Matthew C. Larsen

Contact Information

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Research Interests

Scientific visualization, in-situ analysis infrastructures, high performance computing, ray tracing, volume rendering, computer graphics, performance modeling, GPU and many-core programming

Education

Ph.D Computer Science - University of Oregon - Advisor: Hank Childs (2016)
M.S. Computer Science - University of Oregon (2015)
B.S. Computer Science - CSU Sacramento - Magna Cum Laude (2012)

Work Experience

Staff Scientist	Lawrence Livermore National Laboratory	1/16-Pres
Intern Researcher	Lawrence Livermore National Laboratory	6/15-9/15
Intern Researcher	Oak Ridge National Laboratory	6/14-9/14
Graduate Research Fellow	University of Oregon	9/13-12/15
Developer	POS Portal, Sacramento, Ca.	2/13-9/13

Awards

- Best Paper Award: "Interactive In Situ Visualization and Analysis using Ascent and Jupyter" At the Workshop on In Situ Enabling Extreme-Scale Analysis and Visualization (ISAV) 2019.
- Best Paper Award: "A Flexible System for In Situ Triggers." At the Workshop on In Situ Infrastructures for Enabling Extreme-Scale Analysis and Visualization (ISAV) 2018.
- Best Paper Finalist: "Performance Modeling of In Situ Rendering." At the International Conference for High Performance Computing, Networking, Storage and Analysis (SC) 2016.
- J. Donald Hubbard Family Scholarship in Computer and Information Science, University of Oregon (2015)

Peer-Reviewed First/Last Authored Publications

1. S. Ibrahim, C. Harrison, and M. Larsen. Jit's complicated: A comprehensive system for derived field generation. In *ISAV'20 In Situ Infrastructures for Enabling Extreme-Scale Analysis and Visualization*, ISAV'20, page 27–31, New York, NY, USA, 2020. Association for Computing Machinery.
2. M. Larsen, A. Woods, N. Marsaglia, A. Biswas, S. Dutta, C. Harrison, and H. Childs. A flexible system for in situ triggers. In *Proceedings of the Workshop on In Situ Infrastructures for Enabling Extreme-Scale Analysis and Visualization*, ISAV '18, pages 1–6, New York, NY, USA, 2018. ACM (**Best Paper**).
3. M. Larsen, J. Ahrens, U. Ayachit, E. Brugger, H. Childs, B. Geveci, and C. Harrison. The alpine in situ infrastructure: Ascending from the ashes of strawman. In *Proceedings of the In Situ Infrastructures on Enabling Extreme-Scale Analysis and Visualization*, ISAV'17, pages 42–46, New York, NY, USA, 2017. ACM.
4. M. Larsen, C. Harrison, J. Kress, D. Pugmire, J. S. Meredith, and H. Childs. Performance modeling of in situ rendering. In *SC '16: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis*, pages 276–287, Nov 2016 (**Best Paper Finalist**).
5. M. Larsen, K. Moreland, C. R. Johnson, and H. Childs. Optimizing multi-image sort-last parallel rendering. In *2016 IEEE 6th Symposium on Large Data Analysis and Visualization (LDAV)*, pages 37–46, Oct 2016.

6. M. Larsen, E. Brugger, H. Childs, J. Eliot, K. Griffin, and C. Harrison. Strawman: A batch in situ visualization and analysis infrastructure for multi-physics simulation codes. In *Proceedings of the First Workshop on In Situ Infrastructures for Enabling Extreme-Scale Analysis and Visualization*, ISAV2015, pages 30–35, New York, NY, USA, 2015. ACM.
7. M. Larsen, S. Labasan, P. Navrátil, J. Meredith, and H. Childs. Volume Rendering Via Data-Parallel Primitives. In C. Dachsbacher and P. Navrátil, editors, *Eurographics Symposium on Parallel Graphics and Visualization*. The Eurographics Association, 2015.
8. M. Larsen, J. S. Meredith, P. A. Navrátil, and H. Childs. Ray tracing within a data parallel framework. In *2015 IEEE Pacific Visualization Symposium (PacificVis)*, pages 279–286, April 2015.

Other Peer-Reviewed Publications

9. Y. Kawakami, N. Marsaglia, M. Larsen, and H. Childs. Benchmarking in situ triggers via reconstruction error. In *ISAV'20 In Situ Infrastructures for Enabling Extreme-Scale Analysis and Visualization*, ISAV'20, page 38–43, New York, NY, USA, 2020. Association for Computing Machinery.
10. H. Childs et al. A terminology for in situ visualization and analysis systems. *The International Journal of High Performance Computing Applications*, 34(6):676–691, 2020.
11. J. Kress, M. Larsen, J. Choi, M. Kim, M. Wolf, N. Podhorszki, S. Klasky, H. Childs, and D. Pugmire. Comparing time-to-solution for in situ visualization paradigms at scale. In *2020 IEEE 10th Symposium on Large Data Analysis and Visualization (LDAV)*, pages 22–26, 2020.
12. J. Lukasczyk, C. Garth, M. Larsen, W. Engelke, I. Hotz, D. Rogers, J. Ahrens, and R. Maciejewski. Cinema darkroom: A deferred rendering framework for large-scale datasets. pages 37–41, 10 2020.
13. J. Kress, M. Larsen, J. Choi, M. Kim, M. Wolf, N. Podhorszki, S. Klasky, H. Childs, and D. Pugmire. Opportunities for cost savings with in-transit visualization. In P. Sadayappan, B. L. Chamberlain, G. Juckeland, and H. Ltaief, editors, *High Performance Computing*, pages 146–165, Cham, 2020. Springer International Publishing.
14. S. Ibrahim, T. Stitt, M. Larsen, and C. Harrison. Interactive in situ visualization and analysis using ascent and jupyter. In *Proceedings of the Workshop on In Situ Infrastructures for Enabling Extreme-Scale Analysis and Visualization*, ISAV '19, page 44–48, New York, NY, USA, 2019. Association for Computing Machinery (**Best Paper**).
15. R. Binyahib, T. Peterka, M. Larsen, K.-L. Ma, and H. Childs. A Scalable Hybrid Scheme for Ray-Casting of Unstructured Volume Data. *IEEE Transactions on Visualization and Computer Graphics*, 25(7):2349–2361, July 2019.
16. J. Kress, M. Larsen, J. Choi, M. Kim, M. Wolf, N. Podhorszki, S. Klasky, H. Childs, and D. Pugmire. Comparing the Efficiency of In Situ Visualization Paradigms at Scale. In *ISC High Performance*, pages 99–117, Frankfurt, Germany, June 2019.
17. S. Labasan, M. Larsen, H. Childs, and B. Rountree. Power and Performance Tradeoffs for Visualization Algorithms. In *Proceedings of IEEE International Parallel and Distributed Processing Symposium (IPDPS)*, pages 325–334, Rio de Janeiro, Brazil, May 2019.
18. N. Marsaglia, S. Li, K. Belcher, M. Larsen, and H. Childs. Dynamic I/O Budget Reallocation For In Situ Wavelet Compression. In *Eurographics Symposium on Parallel Graphics and Visualization (EGPGV)*, pages 1–6, Porto, Portugal, June 2019.
19. C. Wood, M. Larsen, A. Gimenez, K. Huck, C. Harrison, T. Gamblin, and A. Malony. Projecting performance data over simulation geometry using sosflow and alpine. In A. Bhatele, D. Boehme, J. A. Levine, A. D. Malony, and M. Schulz, editors, *Programming and Performance Visualization Tools*, pages 201–218, Cham, 2019. Springer International Publishing.

20. B. Lessley, K. Moreland, M. Larsen, and H. Childs. Techniques for data-parallel searching for duplicate elements. In *2017 IEEE 7th Symposium on Large Data Analysis and Visualization (LDAV)*, pages 1–5, Oct 2017.
21. S. Li, M. Larsen, J. Clyne, and H. Childs. Performance impacts of in situ wavelet compression on scientific simulations. In *Proceedings of the In Situ Infrastructures on Enabling Extreme-Scale Analysis and Visualization*, ISAV'17, pages 37–41, New York, NY, USA, 2017. ACM.
22. S. Labasan, M. Larsen, H. Childs, and B. Rountree. PaViz: A Power-Adaptive Framework for Optimizing Visualization Performance. In A. Telea and J. Bennett, editors, *Eurographics Symposium on Parallel Graphics and Visualization*. The Eurographics Association, 2017.
23. K. Moreland, C. M. Sewell, W. Usher, L. Lo, J. S. Meredith, D. Pugmire, J. Kress, H. A. Schroots, K. Ma, H. Childs, M. Larsen, C. Chen, R. Maynard, and B. Geveci. Vtk-m: Accelerating the visualization toolkit for massively threaded architectures. *IEEE Computer Graphics and Applications*, 36(3):48–58, 2016.
24. S. Labasan, M. Larsen, and H. Childs. Exploring tradeoffs between power and performance for a scientific visualization algorithm. In *2015 IEEE 5th Symposium on Large Data Analysis and Visualization (LDAV)*, pages 73–80, Oct 2015.
25. K. Moreland, M. Larsen, and H. Childs. Visualization for exascale: Portable performance is critical. *Supercomput. Front. Innov.: Int. J.*, 2(3):67–75, July 2015.

Software Artifacts

Ascent (primary developer since inception in 2017)

- Ascent is a flyweight library for in situ visualization and analysis, with emphases on minimal memory usage and API, as well as interoperability with external libraries.
- Larsen's contributions include design on the main runtime, which translates the front-facing user API into a data flow network, the expressions language, and in situ triggers infrastructure. Ascent has been integrated into numerous simulation codes, and Ascent has been demonstrated running using over 16K GPUs on LLNL's Sierra supercomuter.

Devil Ray(software architect and developer since inception in 2017)

- Devil Ray is visualization and analysis libary for high-order finite elements targeting modern HPC architectures. Originally, Devil Ray was developed as high-order element ray tracer, but Devil Ray has grown to include general analysis and visualization capabilites responding to the needs of our customers.
- As a staff scientist interacting with LLNL's simulation codes, Larsen identified gaps in our current visualization and analysis capabilities. Larsen secured internal funding to develop Devil Ray and implemented the library along with Masado Ishii, a student funded by LLNL. To date, we have demonstrated Devil Ray running concurrenlty on over 4,000 GPUs is support of LLNL's mission.

Stawman In Situ Visualization Mini-app (primary developer 2016-2017)

- Strawman ia a prototype in situ visualization infrastructure mini-app. The main projects goals were ease of use (i.e., low code footprint for integrations) and execution in distributed-memory parallel batch environments. Strawman is the precursor to Ascent.
- As an intern at LLNL, Larsen's primary contributions included integrating technologies Conduit, EAVL, and the IceT parallel image compositing library into a infrastructure capable of leveraging many-core architectures on leading supercomputers. Responsibilities included visualization and parallel rendering implementation. To demonstrate its capabilities, Strawman was integrated with three physics mini-apps (LULESH, Kripke, and Cloverleaf3D), and performed weak scaling studies up to 4096 cores and 128 GPUs.

VTK-m (participant since inception in 2016)

- VTK-m is a library for portably performance over many-core architectures. It is a follow-on effort to the popular Visualization ToolKit (VTK), with the "m" indicating many-core support.
- Larsen is the primary contributor of the rendering component of VTK-m, developing a portable ray-tracing framework that is capable of structured and unstructured volume rendering, radiography, and surface rendering. Additionally, Larsen has contributed various core components of VTK-m such as support for atomic operations.

VTK-h (primary developer since inception in 2016)

- VTK-h is a library built on top of VTK-m that includes a distributed memory component, with the "h" indicating hybrid-parallel support. The VTK-h library has served as a production prototype for distributed-memory support inside of VTK-m.
- Larsen has developed the composable distributed-memory filter system built using components from VTK-m. Other contributions include a hybrid-parallel image compositing system for surface and volume rendering leveraging DIY2.

ROVER (primary developer since inception in 2016)

- ROVER is set of distributed-memory components that performs multi-group simulated radiography on simulation meshes.
- Larsen's contributions include a generalized multi-group absorption and emission distributed-memory compositing infrastructure. Various components of ROVER have been integrated into Ascent and VTK-m. Additionally, Larsen is the architect of a high-order element ray tracing component, and he has been supervising and advising student contributions.

VisIt (participant since 2016)

- VisIt is developed by over a dozen developers, is used at supercomputing centers around the world, has been downloaded more than 200,000 times, and was recognized with an R&D 100 award in 2005.
- Larsen's contributions include adding enhancements to the pick infrastructure, rendering, VTK-m integration, and various database readers.

EAVL (participant from 2014-2016)

- EAVL (The Extreme-Scale Analysis and Visualization Library) is a portable performance visualization that served as one of the three prototypes for VTK-m.
- As student, Larsen implemented ray-tracing, volume rendering, and radix sort algorithms (OpenMP and CUDA) to the EAVL library. Additionally, Larsen published various research papers showing that algorithms based on data-parallel primitives can be competitive with algorithms that target specific HPC architectures.

Peer Reviewed conference tutorials

- "In Situ Scientific Analysis and Visualization using ALPINE Ascent" at an ECP Training Event - Dec 2020, Virtual
- "In Situ Analysis and Visualization with SENSEI and Ascent" at ACM/IEEE SuperComputing 2020, Atlanta, GA, November, 2020.
- "In Situ Visualization and Analysis with Ascent" at Exascale Computing Project (ECP) Annual Meeting, Houston, TX, February 2020.
- "In Situ Analysis and Visualization with SENSEI and Ascent" at ACM/IEEE SuperComputing 2019, Denver, CO, November, 2019.
- "In Situ Visualization and Analysis with Ascent" at Exascale Computing Project (ECP) Annual Meeting, Houston, TX, January 2019.

Keynote Presentations

- ISC Workshop on In Situ Visualization (WOIV), "The changing balance in HPC and in situ visualization challenges," Frankfurt, Germany, June 2018.

Invited Talks

- Oak Ridge National Laboratory, “Devil Ray: A Portably Performant Ray Tracer for High-Order Element Visualization” Oak Ridge, TN, October 2019.
- University of Oregon, “In Situ Visualization for Exascale Computing,” Eugene, OR, November 2018.
- Rheinisch-Westfaelische Technische Hochschule (RWTH)-Aachen, “The changing balance in HPC and in situ visualization challenges,” Aachen, Germany, July 2018.
- Los Alamos National Laboratory, “Performance Modeling of In Situ Rendering,” Los Alamos, NM, September 2016.
- Texas Advanced Computing Center, “Ray Tracing Within a Data Parallel Framework,” Austin, TX. January 2015.
- Kitware, Inc., “Ray Tracing Within a Data Parallel Framework,” Clifton Park, NY. December 2014.

Invited Seminars

- Schloss Dagstuhl Seminar on Scientific Visualization, Wadern, Germany, July 2018.

Professional Service

- Organization
  - Program Co-Chair: EGPGV co-located with EuroVis, Zurich, Switzerland, 14 June 2021
  - Co-organizer: Visualization in Practice, IEEE Vis associated event, New Orleans, LA, USA October 2021
  - Co-organizer: Visualization in Practice, IEEE Vis associated event, Salt Lake City, USA, October 2020
  - Co-organizer: Visualization in Practice, IEEE Vis associated event, Vancouver, Canada, October 2019
  - Site chair: DOE Computer Graphics Forum, Monterey, CA, April 2019
  - Site chair: VTK-m hackathon, Livermore, CA, August 2018
- Program Committee
  - ACM/IEEE Supercomputing (SC) tutorials 2017, 2018, 2019
  - Eurographics Parallel Graphics and Visualization Symposium 2018, 2019, 2020
  - In Situ Infrastructures for Enabling Extreme-scale Analysis and Visualization (ISAV) 2017, 2018, 2019, 2020
  - Visualization in Practice 2017
- Technical Paper Reviews
  - IEEE Transactions on Visualization and Computer Graphics(TVCG) 2020
  - Journal of Computational Science 2018
  - Journal of Computer Graphics and Applications 2017
  - EuroVis 2017 2021
  - Pacific Vis 2017
  - SIAM Journal on Scientific Computing 2016
  - EuroGraphics Parallel Graphics and Visualization Symposium 2015, 2018, 2019, 2020
  - IEEE Visualization Conference 2015, 2019
  - In Situ Infrastructures for Enabling Extreme-scale Analysis and Visualization 2015, 2017, 2018, 2019, 20202
- Grant Reviews
  - Panelist for DOE Office of Advanced Scientific Computing Research funding opportunity, 2019
- Other Service
  - ACM/IEEE SuperComputing Visualization Showcase 2018, 2019 (Judge)