Santiago Rodriguez

Ω Researcher π Mathematician λ Computer Scientist 𝒪

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Research Interests

I study the intersection of **programming language theory**, **algebraic geometry**, and **computational complexity theory**. Broadly, my work centers around understanding the strengths and limitations of computation from the perspective of *abstract nonsense*.

Education

B.S. in Mathematics and B.S. in Computer Science

Orlando, FL

University of Central Florida | GPA: 3.84 *Sep 2020 – Aug 2024*

- **Relevant Coursework:** Program Analysis, Algorithm Design and Analysis, Machine Learning, Computer Architecture, Security in Computing, Object Oriented Programming, Numerical Methods, Statistical Theory, Real Analysis, Abstract Algebra, Topology, Technical Presentation.

Research Experiences

University of Pennsylvania (Penn)

Philadelphia, PA

Visiting Researcher | Advisor: Steve Zdancewic, Ph.D. in Computer Science *May 2024 – Present*

- Collaborating with the Vellvm team to investigate formal verification of modern compiler optimization algorithms targeting LLVM IR.
- Enhancing Vellvm's mechanized dataflow analysis framework in Coq to support sound dataflow analysis at the instruction level.

  Areas: Compilers, Software Verification, Static Analysis, Interaction Trees, Type Theory.

Visiting Researcher | Advisor: Steve Zdancewic, Ph.D. in Computer Science *May 2023 – Aug 2023*

- Investigated differential programming semantics for proving the correctness of continuous optimization algorithms used in machine learning.
- Extended a coherence space representation theory of real numbers to arbitrary Banach spaces using category theory and functional analysis.
- Constructed a denotational semantics using the above representation theory for the simply-typed lambda calculus (STLC). This introduced a differential calculus internal to STLC, which is computationally interpretable, unlike standard differential programming semantics.

  Areas: Differential Programming, Machine Learning, Denotational Semantics, Type Theory, Category Theory, Topology.

University of Central Florida (UCF)

Orlando, FL

Undergraduate Researcher | Advisor: Alexander Tovbis, Ph.D. in Mathematics *May 2022 – Present*

- Investigated rogue wave occurrences in the deep sea modeled as finite-gap solutions for the focusing Nonlinear Schrödinger Equation.
- Developed efficient and stable numerical simulations in Python and Mathematica for studying the distribution of wave amplitudes using numerical methods on Riemann surfaces.
- Derived asymptotic formulas for the probability of rogue wave occurrences using analytic number theory and ergodic theory. This will then be used to construct a forecast model of rogue wave formations.

  Areas: Analytic Number Theory, Complex Analysis, Ergodic Theory, Numerical Methods.

Undergraduate Researcher | Advisor: Gary T. Leavens, Ph.D. in Computer Science *Jan 2024 – Apr 2024*

- Investigated static analysis methods for computing the worst-case time complexity of any given algorithm.
- Developed an imperative programming language extending the WHILE language with its own parser, compiler and interpreted bytecode language in Python as a testbed for the static analysis problem.
- Designed a data-flow algorithm for approximating the upper bounds of variable assignments using computer algebra and graph theory. This solves for worst-case time complexity when introducing an instruction count variable and then approximating its value.

  Areas: Computational Complexity Theory, Computer Algebra, Computational Graph Theory, Static Analysis.

Independent Researcher *May 2021 – Aug 2021*

- Investigated epistemic theories of thought experiments to justify the apparent knowledge gained from them.
- Developed a possible world account of thought experiments with the corresponding modal logic defined by a world's proximity to ours.
- Characterized two general strategies for reasoning beyond possible worlds, including impossible and underdetermined worlds. This subsumes thought experiments under modal inference, which justifies our knowledge, provided a theory of essence exists.

  Areas: Epistemology, Metaphysics, Modal Logic, Thought Experiments.

Georgia Tech Research Institute (GTRI) & National Security Innovation Network (NSIN)

Atlanta, GA

Senior Design Capstone Researcher | Advisor: Branden Stone, Ph.D. in Mathematics *Sep 2023 – Apr 2024*

- Collaborated with a team of software engineers to build a system for detecting cyberattacks in communication networks.
- Developed a graph autoencoder model in Python using PyTorch, Pandas, and NetworkX that uses a subset of TCP packet data to identify communication network anomalies.
- Selected features based on statistical ensemble analysis, Pearson correlation coefficients, and domain-specific knowledge. This led to a model with 94% testing accuracy after training on the UNSW-NB15 dataset.

  Areas: Cybersecurity, Graph Theory, Machine Learning, Statistical Theory.

Presentations

Conferences

Network Anomaly Detection Using Graph Neural Networks
Emily Hannon, Gustavo N. Perez, Landon Russell, Mukundh Vasudevan, Nicholas Lannon, Santiago Rodriguez
UCF Spring 2024 Senior Design Showcase, Apr. 2024, Orlando, FL

Density of Critical Points in Finite-Gap Solutions of the Focusing Nonlinear Schrödinger Equation
Santiago Rodriguez, Alexander Tovbis
UCF Student Scholar Symposium, Mar. 2024, Orlando, FL

Graduate Student & Prior Summer Research Participants Panel
Julissa Burgos, Santiago Rodriguez, Alanis Davila, Edgar Ocasio
Academic Advancement Program's Graduate School Preparation Conference, Jan. 2024, Fajardo, PR

Seminars

Ergodicity of a Probabilistic Integer Partitioning Problem
Santiago Rodriguez
UCF Integrable Systems and Potential Theory Seminar, Feb. 2024, Orlando, FL

Mechanizing Category Theory in Coq
Santiago Rodriguez, Anthony Marantino
UCF Category Theory Reading Group, Nov. 2023, Orlando, FL

What About the Middleman? Shrinking the Gap Between Theory and Practice in Machine Learning
Santiago Rodriguez, Steve Zdancewic, Stephen Mell
Penn Programming Languages Group, Aug. 2023, Philadelphia, PA

Intro to Topology from Point-Set to Algebraic
Santiago Rodriguez
Penn Research Experiences for Undergraduates in Programming Languages Mini-Seminar Series, June 2023, Philadelphia, PA

Density of Critical Points and Integer Partitioning
Santiago Rodriguez
UCF Integrable Systems and Potential Theory Seminar, Feb. 2023, Orlando, FL

Work Experiences

Independent Various
Computer Science and Mathematics Tutor *Sep 2020 – Present*
- Designed and taught lessons on Python programming, advanced algorithms, and logic to classes with up to 20 students.
- Developed a text-based dungeon crawler in Python using NumPy to teach students about project development and documentation.
- Incorporated a variety of learning modalities to enhance student understanding of logic, calculus, and programming.
- Communicated regularly with students to provide feedback and discuss instructional strategies.

Areas: Algorithm Analysis, Formal Logic, Model Theory, Python, Univariate Calculus.

University of Central Florida Orlando, FL
Varsity Programming Team Member | Supervisor: Arup Guha, M.Sc. in Computer Science *Sep 2021 – Apr 2022*
- Competed in local and southeast regional programming contests as part of the UCF Sakura team.
- Developed efficient solutions to computational problems within graph theory, dynamic programming, and boolean satisfiability using efficient algorithms and data structures in C++, Java, and Python.
- Authored several programming problems and served as a judge at the UCF High School Programming Tournament.

Areas: Advanced Data Structures, Computational Complexity Theory, Logic.

Developmental Programming Team Member | Supervisor: Ali Orooji, Ph.D. in Computer Science *Sep 2020 – Apr 2021*
- Competed in local and southeast regional programming contests as part of the UCF Utah Teapot team.
- Developed efficient solutions to computational problems within dynamic programming, linear programming, and esoteric math using efficient algorithms and data structures in C and Python.

Areas: Advanced Data Structures, Computational Complexity Theory, Logic.

Knowledge & Skills

Programming C/C++, Python (Pandas, PyTorch, NumPy, SciPy, etc.), Mathematica, Coq, Haskell, HTML/CSS, JavaScript/React.
Software Linux, Shell (Bash), LaTeX, Microsoft Office, Git, Docker, Anaconda.
Languages English (Native), Spanish (Native).

Honors, Awards & Scholarships

Summer 2024	**McNair Summer Research Institute Scholarship**
2024	**Tau Beta Pi National Engineering Honor Society**
2023	**International Conference on Functional Programming Travel Award** (McNair Funded)
Summer 2023	**McNair Summer Research Institute Scholarship**
Summer 2023	**University of Pennsylvania Summer Research Fellow** (NSF Funded)
2023	**Pi Mu Epsilon National Math Honor Society**
2022	**Excellence in Action Award**, University of Central Florida
2022	**Ronald E. McNair Scholars Program**
2020 – 2024	**President's Honor Roll** (3 Times), University of Central Florida
2020 – 2024	**Dean's List** (6 times), University of Central Florida
2020	**Top Ten Knights Award**, University of Central Florida
2020	**National Hispanic Scholarship**
2020	**Florida's Bright Futures Academic Scholars Award**

Community Outreach

Blue Bamboo Center for the Arts
Orlando, FL

Jazz Pianist — *Sep 2021 – Present*

- Performed with local musicians and poets, serving to foster a community united across cultural divides.
- Engaged the community and promoted the arts by producing short films in collaboration with local filmmakers, actors, and engineers.
- Taught piano to high school students and undergraduate STEM majors seeking creative outlets for managing stress.

Society for the Advancement of Minorities in Science (SACNAS)
Orlando, FL

Treasurer | Advisor: Raquel A. Toro-Espinal, M.A. in Counselor Education — *Sep 2023 – Apr 2024*

- Collaborated with a team of undergraduate researchers to promote diversity in STEM.
- Hosted workshops that helped students access research, conference travel, and graduate program opportunities.
- Managed chapter funds and organized fundraisers to support chapter activities.

McNair Promising Practices Institute
Fajardo, PR

Volunteer | Supervisor: Raquel A. Toro-Espinal, M.A. in Counselor Education — *Jan 2024*

- Prepared the venue for welcoming and connecting professional staff from multiple McNair programs with graduate school representatives.
- Directed and assisted graduate school representatives with hosting the grad fair portion of the institute.
- Built a network with undergraduates from Puerto Rico institutions to share opportunities and support each other's academic journeys.

UCF University Chorus
Orlando, FL

Choral Singer | Director: Jeffery Redding, Ph.D. in Choral Conducting — *Sep 2021 – Apr 2023*

- Performed at local charities, concerts, and state conferences to promote cultural engagement and music education.
- Collaborated with community choirs, philharmonic orchestras, and youth choirs, serving to unite people across socioeconomic divides.
- Mentored students pursuing careers in both STEM and the arts.