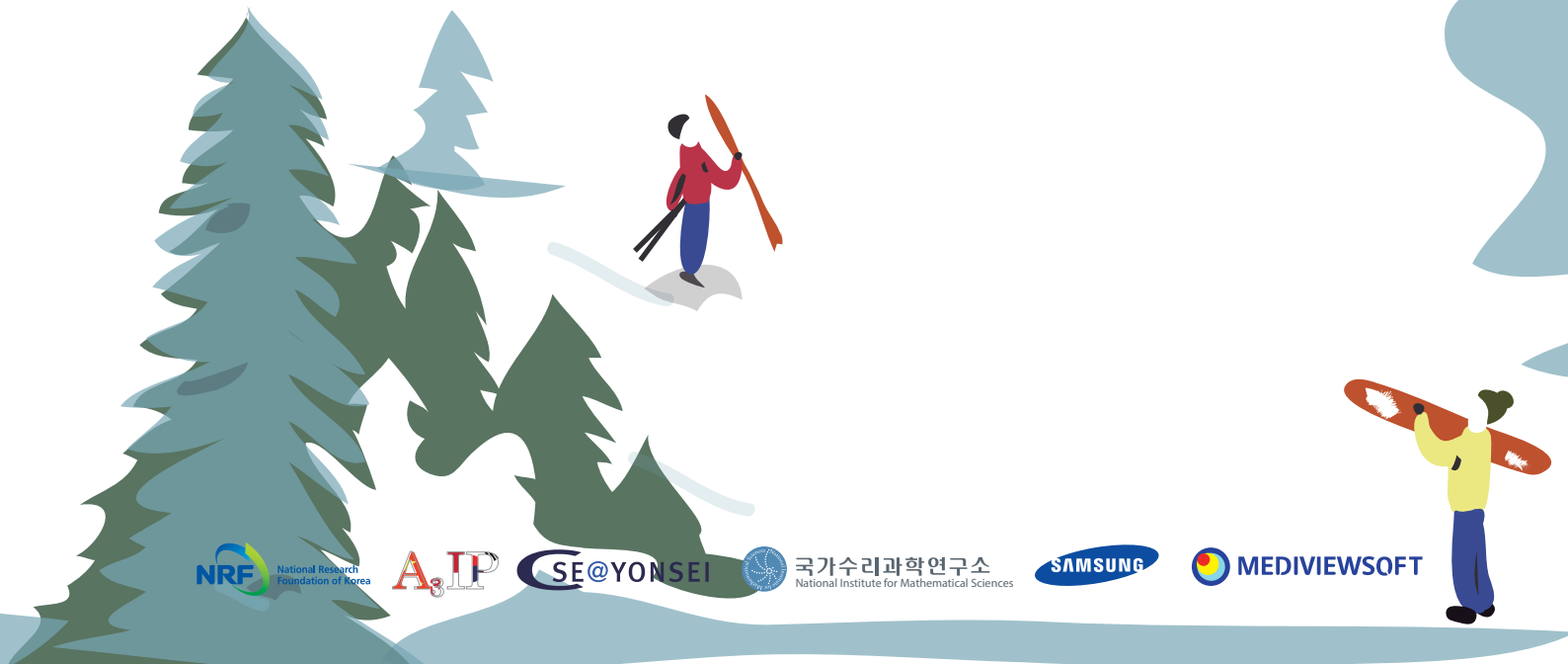
2017 WINTER SCHOOL

IMAGING SCIENCE BOOK OF ABSTRACTS

JANUARY 9–11, 2017

SONOFELICE HONGCHEON GUN GANGWON DO KOREA



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2017 WINTER SCHOOL

The 2nd Winter School in Imaging Science

Date	9–11 January 2017
Location	Sonofelice, Hongcheon–Gun, Gangwon–Do, Korea

Organizing Committee

Jin Keun Seo (Yonsei.) / Jong Chul Ye (KAIST) / Taeuk Jeong (Yonsei.)

Organized by

A3 Foresight Program: Modeling and Computation of Applied Inverse Problems

Homepage

https://winterschool2017.mediviewsoft.com/

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2017 WINTER SCHOOL IN IMAGING SCIENCE

JANUARY 9-11, 2017, SONOFELICE, HONGCHEON GUN, GANGWON DO, KOREA

Time Table

Day 0 / January 8 / Sunday

Time	Zaffiro (80석)	Rubino (13석)	Granato (50석)
09:00-09:30			
09:30-10:00			
10:00-10:30			
10:30-11:00			
11:30-12:00			
12:00-13:30			
13:30-14:00			
14:00-15:00	**[Epidemiology Session]** 백경아.석정주		
15:00-16:00	신유진, 이윤정		
16:00-17:00	이태용, 장준영		**Registration**
17:00-18:00	황윤구, 윤명호		

Day 1 / January 9 / Monday

Time	Zaffiro (80석)	Rubino (13석)	Granato (50석)
09:00-09:30	**[NA Group meeting]**		**[Imaging Session]** Kiwan Jeon
09:30-10:00	Jeehyun Lee		Doyeob Yeo
10:00-10:30			
10:30-11:00			Soomin Jeon
11:30-12:00			Chang-Ock Lee
12:00-13:30			
13:30-14:00		**[CFD Group meeting]** Geunwoo Oh	
14:00-15:00	**[IIRC Group meeting]**	Kyungmin Noh Ki-ha Kim Yunyoung Choi	**[NIMS Session]** Yunkyoung Hyon
15:00-16:00	Eung Je Woo	Seungho Song Sanghee Lee	
16:00-16:30		Hyunsoon Cho	Wanho Lee
16:30-17:00		Jeyun Chun	
17:00-18:30		Sun Xiang Soomin Chun	
18:30-19:30	**[CT Session]** Hyoung Suk Park	**[CFD Group meeting]**	**[CSE-URP Beamer Presentation]**
19:30-20:30	Jin Keun Seo	Junghoon Lee, Juwon Jang	Hwa Pyung Kim

Day 2 / January 10 / Tuesday

Time	Zaffiro (80석)	Rubino (13석)	Granato (50석)
08:30-09:00	[CT Session] **Jiashi Feng**		
09:00-09:30		**[MI(EIT)Group meeting]**	[Imaging Session]
09:30-10:00	Jung Chul Ye	Jin Keun Seo	Junghyun Cho
10:00-10:30	Ho Kyung Kim		
10:30-11:00	Yong Eun Chung		Bumsu Kim
11:30-12:00			
12:00-13:30			
13:30-14:00	**[NA Group meeting]**	[Phase Fields Session]	[Ultrasound Session]
14:00-14:30	Jeehyun Lee	Jaemin Shin	Soonjeong Jo
14:30-15:00		Hyun Jeun Lee	Yoongu Hwang
15:00-15:30			
15:30-16:00			Yoongu Hwang
16:00-16:30		**[CFD Group meeting]**	
16:30-17:00		Hyunsoon Cho	Jaeseong Jang
17:00-17:30		Jeyun Chun	
17:30-18:30			
18:30-19:30	[CT Session] Kyungsang Kim	**[CFD Group meeting]**	**[CSE-URP Beamer Presentation]**
19:30-20:30	Jin Keun Seo	Hojun Lee, Seulgi Lee	Hwa Pyung Kim

Day 3 / January 11 / Wednesday

Time	Zaffiro (80석)	Rubino (13석)	Granato (50석)
08:30-09:00			
09:00-09:30			**[Microwave Session]** Sol-Lip Kwon
09:30-10:00			Hwa Pyung Kim
10:00-10:30			Seong-Ho Son
10:30-11:00			Kwang-Jae Lee
11:00-11:30			Won-Kwang Park
11:30-12:00			
12:00-13:00			
13:00-14:00			
14:00-15:00	**[Epidemiology Session]** 석정주, 이윤정, 장준영		
15:00-16:00	황윤구		

2017 WINTER SCHOOL IN IMAGING SCIENCE

JANUARY 9–11, 2017, SONOFELICE, HONGCHEON GUN, GANGWON DO, KOREA

Schedule

Day 0 / January 8 / Sunday

Registration

Time	Program
16:00-18:00	**Registration & Group Meeting**

Epidemiology Session (Room: Zaffiro)

Time	Program	Speaker
14:00-14:30	**Optimal control of epidemic models**	백경아
14:30-15:00	**Forward and inverse modeling of IBM**	석정주
15:00-15:30	**Parameter estimation using Kalman filter**	신유진
15:30-16:00	**Parameter reduction**	이윤정
16:00-16:30	**Dynamics of deterministic models and stochastic models**	이태용
16:30-17:00	**Constrained optimization**	장준영
17:00-17:30	**Solving optimal control problems by Pontryagin and HJB**	황윤구
17:30-18:00	**Kalman filter algorithms**	윤명호

Day 1 / January 9 / Monday

Imaging Session (Room: Granato)

Time	Program	Speaker
09:00-09:30	**A Study for Mesh Generation using Partial Differential Equation**	**Kiwan Jeon**
09:30-10:00	**Design of an energy functional and an initial curve for the shape prior segmentation**	**Doyeob Yeo**
10:00-10:30	**Break**	
10:30-11:00	**A CT Metal Artifact Reduction Algorithm Based on Sinogram Surgery**	**Soomin Jeon**
11:00-11:30	**Cardiac Motion Tracking in the Ultrasound Image Using the Optical Flow Estimation**	**Chang-Ock Lee**

NIMS Session (Room: Granato)

Time	Program	Speaker
14:00-16:00	**Talk 1: Mathematical Data Analytics and Its Applications**	**Yunkyoung Hyon**
16:00-17:00	**Talk 2: Study on the Human Biological Phenomena**	**Wanho Lee**

CT Session (Room: Zaffiro)

Time	Program	Speaker
18:30-19:30	**Tutorial 1: Sparse sensing: Fundamentals and applications in X-ray CT I**	**Hyoung Suk Park**
19:30-20:30	**Tutorial 2: A tutorial on Deep Learning: CNN I**	**Jin Keun Seo**

Group Meeting [IIRC Group meeting (Eung Je Woo) / Room: Rubino]

Time	Program	Speaker
14:00-18:30	**Group meeting**	**Eung Je Woo**

Day 1 / January 9 / Monday

Group Meeting [NA Group meeting (Jeehyun Lee) / Room: Zaffiro]

Time	Program	Speaker
09:30-12:00	**Group meeting**	**Jeehyun Lee**

Group Meeting [CFD Group meeting (Jung-il Choi) / Room: Rubino]

Time	Program	Speaker
13:30-13:50	**Large Eddy Simulation of Turbulent Boundary Layers with Surface Roughness**	**Geunwoo Oh**
13:50-14:10	**Physics of Atmospheric Boundary Layer and Related Numerical Simulations**	**Kyungmin Noh**
14:10-14:30	**Numerical Methods for Fluid-flexible Body Interactions**	**Ki-ha Kim**
14:30-14:50	**Numerical Modeling of Energy Storage System**	**Yunyoung Choi**
14:50-15:10	**Modeling of Air, Surface, and Underwater Burst Phenomena within Complex Environments after High-Energy Explosion**	**Seungho Song**
15:10-15:40	**Introduction to Probability and Likelihood**	**Sanghee Lee**
15:40-16:00	**Break**	
16:00-16:30	**Introduction to Bayesian Methods**	**Hyunsoon Cho**
16:30-17:00	**Procedure for Solving Nonlinear-ODEs**	**Jeyun Chun**
17:00-17:30	**Overview of Uncertainty Quantification**	**Sun Xiang**
17:30-17:50	**Characteristics of Chemotactical Bio-convection**	**Soomin Chun**

Group Meeting [CFD Group meeting (Changhoon Lee) / Room: Rubino]

Time	Program	Speaker
18:30-19:30	**Turbulence modification in particle-laden horizontal channel flow**	**Junghoon Lee**
19:30-20:30	**Immersed boundary method for a non-uniform grid**	**Juwon Jang**

Day 2 / January 10 / Tuesday

CT Session (Room: Zaffiro)

Time	Program	Speaker
08:30-09:20	**Deep learning**	**Jiashi Feng** *
09:40-10:00	**Wavelet domain deep learning approach for low-dose CT reconstruction**	**Jung Chul Ye**
10:00-10:20	**Discussions on x-ray tomography using sandwich detectors**	**Ho Kyung Kim**
10:20-10:40	**Double dose reduction in CT**	**Yong Eun Chung**
18:30-19:30	**Tutorial 1: Sparse sensing: Fundamentals and applications in X-ray CT II**	**Kyungsang Kim**
19:30-20:30	**Tutorial 2: A tutorial on Deep Learning: CNN II**	**Jin Keun Seo**

* Keynote Speaker

Imaging Session (Room: Granato)

Time	Program	Speaker
09:40-10:30	**Forward and inverse problems of computational geometry in various computer vision and computer graphics applications**	**Junghyun Cho**
11:00-11:30	**A Volume Integral Method for Solving Scattering Problems from Locally Perturbed Infinite Periodic Layers**	**Bumsu Kim**

Ultrasound Session (Room: Granato)

Time	Program	Speaker
13:30-14:30	**Tutorial 1: 심장 및 산부인과 초음파 진단의 임상적 이해**	**Soonjeong Jo**
14:30-15:20	**Tutorial 2: Tensorflow를 사용한 딥러닝 튜토리얼**	**Yoongu Hwang**
15:30-16:30	**Tutorial 2: Tensorflow를 사용한 딥러닝 튜토리얼 (심장영상에 응용)**	**Yoongu Hwang**
16:30-17:30	**Tutorial 3: CNN-based automatic measurement of fetal biometry**	**Jaeseong Jang**

Day 2 / January 10 / Tuesday

Phase Fields Session (Room: Rubino)

Time	Program	Speaker
14:00-14:30	**Numerical methods for phase-field models using convex splitting scheme**	**Jaemin Shin**
14:30-15:00	**A numerical method for the modified vector-valued Allen-Cahn model and its application to multiphase image segmentation**	**Hyun Geun Lee**
15:00-15:30	**Discussion**	**June-Yup Lee**

Group Meeting [NA Group meeting (Jeehyun Lee) / Room: Zaffiro]

Time	Program	Speaker
13:30-16:30	**Group meeting**	**Jeehyun Lee**

Group Meeting [CFD Group meeting (Jung-il Choi) / Room: Rubino]

Time	Program	Speaker
16:00-16:30	**Introduction to Bayesian Methods 2**	**Hyunsoon Cho**
16:30-17:00	**Procedure for Solving Nonlinear-ODEs 2**	**Jeyun Chun**
17:00-18:30	**Discussion**	**Jung-il Choi**

Group Meeting [CFD Group meeting (Changhoon Lee) / Room: Rubino]

Time	Program	Speaker
18:30-19:30	**Numerical simulation of low Reynolds number flow past Rotating in the Streamwise Direction**	**Hojun Lee**
19:30-20:30	**Investigation of particle laden shear turbulence using lyapunov exponent theory**	**Seulgi Lee**

Day 3 / January 11 / Wednesday

Microwave Session (Room: Granato)

Time	Program	Speaker
09:00-09:30	**Time-Domain Microwave Imaging for Breast Cancer Detection**	**Sol-Lip Kwon**
09:30-10:00	**An Introduction to Microwave Imaging – Having Continuous First and Second Derivatives**	**Hwa Pyung Kim**
10:00-10:30	**Basics of Static / Differential Microwave Tomography**	**Seong-Ho Son**
10:30-11:00	**Hardware and Experiments of Microwave Tomographic Imaging**	**Kwang-Jae Lee**
11:00-11:30	**MUSIC Algorithm for Small Anomaly Detection in Microwave Imaging**	**Won-Kwang Park**

Epidemiology Session (Room: Zaffiro)

Time	Program	Speaker
14:00-15:00	**Machine learning**	석정주,이윤정,장준영
15:00-16:00	**Deep learning**	황윤구

Main Topic : Current issues on X-ray computed tomography imaging

Keynote Talk : Deep Learning Solutions to Intelligent Image and Video Processing

Jiashi Feng / National University of Singapore

Deep learning is changing the landscape of image and video processing techniques. In this talk, I will introduce recent deep learning approaches developed by my group for solving fundamental problems in image and video processing, e.g., image/video super resolution, image denoising, small object detection. I will concentrate on presenting solutions to several practical issues in these applications such as how to achieve robustness to signal noise, how to integrate contextual information for content understanding and how to construct a network to learn in a self-evolving way. Towards solving these issues, I will introduce three new deep neural network models, which are recurrent attentive neural networks, multi-path feedback networks, and self-learning networks.

Tutorial 1 : Sparse sensing: Fundamentals and applications in X-ray CT

Hyoung Suk Park / NIMS

We provide a triangular mesh generation method based on elliptic partial differential equations. We first configure initial triangles generated by the body centered rectangular lattice, which are close to the target object. We obtain a deformation field by solving the proposed PDE to move the initial triangles in order to fit the boundary shape and guarantee regular shaped mesh. We discuss the benefit of the proposed algorithm in view of parallel computation.

※ 준비물 : MATLAB이 설치된 노트북을 개인적으로 지참

Tutorial 2 : A tutorial on Deep Learning: CNN I

Jin Keun Seo / Yonsei University

Machine learning techniques are increasingly being used in biomedical imaging. The growing demands placed on health care due to the rapid aging of the population over the last three decades have led to the development of numerous biomedical imaging modalities. This tutorial will teach you deep learning algorithms including CNN (convolution neural network). We also discuss about deep learning for medical imaging analysis.

※ 준비물 : MATLAB이 설치된 노트북을 개인적으로 지참

CT Talk 1 : Wavelet domain deep learning approach for low-dose CT reconstruction

Jung Chul Ye / KAIST

Purpose :
Due to the potential risk of inducing cancers, radiation dose of X-ray CT should be reduced for routine patient scanning. However, in low-dose X-ray CT, severe artifacts usually occur due to photon starvation, beamhardening, etc, which decrease the reliability of diagnosis. Thus, high quality reconstruction from low-dose X-ray CT data has become one of the important research topics in CT community. Conventional model-based denoising approaches are, however, computationally very expensive, and image domain denoising approaches hardly deal with CT specific noise patterns. To address these issues, we aim to develop a new algorithm for low-dose X-ray CT based on a novel deep learning approach.

CT Talk 1 : Wavelet domain deep learning approach for low-dose CT reconstruction

Jung Chul Ye / KAIST

Method :
We propose an algorithm using a deep convolutional neural network (CNN), which is applied to wavelet transform coefficients of low-dose CT images.
Specifically, by using a directional wavelet transform for extracting directional component of artifacts and exploiting the intra- and inter-band correlations, our deep network can effectively suppress CT specific noises. Moreover, our CNN is designed to have various types of residual learning architecture for faster network training and better denoising.

Results :
Experimental results confirm that the proposed algorithm effectively removes complex noise patterns of CT images, originated from the reduced X-ray dose.
In addition, we show that wavelet domain CNN is efficient in removing the noises from low-dose CT compared to an image domain CNN. Our results were rigorously evaluated by several radiologists in Mayo Clinic and won the second place award in 2016 ``Low-Dose CT Grand Challenge'' .

Conclusion :
To the best of our knowledge, this work is the first deep learning architecture for low-dose CT reconstruction that has been rigorously evaluated and proven for its efficacy. Moreover, unlike the existing model based iterative reconstruction (MBIR), the proposed algorithm has significant potential to be benefit from large-scale datasets. Therefore, we believe that the proposed algorithm guides a new direction in low-dose CT research.

CT Talk 2 : Discussions on x-ray tomography using sandwich detectors

Ho Kyung Kim / Pusan National University

For a single x-ray exposure, the back-to-back detector layers with different thicknesses of the phosphors acquire x-ray projections having different x-ray energy spectral information and spatial-resolution characteristics. Different energy measurements make energy-selective imaging possible and different spatial-resolution characteristics enhance details in the resulting dual-energy images. Using the sandwich detector, bone-enhanced tomographic images have been obtained for a postmortem mouse, and they outperform the tomographic images obtained from the conventional single-layer detectors in terms of visualizing bone details. This suggests a potential of x-ray microtomography with a sandwich detector for high-resolution bone-selective imaging without post-processing segmentation procedures. In this study, challenging issues that need to be addressed for the applications of the proposed imaging technique to quantitative imaging are discussed.

CT Talk 3 : CT technique update: double reduction in radiation dose and contrast amount

Yong Eun Chung / Yonsei University

Radiation dose reduction is an actively investigated field in the CT technology. The most effective way to reduce radiation dose is avoiding an unnecessary CT scan. If the CT scan should be performed for the diagnosis, dose optimization that reduces radiation exposure as low as reasonably achievable is necessary. There are two ways to reduce radiation dose during CT scan. The first and the simplest way to reduce radiation dose is lowering the tube current.
Automatic exposure control which can optimize tube current is widely used in most of commercialized CT scanners.
By applying automatic exposure control, tube current decreases or increases from the baseline value depending on the body shape and components, with preservation of predefined image noise (or quality), which results in reducing radiation

dose approximately 20-40%, compared to those without application of automatic exposure control. In contrast to adjusting tube current, tube voltage optimization is recently commercialized by a couple of vendors, even though decreasing tube voltage is a more effective way for reducing radiation dose than reducing tube current. This is because the radiation dose is proportional to tube current, whereas it is proportional to the square of tube voltage. When a tube voltage is changed, there are a couple of technical factors that should be concerned. First, image noise increases as tube voltage decreases. Considering that tube voltage is usually changed as a unit of 10 or 20 kVp in most commercialized scanners, the tube voltage might decrease from 120 kVp to 100 kVp or to 80 kVp. In such case, image noise markedly increases, resulting in significant deterioration of diagnostic performance. Hence, compensation by increasing the tube current is mandatory. Second, the attenuation value of the material changes when tube voltage is changed. This could affect imaging findings of certain lesions or diseases. Increasing image noise is inevitable when reducing the tube voltage or the current, and this results in decreasing signal to noise ratio and contrast to noise ratio in the tissue or between tissue and iodinated contrast media. In order to compensate for decreasing SNR and CNR, various kinds of iterative reconstruction methods have been developed, and most of which are already being used in daily practice. According to previous studies, the iterative reconstruction technique can improve SNR, CNR, and even diagnostic performance. However, there are still some technical issues which should be improved in the future, such as artificial image texture and long processing time. In terms of contrast media, it is responsible not only for non-renal adverse reactions such as anaphylaxis, but also for renal adverse reaction such as contrast induced nephropathy (CIN). CIN increases in-hospital mortality, and morbidity and is one of the leading causes of permanent renal dysfunction. According to previous studies, administered dose of contrast media is proportional to the risk of CIN. During the CT scan, administered dose of contrast media cannot be easily reduced because the optimal amount of contrast media is essential for the diagnosis of disease. Recently, with the widespread usage of low tube voltage technique, there is an attempt to reduce the amount of contrast media. With low kVp, attenuation coefficient of iodine increases as photon energy decreases toward k-edge energy of 33kV, resulting in increased HU of iodinated contrast media in CT images. Increased HU of iodinated contrast media can be used to improve CNR of the focal lesion such as hypervascular HCC or anatomical structures such as vessels, with preservation of exposed radiation dose. It can be also used for radiation dose reduction with preservation of CNR. Furthermore, adjusting CNR and radiation dose with the combination of iterative reconstruction technique, double dose reduction (i.e. reduction of both the amount of contrast media and radiation dose) protocol can be used without deteriorating diagnostic performance.

Tutorial 3 : Tutorial for analytic and iterative CT reconstruction programming | Kyungsang Kim / Harvard Medical School

Abstract: In this tutorial, the iterative CT reconstruction and metal artifact reduction (MAR) methods will be presented by example codes. We will provide the all example codes with MATLAB-based (MEX) functions such as forward and backward projectors. The XCAT phantom will be used in our simulation and the X-ray spectra profile will be generated, which can provide realistic CT measurements with beam-hardening effects. In the measurement, the Poisson noise will be applied. Reconstruction algorithms such as SART (simultaneous algebraic reconstruction technique), MLTR (maximum likelihood transmission) and SQS (separable quadratic surrogate) will be implemented with a penalty function. In addition, the inpainting-based MAR method will be introduced with examples. (Note that the MATLAB is REQUIRED)

※ 준비물 : MATLAB이 설치된 노트북을 개인적으로 지참

Machine learning techniques are increasingly being used in biomedical imaging. The growing demands placed on health care due to the rapid aging of the population over the last three decades have led to the development of numerous biomedical imaging modalities. This tutorial will teach you deep learning algorithms including CNN (convolution neural network). We also discuss about deep learning for medical imaging analysis.

※ 준비물 : 노트북을 개인적으로 지참

Topic : Understanding of Ultrasound Examinations and Applications of Deep Learning

Tutorial 1 : 심장 및 산부인과 초음파 진단의 임상적 이해	Soonjeong Jo / ALPINION MEDICAL SYSTEMS Corporation

심장초음파에서 많이 사용되는 임상 진단 방법 소개 및 2차원 및 3차원 초음파 영상에서의 측정방법, 컬러 도플러 영상에서의 측정방법, 도플러를 이용한 측정 방법을 소개하며, 산부인과 진료에서의 측정 방법도 추가로 설명한다.

Tutorial 2 : Tensorflow를 사용한 딥러닝 튜토리얼	Yoongu Hwang / Yonsei University

TensorFlow(Python)을 활용하여 hand-written digits(MNIST dataset)을 인식하는 것에 대해 참가자들이 직접 실습을 할 수 있도록 구성되었다. 특별히 Simple Regression Model과 Convolution Neural Network Model 2가지 방법을 이용하여 hand-written digits classification 문제를 해결하고자 한다.

※ 준비물 : TensorFlow 설치된 노트북, 설치방법 (https://www.tensorflow.org/get_started/os_setup) 참고

Tutorial 3 : Tensorflow를 사용한 딥러닝 튜토리얼 (심장영상에 응용)	Yoongu Hwang / Yonsei University

앞의 강연의 연장으로 hand-written digits classification 문제를 다루고 시간이 허락되는 경우 초음파 영상에서의 경계추출에 어떠한 방식으로 적용이 가능한지 소개한다.

※ 준비물 : TensorFlow 설치된 노트북, 설치방법 (https://www.tensorflow.org/get_started/os_setup) 참고

Tutorial 4 : CNN-based automatic measurement of fetal biometry	Jaeseong Jang / Yonsei University

Recently, convolutional neural networks (CNN) have shown great successes in the object recognition in natural images by learning high-level features with their deep network structures. Expanding their applications, CNN is considered as a promising framework for detection and segmentation problems in medical imaging. As the first trials, successful structures of CNN are directly applied to the problems. For segmentation in medical imaging, such direction applications reveal relatively high performance and stability compared to previous mathematical approaches. However, without any consideration of physical properties, such application has limitations to deal with and overcome characteristic artifacts of medical imaging modalities; for example, shadowing artifacts in ultrasound imaging. In this talk, we introduce a CNN structure which analysis high-level image feature and integrate it with characteristic properties of ultrasound imaging. Moreover, a framework which combines the structure with a level-set method is proposed to automate fetal biometry measurement in ultrasound images.

Topic : 국가수리과학연구소 내에서의 과제 소개

Talk 1 : Mathematical Data Analytics and Its Applications

현윤영 / NIMS

데이터분석은 사회, 문화, 과학, 정보통신 등 거의 모든 분야에서 새로운 가치를 찾고 많은 현상들을 분석/해석하기 위한 중요한 역할을 하고 있다. 국가수리과학연구소에서는 이와 관련하여 "빅데이터 분석모델 개발과 응용"연구과제를 진행하고 있으며, 데이터 분석방법론에 핵심역할을 할 수 있는 수리과학기반의 데이터 분석기법을 연구개발하고 있습니다. 본 발표에서는 데이터분석방법론을 수리과학 관점에서 설명하고 활용을 소개한다.

Talk 2 : Study on the Human Biological Phenomena

이완호 / NIMS

혈류 순환이나 세포 이동 등 인체 내에서 일어나는 복잡하고 다양한 현상을 이해하고 진단 및 치료에 활용하기 위해 수학적 모델이 급격하게 대두되고 있다. 이에 연구소에서 진행하고 있는 인체 내 생명현상과 관련된 수학적모델링 연구결과를 소개하고 활용방안에 대해 토의한다.

Topic : Computational Mathematics and Imaging

Talk 1: A Study for Mesh Generation using Partial Differential Equation

Kiwan Jeon / NIMS

We provide a triangular mesh generation method based on elliptic partial differential equations. We first configure initial triangles generated by the body centered rectangular lattice, which are close to the target object. We obtain a deformation field by solving the proposed PDE to move the initial triangles in order to fit the boundary shape and guarantee regular shaped mesh. We discuss the benefit of the proposed algorithm in view of parallel computation.

Talk 2 : Forward and inverse problems of computational geometry in various computer vision and computer graphics applications

Junghyun Cho / KIST

Problems of detecting, tracking and reconstructing objects in real life have been actively studied in computer vision and computer graphics as image capturing devices and the related software technologies have been advanced. To solve those problems, various methodologies of computational geometry are utilized. Particularly, this lecture introduces the basics of computational geometry needed to calculate a 3 dimensional surface from arbitrary points cloud, clean it up, parameterize it into 2 dimensional space, and find correspondences. Furthermore the trends of recent researches using deep learning will be discussed.

Talk 3 : Cardiac Motion Tracking in the Ultrasound Image Using the Optical Flow Estimation

Chang-Ock Lee / KAIST

심장 초음파 영상을 이용하여 좌심실 내벽을 3차원으로 영상화하고 내벽의 움직임을 관찰한 후 이를 이용하여 GLS(Global Longitudinal Strain)을 측정하면 확장성 심근증을 진단할 수 있다. 내벽의 움직임을 관찰하기 위하여 지금까지 Speckle Tracking 방법을 사용하여 왔으나 초음파 영상이 가지는 한계와 Speckle Tracking 방법의 한계로 인하여 신뢰할만한 결과를 얻기가 힘들었다. 본 연구에서는 광학 흐름 측정을 이용하여 심장운동을 추적하고 이를 GLS를 측정하는데 사용하고자 한다.

Talk 4 : Design of an energy functional and an initial curve for the shape prior segmentation

Doyeob Yeo / KAIST

심장 초음파 영상을 이용하여 좌심실 내벽을 3차원으로 영상화하고 내벽의 움직임을 관찰한 후 이를 이용하여 GLS(Global Longitudinal Strain)을 측정하면 확장성 심근증을 진단할 수 있다. 내벽의 움직임을 관찰하기 위하여 지금까지 Speckle Tracking 방법을 사용하여 왔으나 초음파 영상이 가지는 한계와 Speckle Tracking 방법의 한계로 인하여 신뢰할만한 결과를 얻기가 힘들었다. 본 연구에서는 광학 흐름 측정을 이용하여 심장운동을 추적하고 이를 GLS를 측정하는데 사용하고자 한다.

Talk 5 : A CT Metal Artifact Reduction Algorithm Based on Sinogram Surgery

Soomin Jeon / KAIST

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 a new algorithm to reduce the metal artifact. We do sinogram surgery, iteratively, to remove the metallic effect in the sinogram using the basic principle of CT image reconstruction.

Talk 5 : A CT Metal Artifact Reduction Algorithm Based on Sinogram Surgery

Soomin Jeon / KAIST

Numerical experiments show that our algorithm fills the missing sinogram data properly, and therefore the artifact in CT image is effectively removed. In this talk, we focus on the empirical analysis for the convergence of our algorithm.

[1] Abdoli, Mehrsima, et al. "Reduction of dental filling metallic artifacts in CT-based attenuation correction of PET data using weighted virtual sinograms optimized by a genetic algorithm."Medical physics 37.12 (2010): 6166-6177.
[2] Chen, Yang, et al. "CT metal artifact reduction method based on improved image segmentation and sinogram in-painting."Mathematical Problems in Engineering 2012 (2012).
[3] Zhang, Xiaomeng, Jing Wang, and Lei Xing. "Metal artifact reduction in x-ray computed tomography (CT) by constrained optimization."Medical physics 38.2 (2011): 701-711.
[4] Faridani, Adel. "Introduction to the mathematics of computed tomography."Inside Out: Inverse Problems and Applications 47 (2003): 1-46.

Talk 6: A Volume Integral Method for Solving Scattering Problems from Locally Perturbed Infinite Periodic Layers

Bumsu Kim / KAIST

In the paper of T. Nguyen and H. Haddar, the scattering problem for the case of locally perturbed periodic layers is formulated as an equivalent system of coupled volume integral equations using the Floquet-Bloch transform. To discretize the obtained system, a spectral method is applied. In this talk, we focus on this problem for the case that the perturbation is contained in multiple periods.

Topic : Microwave Tomography - A tutorial on microwave imaging technique

Talk 1 : Time-Domain Microwave Imaging System for Breast Cancer Detection

Sol-Lip Kwon / Ewha Womans University

전 세계적으로 유방암은 발생률이 매우 높은 암 중의 하나로 조기검진의 중요성이 강조되고 있다. 유방암의 조기검진 수단으로서 기존의 X-ray mammogram방식이외에 방사선 노출의 위험이 없는 microwave imaging 방식이 유럽, 미국, 캐나다 등 해외 여러 나라에서 활발히 연구되고 있다. Microwave imaging 방식은 계산방식에 따라 microwave tomography 방식과 microwave radar-based imaging 방식으로 나눌 수 있으며, 측정방식에 따라 주파수 영역 측정방식과 시간 영역 측정방식으로 나뉠 수 있다. 주파수영역측정방식은 원하는 frequency 대역을 sweep하며 frequence response를 측정하기 때문에 노이즈에 강하지만 상대적으로 신호측정시간이 길어 환자의 움직임으로 인한 distortion이 발생할 수 있다는 단점이 있다. 반면, 시간영역측정방식은 측정시간이 매우 짧아 이러한 distortion을 피할 수 있다는 장점이 있다. 하지만, 고주파수 신호를 샘플링하기 위해 매우 빠른 clock이 필요하기 때문에 clock jitter나 낮은 signal-to-noise(SNR)등으로 인해 결과영상의 질이 저하될 수 있다. 본 연구진은 다수의 CMOS 칩을 이용하여 시간영역에서 신호를 측정함으로써 매우 빠르고 저렴한 제작이 가능한 유방암 조기검진시스템을 제안하고, 시간영역에서 신호측정 시 발생 가능한 노이즈의 최소화를 위한 방안을 제시하였다.

Talk 2 : An Introduction to Microwave Imaging

Hwa Pyung Kim / Yonsei University

Microwave imaging을 처음 접하는 사람들을 위하여 학부생 및 신입대학원생도 이해할 수 있는 수준의 강의를 진행한다. 기초적인 전자기학과 편미분방정식을 통하여 모델링과 알고리즘을 소개하고 측정데이터와 영상의 상관관계 이해를 목표로 한다.

Talk 3 : Static and Differential Microwave Tomography

Seong-Ho Son / ETRI

ETRI에서 연구 중인 마이크로파 이용 정적 및 차분 이미징 기술의 원리와 그 응용 사례를 소개한다. 정적 이미징에서는 인체 암진단을 위한 3차원 영상복원 기술을 중심으로 다룬다. 그리고 최근 정적 이미징의 한계를 극복하기 위한 대안으로 실시간 차분 이미징 기술을 소개하고 그 기술의 파급효과에 대해 논한다.

Talk 4 : Hardware and Experiments of Microwave Tomographic Imaging

Kwang-Jae Lee / ETRI

ETRI에서 개발된 마이크로파 대역(3GHz)의 실시간 이미징 실험 장치 세트를 소개하며, 실시간 이미징 알고리즘을 적용한 실험결과에 대해 논한다. 또한 ETRI에서 연구하고 있는 차분 영상법을 적용한 결과도 다루며, 이에 관해 논한다.

Talk 5 : MUSIC Algorithm for Small Anomaly Detection in Microwave Imaging

Won-Kwang Park / Kookmin University

In this contribution, we consider well-known MUltiple SIgnal Classification (MUSIC)-type algorithm for a fast location detection of small anomaly from microwave data, which is motivated from the early breast cancer detection in biomedical engineering. We carefully analyze imaging functional adopted in MUSIC when the total number of antennas is small by establishing a relationship with an infinite series of Bessel functions of integer order and discuss some properties. This is based on the factorization of collected Multi-Static Response (MSR) matrix whose elements are measured S-parameters and the structure of nonzero singular vectors associated with the nonzero singular values. We present experimental result which demonstrates the pros and cons of the considered method in 1GHz frequency.

Topic : Computational Methods for Phase Fields Models

Talk 1 : Numerical methods for phase-field models using convex splitting scheme	Jaemin Shin / Ewha Womans University

Abstract: We present some numerical methods based on the convex splitting scheme for the phase-field equations. Since a phase-field equation is derived from gradient flow of an energy functional, the energy dissipation is an important property of the numerical method. We introduce various recent attempts for the high-order accuracy and discuss the energy stability of those attempts.

Talk 2 : A numerical method for the modified vector-valued Allen-Cahn model and its application to multiphase image segmentation	Hyun Geun LEE / Ewha Womans University

We present an efficient numerical method for multiphase image segmentation using a multiphase-field model. The method combines the vector-valued Allen - Cahn phase-field equation with initial data fitting terms containing prescribed interface width and fidelity constants. An efficient numerical solution is achieved using the recently developed hybrid operator splitting method for the vector-valued Allen - Cahn phase-field equation. We split the modified vector-valued Allen - Cahn equation into a nonlinear equation and a linear diffusion equation with a source term. The linear diffusion equation is discretized using an implicit scheme and the resulting implicit discrete system of equations is solved by a multigrid method. The nonlinear equation is solved semi-analytically using a closed-form solution. And by treating the source term of the linear diffusion equation explicitly, we solve the modified vector-valued Allen - Cahn equation in a decoupled way. By decoupling the governing equation, we can speed up the segmentation process with multiple phases. We perform some characteristic numerical experiments for multiphase image segmentation.