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 GPUs framework to enable high-resolution acoustic imaging.

Education

University of Illinois Urbana-Champaign (UIUC) **06/2019-Present**
Ph.D. student in Bioengineering, Grainger College of Engineering Urbana, IL
Advisor: Dr. Mark A. Anastasio and Dr. Umberto Villa

Washington University in St. Louis **08/2018-06/2019**
Ph.D. student in Imaging Science Program, McKelvey School of Engineering St. Louis, MO
(Transfer to UIUC at 2019 Summer)

Sun Yat-sen University **09/2012-07/2016**
B. S. in Information and Computing Science, School of Mathematics, GPA 3.7/4 Guangzhou, China
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-fight 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
- Developed computationally efficient, high-resolution speed-of-sound imaging using multi-modality inputs and 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

Automated Clinical Target Volume Delineation Model for Nasopharyngeal Carcinoma **10/2016-12/2017**
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

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*." IEEE transactions on computational imaging 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, "*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

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*." 184th 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