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

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Summary

I am a computational imaging scientist with a focus on MR imaging and also interested in all sorts of imaging modality, such as cameras, CT, and so on. After being formulated as an inverse problems, I usually approach them 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

Machine learning | Computational imaging | Bayesian inference | Generative modeling | Inverse problem | Computer vision | Image/Signal processing | MRI physics | Medical imaging | Numerical computation

Experiences

Employment

01/2020-present: 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 for large-scale data analysis for MR 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-based information using numerical optimization techniques and MR signal simulation.
2. Applied Bayesian estimation to MRI reconstruction from incomplete k-space using 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)

Skills & Open-Source Contribution

- **Programming:** Python, C/C++, Shell scripting, Linux | **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 tool for training generative MR image priors at https://github.com/mrirecon/spreco
  - Generative MRI image priors at https://huggingface.co/Guanxiong/MRI-Image-Priors
  - Inference with TensorRT at https://github.com/ggluo/TensorRT-Cpp-Example
  - Demo 1: TensorFlow + BART Reconstruction at https://github.com/mrirecon/bart-workshop/tree/master/ismrm2021 | Demo 2: Generative priors for MRI reconstruction at https://colab.research.google.com/github/ggluo/image-priors/blob/main/misc/demo_image_priors_colab.ipynb

Academic Activities

Talks

- **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 ICLR (2025), AISTATS (2025), NeurIPS(2024), IEEE TMI, IEEE TCI, Medical Physics, Artificial Intelligence in Medicine, ISMRM

Publications

Journal Articles & Preprints

[1] 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.

[2] **Guanxiong Luo**, Xiaoqing Wang, Mortiz Blumenthal, Martin Schilling, Erik Hans Ulrich Rauf, Raviteja Kotikalapudi, Niels Focke, Martin Uecker *Generative Image Priors for MRI Reconstruction Trained from Magnitude-Only Images*, arXiv:2308.02340, 2023.

[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.

[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)

[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 Proceedings

[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: xxxx-xxxx. (Accepted)

[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*. International Conference on Medical Image Computing and Computer Assisted Intervention. Springer Nature Switzerland; 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.

[10] **Guanxiong Luo**, Moritz Blumenthal, Martin Heide, Martin Uecker *MRI Reconstruction Via Data-Driven Markov Chains With Joint Uncertainty Estimation: Extended Analysis*. 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] Moritz Blumenthal, **Guanxiong Luo**, Martin Schilling, Markus Haltmeier, Martin Uecker. *NLINV-Net: Self-Supervised End-2-End Learning for Reconstructing Undersampled Radial Cardiac Real-Time Data*. Proceedings of the Annual Meeting of ISMRM. Vol 30. ISMRM; 2022: 0499.

[13] **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.

[14] **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)

[15] **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)

[16] **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)

Research Projects

1. Solving inverse problems by distilling diffusion models via expectation maximization

- **Role:** Lead Researcher and Developer | **Duration:** On-going
- **Description:** 3D reconstruction in computer vision and k-space interpolation in MRI are formulated as inverse problem, solved by maximizing the expectation over the pretrained probabilistic diffusion space.
- **Skills & Technologies:**
  - **Machine Learning:** Diffusion Models, Expectation Maximization, Generative Models
  - **Computer Vision:** 3D Reconstruction, Image Formation
  - **Medical Imaging:** MRI Reconstruction, k-space Interpolation

2. Autoregressive Image Diffusion for Sequentially Coherent MRI Reconstruction

- **Role**: Lead Researcher and Developer | **Duration:** 2024/01-2024/06
- **Description:** Developed a novel autoregressive image diffusion model to generate sequentially coherent images and applied it to MRI reconstruction.
- **Model Development:** Combined autoregressive and diffusion models to generate sequences of images, and maintained temporal coherence across sequences.
- **Performance:** 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
- **Description:** Used generative priors as regularization for MRI reconstruction, including 13C MRI, and developed deployment tools for these models using BART and TensorRT.
- **Application of PixelCNN:** Applied PixelCNN image priors to MRI reconstruction and improved image quality by using them as learned regularization. Extended the application to 13C MRI to validate its versatility in other modalities.
- **Tool Development for Model Deployment:**
  - Developed tools to facilitate the deployment of deep learning models with BART using TensorRT on GPU, reducing the inference time and enabling real-time applications. Ensured seamless integration and compatibility with existing MRI reconstruction workflows within BART.
  - Created a command-line interface to convert models implemented in TensorFlow, PyTorch, and JAX for deployment with BART using TensorRT.
- **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. Generative Priors for MRI Reconstruction Trained from Magnitude-Only Images

- **Role:** Lead Researcher and Developer | **Duration:** 2021/05 - 2023/11
- **Description:** Developed a workflow to construct and evaluate generative priors for MRI reconstruction from magnitude-only images and performed phase augmentation for enhanced training datasets.
- **Workflow Development:** Implemented a workflow to train robust generative priors using magnitude-only MR images after phase augmentation. The phase augmentation was achieved using a diffusion model, which was trained on a smaller dataset (~1000 images) of phase information. This model was then used to augment a larger dataset (~80k images). Finally, trained a phase-augmented prior on the large dataset on high-performance computing (HPC) systems using data parallelism across multiple GPUs and nodes.
- **Image Priors Evaluation:** Evaluated the trained priors across different k-space acquisition patterns and reconstruction methods. Worked with cross-functional teams to refine models and validate their clinical applications.
- **Performance:** Demonstrated huge improvements in image quality benefiting from phase-augmented priors, and higher robustness across various difference sequences and sampling patterns compared to traditional methods.

5. **Bayesian MRI Reconstruction with Joint Uncertainty Estimation Using Diffusion Models**
   - **Role:** Leard Researcher and Developer | **Duration:** 2021/01 - 2022/12
   - **Description:** Developed a Bayesian framework for MRI reconstruction with joint uncertainty estimation by sampling posterior probabilities using diffusion models, enable uncertainty-aware MRI reconstruction.
   - **Uncertainty Estimation:** Utilized diffusion models to draw samples from the posterior and computed minimum mean square error estimates and uncertainty maps. The uncertainty map is used to highlight regions of hallucinations for trustworthy reconstructions.
   - **Comprehensive Evaluation:** Conducted extensive evaluations of the framework, focusing on uncertainty interpretation, noise scales in diffusion models, efficient sampling via burn-in phase, and transferability of diffusion priors.

6. **Noise Level Adaptive Diffusion Model for Robust Reconstruction of Accelerated MRI**
   - **Role:** Co-supervisor/Researcher/Developer | **Duration:** 2024/01 - 2024/06
   - **Description:** Developed a Noise Level Adaptive Data Consistency (Nila-DC) for improving the robustness and quality of MRI reconstruction using diffusion models, especially under varying noise conditions.
   - **Algorithm Development:** Integrated the Nila-DC into the reverse process of diffusion models. Conducted extensive experiments on public and clinical MRI datasets to validate the effectiveness of the proposed method.
   - **Improved Quality and Robustness:** Achieved significant improvements in MRI reconstruction quality under various noise levels and outperformed state-of-the-art methods. Demonstrated the robustness of the Nila-DC method across different acceleration factors and noise conditions.