

Yanan Zhao

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Education Background

- Sep. 2018–July 2020 **M.E. in Information and Communication Engineering**, Communication Research Center, HIT, Harbin 150001, Heilongjiang, P. R. China.
GPA: 89.12/100.
Excellent Master Graduate of HIT
Excellent Master Thesis (top 3)
- Sep. 2014–June 2018 **B.E. in Communication Engineering**, Information Science and Engineering College, HIT, Weihai 264209, Shandong, P. R. China.
GPA: 92/100, **Ranking:** 1st/88 since the 4th semester.
Excellent Graduate of Shandong Province, P.R. China
Excellent Graduation Thesis (top 3)

Work Experience

- Sep.2020–Present **Research Assistant**, Information Processing & Algorithm Laboratory (IPAL), PSU, USA.
Sep.2018–June 2020 **Research Assistant**, Intelligence signal processing group, HIT.

Research Interests

- Machine learning theory and applications
- Signal and image computation
- Sparse signal representation

Publications and Patents

- [1] J. Shi, **Y. Zhao** (corresponding author), W. Xiang, V. Monga, X. Liu, and R. Tao, "Deep scattering network with fractional wavelet transform," *IEEE Transactions on Signal Processing*, vol. 69, pp. 4740-4757, 2021. (Supervisor is the first author. As the apprentice of Prof. Jun Shi, I made a main contribution to this paper.)
- [2] J. Shi, X. Liu, **Y. Zhao**, S. Shi, X. Sha, and Q. Zhang, "Filter design for constrained signal reconstruction in linear canonical transform domain," *IEEE Transactions on Signal Processing*, vol. 66, no. 24, pp. 6534-6548, 2018. *Paper Citations:* 22.
- [3] **Y. Zhao**, Y. Li, H. Zhang, V. Monga, and Y. C. Eldar, "Deep, convergent, unrolled non-blind image deconvolution," *IEEE Transactions on Computational Imaging*, Under Review.
- [4] J. Shi, G. Chen, **Y. Zhao**, R. Tao, Y. Wang, and W. Xiang, "Synchrosqueezing transform associated with fractional wavelet transform," *IEEE Transactions on Signal Processing*, Under Review.
- [5] **Y. Zhao**, F. Dai, and J. Shi, "A dredge traffic algorithm for maintaining network stability," *The 7th International Conference on Communications, Signal Processing, and Systems (CSPS)*, July, 2018, Dalian, China.
- [6] Q. Luo, X. Yan, **Y. Zhao**, et al. An uncertainty analysis method based on least-squares positioning (in Chinese). China Patent. Authorization No. CN107219499A.
- [7] X. Yan, Q. Luo, **Y. Zhao**, et al. A outlier-elimination method for range measurement based on nanoLOC (in Chinese). China Patent. Authorization No. CN106125070A.

Research Experience

Sep. 2020–Present **Algorithm Unrolling: Interpretable, Efficient Deep Learning for Signal and Image Processing**, *Overseas Research Project*, PI: Prof. Vishal Monga (The Pennsylvania State University, University Park, USA) collaborating with Applied Scientist Yuelong Li (Amazon Lab 126) and Prof. Yonina C. Eldar (*IEEE Fellow*, Weizmann Institute of Science, Israel).

Future development and practical deployment of deep neural networks is hindered by their blackbox nature, i.e., lack of interpretability, and by the need for large training sets. To eliminate these issues, deep unrolled networks are proposed by providing a concrete and systematic connection between iterative algorithms and deep neural networks. Deep unrolled networks have attracted enormous attention in computational imaging (image inverse problem: e.g., blind image deblurring), computer vision (e.g., image classification) and speech processing (e.g., speech enhancement and separation) by means of their efficient, high-performance and yet interpretable network architectures from reasonable size training sets. **My duties include:**

- Constructed a neural network for deconvolution problems (e.g., blind image deblurring) by algorithm unrolling, and analyzed mathematical convergence of deep unrolled networks;
- Simulation studies of convergent unrolled network in non-blind image deblurring.
- Writing a paper “Deep, convergent, unrolled non-blind image deconvolution” which has been submitted to *IEEE Transactions on Computational Imaging*.

Sep. 2018–Sep. 2020 **The Fractional Wavelet Transform Theory with Applications in Machine Learning and Signal Processing**, *Overseas Cooperative Research Project*, PI: Prof. Jun Shi and Co-PI: Prof. Wei Xiang (La Trobe University, Australia) and Prof. Vishal Monga (The Pennsylvania State University, University Park, USA).

A central task in machine learning is feature extraction and feature representation is required to be invariant, stable, and informative. To meet these basic requirements, Prof. Stéphane Mallat (*IEEE Fellow*) proposed deep scattering networks (DSNs) by cascading wavelet filters and modulus nonlinearities in each network layer. However, DSNs work well for stationary signals but not for non-stationary ones. To overcome this drawback, we propose fractional scattering convolution network (FrScatNet) by using fractional wavelet transform (FRWT).

My duties include:

- The mathematical theory of FrScatNet, including its definition and properties (e.g., adding-noise robustness, energy conservation, translation, rotation invariance and deformation stability in which FrScatNet may yield a smaller Lipschitz constant than that of its DSN counterpart indicating a better stability than the DSN);
- Application of FrScatNet in image classification and experiments show that it can obtain a smaller classification error compared with DSN especially when the training sample is small;
- Writing and revising the paper “Deep scattering network with fractional wavelet transform” which has been published on *IEEE Transactions on Signal Processing*;
- *Investigation of some potential applications of DSNs in SAR change detection.*

Sep. 2017–Sep. 2018 **Signal Sampling and Reconstruction Methods Associated With Linear Canonical Transform**, *National Natural Science Foundation Research Project*, PI: Prof. Jun Shi.

In order to solve the problems of the existing linear canonical transform (LCT)-based sampling theory, sampling and reconstruction mechanism of the LCT has been revealed from four aspects: signal structure, sampling strategy, reconstruction mechanism and noise influence. The sampling theory under noisy background is developed. Moreover, the theory of compressive sensing for analog signals based on the LCT is also proposed. **My duties include:**

- The mathematical modeling for analog signals of measurement and reconstruction associated with the LCT in the presence of noise.
- Partially writing and revising the paper “Filter design for constrained signal reconstruction in linear canonical transform domain”, which has been published on *IEEE Transactions on Signal Processing*.

Sep. 2016–Sep. 2018 **Rapid Generation and Reconstruction of Multiple-parameter Constrained Communication Network: Algorithm Design and Stability Analysis**, *National Natural Science Foundation Research Project*, PI: Prof. Fusheng Dai.

By the means of electromagnetic field transmission prediction, we studied wireless coverage calculation and network topology planning algorithm. C++ dynamic link library is set up for function call. Besides, network reconfiguration method is proposed to solve the network instability caused by node failure. **My duties include:**

- Employed disjoint multi-path routing algorithm to build network protocol model.
- Carried out stability analysis of the network topology by means of Lyapunov stability theory, and proposed a new routing algorithm for maintaining network stability and dredging traffic upon node failure.
- Attended *The 7th International Conference on Communications, Signal Processing, and Systems*, and the paper “A dredge traffic algorithm for maintaining network stability,” was included in *Communications, Signal Processing, and Systems*.

Scholarships and Awards

- Sep. 2019 **First-class Scholarship** for postgraduate academic performance of HIT.
- July 2018 **Special Scholarship** for outstanding postgraduate without entrance exams of HIT.
- Oct. 2017 **National Scholarship** of P.R China. (Top 1)
- Sep. 2017 **First Prize**, *National Undergraduate Electronics Design Contest, TI Cup Shandong Division*.
- July 2017 **Team Runner-up (as the team leader)**, *The 19th National Robot Championship and The 8th International Humanoid Robot Olympics*.
- July 2017 **National First and Second Prize**, *The 19th National Robot Championship and The 8th International Humanoid Robot Olympics*, humanoid gymnastics game and intelligent barrier-free navigation game respectively.
- Oct. 2016 **National Scholarship** of P.R China. (Top 1)
- Oct. 2016 **Provincial Second Prize**, *National Undergraduate Mathematical Contest in Modeling*.
- Oct. 2016 **Third Prize**, *National Undergraduate Electronics Design Contest, TI Cup Shandong Division*.
- Aug. 2016 **Excellent camper**, *FPGA Summer Training Camp in HIT*, Weihai.
- May 2016 **Second Prize Scholarship** of HIT, Weihai.
- Nov. 2015 **National First Prize**, *The 7th National College Student Mathematics Competition*.
- Oct. 2015 **Second Prize Scholarship** of HIT, Weihai.
- Oct. 2015 **Merit Social Work Scholarship** of HIT, Weihai.

Student Leadership

- Sept.2015–June 2016 **Headmaster Assistant**, *Class 1502401*.
- Sept.2014–June 2015 **League Branch Secretary**, *Class 1402403*.
- Sep.2016–Aug.2017 **Lab Manager**, *Robot Lab of School of Information Science and Engineering*, HIT, Weihai.

Skills

- Programming Skills: C/C++, Python, MATLAB, Verilog, LaTeX, MCU Hardware Programming
- Mathematical Skills: Matrix Analysis, Linear Algebra, Calculus, Convex Optimization
- Language Skills: Chinese (Proficient), English (Proficient : IETLS 7)
- Sport Skills: Swimming, Climbing, Badminton