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BIOGRAPHY

I am a **fourth-year Ph.D. student from Computer Science** department at **Washington University in St. Louis**, advised by **Dr. Ulugbek Kamilov** and **Dr. Hongyu An**. My research focuses on algorithms designs and theoretical analysis for deep learning-based computational imaging. My research topics include diffusion models, self-supervised representation learning, image reconstruction, image registration, and correction of physical model uncertainty. My work has been shown to deliver real-world impact for various imaging applications, including computational photography, MRI, PET, and ptychography.

Research Interests: Computer Vision, Computational Imaging, Medical Imaging, Optimization.

EDUCATION

Washington University in St. Louis, St. Louis, MO, United States — 2020.08 - Expected 2024
Ph.D. Candidate in Computer Science
Advisor: Prof. Ulugbek Kamilov and Prof. Hongyu An

Washington University in St. Louis, St. Louis, MO, United States — 2018.08 - 2020.05
M.Sc. in Computer Science

South China University of Technology, Guangzhou, China — 2014.08 - 2018.05
B.Eng. in Automation & B.Business in Administration (dual-degree)

WORK EXPERIENCE

Siemens Healthineers, Knoxville, TN, United States — 2023.05 - 2023.08
Research Intern in the *Physics Group of Molecular Imaging*
Worked with *Dr. Jorge Cabello* and *Dr. Maurizio Conti* on a MRI-guided PET reconstruction algorithm based on deep generative models.

Los Alamos National Laboratory (LANL), Los Alamos, NM, United States — 2022.05 - 2022.10
Research Intern in the *Applied Mathematics and Plasma Physics Group (T-5)*
Worked with Dr. *Brendt Wohlberg* on *(a)* ptychographic image reconstruction algorithm for efficient and high-quality imaging, and *(b)* contributing on the codebase of Scientific Computational Imaging Code (SCICO).

AWARDS

- IEEE CAMSAP Student Paper Award finalist
- AAPM Imaging Best-in-Physics Awards
- Honor PhD (**top 15%**), Department of Computer Science, Washington University in St. Louis, 2021.
- 2019 Fall & 2020 Spring **Master's Fellowship** of Washington University in St. Louis.
- 2019 Fall & 2020 Spring **Engineering School Tuition Scholarship** of Washington University in St. Louis.
- 2015 & 2016 **Annual Third Prize Scholarship** of South China University of Technology.

RESEARCH SUMMARY

Learning without Groundtruth for Imaging Inverse Problems

- Propose DeCoLearn to train DL models exclusively on unregistered noisy measurements by jointly performing image reconstruction and image registration [b7][b10].
- Propose SelfDEQ to *provably* train deep equilibrium model for imaging without ground truth [b5].
- Propose various self-supervised algorithms for imaging that rely on data partition along temporal [b9], spatial [b11], and sampling dimensions [b22][b5][b1].

Joint Inference of Image and System Unknown

- Propose BC-PnP as a principal framework with theoretical guarantees for blind inverse problems that uses denoisers as priors for both images and system unknowns [b4].
- Propose a novel deep unfolding network for parallel MRI that simultaneously estimates images and coil sensitivity maps [b1][b8].

Deliver Real-World Impact in Medical and Scientific Imaging

- Develop an algorithm for diagnosis-quality free-breathing 4D MRI reconstruction [b9], licensed by Siemens Healthineers [d1] and facilitating down-streaming tasks of motion correction in PET/MRI [b16] and low-field MRI [b13] systems. Developed an algorithm for fast parallel MRI, achieved ×10 acceleration without sacrificing performance [b1].
- Develop DL methods for quantitative MRI to reconstruct parameter maps and reduce motion-artifact [a5][b17].
- Develop novel DL algorithms to achieve SOTA performance on: *(a) MR image registration* by using denoisers as priors and implicit neural networks [b3], *(b) ptychographic image reconstruction* by using vision transformer and deep unfolding networks [b2], and *(c) video temporal super-resolution* powered by implicit neural representation [b18].
- Propose to apply dimensionality reduction of system model in deep unfolding and deep equilibrium model to handle the high-dimensional data in imaging [b15][b21].

PUBLICATION

('' indicates equal contribution)*

Preprinted:

a1 **W. Gan**, H. Xie, C. von Gall, G. Platsch, M.T. Jurkiewicz, A. Andrade, U.C. Anazodo, U.S. Kamilov, H. An, J. Cabello. "Pseudo-MRI-Guided PET Image Reconstruction Method Based on a Diffusion Probabilistic Model." [arXiv:2403.18139].

a2 Z. Zou, J. Liu, S. Shoushtari, Y. Wang, **W. Gan**, U. S. Kamilov. "FLAIR: A Conditional Diffusion Framework with Applications to Face Video Restoration". [arXiv:2311.15445].

a3 **W. Gan***, H. Xie*, B. Zhou, X. Chen, Q. Liu, X. Guo, L. Guo, H. An, U. S. Kamilov, G. Wang, and C. Liu. "Dose-aware Diffusion Model for 3D Ultra Low-dose PET Imaging". [arXiv:2311.04248].

a4 **W. Gan***, C. Park*, Z. Zou, Y. Hu, Z. Sun, and U. S. Kamilov. "A Structured Pruning Algorithm for Model-based Deep Learning". [arXiv:2311.02003].

a5 X. Xu, **W. Gan**, S. V.V.N. Kothapalli, D. A. Yablonskiy, and U. S. Kamilov, "CoRRECT: A Deep Unfolding Framework for Motion-Corrected Quantitative R2* Mapping." [arXiv: 2210.06330].

Journal & Conference:

b1 **W. Gan***, Y. Hu*, C. Ying, T. Wang, C. Eldeniz, J. Liu, Y. Chen, H. An, and U. S. Kamilov, "SPICER: Self-Supervised Learning for MRI with Automatic Coil Sensitivity Estimation and Reconstruction", **Magn. Reson. Med. (MRM)**, 2024.

b2 **W. Gan**, Q. Zhai, M. T. McCann, C. G. Cardona, U. S. Kamilov, and B. Wohlberg. "PtychoDV: Vision Transformer-Based Deep Unrolling Network for Ptychographic Image Reconstruction". **IEEE Open J. Signal Process. (OJSP)**, 2024.

b3 **W. Gan***, J. Hu*, Z. Sun, H. An, and U. S. Kamilov. "A Plug-and-Play Image Registration Network". Proc. Int. Conf. Learn. Represent. (**ICLR**), 2024. [acceptance rate: 2250/7304=30.8%]

b4 **W. Gan**, S. Shoushtari, Y. Hu, J. Liu, H. An, and U. S. Kamilov, "Block Coordinate Plug-and-Play Methods for Blind Inverse Problems", Proc. Adv. Neural Inf. Process. Syst. **(NeurIPS)**, 2023. [acceptance rate: 3222/12343=26.1%]

b5 **W. Gan**, C. Ying, P. E. Boroojeni, T. Wang, C. Eldeniz, Y. Hu, J. Liu, Y. Chen, H. An, and U. S. Kamilov, "Self-Supervised Deep Equilibrium Models for Inverse Problems with Theoretical Guarantees and Applications to MRI Reconstruction", **IEEE Trans. Comput. Imag. (TCI)**, 2023.

b6 **W. Gan***, H. Gao*, Z. Sun, and U. S. Kamilov, "SINCO: A Novel structural regularizer for image compression using implicit neural representations", Proc. IEEE Int. Conf. Acoustics, Speech and Signal Process. (**ICASSP**), 2023.

b7 **W. Gan**, Y. Sun, C. Eldeniz, J. Liu, H. An, and U. S. Kamilov, "Deformation-Compensated Learning for Image Reconstruction without Ground Truth", **IEEE Trans. Med. Imag. (TMI)**, 2022. [impact factor=11.03]

b8 **W. Gan***, Y. Hu*, C. Eldeniz, J. Liu, Y. Chen, H. An, and U. S. Kamilov, "SS-JIRCS: Self-Supervised Joint Image Reconstruction and Coil Sensitivity Calibration in Parallel MRI without Ground Truth," Proc. IEEE Int. Conf. Comp. Vis. (**ICCV**) Workshops, 2021.

b9 **W. Gan***, C. Eldeniz*, S. Chen, T. J. Fraum, D. R. Ludwig, Y. Yan, J. Liu, T. Vahle, U. B. Krishnamurthy, U. S. Kamilov, H. An, "Phase2Phase: Respiratory Motion-Resolved Reconstruction of Free-Breathing MRI Using Deep Learning Without a Ground Truth for Improved Liver Imaging," **Investig. Radiol.**, 2021. [impact factor=10.06]

b10 **W. Gan**, Y. Sun, C. Eldeniz, H. An and U. S. Kamilov, "Deep Image Reconstruction using Unregistered Measurements without Groundtruth," Proc. Int. Symp. Biomedical Imaging 2021 (**ISBI**), 2021.

b11 **W. Gan**, C. Eldeniz, J. Liu, H. An, and U. S. Kamilov, "Image Reconstruction for MRI using Deep CNN Priors Trained without Ground Truth," Proc. 54th Asilomar Conf. Signals, Systems, & Computers (**Asilomar**), 2020.

b12 Y. Hu, S. V. V. N. Kothapalli, **W. Gan**, A. L. Sukstanskii, G. F. Wu, M. Goyal, D. A. Yablonskiy, U. S. Kamilov, "DiffGEPCI: 3D MRI Synthesis from mGRE Signals using 2.5D Diffusion Model," Proc. Int. Symp. Biomedical Imaging **(ISBI)**, 2024.

b13 S. Chen, C. Eldeniz, T. J. Fraum, D. R. Ludwig, **W. Gan**, J. Liu, U. S. Kamilov, D. Yang, H. Michael Gach, and H. An. "Respiratory motion management using a single rapid MRI scan for a 0.35 T MRI-Linac system.", **Medical physics**, 2023.

b14 C. Park, S. Shoustari, **W. Gan**, and U. S. Kamilov, "Convergence of Nonconvex PnP-ADMM With MMSE Denoisers," Proc. Int. Workshop on Computational Advances in Multi-Sensor Adaptive Process. (**CAMSAP**) 2023.

b15 J. Liu, X. Xu, **W. Gan**, S. Shoushtari, U. S. Kamilov, "Online Deep Equilibrium Learning for Regularization by Denoising", Proc. Adv. Neural Inf. Process. Syst. **(NeurIPS)**, 2022.

b16 S. Chen, T. J Fraum, C. Eldeniz, J. Mhlanga, **W. Gan**, T. Vahle, U. B Krishnamurthy, D. Faul, H M. Gach, M. M Binkley, U. S. Kamilov, R. Laforest, H. An, "MR-assisted PET respiratory motion correction using deep-learning based short-scan motion fields", **Magn. Reson. Med. (MRM)**, 2022.

b17 X. Xu, S. V. V. N. Kothapalli, J. Liu, S. Kahali, **W. Gan**, D. Yablonskiy, and U. S. Kamilov, "Learning-based Motion Artifact Removal Networks for Quantitative R2* Mapping," **Magn. Reson. Med. (MRM)**, 2022.

b18 W. Shangguan, Y. Sun, **W. Gan**, U. S. Kamilov, "Learning Cross-Video Neural Representations for High-Quality Frame Interpolation", Proc. European Conference on Computer Vision (**ECCV**), 2022.

b19 M. Xie, J. Liu, Y. Sun, **W. Gan**, B. Wohlberg, and U. S. Kamilov, "Joint Reconstruction and Calibration using Regularization by Denoising," Proc. IEEE Int. Conf. Comp. Vis. (**ICCV**) Workshops, 2021.

b20 J. Liu, Y. Sun, **W. Gan**, X. Xu, B. Wohlberg, and U. S. Kamilov, "Stochastic Deep Unfolding for Imaging Inverse Problems," Proc. IEEE Int. Conf. Acoustics, Speech and Signal Process. (**ICASSP**), 2021.

b21 J. Liu, Y. Sun, **W. Gan**, X. Xu, B. Wohlberg, and U. S. Kamilov, "SGD-Net: Efficient Model-Based Deep Learning with Theoretical Guarantees," **IEEE Trans. Comput. Imag. (TCI)**, 2021.

b22 J. Liu, Y. Sun, C. Eldeniz, **W. Gan**, H. An, and U. S. Kamilov, "RARE: Image Reconstruction using Deep Priors Learned without Ground Truth," **IEEE J. Sel. Top. Signal Process. (JSTSP)**, 2020.

Abstract:

c1 M. David, Y. Yuan, A. Bacon, A. Movva, S. Shah, B. Lang, **W. Gan**, I. Berke, U. S. Kamilov, S. Lake, "Machine Learning Approaches To Segment And Cluster Cells Of The Cartilage And Capsule In Rat Elbow Histology Sections." Osteoarthritis and Cartilage 31 (2023): S55-S56.

c2 S. Chen, C. Eldeniz, T. J. Fraum, D. Ludwig, **W. Gan**, U. S. Kamilov, D. Yang, and H. An, "Respiratory Motion Detection and Reconstruction Using CAPTURE and Deep Learning Phase2Phase Network for a 0.35 T MRI-LINAC System," Ann. Meeting American Association of Physicists in Medicine **(AAPM 2022)** (Washington, DC, 10-14 July), p. 66527, 2022. **[Best-in-Physics Award in Imaging]**

c3 S. Chen, **W. Gan**, C. Eldeniz, U. S. Kamilov, T. J Fraum, H. An, "DL-MOTIF: Deep Learning Based Motion Transformation Integrated Forward-Fourier Reconstruction for Free-Breathing Liver DCE-MRI", Proceedings of the 30th Annual Meeting of the **ISMRM**, pp. 3469, 2022.

c4 P. E. Boroojeni, P. Commean, C. Eldeniz, **W. Gan**, G. Skolnick, K. Patel, U. S. Kamilov, H. An, "Rapid high-resolution cranial bone MRI using deep-learning prior image reconstruction", Proceedings of the 30th Annual Meeting of the **ISMRM**, pp. 2440, 2022.

c5 S. Chen, C. Eldeniz, **W. Gan**, U. S. Kamilov, T. Fraum, H. An, "Forward-Fourier Motion-Corrected Reconstruction for Free-Breathing Liver DCE-MRI", Proceedings of the 29th Annual Meeting of the **ISMRM**, pp. 0128, 2021.

c6 S. Chen, C. Eldeniz, **W. Gan**, U. S. Kamilov, D. Yang, M. Gach, H. An, "Respiratory Motion Detection and Reconstruction Using CAPTURE and Deep Learning for a 0.35 T MRI-LINAC System: An Initial Study", Proceedings of the 29th Annual Meeting of the **ISMRM**, pp. 4254, 2021.

c7 J. Liu, C. Eldeniz, Y. Sun, **W. Gan**, S. Chen, H. An, U. S. Kamilov, "RED-N2N: Image reconstruction for MRI using deep CNN priors trained without ground truth", Proceedings of the 28th Annual Meeting of the **ISMRM**, pp. 0993, 2020.

c8 C. Eldeniz, **W. Gan**, S. Chen, J. Liu, U. S. Kamilov, H. An, "Phase2Phase: Reconstruction of free-breathing MRI into multiple respiratory phases using deep learning without a ground truth", Proceedings of the 28th Annual Meeting of the **ISMRM**, pp. 0807, 2020.

Patent:

d1 H. An, U. S. Kamilov, **W. Gan**, C. Eldeniz, and J. Liu, "Systems and Methods of Reconstructing Magnetic Resonance Images using Deep Learning," US Patent App. 17/079,177, 29 2021.

d2 U. S. Kamilov, H. An, Y. Hu, J. Liu, C. Eldeniz, **W. Gan**, and Y. Chen, "Self-supervised joint image reconstruction and coil sensitivity calibration in parallel mri without ground truth." US. Patent App. 17/968,541, 2023

d3 H. An, U. S. Kamilov, P. E. Boroojeni, **W. Gan**, J. Liu, and Y. Hu. "Self-supervised deep learning reconstruction with weighted training loss." U.S. Patent Application 18/483,258, filed April 25, 2024.

PRESENTATION & TALK

p1 "Learning under Inexact Data and Model for Computational Imaging", Grundfest Memorial Lecture Series in Graphics and Imaging, May 2024, Online.

p2 "SINCO: A Novel structural regularizer for image compression using implicit neural representations", Asilomar 2023, Pacific Grove, CA, USA.

p3 "Deep Learning Method for Accelerated Magnetic Resonance Imaging (MRI) without Groundtruth", WashU Imaging Sciences Pathway (ISP) Retreats 2021, Virtual.

p4 "Deep Image Reconstruction using Unregistered Measurements without Groundtruth", Proc. Int. Symp. Biomedical Imaging (ISBI), 2021, Virtual.

p5 "Image reconstruction for MRI using deep CNN priors trained without ground truth", Proc. 54th Asilomar Conf. Signals, Systems, & Computers (Asilomar), 2020, Virtual.

PROFESSIONAL SERVICES

Professional societies:

- IEEE Student Member and IEEE Signal Processing Society Student Member (2020 - present).
- The International Society for Magnetic Resonance in Medicine (ISMRM), Graduate Trainee (2020 - present).

Journal Reviewer:

- BMC **Medical Imaging**
- **Scientific Report**
- IEEE Transaction on Medical Imaging (**TMI**), Distinguished Reviewer 2022-2023
- IEEE Transaction on Computational Imaging (**TCI**)
- IEEE Transaction on Image Processing (**TIP**)
- IEEE Transactions on Circuits and Systems for Video Technology (**TCSVT**)

Conference Reviewer/PC:

- International Conference on Learning Representations (**ICLR 2024**)
- Conference on Neural Information Processing Systems **(NeurIPS 2023**), Top Reviewer 2023
- IEEE CVF Computer Vision and Pattern Recognition Conference (**CVPR 2023/2024**)
- European Conference on Computer Vision (**ECCV 2024**)
- Asian Conference on Computer Vision (**ACCV 2024**)
- IEEE CVF International Conference on Computer Vision (**ICCV 2023**)
- IEEE CVF International Conference on Computer Vision Workshop (**ICCVW 2021**)
- IEEE International Symposium on Biomedical Imaging (**ISBI 2021/2022/2023/2024**)
- IEEE International Conference on Acoustics, Speech and Signal Processing (**ICASSP 2022/2023/2024**)
- International Conference on Machine Learning (**ICML 2022**)
- IEEE International Conference on Image Processing (**ICIP 2022/2023/2024**)
- International Symposium on Computational Sensing (**ISCS 2023**)

MEDIA COVERAGE

m1 *"New deep learning method boosts MRI results without requiring new data."* by Beth Miller, Newsroom of the WashU Source, 7 September 2021, https://source.wustl.edu/2021/09/new-deep-learning-method-boosts-mri-results-without-requiring-new-data/.

m2 *"New deep learning method boosts MRI results without requiring new data"* by Beth Miller, Medical Press, 7 September 2021, https://medicalxpress.com/news/2021-09-deep-method-boosts-mri-results.html?src_id=alt

m3 *"A single MRI scan can manage respiratory motion"* by Tami Freeman, PhysicsWorld, 19 Jul 2022, https://physicsworld.com/a/a-single-mri-scan-can-manage-respiratory-motion/.

TEACHING SERVICE

As Course Teaching Assistant:

- ESE 415 Optimization, WashU. 2021 Spring & 2022 Spring & 2023 Spring
- ESE 513/CSE 534A Large-Scale Optimization for Data Science, WashU. 2021 Fall & 2022 Fall & 2023 Fall

STUDENT SUPERVISION

Co-advised with Prof. Ulugbek Kamilov:

- Harry, Gao (Undergrad student), achievement: [b6].
- Yuan, Yangpeng (Undergrad student, now at Duke), achievement: [c1].
- Hu, Yuyang (MS student, now Ph.D. at WashU), achievement: [b1].
- Ian, Hudson (MS student, now at Microsoft)
- Huang, Nan (MS student)
- Jing, Dian (MS student)
- Siu, Vincent (Undergrad student)
- Park, Chicago (Undergrad student), achievement: [a4].
- James, H. Tillman (Undergrad student)
- Hu, Junhao (MS student, now Ph.D. at WashU), achievement: [b3].