Inverse Problems 2015

December 4-5, 2015
KAIST, Daejeon, Korea
Natural Science Bldg E6-1, Rm 1501

Organizers	Sungwhan Kim (Hanbat National University)
	Eunjung Lee (Yonsei University)
	Mikyoung Lim (KAIST)
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This workshop is sponsored by
KIAS Center for Mathematical Challenges (KIAS CMC) and KAIST.

Friday Morning, December 4 (Room 1501)

10:30 – 11:10 Hyeonbae Kang (Inha University)

Spectral properties of the Neumann-Poincarè operator and uniformity of estimates for the conductivity equation with complex coefficients

11:10 – 11:35 Kiwoon Kwon (Dongguk University)

Numerical findings for the enclosure method in some parabolic equation

11:35 – 12:00 Hyeuknam Kwon (Yonsei University)

Spectroscopic imaging of a cell suspension using homogenization

12:00 – LUNCH

Friday Afternoon, December 4 (Room 1501)

13:30 – 14:10	Jong Chul Ye (KAIST)
	Annihilating filter-based low rank Hankel matrix approaches for biomedical imaging and image processing
14:10 – 14:35	Jae Kyoung Kim (KAIST)
	Reverse constructions of the biochemical network structure from timecourse data
14:35 – 14:50	Coffee Break
14:50 – 15:15	Hyoung Suk Park (Yonsei University)
	Metal Artifacts Reduction in X-ray CT Based on a Beam Hardening Corrector
15:15 – 15:40	Chi Young Ahn (NIMS)
	Intra-Ventricular Flow Reconstruction Using Color Flow Ultrasound
15:40 – 16:00	Coffee Break
16:00 – 16:25	Chang-Ock Lee (KAIST)
	CT metal artifacts reduction by an iterative algorithm based on sinogram surgery
16:25 – 16:50	Kiwan Jeon(NIMS)
	A Study on 3-D Mesh generation for Scientific Computing and Medical Imaging
16:50 – 17:10	Dongyoung Im (KAIST)
	Static hedging and pricing of exotic options under the JDCEV model via integral equation theory
18:00 –	BANQUET

Saturday Morning, December 5 (Room 1501)

09:30 – 09:55 Hyundae Lee (Inha University)

Neutal inclusion and overdetermined problem

09:55 – 10:15 Yong-Gwan Ji (Inha University)

Spectral properties of the Neumann-Poincare operator and cloaking by anomalous localized resonance for the elasto-static system

10:15 – 10:35 Junyong Eom (Inha University)

An inversion scheme for the shear modulus of viscoelastic systems in a finite cylindrical domain

10:35 – 10:45 Coffee Break

10:45 – 11:10 KiHyun Yun (HUFS)

Stability of the Electromagnetic Scattering from a Large Cavity in Two Dimensions

11:10 – 11:35 Sanghyeon Yu (ETH Zurich)

Stress concentration for two nearly touching holes

11:35 – 12:00 Sungwhan Kim (Hanbat National University)

Schwartz Theorem for the Radon Transform and Metal Artifact Reduction

★ **Lecture Hall** : Natural Science B/D E6-1 Rm 1501

★ **Lunch Location** : E5, Faculty Club (2F)

★ **Banquet Locatoin (18:00 – , December 4)**

- 상호: 치브레오
- 주소: 대전 유성구 대학로76번길 13 (TEL : 042-826-8816)

★ **Refreshment Table Location (December 4-5)** : Rm 1401

★ **Group Photo (12:00, December 4)** : Rm 1501 (Lecture Hall)

Hyeonbae Kang

Inha University

Spectral properties of the Neumann-Poincarè operator and uniformity of estimates for the conductivity equation with complex coefficients

We consider well-posedness of the boundary value problem in presence of an inclusion with complex conductivity k. We first consider the transmission problem in $\mathbb{R}^d$ and characterize solvability of the problem in terms of the spectrum of the Neumann-Poincaré operator. We then deal with the boundary value problem and show that the solution is bounded in its H^1-norm uniformly in k as long as k is at some distance from a closed interval in the negative real axis. We then show with an estimate that the solution depends on k in its H^1-norm Lipschitz continuously. We finally show that the boundary perturbation formula in presence of a diametrically small inclusion is valid uniformly in k away from the closed interval mentioned before. The results for the single inclusion case are extended to the case when there are multiple inclusions with different complex conductivities: We first obtain a complete characterization of solvability when inclusions consist of two disjoint disks and then prove solvability and uniform estimates when imaginary parts of conductivities have the same signs. The results are obtained using the spectral property of the associated Neumann-Poincaré operator and the spectral resolution. This is a joint work with K. Kim, H. Lee, J. Shin and S. Yu.

Kiwoon Kwon

Dongguk University

Numerical findings for the enclosure method in some parabolic equation

In the course of numerically implementing the enclosure method in one-dimensional thermal imaging problem, we found that choosing appropriate complex frequency is very important to efficiently approximate numerical inverse problem solution. We showed relative error analysis for the enclousure method with respect to the complex frequency and showed how the selection of the frequency is importnat to the numerical results.

Hyeuknam Kwon

Natural Science Research Institute, Yonsei Univ.

Spectroscopic imaging of a cell suspension using homogenization

In this research, we analytically exhibits the fundamental mechanisms underlying the fact that effective biological tissue electrical properties and their frequency dependence reflect the tissue composition. A homogenization theory is introduced to express the effective admittivity of cell suspensions. A new formula is derived which gives the frequency-dependent effective admittivity. Different microstructures of cell can be distinguished via spectroscopic measurements of the overall admittivity.

Jong Chul Ye

KAIST

Annihilating filter-based low rank Hankel matrix approaches for biomedical imaging and image processing

While the recent theory of compressed sensing or compressive sampling (CS) provides an opportunity to overcome the Nyquist limit in recovering sparse signals, a recovery algorithm usually takes the form of penalized least squares or constraint optimization framework that is different from classical signal sampling theory. In this talk, we provide a drastically different compressive sampling framework that can exploit all the benefits of the CS, but can be still implemented in a classical sampling framework using a digital correction filter. The main idea is originated from the fundamental duality between the sparsity in the primary space and the low-rankness of the Hankel structure matrix in the reciprocal spaces, which demonstrates that the low-rank interpolator as a digital correction filter can enjoy all the optimality of the standard CS. We show that the idea can be generalised to recover signals in large class of signals such as piece-wise polynomial, and spline representations. Moreover, by restricting signal class as cardinal splines, the proposed low-rank interpolation approach can achieve inherent regularization to improve the robustness. Experimental results for various image processing and biomedical imaging applications confirmed that the proposed scheme has significant better results than the conventional CS approaches.

Jae Kyoung Kim

KAIST

Reverse constructions of the biochemical network structure from timecourse data

The development of luciferase markers and other experiment techniques has allowed measurement of the timecourses of the expression of genes and proteins with remarkable accuracy. On the other hand, detecting the underlying biochemical interaction network among gens and proteins requires tremendous experiments. In this talk, I will discuss how the oscillating timecourses can reveal the underlying network structure by testing the existence of ODE model fitting to the timecourse data.

Hyoung Suk Park

Yonsei University

Metal Artifacts Reduction in X-ray CT Based on a Beam Hardening Corrector

X-ray computed tomography (X-ray CT) is the most widely used tomographic imaging technique in the field of dental and medical radiography. In spite of the excellent resolution and contrast of the cross-sectional images, its advantage is partly limited by the metallic object-related artifacts in the images. In this presentation, we proposes a new method to correct metal artifacts for polychromatic X-ray computed tomography without degrading intact anatomical images. Without prior knowledge of the spectrum parameters or energy-dependent attenuation coefficients, the proposed correction allows the background CT image (i.e., the image before its corruption by beam-hardening artifacts) to be extracted from the uncorrected CT image. Computer simulations and phantom experiments demonstrate the effectiveness of the proposed method to alleviate metal artifacts due to beam hardening.

Chang-Ock Lee

KAIST

CT metal artifacts reduction by an iterative algorithm based on sinogram surgery

The streaking artifacts in computed tomography (CT) image caused by the metallic objects (dental implants, surgical clips, or steel-hip) limit the applications of CT image. We propose an algorithm for reducing the streaking artifacts in CT images. We do sinogram surgery, iteratively, to remove the metallic effect in the sinogram using the basic principle of CT image reconstruction. We apply our algorithm for the parallel beam CT model and fanbeam CT model. The numerical experiments show that our algorithm reduces the metal artifacts effectively even for the phantom of complex model such as dental shape in both CT models. We analyze the simulation results both quantitatively and qualitatively.

Kiwan Jeon

NIMS

A Study on 3-D Mesh generation for Scientific Computing and Medical Imaging

과학계산과 의료영상에서 사용할 수 있는 3차원 격자생성 연구에 대해 발표한다. 이 연구와 관련된 수리적 모델을 소개하고, 현재까지의 얻은 수치결과에 대해 간단히 발표한다. 특히, 본 연구에서 어려운 부분을 공유하고 논의하고자 한다.

Dongyoung Im

KAIST

Static hedging and pricing of exotic options under the JDCEV model via integral equation theory

This study provides a systematic approach to construct an exact static hedge for a variety of exotic options under the JDCEV(jump to default extended CEV) model via integral equation theory. We show sufficient conditions for the existence and uniqueness of an exact static hedging portfolio which consists of vanilla and binary options. The solution can be explicitly expressed by confluent hypergeometric functions via Laplace transform. Furthermore, we prove the convergence of the DEK method, which is important in computational finance area. Lastly, several examples of exotic options (double barrier options, partial barrier options, step barrier options) are used to illustrate our approach.

Hyundae Lee

Inha University

Neutal inclusion and overdetermined problem

We consider the neutral inclusion problem which is to prove if a coated structure consisting of a core and a shell is invisible to all uniformelds, then the core and shell must be concentric balls if the matrix is isotropic and confocal ellipsoids if the matrix is anisotropic.

Chi Young Ahn

NIMS

Intra−Ventricular Flow Reconstruction Using Color Flow Ultrasound

We propose a 2D Navier−Stokes model to reconstruct intra−ventricular flows using color flow images and left ventricular boundaries extracted from echocardiography data. The proposed model considers both in−plane and out−of−plane blood flows for an imaging plane in apical long−axis three−chamber view. Blood flows in the imaging domain are reconstructed through solving a system of equations, which include a 2D incompressible Navie−Stokes equation with a mass source term and the color flow data measurement equation.

Yong-Gwan Ji

Inha University

Spectral properties of the Neumann-Poincare operator and cloaking by anomalous localized resonance for the elasto-static system

The Neumann-Poincare (NP) operator is a boundary integral operator which appears naturally when solving classical boundary value problems using layer potentials. In this talk we investigate spectral properties of the Neumann-Poincar e operator and cloaking by anomalous localized resonance for the elasto-static system.

Junyong Eom

Inha University

An inversion scheme for the shear modulus of viscoelastic systems in a finite cylindrical domain

There is an experimental mechanics called PVS(Pendulum-type Viscoelastic Spectrometer) device which designed for measuring the complex shear modulus of viscoelasic materials.We find a time harmonic solution of the viscoelastic systems which satisfies some mixed boundary conditions that corresponds to the PVS device. We estimate that the average of our series solution can be approximated by the average of the first term of our series solution when our specimen is thin. Using that estimation and based on the measured data, we provide an inversion scheme for the shear modulus. Further, viability of our inversion scheme can be explained by comparing an inversion scheme frequently used in mechanics.

KiHyun Yun

HUFS

Stability of the Electromagnetic Scattering from a Large Cavity in Two Dimensions

In this talk, we consider a time harmonic scattering problem of electromagnetic wave from a two-dimensional open cavity embedded in the infinite ground place. A variational formulation reduces the problem into a bounded domain problem. The problem has been challenging both mathematically and computationally due to highly oscillatory nature of the solution. We establish the stability estimates for the solution that provide the explicit dependence on a high wave number.

Sanghyeon Yu

ETH Zurich

Stress concentration for two nearly touching holes

When two elastic inclusions are nearly touching, the stress(the gradient of the solution to the elasticity equation) blows up in the narrow gap region between them. This phenomenon has practical applications such as material failure analysis and densely packed composite materials. However, due to the blow-up feature, it is quite challenging to compute the stress field accurately in the narrow gap. So it is important to investigate its asymptotic behavior in the nearly touching limit. In this talk, we discuss a recent progress on the stress concentration for two elastic holes. This talk is based on a joint work with Prof.Mikyoung Lim.

Sungwhan Kim

Hanbat National University

Schwartz Theorem for the Radon Transform and Metal Artifact Reduction

In this talk, we introduce a novel projection completion algorithm which exploits the Schwartz theorem for the X-ray Radon transform in order to reduce metal artifacts in CT.