Matthew Ali Sotoudeh

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University of California, Davis Davis, CA; 2017 – 2021
BS Computer Science, BS Mathematics; Regents Scholar; GPA: 4.0

Awards

Honorable Mention, CRA Outstanding Undergraduate Research Award
2nd Place at the International POPL 2020 Student Research Competition
UC Davis Regents Scholarship 2017–2021
Rep. Ro Khanna Congressional Award 2016
UC Davis Computer Science Department Undergraduate Travel Award 2020
NeurIPS 2019 Travel Award
UC Davis Undergraduate Research Center Travel Award 2019

Peer-Reviewed Publications

1. **Matthew Sotoudeh** and Aditya V. Thakur. **SyReNN: A Tool for Analyzing Deep Neural Networks**. In *International Conference on Tools and Algorithms for the Construction and Analysis of Systems (**TACAS**)*, 2021
2. **Matthew Sotoudeh** and Aditya V. Thakur. **Abstract Neural Networks**. In *27th Static Analysis Symposium (**SAS**)*, 2020
3. **Matthew Sotoudeh** and Aditya V. Thakur. **Analogy-Making as a Core Primitive in the Software Engineering Toolbox**. In *Proceedings of the 2019 ACM SIGPLAN International Symposium on New Ideas, New Paradigms, and Reflections on Programming and Software (**SPLASH/OOPSLA "Onward!"**)*, 2020
4. **Matthew Sotoudeh**. **Bounded Model Checking of Deep Neural Network Controllers**. In *Symposium on Principles of Programming Languages Student Research Competition (**POPL SRC**)*, 2020
5. **Matthew Sotoudeh** and Aditya V. Thakur. **Computing Linear Restrictions of Neural Networks**. In *Annual Conference on Neural Information Processing Systems (**NeurIPS**)*, 2019
6. **Matthew Sotoudeh**, Anand Venkat, Michael J. Anderson, Evangelos Georganas, Alexander Heinecke, and Jason Knight. **ISA Mapper: A Compute and Hardware Agnostic Deep Learning Compiler**. In *Proceedings of the 16th ACM International Conference on Computing Frontiers (**CF**)*, 2019
7. **Matthew Sotoudeh** and Sara S. Baghsorkhi. **C3-Flow: Compute Compression Co-Design Flow for Deep Neural Networks**. In *Proceedings of the 56th Design Automation Conference 2019 (**DAC**)*, 2019
8. **Matthew Sotoudeh** and Aditya V. Thakur. **Correcting Deep Neural Networks with Small, Generalizing Patches**. In *NeurIPS Workshop on Safety and Robustness in Decision Making (**SRDM**)*, 2019

Conference Presentations

1. "SyReNN: A Tool for Analyzing Deep Neural Networks," TACAS 2021, Virtual
2. "Abstract Neural Networks," SAS 2020, Virtual
3. "Analogy-Making as a Core Primitive in the Software Engineering Toolbox," "Onward!" 2020, Virtual
4. "Bounded Model Checking of Deep Neural Network Controllers," POPL SRC 2020, New Orleans, LA
5. "Computing Linear Restrictions of Neural Networks," NeurIPS 2019, Vancouver, BC, Canada
6. "ISA Mapper: A Compute and Hardware Agnostic Deep Learning Compiler," CF 2019, Alghero, Italy
7. "C3-Flow: Compute Compression Co-Design Flow for Deep Neural Networks," DAC 2019, Las Vegas, NV
8. "Correcting Deep Neural Networks with Small, Generalizing Patches," SRDM 2019, Vancouver, BC, Canada

Research Projects

Except where otherwise stated, my research mentor for the below was Professor Aditya V. Thakur and the research was conducted while at the UC Davis Automated Reasoning Group.

Symbolic Representations for Deep Neural Networks

Project Description: I designed algorithms for efficiently and precisely computing a *symbolic representation* of a DNN's input-output behavior on one- or two-dimensional subsets of its input space. My experiments show that both precision and efficiency can be achieved in DNN analysis for many important problems. My work has led to improvements in an open-source software project from Google and a deeper understanding of *adversarial examples* which drive research in the field of safe machine learning.
Publications: [5], [4], [1] **Code:** `https://github.com/95616ARG/SyReNN`.

Abstract Neural Networks for DNN Analysis

Project Description: I introduced and developed the fundamental theory behind *Abstract Neural Networks* (ANNs), which are like DNNs except weight matrices are replaced by values in an abstract domain. My theory can be used to significantly speed up existing DNN analysis techniques.
Publications: [2] **Code:** `https://github.com/95616ARG/abstract_neural_networks`

Provable Patching of Deep Neural Networks

Project Description: I provided polynomial-time algorithms for repairing DNNs based on a Linear Programming formulation. My algorithms patch DNNs using specifications that involve *infinitely many points*. The key behind my Provable Patching algorithms is the introduction of a new DNN architecture, *Decoupled DNNs*, which decouples the activation- and value-propagation roles of neurons in a DNN.
Publications: [8] **Code:** `https://github.com/95616ARG/SyReNN`.

Analogy-Making as a Core Primitive in Software Engineering

Project Description: I bridged work on analogy in cognitive science with the field of software engineering. I showed how programmers often reason about large codebases using analogy, and how computational models of analogy-making can address many open research problems in software engineering.
Publications: [3] **Code:** `https://github.com/95616ARG/sifter`

Automated Compilers for Linear Algebra Accelerators

Project Description: I designed and built a hardware-agnostic compiler which takes a C-style imperative program and automatically lifts the computation to run on the hardware's instruction set, then schedules the computation on the possibly-heterogeneous and parallel hardware. This automated approach allows for cross-kernel optimization, resulting in a 3–5× speedup compared to using a hand-written assembly kernel library.
Mentor, Location: Dr. Jason Knight, Intel AI Products Group, CTO Office. San Diego, California.
Publications: [6]

Compression of Deep Neural Networks

Project Description: Modern DNNs often have millions or billions of parameters. I developed a new method of compressing them up to 100× while retaining more accuracy than previous methods. I also wrote an efficient compressed matrix-multiplication routine that produces up to 15× speedups for the compressed networks.
Mentor, Location: Dr. Sara S. Baghsorkhi, Intel Labs. Santa Clara, California.
Publications: [7]

Service

1. Peer Tutor and Chair of the UC Davis CS Tutoring Committee
2. Volunteer with UC Davis M-PACT middle-school mathematics outreach
3. Started STEM summer camp for middle schoolers