

Tyler Sorensen – CV

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Research Summary

My research interests are in enabling efficient and reliable applications to be developed and executed on current and near-future systems (e.g. heterogeneous architectures). I am interested in a three step approach: *modeling* the semantics of underspecified areas of the system (e.g. operational/axiomatic semantic modeling), *validating* the semantics (e.g. empirical testing, model checking), and *developing* more efficient and reliable applications using the new understanding of the system (e.g. auto-tuning, domain-specific languages).

Current Position

July 2020 - Present - UC Santa Cruz: Department of Computer Science and Engineering
Assistant Professor

Professional Memberships

July 2019 - Present - Khronos Group
Invited Individual Contributor

Prior Positions

July 2018 - June 2020 - Princeton University: Department of Computer Science
Postdoctoral research associate
Supervisor: Margaret Martonosi

Education

Fall 2014- Fall 2018 - PhD in Computer Science - Imperial College London, UK
Thesis: *Device-wide Barrier Synchronisation on Graphics Processing Units*
Supervisor: Alastair F. Donaldson

Fall 2013 - Spring 2014 - MS in Computer Science - University of Utah, USA
Thesis: *Testing and Exposing Weak GPU Memory Models*
Supervisor: Ganesh Gopalakrishnan

Fall 2010 - Spring 2012 - BS in Computer Science - University of Utah, USA
Thesis: *Towards Shared Memory Consistency Models for GPUs*
Supervisor: Ganesh Gopalakrishnan

Fall 2010 - Spring 2012 - BS in Applied Mathematics - University of Utah, USA

Fall 2008 - Spring 2010 - AA with engineering emphasis - Snow College (community college), USA

Publications

Key: ★ Lead (or co-lead) author. A+, A, B, C: The venue CORE ranking (where available).

Conference Publications

- [1] Jake Kirkham, Tyler Sorensen, Esin Tureci, Margaret Martonosi. “Foundations of Empirical Memory Consistency Testing”. In: *Object Oriented Programming Systems Languages and Applications (OOPSLA)*. 2020. OOPSLA A+
2020
- [2] Dan Iorga, Tyler Sorensen, John Wickerson, Alastair F. Donaldson. “Slow and Steady: Measuring and Tuning Multicore Interference”. In: *Real-Time and Embedded Technology and Applications Symposium (RTSS)*. 2020. RTSS A+
2020
- [3] Opeoluwa Matthews, Aninda Manocha, Davide Giri, Marcelo Orenes-Vera, Esin Tureci, Tyler Sorensen, Tae Jun Ham, Juan L. Aragon, Luca P. Carloni, Margaret Martonosi. “MosaicSim: A Lightweight, Modular Simulator for Heterogeneous Systems”. In: *Int. Symp. on Performance Analysis of Systems and Software (ISPASS)*. 2020. **Best paper nomination**. ISPASS B
2020
- [4] Tyler Sorensen, Sreepathi Pai, Alastair F. Donaldson. “One Size Doesnt Fit All: Quantifying Performance Portability of Graph Applications on GPUs”. In: *Int. Symp. on Workload Characterization (IISWC)*. 2019. **Best paper award**. ★ IISWC
2019
- [5] Tyler Sorensen, Hugues Evrard, Alastair F. Donaldson. “GPU Schedulers: How Fair is Fair Enough?”. In: *Int. Conf. on Concurrency Theory (CONCUR)*. 2018. ★ CONCUR A
2018
- [6] Nathan Chong, Tyler Sorensen, John Wickerson. “The Semantics of Transactions and Weak Memory in x86, Power, ARM, and C++”. In: *ACM Conf. on Programming Language Design and Implementation (PLDI)*. 2018. **Artifact evaluated and accepted. Industry collaboration (Nathan Chong at ARM). Distinguished paper award**. PLDI A+
2018
- [7] Tyler Sorensen, Hugues Evrard, Alastair F. Donaldson. “Cooperative Kernels: GPU Multitasking for Blocking Algorithms”. In: *ACM Symp. on The Foundations of Software Engineering*. 2017. **Distinguished paper award**. ★ FSE A+
2017
- [8] John Wickerson, Mark Batty, Tyler Sorensen, George A. Constantinides. “Automatically Comparing Memory Consistency Models”. In: *ACM Symp. on Principles of Programming Languages (POPL)*. 2017. **Artifact evaluated and accepted. Methodology used by Industry in defining the Vulkan GPU memory consistency model**. POPL A+
2017
- [9] Tyler Sorensen, Alastair F. Donaldson, Mark Batty, Ganesh Gopalakrishnan, Zvonimir Rakamarić. “Portable Inter-workgroup Barrier Synchronisation for GPUs”. In: *ACM Conf. on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA)*. 2016. **Artifact evaluated and accepted**. ★ OOPSLA A+
2016
- [10] Tyler Sorensen, Alastair F. Donaldson. “Exposing Errors Related to Weak Memory in GPU Applications”. In: *ACM Conf. on Programming Language Design and Implementation (PLDI)*. 2016. ★ PLDI A+
2016
- [11] Jade Alglave, Mark Batty, Alastair F. Donaldson, Ganesh Gopalakrishnan, Jeroen Ketema, Daniel Poetzl, Tyler Sorensen, John Wickerson. “GPU Concurrency: Weak Behaviours and Programming Assumptions”. In: *Int. Conf. on Architectural Support for Programming Languages and Operating Systems (ASPLOS)*. 2015. **HiPEAC Paper Award. Invited for fast-track submission to ACM Transactions on Computer Systems**. ★ ASPLOS A+
2015

Workshop/Other Publications (Peer reviewed)

- [12] Tyler Sorensen, Aninda Manocha, Marcelo Orenes-Vera, Esin Tureci, Juan L. Aragon, Margaret Martonosi. “A Simulator and Compiler Framework for Agile Hardware-Software Co-design Evaluation and Exploration: Invited Talk”. In: *Int. Conf. on Computer-Aided Design (ICCAD)*. 2020. ★ **ICCAD** 2020
- [13] Tyler Sorensen, Sreepathi Pai, Alastair F. Donaldson. “Performance Evaluation of OpenCL Standard Support (and Beyond)”. In *Int. Workshop on OpenCL (IWOCL)*. 2016. ★ **IWOCL** 2019
Best paper award.
- [14] Tyler Sorensen, Alastair F. Donaldson. “The Hitchhiker’s Guide to Cross-platform OpenCL Application Development”. In *Int. Workshop on OpenCL (IWOCL)*. 2016. ★ **IWOCL** 2016
- [15] Jade Alglave, Luc Maranget, Daniel Poetzl, Tyler Sorensen. “I Compute, Therefore I am (Buggy): Methodic Doubt Meets Multiprocessors”. In *Tiny Transactions on Computer Science Volume 3 (Tiny ToCS)*. 2015. ★ **TinyToCS** 2015
- [16] Tyler Sorensen, Ganesh Gopalakrishnan, Vinod Grover. “Towards Shared Memory Consistency Models for GPUs”. In *Int. Conf. on Supercomputing (ICS)*. 2013. **1st place ACM undergrad student research competition (SRC)**. ★ **ICS A** 2013

Professional Service

Conference and workshops

Year	Venue	Role
2021	PLDI	SRC co-chair
2021	IA ³	Program Committee (PC)
2021	ASPLOS	External Program committee (ERC)
2020	FORTE	Program committee (PC)
2020	OOPLSA	External Program committee (ERC)
2020	MICRO	External Program committee (ERC)
2020	ASPLOS	External Program committee (ERC)
2020	PLDI	Program committee (PC)
2019	ISCA	External review committee (ERC)
2018	PLDI	External review committee (ERC)
2018	ECOOP	Program committee for doctoral symposium (PC for DS)
2016	ASPLOS	Sub-reviewer
2016	TinyToCS	Program committee (PC)
2016	POPL	Artifact evaluation committee (AEC)
2014	POPP	Sub-reviewer

Journals

Year	Venue	Role
2018	Formal Methods in System Design (FMDS)	Article reviewer
2018	ACM Trans. on Arch. and Code Optimization (TACO)	Article reviewer
2014	ACM Trans. on Prog. Lang. and Systems (TOPLAS)	Sub-reviewer

Invited Talks and Panels

Industry

- Accelerating Graph Applications on Parallel Heterogeneous Architectures
 - Oct., 2020: Princeton ACM / IEEE Computer Society Meeting, Princeton NJ
- Reasoning about Heterogeneous Computing, Starting with GPGPU Programming
 - Sept., 2020: Apple, Cupertino, CA
- Cooperative Kernels: GPU Multitasking for Blocking Algorithms (extended FSE'17 talk)
 - Feb., 2017: ARM Cambridge, UK
- Portable Inter-workgroup Barrier Synchronisation for GPUs (extended OOPSLA'16 talk)
 - May, 2016: AMD Bellevue, WA

Academic

- IA³ Debate: Programming Abstractions VS. High-performance
 - Nov, 2019: IA³ at SC'19, Denver, CA
- Reasoning about Heterogeneous Computing
 - April, 2019: Lehigh University, PA
- GPU Concurrency: The Wild West of Programming (PhD Talk):
 - June, 2018: University of Utah, UT
 - Sept., 2018: TU Darmstadt, Germany
 - March, 2018: University of Glasgow, UK
- Exposing Errors Related to Weak Memory in GPU Applications (extended PLDI'16 talk)
 - Nov., 2016: University College London, UK
 - Oct., 2015: University of Kent, UK

Awards, Press and Recognition

Fall 2020	Contributions to GPU forward progress models mentioned in blog: https://raphlinus.github.io/gpu/2020/04/30/prefix-sum.html
Fall 2020	GPU testing found a bug and led to an official patch in Intel OpenCL compilers https://github.com/intel/intel-graphics-compiler/commit/1c6b78c8b02d7383a1b12bc2323c9bf56380a72c
Fall 2020	Distinguished paper nomination – Int. Symp. on Perf. Analysis of Systems & Software (ISPASS). 2020
Fall 2019	Distinguished paper award – Int. Workshop on OpenCL (IWOCL) 2019
Fall 2019	Distinguished paper award – Int. Symp. on Workload Characterization (IISWC) 2019
Summer 2018	Distinguished paper award – Programming Language Design and Implementation (PLDI) 2018
Summer 2017	Distinguished paper award – Foundations of Software Engineering (FSE) 2017
Fall 2016	Art of research staff pick award – Imperial College http://multicore.doc.ic.ac.uk/projects/artofresearch

- Fall 2015** GPU testing led to errata entry for textbook: *CUDA by Example*
<https://developer.nvidia.com/cuda-example-errata-page>
- Fall 2015** GPU testing contributions mentioned in LWN article
Axiomatic validation of memory barriers and atomic instructions
<https://lwn.net/Articles/608550/>
- Spring 2014** Outstanding graduating senior award – University of Utah
- Spring 2014** List of 40 outstanding alumni under 40 – Snow College
- Fall 2013** Top 5 in undergraduate researcher competition – Computing Research Association (CRA)
- Summer 2013** 1st place ACM undergrad student research competition – Int. Conf. on Supercomputing (ICS)
- Fall 2012** 1st place team super computing student cluster competition - Super Computing (SC)
- Fall 2012** 2nd place at local ACM fall programming competition – Brigham Young University (BYU)
- Spring 2012** 1st place at local ACM spring programming competition – Brigham Young University (BYU)
- Spring 2011** Honorable mention in the Microsoft Imagine Cup game design competition

Industry Impact Summary

The work I have been involved in has had significant impact in industry. In particular:

- **Memory Consistency Models for GPUs:** Over the last few years, GPU standards have provided more precise memory model documentation: OpenCL (in 2014), HSA (in 2016), Nvidia PTX (in 2017), Vulkan (in 2018). Our ASPLOS'15 and PLDI'16 work revealed significant misunderstandings in the GPU programming community and is considered a key motivator of this industrial trend. My BS thesis (2013) is one of the first works on formalizing GPU memory consistency models.
- **Vulkan Memory Consistency:** The cross-vendor GPU programming language Vulkan added a formal memory consistency model in 2018 using the exact methodology of our POPL'17 paper. The influence of our work was directly acknowledged in communication with members of the standards committee.
- **ARM Transactional Memory:** The framework of our PLDI'18 work revealed a subtle bug in an internal ARM proposal for transactional memory support. ARM acknowledged the issue internally and used our methodology to provide confidence in subsequent proposals.

Coding Projects

Primary Author/Contributor

- **OpenCL Irgl:** DSL/compiler for portable GPU graph algorithms
Code available on request; public release planned soon
Portable state-of-the-art fundamental graph algorithms (BFS, SSSP, etc.) in portable OpenCL. Tested on Nvidia, AMD, ARM and Intel GPUs. *Currently the fastest implementations we are aware of for AMD, ARM and Intel GPUs.*
- **Discovery Barrier:** Portable device-wide GPU synchronization barrier
https://github.com/mc-imperial/gpu_discovery_barrier
Portable library for a GPU device-wide synchronization barrier using theory from the OOPSLA'16 paper. Tested on Nvidia, AMD, ARM and Intel GPUs. *Currently the only implementation that we are aware of that is capable of providing this synchronization in a portable way.*

- **PBDD**: Binary decision diagram (BDD) web application
<https://github.com/tyler-utah/PBDD>
 Interactive web application for constructing BDDs from logic formulas, intended for pedagogical use.
 - Average of 98 visits a month (as of Sept. 2018)
 - Used in courses taught at Cambridge University (UK), University of Utah (USA), University of Nebraska (USA), Washington University in St. Louis (USA)

Contributor

- **MemAlloy**: Relational modeling and checking of memory consistency semantics
<https://github.com/johnwickerson/memalloy>
 A framework based on the Alloy relational constraint solver for performing bounded model checking of many interesting memory consistency queries. My contributions examined exhaustively enumerating conformance tests (up to a bound) for a given memory consistency model. Used in POPL'17 and PLDI'18 publications.
- **CLBlast**: Tuned OpenCL BLAS library
<https://github.com/CNugteren/CLBlast>
 Added low-level Nvidia-specific instructions to achieve up to a *1.5x speedup* for some GEMM (General matrix-matrix multiplication) configurations.

Teaching

Classes

Unless explicitly mentioned, all classes taught are at UCSC

- Fall 2020: CSE 211: Advanced Compiler Design

Student Supervision

PhD Students (primary supervisor)

- Reese Levine (starting Fall 2020)

PhD Students (co-supervising)

- Dan Iorga (Imperial College London)
 Primarily supervised by Alastair F. Donaldson.
- Aninda Manocha (Princeton University)
 Primarily supervised by Margaret Martonosi.

Undergraduate Projects (primary supervisor)

- Jake Kirkham (Princeton University): Project led to top tier publication in OOPSLA 2020: "Foundations of Empirical Memory Consistency Testing".
- Harmit Raval and Lucas Salvador (Princeton University): Project on GPU forward progress was presented to Khronos Group and produced a paper currently under submission.

Guest Lectures

Term	Course	Professor
Spring 2019	Princeton: COS 375 Comp. Arch.	3 Lectures on parallel + GPU programming
Fall 2012	University of Utah: CS3100 Models of Comp.	2 Lectures on functional Python programming

Teaching Assistant

Term	Course	Professor
Fall 2012	University of Utah: CS3100 Models of Computation	Ganesh Gopalakrishnan
Fall 2011	University of Utah: CS1410 Object Orient Programming	Joe Zachary

Misc. Teaching Activities

- Fall 2014** Microsoft research student workshop: *Think Computer Science*
<https://www.microsoft.com/en-us/research/event/think-computer-science-2014/>
Tutored lab sessions for middle school students using Python on Raspberry Pis
- Summer 2012** Summer project developing pedagogical material
Created (and continue to maintain) interactive tools for propositional logic courses.
Used in courses taught at Cambridge University (UK), University of Utah (USA),
University of Nebraska (USA), Washington University in St. Louis (USA)

Grants

I contributed significantly to the writing of the following grant:

- **Multi-Core Microprocessor Test Harness (R1000115750)**
Defence Science and Technology Laboratory (DSTL)
Principal Investigator: Alastair F. Donaldson
Amount: 73,854 GBP
We proposed a methodology for rigorously testing the runtime of sequential applications in the presence of independent adversarial processes running on distinct cores of a multi-core system.

Internships

- Spring 2017** Microsoft Research - *RiSE group*
Mentors: Todd Mytkowicz, Madan Musuvathi, Saeed Maleki
Project: a parallel algorithm for DNNs that preserves sequential semantics
- Spring 2016** Microsoft - *Speech decoding product group*
Mentors: Veljko Miljanic, Hosam Khalil, Madan Musuvathi
Project: practical parallel speech decoding for product (Cortana backend)
Impact: several contributions accepted to main production branch
- Summer 2014
and
Summer 2013** Nvidia - *Compiler group*
Mentor: Vinod Grover
Project: Contributed to internal shared memory consistency model