Ignacio Contreras Zúñiga

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Education

Pontificia Universidad Católica de Chile 2022-2023
Master of Science in Engineering, advised by Carlos Sing-Long

- Thesis: *Analysis of techniques for lifting to measure spaces for nonlinear inverse problems*

Pontificia Universidad Católica de Chile 2017-2022
Professional degree in Mathematical and Computational Engineering

Pontificia Universidad Católica de Chile 2017-2021
B.Sc. (Licenciatura) in Engineering Physics, Minor in Applied Mathematics

Research Interests Mathematical signal processing, computational harmonic analysis, convex analysis and optimization, scientific computing. Applications to sparse recovery-inverse problems, data science and PDEs.

Publications

[1] Lifting IDEAL: Super-Resolution for Chemical Shift in MRI March 2024
In preparation. Ignacio Contreras Zúñiga, Carlos Sing-long

[2] RKHS and Inverse Problems in Measure Spaces
Ongoing. Ignacio Contreras Zúñiga, Carlos Sing-Long May 2024

Research Experience

Master Thesis, advised by Carlos-Sing-long August 2022-Present

- My current thesis project is in the problem of Super-Resolution of point sources: To recover a sparse point measure from low-frequency information, which can be modeled as a infinite-dimensional optimization problem as a minimization of the total variation norm (of measures) subject to observations. I work in two projects, a particular application to off-resonance/chemical shift correction in magnetic resonance imaging and on the stability of the reconstruction in presence of noise in Super-Resolution using the theory of reproducing kernel Hilbert spaces.

Undergraduate Research, advised by Carlos Sing-Long April 2021-December 2021

- Studied the Atomic norm minimization for super-resolution and implemented the SDP dual formulation in Julia.

Summer Research in Mathematics, advised Carlos Pérez-Arancibia November 2020-January 2021

- Studied Boundary Integral Equations (BIE) for 2D scattering for the Helmholtz equation
- Implemented in Julia the Adjoint-based method for shape optimization with BIE constraints.

Undergraduate Research, advised by Clémentine Béchet August-December 2020

- Studied statistical model selection an implemented in OpenCV different distorsion models for close-range photogrammetry for the MOONS project of the European Southern Observatory.

Summer Research in Physics, advised by Rafael Benguria January 2020

- Studied 3 classic inverse problems in mathematical physics: The Radon transform and medical imaging, the inverse eigenvalue problem "Can one hear the shape of a drum ?" and Electrical Impedance Tomography.

Work Experience

Capstone Project: Mathematical Engineering March-July 2022

- Implemented in Python a web-scrapping algorithm and sentiment analysis of social media (Twitter/X) and news outlets for credit risk prediction. Capstone project in partnership with Itaú Bank.

European Southern Observatory (ESO), advised by Dr. Angel Otárola & Dr. Alain Smette January-March 2022
Internship - Paranal Observatory. The Science Operations department

- Studied and implemented in Python the detrended fluctuation analysis and other statistical methods for cloud and precipitation detection from time series data,
- Demonstrated that an old implementation of the method that was still in use was poorly implemented and corrected it.
- The implementation that resulted from the internship will serve to automatically report the weather condition of the Extremely Large Telescope (ELT) (in construction)

Teaching Experience

Teaching Assistant

- TA and grader for graduate and undergraduate courses for the Engineering, Mathematics and Physics faculty.

- Intro to Microlocal Analysis (graduate). Instructor: Benjamín Palacios August-December 2023
- Advanced Optimization (graduate). Instructor: Cristobal Guzmán March-July 2023
- Applications of PDE's and Functional Analysis (graduate). Instructor: Federico Fuentes March-July 2023
- Topics in Inverse Problems (graduate). Instructor: Carlos Sing-Long March-July 2023

- Expert TA: Held weekly office hours, designed homework questions and final projects. Example of topics are: Distribution Theory and PDEs, Radon Transform, Denoising, Robust PCA, Compressed Sensing-MRI reconstruction, Phase Retrieval, and others.

- Scientific Computing I August-December 2022
- Biomedical Imaging. Instructor: Carlos Sing-Long August-December 2022

- Expert TA: Designed final projects and prepared weekly Jupyter notebooks to teach students the different biomedical imaging modalities in Python. Topics included: basic signal processing, modern physics, X-rays, Radon transform, CT, Gammagraphy, SPECT, Acoustic & Optics, MRI, Undersampled reconstruction in MRI.

- Topics in Inverse Problems (graduate) March-July 2022
- Fourier Analysis. August-December 2021
- Calculus III March-July 2021
- Electricity & Magnetism Laboratory January 2021
- Scientific Computing I March-July 2020
- Electricity & Magnetism (grader) March-July 2020

Leadership & Service

Organizer SIAM-PUC Summer School. 200 years of Fourier Analysis January 2023

- Main organizer of summer school celebrating 200 yeas of Fourier analysis. See webpage here

Organizer Mathematical Engineering National Meeting ENIM 2022 August 2022

- Main organizer, more thant 200 students from applied math and engineering from across the country assisted. See picture here

President SIAM-PUC Student Chapter August 2021-August 2023

- Organized many activities for the SIAM Chapter and math engineering community for more than 3 years. Represented our institute in SIAM annual meeting 2022 (on site, news here) and 2021 (virtual). Interview here (in spanish)

Student representative Mathematical and computational engineering April 2021-Present

- Represent math engineering students. Regularly participate in conversation panels for new students. Participate in the Curriculum Committee of the institute.

Student representative Engineering Physics Major — April 2020-April 2021
Vice president SIAM-PUC Student Chapter — August 2020-August 2021

Awards & Honors

HackSciML - Hackathon on Scientific Machine Learning — October 2023
Winner Team: Predict the heat source from the diffusion equation through partial data challenge
SIAM Student Chapter certificate of recognition — April 2023
For exceptional service to the SIAM-PUC Student Chapter
SIAM-IMC travel award — July 2022
Representative from SIAM-PUC Student Chapter and the Institute for Mathematical and Computational Engineering (IMC) in SIAM Anual Meeting 2022

Attended Workshop and Conferences

Workshop on Scientific Machine Learning Staff. Santiago, Chile. — November 2022
Minimum Residual & Least-Squares Finite Element Methods Santiago, Chile. — October 2022
2022 SIAM Annual Meeting (AN22) — July 2022
Pittsburgh, US. Student Representative from SIAM-PUC Student Chapter
2021 SIAM Annual Meeting (AN21, Virtual) — July 2021
Student Representative from SIAM-PUC Student Chapter

Skills

Programming: Python (numpy, pandas, sklearn), Julia, Matlab, Mathematica, R, LaTeX, C++
Languages: Spanish (native), English (advanced), French (Beginner).

Memberships

SIAM (student member), **IEEE** (student member)

Coursework

Mathematics & Statistics
◦ **Graduate Level**
High-Dimensional Probability, Topics in Inverse Problems, Mathematical Foundations of Machine Learning, Advanced Optimization, Engineering Applications of PDE's and Functional Analysis, Computational Complexity
◦ **Undergraduate Level**
Theory of Probability, Partial Differential Equations, Functional Analysis, Fourier Analysis, Measure Theory, Real Analysis, Scientific Computing I (intro to numerical analysis), Optimization, Discrete Mathematics, Regression Analysis, Statistical Inference, Probability and Statistics
Physics
◦ **Undergraduate Level**
Quantum Physics I and II, Statistical Mechanics, Topics in Mathematical Physics (spectral theory in quantum physics), Electromagnetic Theory, Waves and Optics, Mathematical Methods in Physics I and II, Modern Physics (special relativity and intro to quantum physics), Classical Mechanics II (Analytical Mechanics)
Science and Engineering
Biomedical Image Formation, Parallel Algorithms in Scientific Computing, Intro to Astronomy, Programming in Python, Scientific Communication

Misc.

Seminars: I like to organize seminars and reading groups with my fellow classmates

- Group reading in Randomized Numerical Linear Algebra (following Martinsson, Tropp 2020) August 2023-Present
- Group Reading in Compressed Sensing (following Wright, Ma 2022 & Foucart, Rauhut 2013) July 2023-Present

References

Carlos Sing-Long: Msc. advisor (casinglo@uc.cl)
Rafael Benguria: Undergrad physics mentor (rbenguri@fis.puc.cl)
Federico Fuentes: Math Engineering and PDEs mentor (federico.fuentes@uc.cl)
Cristobal Guzmán: Math Engineering and optimization mentor (crguzmanp@mat.uc.cl)
Benjamín Palacios: Math Engineering and analysis mentor. (benjamin.palacios@mat.uc.cl)