Lincoln**, Lincoln, Nebraska

At Nebraska I took classes in image processing and computer vision and investigated AVHRR image restoration as part of an NSF Research Experience for Undergraduates (REU) program. My investigation showed that the effective accuracy of AVHRR image restoration with small convolution kernels depends on the mechanism used to display the restored images.

## PUBLICATIONS

Dennis Strelow, Qifan Wang, Luo Si, and Anders Eriksson. General, nested, and constrained Wiberg minimization, accepted to IEEE Pattern Analysis and Machine Intelligence (PAMI).

Dennis Strelow. General and nested Wiberg minimization:  $L_2$  and maximum likelihood. European Conference on Computer Vision (ECCV 2012), Florence, Italy, October 2012.

Dennis Strelow. General and nested Wiberg minimization. **Oral presentation (2.5% acceptance rate)**, Computer Vision and Pattern Recognition (CVPR 2012), Providence, RI, June 2012.

Jay Yagnik, Dennis Strelow, David A. Ross, and Ruei-sung Lin. The power of comparative reasoning. International Conference on Computer Vision (ICCV 2011), Barcelona, Spain, November 2011.

Samy Bengio, Fernando Pereira, Yoram Singer, and Dennis Strelow. Group sparse coding. Neural Information Processing Systems (NIPS 2009), Vancouver, December 2009.

Dennis Strelow and Sanjiv Singh. Long-term motion estimation. International Symposium on Experimental Robotics (ISER 2006), Rio de Janeiro, July 6-10 2006.

Dennis Strelow and Sanjiv Singh. Motion estimation from image and inertial measurements. The International Journal of Robotics Research, Vol. 23, No. 12, December 2004, pp. 1157-1195.

Dennis Strelow and Sanjiv Singh. Online motion estimation from image and inertial measurements. Workshop on the Integration of Vision and Inertial Sensors (INERVIS 2003), Coimbra, Portugal, June 2003.

Dennis Strelow and Sanjiv Singh. Reckless motion estimation from omnidirectional image and inertial measurements. IEEE Workshop on Omnidirectional Vision and Camera Networks (OMNIVIS 2003), Madison, Wisconsin, June 2003.

Dennis Strelow and Sanjiv Singh. Optimal motion estimation from visual and inertial measurements. IEEE Workshop on Applications of Computer Vision (WACV 2002), Orlando, Florida, December 2002.

Henele Adams, Sanjiv Singh and Dennis Strelow. An empirical comparison of methods for image-based motion estimation. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2002), Lausanne, Switzerland, October 2002.

Sanjiv Singh, George Kantor and Dennis Strelow. Recent results in extensions to simultaneous localization and mapping. International Symposium on Experimental Robotics (ISER 2002), Sant'Angelo d'Ischia, Italy, July 2002.

Dennis Strelow, Jeffrey Mishler, David Koes and Sanjiv Singh. Precise omnidirectional camera calibration. IEEE Computer Vision and Pattern Recognition (CVPR 2001), Kauai, Hawaii, December 2001.

Dennis Strelow, Jeff Mishler, Sanjiv Singh and Herman Herman. Extending shape-from-motion to noncentral omnidirectional cameras. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2001), Maui, Hawaii, October 2001.

Dan Foygel and Dennis Strelow. Reducing web latency with hierarchical cache-based prefetching. IEEE Workshop on Scalable Web Services (SWS 2000), Toronto, Canada, June 2000.

Nathaniel Daw, Seth Goldstein and Dennis Strelow. Embedded compilation for multimedia applications (abstract). IEEE Symposium on Field-Programmable Custom Computing Machines (FCCM 2000), Napa Valley, California, May 2000.

Dennis Strelow, Warren Gardner, Regis Hoffman, Jeff Mishler and Fred Persi. A shape and motion engine for parameterized models. Proceedings of the 1998 DARPA Image Understanding Workshop, Monterey, California, November 1998.

Dennis Strelow, Clinton S. Potter and Paul C. Lauterbur. A virtual environment for the visualization of functional MRI data (abstract). Current progress in functional brain mapping: science and applications, T. Yuasa, J.W. Prichard and S. Ogawa, editors, Nishumira/Smith-Gordon, November 1998.

Dennis W. Strelow, Clinton S. Potter and Paul C. Lauterbur. The construction and visualization of surfaces from MRI data. NCSA Technical Report 036, August 1996.

E. Reiger, D.F. Neidig, D.W. Engfer and D. Strelow. The role of high-energy protons and electrons in powering the solar white light flare emissions. Solar Physics, 167:307-320, 1996.

S. Reichenbach, D. Koehler and D. Strelow. Restoration and reconstruction of AVHRR images. IEEE Transactions on Geoscience and Remote Sensing, 33(4):997-1007, May 1995.

## **TEACHING EXPERIENCE**

Fall 1994 and Spring 1995

Teaching assistant, Introduction to Computer Science for Engineering Students, University of Spring 1995 Illinois Department of Computer Science

Fall 1995

Teaching assistant, Introduction to Artificial Intelligence, University of Illinois Department of Computer Science

Fall 1999

Teaching assistant, Introduction to Data Structures, Carnegie Mellon University Computer Science Department

Spring 2000

Teaching assistant, Computer Vision, Carnegie Mellon University Computer Science Department

## **SELECTED TALKS**

*Besides conference talks.*

October 2015

Ultra-wide baseline matching. Technical University of Vienna.

December 2011 - June 2012

General and nested Wiberg minimization. Carnegie Mellon, University of Wisconsin, Willow Garage, and others.

October 2003 - January 2006

Motion estimation from image and inertial measurements. Google, Northrop Grumman, NASA Ames, and others.

December 2001

Extending shape-from-motion to noncentral omnidirectional cameras. University of Wisconsin-Madison.

September 1997

Three-dimensional models from video. University of Illinois at Urbana-Champaign.

## **SELECTED PATENTS / PATENT APPLICATIONS**

Dennis Strelow, Craig Robinson, and Samuel Felix de Sousa, Jr. Aligning panoramic imagery and aerial imagery.

Dennis Strelow and Jay Yagnik. General and nested Wiberg minimization.

Luca Bertelli, Dennis Strelow, and Sally Goldman. Foreground object detection from multiple images.

Dennis W. Strelow. Method and apparatus for propagating high resolution detail between multimodal data sets.

## OTHER

Fall 2015

Ph.D. committee member, Samuel de Sousa, Technical University of Vienna.

Spring 2008

Ph.D. committee member, Craig Yoshioka, Scripps Institute.

Summer 2001 to Summer 2004

NASA Graduate Student Researchers Program (GSRP) fellowship

Spring 1995 to Fall 1995

Excellent Teaching Assistant award, University of Illinois Department of Computer Science

Spring 1994

Graduation with distinction, University of Wisconsin-Madison

## TECHNICAL SKILLS

- Operating systems: more than 20 years Linux/Unix development. Limited experience with Windows and OS X development.
- Languages: more than 20 years C++ development. Limited experience with dozens of other languages, most recently Java, JavaScript, Python, and MATLAB.
- Tools: revision systems (mainly Perforce), debuggers, performance profilers, heap checkers.
- Third-party libraries: OpenCV, LAPACK, image libraries (e.g., jpeglib). Very limited experience with Ceres and testing libraries (e.g., googletest and googlemock).
- Parallel computing: Google's MapReduce (> 5 years) and Flume (2 years), RPC, multithreading.
- Web programming: very limited experience with client-side JavaScript and C++ server programming.
- Computer vision: more than 20 years experience in 3D vision, including structure-from-motion, visual odometry, image and inertial fusion, feature extraction and tracking, wide baseline matching, depth from stereo and stereo calibration, omnidirectional cameras, and camera calibration. Image classification and autocropping. Limited experience with Markov random fields (Gibbs sampling), image segmentation, and image restoration.
- Numerical methods and optimization: More than 20 years experience, including matrix factorization, Levenberg-Marquardt, maximum likelihood estimation, robust estimation with RANSAC, and iterated extended Kalman filters. Limited experience with branch and bound and  $L_1$  minimization via successive linear programming.



- Machine learning: limited experience with distance learning and image classification using SVMs, boosting, and sparse coding. Good working understanding of probability.
- LaTeX

Interested in learning: more web programming, mobile programming, GPU programming, deep learning.