

Cheng Li

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OBJECTIVE

Full-time position in research and engineering

RESEARCH INTEREST

My research lies in the field of GPU-accelerated applications, with an emphasis on Deep Learning (DL). My work has focused on understanding and optimizing Deep Learning workloads. In the process, I have developed several open-source tools to benchmark, profile, and summarize Deep Learning training and inference across hardware and software stacks.

EDUCATION

University of Illinois Urbana-Champaign

Ph.D. in Computer Science

GPA: 3.95/4.0

Champaign, IL

Expected August 2020

Thesis: Performance Benchmarking, Analysis and Optimization of Deep Learning Inference

University of Michigan

M.S. in Computer Science and Engineering

GPA: 3.96/4.0

Ann Arbor, MI

May 2015

Shanghai Jiao Tong University

B.S. in Electrical Engineering

GPA: 3.85/4.0

Shanghai, China

August 2013

University of Michigan

B.S. in Computer Engineering

GPA: 3.63/4.0

Ann Arbor, MI

May 2013

WORK EXPERIENCE

Alibaba Group

Research Intern

Sunnyvale, CA

May - August 2019

- Extended MLModelScope with automatic across-stack analysis capability.
- Used MLModelScope to benchmark and characterize public, MLPerf and AI Matrix models across systems of interest.
- Performed model/framework/system advising using the data collected, and explore its applicability in the Alibaba Cloud.

IBM Thomas J. Watson Research Center

Research Intern

Yorktown Heights, NY

May - August 2018

- Evaluated existing techniques for Deep Learning performance estimation on different models and systems, and understood the sources of inaccuracy.
- Developed an analysis tool that generates layer benchmarks, finds patterns within models, and performs performance prediction for Deep Learning models across hardware.

9th Programming and Tuning Massively Parallel Systems and AI School
Teaching Assistant

Barcelona, Spain
July 2018

- Designed GPU labs and projects for the summer school students.
- Advised the students during the summer school's hackathon.

IBM Thomas J. Watson Research Center
Research Intern

Yorktown Heights, NY
May - August 2017

- Developed **MLModelScope** a hardware/software agnostic platform for consistent benchmarking and analysis of Deep Learning inference at scale.
- Profiled and optimized GPU-accelerated alternating least square(ALS) algorithms for Matrix Factorization and conducted profiling with nvprof and nvvp.

University of Illinois Urbana-Champaign
Lead Teaching Assistant for CS483 - Applied Parallel Programming

Champaign, IL
August - December 2016

- Designed GPU labs, exams, and projects for a class of 200 students. Maintained the assignment and the project submission systems - **WebGPU** and **RAI**.

RECENT PROJECTS

XSP

- XSP is an across-stack profiling design that innovatively leverages distributed tracing to aggregate profile data from different profiling sources and construct a holistic and hierarchical view of DL model execution.
- XSP introduces a leveled and iterative measurement approach that accurately captures the latencies at all levels of the HW/SW stack despite the profiling overhead.
- We implement the design for GPUs and couple it with an automated analysis pipeline that enables systematic characterization and comparison.

Benanza

- We propose a "lower-bound" latency metric for DL models on GPUs based on the observation that the latency of a DL model is bounded by the latencies of the cuDNN and cuBLAS API calls corresponding to the model layers.
- Benanza is a sustainable and extensible benchmarking and analysis design that automatically generates micro-benchmarks given a set of models, computes their "lower-bound" latencies using the benchmark data, and informs optimizations of their execution on GPUs.

MLModelScope

- MLModelScope is a framework- and hardware-agnostic distributed platform for benchmarking and profiling DL models across datasets/frameworks/systems.
- MLModelScope proposes a specification to define DL model evaluations and techniques to provision the evaluation workflow using the user-specified HW/SW stack.
- MLModelScope is implemented as an open-source project with support for all major frameworks and hardware architectures.

DLBricks

- DLBricks is a composable benchmark generation design that reduces the effort of developing, maintaining, and running DL benchmarks on CPUs.
- DLBricks decomposes DL models into a set of unique runnable networks and constructs the original model's performance using the performance of the generated benchmarks.

TrIMS: Transparent and Isolated Model Sharing for DL Inference

- TrIMS is a generic memory sharing technique that enables constant data to be shared across processes or containers while still maintaining isolation between users.
- TrIMS mitigates the DL model loading overhead and increases the hardware resource utilization in inference by sharing models across all levels of the memory hierarchy in the cloud environment — GPU, CPU, local storage, and remote storage.

TOPS

- TOPS is a library of collectives expressed as matrix multiplication operations on Tensor Cores Units (TCU, specialized hardware for matrix multiplication).
- It is the first to broaden the class of algorithms expressible as TCU operations and show benefits of the mapping in terms of program simplicity, efficiency, and performance.
- We implemented reduction and scan using NVIDIA V100 Tensor Cores and achieved up to 100× and 3× speedup compared to state-of-the-art methods while decreasing the power consumption by up to 22% and 16% correspondingly.

PUBLICATIONS

1. **XSP: Across-Stack Profiling and Analysis of Machine Learning Models on GPUs** (IPDPS'20, Best Paper Nomination)
Cheng Li, Abdul Dakkak*, Jinjun Xiong, Wei Wei, Lingjie Xu, Wen-Mei Hwu*
2. **Benanza: Automatic uBenchmark Generation to Compute "Lower-bound" Latency and Inform Optimizations of Deep Learning Models on GPUs** (IPDPS'20)
Cheng Li, Abdul Dakkak*, Jinjun Xiong, Wen-Mei Hwu*
3. **DLBricks: Composable Benchmark Generation to Reduce Deep Learning Benchmarking Effort on CPUs** (ICPE'20)
Cheng Li, Abdul Dakkak, Jinjun Xiong, Wen-Mei Hwu
4. **The Design and Implementation of a Scalable DL Benchmarking Platform** (arXiv'19)
Cheng Li, Abdul Dakkak, Jinjun Xiong, Wen-Mei Hwu
5. **AI Matrix: A Deep Learning Benchmark for Alibaba Data Centers** (arXiv'19)
Wei Zhang, Wei Wei, Lingjie Xu, Lingling Jin, Cheng Li
6. **MLModelScope: Evaluate and Introspect Cognitive Pipelines** (IEEE Services'19)
Cheng Li, Abdul Dakkak, Jinjun Xiong, Wen-Mei Hwu
7. **TrIMS: Transparent and Isolated Model Sharing for Low Latency Deep Learning Inference in Function as a Service Environments** (IEEE CLOUD'19)
Abdul Dakkak, Cheng Li, Simon Garcia de Gonzalo, Jinjun Xiong, Wen-Mei Hwu
8. **Accelerating Reduction and Scan Using Tensor Core Units** (ICS'19)
Abdul Dakkak, Cheng Li, Jinjun Xiong, Isaac Gelado, Wen-Mei Hwu
9. **Evaluating Characteristics of CUDA Communication Primitives on High-Bandwidth Interconnects** (ICPE'19, Best Paper)
Carl Pearson, Abdul Dakkak, Sarah Hashash, Cheng Li, I-Hsin Chung, Jinjun Xiong, Wen-Mei Hwu
10. **Accelerating Reduction Using Tensor Core Units** (HPCaML'19)
Abdul Dakkak, Cheng Li, Jinjun Xiong, Wen-Mei Hwu
11. **SCOPE: C3SR Systems Characterization and Benchmarking Framework** (arXiv'18)
Carl Pearson, Abdul Dakkak, Cheng Li, Sarah Hashash, Jinjun Xiong, Wen-mei Hwu
12. **Matrix Factorization on GPUs with Memory Optimization and Approximate Computing** (ICPP'18)
Wei Tan, Shiyu Chang, Liana Fong, Cheng Li, Zijun Wang, LiangLiang Cao
13. **RAI: A Scalable Project Submission System for Parallel Programming Courses** (IPDPSW'17)
Abdul Dakkak, Carl Pearson, Cheng Li, Wen-mei Hwu
14. **KLAP: Kernel Launch Aggregation and Promotion for Optimizing Dynamic Parallelism** (MICRO'16)
Izzat El Hajj, Juan Gomez-Luna, Cheng Li, Li-Wen Chang, Dejan Milojicic, Wen-mei Hwu
15. **DjiNN and Tonic: DNN as a Service and Its Implications for Future Warehouse Scale Comput-**

ers

(ISCA'15)

Johann Hauswald, Yiping Kang, Michael A. Laurenzano, Quan Chen, **Cheng Li**, Trevor Mudge, Ronald G. Dreslinski, Jason Mars, Lingjia Tang

16. **Sirius: An Open End-to-End Voice and Vision Personal Assistant and Its Implications for Future Warehouse Scale Computers** (ASPLOS'15)

Johann Hauswald, Michael A. Laurenzano, Yunqi Zhang, **Cheng Li**, Austin Rovinski, Arjun Khurana, Ronald G. Dreslinski, Trevor Mudge, Vinicius Petrucci1, Lingjia Tang, Jason Mars

17. **Stochastic circuits for real-time image-processing applications** (DAC'13)

Armin Alaghi, **Cheng Li**, John P. Hayes

TALKS & POSTERS

Super Computing 2019

Across-stack Profiling and Analysis of ML Models on GPUs

Denver, CO

November 18, 2019

Tutorial at IISWC 2019

Challenges and Solutions for End-to-End and Across Stack ML Benchmarking

Orlando, FL

November 3, 2019

HotChips 2019

MLModelScope: Evaluate and Profile ML Models at Scale and Across Stack

Palo Alto, CA

August 18, 2019

Tutorial at ISCA 2019

Benchmarking Deep Learning Systems

Phoenix, AZ

June 22, 2019

Tutorial at ASPLOS 2019

Benchmarking Deep Learning Systems

Providence, RI

April 14, 2019

NVIDIA GPU Technology Conference 2019

TOPS: Accelerating Reduction Using Tensor Core Units

San Jose, CA

March 22, 2019

NVIDIA GPU Technology Conference 2019

TrIMS: Transparent and Isolated Model Sharing for Low Latency DL Inference

San Jose, CA

March 22, 2019

NVIDIA GPU Technology Conference 2019

MLModelScope

San Jose, CA

March 22, 2019

Super Computing 2018

MLModelScope

Dallas, TX

November 11, 2018

IBM AI Research Week 2018

MLModelScope

Boston, MA

October 11, 2018

NVIDIA GPU Technology Conference 2017

RAI: A Scalable Submission System for GPU Applications

San Jose, CA

March 22, 2017

LANGUAGES

C/C++, Go, CUDA, Python, JavaScript, Bash, Mathematica

Chinese, English

MEMBERSHIP

IEEE, ACM, CRA-W (Computing Research Association-Women), WCS (Women in Computer Science)