Matthew Zachary Weaver

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Education

- **Princeton University** — Princeton, New Jersey
  Doctor of Philosophy - Computer Science — *July 2016 - November 2024*
  Advisors: *Andrew Appel (2016 - present), Daniel Licata (2017 - present), Vladimir Voevodsky (2016 - 2017)*

- **Princeton University** — Princeton, New Jersey
  Master of Arts - Computer Science — *July 2016 - May 2018*

- **University of Pennsylvania** — Philadelphia, Pennsylvania
  Bachelor of Arts - Magna Cum Laude with Distinction in Mathematics — *September 2012 - December 2015*
  Honors: *Benjamin Franklin Scholar, University Scholar*
  Advisors: *Rajeev Alur (2014 - 2015), Scott Weinstein (2012 - 2014), Stephanie Weirich (2014 - 2016)*

Skills Summary

- **Languages** Agda, Coq, Haskell, OCaml, C, Java, JavaScript, Rust, Scala
- **Areas of Expertise** Functional Programming, Formal Verification, Type Systems, Syntax and Semantics of Programming Languages, Category Theory, Mathematical Logic, Mathematic Models of Computational Systems and Structures
- **Soft Skills** Writing, Public Speaking, Teaching, Mentoring, Self-Guided Learning

Projects

- **Bicubical Directed Type Theory - a constructive type theory for synthetic (∞, 1)-categories with directed univalence:** Directed type theory is an analogue of homotopy type theory where types represent categories, generalizing groupoids. In my work, I took inspiration from a bisimplicial approach developed by Riehl and Shulman, and translated the theory to a bicubical setting to ultimately define a constructive model of directed type theory. Additionally, I developed a construction of directed univalence – a directed analogue of univalence where directed paths correspond to functions in the universe of types. Much of this work is formalized in Agda, and a substantial portion is implemented in OCaml as an extention of the cooltt proof assistant. Advised by Daniel Licata. (2017 - 2024)
- **CertiCoq - a formally verified compiler for Coq:** CertiCoq is a compiler for Coq that is both written and proven correct in Coq. The compiler targets CompCert, a formally verified C compiler. I wrote the final compilation pass of the compiler, translating a lambda-lifted, closure-converted untyped lambda calculus intermediate language into (a minimal subset of) CompCert C. I also implemented a simple generational garbage collector for the compiler in C. Advised by Andrew Appel. (2016 - 2019)
- **Automata Tutor - an online tool for teaching automata theory and providing personalized feedback using program synthesis:** Automata Tutor allows students to draw automata matching language descriptions, and receive intelligent feedback for any errors. It has been used by over 9000 students at more than 30 universities throughout the world. The tool uses techniques from program synthesis to provide the feedback to students. While working on the project, I redesigned and implemented the drawing interface to improve the usability of the tool, and extended Automata Tutor to support non-deterministic finite automata. The interface is implemented in JavaScript using the D3.js library, and the backend is implemented in Scala. Advised by Loris D'Antoni and Rajeev Alur. (2014 - 2015)

Publications

- **Bicubical Directed Type Theory.** Ph.D. Thesis. Princeton University, 2024.
- **Directed Higher Inductive Types in Bicubical Directed Type Theory.** with D. Licata. (in progress).
- **Syntax and Semantics of Type Theory with Internally Definable Universes for Lifting Problems.** with D. Licata. (in progress).
- **A Constructive Model of Directed Univalence in Bicubical Sets.** with D. Licata. Logic in Computer Science, 2020.
- **Certified code generation from CPS to C.** with O. Savary Bélanger and A. Appel. preprint, 2019.
- **Finite Inverse Categories as Signatures.** with D. Tsementzis. arXiv:1707.07339, 2018.
- **Automata Tutor and what we learned from building an online teaching tool.** with L. D'Antoni, A. Weinert, and R. Alur. Bulletin of European Association of Theoretical Computer Science, 3(117), 2015.

Selected Talks and Workshops

- **Theory and Implementation of Bicubical Directed Type Theory.** Conference on Homotopy Type Theory, 2023.
- **Deciding the Cofibration Logic of Cartesian Cubical Type Theories.** with D. Licata and R. Rose. International Conference on Types for Proofs and Programs, 2022.
- **Directed Higher Inductive Types in Bicubical Directed Type Theory.** Workshop on Homotopy Type Theory/Univalent Foundations (invited keynote), 2021.
- **A Constructive Model of Directed Univalence in Bicubical Sets.** Homotopy Type Theory Electronic Seminar Talks (invited lecture), 2020.
- **A Constructive Model of Directed Univalence in Bicubical Sets.** International Congress on Mathematical Software, 2020.
- **A Model of Type Theory with Directed Univalence in Bicubical Sets.** Conference on Homotopy Type Theory, 2019.
- **Unfolding FOLDS.** with D. Tsementzis. Workshop on Homotopy Type Theory/Univalent Foundations, 2017.
- **CertiCoq: A verified compiler for Coq.** with A. Anand, A. Appel, G. Morrisett, Z. Paraskevopoulou, R. Pollack, O. Savary Bélanger, and M. Sozeau. Workshop on Coq for Programming Languages, 2017.
- **Automata Tutor and what I learned from building an online teaching tool.** with L. D'Antoni, R. Alur, D. Kini, M. Viswanathan, S. Gulwani, B. Hartmann. Workshop on Programming Languages Technology for Massive Open Online Courses, 2015.

Professional Activities

- **LGBTQ+ Social at the International Conference on Functional Programming.** co-organized with David Walker. 2020.
- **Computer Science Logic.** Reviewer, 2020.
- ***Theoretical Computer Science for the Working Category Theorist* by Noson Yanofsky, Cambridge University Press.** Reviewer, 2019.
- **Certified Programs and Proofs.** Reviewer, 2018.
- **School and Workshop on Univalent Mathematics.** Mentor, 2017.
- **Benjamin Franklin Scholars Advisory Board.** University of Pennsylvania. Social Media Chair, 2013. Vice-President, 2014. President, 2015.

Advising

- **Isaac Valasquez.** co-advised senior thesis with Zachary Kincaid. *Types as Categories Using Simplicial Sets.* Fall 2019 - Spring 2021. Current Placement: Ph.D. Candidate in Computer Science at the University of Minnesota.
- **Yanjun Yang.** co-advised senior thesis with David Walker. *Modeling Routing Algebras and the Stable Routing Problem in Cubical Type Theory.* Fall 2018 - Spring 2020. Current Placement: Software Developer at Jane Street.

Teaching

- **Independent Study on Category Theory and Categorical Logic.** Instructor. Princeton University. Fall 2018, Fall 2021.
- **COS 226: Data Structures and Algorithms.** Teaching Assistant. Princeton University. Spring 2019.
- **COS 326: Functional Programming.** Teaching Assistant. Princeton University. Fall 2018.
- **CIS 500: Software Foundations.** Teaching Assistant. University of Pennsylvania. Spring 2016.
- **CIS 261: Discrete Probability, Stochastic Processes, and Statistical Inference.** Teaching Assistant. University of Pennsylvania. Fall 2014, Fall 2015.
- **CIS 160: Mathematical Foundations of Computer Science.** Teaching Assistant. University of Pennsylvania. Summer 2014, Summer 2015.

Selected Coursework

- **COS 598: Automated Reasoning and Machine Learning.** Princeton University. Taught by Aarti Gupta. Spring 2020.
- **COS 511: Theoretical Machine Learning.** Princeton University. Taught by Robert Schapire. Spring 2018.
- **COS 516: Automated Reasoning.** Princeton University. Taught by Aarti Gupta. Fall 2017.
- **MAT 560: Algebraic Topology.** Princeton University. Taught by Peter Ozsváth. Spring 2017.
- **COS 587: Automated Reasoning for Concurrency.** Princeton University. Taught by Zachary Kinkaid. Fall 2016.
- **CIS 500: Software Foundations.** University of Pennsylvania. Taught by Stephanie Weirich. Fall 2014.
- **STAT 928: Statistical Learning Theory and Sequential Prediction.** University of Pennsylvania. Taught by Alexander Rakhlin. Fall 2013.

Hobbies and Interest

- **NWS Certified Sommelier.** Wine School of Philadelpha. Fall 2022.
- **Food.** I love all things food: eating at restaurants, cooking, baking, talking about favorite meals and/or restaurants, etc. . . .
- **Visual Arts.** My preferred media include analogue photography, charcoal, painting, machine embroidery, sculpture and combinations of those listed prior.