

curriculum vitae of
Jacob Scott Laurel

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RESEARCH SUMMARY

My mission as a programming languages researcher is to build automated and mathematically principled program analyses for continuous computations. My efforts focus on two popular paradigms that expose continuous computations: differentiable and probabilistic programming languages. While a programming languages viewpoint anchors my research, my work spans the full computing stack: from applying formal methods to prove properties about differentiable programs all the way down to building compilers to generate fast inference code on embedded systems.

EDUCATION

- Aug. 2017 – present **Ph.D.** in Computer Science UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Advisor: Sasa Misailovic
Research areas: Differentiable and Probabilistic Programming Languages, Abstract Interpretation, Program Analysis, Formal Methods, Compilers, Embedded Systems
- Aug. 2012 – May 2017 **B.S.E.E** in Electrical Engineering Summa Cum Laude UNIVERSITY OF ALABAMA AT BIRMINGHAM
B.S. in Mathematics (Applied Mathematics and Scientific Computation Track) Summa Cum Laude
GPA: 3.95/4.0

WORK EXPERIENCE

- July 2018 – Present Research Assistant UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN
Advisor: Sasa Misailovic
- May 2019 – Aug. 2019 Ph.D. Research Intern NASA LANGLEY RESEARCH CENTER
Mentors: Cesar Muñoz and Aaron Dutle
Applied program analysis to quantify floating point error in probabilistic programs.
- May 2016 – Aug. 2016 Undergraduate Research Intern UNIVERSITY OF CENTRAL FLORIDA
Helped develop a novel video summarization technique using LSTM Deep Neural Networks.
Work published in CVPR 2017.

PUBLICATIONS

PEER-REVIEWED CONFERENCE AND JOURNAL PUBLICATIONS

1. **Jacob Laurel**, Siyuan Brant Qian, Gagandeep Singh, Sasa Misailovic. Synthesizing Precise Static Analyzers for Automatic Differentiation. In *Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA 2023)*. Acceptance rate: 36%.
2. Rem Yang, **Jacob Laurel**, Sasa Misailovic, Gagandeep Singh. Provable Defense Against Geometric Transformations. In *11th International Conference on Learning Representations (ICLR 2023)*. Acceptance rate: 31%. Designated **notable, top 25% of papers**.
3. Vimuth Fernando, Keyur Joshi, **Jacob Laurel**, Sasa Misailovic. Dynamic Monitoring of Uncertainty for Distributed Asynchronous Programs with Diamont. In *International Journal on Software Tools for Technology Transfer (STTT 2023)*.
4. Ashitabh Misra, **Jacob Laurel**, Sasa Misailovic. ViX: Analysis-driven Compiler for Efficient Low-Precision Differentiable Inference. In *Design Automation and Test in Europe (DATE 2023)*. Full Paper Acceptance rate: 25%.

5. **Jacob Laurel**, Rem Yang, Shubham Ugare, Robert Nagel, Gagandeep Singh, Sasa Misailovic. A General Construction for Abstract Interpretation of Higher-Order Automatic Differentiation. In *Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA 2022)*. Acceptance rate: 31%.
6. **Jacob Laurel**, Rem Yang, Gagandeep Singh, Sasa Misailovic. A Dual Number Abstraction for Static Analysis of Clarke Jacobians. In *Symposium on Principles of Programming Languages (POPL 2022)*. Acceptance rate: 23%.
7. Vimuth Fernando, Keyur Joshi, **Jacob Laurel**, Sasa Misailovic. Diamont: Dynamic Monitoring of Uncertainty for Distributed Asynchronous Programs. In *21st International Conference on Runtime Verification (RV 2021)*. Acceptance rate: 38%.
8. **Jacob Laurel**, Rem Yang, Atharva Sehgal, Shubham Ugare, Sasa Misailovic. Statheros: A Compiler for Efficient Low-Precision Probabilistic Programming. In *58th Design Automation Conference (DAC 2021)*. Acceptance rate: 23%.
9. **Jacob Laurel**, Sasa Misailovic. Continualization of Probabilistic Programs with Correction. In *29th European Symposium on Programming (ESOP 2020)*. Acceptance rate: 31%.
10. Aidean Sharghi, **Jacob Laurel**, Boqing Gong. Query-Focused Video Summarization: Dataset, Evaluation, and A Memory Network Based Approach. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2017)*. Acceptance rate: 29%.

PREPRINTS

11. Zixin Huang, **Jacob Laurel**, Saikat Dutta, Sasa Misailovic. Precise Abstract Interpretation of Probabilistic Programs with Interval Data Uncertainty. Under Submission

POSTERS AND WORKSHOP PAPERS

12. **Jacob Laurel**, Siyuan Brant Qian, Gagandeep Singh, Sasa Misailovic. Abstract Interpretation for Automatic Differentiation. In *Languages for Inference Workshop (LAFI 2024)*.
13. **Jacob Laurel**. Exact Quantification of Continuity Correction Error in Probabilistic Programs. Poster presented at *1st International Conference on Probabilistic Programming (PROBPROG 2018)*.

HONORS AND AWARDS

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| 2023 | One of 6 UIUC students selected to attend the Global Young Scientists Summit in Singapore (GYSS 2024) |
| 2023-2024 | UIUC Mavis Future Faculty Fellowship (\$ 2000 Award) |
| 2023 | UIUC CS Department Outstanding Graduate Student Ambassador (\$ 100 Award) |
| 2023 | UIUC ALERT Program Mentor Award (\$ 1000 Award) |
| 2017-Present | UIUC Sloan UCEM Scholarship (\$ 40,000 Award) |
| 2012-2017 | UAB Presidential Honors List for 4.0 GPA during semester |
| 2012-2016 | UAB Presidential Scholarship as National Hispanic Recognition Program Scholar |
| 2015 | UAB School of Engineering Dupuis Scholarship |
| 2015 | UAB School of Engineering Undergraduate Research Award for Honors Research |
| 2013 | Inducted into Tau Beta Pi Engineering Honor Society |

RESEARCH TALKS AND PRESENTATIONS

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| Dec. 2023 | Invited Talk: "Abstractly Interpreting Differentiable Programming" - Purdue University PurPL Seminar (host: Ben Delaware) |
| Oct. 2023 | Invited Talk: "Abstractly Interpreting Differentiable Programming" - University of Michigan Midwest Programming Languages Summit 2023 |
| Oct. 2023 | Invited Talk: "Abstractly Interpreting Differentiable Programming - A Trilogy" - Cornell University PLDG Seminar (host: Adrian Sampson) |

- Aug. 2023 Invited Talk: “Abstractly Interpreting Differentiable Programming” - Argonne National Laboratory CS Seminar (host: Jan Hückelheim)
- June 2023 Invited Talk: “A General Construction for Abstract Interpretation of Higher-Order Automatic Differentiation” - UCF CRCV Seminar (host: Niels Da Vitoria Lobo)
- July 2022 Invited Talk: “Abstract Interpretation for Differentiable Programming” - UC Berkeley Formal Methods Seminar (host: Sanjit Seshia)
- June 2022 Invited Talk: “Abstract Interpretation for Differentiable Programming” - Stanford Software Seminar (host: Clark Barrett)

RESEARCH MENTORING

Mentored two graduate students and five undergraduate students:

- Feb. 2020 - May 2023 Rem Yang (BS, UIUC) - Co-author on DAC21, POPL22, OOPSLA22, ICLR23
- Mar. 2020 - May 2021 Atharva Sehgal (BS, UIUC) - Co-author on DAC21
- May. 2021 - May 2023 Robert Nagel (BS, UIUC) - Co-author on OOPSLA22
- Nov. 2020 - Aug. 2022 Shubham Ugare (PhD, UIUC) - Co-author on DAC21, OOPSLA22
- May. 2022 - Feb. 2023 Ashitabh Misra (PhD, UIUC) - Co-author on DATE23
- Jan. 2023 - present Siyuan Brant Qian (BS, UIUC/ZJU) - Co-author on OOPSLA23, LAFI24
- May 2023 - Aug. 2023 Jonah Black (BS UIUC) - Mentored through the UIUC ALERT Program

TEACHING EXPERIENCE

- Spring 2023 UIUC CS 477 Formal Software Development Methods (Guest Lecture)
- Fall 2019 UIUC CS 421 Programming Languages and Compilers (Teaching Assistant)
- Spring 2019 UIUC CS 126 Software Design Studio (Teaching Assistant)
- Fall 2018 UIUC CS 173 Discrete Structures (Teaching Assistant)
- Spring 2018 UIUC CS 374 Algorithms and Models of Computation (Teaching Assistant)
- Spring 2014 UAB ECE 312 Electrical Systems (Undergraduate Course Assistant)

OPEN-SOURCE SOFTWARE CONTRIBUTIONS

I have led the development of the following open-source software libraries:

AbstractAD: AbstractAD is a parametric abstract interpretation of higher-order differentiable programs that allows for expressive abstract domains (like Zonotopes), published in OOPSLA22.

It is available at <https://github.com/uiuc-arc/AbstractAD>

DeepJ: DeepJ is a sound abstract interpretation of Clarke Generalized Jacobians, published in POPL22. It is available at <https://github.com/uiuc-arc/DeepJ>

Statheros: Statheros is a compiler for fixed-point probabilistic programming, published in DAC21. It is available at <https://github.com/uiuc-arc/Statheros>

Pasado: Pasado is a tool for synthesizing static analyzers for Automatic Differentiation, published in OOPSLA23. It is available at <https://github.com/uiuc-arc/Pasado> as well as <https://doi.org/10.5281/zenodo.8332724>

EXPERIENCE WITH RESEARCH GRANTS

Assisted Sasa Misailovic and Gagandeep Singh in the preparation of the following research grant applications:

- Fall 2023 Static Analysis of Gradients for Building Trustworthy AI Systems - NSF CCF SHF:Medium grant application

SERVICE

- Fall 2023 Graduate Student Representative for UIUC Faculty Awards Committee
- Summer 2023 Reviewer - WFVML 2023
- Summer 2023 Mentor for UIUC Accelerated Learning and Engineering Research Training (ALERT) Program

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| Mar. 2023 | Graduate Ambassador and Panelist for session on Diversity and Inclusivity for UIUC CS Visit Day |
| Fall 2022 - Spring 2023 | Graduate Student Representative for UIUC's CS Graduate Study Committee |
| Summer 2022 | Reviewer - ECCV 2022 |
| Summer 2022 | Artifact Evaluation Committee - SAS 2022 |
| Fall 2021 | Panelist for UIUC's Society of Hispanic Professional Engineers Graduate Student Panel |
| Summer 2021 | Artifact Evaluation Committee - OOPSLA 2021 |
| Mar. 2020 | Graduate Ambassador for UIUC CS Visit Day |
| Jan. 2020 | Graduate Volunteer for UIUC School of Engineering Undergraduate Research Expo |
| Fall 2019 | Organizer - UIUC Brett Daniel Software Engineering Seminar |

REFERENCES

Sasa Misailovic (advisor)

Associate Professor
Department of Computer Science
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Gagandeep Singh

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