Guanxiong Luo, PhD in Computer Science

Computational imaging scientist | Scholar: Guanxiong Luo | luoguanxiong@outlook.com | +49 17634523929

Summary

I am a computational imaging scientist with a focus on MR imaging who is interested in all sorts of imaging modality, such as cameras, CT, and so on. After being formulated as an inverse problem, I usually approach these imaging problems from the statistical aspect to develop new algorithms for the improvement of image quality and the quantification of uncertainty.
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 | Bayesian inference | Computational imaging | Generative modeling | Inverse problem | Computer vision | Image/Signal processing | MRI physics | Personal Page @ ggluo.github.io

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 application.
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 incorporating physics information using numerical optimization technique and MR signal simulation.
2. Applied Bayesian estimation to MRI reconstruction from incomplete k-space through the exploiting of the prior knowledge learned by generative models.

Education

- **10/2020-11/2023**: PhD in Computer Science, University of Göttingen, Göttingen, Germany
- **09/2017-10/2019**: M.Phil in Biomedical Engineering, The University of Hong Kong, China
- **09/2013-07/2017**: B. Eng in Biomedical Engineering, Xi'an Jiaotong University, Xi'an, China

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)

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

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2. Autoregressive Image Diffusion for Sequentially Coherent MRI Reconstruction

- **Role**: Lead Researcher and Developer | **Duration:** 2024/01-2024/06
- **Description:** Developed and implemented a novel autoregressive image diffusion model to generate sequentially coherent images, significantly enhancing the trustworthiness of MRI reconstruction by reducing hallucinations.
- **Skills & Technologies:**
  - **Machine Learning:** Autoregressive Models, Diffusion Models

- **Medical Imaging:** MRI Reconstruction, k-space Data Processing, Inverse Problems
- **Programming Languages:** Python, PyTorch, Shell

- **Key Responsibilities:**
  - **Model Development:** Combined autoregressive and diffusion models to generate sequences of images, and maintained temporal coherence across sequences.
  - **Application in MRI Reconstruction:** Applied the autoregressive image diffusion model to accelerated MRI reconstruction and evaluated the model's performance on fastMRI dataset, demonstrating superior results compared to standard diffusion models, and significantly reducing hallucinations in reconstructed images.
- **Achievements:**
  - **Improved Reconstruction Quality:** Demonstrated significant improvements in MRI reconstruction quality by leveraging autoregressive image diffusion models.
  - **Reduced Artifacts:** Effectively reduced hallucinations and other artifacts in MRI reconstructions and ensured higher accuracy and reliability.
  - **Publications:** [NIPS 2024], "Autoregressive Image Diffusion: Generating Image Sequence and Application in MRI," G. Luo et al. (under review)
  - **Open-Source Contribution:** Contributed to the open-source community with project code available at https://github.com/mrirecon/aid

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3. Noise Level Adaptive Diffusion Model for Robust Reconstruction of Accelerated MRI

- **Role:** Co-supervisor/Researcher/Developer | **Duration:** 2024/01 - 2024/06
- **Description:** Developed and implemented 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.
- **Skills & Technologies:**
  - **Machine Learning:** Diffusion Models, Bayesian Inversion
  - **Medical Imaging:** MRI Reconstruction, Image Processing, Signal Processing, Inverse Problems
  - **Noise Handling:** Adaptive Data Consistency Techniques
  - **Programming Languages:** Python, PyTorch
- **Key Responsibilities:**
  - **Algorithm Integration:** Integrated the Nila-DC with diffusion models for robust MRI image reconstruction.
  - **Experimental Evaluation:** Conducted extensive experiments on public and clinical MRI datasets to validate the effectiveness of the proposed method.
- **Achievements:**
  - **Enhanced Reconstruction Quality:** Achieved significant improvements in MRI reconstruction quality under various noise levels and outperformed state-of-the-art methods.
  - **Robustness and Adaptability:** Demonstrated the robustness of the Nila-DC method across different acceleration factors and noise conditions.
  - **Publications and Presentations:** [MICCAI 2024], "Noise Level Adaptive Diffusion Model for Robust Reconstruction of Accelerated MRI", S. Huang, G. Luo et al. (equally contributed)
  - **Open-Source Contribution:** Contributed to the open-source community with project code available at https://github.com/Solor-pikachu/Nila

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4. Generative Image 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 image priors for MRI reconstruction from magnitude-only images and performed phase augmentation for enhanced training datasets.
- **Skills & Technologies:**
  - **Machine Learning:** Generative Models, Diffusion Models, PixelCNN
  - **Programming Languages:** Python, TensorFlow, C, Shell
  - **Medical Imaging:** MRI Reconstruction, Image Priors, Inverse Problems, Algorithm Evaluation
  - **High-Performance Computing:** Distributed Training, Data Parallelism
- **Key Responsibilities:**
  - **Workflow Development:** Designed and implemented a workflow to train robust generative image priors from magnitude-only MR images after phase augmentation.
  - **Phase Augmentation:** Utilized a diffusion model to augment a large dataset (~80k images) from a smaller set (~1000 images) with phase data to use existing databases.
  - **Evaluation:** Conducted comprehensive evaluations of the trained priors across different k-space acquisition patterns and reconstruction methods.
  - **Optimization:** Performed distributed training on high-performance computing (HPC) systems using data parallelism across multiple GPUs and processed approximately 80k MRI images.

- **Collaboration:** Worked with cross-functional teams to refine models and validate their clinical applications.

- **Achievements:**
  - **Improved Reconstruction Quality:** Demonstrated significant improvements in MRI reconstruction quality benefiting from phase-augmented generative image priors.
  - **Enhanced Robustness:** Showcased higher robustness of trained priors across various reconstruction scenarios and sampling patterns compared to traditional methods.
  - **Efficient Training:** Successfully performed distributed training on HPC clusters, leveraging computational resources and reducing training time.
  - **Publications and Presentations:** Published findings in prestigious journals and major conferences.
    - [Philos. Trans. R. Soc. A], "Generative Priors for MRI Reconstruction Trained from Magnitude-Only Images Using Phase Augmentation," G. Luo et al. (under review)
    - [ISMRM], Proc. Intl. Soc. Mag. Reson. Med., 30, 1510, "All you need are DICOM images," G. Luo et al.
    - [ISMRM], Proc. Intl. Soc. Mag. Reson. Med., 29, 0280, "Joint estimation of coil sensitivities and image content using a deep image prior," G. Luo et al. (oral session)
  - **Open-Source Contribution:** Contributed to the open-source community with project code available at https://github.com/mrirecon/image-priors

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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 using diffusion models, enhancing the efficiency and accuracy of MRI reconstructions from undersampled k-space data.
- **Skills & Technologies:**
  - **Machine Learning:** Bayesian Inference, Diffusion Models, Markov Chain Monte Carlo (MCMC)
  - **Programming Languages:** Python, TensorFlow, Shell
  - **Medical Imaging:** MRI Reconstruction, Image Priors, Inverse Problems, Algorithm Evaluation and Comparison
  - **High-Performance Computing:** Distributed Training, Data Parallelism
- **Key Responsibilities:**
  - **Framework Development:** Designed and implemented a Bayesian framework for sampling posterior probabilities in MRI reconstruction.
  - **Uncertainty Estimation:** Utilized diffusion models to draw samples from the posterior and computed minimum mean square error estimates and uncertainty maps.
  - **Comprehensive Evaluation:** Conducted extensive evaluations of the framework, focusing on uncertainty interpretation, noise scales in generative models, computational efficiency via burn-in phase, and transferability of learned priors.
- **Achievements:**
  - **Improved Reconstruction Accuracy:** Demonstrated significant improvements in MRI reconstruction accuracy through joint uncertainty estimation.
  - **Confidence Highlighting:** Provided detailed uncertainty maps of hallucinations for trustworthy reconstructions.
  - **Computational Efficiency:** Enhanced computational efficiency by using a burn-in phase in MCMC sampling.
  - **Publications and Presentations:** Published findings in prestigious journals and major conferences.
    - [MRM], "Bayesian MRI reconstruction with joint uncertainty estimation using diffusion models," G. Luo et al.
    - [ISMRM], Proc. Intl. Soc. Mag. Reson. Med., 31, 0990, "MRI Reconstruction Via Data-Driven Markov Chains With Joint Uncertainty Estimation: Extended Analysis," G. Luo et al. (oral session)
    - [ISMRM], Proc. Intl. Soc. Mag. Reson. Med., 30, 0298, "Using data-driven Markov chains for MRI reconstruction with joint uncertainty estimation," G. Luo et al. (power pitch)
  - **Open-Source Contribution:** Contributed to the open-source community with project code available at https://github.com/mrirecon/spreco

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6. Using PixelCNN Image Priors as Regularization for MRI Reconstruction

- **Role:** Researcher, Developer and Collaborator | **Duration:** 01/2020-03/2024
- **Description:** Using PixelCNN image priors as regularization for MRI reconstruction, including 13C MRI, and developed deployment tools for these models using BART and TensorRT.
- **Skills & Technologies:**
  - **Machine Learning:** PixelCNN, Generative Models
  - **Medical Imaging:** MRI Reconstruction, 13C MRI, Inverse Problems
  - **Programming Languages:** Python, C, C++, Shell
  - **Software Development:** BART (Berkeley Advanced Reconstruction Toolbox), TensorRT, TensorFlow, PyTorch
  - **High-Performance Computing:** Model Deployment, Inference Optimization
- **Key Responsibilities:**
  - **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, demonstrating its versatility and robustness in various MRI modalities.
  - **Tool Development for Model Deployment:**
    - Developed tools to facilitate the deployment of deep learning models using BART and TensorRT on GPU, ensuring the significant reductions in computation time and real-time reconstruction capabilities.
    - Created a command-line interface to convert models implemented in TensorFlow, PyTorch, and JAX for deployment with TensorRT as the backend.
  - **Integration with BART:**
    - Integrated PixelCNN models into the BART toolbox and enhanced its capabilities for MRI reconstruction tasks.
    - Ensured seamless integration and compatibility with existing MRI reconstruction workflows within 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 detailed.
- **Achievements:**
  - **Enhanced Reconstruction Quality:** Significantly improved MRI reconstruction quality by applying PixelCNN image priors for regularization, reducing artifacts and enhancing detail.
  - **Tool Development and Deployment:** Successfully developed and deployed tools for integrating deep learning models into BART and TensorRT, facilitating efficient model deployment and inference.
  - **Publications and Presentations:**
    - [MRM], "Using a Deep Learning Prior for Accelerating Hyperpolarized 13C Magnetic Resonance Spectroscopic Imaging on Synthetic Cancer Datasets," Z. Wang et al, G. Luo et al. (2024)
    - [MRM], "Deep, deep learning with BART," M. Blumenthal, G. Luo et al. (2023)
    - [MRM], "MRI reconstruction using deep Bayesian estimation," G. Luo et al. (2020)
    - [ISMRM], Proc. Intl. Soc. MRM, 28, 0996, "MRI Reconstruction Using Deep Bayesian Inference," G. Luo et al.
  - **Open-Source Contribution:** Contributed to the open-source community by enhancing the BART toolbox. Related codes and demos are listed below:
    - Demo 1: TensorFlow-Regularizer + BART Reconstruction at https://github.com/mrirecon/bart-workshop/tree/master/ismrm2021
    - Demo 2: Generative pretrained image priors for MRI reconstruction at https://colab.research.google.com/github/ggluo/image-priors/blob/main/misc/demo_image_priors_colab.ipynb
    - Image Priors at https://huggingface.co/Guanxiong/MRI-Image-Priors
    - Inference with TensorRT at https://github.com/ggluo/TensorRT-Cpp-Example
    - BART + TensorRT at https://github.com/ggluo/bart-trt

Academic Activities

Thesis

1. Development of Advanced Generative Priors for MRI Reconstruction, PhD thesis, 2023
2. The application of generative networks in MR image reconstruction, M.Phil thesis, 2019

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
- **09/2021**: About Bayesian Image Reconstruction with Learned Prior at Workshop on MRI Acquisition & Reconstruction, 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 NeurIPS(2024), IEEE TMI, IEEE TCI, Artificial Intelligence in Medicine, ISMRM

Other

Languages: Mandarin, English | **Hobbies**: Soccer, Tennis, Photography | **Citizenship**: Chinese