RAHUL SARKAR

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CONTACT INFORMATION

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RESEARCH INTERESTS

- Inverse Problems, Quantum Information Theory, Analysis

EDUCATION

Ph.D., Sept 2017 - Present
Institute for Computational and Mathematical Engineering, Stanford University
Advised by Prof. Biondo L. Biondi & Prof. András Vasy

Master of Science, 2017
Institute for Computational and Mathematical Engineering, Stanford University

- GPA - 3.97 / 4.0

Integrated Masters (B.Sc & M.Sc), 2011
Indian Institute of Technology Kharagpur, India

ACADEMIC HONORS AND SCHOLARSHIPS

- Schlumberger Innovation Fellowship - Stanford University, 2019
- Shell Fellowship - Stanford University, 2015
- Institute Silver Medal - IIT Kharagpur, 2011
- DAAD WISE Scholarship - Germany, 2010
- J.C Ghosh Memorial Prize - IIT Kharagpur, 2010

WORK EXPERIENCE

IBM Thomas J. Watson Research Center - Yorktown Heights, USA **06/2019 - 09/2019**

- Mathematical research that led to some new discoveries about of the Pauli group *(joint work with Ewout van den Berg)*. This work resulted in a paper that has been published in the journal *Research in Mathematical Sciences*.
- I formulated a technique that allows you to generate efficient Ising Hamiltonians for a large class of optimization problems involving polynomial constraints and a polynomial objective function of integer variables *(joint work with Marco Pistoia)*. The method builds on existing quadratization techniques and roof duality techniques for variable reduction. A US patent has been filed.

QC Ware - Palo Alto, USA **07/2018 - 09/2018**

- Experimental quantum topological data analysis on the IBM 16-qubit quantum computer.
- Published a white paper titled *"A quadratic unconstrained binary optimization problem formulation for single-period index tracking with cardinality constraints"*.

QC Ware - Palo Alto, USA **07/2017 - 09/2017**

- Applications developer for solving optimization problems on a quantum computer.
- Focused on developing quantum annealing and circuit model algorithms for financial applications, topological data analysis and quantum machine learning.

Schlumberger - USA & Mexico **06/2011 - 08/2015**

- Worked on advanced imaging and inversion algorithms on large seismic datasets; mostly real projects with integration of the technologies into the upstream workflow, member of the Center of Excellence Incubator Program (about 10 people recruited globally), assisting in technical sales, training and teaching local staff in Mexico.

TEACHING AT STANFORD

GEOPHYS 280, 3D Seismic Imaging [Explore Courses] [Website] **04/2020 - 06/2020**
Course Assistant with Prof. Biondo Biondi, Department of Geophysics

- Responsibilities included holding weekly office hours, and grading. I also gave a lecture on Linearized Waveform Inversion, and created a separate computational lab assignment.

CME 250Q, Introduction to Quantum Computing and Quantum Algorithms [Explore Courses] [Github] **09/2019 - 12/2019**

Instructor

- This is a 1-unit short course (9 lectures) that covered the fundamentals of quantum computing and some fundamental quantum algorithms such as Quantum Fourier Transform, Quantum Phase Estimation, and Grover's search.

MATH 220, PDEs of Applied Mathematics [Explore Courses] [Website] **09/2018 - 12/2018**
Course Assistant with Prof. Andras Vasy, Department of Mathematics

- Responsibilities included holding weekly office hours and grading.

CME 193, Introduction to Scientific Python [Explore Courses] [GitHub] [Website] **09/2018 - 12/2018**
Co-Instructor with Brad Nelson, Institute for Computational & Mathematical Engineering

- Designed and taught course material from scratch for 2 lectures — Introduction to optimization using SciPy (Nonlinear optimization) [github], & Introduction to optimization using OR-Tools (Combinatorial optimization)[github].

CS 234, Reinforcement Learning [Explore Courses] [Website] **01/2018 - 03/2018**
Course Assistant with Prof. Emma Brunskill, Stanford Computer Science

- Created lecture notes on Markov Decision Processes, with focus on selected topics like policy evaluation, policy iteration and value iteration.
- Designed the course website; designed the midterm, in addition to other miscellaneous required tasks such as holding office hours and grading.

Publications

Under Preparation

- Rahul Sarkar, Theodore J. Yoder, *An alternation theorem for approximation by constrained varisolvent families*.

Refereed Publications

- Rahul Sarkar, Stewart A. Levin, *Snell tomography for net-to-gross estimation using quantum annealing*, Expanded Abstracts of the 88th SEG Annual International Meeting, (2018). doi:10.1190/segam2018-2998409.1. [Paper]
- Rahul Sarkar, Bradley J. Nelson, *Texture Based Classification Of Seismic Image Patches Using Topological Data Analysis*, 81st EAGE Conference and Exhibition 2019, (2019). doi:10.3997/2214-4609.201901608. [Paper] [Poster]
- Rahul Sarkar, Biondo Biondo, *Illumination compensation of shadow zones in extended least squares migrated images by solving the linear inverse problem in tomographic full waveform inversion*, Expanded Abstracts of the 89th SEG Annual International Meeting, (2019). doi:10.1190/segam2019-3215094.1. [Paper]
- Gabriel Fabien-Ouellet, Rahul Sarkar, *Seismic velocity estimation: a deep recurrent neural-network approach*, Geophysics, (2020). doi:10.1190/geo2018-0786.1. [Paper] [Code]
- Leopold Cambier, Rahul Sarkar. *The index of invariance and its implications for a parameterized least squares problem*, (2020). [Pre-print]
- Rahul Sarkar, Ewout van den Berg, *On sets of maximally commuting and anticommuting Pauli operators*, Research in the Mathematical Sciences, (2021). [Paper]
- Rahul Sarkar, Theodore J. Yoder, *A graph-based formalism for surface codes and twists*, (2021). [Pre-print]
- Rahul Sarkar, Biondo Biondi, *A numerical scheme to solve the Lippmann-Schwinger equation for a linearly varying background*, First International Meeting for Applied Geoscience & Energy, (2021). [Paper]
- Alejandro Cabrales-Vargas, Rahul Sarkar, Biondo Biondi, Robert Clapp, *Joint inversion of the reflectivity and the velocity model*, Geophysics, (2021). [Paper]
- Rahul Sarkar, Theodore J. Yoder, *Density theorems with applications in quantum signal processing*, (2021). [Pre-print]

Internal Reports

- Stewart A. Levin, Rahul Sarkar, Snell tomography using quantum annealing, SEP Report 172, 377-396 (2018).
- Rahul Sarkar, Biondo Biondi, Frequency domain tomographic full waveform inversion, SEP Report 172, 173-192 (2018).
- Rahul Sarkar, Biondo Biondi, A 2D Helmholtz equation solver library based on C++ and SuiteSparse, SEP Report 170, 157-174 (2017).

Undergraduate Thesis **2011**

Advisor: Prof. Dr. Laurent Gizon, and Prof. William Mohanty
Title: "A Mass Conserved Formalism for Helioseismic Inversions"

- Numerical computation of Sensitivity Kernels, testing and verification of an inversion scheme in local helioseismology that is consistent with mass conservation. This was a continuation of my internship work under the DAAD fellowship.

Internships

DAAD Fellowship - Katlenburg-Lindau, Germany **05/2010 - 07/2010**
Max-Planck-Institute for Solar System Research

Advisor: Prof. Dr. Laurent Gizon
Title: "Inversions in Local Helioseismology"

- Selected for the prestigious DAAD fellowship for an academic internship in Germany.
- Reformulated the travel time equation for flow fields in the Sun by replacing the three velocity components with two new scalars obtained from the Poloidal-Toroidal decomposition of a divergence free vector field, so as to carry out inversions in local helioseismology that are consistent with the principle of mass conservation.
- Derived analytical expressions for the Sensitivity Kernels for these new scalars in terms of the Sensitivity Kernels of the velocity components, and derived travel time equations and associated Sensitivity Kernels and target functions, which can be used to invert for the components of the velocity correlation tensor.

The University of Western Ontario - London, Canada **05/2009 - 07/2009**

Advisor: Prof. Kristy F. Tiampo
Title: "Analysis of LIDAR data"

- Performed spectral analysis of 2D spatial LIDAR (Light Detection And Ranging) data from California, to locate geographical features using localized time-frequency analysis.
- Developed computer codes in MATLAB to compute The Discrete Hartley S Transforms.

Other Academic Projects

Information Directed Reinforcement Learning **01/2017 - 03/2017**

Joint work with Andrea Zanette

- This is a project done as part of CS 234 (Advanced Reinforcement Learning) class at Stanford University. In this project, we explored an efficient exploration strategy based on information directed reinforcement learning. Details are provided in the attached paper.
- Final report.

Automated Aircraft Touchdown **10/2016 - 12/2016**

Joint work with Amy Shoemaker & Sagar Vare

- This was a class project done as part of the "Decision Making Under Uncertainty" class at Stanford University. In this project we experiment with a few Reinforcement Learning algorithms with the goal to safely land an aircraft, in the presence of stochastic winds. The project was implemented in python 2.7.
- Final report, Github code repository.

Finding a cover for an ellipse with N rectangles **01/2016 - 03/2016**

- This is an interesting class project done as part of the "Numerical Optimization" class at Stanford

University where the goal is to find a cover for an ellipse with N rectangles, such that the area outside the ellipse is minimized. In this project, I first formulate an equivalent problem that reduces to finding a cover for a circle with the same number of rectangles. The problem is then solved using a Modified-Newton Hessian based approach, and the performance is compared against Steepest Descent. It is found that Modified Newton based approach is much more efficient, although each iteration is significantly more expensive compared to Steepest Descent. I also compare the performance of using different line search algorithms like Goldstein vs Strong-Wolfe conditions, and conclude that the Strong-Wolfe conditions provide much better results.

- Final report.

Finite Difference Analysis of Energy Eigenvalues for a Vibrating Membrane

Advisor: Prof. S.P. Khastgir, IIT Kharagpur. **05/2007 - 07/2007**

- Successfully developed a finite difference algorithm in C, based on hexagonal grid meshing to compute the energy eigenvalues of a vibrating membrane satisfying Dirichlet boundary conditions over a super elliptic boundary.
- The code was used to validate analytical perturbative calculations of the same.

Selected Courses at Stanford

- Partial Differential Equations, Functional Analysis, Differential Geometry, Advanced Probability
- Numerical Linear Algebra, Numerical Optimization, Convex Optimization I & II
- Artificial Intelligence, Reinforcement Learning, Decision Making under Uncertainty
- Discrete Math and Algorithms, Stochastic Methods in Engineering, 3D Seismic Imaging

Computer Skills

- Fluent in Python, Modern C++ (mainly C++11), MATLAB.
- *Scientific Writing:* LaTeX.
- *Hobby Programming:* Julia, Haskell, Coq.
- *Operating Systems:* Windows, macOS, Linux.

Personal Interests

Travel, Finance, Chess, Astronomy