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研究员, 博士生导师
国家“海外优青”
中科院“百人计划”, 江苏省“双创人才”, 苏州市“姑苏领军人才”
Professor, Ph.D. Supervisor

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Working Experience (工作经历)

2023.01–	Lab Director Assistant (主任助理), Academic Leader (学术带头人)
2022.04–	Professor (研究员), Ph.D Supervisor (博士生导师)
2021.01–2022.04	Associate Professor (副研究员, “百人计划”创新研究员), 硕士生导师 Aerospace Information Research Institute, CAS 中国科学院空天信息创新研究院 , Beijing 100190, China Suzhou Aerospace Information Research Institute 苏州空天信息研究院 , Suzhou, Jiangsu 215000, China 研究方向: 稀疏信号处理, 稀疏微波成像, 合成孔径雷达, 三维成像, 深度学习与信号处理的结合, 机器学习.
2023.10–	Double Employed Professor (双聘教授) University of Chinese Academy of Sciences 中国科学院大学 , Beijing 100190, China
2023.09–	Adjunct Professor (兼职教授) Qian Xuesen Honors College, Xi'an Jiaotong University 西安交通大学, 钱学森学院 , Xi'an, Shaanxi 710049, China
2016.12–2020.06	Post-Doctoral Research Fellow (博士后研究员) George Mason University , Fairfax, VA 22030, USA Advisor: Tian, Zhi (田智), Professor, IEEE Fellow 研究方向: 稀疏信号处理, 原子范数优化, 深度学习与信号处理的结合.
2015.12–2016.11	Post-Doctoral Research Scientist (博士后研究员) George Washington University , Washington, DC 20052, USA Advisor: Tian, Zhi (田智), Professor, IEEE Fellow Cheng, Xiuzhen (成秀珍), Professor, IEEE Fellow 研究方向: 稀疏信号处理, 原子范数优化.

Education (教育经历)

2009.09–2015.07	PH.D. (工学博士) / 信号与信息处理 Institute of Electronics, Chinese Academy of Sciences University of Chinese Academy of Sciences 中国科学院电子学研究所 / 中国科学院大学, Beijing 100190, China Supervisor: 吴一戎, 中国科学院院士, 研究员 研究方向: 稀疏微波成像, 稀疏信号处理, 合成孔径雷达.
2014.01–2014.04	VISITING STUDENT (访问学生) University of Connecticut, Storrs, CT 06269, USA Supervisor: Zhou, Shengli (周胜利), Professor, IEEE Fellow.
2004.09–2008.07 2003.09–2004.07	B. ENG. (工学学士) / 信息工程, 电子与信息工程学院 SPECIAL CLASS FOR GIFTED YOUNG (少年班) Xi'an Jiaotong University 西安交通大学, Xi'an, Shaanxi 710049, China.

Research Projects (研究经历)

2023.12–	多波束星载高分宽幅 SAR 系统技术, 2535 万元 资助: 国家重点研发计划, #2023YFB3904900 项目主持人 (首席科学家).
2023.1–	稀疏信号处理及其在微波成像中的应用研究, 300 万元 资助: 国家自然科学基金 (NSFC) 优秀青年科学基金 (海外) 项目主持人.
2021.1–2023.12	稀疏信号处理与深度学习及其在微波成像中的应用, 400 万元 资助: 中国科学院 “百人计划” 项目主持人.
2021.12–	微波三维成像的高效感知系统与技术的研发, 50 万元 资助: 苏州市科技发展项目, #ZXL2022381 项目主持人.
2023.1–	智能边端系统算力评估与协同部署研究, 200 万元 资助: KJW * * * * 协同创新中心课题 课题负责人.
2023.1–	* * * * * SAR 成像处理与信息提取, 200 万元 资助: 中国科学院 * * * * * 重点部署项目 课题负责人.
2021.7–	结构信号的自适应高效感知理论及在微波成像中的应用, 130 万元 资助: 中科院空天院前沿科学与颠覆性先导专项 项目主持人.

2023.1-	*****星载 SAR 系统技术, 8500 万元 资助: KJW ***** 创新特区重点项目 项目核心参与人, 处理系统负责人.
2023.1-	街角盲区建筑布局重建机理与方法, 500 万元 资助: KJW ***** 基础加强课题 子课题负责人.
2020.1-	合成孔径雷达微波视觉三维成像理论与应用基础研究, 2000 万元 资助: 国家自然科学基金 (NSFC) 重大项目, #61991421, 61991420 子课题负责人.
2018.8-2018.11	A Gated LFM CW TDMA MIMO SAR based Hidden Chamber Detector, 15 万美元 资助: USSOCOM SBIR, #S173-004-0118 信号处理及仿真负责人.
2015.12-2020.6	Task-Cognizant Sparse Sensing for Inference, 40 万美元 资助: National Science Foundation (NSF) Standard Grant, #1527396 参与.
2010.04-2015.07	稀疏微波成像的理论、体制和方法研究, 3300 万元 资助: 国家重大基础科学研究计划 (973 计划), #2010CB731900 机载部分负责人.
2012.04-2015.07	先进微波探测与信息处理, 430 万元 资助: 中国科学院 / 国家外国专家局 “创新团队” 合作伙伴计划 核心参与人.

Honors (荣誉)

2022.01	国家优秀青年基金 (海外) / 国家自然科学基金委员会 (NSFC)
2021.01	中国科学院 “百人计划” / 中国科学院
2021.12	苏州市 “姑苏领军人才” / 苏州市
2022.12	江苏省 “双创人才” / 江苏省
2022	中国科学院 “青年交叉团队” 成员 / 中国科学院

Awards (获奖)

2022.03	全国颠覆性技术创新大赛 / 中华人民共和国科技部 总决赛优秀奖
2021.12	优胜奖
2021.12	优秀奖

2008.04	德州仪器 (TI) DSP 大奖赛 / <i>Texas Instruments</i> 优胜奖
2008.02	美国大学生数学建模竞赛 / <i>COMAP</i> <i>Meritorious</i> (一等奖)
2007.02	<i>Honorable Mentioned</i> (二等奖)
2006.09	中国大学生数学建模竞赛 / 中国工业与应用数学学会 (<i>CSIAM</i>) 二等奖

Professional Skills (专业技能)

专业方向: 深度学习/AI, 机器学习与信号处理方法的结合, 稀疏信号处理与低秩优化, 合成孔径雷达.

专业技能: 大型在线社区开发、运营与维护, Linux 运维, GNU 工具链, \LaTeX .
MATLAB, C/C++/Python/JavaScript.

Languages (语言)

ENGLISH: Professional (Reside in US for 5 years, CET-6/PETS-5/WSK pass, TOEFL 96)

JAPANESE: Fair

Hobbies (兴趣)

IT, 开源, 编程, Linux, 数码, 互联网.

音乐, 动漫, 历史, 常旅客.

Open Source Projects and Services (主持开源项目)

2006.04–2015.11	兵马俑 BBS (http://bbs.xjtu.edu.cn/ , http://bmybbs.com/) Host: https://github.com/bmybbs?type=source <i>Technical Leader</i> 兵马俑 BBS 是中国教育网最大的 BBS 站点之一, 属于西安交通大学. 兵马俑 BBS 服务 50000 多名用户, 同时在线数最高 5000. 项目代码超过 10 万行.
2010.06–2019.04	科苑星空 BBS (http://bbs.ucas.ac.cn/ , http://kyxk.net/) <i>Technical Leader</i> 科苑星空 BBS 是中国科学院的官方社区. 科苑星空 BBS 服务 30000 多名用户, 同时在线数最高 1500. 项目代码超过 12 万行.
2018.09–	hCNN (https://github.com/pzhg/hCNN) <i>Principle Developer</i> hCNN 是一个开源的、深度学习与信号处理结合的开发框架, 可方便的进行深度学习开发与训练, 并与传统信号处理方法兼容.

Services (学术服务)

Professional Society Membership and Services (学术组织与服务)

2021.07–	Xi'an Jiaotong-Liverpool University (西交利物浦大学)
2021.11–	<i>External Mentor (校外导师)</i>
	<i>Pilotage Mentor (领航导师)</i>
2024.01–	IEEE
2016.01–2024.01	<i>Senior Member</i>
2010.01–2015.12	<i>Member</i>
	<i>Student Member</i>
2021.04–	CIE (中国电子学会)
	<i>Member (会员)</i>
2020.11–	JSAAI (江苏省人工智能学会)
	<i>Member (会员)</i>

Journal Reviewers (期刊审稿人)

- *IEEE Transactions on Signal Processing* Journal, SCI.
- *IEEE Signal Processing Letters* Journal, SCI.
- *Signal Processing* Journal, SCI.
- *National Science Open* Journal, SCI.
- *IEEE Transactions on Geoscience and Remote Sensing* Journal, SCI.
- *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* Journal, SCI.
- *IEEE Geoscience and Remote Sensing Letters* Journal, SCI.
- *IET Radar, Sonar & Navigation* Journal, SCI.
- *IET Electronics Letters* Journal, SCI.
- *IET Signal Processing* Journal, SCI.
- *Science China Information Science* Journal, SCI.
- *Cogent Engineering* Journal, SCI.
- 雷达学报 Journal, EI.

Organizing Committee Member and Technical Program Chair (学术会议组委会成员及学术主席)

- 2022 International Workshop on Microwave Vision and 3D SAR Imaging (MiViSAR 2022), Suzhou, China, Oct 17-19, 2022.

Session Chair (学术会议分会场主席)

- 2023 IET International Radar Conference, Chongqing, China, Dec 3-5, 2023.
- 2024 Photonics and Electromagnetics Research Symposium (PIERS), Chengdu, China, Apr 21-25, 2024.

TPC Member / Reviewer (学术会议学术委员会成员 / 审稿人)

2024	PIERS 2024, ICC 2024, CoSeRa 2024, EECSI 2024.
2023	EECSI 2023, iSemantic 2023, Globecom 2023, SIRS 2023, IJCDS 2023, IJEECS 2023, IET Radar 2023.
2022	EEET 2022, EECSI 2022, IJCDS, IJECE 2021-22, FSDM 2022.
2021	IJEECS 2021, BEEI 2020-21, ICITech 2021, FSDM 2021, TELKOMNIKA 2021.
2020	CITEI 2020, SIRS 2020, FSDM 2020.
2019	SIRS 2019, DISP 2019
2018	CoSeRa 2018, SIRS 2018, EECSI 2018, ICW-TELKOMNIKA 2018, FSDM 2018.
2017	ICITech 2017, EECSI 2017, SIRS 2017, FSDM 2017.
2016	CoSeRa 2016.
2015	CoSeRa 2015, ISSPIT 2015, ICSPDM 2015.

Publications (Bold for Corresponding / First Authorship)

JOURNAL ARTICLES

1. Z. Wang, Z. Wang, X. Qiu, and Z. Zhang*, "Fine Classification of Multi-Frequency PolSAR Images using an Adaptive Fusion Network," *Electron. Lett.*, *under review*.
2. P. Jiang, S. Gao, Z. Zhang*, and B. Zhang, "Gridless Direction-of-Arrival Estimation with Extended Array Aperture Using Gridless Atomic Norm Methods and Nested Array in Automotive Radar Applications," *Electron. Lett.*, *under review*.
3. S. Gao, W. Wang, M. Wang, Z. Zhang*, Z. Yang, X. Qiu, B. Zhang, and Y. Wu, "A Robust Super-resolution Gridless Imaging Framework for UAV-borne SAR Tomography," *IEEE Trans. Geosci. Remote Sens.*, *under review*.
4. S. Song, X. Qiu, S. Shangguan, Y. Luo, Z. Li, Z. Zhang, and H. Li, "A study on three-dimensional imaging methods for UAV-borne Fully Polarized Array InSAR datasets," *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.*, *under review*.

5. Z. Wang, Z. Wang, X. Qiu, and Z. Zhang*, "Global Polarimetric Synthetic Aperture Radar Image Segmentation with Data Augmentation and Hybrid Architecture Model," *Remote Sens.*, vol. 16, no. 2, p. 380, Jan. 2024, doi: 10.3390/rs16020380.
6. Y. Zhao, Q. Liu, H. Tian, B. W.-K. Ling, and Z. Zhang*, "DeepRED Based Sparse SAR Imaging," *Remote Sens.*, vol. 16, no. 2, p. 212, Jan. 2024, doi: 10.3390/rs16020212.
7. Y. Zhao, Q. Liu, H. Tian, M. Luo, B. W.-K. Ling, and Z. Zhang*, "New convex approaches to general MVDR robust adaptive beamforming problems," *Electron. Lett.*, vol. 59, no. 18, p. e12957, Sep. 2023, doi: 10.1049/ell2.12957.
8. Y. Bai, J. Kang, X. Ding, A. Zhang, Z. Zhang, and N. Yokoya, "LaMIE: Large-Dimensional Multipass InSAR Phase Estimation for Distributed Scatterers," *IEEE Trans. Geosci. Remote Sens.*, vol. 61, pp. 1–15, Nov. 2023, doi: 10.1109/TGRS.2023.3330971.
9. D. Zhao, Z. Zhang*, D. Lu, J. Kang, X. Qiu, and Y. Wu, "CVGG-Net: Ship Recognition for SAR Images Based on Complex-Valued Convolutional Neural Network," *IEEE Geosci. Remote Sens. Lett.*, vol. 20, pp. 1–5, 2023, doi: 10.1109/LGRS.2023.3316133.
10. M. Shao, Z. Zhang*, J. Li, J. Kang, and B. Zhang, "TADCG: A Novel Gridless Tomographic SAR Imaging Approach Based on the Alternate Descent Conditional Gradient Algorithm With Robustness and Efficiency," *IEEE Trans. Geosci. Remote Sens.*, vol. 62, pp. 1–13, 2024, doi: 10.1109/TGRS.2023.3345454.
11. Y. Wu, Z. Zhang*, X. Qiu, Y. Zhao and W. Yu, "MF-JMoDL-Net: A Deep Network for Azimuth Undersampling Pattern Design and Ambiguity Suppression for Sparse SAR Imaging", *IEEE Trans. Geosci. Remote Sens.*, *under review*.
12. G. Zhou, Z. Xu, Y. Fan, Z. Zhang, X. Qiu, B. Zhang, K. Fu* and Y. Wu, "HPHR-SAR-Net: Hyper-pixel High-resolution SAR Imaging Network Based on Nonlocal Total Variation," *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.*, vol. 16, pp. 8595–8608, 2023, doi: 10.1109/JSTARS.2023.3295728.
13. S. Gao, Z. Zhang*, M. Wang, Y. Zhang, J. Zhao, B. Zhang, Y. Wang and Y. Wu, "Gridless Single Snapshot Super-resolution DoA Estimation Method for Non-uniform Linear Arrays in Automotive Radars with Efficiency," *IEEE Trans. Vehicular Tech.*, *under review*.
14. M. Wang, Z. Zhang*, X. Qiu, S. Gao, and Y. Wang, "ATASI-Net: An Efficient Sparse Reconstruction Network for Tomographic SAR Imaging with Adaptive Threshold," *IEEE Trans. Geosci. Remote Sens.*, vol. 61, pp. 1–18, 2023, doi: 10.1109/TGRS.2023.3268132.
15. R. Shi, Z. Zhang*, X. Qiu, and C. Ding, "A Novel Gradient Descent Least-Squares (GDLs) Algorithm for Efficient Gridless Line Spectrum Estimation With Applications in Tomographic SAR Imaging," *IEEE Trans. Geosci. Remote Sens.*, vol. 61, pp. 1–13, 2023, doi: 10.1109/TGRS.2023.3273568.
16. J. Li, Z. Xu, Z. Li, Z. Zhang*, B. Zhang, and Y. Wu, "An Unsupervised CNN-Based Multichannel Interferometric Phase Denoising Method Applied to TomoSAR Imaging," *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.*, vol. 16, pp. 3784–3796, Jul. 2023, doi: 10.1109/JSTARS.2023.3263964.

17. Y. Zhao, Y. Chen, H. Tian, X. Quan, B. W.-K. Ling, and Z. Zhang*, "Wide angle SAR imaging method based on hybrid representation," *Electron. Lett.*, vol. 59, no. 15, p. e12897, Aug. 2023, doi: 10.1049/ell2.12897.
18. P. Jiang, Z. Zhang*, B. Zhang, and Z. Xu, "A novel TomoSAR imaging method with few observations based on nested array," *IET Radar, Sonar Navig.*, vol. 17, no. 6, pp. 925–938, Jun. 2023, doi: 10.1049/rsn2.12388.
19. J. Kang*, T. Ji, Z. Zhang, and R. Fernandez-Beltran, "SAR Time Series Despeckling via Nonlocal Matrix Decomposition in Logarithm Domain," *Signal Processing*, vol. 209, p. 109040, Aug. 2023, doi: 10.1016/j.sigpro.2023.109040.
20. J. Kang*, F. Tong, Y. Bai, T. Ji, and Z. Zhang*, "SAR Time Series Despeckling and Component Analysis Method based on Matrix Decomposition," *Journal of Radars*, vol. 12, no. 5, pp. 1031–1043, Mar. 2023, doi: 10.12000/JR22242, in Chinese.
21. X. Ding, J. Kang*, Z. Zhang, Y. Huang, J. Liu, and N. Yokoya, "Coherence-Guided Complex Convolutional Sparse Coding for Interferometric Phase Restoration," *IEEE Trans. Geosci. Remote Sens.*, vol. 60, pp. 1–14, 2022, doi: 10.1109/TGRS.2022.3228279.
22. Z. Zhu, J. Kang*, T. Ji, Z. Zhang, and R. Fernandez-Beltran, "SAR Time-Series Despeckling via Nonlocal Total Variation Regularized Robust PCA," *IEEE Geosci. Remote Sens. Lett.*, vol. 19, pp. 1–5, 2022, doi: 10.1109/LGRS.2022.3227187.
23. Y. Zhao, W. Huang, X. Quan, W.-K. Ling, and Z. Zhang*, "Data-driven sampling pattern design for sparse spotlight SAR imaging," *Electron. Lett.*, vol. 58, no. 24, pp. 920–923, Nov. 2022, doi: 10.1049/ELL2.12650.
24. Z. Xu, B. Zhang, Z. Zhang*, M. Wang, and Y. Wu, "Nonconvex-Nonlocal Total Variation Regularization Based Joint Feature-Enhanced Sparse SAR Imaging," *IEEE Geosci. Remote Sens. Lett.*, vol. 19, pp. 1–1, 2022, doi: 10.1109/lgrs.2022.3222185.
25. Z. Lyu, X. Qiu*, Z. Zhang and C. Ding, "Error Analysis of Polarimetric Interferometric SAR under Different Processing Modes In Urban Areas," *Journal of Radars*, 2022, doi: 10.12000/JR22059, in Chinese.
26. Z. Xu, G. Zhou, B. Zhang, Z. Zhang* and Y. Wu, "Sparse Regularization Method Combining SVA for Feature Enhancement of SAR Images," *Electronics Letters*, Jun. 2022, doi: 10.1049/ell2.12509.
27. Y. Zhao, J. Xu, X. Quan, L. Cui and Z. Zhang*, " L_1 Minimization with Perturbation for Off-grid Tomographic SAR Imaging," *Journal of Radars*, vol. 11, no. 1, pp. 52-61, 2022, in Chinese.
28. B. Du, X. Qiu*, Z. Zhang, B. Lei and C. Ding, "Tomographic SAR Imaging Method Based on Sparse and Low-rank Structures," *Journal of Radars*, vol. 11, no. 1, pp. 62-70, 2022, in Chinese.
29. Z. Zhang*, B. Zhang, C. Jiang, X. Liang, L. Chen, W. Hong and Y. Wu, "The First Airborne Experiment of Sparse Microwave Imaging: Prototype System Design and Result Analysis," Available: <http://arxiv.org/abs/2110.10675>.
30. Z. Zhang*, Y. Wang, and Z. Tian, "Efficient Two-Dimensional Line Spectrum Estimation Based on Decoupled Atomic Norm Minimization," *Signal Processing*, Vol. 163, pp. 95-106, 2019.

31. **Z. Zhang***, B. Zhang, W. Hong and Y. Wu, “Accelerated Error Compensation Algorithm of Sparse Microwave Imaging with Combination of Map-drift and SAR Raw Data Simulator,” *Journal of Radars*, vol. 5, no. 1, pp. 25-34, 2016, in Chinese.
32. B. Zhang, **Z. Zhang***, C. Jiang, Y. Zhao, W. Hong and Y. Wu, “System Design and First Airborne Experiment of Sparse Microwave Imaging Radar: Initial Results,” *Science China Information Sciences (Series F)*, vol. 58, no. 6, 2015.
33. C. Jiang*, Y. Zhao, **Z. Zhang**, B. Zhang, and W. Hong, “Azimuth Sampling Optimization Scheme for Sparse Microwave Imaging Based on Mutual Coherence Criterion,” *Journal of Electronics and Information Technology*, vol. 37, no. 3, 2015.
34. Y. Wu, W. Hong, B. Zhang*, C. Jiang, **Z. Zhang** and Y. Zhao, “Current Developments of Sparse Microwave Imaging,” *Journal of Radars*, vol.3, no. 4, pp. 383–395, 2014, in Chinese.
35. C. Jiang*, B. Zhang, J. Fang, **Z. Zhang**, W. Hong, Y. Wu and Z. Xu, “An efficient Lq regularization algorithm with range-azimuth decoupled for SAR imaging,” *Electronics Letters*, vol. 50, no. 3, pp. 204–205, 2014.
36. **Z. Zhang***, B. Zhang, C. Jiang, Y. Xiang, W. Hong, and Y. Wu, “Influence factors of sparse microwave imaging radar system performance: approaches to waveform design and platform motion analysis,” *Science China Information Sciences (Series F)*, vol. 55, no. 10, pp. 2301–2317, 2012.
37. C. Jiang*, B. Zhang, **Z. Zhang**, W. Hong, and Y. Wu, “Experimental results and analysis of sparse microwave imaging from spaceborne radar raw data,” *Science China Information Sciences (Series F)*, vol. 55, no. 8, pp. 1801–1815, 2012.
38. M. Xie*, R. Qiao, Z. Pan, D. Li, Y. Qiao and **Z. Zhang**, “Realization of an Improved Absolute Error Inequality Algorithm on DM642,” *Microelectronics & Computer*, vol. 27, no. 4, pp. 182-185, 2010, in Chinese.
39. T. Wang*, R. Qiao, Z. Pan, D. Li, Y. Qiao, F. Gao and **Z. Zhang**, “Research and Application of Vector Quantization Algorithm Based on DM642”, in *Proceedings of 2008 TI DSP Contest*, pp. 143–161, Publishing House of Electronics Industry, Beijing, 2008, in Chinese.

KEYNOTES / INVITED TALKS

1. **Z. Zhang***, “无网格稀疏信号处理及其在微波成像中的应用”, in *当稀疏信号处理技术遇见雷达研讨会*, Nanjing, 2021, *invited*.

INVITED PEER-REVIEWED CONFERENCE PAPERS

1. **Z. Zhang***, M. Jian, Z. Lu, H. Chen, S. James, C. Wang. and R. Gentile, “Embedded Micro Radar for Pedestrian Detection in Clutter”, in *IEEE International Radar Conference (RADAR 2020)*, 2020, *invited*.
2. **Z. Zhang***, B. Zhang, W. Hong, H. Bi and Y. Wu, “SAR Imaging of Moving Target in a Sparse Scene Based on Sparse Constraints: Preliminary Experimental Results,” in *2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2015)*, *invited*.

3. W. Hong, B. Zhang, Z. Zhang*, C. Jiang, Y. Zhao and Y. Wu, “Radar Imaging with Sparse Constraint: Principle and Initial Experiment,” in 10th European Conference on Synthetic Aperture Radar (EuSAR 2014), *invited*.

PEER-REVIEWED CONFERENCE PAPERS

1. M. Wang, S. Gao, Z. Zhang*, and X. Qiu, “A Novel Multi-Channel Phase Error Estimation Method Based On Stochastic Optimization For Tomographic SAR Autofocusing,” in IGARSS 2023 - 2023 IEEE International Geoscience and Remote Sensing Symposium, Jul. 2023, pp. 7953–7956. doi: 10.1109/IGARSS52108.2023.102829
2. T. Chen, Y. Meng, G. Zhou, Z. Zhang, B. Zhang, and Y. Wu, “An Improved Imaging Method for Highly-Squinted SAR Based on Hyper-Optimized ADMM,” in IGARSS 2023 - 2023 IEEE International Geoscience and Remote Sensing Symposium, Jul. 2023, pp. 4548–4551. doi: 10.1109/IGARSS52108.2023.10281842.
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