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Personal Data

Name Ingo Wald
Born March 29, 1974, in Bad Kreuznach, Germany
Nationality: German; Residency: US (Permant Resident Card)

Scientific Achievements in Brief

Publications 4 patents, 23 journal articles; 40 conference papers; 3 peer-reviewed STAR reports; 2 conference proceedings (edited); (Intel-internal papers intentionally excluded)
Academic Citation count (scholar.google.com) for most cited paper (Oct): > 500.
Impact h-index (#publications with more than N citations): 37 (google scholar, Oct'15).

Professional Experience

2013–current **Intel Technical Computing Group (Data Center Group), Intel Corp**, *Senior Research Scientist*, Tech Lead High-Fidelity and Software Defined Visualization .
2007–2013 **Intel Labs, Intel Corp**, *Senior Research Scientist*.
2005–2007 **Scientific Computing and Imaging (SCI) Institute and School of Computing, University of Utah**, *Research Assistant Professor (adjunct appointment still active)*.
2004–2005 **Max Planck Institut Informatik Saarbrücken**, *Research Associate (Post-Doc)*.
2000–2004 **Saarland University**, *Research Associate, Computer Graphics Group*.

Education

2000–2004 **Dr.-ing. (PhD equivalent)**, *Saarland University, Saarbrücken, Germany*.
Awarded Degree: Dr.-ing. mit Auszeichnung (PhD in Computer Science, with Distinction).
1993–1999 **Dipl-inform.(MS equivalent)**, *Kaiserslautern University, Kaiserslautern, Germany*.
Awarded Degree: Dipl-inform, sehr gut (Masters in Computer Science, A equivalent).
1984–1993 **Abitur (High-School equivalent)**, *Alfred Delp Schule Hargesheim, Germany*.
Awarded Degree: Allgemeine Hochschulreife (Abitur), sehr gut (High School, A equivalent).

Research Interests

- ▷ Efficient Computing on High-Throughput Compute Architectures (MIC/Xeon Phi)
- ▷ Ray Tracing (in particular, using Embree and OSPRay)
- ▷ Parallel and High-Performance Rendering (in part. using ray tracing)
- ▷ Ray Tracing for High-Fidelity Visualization
- ▷ Photo-realistic Rendering / Monte-Carlo lighting simulation
- ▷ SPMD Compilers and Languages for High-Performance Computing Architectures
- ▷ Efficient data structures and algorithms, in particular on innovative HPC platforms

Publications

Patents

- ▷ **Ray Tracing a Three Dimensional Scene using a Grid.** Ingo Wald, Thiago Ize, Steven G Parker, and Aaron Knoll. *US 8384711 B2*. Filed 11/06, Issued 2/2013.
- ▷ **Ray Tracing A Three-Dimensional Scene using A Hierarchical Data Structure.** Ingo Wald, Peter Shirley and Solomon Boulos. *US 8259105 B2 / US 20100060634 A1*. Filed 7/2007, Issued 9/2012.
- ▷ **Parallel Grid Population.** Ingo Wald and Thiago Ize. *WO 2008067490 A2*. Filed 11/2007, Issued 6/2008.
- ▷ **Method and device for creating a two-dimensional representation of a three dimensional world.** Jörg Schmittler, Ingo Wald, and Philipp Slusallek. *US Patent Number 7289118*. Universität des Saarlandes and Garching Innovation Technologien aus der Max-Planck Gesellschaft. Filed Aug 20, 2003; Issued Oct 30, 2007.

Books & Proceedings (edited)

- ▷ **High-Performance Graphics 2014.** Ingo Wald and Jonathan Ragan-Kelley, editors.
- ▷ **Proceedings of the 2006 IEEE Symposium on Interactive Ray Tracing.** Ingo Wald and Steven G. Parker, editors. IEEE Computer Society Press, ISBN 1-4244-0693-5, 2006.

Book Chapters

- ▷ **Chapter 21 – High Performance Ray Tracing.** Gregory S. Johnson, Ingo Wald, Sven Woop, Carsten Benthin, and Manfred Ernst. *in High Performance Parallelism Pearls: Multicore and Many-core Programming Approaches, James Reinders and Jim Jeffers (editors), Morgan Kaufman*. 2015.

Company-Internal Papers and Whitepapers

- ▷ **(confidential, intentionally omitted).**

Journal Articles (peer reviewed)

- ▷ **An Evaluation of Existing BVH Traversal Algorithms for Efficient Multi-Hit Ray Tracing.** Jefferson Amstutz, Christiaan Gribble, Johannes Guenther, and Ingo Wald. *Journal of Computer Graphics Techniques*. 2015 (to appear).
- ▷ **Embree–A Kernel Framework for Efficient CPU Ray Tracing.** Ingo Wald, Sven Woop, Carsten Benthin, Gregory S. Johnson, and Manfred Ernst. *ACM Transactions on Graphics (Proceedings of ACM SIGGRAPH)*. 2014.

- ▷ **RBF Volume Ray Casting on Multicore and Manycore CPUs.** Aaron Knoll, Ingo Wald, Paul Navratil, Anne Bowen, Khairi Reda, Michael E Papka, and Kelly P Gaither. *Computer Graphics Forum (Proceedings of EuroVis)*. 2014 (to appear).
- ▷ **Water-tight Ray-Triangle Intersection.** Sven Woop, Carsten Benthin, Ingo Wald. *Journal of Computer Graphics Techniques*. 2013.
- ▷ **Combining Single and Packet Ray Tracing for Arbitrary Ray Distributions on the Intel[®]MIC Architecture.** Carsten Benthin, Ingo Wald, Sven Woop, Manfred Ernst, William R. Mark. *IEEE Transactions on Visualization and Computer Graphics*. 2012.
- ▷ **Fast Construction of SAH BVHs on the Intel[®]Many Integrated Core (MIC) Architecture.** Ingo Wald. *IEEE Transactions on Visualization and Computer Graphics*. 2011.
- ▷ **State of the Art in Ray Tracing Animated Scenes.** Ingo Wald, William R Mark, Johannes Günther, Solomon Boulos, Thiago Ize, Warren Hunt, Steven G. Parker, and Peter Shirley. *Computer Graphics Forum*. Volume 28, Number 6, 2009.
- ▷ **Sequential Monte Carlo Adaption in Low-Anisotropy Participating Media.** Vincent Pegoraro, Ingo Wald, and Steven G Parker. *Computer Graphics Forum (Proceedings of the 2008 Eurographics Symposium on Rendering)*. 2008.
- ▷ **Coherent Multiresolution Isosurface Ray Tracing.** Aaron Knoll, Charles D Hansen, and Ingo Wald. *The Visual Computer* . Volume 25, Number 3, March 2009.
- ▷ **Fast, Parallel, and Asynchronous Construction of BVHs for Ray Tracing Animated Scenes.** Ingo Wald, Thiago Ize, and Steven G. Parker. *Computers and Graphics*. Volume 32, Number 1, Feb 2008.
- ▷ **Exploring a Boeing 777 – Ray Tracing Large-Scale CAD Data.** Andreas Dietrich, Abe Stephens, and Ingo Wald. *IEEE Computer Graphics and Applications*. Volume 27, Issue 6, (November 2007), pages 36–46.
- ▷ **Interactive Isosurface Ray Tracing of Time-Varying Tetrahedral Volumes.** Ingo Wald, Heiko Friedrich, Aaron Knoll, and Charles D. Hansen. *IEEE Transactions on Visualization and Computer Graphics*. (Proceedings of IEEE Visualization/InfoVis 2007), Volume 13, Issue 6 (November 2007), pages 1727-1734.
- ▷ **A Coherent Grid Traversal Approach to Visualizing Particle-based Simulation Data.** Christiaan P. Gribble, Thiago Ize, Ingo Wald, Andrew E. Kensler, and Steven G. Parker. *IEEE Transactions on Visualization and Computer Graphics* 13(4), 2007.
- ▷ **Ray Tracing Deformable Scenes using Dynamic Bounding Volume Hierarchies.** Ingo Wald, Solomon Boulos, and Peter Shirley. *ACM Transactions on Graphics* 26(1), 2007. pages 1–18.
- ▷ **Ray Tracing Animated Scenes using Coherent Grid Traversal.** Ingo Wald, Thiago Ize, Andrew E Kensler, Aaron Knoll, and Steven G Parker. *ACM Transactions on Graphics* 25(3), 2006. pages 485-493, (Proceedings of ACM SIGGRAPH 2006).

- ▷ **Realtime Ray Tracing for Advanced Visualization in the Aerospace Industry.** Andreas Dietrich, Ingo Wald, Holger Schmidt, Kristian Sons, and Philipp Slusallek . *Proceedings of the 5th Paderborner Workshop Augmented und Virtual Reality in der Produktentstehung* .
- ▷ **Ray Tracing Animated Scenes using Motion Decomposition.** Johannes Günther, Heiko Friedrich, Ingo Wald, Hans-Peter Seidel, and Philipp Slusallek. *Computer Graphics Forum* 25(3), 2006. pages 517–525 (Proceedings EUROGRAPHICS 2006).
- ▷ **Techniques for Interactive Ray Tracing of Bézier Surfaces.** Carsten Benthin, Ingo Wald, and Philipp Slusallek. *Journal of Graphics Tools* 11(2), 2006. pages 1–16.
- ▷ **Faster Isosurface Ray Tracing using Implicit KD-Trees.** Ingo Wald, Heiko Friedrich, Gerd Marmitt, Philipp Slusallek, and Hans-Peter Seidel. *IEEE Transactions on Visualization and Computer Graphics* 11(5), 2005. pages 562–572.
- ▷ **Balancing Considered Harmful – Faster Photon Mapping using the Voxel Volume Heuristic.** Ingo Wald, Johannes Günther, and Philipp Slusallek. *Computer Graphics Forum* 22(3), 2004. pages 595–603, (Proceedings of EUROGRAPHICS).
- ▷ **A Scalable Approach to Interactive Global Illumination.** Carsten Benthin, Ingo Wald, and Philipp Slusallek. *Computer Graphics Forum* 22(3), 2003. pages 621–630, (Proceedings of EUROGRAPHICS).
- ▷ **Interactive Distributed Ray Tracing on Commodity PC Clusters – State of the Art and Practical Applications.** Ingo Wald, Carsten Benthin, Andreas Dietrich, and Philipp Slusallek. *Harald Kosch, Laszlo Böszörményi, and Hermann Hellwagner, editors, Euro-Par 2003, volume 2790 of Lecture Notes in Computer Science.* pages 499–508, Springer, 2003.
- ▷ **Interactive Rendering with Coherent Ray-Tracing.** Ingo Wald, Carsten Benthin, Markus Wagner, and Philipp Slusallek. *Computer Graphics Forum* 20(3), 2001. pages 153–164, (Proceedings of EUROGRAPHICS 2001).

Articles in Conference Proceedings (peer reviewed)

- ▷ **CPU Ray Tracing Large Particle Data with Balanced P-k-d Trees.** Ingo Wald, Aaron Knoll, Gregory P Johnson, Will Usher, Valerio Pascucci, and Mike E Papka. *Proceedings of IEEE Visualization*. 2015.
- ▷ **Efficient Ray Tracing of Subdivision Surfaces using Tessellation Caching.** Carsten Benthin, Sven Woop, Matthias Niessner, Kai Selgard, and Ingo Wald. *Proceedings of High Performance Graphics*. 2015.
- ▷ **SIMD Parallel Ray Tracing of Homogeneous Polyhedral Grids.** Brad Rathke, Ingo Wald, Kenneth Chiu, and Carson Brownlee. *Eurographics Symposium on Parallel Graphics and Visualization (EGPGV)*. 2015.
- ▷ **Ray Tracing and Volume Rendering Large Molecular Data on Multi-core and Many-core Architectures.** Aaron Knoll, Ingo Wald, Paul Navratil, Michael E Papka, and Kelly P Gaither. *Proc. 8th International Workshop on Ultrascale Visualization at SC13 (Ultravis)*. 2013.

- ▷ **Extending a C like Language for Portable SIMD Programming.** Roland Leissa, Sebastian Hack, and Ingo Wald. *PPoPP '12: Proceedings of the 17th ACM SIGPLAN symposium on Principles and Practice of Parallel Programming 2012*.
- ▷ **Full-Resolution Interactive CPU Rendering with Coherent BVH Traversal.** Aaron Knoll, Sebastian Thelen, Ingo Wald, Charles D Hansen, Hans Hagen, Machael E Papka. *Proceedings of IEEE Pacific Visualization 2011*.
- ▷ **Active Thread Compaction for GPU Path Tracing.** Ingo Wald. *Proceedings of High Performance Graphics 2011*.
- ▷ **Efficient Stack-less Traversal Algorithm for Ray Tracing with BVH.** M Hapala, T Davidoviv, I Wald, V Havran, P Slusallek. *Proceedings of SCCG 2011*. pages 29–34.
- ▷ **Efficient ray traced soft shadows using multi-frusta tracing.** Carsten Benthin and Ingo Wald. *In Proceedings of High-Performance Graphics 2009 (HPG09)*.
- ▷ **Getting Rid of Packets – SIMD Single-Ray Traversal using Multi-Branching BVHs.** Ingo Wald, Carsten Benthin, Solomon Boulos . *In Proceedings of the 2008 IEEE/Eurographics Symposium on Interactive Ray Tracing*. Los Angeles, 2008.
- ▷ **Adaptive Ray Packet Reordering.** Solomon Boulos, Ingo Wald, Carsten Benthin . *In Proceedings of the 2008 IEEE/Eurographics Symposium on Interactive Ray Tracing*. Los Angeles, 2008.
- ▷ **Ray Tracing with the BSP Tree.** Thiago Ize, Ingo Wald, Steven Parker . *In Proceedings of the 2008 IEEE/Eurographics Symposium on Interactive Ray Tracing*. Los Angeles, 2008.
- ▷ **On Fast Construction of SAH based Bounding Volume Hierarchies.** Ingo Wald. *In Proceedings of the 2007 IEEE/Eurographics Symposium on Interactive Ray Tracing*. Ulm, Germany, 2007.
- ▷ **Interactive Ray Tracing of Arbitrary Implicits with SIMD Interval Arithmetic.** Aaron Knoll, Charles D. Hansen, Younis Hijazi, Hans Hagen, and Ingo Wald. *In Proceedings of the 2007 IEEE/Eurographics Symposium on Interactive Ray Tracing*.
- ▷ **Interactive Iso-Surface Ray Tracing of Massive Volumetric Data Sets.** Heiko Friedrich, Ingo Wald, and Philipp Slusallek. *Eurographics Symposium on Parallel Graphics and Visualization '07*.
- ▷ **Asynchronous BVH Construction for Ray Tracing Dynamic Scenes.** Thiago Ize, Ingo Wald, and Steven G. Parker. *Eurographics Symposium on Parallel Graphics and Visualization '07*.
- ▷ **Packet-based Whitted and Distribution Ray Tracing.** Solomon Boulos, Dave Edwards, J. Dylan Lacewell, Joe Kniss, Jan Kautz, Ingo Wald, and Peter Shirley. *Graphics Interface 2007*. (to appear).
- ▷ **Interactive Isosurface Ray Tracing of Large Octree Volumes.** Aaron Knoll, Ingo Wald, Steven G. Parker, and Charles D. Hansen. *In Proceedings of the 2006 IEEE Symposium on Interactive Ray Tracing*. Salt Lake City, UT, 2006, pages 115–124.

- ▷ **Realtime Ray Tracing on the CELL Processor.** Carsten Benthin, Ingo Wald, Michael Scherbaum, and Heiko Friedrich. *In Proceedings of the 2006 IEEE Symposium on Interactive Ray Tracing.* Salt Lake City, UT, Sep 18–20, 2006, pages 15–23.
- ▷ **An Evaluation of Parallel Grid Construction for Ray Tracing Dynamic Scenes.** Thiago Ize, Ingo Wald, Chelsea Robertson, and Steven G Parker. *In Proceedings of the 2006 IEEE Symposium on Interactive Ray Tracing.* Salt Lake City, UT, Sep 18–20, 2006, pages 47–55.
- ▷ **Applying Ray Tracing for Virtual Reality and Industrial Design.** Ingo Wald, Andreas Dietrich, Carsten Benthin, Alexander Efremov, Tim Dahmen, Johannes Günther, Vlastimil Havran, Hans-Peter Seidel, and Philipp Slusallek. *In Proceedings of the 2006 IEEE Symposium on Interactive Ray Tracing.* Salt Lake City, UT, Sep 18–20, 2006, pages 177–185.
- ▷ **On building good KD-Trees for Ray Tracing, and on doing that in $O(N \log N)$.** Ingo Wald and Vlastimil Havran. *In Proceedings of the 2006 IEEE Symposium on Interactive Ray Tracing.* Salt Lake City, UT, Sep 18–20, 2006, pages 61–69.
- ▷ **An Application of Scalable Massive Model Interaction using Shared Memory Systems.** Abe Stephens, Solomon Boulos, and Ingo Wald. *In Proceedings of EUROGRAPHICS Symposium on Parallel Graphics and Visualization.* Braga, Portugal, 11.–12. May 2006, pages 19–26.
- ▷ **Large-Scale CAD Model Visualization on a Scalable Shared-Memory Architecture.** Andreas Dietrich, Ingo Wald, and Philipp Slusallek. *In Proceedings of Vision, Modeling, and Visualization (VMV) 2005.* pages 303–310, Erlangen, Germany, November 16–18, 2005.
- ▷ **Efficient Acquisition and Realistic Rendering of Car Paint.** Johannes Günther, Tongbo Chen, Michael Goesele, Ingo Wald, and Hans-Peter Seidel. *In Proceedings of Virtual Reality, Modeling, and Visualization (VMV) 2005.* pages 487–494, Erlangen, Germany, November 16–18, 2005.
- ▷ **Interactive Ray Tracing of Point Based Models.** Ingo Wald and Hans-Peter Seidel. *Proceedings of 2005 Symposium on Point Based Graphics.* 2005.
- ▷ **Interactive Ray Tracing of Free-Form Surfaces.** Carsten Benthin, Ingo Wald, and Philipp Slusallek. *In Proceedings of Afrigraph 2004.* pages 99–106, Stellenbosch, ZA, Nov 3–5, 2004.
- ▷ **An Interactive Out-of-Core Rendering Framework for Visualizing Massively Complex Models.** Ingo Wald, Andreas Dietrich, and Philipp Slusallek. *In Rendering Techniques 2004, EUROGRAPHICS Symposium on Rendering.* pages 81–92, Norrköping, Sweden, June 21–23, 2004.
- ▷ **Realtime Caustics using Distributed Photon Mapping.** Johannes Günther, Ingo Wald, and Philipp Slusallek. *In Rendering Techniques 2004, EUROGRAPHICS Symposium on Rendering.* pages 111–121 Norrköping, Sweden, June 21–23, 2004.
- ▷ **VRML Scene Graphs on an Interactive Ray Tracing Engine.** Andreas Dietrich, Ingo Wald, Markus Wagner, and Philipp Slusallek. *In Proceedings of IEEE VR 2004.* pages 109–116, Chicago, USA, Mar 27–31, 2004.

- ▷ **Fast and Accurate Ray-Voxel Intersection Techniques for Iso-Surface Ray Tracing.** Gerd Marmitt, Andreas Kleer, Ingo Wald, Heiko Friedrich, and Philipp Slusallek. *In Proceedings of Virtual Reality, Modelling, and Visualization (VMV) 2004.* pages 429–435, 2004.
- ▷ **Distributed Interactive Ray Tracing of Dynamic Scenes.** Ingo Wald, Carsten Benthin, and Philipp Slusallek. *In Proceedings of the IEEE Symposium on Parallel and Large-Data Visualization and Graphics (PVG).* pages 77–86, Blaubeuren, Germany, Sep 9–10, 2003.
- ▷ **Streaming Video Textures for Mixed Reality Applications in Interactive Ray Tracing Environments.** Andreas Pomi, Gerd Marmitt, Ingo Wald, and Philipp Slusallek. *In Proceedings of Vision, Modeling and Visualization (VMV) 2003.* pages 261–269, Germany, Nov 19–21, 2003.
- ▷ **Interactive Global Illumination in Complex and Highly Occluded Environments.** Ingo Wald, Carsten Benthin, and Philipp Slusallek. *Proceedings of the 14th EUROGRAPHICS Workshop on Rendering.* P. H. Christensen and D. Cohen-Or (editors), pages 74–81, Leuven, Belgium, 2003.
- ▷ **The OpenRT Application Programming Interface - Towards A Common API for Interactive Ray Tracing.** Andreas Dietrich, Ingo Wald, and Philipp Slusallek. *Proceedings of the 2003 OpenSG Symposium.* pages 23–31, Darmstadt, Germany, Apr 1–2, 2003.
- ▷ **SaarCOR - A Hardware Architecture for Ray Tracing.** Jörg Schmittler, Ingo Wald, and Philipp Slusallek. *In Proceedings of ACM SIGGRAPH/EUROGRAPHICS Graphics Hardware 2002.* pages 27–36, Saarbrücken, Germany, Sep 1–2, 2002.
- ▷ **Interactive Headlight Simulation - A Case Study for Interactive Distributed Ray Tracing.** Carsten Benthin, Tim Dahmen, Ingo Wald, and Philipp Slusallek. *In Proceedings of EUROGRAPHICS Workshop on Parallel Graphics and Visualization (PGV).* pages 81–88, Seattle, WA, Oct 20–21, 2002.
- ▷ **Interactive Global Illumination using Fast Ray Tracing.** Ingo Wald, Thomas Kollig, Carsten Benthin, Alexander Keller, and Philipp Slusallek. *Proceedings of the 13th EUROGRAPHICS Workshop on Rendering.* P. Debevec and S. Gibson (editors), pages 15–24, Pisa, Italy, 2002.
- ▷ **Interactive Distributed Ray-Tracing of Highly Complex Models.** Ingo Wald, Philipp Slusallek and Carsten Benthin. *Rendering Techniques 2001 / Proceedings of the EUROGRAPHICS Rendering Workshop 2001.* S.J. Gortler and K. Myszkowski (editors), pages 274–285, Jun 2001.
- ▷ **Efficient Importance Sampling Techniques for the Photon Map.** Alexander Keller and Ingo Wald. *In Proceedings of Vision Modelling and Visualization (VMV).* Saarbrücken, Germany, Nov 2000.

State of the Art Reports (peer reviewed)

- ▷ **State of the Art in Ray Tracing Animated Scenes.** Ingo Wald, William R Mark, Johannes Günther, Solomon Boulos, Thiago Ize, Warren Hunt, Steven G. Parker, and Peter Shirley. *EUROGRAPHICS 2007 State of the Art Reports*. Prague, Czech Republic, 2007.
- ▷ **Realtime Ray Tracing and its use for Interactive Global Illumination.** Ingo Wald, Timothy J. Purcell, Jörg Schmittler, Carsten Benthin, and Philipp Slusallek. *EUROGRAPHICS 2003 State of the Art Reports*. Granada, Spain, 2003.
- ▷ **State-of-the-Art in Interactive Ray Tracing.** Ingo Wald and Philipp Slusallek. *EUROGRAPHICS 2001 State of the Art Reports*. EUROGRAPHICS, 2001.

Refereed Tutorials and Courses at Conferences

- ▷ **ACM SIGGRAPH 2013 Course on the Future of Ray Tracing.** organized by Alexander Keller, NVidia. *ACM SIGGRAPH 2013*. (to appear).
- ▷ **ACM SIGGRAPH 2006 Course on Realtime Ray Tracing.** with Philipp Slusallek, Peter Shirley (University of Utah), Bill Mark (University of Texas), Gordon Stoll (INTEL), and Dinesh Manocha (UNC). *ACM SIGGRAPH 2006*. Boston, USA, 2006.
- ▷ **ACM SIGGRAPH 2005 Course on Realtime Ray Tracing.** with Philipp Slusallek, Peter Shirley (University of Utah), Bill Mark (University of Texas), and Gordon Stoll (INTEL). *ACM SIGGRAPH 2005*. Los Angeles, USA, 2005.
- ▷ **Afrigraph 2004 Course on Massive Model Visualization.** with Andreas Dietrich. *Afrigraph 2004*. Stellenbosch, South Africa, 2004.
- ▷ **ACM SIGGRAPH 2003 Course on Global Illumination for High-Quality Animations and Interactive Applications.** with Karol Myszkowski, Cyrille Damez, Per H. Christensen, Bruce Walter, and Philipp Slusallek. *ACM SIGGRAPH 2003*. Los Angeles, USA, 2003.
- ▷ **Afrigraph 2003 Course on Advanced Issues in Realtime Ray Tracing and Interactive Global Illumination.** with Carsten Benthin. *Afrigraph 2003*. Cape Town, South Africa, 2003.
- ▷ **Afrigraph 2001 Course on Interactive Ray Tracing.** Ingo Wald. *Afrigraph 2001*. Cape Town, South Africa, 2001.

Masters and Doctoral Theses

- ▷ **Realtime Ray Tracing and Interactive Global Illumination.** Ingo Wald. *PhD thesis*. Saarland University, 2004 (Grade: with distinction).
- ▷ **Photorealistic Rendering using the Photon Map.** Ingo Wald. *Diplomarbeit (masters thesis)*. Universität Kaiserslautern, 1999. Grade: sehr gut (A equivalent).

Technical Reports (if not mentioned otherwise)

- ▷ **Screen-Space Spherical Harmonics Filters for Instant Global Illumination.** Benjamin Segovia and Ingo Wald. *Intel Corp.* 2009.
- ▷ **Fast Ray Tracing of Catmull-Clark Subdivision Surfaces.** Carsten Benthin, Solomon Boulos, Jesse Dylan Lacewell, and Ingo Wald. *SCI Institute, University of Utah.* 2007.
- ▷ **SIMD Stream Tracing — SIMD Ray Traversal with Generalized Ray Packets and On-the-fly Reordering.** Ingo Wald. *SCI Institute, University of Utah.* 2007.
- ▷ **Geometric and Arithmetic Culling Methods for Entire Ray Packets.** Solomon Boulos, Ingo Wald, and Peter Shirley. *Technical Report No. UUCS-06-010.* School of Computing, University of Utah, 2006.
- ▷ **Interactive Distribution Ray Tracing..** Solomon Boulos, David Edwards, Jesse Dylan Lacewell, Joe Kniss, Jan Kautz, Peter Shirley, and Ingo Wald. *Technical Report No. UUSCI-2006-022.* SCI Institute, University of Utah, 2006.
- ▷ **Ray Tracing Deformable Scenes using Bounding Volume Hierarchies.** Ingo Wald, Solomon Boulos, and Peter Shirley. *Technical Report No. UUSCI-2006-023.* SCI Institute, University of Utah. 2006. (more detailed version of *ACM Transactions on Graphics*, 26 (1), 2007).
- ▷ **Discretized Incident Radiance Maps for Interactive Global Illumination in Complex Environments.** Ingo Wald. *Technical Report No. UUSCI-2005-010.* SCI Institute, University of Utah. 2005.
- ▷ **Towards Realtime Ray Tracing—Issues and Potential.** Ingo Wald, Carsten Benthin, and Philipp Slusallek. *Technical Report.* Saarland University. 2003.
- ▷ **OpenRT—A Flexible and Scalable Rendering Engine for Interactive 3D Graphics.** Ingo Wald, Carsten Benthin, and Philipp Slusallek. *Technical Report.* Saarland University. 2002.
- ▷ **Interactive Raytracing on Notebooks.** Ingo Wald, Philipp Slusallek, Carsten Benthin, and Markus Wagner. *Technical Report.* Saarland University. 2002.

ACM SIGGRAPH Sketches and Tech Talks, peer-reviewed

- ▷ **Embree 2.0: A Real-time Ray Tracing Infrastructure for Xeon and Xeon PHI.** With Louis Feng, Sven Woop, and Carsten Benthin. *ACM SIGGRAPH Tech Talks (peer reviewed).* 2013.
- ▷ **Interactive Ray Tracing of Point Based Models.** Ingo Wald and Hans-Peter Seidel. *ACM SIGGRAPH Sketches and Applications.* 2005.
- ▷ **Precomputed Light Sets for Fast High Quality Global Illumination.** Johannes Günther, Ingo Wald, and Hans-Peter Seidel. *ACM SIGGRAPH Sketches and Applications.* 2005.

- ▷ **Interactive Visualization of Exceptionally Complex Industrial Datasets.** Andreas Dietrich, Ingo Wald, and Philipp Slusallek. *ACM SIGGRAPH Sketches and Applications*. 2004.

Other Publications and Invited Papers

- ▷ **SIMD Stream Tracing – SIMD Ray Tracing with Generalized Packets and On-the-fly Re-ordering.** Ingo Wald. Poster at the 2007 IEEE/EG Symposium on Interactive Ray Tracing.
- ▷ **Realtime Ray Tracing and Interactive Global Illumination.** Ingo Wald. *it-Information Technology*. Nummer 4, 2006. (in german).
- ▷ **Ray Tracing Animated Scenes—One Experiment and Three Solutions.** Ingo Wald. *The Utah Teapot*. Fall 2006.
- ▷ **Realtime Ray Tracing and Interactive Global Illumination.** Ingo Wald. *Ausgezeichnete Informatikdissertationen 2005*. Bonner Köllen Verlag, Dorothea Wagner et al.(eds), series GI-Edition Lecture Notes in Informatics (LNI), 2005. (in german).
- ▷ **Interaktive Beleuchtungssimulation und Bildsynthese mit Ray-Tracing – Effiziente Software schlägt Spezial-Hardware.** Philipp Slusallek and Ingo Wald. *Magazin Forschung 1/2002 der Universität des Saarlandes*. ISSN 0937-7301, pages 2–12, May 2002 (in german).

Invited Talks and Presentations (selected)

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- ▷ **Embree—A Ray Tracing Kernel Framework for Efficient CPU Ray Tracing.** *Graphics Seminar, University of Texas in Austin*. 2014.
 - ▷ **Ray Tracing for Interactive Rendering and Visualization: Are we done, yet?.** *Keynote at the Eurographics Conference on Parallel Graphics and Visualization (EGPGV) 2013*.
 - ▷ **IVL—A experimental SPMD Compiler for SSE and MIC.** *Intel VPG Tech Summit (MIC)*. Jan 2012, (best presentation award).
 - ▷ **Active Thread Compaction for GPU Path Tracing.** *Intel OpenCL Forum*. 2011.
 - ▷ **IVL+R(IVL)—A experimental SPMD Compiler for SSE, AVX, and MIC, and its application to Real-Time Realistic Rendering.** *Illinois-Intel Parallelism Center (I2PC) at the University of Illinois Urbana Champaign (UIUC)*. Oct 20, 2011.
 - ▷ **Fast Ray Tracing on LRB using Multi-Packet/Multi-Frustum Traversal.** *Intel UPCRC Summit*. Oregon 2009 (best talk award).
 - ▷ **Aggressive Packet-/Frustum Traversal Techniques – State of the Art and Current Issues.** *Eurographics IPC Minisymposium*. Prague, Czech Republic. April 2007.

- ▷ **On ray tracing and future graphics architectures – and how these two will influence each other.** *NVidia Corp.* Santa Clara, CA, USA. Feb 2007.
- ▷ **Realtime Ray Tracing.** *IBM TJ Watson.* Yorktown Heights, Oct 2006.
- ▷ **Realtime Ray Tracing.** *University of Wales in Bangor.* Bangor, Wales, UK, Sep 2006.
- ▷ **Ray Tracing Dynamic Scenes – Recent Progress, Current Issues.** *Intel Corp.* Santa Clara, CA, USA, 2006.
- ▷ **Recent Trends in Realtime Ray Tracing – Practical Applications, Complex Models, and Animated Scenes.** *Invited Talk at the annual meeting of the advisory board of german university professors.* 2006.
- ▷ **Ray Tracing Animated Scenes.** *MPI für Informatik.* Saarbrücken, Germany, 2006.
- ▷ **Realtime Ray Tracing and Interactive Global Illumination.** *Finalists round of the BMW Innovation Award.* BMW FIZ, München, Germany, 2005.
- ▷ **Realtime Ray Tracing and Interactive Global Illumination.** *Finalists round of the GI Dissertationspreis (Dissertation Award of the German Association of Computer Scientists).* Mainz, Germany, 2005.
- ▷ **Realtime Ray Tracing and Interactive Global Illumination.** *Stanford.* 2002.
- ▷ **The Saarland RTRT/OpenRT Realtime Ray Tracing Project.** *Intel Corp.* 2002.
- ▷ **Towards interactive Global Illumination.** *Dagstuhl Seminar.* 2001.
- ▷ **Photorealistic Rendering using the Photon Map.** *Dagstuhl Seminar.* 2000.

Awards

- ▷ **HPG'15 “Test of Time 2006” Award.** (*1st place*). for Wald and Havran, *On Building kd-Trees for Ray Tracing, and on doing that in $O(N \log N)$* .
- ▷ **HPG'15 “Test of Time 2006” Award.** (*2nd place*). for Benthin et al, *Ray Tracing on the CELL processor*.
- ▷ **HPG'15 “Wolfgang Strasser” Best Paper Award.** for Benthin et al, *Efficient Ray Tracing of Subdivision Surfaces using Tessellation Caching*.
- ▷ **Intel Technical Computing Group (TCG) Recognition Award.** For the creation and public release of Embree 2.0, Q3-2013.
- ▷ **Intel DRD Divisional Recognition Award.** *SSG/DCSG (Software Solutions Group/Datacenter and Services Group).* SC12 Keynote Demo of Dreamworks Xeon Phi App, Q1-2013.
- ▷ **Intel Divisional Recognition Award.** *Microprocessor and Programming Research.* to Ingo Wald, For developing Embree 2.0 for Xeon Phi, demonstrating superior performance for photo-realistic rendering, transforming Dreamworks' lighting engine from tens of minutes-per-frame to near real-time, Q4-2012.

- ▷ **Best Presentation, 2nd prize – Intel VCG Tech Summit 2012.** *In recognition of the Best Presentation during the Intel VCG (Visual Computing Group) Tech Summit – Spring 2012.*
- ▷ **Intel Divisional Recognition Award.** *Microprocessor and Programming Research Lab. to Ingo Wald, for Demonstrating Intel Graphics Leadership with the first public live Advanced Graphics Demonstration on Larrabee, Q1-2010.*
- ▷ **MIC (Larrabee) - Committed to a new Parallel Computing Roadmap.** *to Ingo Wald. Mai 2010.*
- ▷ **Best Demo Award – Intel VCG Tech Summit.** *In recognition of the Best Demo during the Intel VCG (Visual Computing Group) Tech Summit – Fall 2009.*
- ▷ **Best Talk – Intel UPCRC Summit.** *for a talk on Fast Ray Tracing on LRB using Multi-Packet Traversal. Beaverton, OR, September 2009.*
- ▷ **SaarLB Wissenschaftspreis 2004 (SaarLB Science Award 2004).** *Science award of the Saarländische Landesbank (endowed with 25,000 Euros). for the dissertation Realtime Ray Tracing and Interactive Global Illumination, 2005.*
- ▷ **Finalists round of the BMW Innovation Award (5 Finalists).** *BMW Group. München, July 2005, Realtime Ray Tracing and Interactive Global Illumination.*
- ▷ **Finalists round of the GI Dissertation Award 2004.** *(Dissertation award of the German Association of Computer Scientists). Mainz, Germany, 2005.*
- ▷ **Dr.-ing. “mit Auszeichnung” (PhD “with distinction”).** *Universität des Saarlandes. For the dissertation Realtime Ray Tracing and Interactive Global Illumination.*
- ▷ **Best paper award. (2nd place).** *Eurographics 2001, for Interactive Rendering with Coherent Ray Tracing (with over 500 scholar.google.com citations to date).*
- ▷ **HPCwire Editor’s Choice Award.** *awarded to the OpenRT Realtime Ray Tracer.*
- ▷ **European Innovation Prize.** *awarded to inTrace GmbH.*

Professional Service

Chair/Organizer Duty

- ▷ Papers chair, High-Performance Graphics 2014
- ▷ Papers chair, High-Performance Graphics 2009
- ▷ Conference Chair, IEEE Symposium on Interactive Ray Tracing 2006
- ▷ Co-Organizer, ACM SIGGRAPH 2006 Course on Interactive Ray Tracing

Committees

- ▷ Intel Labs Patent Committee
- ▷ Selection Committee for the4 “Intel Sponsored Sessions” at ACM SIGGRAPH
- ▷ Steering Committee, High Performance Graphics
- ▷ Steering Committee, EG/ACM Symposium on Interactive Ray Tracing
- ▷ Intel University Program Office (Implementation Task Force for the European University Programme - 'til 2013)

Editorial Boards

- ▷ Computer Graphics Forum
- ▷ Computers and Graphics

Programme Committees (selected)

- ▷ High-Performance Graphics 2009–current
- ▷ Eurographics Symposium on Parallel Graphics and Visualization 2008–current
- ▷ Graphics Hardware 2008
- ▷ Eurographics 2007, 2009, 2010
- ▷ Afrigraph 2004, 2007
- ▷ IEEE Symposium on Interactive Ray Tracing 2006, 2007, 2008
- ▷ International Symposium on Visual Computing (ISVC) 2007, 2008
- ▷ Computer Graphics and Visualization 2007 (CGV2007)

Reviewer for (selected)

- ▷ ACM Transactions on Graphics
- ▷ IEEE Transactions on Visualization and Computer Graphics
- ▷ IEEE Computer Graphics and Applications
- ▷ Computer Graphics Forum
- ▷ ACM SIGGRAPH
- ▷ Eurographics Symposium on Rendering (EGSR)
- ▷ IEEE Visualization
- ▷ Eurographics
- ▷ Virtual Reality, Modeling, and Visualization (VMV)
- ▷ Graphics Interface
- ▷ Pacific Graphics
- ▷ Central European Journal of Physics
- ▷ International Symposium on Visual Computing (ISVC)

Grant Capture

Note: Grant capture applies only between mid 2006 (when I became a research professor eligible to submit proposals) and mid 2007 (when I joined Intel).

Grants awarded

- ▷ **OSPRay: A Open, Scalable, and Parallel Ray Tracing Infrastructure.** *Intel Visual Computing Institute Research Project Proposal.* PI: Ingo Wald, Intel Corp. Co-PIs: Prof Dr.-ing. Philipp Slusallek, Saarland University, requested amount 3xEUR 75,000 (granted Feb 2012).
- ▷ **SDCI HPC: Improvement and Release of the Uintah computational framework.** *NSF proposal number OCI-0721659.* PI: Martin Berzins, University of Utah. Co-PIs: Steven G. Parker and Ingo Wald, University of Utah. Requested amount: \$920,495 (awarded to M. Berzins & S. Parker after I left the University of Utah).
- ▷ **Consulting Agreement.** *Intel Corp, \$50,000.* Summer 2007.

Applications Cancelled when I left Academia

- ▷ **Intel Systems and Communications Research Council.** *Realtime Ray Tracing of Advanced Lighting Effects using modern Multi-core Architectures.* PI: Ingo Wald, University of Utah. Requested amount: \$225,000 over three years, plus equipment (positively reviewed, then cancelled due to conflict-of-interest once I joined Intel).

Industrial Experience

Jul 2013–current	Intel Corp , <i>Technical Computing Group / Data Center Group</i> , Austin, TX. Senior Staff Research Scientist, Tech Lead Ray Tracing and Software Defined Visualization
Feb 2013–Jun 2013	Intel Corp , <i>Experiences Technology Lab, Intel Labs</i> , Austin, TX, Senior Staff Research Scientist.
Mar 2012–Feb 2013	Intel Corp , <i>Intel Labs, Visual Applications Research Lab (VAR)</i> , Staff Research Scientist, attached to the Intel Visual Computing Institute, Saarbruecken, Germany.
Nov 2007–Mar 2012	Intel Corp , <i>Corporate Technology Group/Intel Labs, Research Scientist Visual Applications Research Lab (VAR)</i> .
May–Aug 2007	Intel Corp , <i>Santa Clara, CA, USA</i> . Visiting Professor / Consultant in the Advanced Graphics Architectures Lab.
2003–2006	inTrace Realtime Ray Tracing GmbH , <i>Saarbrücken, Germany</i> . Co-founder and Vice-CEO.
May–Aug 2002	Intel Corp , <i>Santa Clara, CA, USA</i> . Internship, Microprocessor Research Labs / Advanced Graphics Architectures.

Research Projects I am/was Involved In (selected)

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- 2013–ongoing **OSPRay—A Open, Scalable, and Portable Ray Tracing Infrastructure.** *Development of a new ray tracing based software renderer for scalable and high-fidelity visualization (early prototype).*
- SC 2013 **Intel “Marquee” demo at SuperComputing 2013.** *The Marquee demo at SC13 showcased several ray tracing vis applications (using Embree and RIVL/BNSView) on the “Cherry Creek” supercomputer (then #400 on the Top500 list).*
- 2013– **Ray Tracing based Visualization on Intel Architectures at TACC.** *In close collaboration with the Texas Advanced Computing Center (TACC), funded by Intel Technical Computing Group and building on certain software packages I am tech lead on..*
- SC 2012 **Xeon Phi/KNC Launch Demo at Supercomputing 2012.** *Using the Dreamworkd “torch” interactive lighting tool to showcase the launch of the Intel Xeon Phi product line at Supercomputing 2012 in Salt Lake City, UT. In collaboration with Dreamworks, the Intel Embree Team, and a team in Intel SSG..*
- 2012– **Intel-Dreamworks Rendering Collaboration.** *As part of an ongoing collaboration with Dreamworks, we are developing several technologies based on fast ray tracing on intel hardware, all using Embree 2.0: The Dreamworks “torch” interactive lighting preview tool, ray tracing of hair, ... In collaboration with Dreamworks, the Intel Embree Team, and a team in Intel SSG..*
- 2012– **Embree 2.0.** *A (originally IVL-based) version of the Intel Embree ray tracer that now embraces SPMD, also now runs on AVX and MIC/Xeon Phi.*
- 2012– **(R)IVL.** *A (IVL-based) portable and extensible high-performnace ray tracing architecture for Intel CPUs, with support for compressed large models, isosurfaces, volume rendering, balls-and-sticks, etc. Demo'ed, for example, at the Intel VCG Tech Summit (best presentation award), Research at Intel Europe Day, etc. Main author: Ingo Wald, in collaboration with Carsten Benthin..*
- 2011– **ISPC.** *The Intel SPMD Compiler Project (now available as open source at <https://ispc.github.org>). Main Author: Matt Pharr, Intel Corp.*
- 2011– **IVL.** *A SPMD Program Compiler for Intel CPUs (with back-ends for SSE, AVX, and MIC/Knights), allowing to program Intel CPUs in a way similar to CUDA, while explicitly exposing the advantages of CPUs. Main Author: Ingo Wald; underlying theoretical part in collaboration with Hack et al, Saarland University.*
- 2010 **Denali.** *A photo-realistic renderer infrastructure for Intel CPUs. Since released in Open Source under the name of “Embree”) Main Authors: S. Woop, M. Ernst.*
- 2010– **Programming models research and evaluation.** *Evaluating various programming models (intrinsics, AN, Elemental Functions, OpenCL, IVL/ISPC, ...) in terms of both effectiveness and performance on various hardware architectures (integrated graphics, (GP)GPU, CPU, MIC, ...).*

- 2008–2010 **Garfield.** A Intel-MIC (Larrabee/Knights)-based real-time ray tracing engine for game-like content. Demoed at various public events like Intel IDF, CeBit, etc.
- 2007–2008 **RTTL (The Ray Tracing Template Library).** A real-time ray tracing engine for many-core CPUs. Demo'ed at several public events like Intel IDF, Siggraph, ...
- 2005–2007 **Utah Ray Tracing Center of Excellence.** The State of Utah Ray Tracing Center of Excellence is funded by the State of Utah, with the explicit aim of commercializing the ray tracing IP that is being developed at the University of Utah. While established prior to my arrival in Utah, this explicitly includes the recently developed techniques for fast packet/frustum traversal and for handling dynamic scenes (DynRT).
- 2006–2007 **Dynamic Ray Tracing for visualizing large and time-varying data sets.** Largely as part of the CSafe project (CSafe - Center for the Simulation of Advanced Fires and Explosions), this project concentrated on interactively visualizing large and time-varying data sets based on the DynRT codebase. During the course of this (ongoing) project we developed methods for visualizing particle data sets, as well as large and time-varying volume data sets in both structured and unstructured form.
- 2005–2007 **DynRT: Ray Tracing Dynamic Scenes.** Development of a ray tracing architecture that is particularly optimized for SMP desktop PCs, and which allows for ray tracing dynamically animated scenes via the development of new, unconventional acceleration data structures. The project developed several new approaches to ray tracing animated scenes, while at the same time staying at least competitive with the fastest known ray tracers even for static data sets. It led to several papers at prestigious places like SIGGRAPH, TOG, Eurographics, etc. Since the developed methods are also competitive. The developed codebase forms the core for most of the recent ray tracing based rendering and visualization projects I was later on involved in.
- SaarCOR
2001–2003 **Design of special-purpose Ray Tracing Hardware.** I have been actively involved in two different hardware ray tracing projects, one at Saarbrücken, and one at Utah. At Saarbrücken, the "SaarCOR" project started as a spin-off project off the OpenRT software ray tracing project. It was started by myself, Jörg Schmittler, and Philipp Slusallek, and developed a hardware implementation of the OpenRT software core. Unrelated to the SaarCOR project, the University of Utah has also started a hardware ray tracing project that was originally proposed as a collaborative project between Peter Shirley, Steven Parker, Erik Brunvand, and Al Davis prior to me being at Utah. The project finally got funded and started in early 2006, after which I joined it.
- Utah HWRT
2006–2007
- 2003–2006 **inTrace – Ray Tracing Solutions for Industrial Applications.** Based on the OpenRT realtime ray tracing engine, we developed several ray tracing based solutions to practical industrial problems, including the interactive visualization of massively complex engineering models (VW, Boeing), as well as interactive photorealistic rendering of important lighting effects like shadows, reflections, glass, etc, that current, non-ray tracing based solutions cannot accurately simulate. This project led to the foundation of inTrace realtime ray tracing technologies GmbH, which commercializes this technology. The technology is already being used by a large number of high-end customers, including VW, Audi, DaimlerChrysler, EADS, BMW, etc.

- 2002–2005 **Fast and Interactive Global Illumination.** With the availability of a fast ray tracing architecture (OpenRT, see below), it was a natural step to also use this architecture for simulating global illumination. This project led to a variety of interactive global illumination systems, including Instant Radiosity, a method to interactively compute global illumination in highly complex scenes, interactive photon mapping, and several precomputed global illumination techniques. Due to Utah having a stronger focus on visualization problems, I mostly stopped working on this project after moving to Utah, but recent trends in rendering seem to make a revival of this topic imminent; first steps towards interactive distribution ray tracing are already being done.
- 2000–2006 **OpenRT.** OpenRT is a highly versatile software system that enables realtime ray tracing applications on PCs and PC cluster. The OpenRT project was envisioned, designed, and realized in the course of my PhD thesis. Since its foundation in 2000, the project was continuously extended; while originally based on a highly optimized implementation of the ray tracing algorithm only, it has since then grown to support a whole set of additional services: visualization of highly complex datasets, a out-of-core rendering module, direct visualization of spline surfaces, parallel and distributed rendering, support for volume and isosurface data sets, point-based rendering, interactive visualization of indirect illumination and caustics, etc. The OpenRT project has led to several spin-off projects (the MassiveRT project, SaarCOR, Instant Global Illumination, etc), provided the basis for founding the *inTrace* Realtime Ray Tracing GmbH, led to more than 30 OpenRT-based papers, and 5 different PhD theses.
- 1997–1999 **McRender.** McRender is a Monte Carlo-based global illumination rendering package designed and developed by Alexander Keller at the University of Kaiserslautern. I was first involved in the project as a research assistant, in the course of which I added several new ray tracing data structures and traversal methods, as well as helped in developing various hierarchical global illumination schemes. During my masters thesis, I also extended it to handle Photon Mapping, including several new importance sampling schemes that were published later on.