Guanxiong Luo, PhD in Computer Science, ML Researcher in Computational Imaging

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Summary

I am a computational imaging scientist with a strong theoretical and experimental background in algorithm development, computational imaging, and signal processing methods. I usually approach imaging problems from the Bayesian perspective to develop new algorithms for the improvement of image quality and the uncertainty quantification. This allows me to combine my expertise in machine learning (generative models) and imaging physics (data likelihood) to develop new algorithms for many imaging applications. I am also a machine learning engineer with many experiences in developing and deploying generative models using frameworks like PyTorch, TensorFlow/JAX, and TensorRT. I am comfortable with Python, C/C++, shell scripting, and a Linux-like environment.

Expertise

Computational imaging | Bayesian inference | Diffusion models | Inverse problem | Computer vision | Image/Signal processing | MRI physics | Medical imaging | Applied mathematics

Experiences

Employment

01/2020-10/2024: Research Scientist at University Medical Center Göttingen, Germany

1. Employed under the project "Learning quantitative imaging biomarkers from MRI raw data," funded by the Lower Saxony Ministry of Science and Culture.
2. Develop and implement machine learning models and algorithms for large-scale data analysis for MR imaging applications.
3. Collaborate with cross-disciplinary teams from clinicians at UMG and computation teams from Gesellschaft für wissenschaftliche Datenverarbeitung mbH Göttingen (GWDG).
4. Publish multiple papers in journals and conferences and tutor students in their research projects.

09/2017-11/2019: Research Assistant at LKS Faculty of Medicine, University of Hong Kong

1. Improved MR Fingerprinting by integrating physics information using numerical optimization techniques and MR signal simulation.
2. Applied Bayesian estimation to accelerated MRI reconstruction with the prior knowledge learned by generative models.

Education

- **10/2020-11/2023**: PhD in Computer Science, University of Göttingen;
  Advisor: Prof. Dr. Martin Uecker; Thesis: *Development of Advanced Generative Priors for MRI Reconstruction*.
- **09/2017-10/2019**: M.Phil in Biomedical Engineering, University of Hong Kong;
  Advisor: Prof. Dr. Cao Peng; Thesis: *The Application of Generative Networks in MR Image Reconstruction*.
- **09/2013-07/2017**: B. Eng in Biomedical Engineering, Xi'an Jiaotong University;
  Advisor: Prof. Dr. Junbo Duan; Final Project: *Fast MRI Using Compressed Sensing*.

Award & Honor

- **12/2023**: PhD Graduated with Magna cum Laude, University of Göttingen
- **2017-2019**: Postgraduate Scholarship awarded by The University of Hong Kong
- **06/2017**: Outstanding Graduate of Class 2017 awarded by Xi'an Jiaotong University
- **10/2015**: National Encouragement Scholarship awarded by Xi'an Jiaotong University
- **04/2015**: Meritorious Winner in American Mathematical Contest in Modeling (MCM)

Academic Activities

Talks

- **01/2025**: About *How to use prior information in MR imaging?* at Prof. Dr. Reinhard Heckel's group, Technical University of Munich
- **09/2023**: About *Bayesian MRI reconstruction with joint uncertainty estimation using diffusion priors* at 11th Applied Inverse Problems Conference, Göttingen
- **01/2023**: About *Estimate the uncertainty for MRI reconstruction with learned Bayesian models* at Institute for Numerical and Applied Mathematics, University of Göttingen
- **07/2022**: About *Data Driven Methods for Fast MRI reconstruction* at Cardiac MRI Lab, SJTU, Shanghai
- **09/2021**: About *Bayesian Image Reconstruction with Learned Prior* at Workshop on MRI Acq. & Rec., MGH Harvard
- **05/2021**: About *Using image priors with BART* at ISMRM 2021 Software Session on BART

Teaching and Tutoring

- **WS 2021**: Tutorials for undergraduates and graduates, teaching assistant for a course on deep learning
- **WS 2021**: Teaching assistant for a course on the application of data science to smart city
- **WS 2022**: Tutored one master thesis on MRI reconstruction using deep learning
- **WS 2023**: Tutored one bachelor thesis on MRI reconstruction using diffusion models

Service to the Profession

- Reviews for ICML, ICLR, AISTATS, NeurIPS, IEEE TMI, IEEE TCI, Medical Physics, Magnetic Resonance in Medicine

Technical Skills & Open-Source Contributions

- **Programming:** Python, C/C++, Shell scripting, Linux/Unix | **Deep Learning:** PyTorch, TensorFlow, JAX, TensorBoard, Jupyter
- **Deployment Toolchain:** CUDA, TensorRT, ONNX | **HPC Cluster:** SLURM, Docker, MPI |**Version Control:** Git, GitLab
- **Open-Source Contribution:**
  - A library for training diffusion models for MRI at https://github.com/mrirecon/spreco, implemented with TensorFlow
  - Autoregressive image diffusion at https://github.com/mrirecon/aid, implemented with PyTorch
  - Inference with TensorRT at https://github.com/ggluo/TensorRT-Cpp-Example, implemented with C++ and C
  - Tensorflow C wrapper to BART at https://github.com/mrirecon/bart/commit/8b8d4ed2a727bcbc19a11e9ddd64d46f7e5e21d9

Selected Projects

1. Self-diffusion for Solving Inverse Problems

- **Role:** Lead Researcher and Developer | **Duration:** On-going
- **Summary:** Proposed self-diffusion, a novel framework for solving inverse problems without relying on pretrained generative models, that is a self-contained iterative process that alternatingly applies noising and denoising steps to refine its estimate of the solution. A theoretical form is provided to offer guidance for understanding its behavior from the perspective of spectral bias.

2. Autoregressive Image Diffusion: Generation of Image Sequence

- **Role**: Lead Researcher and Developer | **Duration:** 2024/01-2024/06
- **Summary:** Developed a novel model, which combines with autoregressive and diffusion models, to generate coherent image sequences and applied it to MRI reconstruction in a Bayesian inference framework. Evaluated the model's performance on fastMRI dataset, demonstrating superior results compared to standard diffusion models, and significantly reducing hallucinations in reconstructed images. Successfully generated 3D brain image volumes of size 46×128×128 without temporal sliding window and full 3D volumes with sliding window.

3. Using Generative Image Priors as Regularization for MRI Reconstruction

- **Role:** Lead Researcher, Developer and Collaborator | **Duration:** 01/2020-03/2024
- **Summary:** Used generative image priors for regularization in MRI reconstruction, focusing on 13C MRI, and developed libraries for training and inference of these models. The project encompassed the full workflow, including data preprocessing, model training, testing, model conversion, and optimization, with deployment on HPC clusters using data parallelism across multiple GPUs and nodes. Evaluated the framework on the HPC cluster with diverse k-space acquisition patterns and reconstruction methods, demonstrating significant improvements in image quality and robustness. Created command-line tools to streamline the deployment of deep learning models for MRI reconstruction within BART using TensorRT on GPUs, ensuring seamless integration and compatibility with existing MRI reconstruction workflows in BART.
- **Collaboration and Documentation:** Worked closely with cross-functional teams to integrate models and tools. Documented the development process, model performance metrics, and deployment procedures in detail.

4. Bayesian MRI Reconstruction with Joint Uncertainty Estimation Using Diffusion Models

- **Role:** Leard Researcher and Developer | **Duration:** 2021/01 - 2022/12
- **Summary:** Applied Bayesian inference framework to MRI reconstruction and achieved uncertainty estimation by sampling posterior probabilities using diffusion models. The prior learning is independent of data acquisition, which makes this approach more general to arbitrary forward operators and noisy observations. Then, the framework is broadly applicable and uncertainty-aware, enabling trustworthy reconstructions. Extensive evaluations were conducted for the framework, focusing on uncertainty interpretation, noise scales in diffusion models, efficient sampling via burn-in phase, and transferability of diffusion priors.

Publications

Journal Articles & Preprints

[1] **Guanxiong Luo**, Xiaoqing Wang, Mortiz Blumenthal, Martin Schilling, Erik Hans Ulrich Rauf, Raviteja Kotikalapudi, Niels Focke, Martin Uecker *Generative Priors for MRI Reconstruction Trained from Magnitude-Only Images Uisng Phase Augmentation*, Phil. Trans. R. Soc. A. 2025; (In theme issue on *Generative modelling meets Bayesian inference: a new paradigm for inverse problems*)

[2] Shoujin Huang, **Guanxiong Luo**, Yuwan Wang, Kexin Yang, Lingyan Zhang, Jingzhe Liu, Hua Guo, Min Wang, Mengye Lyu. *Robust Simultaneous Multislice MRI Reconstruction Using Deep Generative Priors*, arXiv:2407.21600, 2024.

[3] Zuojun Wang, **Guanxiong Luo**, Ye Li, Peng Cao. *Using a deep learning prior for accelerating hyperpolarized 13C MRSI on synthetic cancer datasets*. Magn Reson Med. 2024; 92(3): 945-955.

[4] **Guanxiong Luo**, Moritz Blumenthal, Martin Heide, Martin Uecker. *Bayesian MRI Reconstruction with Joint Uncertainty Estimation Using Diffusion Priors*. Magn Reson Med. 2023; 90: 295-311. (In collection of Machine Learning and AI in MRM, top-ten cited articles published in MRM in 2023, featured in the homepage of IBI at TU Graz)

[5] Moritz Blumenthal, **Guanxiong Luo**, Martin Schilling, H. Christian M. Holme, Martin Uecker. *Deep, deep learning with BART*. Magn Reson Med. 2023; 89: 678-693. (Top downloaded MRM article of 2022, featured in the homepage of IBI at TU Graz)

[6] **Guanxiong Luo**, Na Zhao, Wenhao Jiang, Edward S. Hui, Peng Cao. *MRI reconstruction using deep Bayesian estimation*. Magn Reson Med. 2020; 84: 2246-2261.

Conference Papers

[7] **Guanxiong Luo**, Shoujin Huang, Martin Uecker. *Autoregressive Image Diffusion: Generation of Image Sequence and Application in MRI*. Advances in Neural Information Processing Systems. Vol 38. Curran Associates, Inc.; 2024. (Accepted by NeurIPS 2024)

[8] Shoujin Huang, **Guanxiong Luo**[*], Xi Wang, Ziran Chen, Yuwan Wang, Huaishui Yang, Pheng-Ann Heng, Lingyan Zhang, Mengye Lyu. *Noise Level Adaptive Diffusion Model for Robust Reconstruction of Accelerated MRI*. MICCAI 2024: 498-508. (Equal contribution)

[9] **Guanxiong Luo**, Mengmeng Kuang, Peng Cao. *Generalized Deep Learning-based Proximal Gradient Descent for MR Reconstruction*. International Conference on Artificial Intelligence in Medicine. Springer Nature Switzerland; 2023: 239-244.

Conference Abstracts

[10] **Guanxiong Luo**, Moritz Blumenthal, Martin Heide, Martin Uecker *MRI Reconstruction Via Data-Driven Markov Chains With Joint Uncertainty Estimation*. Proceedings of the Annual Meeting of ISMRM. Vol 31. ISMRM; 2023: 0990. (Oral presentation)

[11] **Guanxiong Luo**, Martin Heide, Martin Uecker. *Using data-driven Markov chains for MRI reconstruction with Joint Uncertainty Estimation*. Proceedings of the Annual Meeting of ISMRM. Vol 30. ISMRM; 2022: 0298.

[12] **Guanxiong Luo**, Moritz Blumenthal, Xiaoqing Wang, Martin Uecker. *All you need are DICOM images*. Proceedings of the Annual Meeting of ISMRM. Vol 30. ISMRM; 2022: 1510.

[13] **Guanxiong Luo**, Xiaoqing Wang, Volkert Roeloffs, Zhengguo Tan, Martin Uecker. *Joint estimation of coil sensitivities and image content using a deep image prior*. Proceedings of the Annual Meeting of ISMRM. Virtual Conference. Vol 29. ISMRM; 2021: 0280. (Oral presentation)

[14] **Guanxiong Luo**, Moritz Blumenthal, Martin Uecker. *Using data-driven image priors for image reconstruction with BART*. Proceedings of the Annual Meeting of ISMRM. Virtual Conference. Vol 29. ISMRM; 2021: 1756. (Power Pitch)

[15] **Guanxiong Luo**, Cao Peng. *MRI Reconstruction Using Deep Bayesian Inference*. Proceedings of the Annual Meeting of ISMRM. Virtual Conference. Vol 28. ISMRM; 2020: 0996. (Oral presentation)