Rafael Orozco

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Education

Georgia Institute of Technology
Advised by Prof. Felix J. Herrmann at Seismic Laboratory for Imaging and Modeling
PhD in Computational Science and Engineering *Graduated: 12/2024*

Researched generative machine learning for uncertainty quantification of inverse problems. My main research contributions are in generative models that learn to sample from the Bayesian posterior of realistic inverse problems. I explore seismic imaging and medical imaging modalities (MRI, CT, Ultrasound, Photoacoustic) but generally focus on imaging problems governed by computationally expensive partial differential equations (PDEs). These problems are best suited for physics hybrid frameworks that are accelerated by machine learning but informed by domain physics knowledge in the form of PDE simulations. My engineering mindset drives me to bridge the gap between innovative algorithms and practical applications, making these solutions impactful for industry needs.

Bucknell University
Bachelor of Science in Computer Science, Minor in Mathematics *Graduated 05/2019*

Work experience

Institute for Mathematics and Computer Science Amsterdam, NL *Summer 2024*
• Worked with CWI computational imaging group to developed generative networks to accelerate uncertainty-aware imaging of large 2D X-ray CT field datasets and extended the workflow for 3D reconstructions.
• Manuscript in preparation to submit in Nature Scientific Reports.

NASA Langley Research Center Hampton, VA *Summer 2019*
• Worked on the Program to Optimize Simulated Trajectories II (POST2) software used in trajectory planning for atmosphere entry and landing of rovers.
• Updated continuous integration suite from legacy workflow to a modern HDF5-based implementation.
• Increased ease of code maintenance and leveraged HDF5 compression to minimize memory usage.

Lawrence Berkeley National Laboratory Berkeley, CA *Summer 2018*
• Proposed then implemented a statistics-based compression algorithm for multi-dimensional sensor data.
• Benchmarked against JPEG and found higher compression rates with comparable visual quality.
Paper: Multidimensional Compression with Pattern Matching. 2019 Data Compression Conference

National Renewable Energy National Laboratory Golden, CO *Summer 2017*
• Trained models on historical wind turbine sensor datasets for early diagnosis and warning of failures.
• Implemented the machine learning algorithm with big data software Hadoop and Spark due to large scale of the sensor data.
Paper: Diagnostic models for wind turbine gearbox components using scada time series data. IEEE International Conference on Prognostics and Health Management 2018 (ICPHM)

Technical skills

- Python & Julia for scientific machine learning
- Generative AI: Normalizing Flows & Diffusion
- Bayesian Inference and Digital Twins
- Devito & JUDI for Seismic Inversion
- MRI, CT, Photoacoustic, Ultrasound
- HDF5, Spark and Hadoop for big data
- GIT, Github Actions, LaTeX
- Native English and Spanish

Software development

InvertibleNetworks.jl *Main developer since 05/2022*
Allows for memory efficient machine learning on GPUs. As main developer, I contributed physics-based and learned summary networks enabling high-resolution imaging in various seismic and medical inverse problems. Maintenance & testing with Github Actions for continuous integration.
Paper: A Julia package for scalable normalizing flows. (Published in Journal of Open Source Software)

PhotoAcoustic.jl *Main developer since 04/2023*
Derived adjoints of the photoacoustic PDE. Implemented the adjoint simulation with JUDI to accelerate algorithm development of photoacoustic image reconstruction.
Paper: Memory efficient invertible neural networks for 3D photoacoustic imaging.

Selected publications

An Uncertainty-aware Digital Shadow for Underground Multimodal CO2 Storage Monitoring *05/2024*
Abhinav Gahlot, **Rafael Orozco**, Ziyi Yin, Felix J. Herrmann
Submitted to Geophysical Journal International

ASPIRE: Iterative Amortized Posterior Inference for Bayesian Inverse Problems *05/2024*
Rafael Orozco, Ali Siahkoohi, Mathias Louboutin, Felix J. Herrmann
Submitted to Inverse Problems Journal

BEACON: Bayesian Experimental design Acceleration with Conditional Normalizing flows – a case study in optimal monitor well placement for CO2 sequestration *03/2024*
Rafael Orozco, Abhinav Gahlot, Felix J. Herrmann
Accepted to IMAGE 2024

WISE: full-Waveform variational Inference via Subsurface Extensions *03/2024*
Ziyi Yin, **Rafael Orozco**, Mathias Louboutin, Felix J. Herrmann
Accepted as letter to Geophysics

Normalizing Flows for Bayesian Experimental Design in Imaging Applications *02/2024*
Rafael Orozco, Abhinav Gahlot, Peng Chen, Mathias Louboutin, Felix J. Herrmann
SIAM Uncertainty Quantification

Inference of CO2 flow patterns–a feasibility study *11/2023*
Abhinav Gahlot, Tuna Erdinc, **Rafael Orozco**, Ziyi Yin, Felix J. Herrmann
NeurIPS 2023 Workshop on Tackling Climate Change with Machine Learning

Amortized Normalizing Flows for Transcranial Ultrasound with Uncertainty Quantification *06/2023*
Rafael Orozco, Mathias Louboutin, Gabrio Rizzuti, Tristan van Leeuwen, Felix J. Herrmann
PMLR Medical Imaging with Deep Learning

Adjoint operators enable fast and amortized Bayesian uncertainty quantification *04/2023*
Rafael Orozco, Ali Siahkoohi, Gabrio Rizzuti, Tristan van Leeuwen, Felix J. Herrmann
SPIE Medical Imaging Conference

Normalizing flows for regularization of 3D seismic inverse problems *11/2022*
Rafael Orozco, Mathias Louboutin, and Felix J. Herrmann
ML4Seismic Consortium Meeting

Photoacoustic imaging with conditional priors from normalizing flows *12/2021*
Rafael Orozco, Ali Siahkoohi, Gabrio Rizzuti, Tristan van Leeuwen, Felix J. Herrmann
NeurIPS - Deep Learning and Inverse Problems