Peiyang Song

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EDUCATION

❑ **University of California, Santa Barbara (UCSB)** Santa Barbara, CA
B.S. in Computer Science, College of Creative Studies (CCS) Honors Sep. 2022—Present

Advisors: Prof. Richert Wang, Prof. Phill Conrad

GPA: 4.0/4.0, mostly A+

❑ **Tianjin No.1 High School** Tianjin, China
High school diploma, Provincial Elite Class Honors Sep. 2019—Jul. 2022

GPA: 98.1/100, ranking top 2 at school

❑ **Tsinghua University (THU)** Beijing, China
Summer student @ Advanced Science Camp for high school students Aug. 2020—Sep. 2020

Double majors in Computer Science and Mathematics

RESEARCH INTERESTS

Machine Learning • Natural Language Processing • Automated Reasoning • Neuro-symbolic AI

PUBLICATIONS

Preprint **Towards Large Language Models as Copilots for Theorem Proving in Lean**
Peiyang Song, Kaiyu Yang[†], and Anima Anandkumar[†]. ([†] Equal advising)
NeurIPS MATH-AI Workshop 2023 (manuscript available upon request)

NeurIPS 2023 **LeanDojo: Theorem Proving with Retrieval-Augmented Language Models**
Kaiyu Yang, Aidan Swope, Alex Gu, Rahul Chalamala, Peiyang Song, Shixing Yu, Saad Godil, Ryan Prenger, and Anima Anandkumar.
Neural Information Processing Systems (NeurIPS), 2023, **Oral**

RESEARCH EXPERIENCES

❑ **California Institute of Technology (Caltech)** Pasadena, CA
SFP SURF Fellow @ Anima AI+Science Lab Jan. 2023—Present

Advisor: Prof. Anima Anandkumar; Co-Advisor: Dr. Kaiyu Yang

Project #1: LeanDojo – built the first open-source playground consisting of toolkits, benchmarks, and models for LLMs to prove formal theorems in Lean 4; added full support for real-time data extraction and programmatic interactions; constructed a largest-ever and fine-grained benchmark consisting of 96,962 theorems and proofs extracted from Lean's math library, released under a permissive MIT license to facilitate further research. Specifically, my work focused on adding LeanDojo's full support for rich data extraction from Lean 4, the latest stable enhanced version of Lean theorem prover, and thereby generating LeanDojo Benchmark 4 from meta-programming and compilation-simulating in Lean 4.

Project #2: ReProver – built the first LLM-based prover that is augmented with retrieval for selecting premises from a vast math library; beat the state-of-the-art non-retrieval baselines and the GPT4 model by 40%. These first two projects are published at NeurIPS 2023 Datasets and Benchmarks Track as an Oral Presentation.

Project #3: Lean Copilot – built the first open-source framework to run machine learning inferences and applications natively in Lean theorem prover; remain the best tool with the simplest installation burden and usage, fastest runtime, and lowest memory consumption; developed the best-performing machine-learning-powered tactic suggestion and first-ever neural proof search tools for Lean. I led this project and was responsible for all its technical components except the optimization of installation process. This work has been accepted by NeurIPS 2023 MATH-AI Workshop.

❑ **University of California, Santa Barbara (UCSB)** Santa Barbara, CA

Researcher @ ArchLab Nov. 2022—Present

Advisor: Prof. Tim Sherwood.

Project #1: Race logic – established the first complete algebraic space and sound theoretical foundation for race logic, a particular type of temporal logic with high energy-efficiency and unlimited approximation accuracy; developed multiple optimizations for the temporal operator codebase. Results are collected in a to-be-published book on Race Logic for energy-efficient machine learning by UCSB ArchLab. I led this project and was responsible for all the findings and writing work above.

Project #2: Energy-Efficient Convolutions – implemented energy-efficient convolutions by usage of a negative log transformation of the traditional numeric space into a delay space to enable high energy-efficiency powered by temporal arithmetic; designed and optimized hardware implementation of this method which improve the energy per pixel of each convolution frame by 8x compared to the state-of-the-art. Results are reported in a paper under review at ASPLOS 2024. My work was mainly in establishing the foundation of this method, including the numeric space transformation, the complete temporal arithmetic, and the implementation of energy-efficient convolutions.

Project #3: Delaynet – Employed temporal operators to quantize important functions such as nLSE and nLDE; discovered and proved safe operations for temporal logic and efficient dimensionality reduction without loss of generality; built energy-efficient inferences for DNNs and CNNs on top of the theoretical results. Results are presented in a paper under submission to MLSys 2024. I took leadership of this project and was responsible for all the work above except the experimental implementations of inference.

❑ **Nankai University (NKU)** Tianjin, China

National Talent (Ying Cai Ji Hua) Research Fellow @ Media Computing Lab Jan. 2020—Dec. 2020

Advisor: Prof. Ming-Ming Cheng, Prof. Jun Xu

Project #1: Auxiliary Parking System for Self-Driving Vehicles – employed the Canny Operator for Edge Detection and the Cumulative Probability Hough Transform to extract the parking line information; completed effective Polygon Detection with the Douglas-Poke Polygon Detection Algorithm; developed a panoramic auxiliary parking system to reduce scratch accidents when parking vehicles. The product was honored to be included in the Ministry of Education of China database. My work focused on the choice and implementation of all the algorithms above and the experimental analysis of their performance.

Project #2: Real-Time Dark Channel Prior Algorithm – applied the Wavelet Decomposition technique to improve the real time of the Dark Channel Prior Algorithm by 44%, which better addressed the blurred horizon problem for car drivers in low-visibility weather conditions. I took leadership of this project and was responsible for all the work above.

ACADEMIC SERVICE

❑ **Reviewer**

- Neural Information Processing Systems (NeurIPS) MATH-AI Workshop

AWARDS & HONORS

❑ **Early Research Scholarship** Aug. 2023

❑ **Caltech SURF award** Apr. 2023

❑ **UCSB Creative Studies Honors** Sep. 2022

❑ Computer Science Competitions:

- **National Team Silver Award** in **the invited ALL-STAR Contest of American Computer Science League (ACSL)** (As team leader) Aug. 2021
- **National Individual Silver Award** in **the invited ALL-STAR Contest of American Computer Science League (ACSL)** Aug. 2021
- **Global Individual Top Score** in **American Computer Science League (ACSL)** (World Rank #1) May 2021

❑ Mathematics Competitions:

- **Gold Medal** & **Distinction Award** in **Euclid Mathematics Contest (CEMC)** (World top 0.79%) Jul. 2022
- Scored **8** in **American Invitational Mathematics Examination (AIME)** Mar. 2021
- **Honor Roll with Distinction** in **American Mathematics Competition (AMC) 12** Nov. 2021
- **Gold Medal** & **Distinction Award** in **Euclid Mathematics Contest (CEMC)** (World top 2.4%) Jul. 2021
- **Top Gold Award** in **Math Kangaroo Contest** (Highest level, National top 3%) May 2021
- **Gold Medal** & **Distinction Award** in **Canadian Senior Mathematics Contest (CSMC)** (World Rank #22) Dec. 2020
- **High Distinction Award** in **Australian Mathematics Competition** (National top 5%) Apr. 2021
- **National Gold Award** in **Canadian Open Mathematics Challenge (COMC)** (National top 5%) Dec. 2020
- **Distinction Award** in **Canadian Senior Mathematics Contest (CSMC)** (World Rank #91) Dec. 2019

❑ Physics Competitions:

- **Global Silver Award** in **British Physics Olympiad (BPhO)** Apr. 2020

❑ American Debating Competitions:

- **National top 16** in **National High School Debate League of China (NHSDLC)** (Broke school record, as team leader) Nov. 2020
- **American Debate Champion** in **Intramural American Debates** (As team leader) Dec. 2019
- **Best Debater Honor** in **Intramural American Debates** Dec. 2019

LANGUAGES

➢ **Programming Languages**: C++, Python, Lean, Java, C, PASCAL

➢ **Natural Languages**: English (TOEFL 117/120), Mandarin (Native)

TALKS

➢ **Towards Large Language Models as Copilots for Theorem Proving in Lean**

- Neural Information Processing Systems (NeurIPS) 2023 MATH-AI Workshop Dec. 2023
- CCS Research & Creative Activities Conference (RACA-CON) 2023 Oral Presentation Nov. 2023
- Caltech SURF Seminar Day 2023 Aug. 2023