Tianyuan Workshop on Mathematical and Computational Challenges of Medical Imaging and Inverse Problems

August 13 – 16, 2018

Organized by

Fudan University

Shanghai University of Finance and Economics (SUFE)

School of Mathematics, SUFE
No.777 Guoding Road, Yangpu District, Shanghai, China

Introduction

The aim of this workshop is to provide a forum for mathematicians and engineers who are working in the areas of medical imaging and related inverse problems to share their recent research progress and develop further collaborations in this field.

Topics of the workshop will include

1. New engineering technology in medical imaging such as Photo-Acoustic, Optical Tomography, CT, MRI and Ultrasound;
2. Mathematical and numerical modelling of medical imaging;
3. Theoretical and numerical inversion of medical imaging.

Scientific Committee

Jin Cheng

Fudan University, Shanghai University of Finance and Economics, China

Jianliang Qian

Michigan States University, USA

Invited Speakers

Mark Anastasio

Washington University in Saint Louis, USA

Gang Bao

Zhejiang University, China

Chong Chen

Chinese Academy of Sciences, China

Yoko Hoshi

Hamamatsu University School of Medicine, Japan

Junxiong Jia

Xi'an Jiaotong University, China

Sergey Kabanikhin

Russian Academy of Sciences, Russia

Shingyu Leung

The Hong Kong University of Science and Technology, Hongkong, China

Wenbin Li

Harbin Institute of Technology, Shenzhen, China

Jijun Liu

Southeast University, China

Manabu Machida

Hamamatsu University School of Medicine, Japan

Goro Nishimura

Hokkaido University, Japan

Xiaochuan Pan

University of Chicago, USA

Chunqi Qian

Michigan State University, USA

Eric Todd Quinto

Tufts University, USA

Kui Ren

University of Texas at Austin, USA

Ge Wang

Rensselaer Polytechnic Institute, USA

Haibing Wang

Southeast University, China

Masahiro Yamamoto

The University of Tokyo, Japan

Yang Yang

Michigan State University, USA

Xiaotong Zhang

Zhejiang University, China

Hongkai Zhao

University of California at Irvine, USA

Hotel Information

Howard Johnson Caida Plaza Shanghai

No.188 Wudong Road, Yangpu District, Shanghai, China

Conference Information

Conference Hall

1st Floor, Administrative Building, SUFE

Sponsors

Tianyuan Fund for Mathematics, National Natural Science Foundation of China

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Key Laboratory of Modern Applied Mathematics in Shanghai, China

Program at a glance

	Aug. 12 (SUN)	Aug. 13 (MON)	Aug. 14 (TUE)	Aug. 15 (WED)	Aug. 16 (THU)
08:30 – 09:00		Opening Ceremony			
09:00 – 09:45		Gang Bao	Mark Anastasio	Hongkai Zhao	Chunqi Qian
09:45 – 10:30		Eric Todd Quinto	Ge Wang	Sergey Kabanikhin	Jijun Liu
10:30 – 11:00		Coffee Break			
11:00 – 11:45		Kui Ren	Yoko Hoshi	Shingyu Leung	Yu Jiang
11:45 – 13:30		Lunch			Closing Ceremony Lunch
13:30 – 14:15		Xiaochuan Pan	Goro Nishimura	Wenbin Li	
14:15 – 15:00		Yang Yang	Masahiro Yamamoto	Xiaotong Zhang	
15:00 – 15:30	Registration	Coffee Break			
15:30 – 16:15		Chong Chen	Manabu Machida	Symposium	
16:15 – 17:00		Junxiong Jia	Haibing Wang		
17:00 – 19:00		Dinner	Banquet	Dinner	

Registration

August 12 (Sunday)

15:00 – 19:00 **Room 723**, Red Tile Building, SUFE

August 13 (Monday)

08:00 – 08:30 **Lobby** of Administrative Building, SUFE

Program

August 13, 2018
Monday

08:30 – 09:00	**Opening Ceremony**
Chair	Prof. Jin Cheng
	Welcoming Remarks
	Group Photo

09:00 – 11:45	**Plenary Talk**
Chair	Prof. Jin Cheng
09:00	Gang Bao
Title:	TBA
09:45	Eric Todd Quinto
Title:	Artifacts in Tomography
10:30	**Coffee Break**
11:00	Kui Ren
Title:	Quantitative Photoacoustics with Additional Optical Measurements
11:45 – 13:30	**Lunch**

August 13, 2018
Monday

13:30 – 16:15 **Plenary Talk**

Chair Prof. Eric Todd Quinto

13:30 Xiaochuan Pan

Title: Investigation of Non-Linear Problems in X-ray CT

14:15 Yang Yang

Title: Some Mathematical Theory of Ultrasound-aided Optical Tomography

15:00 **Coffee Break**

15:30 Chong Chen

Title: Large Diffeomorphic Deformation Based Image Reconstruction Method for Spatiotemporal Medical Imaging

16:15 Junxiong Jia

Title: Recursive Linearization Method for Inverse Medium Scattering Problems with Complex Mixture Gaussian Error Learning

17:00 – 19:00 **Dinner**

August 14, 2018
Tuesday

09:00 – 11:45 **Plenary Talk**

Chair Prof. Xiaochuan Pan

09:00 Mark Anastasio

Title: Photoacoustic Computed Tomography in Heterogeneous Acoustic Media: Status and Open Challenges

09:45 Ge Wang

Title: Machine Learning for Biomedical Imaging

10:30 **Coffee Break**

11:00 Yoko Hoshi

Title: Toward Next Generation Diffuse Optical Tomography: the Issue of Internal Refractive Index Variations

11:45 – 13:30 **Lunch**

August 14, 2018
Tuesday

13:30 – 16:15 **Plenary Talk**

Chair Prof. Mark Anastasio

13:30 Goro Nishimura

Title: Time-Domain Optical Tomography For Fluorescence Objects

14:15 Masahiro Yamamoto

Title: Stability and Uniqueness for Inverse Problems for Transport Equations

15:00 **Coffee Break**

15:30 Manabu Machida

Title: Spatial-Frequency Optical Tomography in the Radiative-Transport Regime

16:15 Haibing Wang

Title: Reconstruction of Unknown Inclusions Based on the Diffusion Model

17:00 – 19:00 **Banquet**

August 15, 2018
Wednesday

09:00 – 11:45 Plenary Talk

Chair Prof. Ge Wang

09:00 Hongkai Zhao

Title: A Hybrid Adaptive Phase Space Method for Reflection Traveltime Tomography

09:45 Sergey Kabanikhin

Title: Inverse Problems of Thermo-acoustics

10:30 Coffee Break

11:00 Shingyu Leung

Title: Some Numerical Methods for Inverse Problems from Traveltime Tomography and Gravimetry

11:45 – 13:30 Lunch

August 15, 2018
Wednesday

13:30 – 14:15 Plenary Talk

Chair Prof. Sergey Kabanikhin

13:30 Wenbin Li

Title: A Level-set Adjoint-state Method for Crosswell Transmission-reflection Traveltime Tomography

14:15 Xiaotong Zhang

Title: Computational Electromagnetic Problems in 7T MRI

15:00 Coffee Break

15:30 – 17:00 Symposium

Chair Prof. Jianliang Qian & Prof. Jin Cheng

Title: Challenges of Medical Imaging and Inverse Problems

17:00 – 19:00 Dinner

August 16, 2018
Thursday

09:00 – 11:45 **Plenary Talk**

Chair Prof. Kui Ren

09:00 Chunqi Qian

Title: MRI Detection and Inverse Problems

09:45 Jijun Liu

Title: On Image Restoration from Random Sampling Noisy Frequency Data with Regularization

10:30 **Coffee Break**

11:00 Yu Jiang

Title: Inversion Analysis for Magnetic Resonance Elastography

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11:45 – 12:15 **Closing Ceremony**

Chair Prof. Jin Cheng

Closing Remarks

12:15 – 13:30 **Lunch**

Abstract

Photoacoustic Computed Tomography in Heterogeneous Acoustic Media: Status and Open Challenges

Mark Anastasio

Washington University in St. Louis

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Photoacoustic computed tomography (PACT) is an emerging soft-tissue imaging modality that has great potential for a wide range of preclinical and clinical imaging applications. It can be viewed as a hybrid imaging modality in the sense that it utilizes an optical contrast mechanism combined with ultrasonic detection principles, thereby combining the advantages of optical and ultrasonic imaging while circumventing their primary limitations. In this talk, we review our recent advancements in image reconstruction approaches for PACT in acoustically heterogeneous fluid and elastic media.

TBA

Gang Bao

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TBA

Large Diffeomorphic Deformation Based Image Reconstruction Method for Spatiotemporal Medical Imaging

Chong Chen

Chinese Academy of Sciences

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We propose a new image reconstruction model for spatiotemporal medical imaging in large deformation diffeomorphic metric mapping framework. This model can be divided into two subproblems, where one is the usually static image reconstruction, and the other is the so-called indirect image registration. The indirect image registration is one of the significant problems for the image reconstruction in spatiotemporal medical imaging. We adapt the large deformation diffeomorphic metric mapping framework for image registration to the indirect setting, where a template is registered against a target that is given through indirect noisy observations. The registration uses diffeomorphisms that transform the template through a (group) action. These diffeomorphisms are generated by solving a flow equation that is defined by a velocity field with certain regularity. The theoretical analysis and an efficiently computational method are also presented. The talk concludes with some examples of indirect image registration in 2D tomography with very sparse and/or highly noisy data, and the ongoing work.

Toward Next Generation Diffuse Optical Tomography: the Issue of Internal Refractive Index Variations

Yoko Hoshi

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Diffuse optical tomography (DOT) is a technique to reconstruct images of absorption and scattering coefficient distribution in turbid media. The main applications of DOT have been breast, neonatal brain, joint, limb and fluorescence imaging over the last 30 years. However, image quality is still far from widespread clinical use, which is attributed to difficulty in accurate numerical modeling of light propagation in biological tissue as well as ill-posed nature of inverse problems. The radiative transfer equation (RTE) describes light propagation in biological tissue correctly, whereas knowledge about optical properties, including refractive index and anisotropy factor, which are parameters of the RTE, is incomplete. Although it is widely accepted that refractive indices vary with each tissue, these values are generally assumed to be homogeneous throughout the imaging region. This assumption is supported by the previous simulation study reporting that the effect of internal refractive index variations on boundary measurements was slight in a two-layered slab model[1]. However, our some recent studies have suggested that refractive-index mismatch conditions should be taken into account when reconstructing DOT images. In this workshop, firstly I will talk about the general aspects of DOT briefly, and then talk about the issue of the internal refractive index variations.

1. Dehghani H, et al. Phys. Med. Biol. 48 (2003) 2713-2727.

Recursive Linearization Method for Inverse Medium Scattering Problems with Complex Mixture Gaussian Error Learning

Junxiong Jia and Jigen Peng

Xi'an Jiaotong University

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Joint work with Bangyu Wu and Jinghuai Gao.

This talk is concerned with the modeling errors appeared in the numerical methods of inverse medium scattering problems (IMSP).Optimization based iterative methods are wildly employed to solve IMSP, which are computationally intensive due to a series of Helmholtz equations need to be solved numerically. Hence, rough approximations of Helmholtz equations can significantly speed up the iterative procedure. However, rough approximations will lead to instability and inaccurate estimations. Using the Bayesian inverse methods, we incorporate the modelling errors brought by the rough approximations. Modelling errors are assumed to be some complex Gaussian mixture(CGM) random variables, and in addition, well-posedness of IMSP in the statistical sense has been established by extending the general theory to involve CGM noise. Then, we generalize the real valued expectation-maximization (EM) algorithm used in the machine learning community to our complex valued case to learn parameters in the CGM distribution. Based on these preparations, we generalize the recursive linearization method (RLM) to a new iterative method named as Gaussian mixture recursive linearization method (GMRLM) which takes modelling errors into account. Finally, we provide two numerical examples to illustrate the effectiveness of the proposed method.

Inversion Analysis for Magnetic Resonance Elastography

Yu Jiang

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A diagnosing modality called MRE (Magnetic Resonance Elastography) whose hardware consists of a MRI and vibration system can measure the displacement vector of a shear wave inside a human tissue. The so called elastogram of MRE is to recover viscoelasticity of human tissue from the *MRE measured data*. This is an inverse problem with single interior measurement.

The importance of MRE is that it can realize doctors' palpation inside a human boday which had been dreamed by doctors for a long time. Although the hardware of MRE is developing very quickly, the elastogram has not yet developed enough and there are so many challenging questions for elastogram.

I will introduce the fundamental principal and mathematical model of MRE in the talk. Some inversion sheme to recover the unknown viscoelastic coefficients will also be present.

This is a joint work with Prof. Gen Nakamura in Hokkaido University, Japan.

Inverse Problems of Thermo-acoustics

Sergey Kabanikhin

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We consider an elastic domain Ω . Assume that starting with time $t = 0$, the domain Ω is exposed to electromagnetic radiation of intensity $I(t)$ partially absorbed by the medium. The energy thus absorbed is converted to heat. The temperature increases, the medium expands, and there appear acoustic pressure waves. Propagating in the medium, the acoustic pressure waves reach boundary Γ of the domain. Assume that they can be measured on part of the domain. The problem is to determine the absorption coefficient of electromagnetic radiation in Ω with acoustic pressure measurements. Using the mathematical language we consider the inverse problem of determining the initial condition of an initial boundary value problem for the wave equation with some additional information about solving a direct initial boundary value problem.

The information is obtained from measurements at the boundary of the solution domain. The purpose of our paper is to construct a numerical algorithm for solving the inverse problem by an iterative method called a method of simple iteration (MSI) and to study the resolution quality of the inverse problem as a function of the number and location of measurement points. Three two-dimensional inverse problem formulations are considered. The results of our numerical calculations are presented. It is shown that the MSI decreases the objective functional at each iteration step. However, due to the ill-posedness of the inverse problem the difference between the exact and approximate solutions decreases up to some fixed number, and then monotonically increases. This shows the regularizing properties of the MSI, and the iteration number can be considered as the regularization parameter.

A Level-set Adjoint-state Method for Crosswell Transmission-reflection Traveltime Tomography

Wenbin Li

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We propose a level-set adjoint-state method for crosswell traveltime tomography using both first-arrival transmission and reflection traveltime data. Since our entire formulation is based on solving eikonal and advection equations on finite-difference meshes, our traveltime tomography strategy is carried out without computing rays explicitly. We incorporate reflection traveltime data into the formulation so that possible reflectors (slowness interfaces) in the targeted subsurface model can be recovered as well as the slowness distribution itself. Since a reflector may assume a variety of irregular geometries, we propose to use a level-set function to implicitly parametrize the shape of a reflector. Therefore, a mismatch functional is established to minimize the traveltime data misfit with respect to both the slowness distribution and the level-set function, and the minimization is achieved by using a gradient descent method with gradients computed by solving adjoint state equations. To assess uncertainty or reliability of reconstructed slowness models, we introduce a labelling function to characterize first-arrival ray coverage of the computational domain, and this labelling function satisfies an advection equation. We apply fast-sweeping type methods to solve eikonal, adjoint-state and advection equations arising in our formulation.

Some Numerical Methods for Inverse Problems from Traveltime Tomography and Gravimetry

Shingyu Leung

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We discuss various numerical methods to some inverse problems originated from traveltime tomography and inverse gravimetry. We first formulate these inverse

problems in variational formulations. To minimize the energy in the variational formulation, we derive the gradient of the nonlinear functional which can be efficiently computed using the adjoint state method. We also propose an operator splitting approach to some of these inverse problems. We will also show various numerical examples to demonstrate the feasibility and the robustness of these new formulations.

On Image Restoration from Random Sampling Noisy Frequency Data with Regularization

Jijun Liu

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Consider the image restoration using random sampling noisy frequency data by total variation regularization. By exploring image sparsity property under wavelet expansions, we establish an optimization model with two regularizing terms specifying image sparsity and edge preservations on the restored image. The choice strategies for the regularizing parameters are rigorously set up together with corresponding error estimate on the restored image. The cost functional with data-fitting in frequency domain is minimized using the Bregman iteration scheme. By deriving the gradient of the cost functional explicitly, the minimizer of the cost functional at each Bregman step is also generated by an inner iteration process with Tikhonov regularization, which is implemented stably and efficiently due to the special structure of the regularizing iterative matrix. Numerical tests are given to show the validity of the proposed scheme.

Spatial-Frequency Optical Tomography in the Radiative-Transport Regime

Manabu Machida

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It has been reported that noncontact optical tomography is improved by the use of illumination with sinusoidal intensity pattern. Although this imaging method of using spatial frequency is promising, most research so far has relied on the diffusion approximation to the radiative transport equation. In this talk, I will present numerical algorithms of optical tomography with spatially sinusoidal illumination for the radiative transport equation. With the help of the technique of rotated reference frames, the forward problem, i.e., the three-dimensional radiative transport equation is solved in two ways: the spherical-harmonic expansion and the FN method. Then the inverse problem is solved by making use of the Green's function, which is the solution to the forward problem.

Time-Domain Optical Tomography for Fluorescence Objects

Goro Nishimura

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Fluorescence imaging technique is very common to assess the biological samples. However, it is really difficult to image the fluorescence from thick samples, like human tissues. The fluorescence photons are strongly scattered and the spatially localized information is spreading in the whole space and lost. The image is obtainable from data with a reconstruction based on the mathematical model of photon transport. We have employed the time-domain photon diffusion (PD) model instead of the steady state PD model because time-domain method is a method to increase the spatial information. In this talk, I introduce our approach

and experimental results. I also discuss the effect of the contaminations in time-domain data.

Investigation of Non-Linear Problems in X-ray CT

Xiaochuan Pan

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Non-linear data models arise in X-ray computed tomography (CT). Current CT imaging applications are based largely on a linear data model. While the linear data model can be of sufficient utility for a wide variety of CT imaging applications, it is recognized also that non-linear effect can result in artifacts in CT images, which could distract the visualization/detection of subtle, low-contrast structures of application significance. There has been a renewed, strong interest in research on and application of multi-spectral (or photon-counting) CT in the field. In multi-spectral CT, accurate image reconstruction remains challenging because its appropriate data model is highly non-linear due to the polychromatic nature of X-ray spectra used. Also, in realistic CT imaging, the presence of non-linear partial volume (NLPV) effect can lead to artifact that obscure low-contrast signals especially when they are embedded within an environment of high contrast structures. The consideration of multi-spectral and NLPV can lead to non-linear data models in CT. In the presentation, I will discuss recent advances in the development of methods, with a focus on a non-convex optimization-based image reconstruction (OBIR) method, for solving non-linear data model in realistic CT through considering the effect of multi spectra or NLPV. Following the discussion, specific examples will be used to illustrate the applications of the methods to CT imaging and to demonstrate their effectiveness in compensation for the effect of multi spectra or NLPV.

MRI Detection and Inverse Problems

Chunqi Qian

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Magnetic Resonance Imaging (MRI) is a powerful and versatile technique for diseases diagnosis and preclinical research. The applicability of MRI, however, is often limited by its detection sensitivity, which determines the achievable spatial resolution. Although the detection sensitivity of MRI has steadily increased over the last four decades of its existence, I will introduce a complementary method that can further improve its detection sensitivity. This method benefits from the well-known fact that a miniaturized detector has better local sensitivity when it is placed in vicinity to the detection object. But unlike the traditional micro-coils that need wired connections, the wireless amplified detector can maintain the superior local sensitivity by amplifying signals in situ before wirelessly coupling them to the external receiver. The detector has an integrated amplifier that doesn't require an internal power source. After going through the operation principles, I will demonstrate the detection capabilities of Wireless Amplified NMR Detectors (WAND) with high resolution kidney and vascular images obtained on animal models. Such high resolution capability has enabled the in vivo observation of kidney functions at near histological level. Finally, I will address inverse problems related to the future development of the wireless amplifier technology.

Artifacts in Tomography

Eric Todd Quinto

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In this talk, we will describe how artifacts are generated in limited data X-ray tomography. We characterize artifacts both by their shape and their cause. We will explain the artifacts using Fourier and microlocal analysis. We will provide examples from real and simulated data that illustrate our results for X-ray CT and, if time, photoacoustic CT and sonar.

Quantitative Photoacoustics with Additional Optical Measurements

Kui Ren

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We will study here an inverse problem in quantitative photoacoustic tomography (QPAT) where we supplement photoacoustic data with additional boundary optical data as measured in optical tomography (OT). We demonstrate computationally the benefits of such combination of QPAT and OT. In particular, we show that this combination can improve the separation of the absorption and scattering coefficients in numerical image reconstructions.

Machine Learning for Biomedical Imaging

Ge Wang

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Computer vision and image analysis are great examples of machine learning especially deep learning. While computer vision and image analysis deal with existing images and produce features of these images (images to features), tomographic reconstruction produces images of internal structures from externally measured data which are various features of the underlying images (features to images). Recently, deep learning techniques are being actively developed worldwide for tomographic reconstruction, with encouraging results at RPI and other institutions. We believe that deep reconstruction is a next frontier of machine learning, has a revolutionary potential to improve tomographic solutions, and promises major impacts on development of imaging methods and their applications. Along this direction, we have been working on data-driven algorithms based on modern analytic and iterative reconstruction algorithms, for optimized workflow with multi-stages and/or in multi-modes, and toward superior performance in clinical and preclinical applications. In addition to my general perspective of "deep imaging" (https://ieeexplore.ieee.org/document/7733110), our recent results will be reported on methodological exploration, learning-based reconstruction, and hybrid imaging.

Reconstruction of Unknown Inclusions Based on the Diffusion Model

Haibing Wang

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We will consider the problem of reconstructing unknown inclusions inside a diffusive medium from boundary measurements, which arises from active thermography and diffuse optical tomography. It is formulated as an inverse boundary value problem for the diffusion equation. We introduce two non-iterative methods for reconstructing the boundary of the unknown inclusion. One is a sampling-type method, which is based on the characterization of the solution to the so-called Neumann-to-Dirichlet map gap equation. The second is a direct algorithm for locating small inclusions, which is based on the asymptotic expansion for the weighted boundary measurement. Some close relations between them are discussed. Numerical results are also presented to show the efficiency and stability of the proposed methods.

Stability and Uniqueness for Inverse Problems for Transport Equations

Masahiro Yamamoto

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We consider a transport equation in a bounded domain $\Omega \subset \mathbb{R}^n$:

$$\partial_t u(x,t) + p(x,t) \cdot \nabla u(x,t) + q(x,t)u = F(x,t), \quad x = (x_1, ..., x_n) \in \Omega,\ 0 < t < T. \tag{1}$$

The transport equation (1) is a fundamental component of a governing equation in the optical tomography and describes a conservation law which is important also for the fluid dynamics.

First we discuss the following problems.

- **Energy estimate**: estimate of $\|u(\cdot,t)\|_{L^2(\Omega)}$ by data of $u|_{\partial\Omega\times(0,T)}$ with sufficiently large $T > 0$.
- **Inverse coefficient problem**: Let the coefficients p and q in (1) be t-independent. Then determine $p(x)$ by $u(x,0)$ for $x \in \Omega$ and data of u on some lateral boundary.

The main tool is a Carleman estimate and we aim also at generous condition on $p(x,t)$ admitting a Carleman estimate.

Second as a related inverse problem by the Carleman estimate, I will present stability for inverse coefficient problems for the radiative transport equation in the optical tomography.

This talk is based on joint works with Professor P. Cannarsa (Univ. di Roma ”Tor Vergata”), Professor Giuseppe Floridia (Univ. Napoli Federico II), Professor F. Gölgeleyen (Bulent Ecevit Univ.) and Professor M. Machida (School of Medicine, Hamamatsu Univ.)

Some Mathematical Theory of Ultrasound-aided Optical Tomography

Yang Yang

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Optical tomography is a high-contrast modality that is often used in medical imaging. Its application however is limited by the lack of spatial resolution. Various remedies have been proposed recently to break the limitation by introducing high-resolution ultrasound imaging as an aid. Examples include photoacoustic tomography (PAT), thermoacoustic tomography (TAT), and ultrasound modulated optical tomography (UMOT). We will discuss some mathematical theory of these novel imaging modalities concerning uniqueness, stability, and reconstruction of the desired physical parameters. This is based on joint work with Plamen Stefanov, Wei Li and Yimin Zhong.

Computational Electromagnetic Problems in 7T MRI

Xiaotong Zhang

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The RF receive coil array has become increasingly vital in current MR imaging practice due to its extended spatial coverage, maintained high SNR, and improved capability of accelerating data acquisition. The performance of a coil array is intrinsically determined by the current patterns generated in coil elements as well as by the induced electromagnetic fields inside the object. Through numerical electromagnetism computation, investigations of the ultimate performance constrained by a specific coil space, which defines all possible current patterns flowing

within, offers the opportunity to evaluate coil-space parameters without the necessity of considering the realistic coil element geometry, coil elements layout, and number of receive channels in modeling. In this talk, I will introduce our recent studies of the influences of coil-space design parameters through evaluating the corresponding spatial constrained ultimate intrinsic SNR (UISNR) and ultimate g-factor (uGF), and provide our insights on to what extent, the ultimate coil performance can be achieved by using practical coil designs. We hope the present analysis will offer important implications in novel receive array design for primate brain MR imaging at ultra-high field (UHF).

A Hybrid Adaptive Phase Space Method for Reflection Traveltime Tomography

Hongkai Zhao

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We present a hybrid imaging method for travel time tomography problem which includes both unknown medium and unknown scatterers in a bounded domain. The goal is to recover both the medium and the boundary of the scatterers from the scattering relation data on the domain boundary. Our method is composed of three steps: 1) preprocess the data to classify them into three different categories of measurements corresponding to non-broken rays, broken-once rays, and others, respectively, 2) use the the non-broken ray data and an effective data-driven layer stripping strategy–an optimization based iterative imaging method–to recover the medium velocity outside the convex hull of the scatterers, and 3) use selected broken-once ray data to recover the boundary of the scatterers–a direct imaging method. We show that our hybrid method can recover both the unknown medium and the not-too-concave scatterers efficiently and robustly.

School of Mathematics (SoM)

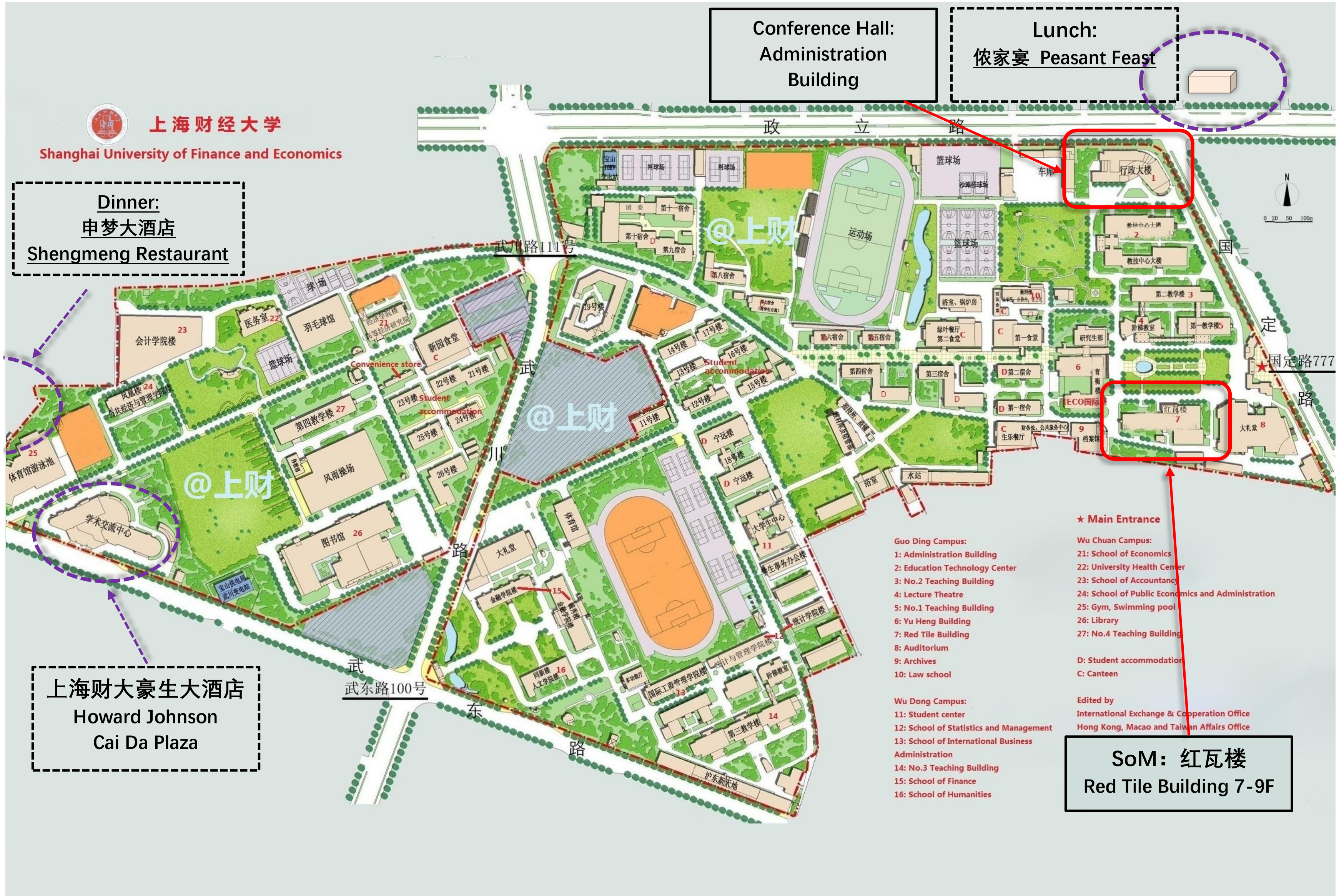
Shanghai University of Finance and Economics (SUFE)

Formerly named as Department of Applied Mathematics, the School of Mathematics at SUFE was founded in July 2014. The school currently offers a doctoral degree program in Applied Probability. By collaborating with the School of Finance and Economics, SoM also trains Ph.D. candidates in the major of Financial Mathematics and Financial Engineering. As for the Master's Degree programs, it provides several research areas, namely, Pure Mathematics, Computational Mathematics, Operational Research and Cybernetics, Applied Mathematics, Applied Probability and Financial Mathematics. SoM also has Bachelor's Degree programs in Pure Mathematics and Applied Mathematics, and, Informational and Computing Science. It owns the Computational Mathematics Laboratory and the Mathematical Modeling Laboratory. Most importantly, the school established the Institute of Scientific Computation and Financial Data Analysis in 2016, providing innovative and frontier researches for modeling and computing of financial data. The school established in 2017 the Economics-Mathematics Program under the special configurations for undergraduates to fully satisfy the demand for cultivating outstanding talents in the fields of mathematical finance and data science.

The School of Mathematics is proud of its promising faculty group. The faculty members focus on the international engagements and have partnered with worldwide prestigious universities and institutions, making their great effort to the students' all-around development.

Being of the solid fundamental knowledge in mathematics, the undergraduates and postgraduates students in SoM also have a good mastery of applied disciplines, such as economics, finance, and management. Consequently they are highly praised by employers after graduation with complete employment.

The graduated students from SoM own diversified and promising career future. In 2016, more than 70% of the graduates pursued further study in prestigious domestic and foreign institutions, including Harvard University, University of Cambridge, the London School of Economics and Political Science, Columbia University, etc. Most of the postgraduate students take on challenging jobs in financial institutions, as well as educational and research institutions.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Shanghai University of Finance and Economics
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10: Law school
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Hong Kong, Macao and Taiwan Affairs Office
行政大楼
红瓦楼
大礼堂
运动场
篮球场
图书馆
风雨操场
学术交流中心
会计学院楼
体育馆游泳池
第四教学楼
羽毛球馆
体育馆
大礼堂
第三教学楼
Student accommodation
Convenience store

數通古今
學達中外

School of Mathematics, SUFE