Dr. Isaac D. Gerg

December 2024

CONTACT INFORMATION

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Google Scholar | Research Gate | Github | Personal

CURRENT POSITION

Computer Vision Researcher, Kitware, Inc., Remote, USA 2023 - Present, TS/SCI

- Identified opportunity to expand ML/AI research portfolio by leading proposal writing efforts, resulting in secured DARPA and Navy SBIR awards totaling $2M+ within first 9 months of employment.
- Addressed team's need for structured development by implementing HPC best practices and developing core ML infrastructure, enabling 2-5 person teams to save 2,000+ development hours while improving model architectures for complex sensor data (MWIR, SAR, SAS, acoustics).
- Recognized gap in validation practices and introduced statistical testing protocols to differentiate true model improvements from random variations, leading to more robust evaluation methods and better-informed development decisions.
- Expanded research visibility by identifying key technical conferences and presenting findings, successfully disseminating results at NAML, DoD ATRWG, IGARSS, and Acoustical Society of America conferences.

PREVIOUS EXPERIENCE

Senior Scientist, Penn State Applied Research Lab, Hybrid, USA 2009-'23; TS/SCI, NATO

- Identified critical Navy ML capability gaps and proposed innovative solutions, securing continuous ONR funding for 10 years while establishing lasting international research collaborations.
- Recognized performance bottlenecks in undersea drone synthetic aperture sonar (SAS) imaging and developed ASASIN real-time sonar software using CUDA/C++, achieving 100x speed increase and 10x power reduction, earning lab's highest award. This code still in use today.
- Advanced underwater remote sensing field by pioneering novel non-image ML representations and computer vision algorithms for synthetic aperture sonar, resulting in state-of-the-art performance and multiple prestigious publications in TGRS, JOE, JSTARS.
- Demonstrated research excellence through 100% soft-money funding maintenance and successful IRAD awards, while simultaneously completing a PhD in 4 years - transforming rapid prototypes into funded programs and new laboratory capabilities.

Visiting Research Scientist, Centre for Maritime Research and Experimentation, Italy 2018, NATO S

- Identified opportunity for international collaboration through NATO sabbatical, securing a direct invitation to selective visiting scientist position in Italy, where development of novel Fourier domain analysis techniques achieved state-of-the-art ML results for synthetic aperture sonar imagery, earned highest performance review, and produced enduring source code and a publication.

Senior Software Engineer / Systems Engineer, Raytheon, PA, USA 2004-2009, TS/SCI

- Contributed to the large-scale distributed signal processing system (Top 50 in Top 500 supercomputers) through C++ DSP development and technical leadership of software & design reviews.
- Recognized potential of academic research (my MS thesis) for operational impact by transforming multiple thesis concepts into funded IRAD prototypes, resulting in successful technology transition including NGA CRADA and new company capabilities in hyperspectral processing, ML, and distributed optimization.
- Pioneered low-SWaP processing solutions by implementing early integration of software-defined radio with CUDA acceleration, establishing company's initial capabilities in efficient RF processing.

- Disseminated research and trade-study findings from several key projects by being selected to present at company-wide academic-style conferences to share methodologies & results with cross-functional teams.

Intern, Penn State Applied Research Laboratory, PA, USA 2004;

Intern, Naval Nuclear Laboratory, Pittsburgh, PA, USA 2002, 2003; DOE L

EDUCATION

Pennsylvania State University, University Park, PA

Ph.D., Electrical Engineering, December 2022

- Thesis Topic: *Domain Enriched Machine Learning for Synthetic Aperture Sonar*
- Advisor: Professor Vishal Monga, Information Processing & Algorithms Laboratory

M.S., Electrical Engineering, August 2008

- Thesis Topic: *Hyperspectral Image Unmixing*
- Advisor: Professor Timothy Kane, Remote Sensing and Space Systems

B.S., Schreyer Honors College, Computer Engineering, August 2004

- Thesis Topic: *Real-Time Gesture Recognition in Video*
- Advisor: Professor Richard Tutwiler

SELECTED TECHNICAL SKILLS

- **Algorithms & Mathematics:** Adaptive filtering, Classical machine learning, Deep learning theory, Design of experiments, Global optimization, Human preference studies, Linear algebra, Machine learning theory, Nonlinear least squares, PDEs, Physical modeling, Statistical testing
- **Machine Learning:** Adversarial example mitigation, Classification, Data compression, Detection, Domain transfer, Enhancement, Few-shot learning, Generative AI, Human perception modeling, LLMs, Open-set recognition, Out-of-distribution detection, Segmentation, Self-supervised learning
- **Phenomenologies:** Active sonar acoustics, Air acoustics, Communications (HF/VHF/UHF), EO, Hyperspectral, Microwave remote sensing, MWIR, NIR, Passive underwater acoustics, Radar, Tabular Data, Text, SWIR, Synthetic aperture radar/sonar, Video
- **Programming:** C++, CUDA, Ceres Solver, Cython, HPC (SLURM, PBS), Julia, MATLAB, NumPy/SciPy, Python, PyTorch, TensorFlow
- **Signal & Image Processing:** Acoustic/RF processing, Beamforming, Bioinformatics, Demodulation, Filter design, Geolocation, Image compression, Inertial Navigation Unit, K-space processing, Photogrammetry, SLAM, 3D reconstruction, Through the sensor navigation, Visual odometry, Wave propagation physics

AWARDS

- 2nd place student, poster competition. IEEE OCEANS. 2021.
- 3rd place, student paper competition (out of 239 submissions). IEEE International Geoscience and Remote Sensing Symposium (IGARSS). 2021.
- Penn State Applied Research Lab Engineering Award of Excellence for work on synthetic aperture sonar image reconstruction. 2016. (Out of 1000+ scientists and engineers)

RESEARCH LEADERSHIP - PI UNLESS OTHERWISE STATED

1. "MARINA: Maritime Acoustic Recognition and Identification with Novel Algorithms," DARPA. est. $1.5M. 2024-Present. (Collaboration with University of New Hampshire, USA).
2. "Marine Mined: Few-shot learning for undersea mine countermeasures (MCM).", Navy SBIR Phase 1, $140k. 2024-Present. (Collaboration with University of New Hampshire, USA).
3. "AI-based medical image segmentation for 3D patient-specific surgical planning," Penn State College of Medicine Artificial Intelligence and Biomedical Informatics (AIBI) Pilot Funding, $35k, 2023. (Collaboration with Penn State College of Medicine). (Note: Awarded, but not executed due to accepting a new position.)

4. "Enhancing Machine Learning using Synthetic Data Pipeline for Coherent Underwater Acoustic Images," Office of Naval Research, $350k, 2023-Present. (Collaboration with University of Bath, UK)
5. "Understanding the Fragility of Neural Network Representations for Mine Countermeasures (MCM)," Office of Naval Research, $350k, 2020-2023.
6. "Force Reconstruction by Simulation and Machine Learning," ARL Internal, $50k, 2022-2023
7. "Learned Frequency Domain Masks for Training-Size-Robust Sonar Automatic Target Recognition," Office of Naval Research, $389k, 2020-2022.
8. "Advanced Sonar Image Compression for UUV Teaming," ARL Internal, $50k, 2019-2020.
9. "Solving SAS ATR with Deep Neural Networks," ARL Internal, $50k, (Co-PI), 2014.
10. "Real-time Synthetic Aperture Sonar Processing," ARL Internal, $50k, Co-PI, 2013.
11. "Silent Synchronization," ARL Internal, $50k, Co-PI, 2013.
12. "OpenBTS – An Inexpensive Wireless Security Research Platform," ARL Internal, 2010.
13. "Unsupervised Hyperspectral Unmixing Using High Performance Computing, " Raytheon Internal (IDEA Program), $50k, 2008-2009.

Refereed Journal Publications

1. I. D. Gerg, D. A. Cook, and V. Monga, "Deep adaptive phase learning: Enhancing synthetic aperture sonar imagery through learned coherent autofocus," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, pp. 1–17, 2024. DOI: 10.1109/JSTARS.2024.3393139
2. T. Hoang, K. S. Dalton, I. D. Gerg, *et al.*, "Resonant scattering inspired deep networks for munition detection in 3d sonar imagery," *IEEE Transactions on Geoscience and Remote Sensing*, pp. 1–1, 2023. DOI: 10.1109/TGRS.2023.3324223
3. I. D. Gerg and V. Monga, "Deep multi-look sequence processing for synthetic aperture sonar image segmentation," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 61, pp. 1–15, 2023. DOI: 10.1109/TGRS.2023.3234229
4. Y.-C. Sun, I. D. Gerg, and V. Monga, "Iterative, deep synthetic aperture sonar image segmentation," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1–15, 2022. DOI: 10.1109/TGRS.2022.3162420
5. I. D. Gerg and V. Monga, "Structural prior driven regularized deep learning for sonar image classification," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1–16, 2022. DOI: 10.1109/TGRS.2020.3045649
6. D. C. Brown, I. D. Gerg, and T. E. Blanford, "Interpolation kernels for synthetic aperture sonar along-track motion estimation," *IEEE Journal of Oceanic Engineering*, vol. 45, no. 4, pp. 1497–1505, 2020. DOI: 10.1109/JOE.2019.2921510

Refereed Conference Publications

1. D. Melamed, C. Johnson, I. D. Gerg, *et al.*, "Uncovering bias in building damage assessment from satellite imagery," in *IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium*, 2024, pp. 8095–8099. DOI: 10.1109/IGARSS53475.2024.10642347
2. B. V. Bingol, I. D. Gerg, and V. Monga, "Progressive diffusion autofocus for synthetic aperture sonar imagery," in *IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium*, 2024, pp. 7244–7248. DOI: 10.1109/IGARSS53475.2024.10641695
3. I. D. Gerg and C. F. Cotner, "A perceptual metric prior on deep latent space improves out-of-distribution synthetic aperture sonar image classification," in *IGARSS 2023 - 2023 IEEE International Geoscience and Remote Sensing Symposium*, 2023, pp. 6576–6579. DOI: 10.1109/IGARSS52108.2023.10283358
4. I. D. Gerg and V. Monga, "Synthetic aperture sonar image segmentation using adaptive, learned beam steering," in *IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium*, 2022, pp. 983–986. DOI: 10.1109/IGARSS46834.2022.9883235
5. T. Hoang, K. S. Dalton, I. D. Gerg, *et al.*, "Domain enriched deep networks for munition detection in underwater 3d sonar imagery," in *IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium*, 2022, pp. 815–818. DOI: 10.1109/IGARSS46834.2022.9884793
6. I. D. Gerg and V. Monga, "Real-time, deep synthetic aperture sonar (sas) autofocus," in *2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS*, 2021, pp. 8684–8687. DOI: 10.1109/IGARSS47720.2021.9554141
7. I. D. Gerg, D. P. Williams, and V. Monga, "Data adaptive image enhancement and classification for synthetic aperture sonar," in *IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium*, 2020, pp. 2835–2838. DOI: 10.1109/IGARSS39084.2020.9324047
8. J. McKay, I. Gerg, and V. Monga, "Bridging the gap: Simultaneous fine tuning for data re-balancing," in *IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium*, 2018, pp. 7062–7065. DOI: 10.1109/IGARSS.2018.8518664

Conference Publications

1. I. D. Gerg and B. Cowen, "Exploring the impact of erroneous labels on synthetic aperture sonar classifier performance," in *Institute of Acoustics 5th International Conference for Synthetic Aperture Sonar and Radar*, 2023
2. I. D. Gerg and V. Monga, "Preliminary results on distribution shift performance of deep networks for synthetic aperture sonar classification," in *OCEANS 2022, Hampton Roads*, 2022, pp. 1–9. DOI: 10.1109/OCEANS47191.2022.9977362
3. I. D. Gerg and V. Monga, "A learnable image compression scheme for synthetic aperture sonar imagery," in *OCEANS 2021: San Diego – Porto*, 2021, pp. 1–7. DOI: 10.23919/OCEANS44145.2021.9705685
4. Y.-C. Sun, I. D. Gerg, and V. Monga, "Iterative, deep, and unsupervised synthetic aperture sonar image segmentation," in *OCEANS 2021: San Diego – Porto*, 2021, pp. 1–5. DOI: 10.23919/OCEANS44145.2021.9705927
5. I. D. Gerg, D. C. Brown, S. G. Wagner, *et al.*, "Gpu acceleration for synthetic aperture sonar image reconstruction," in *Global Oceans 2020: Singapore – U.S. Gulf Coast*, 2020, pp. 1–9. DOI: 10.1109/IEEECONF38699.2020.9389388
6. A. Reed, I. D. Gerg, J. D. McKay, *et al.*, "Coupling rendering and generative adversarial networks for artificial sas image generation," in *OCEANS 2019 MTS/IEEE SEATTLE*, 2019, pp. 1–10. DOI: 10.23919/OCEANS40490.2019.8962733

7. D. C. Brown, S. F. Johnson, I. D. Gerg, *et al.*, "Simulation and testing results for a sub-bottom imaging sonar," *Proceedings of Meetings on Acoustics*, vol. 36, no. 1, p. 070 001, Jun. 2019, ISSN: 1939-800X. DOI: 10.1121/2.0001012. eprint: https://pubs.aip.org/asa/poma/article-pdf/doi/10.1121/2.0001012/18160692/pma.v36.i1.070001_1.online.pdf. [Online]. Available: https://doi.org/10.1121/2.0001012

8. D. P. Williams, R. Hamon, and I. D. Gerg, "On the benefit of multiple representations with convolutional neural networks for improved target classification using sonar data," in *Underwater Acoustics Conference and Exhibition*, 2019

9. B. Reinhardt, I. D. Gerg, D. C. Brown, *et al.*, "Measuring human assessed complexity in synthetic aperture sonar imagery using the elo rating system," in *Institute of Acoustics 4th International Conference for Synthetic Aperture Sonar and Radar*, 2018

10. I. D. Gerg and D. P. Williams, "Additional representations for improving synthetic aperture sonar classification using convolutional neural networks.," in *Institute of Acoustics 4th International Conference for Synthetic Aperture Sonar and Radar*, 2018

11. J. McKay, I. Gerg, V. Monga, *et al.*, "What's mine is yours: Pretrained CNNs for limited training sonar ATR," in *OCEANS 2017 - Anchorage*, 2017, pp. 1–7

12. I. D. Gerg, "Multiband SAS imagery," in *Institute of Acoustics 3rd International Conference for Synthetic Aperture Sonar and Radar*, 2012

13. I. Gerg, "An evaluation of three endmember extraction algorithms: Atgp, ica-eea & vca," in *2010 2nd Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing*, 2010, pp. 1–4. DOI: 10.1109/WHISPERS.2010.5594830

Invited Talks

1. I. D. Gerg. Metamers in Deep Learning for Synthetic Aperture Sonar Image Classification and Their Significance in Understanding Deep Networks. At *Acoustical Society of America*, United States. November 2024.

2. I. D. Gerg. AI/ML Integration in the Synthetic Aperture Sonar (SAS) Processing Pipeline: A Comprehensive Approach. At *Naval Applications of Machine Learning (NAML)*, San Diego, CA, United States. March 2024.

3. I. D. Gerg. Demystifying AI in Healthcare: An Intro to Large Language Models. At *International Pediatric Endosurgery Group*, Virtual, United States. June 2023.

4. I. D. Gerg. Preliminary Results on Distribution Shift Performance of Deep Networks for Synthetic Aperture Sonar Classification. At *IEEE OCEANS Conference*, Virginia, United States. October 2022.

5. I. D. Gerg, et al. Coupling rendering and generative adversarial networks for artificial sonar image generation. At *Synthetic Data for Privacy, Security and Augmentation*. Center for Accountable, Responsible and Transparent AI. University of Bath. 2022.

6. I. D. Gerg and D. C. Brown. The Advanced Synthetic Aperture Sonar Imaging eNgine (ASASIN), a time-domain backprojection beamformer using graphics processing units. At *Acoustical Society of America*, Hawaii, United States. October 2016.

7. I. D. Gerg and D. C. Brown. Moving away from the phase center approximation in micron-avigation for synthetic aperture sonar. At *Acoustical Society of America*, October 2016. Hawaii, United States.

Other Publications

1. I. D. Gerg. An Overview and Example of the Buffer-Overflow Exploit. In: *IA Newsletter*. Department of Defense Information Assurance Technology Analysis Center (IATAC), Vol. 7, No.4, 2005.

Conference Talks Without Publication

1. I. D. Gerg, C. Sanford, and A. Hunter. Augmenting Machine Learning with Simulated Data for Robust Undersea Sensing with Synthetic Aperture Sonar (SAS). At *78th Aided/Automatic Target Recognition Working Group*, AvMC. Huntsville, AL. November 2024.
2. I. D. Gerg. Scott Kangas, and Adam Birenbaum. Black Box Adversarial Robustness Assessment for Synthetic Aperture Radar (SAR). At *Conference for Adversarial Machine Learning for Intelligence Agencies (CAMELIA)*, United States. Poster. November 2024.
3. I. D. Gerg. New and Open Source Technologies for Next Generation SIGINT Applications. At *Raytheon Information Systems & Computing Symposium*, Norwood, MA. April 2009.
4. I. D. Gerg. Speedy, Unsupervised Hyperspectral Exploitation. At *7th Raytheon Systems and Software Symposium*, Tucson, AZ. May 2008.
5. I. D. Gerg and S. Wagner. High-Speed Interconnect Trade Study for a Real-Time Signal Processing System. At *5th Raytheon Systems and Software Symposium*, Denver, CO. March 2006.
6. I. D. Gerg. Low Cost/Performance Distributed Architecture Evaluation for Use in a Real-Time Signal Processing System. At *Raytheon PSTN Mini-Expo*, Fort Wayne, ID. October 2005.

Personal Research

1. I. D. Gerg. Chronic Spontaneous Urticaria (CSU) Following COVID-19 Vaccine: Preliminary Observations and Self-Tracking Data. Link. 2021.
2. I. D. Gerg. Longitudinal Analysis of Microbiome Dynamics Using uBiome Sequencing Data. Link. 2019.

Software

Creator the Open Source MATLAB Hyperspectral Toolbox - spectral unmixing, target detection, signal processing, and visualization of HSI datacubes. 100+ stars and 40+ forks as of June 2024. (https://github.com/isaacgerg/matlabHyperspectralToolbox)

Service

Referee Service

- *IEEE Geoscience and Remote Sensing Letters (GRSL)*
- *IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*
- *IEEE International Conference on Acoustics, Speech, & Signal Processing (ICASSP)*
- *IEEE International Conference in Image Processing (ICIP)*
- *IEEE Journal of Oceanic Engineering (JoE)*
- *IEEE Sensors Journal*
- *IEEE Transactions on Geoscience and Remote Sensing (TGRS)*
- *Multidisciplinary Digital Publishing Institute (MDPI)*
- *National Science Foundation (NSF)*
- *Penn State College of Engineering / ARL Seed Proposals*
- *Penn State Schreyer Honors College Application Reviewer 2002.*

Session Chair

- *IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 2022*