

# NATANAEL S. ALPAY

AI-ASSISTED RESEARCH | MACHINE LEARNING | APPLIED MATHEMATICS

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Expected May 2027

May 2022

Mathematics Ph.D. candidate with 10+ publications and preprints in analysis, probability, and machine learning. Uses LLMs as conjecture engines, then verifies candidate results through mathematical proof and reproducible computation. Applied work spans healthcare signal prioritization and ongoing hedging research. Presented 20+ research talks.

## EDUCATION

### University of California, Irvine

Ph.D. Candidate, Mathematics; M.S. Applied Mathematics (December 2025).

### Chapman University

B.S. Mathematics | B.S. Physics | B.S. Computer Science | B.A. French

**Honors:** Ronald M. Huntington Outstanding Scholarship Award; DataFest First Place/Best Insight.

## TECHNICAL SKILLS

**Quantitative Methods:** Probability, stochastic processes, martingales, optimization, numerical analysis, kernel methods.

**Machine Learning:** SGD, logistic regression, gradient boosting, temporal validation, calibration, feature ablations.

**Programming:** Python (NumPy, pandas, Matplotlib), SQL, R, C/C++, JavaScript, MATLAB, Mathematica.

## MATHEMATICAL AND COMPUTATIONAL RESEARCH

### Graduate Research Assistant | University of California, Irvine

Sep 2022–Present

- **Portfolio Compression for Entropic Hedging:** Studying low-dimensional portfolio representations with transaction costs and constraints; developing bounds linking approximation, estimation, and optimization errors to excess hedging risk.
- **Complex-valued learning:** Extended representer-theorem methods to complex reproducing kernel Hilbert spaces (RKHS); constructed kernel-regression problems with prescribed solutions.
- **Optimization:** Developed a complex SGD variant; analyzed convergence and directional bias and implemented numerical experiments recovering theoretical solutions.
- **Probability:** Derived sharp bounds for dyadic square functions using martingale and Brownian exit-time methods.
- **LLM-assisted research:** Generate candidate conjectures with LLMs; verify through proof and computational checks.

### Machine Learning Research & Data Analysis | Chapman University

Jun 2020–Sep 2022

- Cleaned and analyzed Brain Institute datasets. In separate projects, implemented ML algorithms and built Python/SQL and JavaScript tools for scientific data exploration.

## APPLIED MACHINE LEARNING AND EVALUATION

### VAERS Vaccine–Symptom Signal Prioritization

2025–2026

- Built a quarter-ahead ranking pipeline for future classical reporting signals using logistic regression and calibrated gradient boosting. Benchmarked against PRR and EBGM-style scores using AUPRC, calibration, and precision@k. Presented at CHOC's Pediatric and Lifespan Data Science Conference, April 29, 2026.

### FAERS Drug–Adverse-Event Signal Prioritization

2026

- Evaluated gradient boosting with future-quarter holdouts, rolling four-quarter validation, calibration, and feature ablations. Presented at the Biostatistics Symposium of Southern California, January 2026.

## TEACHING AND RESEARCH MENTORSHIP

- **UCI:** Numerical Analysis instructor of record (Summer 2026); Teaching Assistant (Sep 2022–Present).
- **DATA@UCI (Jan–Jun 2025):** Mentored undergraduates in high-dimensional data reduction, analysis, and presentation.
- **Research mentorship:** Guided an undergraduate random-matrix project; preparing a student project on deep hedging.

## SELECTED PUBLICATIONS & PREPRINTS

Alpay & Battaglia. Complex Stochastic Gradient Descent and Directional Bias in Reproducing Kernel Hilbert Spaces. arXiv, 2026.

Alpay & Ivanisvili. Sharp Lower Bounds for Dyadic Square Functions of Indicator Functions of Sets. arXiv, 2025; revised 2026.

Alpay, Cerejeiras & Kähler. Generalized Fock-space and fractional derivatives: Uniqueness of sampling and interpolation sets. Results in Applied Mathematics, 2026.

**Languages:** English, French, Russian, Hebrew. **Interests:** Weightlifting, LEGO, karaoke.