

curriculum vitae of  
Jacob Scott Laurel

🌐 <https://jsl1994.github.io/>    ✉ [jlaurel2@illinois.edu](mailto:jlaurel2@illinois.edu)    📄 Google Scholar

## RESEARCH SUMMARY

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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

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

## WORK EXPERIENCE

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

## PUBLICATIONS

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### 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 *58<sup>th</sup> Design Automation Conference (DAC 2021)*. Acceptance rate: 23%.
9. **Jacob Laurel**, Sasa Misailovic. Continualization of Probabilistic Programs with Correction. In *29<sup>th</sup> 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 *1<sup>st</sup> 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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| Jan. 2024 | Invited Talk: "Automated Analyses for Continuous Computations" - Columbia University Systems Seminar (host: Baishakhi Ray)            |
| 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 |

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| 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

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Mentored two graduate students and five undergraduate students:

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| 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

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| 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

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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

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

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

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

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## REFERENCES

**Sasa Misailovic** (advisor)

Associate Professor

Department of Computer Science

<https://misailo.cs.illinois.edu/>

misailo@illinois.edu

**Gagandeep Singh**

Assistant Professor

Department of Computer Science

<https://ggndpsngh.github.io/>

ggnds@illinois.edu

**Darko Marinov**

Professor

Department of Computer Science

<https://mir.cs.illinois.edu/marinov/>

marinov@illinois.edu

**Sayan Mitra**

Professor

Department of Electrical and Computer Engineering

<https://mitras.ece.illinois.edu/>

mitras@illinois.edu