Dr. Pedro Juan Soto

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Senior Postdoctoral Researcher in Applied Mathematics and Computer Science at Virginia Tech. Passionate about science and mathematics, with strong technical and interpersonal skills for working in a team.

Education

- **City University of New York** — **New York, NY**
  Ph.D student in Computer Science — *2020–2022*
- **Florida International University** — **Miami, FL**
  Graduate student in Computer Science — *2017–2020*
- **Florida International University** — **Miami, FL**
  Majored in Mathematics, Minored in Physics — *2012–2016*

Publications

Peer-Reviewed

- **Pedro Soto**, Jun Li, and Xiaodi Fan. Dual Entangled Polynomial Code: Three-Dimensional Coding for Distributed Matrix Multiplication. In *Proceedings of the 36th International Conference on Machine Learning (ICML)*, volume 97 of *Proceedings of Machine Learning Research*, pages 5937–5945. PMLR, 09–15 Jun 2019
- **Pedro Soto** and Jun Li. Straggler-free Coding for Concurrent Matrix Multiplications. In *2020 IEEE International Symposium on Information Theory (ISIT)*, pages 233–238. IEEE, 2020
- Xiaodi Fan, **Pedro Soto**, Xiaomei Zhong, Dan Xi, Yan Wang, and Jun Li. Leveraging Stragglers in Coded Computing with Heterogeneous Servers. In *2020 IEEE/ACM 28th International Symposium on Quality of Service (IWQoS)*, pages 1–10. IEEE, 2020
- Xiaodi Fan, Angel Saldivia, **Pedro Soto**, and Jun Li. Coded Matrix Chain Multiplication. In *2021 IEEE/ACM 29th International Symposium on Quality of Service (IWQoS)*, pages 1–6. IEEE, 2021
- **Pedro Soto**, Xiaodi Fan, Angel Saldivia, and Jun Li. Rook coding for batch matrix multiplication. *IEEE Transactions on Communications*, 70(6):3641–3654, 2022
- **Pedro Soto**, Ilia Ilmer, Haibin Guan, and Jun Li. Lightweight projective derivative codes for compressed asynchronous gradient descent. In *Proceedings of the 39th International Conference on Machine Learning*, volume 162 of *Proceedings of Machine Learning Research*, pages 20444–20458. PMLR, 17–23 Jul 2022
- Felisa J. Vázquez-Abad, Oliver Shetler, and **Pedro Soto**. Quantile formulation for optimization under a qualitative risk constraint. In *2022 IEEE 61st Conference on Decision and Control (CDC)*, pages 2979–2984, 2022
- Xiaodi Fan, **Pedro Soto**, Yuchun Zou, Xian Su, and Jun Li. Sequence-Aware Coding for Leveraging Stragglers in Coded Matrix Multiplication. In *IEEE International Conference on Communications (ICC)*. IEEE, 2023
- Soo Go, Victor Pan, and **Pedro Soto**. Root-Squaring for Root-Finding. In *Computer Algebra in Scientific Computing*. Springer International Publishing, 2023

- Keren Censor-Hillel, Yuka Machino, and **Pedro Soto**. Near-optimal fault tolerance for efficient batch matrix multiplication via an additive combinatorics lens. In *31st International Colloquium On Structural Information and Communication Complexity*, 2024

Preprints

- **Pedro Soto**, Haibin Guan, and Jun Li. Locally Random P-adic Alloy Codes with Channel Coding Theorems for Distributed Coded Tensors. In *Arxiv*, abs/2202.03469
- Mariya Bessonov, Ilia Ilmer, Tatiana Konstantinova, Alexey Ovchinnikov, Gleb Pogudin, and **Pedro Soto**. Obtaining Weights for Gröbner Basis computation in Parameter Identifiability Problems. In *Arxiv*, abs/2202.06297
- Ilia Ilmer, Alexey Ovchinnikov, Gleb Pogudin, and **Pedro Soto**. More Efficient Identifiability Verification in ODE Models by Reducing Non-Identifiability. In *Arxiv*, abs/2204.01623
- Oren Bassik, Yosef Berman, Soo Go, Hoon Hong, Ilia Ilmer, Alexey Ovchinnikov, **Pedro Soto**, and Chee Yap. Robust parameter estimation for rational ordinary differential equations. In *Arxiv*, 2303.02159
- Helen Byrne, Heather Harrington, Alexey Ovchinnikov, Gleb Pogudin, Hamid Rahkooy, and **Pedro Soto**. Algebraic identifiability of partial differential equation models, 2024

Presentations

- Dual Entangled Polynomial Code: Three-Dimensional Coding for Distributed Matrix Multiplication, *International Conference on Machine Learning*, Long Beach, CA, June 2019.
- A Distributed Decoding Algorithm for Coded Matrix Multiplication, *International Symposium on Information Theory*, Paris, France, July 2019.
- Dual Entangled Polynomial Code: Three-Dimensional Coding for Distributed Matrix Multiplication, *CRA-WP Grad Cohort for URMD*, Austin, TX, March 2020.
- Straggler-free Coding for Concurrent Matrix Multiplications, *International Symposium on Information Theory*, Los Angeles, California, USA, June 2020
- Coded matrix chain multiplication, *2021 IEEE/ACM29th International Symposium on Quality of Service (IWQOS)*, Virtual Conference, June 2021.
- Lightweight Projective Derivative Codes for Compressed Asynchronous Gradient Descent, *International Conference on Machine Learning*, Baltimore, Maryland, July 2022.
- Quantile Formulation for Optimization under a Qualitative Risk Constraint, *IEEE Conference on Decision and Control (CDC)*, Cancun, Mexico, December 2022
- Robust Parameter Estimation, *Differential Algebra and Related Topics XI (DART)*, Queen Mary University of London, London, UK, June 2023
- Coded Distributed Batch Matrix Multiplication via an Additive Combinatorics Lens, *SIAM Conference on Applied Algebraic Geometry (AG23)* Eindhoven University of Technology, Eindhoven, The Netherlands July, 2023
- Lightweight Projective Derivative Codes for Compressed Asynchronous Gradient Descent*Special Session on Optimization, Machine Learning, and Digital Twins at the AMS 2024 Spring Eastern Sectional Meeting* Washington DC 2024
- Coded Distributed Batch Matrix Multiplication via an Additive Combinatorics Lens *AMS Special Session on Advances in Coding Theory at the Joint Mathematics Meetings (JMM) 2024*

Committees, Reviewing, and Professional Activity

- (Reviewer) (ICML) International Conference on Machine Learning (2022)
- (L-CSS) Control Systems Letters (2022) Reviewer
- (Reviewer) (CDC) Conference on Decision and Control (2022)
- (Reviewer) Advances in Applied Mathematics (2022)
- (Reviewer) Advances in Mathematics of Communications (2022)
- (Program Committee) (ICA3PP) International Conference on Algorithms and Architectures for Parallel

Processing (2023)
- (Organizer) Special Session on Tensor Algebra & Networks at the AMS 2024 Spring Eastern Sectional Meeting (2024)
- (Reviewer) (ISIT) International Symposium on Information Theory (2024)

Previous Research Experience

- **Department of Mathematics, Virginia Tech** — **Blacksburg, Virginia**
  Postoctoral Associate — *2023-2024*
  Currently performing research on applying algebraic coding theory to distributed computing, under the supervision of Dr. Gretchen Matthews.
- **Mathematical Institute, University of Oxford** — **Oxford, United Kingdom**
  Senior Postoctoral Scholar — *2022-2023*
  Performed research on Integrative Algebraic and Systems Biology, under the supervision of Dr. Heather Harrington and Dr. Julian Edwards, on the use of tensor decomposition for multi-omics data analysis.
- **The Taub Faculty of Computer Science, Technion** — **Haifa, Israel**
  Visiting Postdoctoral Researcher — *2022*
  Performed research on Distributed Coded computation under the supervision of Dr. Keren Censor-Hillel. We worked on extending her work on matrix multiplication on the clique model to include faulty nodes.
- **The Graduate Center at CUNY** — **New York, NY**
  Ph.D. researcher in coding theory, distributed computing, and its applications to ML — *2020-2022*
  Performed research, under the supervision of Dr. Jun Li, on generalizing coded distributed matrix multiplication to handle stragglers and other faults encountered in more general (multi)-linear computations such as tensor computations and machine learning algorithms in distributed systems.
- **School of Computing & Information Sciences, FIU** — **Miami, FL**
  Ph.D. researcher in coding theory and distributed computing — *2018-2020*
  Performed research, supervised by Dr. Jun Li, on the use of coded computation for matrix multiplication and machine learning algorithms in distributed systems.
- **School of Computing & Information Sciences, FIU** — **Miami, FL**
  Ph.D researcher in Quantitative Information Flow — *2017*
  Performed research, under the supervision of Dr. Geoffry Smith, into a new axiomatic foundation of cybersecurity centered around the concept of Bayes vulnerability, a generalization of g-leakage, which generalizes many of the traditional information measures (such as Shannon and Renyi entropy).
- **Department of Mathematics, University of Notre Dame** — **South Bend, Indiana**
  Undergraduate Research - Ramsey Theory (Combinatorics) — *2016*
  Performed research, under the guidance of Dr. David Galvin, in a sub-branch of combinatorics called Ramsey Theory, and investigated a conjecture made by Neil Hindman dealing with the algebraic properties of subsets of the natural numbers that are preserved when randomly painted with a finite collection of colors.
- **Department of Physics, Florida International University** — **Miami, FL**
  Undergraduate Research Assistant – Modern Physics Education — *2012-2014*
  Co-authored a manuscript which at the time was called "Modern Physics from an Undergraduate View" together with Farid Salazar and Josuan Calderon, based on a set of lecture notes of Dr. Rajamani Narayanan. Conducted advanced studies in theories of special relativity, wave mechanics, simple solid-state models, and quantum and statistical physics under the supervision of Dr. Rajamani Narayanan. The manuscript has now evolved into a textbook that is under contract to be published by the CRC press.

Teaching Experience

The Graduate Center at CUNY — **New York, NY**
Teaching Assistant — *2022*

My task was to teach the students how to engage in research-level projects by teaching them how to read scientific articles, pose scientific hypotheses, and design experiments to test said hypotheses. I also taught the students how to effectively communicate their scientific results and helped the students learn many distributed systems concepts that I have acquired through my research experience.

School of Computing & Information Sciences, FIU — **Miami, FL**
Teaching Assistant — *2018-2020*

Teach/Lead a programming lab/class where students learn basic programming in Java. I taught many students the basics of algorithms as well as low-level behavior of the Java virtual machine.

Wyzant, Inc — **Miami, FL**
Wyzant Tutor — *2016-2018*

Worked as a private tutor where I tutored a variety of subjects such as Calculus I, II, III, Differential Equations, Discrete mathematics, Linear Algebra, Geometry, Algebra, and High School level Competition Mathematics.

Florida International University — **Miami, FL**
Teaching/Learning Assistant — *2012-2016*

Duties included, but were not limited to helping teachers prepare lectures, grade assignments, and research-specific class topics of the following courses: Calculus I, Calculus II, Calculus III, Differential Equations, Linear Algebra, Introduction to Advanced Math, Finite Math, Discrete Math, College Algebra, Physics I, Physics I Lab, Physics II Lab, and Modern Physics.

Mentorships

Manuel Fernandez — **Miami, FL**
High School Student — *2014-2015*

- As an undergrad I lead the preparations for the Putnam Competition in the FIU math club.
- At the time Manuel was a talented High School student who has sitting in on college level math courses.
- I invited him to come to the Putnam training sessions where we solved problems together; we would often continue discussing long after classes and training sessions were over and I would stay with him to make sure his parent picked him up safely (since his iPad was once stolen, I felt obliged to help keep him safe).
- He was accepted to Carnegie Melon University and he was proud to tell me he had achieved a 30-something score on the Putnam Competition. He has also been published in conferences like ICML.

Phillipe Dumeny — **Miami, FL**
High School Student — *2016-2019*

- I would often tutor him in competition math problems.
- I eventually would help mentor him on my free time without charging his mother because it was rewarding to help him discover the beauty of mathematics as well as other esoteric mathematical techniques.
- I helped him with his college entrance process in addition to helping him practice for exams.
- Phillipe's team, the Broward College Math Team, attended the Math Olympics at University of North Florida in Jacksonville April 19-21, 2019. His team won first place place in the team competition and Phillipe was an honorable mention.
- He was accepted to Columbia University and pursuing a Bachelor's degree in Mechanical Engineering.

Angel Saldivia — **Miami, FL**
Undergraduate Student — *2020*

- Angel was a student that joined our research group at FIU as part of the NSF REU program.
- He is a co-author in two of my publications.
- I often met with Angel after meetings (during my free time) and helped explain some of the theoretical aspects of the algorithms we were programming; *e.g.*, I helped explain why certain computer algebra algorithms for polynomial interpolation and multi-point evaluation worked.
- It was rewarding to learn that he went on to accept an offer to be a Software Engineer at Microsoft.

○ **Yuhka Machino** **Haifa, Israel**
Undergraduate Student *2022*

- Yuhka was a very gifted Mathematical Olympiad and undergrad at MIT who was doing a summer research program under the supervision of Dr. Keren Censor-Hillel at Technion when I was a visiting post-doc with the same research group.
- Upon discovering that she was talented at additive combinatorics, I translated one of my open research problems from my recently completed dissertation into a pure math puzzle for her to solve.
- Dr. Keren Censor-Hillel, Yuhka, and I are currently completing the write-up of the results and preparing it for submission.

Technical Skills

○ **Programming Languages:** Proficient in: C, C++, Python, Haskell, MPI, Java, and TeX
Also basic ability with: SQL, Neo4J, Apache Spark, Maple, and Sage

○ **Research Skills:** I have a solid understanding of
- *(Mathematics)* Functional Analysis, Algebraic Structures, Axiomatic Set Theory, Topology, Homology of Simplicial Complexes, Graph Theory, Combinatorics, Geometry (Differential & Algebraic), and Differential Equations (Ordinary and Partial).
- *(Computer Science)* Algorithms, Computability Theory, Coding Theory, Information Theory, Symbolic Computing, Numerical Algorithms, Artificial Intelligence, and Machine Learning.
- *(Experimental Techniques)* I have an understanding of experimental methods such as line-fiting data points (regression), correlating experimental errors to uncertainty in measurements, etc.

Community Outreach and Other Professional Activity

○ Presented my research at the *CRA-WP Grad Cohort for URMD* which is now called the CRA-WP IDEAL (Inclusion, Diversity, Equity, Accessibility, and Leadership Skills), Austin, TX, March 2020.
○ Participated in the *MSRI Modern Math Workshop*, a workshop designed to encourage undergraduates from underrepresented minority groups to pursue careers in the mathematical sciences, and to build research and mentoring networks among undergraduates, graduate students, and recent PhDs
○ Participated in the *SACNAS National Diversity in Stem Conference (NDiSTEM)*, which is dedicated to fostering the success of Chicanos/Hispanics and Native Americans, from college students to professionals, in attaining advanced degrees, careers, and positions of leadership in STEM.
○ Participated in the *MSRI Summer Graduate School on Algebraic Theory of Differential and Difference Equations, Model Theory and their Applications*
○ Participated in *Students Offering Support* at FIU, a non-profit tutoring service whose proceeds went to helping build infrastructure in developing countries.