

# Fu Li

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## Personal Summary

My research interests include computational imaging, optimization, and inverse problems. My Ph.D. work mainly focuses on ultrasound computed tomography, medical image reconstruction. During my Ph.D., I developed a high performance distributed multi-GPUs framework to enable high-resolution acoustic imaging.

## Education

### University of Illinois Urbana-Champaign (UIUC)

06/2019-Present  
Urbana, IL

Ph.D. student in Bioengineering, Grainger College of Engineering  
Advisor: Dr. Mark A. Anastasio and Dr. Umberto Villa

### Washington University in St. Louis

08/2018-06/2019  
St. Louis, MO

Ph.D. student in Imaging Science Program, McKelvey School of Engineering  
(Transfer to UIUC at 2019 Summer)

### Sun Yat-sen University

09/2012-07/2016  
Guangzhou, China

B. S. in Information and Computing Science, School of Mathematics, GPA 3.7/4  
Advisor: Dr. Yao Lu

## Work Experience

### Perception Vision Medical Technologies

07/2016-06/2018

Imaging algorithm engineer

Guangzhou, China

- Medical image processing and clinical data analysis
- Developed software and deep learning algorithms for computer-aided diagnosis of Nasopharyngeal Carcinoma

## Research Experience

### Advanced High-resolution Reconstruction for 3-D Quantitative Ultrasound Computed Tomography. In progress

Computational Imaging Science Laboratory, UIUC (Dr. Mark A. Anastasio)

Collaborative project with Delphinus Medical Technology, Inc

**Goal:** To develop advanced image reconstruction methods for the accurate estimation of bio-parameters in breast tissues using transmission ultrasound

- Developed time-of-flight and bent-ray tomography methods based on Eikonal equation to estimate initial speed-of-sound model
- Utilized a full wave equation-based inversion method (refer as FWI) to estimate the high-resolution speed-of-sound and acoustic attenuation distribution in biological tissues using clinical patient data
- Modeling elevation-focused transducers of ring-array USCT to enable an accurate 3D wave simulation
- Developed a distributed multi-GPU implementation for multi-ring 3D FWI, which largely reduces the image reconstruction times. The developed 3D method largely improves image quality compared to 2D slice-by-slice FWI
- Developed a speed-of-sound corrected reflectivity tomography method. The results show reflection characteristics of each tissue and improved image quality comparing with the model assumed constant speed-of-sound

### Development of Learning-based Computationally Efficient Algorithms for Ultrasound Tomography. In progress

Computational Imaging Science Laboratory, UIUC (Dr. Mark A. Anastasio)

**Goal:** To develop fast reconstruction method that alleviate the computational burden of FWI

- Developed a supervised learning method for 2D-3D model mismatch compensation on waveform data using CNN-LSTM network, allowing for an accurate and fast 2D FWI reconstruction
- High-resolution speed-of-sound imaging using multi-modality inputs using image-to-image neural networks

### Anatomically Realistic 3-D Breast Phantom Modeling

02/2020-01/2021

Computational Imaging Science Laboratory, UIUC (Dr. Mark A. Anastasio)

**Goal:** To public 3D realistic numerical breast phantoms datasets allows for realistic virtual imaging trials of USCT and photoacoustic imaging

- Generated large amount of three-dimensional realistic breast phantoms by virtual imaging clinical trials from FDA, including four types of anatomically phantoms (dense, hetero, scattered, and fatty breasts) in various shapes
- Modeled the realistic acoustic properties distribution, designed truncated gaussian sampling function for acoustic properties assignment and modeled tissue texture by spatial autocorrelation acoustic impedance function
- Published open-source datasets of the generated 3D and 2D data and simulation code

*Perception Vision Medical Technologies*

*Collaborative project with Department of Radiation Oncology, Sun Yat-sen University Cancer Center and Philips Healthcare, China*

**Goal:** To define a radiotherapy treatment plan, radiotherapists need to determine clinical target areas manually. In this study, we developed a general automatic method to determine clinical targeted area in 3D. Our method simulates tumor growth by considering different growth rates and different anatomies, which are learned from massive clinical data

- Adopted the association rules learning method to capture region relations from clinical data
- Designed a novel Markov graph model to simulate the tumor growth process
- Validated our approach with an average dice score of 90% between computed results and manual results of senior radiotherapists
- Developed a user interface of a computer-aid-diagnosis system for clinical radiotherapy treatment planning using QT and VTK with Client-Server architecture
- Implemented a radiotherapy treatment plan predication software on Philips IntelliSpace Discovery system for commercial application

### **Publications**

**Fu Li**, Umberto Villa, Nebojsa Duric, and Mark A. Anastasio. "A forward model incorporating elevation-focused transducer properties for 3D full-waveform inversion in ultrasound computed tomography." *IEEE transactions on ultrasonics, ferroelectrics, and frequency control* 2023

Park, Seonyeong, Umberto Villa, **Fu Li**, Refik Mert Cam, Alexander A. Oraevsky, and Mark A. Anastasio. "Stochastic three-dimensional numerical phantoms to enable computational studies in quantitative optoacoustic computed tomography of breast cancer." *Journal of Biomedical Optics* 28, no. 6 2023

Gangwon Jeong, **Fu Li**, Umberto Villa, and Mark A. Anastasio, "Investigating the Use of Traveltime and Reflection Tomography for Deep Learning-Based Sound-Speed Estimation in Ultrasound Computed Tomography." *arXiv preprint arXiv:2311.10193* 2023

Lozenski, Luke, Hanchen Wang, **Fu Li**, Mark A. Anastasio, Brendt Wohlberg, Youzuo Lin, and Umberto Villa. "Learned Full Waveform Inversion Incorporating Task Information for Ultrasound Computed Tomography." *arXiv preprint arXiv:2308.16290* 2023

**Fu Li**, Umberto Villa, Nebojsa Duric, and Mark A. Anastasio. "3D full-waveform inversion in ultrasound computed tomography employing a ring-array." In *Medical Imaging 2023: Ultrasonic Imaging and Tomography*, vol. 12470, pp. 99-104-1. SPIE 2023

Gangwon Jeong, **Fu Li**, Umberto Villa, and Mark A. Anastasio. "A deep learning-based image reconstruction method for USCT that employs multimodality inputs." In *Medical Imaging 2023: Ultrasonic Imaging and Tomography*, vol. 12470, pp. 105-110. SPIE 2023

**Fu Li**, Umberto Villa, Seonyeong Park, and Mark A. Anastasio. "Three-dimensional stochastic numerical breast phantoms for enabling virtual imaging trials of ultrasound computed tomography". *IEEE transactions on ultrasonics, ferroelectrics, and frequency control* 69, 135 – 146 2022

**Fu Li**, Umberto Villa, Nebojsa Duric, and Mark A. Anastasio. "Investigation of an elevation-focused transducer model for three-dimensional full-waveform inversion in ultrasound computed tomography." In *Medical Imaging 2022: Ultrasonic Imaging and Tomography*, vol. 12038, pp. 206-214. SPIE 2022

Jason L. Granstedt, **Fu Li**, Umberto Villa, and Mark A. Anastasio. "Learned Hotelling observers for use with multi-modal data." In *Medical Imaging 2022: Image Perception, Observer Performance, and Technology Assessment*, vol. 12035, pp. 262-268. SPIE 2022

**Fu Li**, Umberto Villa, Seonyeong Park, Shenghua He, and Mark A. Anastasio. "A framework for ultrasound computed tomography virtual imaging trials that employs anatomically realistic numerical breast phantoms." In *Medical Imaging 2021: Ultrasonic Imaging and Tomography*, vol. 11602, p. 116020V. SPIE 2021

### **Conference Presentations & Invited Seminars**

"Advanced image reconstruction for accurate and high-resolution breast ultrasound tomography." Seminar, Bioengineering Distinguished Seminar Series, University of Illinois Urbana-Champaign, Urbana, 2023

"Three-dimensional time-domain full-waveform inversion for ring-array-based ultrasound computed tomography." 184<sup>th</sup> Acoustic society meeting, Chicago, 2023.

"Automatic Gross Tumor Volume Delineation for Nasopharyngeal Carcinoma Radiotherapy on Multi-modal MRI: A Deep Learning Model Trained from 1000 Patient Dataset". Annual Meeting of the Radiological Society of North America (RSNA), Oral Presentation, Chicago, 2018.

"Prediction of Clinical Target Volume for Nasopharyngeal Carcinoma Using Hidden Markov Model Trained from 2000 Patient Dataset". Annual Meeting of the Radiological Society of North America (RSNA), Oral Presentation, Chicago, 2017.

### **Patents**

Yao Lu, Ying Sun, Sha Yu, Jiao Tian, Li Lin, **Fu Li**. *An association rule based Clinical Target Volume automatically delineation algorithm for Nasopharyngeal Carcinoma*. Chinese Patent, Disclosure, 2017. (CN106875367A)

### **Awards**

#### **Honors:**

- Honorable Mention in the Mathematical Contest in Modeling for undergraduate student **2015**
- Scholarship for Outstanding Students in Sun Yat-sen University **2013, 2014, 2015**
- Conference Presentation Award for Graduate Students, UIUC **2021, 2022, 2023**

#### **Computational Resources Awards:**

- Distributed GPU-accelerated image reconstruction methods for breast ultrasound computed tomography, Illinois Delta research allocation, 25,000 GPU-hours **2022**
- A computational framework integrating wave physics simulation and machine learning for fast and accurate transcranial photoacoustic tomography reconstruction, Illinois Blue Waters research allocation, 210,000 node-hours **2021**

### **Skills**

General: Numerical optimization, Image processing, Image reconstruction, Wave simulation, Full waveform inversion, Deep learning

Programming language and libraries: C/C++, Python, MATLAB, CUDA, MPI, Tensorflow, Pytorch