

SOMESH SINGH

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RESEARCH INTERESTS

High-Performance Computing; Parallel Computing; Graph Analytics.

AREA OF RESEARCH

The focus of my dissertation research is on accelerating large-scale (irregular) graph processing on graphics processing unit (GPU). I approach this problem by designing approximate computing techniques for improving execution performance of parallel graph analytics by trading off computational accuracy.

GRADUATE COURSES

Mathematical Concepts for Computer Science, Advanced Data Structures and Algorithms, Computer Architecture, High-Performance Parallel Computing, Program Analysis, Modern Compilers, Indexing and Searching in Large Datasets, Probability and Computing, Pattern Recognition and Machine Learning, Digital Design Verification, CAD for VLSI Systems.

PROGRAMMING LANGUAGES

- Fluent: C/C++, CUDA, OpenMP
- Familiar: OpenCL, Python, MATLAB, LLVM

PUBLICATIONS

- **Somesh Singh** and Rupesh Nasre, “Scalable and Performant Graph Processing on GPUs using Approximate Computing”, *IEEE Transactions on Multi-Scale Computing Systems (TMSCS)*, vol. 4, no. 3, pp. 190–203, 2018. <https://doi.org/10.1109/TMSCS.2018.2795543>. [Citation count: 3]
- **Somesh Singh** and Rupesh Nasre, “Optimizing Graph Processing on GPUs using Approximate Computing: Poster”, *24th ACM SIGPLAN Annual Symposium on Principles and Practice of Parallel Programming (PPoPP 2019)*, pp. 395–396. <https://doi.org/10.1145/3293883.3295736>.
- R. De Maria, J. Andersson, V.K.B. Olsen, L. Field, M. Giovannozzi, P.D. Hermes, N. Høimyr, S. Kostoglou, G. Iadarola, E. McIntosh, A. Mereghetti, J. Molson, D. Pellegrini, T. Persson, M. Schwinzerl, E.H. Maclean, K.N. Sjobak, I. Zacharov and **S. Singh**, “SixTrack Project: Status, Runtime Environment and New Developments”, *13th International Computational Accelerator Physics Conference (ICAP 2018)*, pp. 172–178. <https://doi.org/10.18429/JACoW-ICAP2018-TUPAF02>.
- R. De Maria, J. Andersson, V.K.B. Olsen, L. Field, M. Giovannozzi, P.D. Hermes, N. Høimyr, S. Kostoglou, G. Iadarola, E. McIntosh, A. Mereghetti, J. Molson, D. Pellegrini, T. Persson, M. Schwinzerl, E.H. Maclean, K.N. Sjobak, I. Zacharov and **S. Singh**, “SixTrack V and runtime environment”, *International Journal of Modern Physics A (IJMPA)*, vol. 34, no. 36, 1942035, 2019. <https://doi.org/10.1142/S0217751X19420351>. (Invited paper)

WORKS UNDER SUBMISSION

- Approximate computing techniques targeting GPU-specific aspects for efficient graph processing on SIMT architectures.
- Faster estimation of top- k betweenness centrality vertices in a graph on heterogeneous architectures using approximate computing.

ACCOMPLISHMENTS AND AWARDS

- Google Summer of Code 2018 participant with CERN-HSF.
 - Developed a standalone optimized parallel implementation of (a part of) SixTrackLib, a particle-tracking library.
 - The work contributed to the IJMPA 2019 and ICAP 2018 papers.
 - Major challenges: writing library code that is performance-portable across multicore CPUs and manycore GPUs.
 - Technologies involved: C/C++, OpenCL 1.2
- Google Summer of Code 2017 participant with CERN-HSF.
 - Developed SALLOC, an arena based memory allocator for SIMT architectures, with support for the *vector* container, in CUDA.
 - The arena supports allocation of multiple vectors; vector container on the arena supports `push_back()`, `pop_back()` and `getIndex()` operations.
 - Major challenges: designing a suitable data structure for the arena that is amenable to parallelization of vector operations on GPU; deciding the APIs to be exposed to the user.
- Secured 4th place in HiPC 2016 Student Parallel Programming Challenge (Intel Xeon-Phi track) (Team of 2).
 - Implemented an efficient scheme for labeling connected clusters in a 3-dimensional grid using the Union-Find data structure. All points in a cluster were to be assigned the same label.
 - Major challenges: choosing or designing a data structure that supports set membership; designing an algorithm for the task, with reduced computational complexity.
 - Technologies involved: C++, OpenMP.
- Secured 4th place in HiPC 2015 Student Parallel Programming Challenge (Intel Xeon-Phi track) (Team of 3).
 - Implemented an efficient parallel version of the KMeans++ algorithm for assigning membership to each data point in a high dimensional unlabeled data set, to maximize the Dunn-index.
 - Major challenge: choosing or designing a clustering algorithm with low computational complexity and sufficient data parallelism.
 - Technologies involved: C++, OpenMP.
- Organized CUDA Workshop during Exebit 2018 at the Indian Institute of Technology Madras.
- Awarded ACM SIGPLAN PAC grant for attending PPOPP 2019.
- Awarded the STAR TA award for contributions as a Teaching Assistant to the course “GPU Programming” for the period July – November 2017.

SERVICES

- Committee Member in Artifact Evaluation Committee for ECOOP 2020.
- Committee Member in Artifact Evaluation Committee for PPOPP 2018.
- Reviewer for INAE Letters in 2018.
- Reviewer for IEEE Embedded Systems Letters in 2017.

PROJECTS AND INTERNSHIPS

COURSE PROJECTS

- Supergraph Containment Search (Team of 2). *October – November 2016*
 - Implemented an efficient supergraph containment search technique using the *filtering* and *verification* framework, in C++.
 - Optimized the online processing time required for finding the (small) graphs, in the database, that are present in the (large) query graph. Our team **won** the contest for minimizing the querying time over 200 query graphs for a database containing 70K graphs.
 - Major challenges: indexing the database graphs; selecting graph *features* that help minimize the number of database graphs to be searched in the query graph during the *verification* phase.

- Five stage RISC pipeline. *October – November 2015*
 - Implemented a five stage pipeline for a RISC processor with operand-forwarding using Bluespec.
- Domain Specific Language For Circuit Design (Team of 2). *March – April 2015*
 - Implemented an internal DSL, in Python, that allows specifying a boolean expression in the Disjunctive Normal Form (DNF), and supports generating a netlist, comprising AND, OR, NOT logic gates, for the minimal form of the boolean expression.
 - Major challenges: deciding the APIs to be exposed to the user; choice of the right data structure for storing the boolean function, that is amenable to the algorithm (Quine-McCluskey algorithm) for minimizing the boolean function.

OTHER PROJECTS

- Object Tracking in Video Using Parallel Computing *March – April 2014*
 - Implemented a sum of absolute differences (SAD) based parallel block-matching algorithm for tracking the object of interest in a video, in CUDA.
- Online Gaming *April 2013*
 - Designed an interactive single player online game, using HTML5 and JavaScript, that can be played on an internet browser.

INTERNSHIPS

- RTOS based Embedded Software Design and Verification of Serial Communication *June – July 2013*
 - Intern at Larsen and Toubro SIPL, Bengaluru, India.
 - Implemented a device driver for an external UART device for the RTOS, VxWorks; established communication between host-PC and target PowerPC board using a serial protocol.
- Autonomous Mobile Robots – A Study *May - June 2012*
 - Intern at the Indian Institute of Technology Delhi, India.
 - Programmed a mobile robot (iRobot) to move autonomously in an unstructured environment, using ‘kinect’ for visual feedback, using the Player/Stage software.

MENTORING

- Mentor for a masters project *2017-18*
 - Objective of the project: Fast estimation of top- k betweenness centrality vertices in a graph, aided by approximate computing.
- Mentored two undergraduate students. They worked on:
 - Graph-based Image Segmentation *December 2016*
 - * Modeled an image as a weighted graph and performed image segmentation using various graph algorithmic techniques on the underlying graph.
 - Image Segmentation and Object Tracking on GPU *May - June 2015*
 - * Implemented a parallel seed-based region growing algorithm for image segmentation in CUDA.

EDUCATION

- Doctor of Philosophy (Ph.D.) *July 2014 - August 2020 (expected)*
 Indian Institute of Technology Madras
- Adviser: Dr. Rupesh Nasre
 - CGPA: 7.79 of 10
- Bachelor of Technology in Computer Science and Engineering *July 2010 - May 2014*
 National Institute of Technology Uttarakhand
- CGPA: 8.68 of 10