Sebastián Rodríguez Falcón

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Education

Pontifical Catholic University of Peru (PUCP), BS in Physics 2016 – 2021

- Graduated in the top quintile of the Faculty of Science and Engineering
- **Coursework:** Thermodynamics, Perturbation Theory in Quantum Mechanics, Nonlinear Dynamics, Data Analysis and Stochastic Processes (graduate level)

Experience

Quantum Computing Researcher, Wolfram Research 2023 – Present

- Research and algorithm development in quantum computing, with a focus on hybrid quantum-classical variational methods for optimization
- Published courses, documentation and computational essays on Wolfram Community.
- Deliver lectures, tutorials, and conferences on quantum algorithms and applications using the Wolfram Quantum Framework
- Representative in the Open Quantum Institute's Smart Grid Management project (hosted by CERN), conducted in collaboration with Classiq and aligned with UN Sustainable Development Goals 7, 9, and 11

Full-Stack Developer, Wolfram Research South America 2022 – 2023

- Developed the backend for the Wolfram|Alpha Scanner, including automated data collection, validation, and cleaning pipelines.
- Developed interactive UI components for Wolfram|Alpha, including dynamic family trees and information pods for real and fictional entities.
- Implemented the WordFrequencyData function (analogous to Google Ngrams) to analyze historical trends in word usage

Teaching Assistant, PUCP 2021 – 2024

- Supervised and led undergraduate sessions in Introduction to Physics, Physics I and Physics III.
- Graded and provided feedback on student assignments.

Research Assistant, Complex Systems and Non-Linear Dynamics - PUCP 2022 – Present

- Under the supervision of Dr. Luciano Stucchi (Universidad del Pacífico), developed a multi-agent biased random walk model in a 2D continuous space, where agents move toward one another, leading to the emergence of a macro-agent exhibiting large-scale random walk behavior. Extended this idea to a 2D discrete-space model, generating different types of system behavior.
- Proposed a novel methodology for analyzing emergent patterns, offering a quantitative approach to phenomena typically interpreted through human visual recognition

Publications

Quantifying Emergent Behaviors in Agent-Based Models using Mean Information Gain *(Preprint submitted to PRL)* Oct 2025

Sebastian Rodriguez-Falcón, Luciano Stucchi

arXiv:2510.10381

This work applies the Mean Information Gain (MIG), a conditional entropy–based metric, to quantify emergence in multi-agent systems. By identifying Wolfram's four behavioral regimes (convergent, periodic, complex, chaotic) directly from agent dynamics, it provides one of the first quantitative classifications of emergent order and disorder. The approach connects complexity science and statistical physics through an information-theoretic lens, offering a general tool for studying collective behavior.

Introduction to Quantum Optimization *(Computational Book)* July 2025

Sebastian Rodriguez

Wolfram Cloud Link

Computational reference introducing the theory and implementation of Variational Quantum Algorithms (VQE, QAOA) and advanced methods such as Quantum Natural Gradient Descent and Quantum Linear Solvers, using the Wolfram Quantum Framework and modern quantum libraries such as Pennylane and Classiq.

Quantum Potato Chips (*ArXiv Preprint)* Nov 2024

Sebastian Rodriguez, Nikolay Murzin, Bruno Tenorio, John McNally, Mohammad Bahrami

arXiv:2411.01082

We examined qubit states and identified a specific region shaped like a "potato chip", where the probability vectors reduce to two classical binary variables. In this region, the states can be fully reconstructed using only two projective measurements, something unique within the state space.

Symbolic methods in quantum optimization: introduction to QAOA-in-QAOA (*Wolfram Community*) May 2025

Sebastian Rodriguez

Computational essay on QAOA-in-QAOA chosen by Wolfram Research editorial: https://community.wolfram.com/groups/-/m/t/3462606

This computational essay extends my presentation at the Open Quantum Institute's Knowledge Share event (CERN), where I introduced the QAOA-in-QAOA algorithm, an approach that nests QAOA instances to optimize variational parameters.

Exploring the quantum approximate optimization algorithm (QAOA) through the Max-Cut problem (*Wolfram Community*) April 2025

Sebastian Rodriguez

Computational essay on QAOA chosen by Wolfram Research editorial: https://community.wolfram.com/groups/-/m/t/3449705

This computational essay explores the Quantum Approximate Optimization Algorithm (QAOA) through the Max-Cut problem, formulating it in quantum terms, analyzing the structure of the QAOA Ansatz, and presenting examples that illustrate its extension to other combinatorial optimization problems.

Billiard dynamics: from regularity to chaos (*Wolfram Community*) Feb 2025

Sebastian Rodriguez

Computational essay on billiard dynamics chosen by Wolfram Research editorial: https://community.wolfram.com/groups/-/m/t/3391864

This computational study simulates billiard dynamics and investigates various emerging orbital structures. It provides a quick review and implementation of Sir Michael Berry's fundamental article, "Regularity and chaos mechanics, illustrated in classical by three deformations of a circular 'billiard'". Eur. J. Phys 2, 91-102.

Multiplexer-based variational quantum linear solver (*Wolfram Community*) Sep 2024

Sebastian Rodriguez

Computational essay on a new theoretical proposal for a quantum linear system solver chosen by Wolfram Research editorial: https://community.wolfram.com/groups/-/m/t/3253903

This original proposal explores solving equations via a variational quantum circuit based on multiplexed Pauli gates, along with optimization methods to minimize quantum fidelity and solve the problem.

Variational quantum linear solver (*Wolfram Community*) May 2024

Sebastian Rodriguez

Computational essay on the variational quantum linear solver algorithm chosen by Wolfram Research editorial: https://community.wolfram.com/groups/-/m/t/3180154

Exploration of applying the "Variational Quantum Linear Solver" algorithm proposed by Bravo-Prieto (Quantum 7, 1188) to solve linear systems.

Natural gradient descent optimization for quantum circuits with Fubini–Study metric tensor (*Wolfram Community*) Feb 2024

Sebastian Rodriguez

Computational essay on quantum natural gradient chosen by Wolfram Research editorial: https://community.wolfram.com/groups/-/m/t/3180154

This essay illustrates applying the “Natural Gradient Descent” optimization method in quantum state space within parameterized quantum circuits, calculating the Fubini-Study metric tensor through various approximations.

Conferences

Quantum Hackaton LATAM 2025 - Open Quantum Institue & Universidad de Montevideo LinkedIn Post

- Mentored the team ’Q-Quest Distribution’ in developing a quantum optimization model for efficient water distribution during disaster scenarios in Colombia
- Implemented an iterative and nested QAOA approach using Wolfram Quantum Framework and deployed via QBraid

Conferencia Latinoamericana de Innovación, Tecnología y Negocios - IEEE & Universidad del Pacifico WebPage

- Conference presentation on "A Biased Random Walk Model of Collective Imitation"

LANET 2025 - 4th Latin American Conference on Complex Networks Poster

- Poster presentation on "Quantifying Emergent Behaviors in ABM and CA using Conditional Entropy"

Wolfram Tech Talk 2024 YouTube

- Talk on "Variational Quantum Algorithms and Hybrid Optimization Methods"

IBM Qiskit Hands-On Workshop LinkedIn Post

- Talk on "Quantum Natural Gradient Descent for Optimization"
- Organized by Zeta Science Forum
- Collaboration with IBM Qiskit and School of Mathematics and Computer Science, IBA Karachi

PUCP Colloquium YouTube

- Talk on "Quantum Natural Gradient Descent in Variational Quantum Circuits"

Knowledge Share – Open Quantum Institute (hosted by CERN) LinkedIn Post

- Talk on "Demystifying QAOA: Symbolic Methods in Quantum Optimization"
- Presented work on QAOA and the QAOA-in-QAOA approach for solving Max-Cut and other combinatorial optimization problems

Workshops and Schools

Santa Fe Institute – Introduction to Agent-Based Modeling Certificate

Massive Open Online Course, Spring 2020

ICTP-SAIFR Workshop on Sociophysics Event Page

Virtual attendee, October 18–22, 2021

ENREDANDO 2022 – Escuela Iberoamericana y Workshop de Redes y Sistemas Complejos Event Page

Universidad del Pacífico, July 18–22, 2022

Teaching and Service

200 Embajadoras del Bicentenario - Embassy of the United States in Peru & Concytec LinkedIn Post

- Selected as a STEM specialist to deliver science and technology workshops to 200 girls aged 6–12 from all 25 regions of Peru, primarily from under-resourced backgrounds

- Introduced participants to agent-based computational models and guided them in applying these tools to analyze real social dynamics
- Proposed and developed a model to simulate urban cleanliness dynamics using agents, determining the minimum number of cleaning agents needed to maintain a clean city, this project won the event's competition

Daily Study Group on Quantum Optimization - Wolfram Wolfram U

- Five-day daily study group introduces the fundamentals as well as state-of-the-art variational algorithms, quantum optimization and their applications.

Wolfram Summer School 2024 LinkedIn Post

- Served as a mentor for undergraduate students, guiding research projects in quantum computing and cellular automata
- Provided technical and conceptual support throughout the program, helping participants design, implement, and present their computational models

Open Course: Introduction to Complexity and Agent-Based Modeling Web Page

- Delivered a free, full-length introductory course in Spanish on modeling complex systems using NetLogo, aimed at Peruvian undergraduate students
- Covered applications in social, ecological, and physical systems, based on the Santa Fe Institute's Agent-Based Modeling course from Complexity Explorer

Skills

- ***Programming Language***: Wolfram Language, Python, NetLogo, SPARQL, Fortran
- ***Languages***: Languages: Spanish (Native), English (C1 – DET certified)