Fan Yin

No. 301, Jinqiao Road, Shanghai
+86 18326076211 | yinfan@mail.ustc.edu.cn

EDUCATION

University of Science & Technology of China **Hefei, China**

School of Information Science and Technology

Doctor of Electronics Science and Technology **09/2016-06/2022**

Relevant Courses: Real variable Function and Function Analysis, Optimization Theory, Matrix Analysis and Its Applications, Digital Signal Processing (II), Advanced Electromagnetic Field Theory, Computational Electromagnetics, Microwave Network Theory and Its Applications, Advanced Antenna Technology, Microwave Systems and Engineering.

Anhui University **Hefei, China**

School of Electronic and Information Engineering

Bachelor of Electronic Information Engineering **09/2012-06/2016**

Relevant Courses: Advanced Mathematics A, Linear Algebra, Probability Theory and Mathematical Statistics, Mathematic and Physical Method, College Physics, Electromagnetic Field and Waves, Signal and Linear System, Digital Signal Processing, Digital Image Processing, Linear & nonlinear Electronic Circuit, Digital Circuits & Logic Design, Microwave Technology, Electronic Measurements, Microcomputer & Embedded System.

RESEARCH INTERESTS

Nonlinear Inverse Scattering

Inverse Problem

Super-resolution

Through Wall Imaging

PUBLICATIONS

Fan Yin, Chang Chen, Weidong Chen, et al. "Superresolution quantitative imaging based on superoscillatory field," **Optics Express**, vol. 28, no. 5, pp. 7707-7720, 2020.

Fan Yin, Chang Chen and Weidong Chen, "Resolution enhancement for mixed boundary conditions in inverse scattering problems," **IEEE Transactions on Antennas and Propagation**, vol. 70, no. 5, pp. 3643-3655, 2021.

Fan Yin, Chang Chen and Weidong Chen, "A value piking method for mixed boundary conditions in inverse scattering problems," **Progress in Electromagnetics Research Symposium**, 2022.

RESEARCH EXPERIENCE

Sep. 2019 – Sep. 2020

Study of super-resolution in nonlinear inverse scattering methods based on super-oscillation

This research is developed in three stages:

Stage 1: Studying the super-resolution effect of vortex waves, which was attributed to superoscillation effects in monochromatic waves. The results were summarized in the final research project report of the National Nature Science Foundation of China.

Stage 2: Proposing an incident field optimization method to improve the imaging resolution without changing the

imaging structure. The reconstructed result with proposed incident field is better than the results with vortex waves. The results were published on *Optics Express* with title "Superresolution quantitative imaging based on superoscillatory field".

Stage 3: Proposing an explanation of the super-resolution effect in nonlinear inverse scattering methods and corresponding resolution limit based on the theory of superoscillation. The results were summarized in the dissertation for doctor's degree with title "Research on Superresolution Methods of Electromagnetic Inverse Scattering Reconstruction".

Sep. 2020 – Sep. 2021

Quantitative reconstruction for mixed boundary scatterers

This research is developed in three stages:

Stage 1: Studying the spatial-spectrum of total fields in the two-cylinder scattering case and generalize it to multi-cylinder cases, which happened to be the T-matrix formulation of multiple scattering.

Stage 2: Proposing a scattering model combined of the T-matrix formulation and the volume equivalence formulation, where the scattering coefficients are linear to the contrast sources.

Stage 3: Proposing an inversion method for the combined scattering model, where the contrast of dielectrics and the T-matrix of conductors are updated alternately. The method avoids the contrast interfered by the large imaginary parts of the conductors and improves the accuracy of the reconstructed T-matrix.

These results were summarized and published on *IEEE Transactions on Antennas & Propagation* with title "Resolution enhancement for mixed boundary conditions in inverse scattering problems".

Sep.2021 – Jun.2022

Nonlinear inverse scattering based on material sparsity

This research is developed in two stages:

Stage 1: Introducing a value piking regularization into the combined scattering model to constrain the solution space, where the T-matrix value of conductors is piecewise homogeneous. The results were published on *Progress in Electromagnetics Research Symposium* with title "A value piking method for mixed boundary conditions in inverse scattering problems".

Stage 2: Proposing a nonlinear Bayesian method for the inverse scattering of dielectric objects, where the prior model takes into account the piecewise homogeneity of the contrast. The results were summarized in the dissertation for doctor's degree with title "Research on Superresolution Methods of Electromagnetic Inverse Scattering Reconstruction".

PROJECT EXPERIENCE

Feb 2016– Sep 2016

The National High Technology Research and Development Program of China (863 Program) —— Microwave Staring Correlated Imaging (MSCI) System

- **Project Description**: The project was a prototype of the SAR (Synthetic Aperture Radar) based on the MSCI technique. The key point of MSCI is to construct the temporal-spatial stochastic radiation field, which ensure the restricted isometry properties for observation matrices. Based on this, compressed sensing methods can be carried out for the sparse objects. Therefore, the imaging results of MSCI are greatly influenced by the computation accuracy of the computed TSSRF matrix, which depends on the precise prior knowledge of the radar systems. The research group has focused on the development of a balloon-borne microwave synthetic aperture correlation imaging system and the research of basic theoretical methods for imaging.

- **Individual Tasks**: I was responsible for the baseband module, which consists of a FPGA (EP3C16F256C6N/ ALTERA), a DDS chip (AD9914/ ADI) and a SDRAM (MT48LC32M8A2P-6A/ Micron). The baseband module outputs the signal of preset parameters under the control of system main control board. Frequency agility is achieved by directly controlling DDS parameters (frequency, amplitude, phase or different combinations between them), external control pins and parallel pins to achieve high-speed modulation. However, the time synchronization errors between each module always exist in practice, which deteriorates the imaging results.

Feb 2019– Sep. 2022

The National Nature Science Foundation of China (Face Item) —— Research on Super-resolution imaging mechanism and system based on multi-mode non-diffraction vortex wave

- **Project Description**: The project aims to study and validate the super-resolution principle of vortex EM waves imaging, which is based on the introduction of the super-oscillation theory. A multi-mode non-diffraction vortex EM wave antenna is designed for the imaging experiments, which trying to verify the super-resolution ability of vortex waves.
- **Individual Tasks**: I was responsible for the fund application, the research of super-resolution mechanism and the optimization of the imaging configuration, while Dr. Shan Jiang is responsible for the design of UCA antenna array.

  The resolution of vortex wave imaging depends on the module number, which is also known as Orbital Angular Momentum (OAM) or the topological charge. In most research conclusions, the super-resolution effect was attributed to the new degree of freedom offered by OAM in VWI.

  However, the vortex wave is a typical cylindrical wave function, of which the order corresponds to the OAM.

  Most of EM waves can be expanded by cylindrical wave functions with different order. In other words, there is no new degree of freedom offered by the vortex wave.

  Although most EM waves can be represented as linear combination of vortex waves, only few kinds of combination can achieve super-resolution effects. It can be explained ingeniously by superoscillation theory. Superoscillatory functions are band-limited functions with the counter-intuitive property that they locally oscillate faster than their highest Fourier frequency. They come at a cost: any superoscillatory function must necessarily have a portion of its energy outside the superoscillatory region. Most of them occur naturally, such as the diffraction from a (quasi) random nanohole array, the random fields and a higher-order radially-polarized Laguerre-Gaussian beam. In this projection, we demonstrated that a high-order cylindrical wave function is a kind of superoscillatory function. The superoscillatory part locates at center of each high order cylindrical wave, where the energy is far lower than the average power. With higher order, the low energy hole centered at the cylindrical wave covers larger area.

  Therefore, we proposed a super-resolution theory based on superoscillation. With superoscillatory incident waves, scattering field can keep high frequency information of the objects from the spatial filtering effects of the Green function by the convolution between the spectrum of objects and the local spectrum of total fields. The theory was written and published as *Fan Yin, Chang Chen and Weidong Chen et. al, "Superresolution quantitative imaging based on superoscillatory field," Opt. Express 28(5), 7707–7720 (2022)*.

Jul 2022– Dec. 2023

Beijing Xiaomi Mobile Software Co., Ltd —— Algorithm for RFIC in modem chip M1

- **Project Description**: The project aims to design and fabrication a 4G modem chip for smart watch. The chip is divided into a radio frequency part and a baseband part, which is also called RFIC and BBIC.
- **Individual Tasks**: I was responsible to the algorithm of I/Q imbalance calibration in RFIC, which includes the design, fixation, optimization and application in FPGA.

  Since the phase difference between in-phase/quadrature (IQ) mixers is never exactly 90 degrees. Neither is

the gain perfectly matched between the parallel sections of circuitry dealing with the I/Q signal paths. The I/Q imbalance of the direct conversion receiver results in the mirror frequency component inside the baseband. Different with BBIC, RFIC cannot detect the pilot and estimate the signal with data-aided. Therefore, the calibration applied in RFIC is called "blind".

As the reference signal is unavailable, a prior information has to be applied to recover the I/Q balanced signal. Fortunately, a principle called circularity or properness feature of complex communication waveforms can be utilized. Circularity is a property of the probability density function and 'properness' is a second order statistical property. A complex random variable is called circular if its rotation by any angle has the same probability distribution. It is called proper or second order circular if its pseudo covariance vanishes.

Base on properness, a widely linear estimator is designed for the blind compensation of I/Q imbalance, of which image rejection ratio can be improved 30dB. The auto correlation and the properness are tracked by alpha-beta filter and the filter coefficient is estimated by CBC-LMS method for the easy of calculation.

Dec 2023– Jun. 2023

Beijing Xiaomi Mobile Software Co., Ltd —— Algorithm for RFIC in modem chip M2

- **Project Description**: The project aims to design and fabrication a 5G modem chip for smart phone. The chip is also divided into a radio frequency part and a baseband part, which is also called RFIC and BBIC.
- **Individual Tasks**: I was responsible to the calibration algorithm of Rx channel in RFIC, which includes DC cancellation, receiver signal strength indication (RSSI), automatic gain control (AGC), Farrow, down sampling, post equalization, I/Q compensation, wideband equalization, mixer calibration, etc.

  All of these modules appear to compensate specific RF impairments. DC cancellation suppresses the local oscillator (LO) leakage. RSSI detects the level of input signal and AGC compensates path loss with the control of LNA. Farrow and down sampling modules are designed for adapting different ADC sample rates to the baseband rate. Post equalization and wideband equalization compensate the unflattens of low-pass filters in baseband and duplexers in RF band, respectively. I/Q compensation is applied for frequency-dependent I/Q imbalance. Mixer calibration suppresses the 2nd order intermodulation distortion of Gilbert mixers.

  However, the combination of these algorithms is equivalent to a signal estimator for specific Rx analog structure. The DC cancellation ensures the mean-zero error assumption. Then the blind I/Q compensation minimized pseudo covariance of the estimator, which results in an asymptotically unbiased estimator for the bias-variance tradeoff. To achieve unbiased estimation, equalization is applied to compensate the digital impairments caused by former modules. Therefore, these compensations can improve the signal error vector magnitude (EVM) from 25% to 1.8% under 30dB SNR. One of the methods was applied for the patent.

HONOR & SCHOLARSHIP

Dec 2013	Outstanding Student scholarship in Anhui University
Dec 2014	Outstanding Student scholarship in Anhui University
Dec 2014	First Prize of TI Cup Anhui Undergraduate Electronic Design Competition
Sep 2018	The First Academic scholarship in University of Science & Technology of China
Sep 2019	The Second Academic scholarship in University of Science & Technology of China
Sep 2020	The Second Academic scholarship in University of Science & Technology of China
Sep 2021	The First Academic scholarship in University of Science & Technology of China
Dec 2021	The “Zeng Hua” scholarship in University of Science & Technology of China

SKILLS

- Programming Language: MATLAB, C/C++, Python, Verilog.
- Hardware Development: PCB Design, ARM/FPGA Development.
- Computational Electromagnetics: Method of Moments, Multipole Method.