

# Workshop on Approximation Theory, Wavelets & Imaging

*In honour of Professor Lee Seng Luan's 80th birthday*

**8 July 2024, Monday, 9.30am to 5.00pm**

## Venue

Block S17, Level 4, Rooms 04-05 and 04-06  
Department of Mathematics  
National University of Singapore  
10 Lower Kent Ridge Road  
Singapore 119076

## **About the Workshop**

This workshop celebrates the achievements of Professor Lee Seng Luan on the occasion of his 80th birthday, recognising his pivotal role in cultivating a strong and dynamic applied mathematics community within the Department of Mathematics. It also honours his dedication to fostering interdisciplinary research and education, particularly in developing the fields of approximation theory, wavelet theory, and their applications. Presentations by current and former members of the approximation and wavelet group in the Department of Mathematics, including individuals who are pursuing successful careers in academia as well as industry, will showcase the profound and enduring impact of his leadership.

## **Register for the Workshop**

[qrstud.io/8jul24](https://qrstud.io/8jul24)



## Workshop on Approximation Theory, Wavelets and Imaging (8 July 2024)

Programme	
09:15am - 09:30am	<b>Registration</b>
	Venue: S17 #04-05 (Seminar Room 2) (Chair: Shen Zuowei)
09:30am - 09:40am	<b>Opening Remarks</b> Shen Zuowei, National University of Singapore, Singapore
09:40am - 10:40am	<b>From Applied Mathematics to Interdisciplinary Research and Education: Honouring Professor Lee Seng Luan's Contributions and Leadership</b> Goh Say Song, National University of Singapore, Singapore
10:40am - 11:10am	--- Coffee Break @ S17 Level 4 Staff Lounge ---
	Venue: S17 #04-05 (Seminar Room 2) (Chair: Shen Zuowei)
11:10am - 11:40am	<b>A Direct Time-frequency Method for Component Recovery of Multi-component Non-stationary Signals</b> Jiang Qingtang, University of Missouri at St. Louis, USA
11:40am - 12:10pm	<b>Generalizations of Poisson's Summation Formula</b> Wayne Lawton, Siberian Federal University, Russia
12:10pm - 02:00pm	--- Lunch Break @ S17 Level 4 Staff Lounge ---
	Venue: S17 #04-05 (Seminar Room 2) (Chair: Goh Say Song)
02:00pm - 02:30pm	<b>Barron Space for Graph Convolution Neural Networks</b> Sun Qiyu, University of Central Florida, USA
02:30pm - 03:00pm	<b>Computing Proximity Operators of Scale and Signed Permutation Invariant Functions</b> Shen Lixin, Syracuse University, USA
03:00pm - 03:30pm	<b>Splines and Wavelets for Biomedical Imaging Data Analysis</b> Wang Yu-Ping, Tulane University, USA
03:30pm - 04:00pm	--- Coffee Break @ S17 Level 4 Staff Lounge ---
	Venue: S17 #04-06 (Seminar Room 1) (Chair: Goh Say Song)
04:00pm - 05:00pm	<b>Panel Discussion</b> <b>From Academia to Industry: Charting the Journey from Graduate Studies to Professional Success</b> Liu Bao, Apple, USA Tham Jo Yew, ESP xMedia Pte. Ltd., Singapore Xia Tao, Piotech Inc, USA Yang Gan, NXP Semiconductors, USA

--- End of Programme ---

## Abstracts

### **From Applied Mathematics to Interdisciplinary Research and Education: Honouring Professor Lee Seng Luan's Contributions and Leadership**

*Goh Say Song*

*National University of Singapore, Singapore*

This talk will celebrate Professor Lee Seng Luan's visionary approach and his substantial contributions to the advancement of applied mathematics as well as interdisciplinary research and education. It will first trace his academic journey, beginning with his foundational work on cardinal Hermite B-splines and culminating in the groundbreaking development of multiwavelets, which significantly broadened the scope of the research area wavelets. A strong advocate of interdisciplinary collaboration, Professor Lee foresaw the rich potential of integrating mathematical theories with practical problem-solving. In the 1990s, he pioneered the formation of a multidisciplinary research team, who subsequently became core members of the Centre for Wavelets, Approximation and Information Processing, within the Department of Mathematics, spearheading the application of wavelet-based methodologies to areas such as signal processing, image and video compression, and fingerprint identification. This initiative not only ushered in a new era of interdisciplinary research within the Department but also contributed to the subsequent growth of its applied mathematics community. In recognition of his achievements, Professor Lee jointly received a National Science Award in 1998. His dedication to mentorship has also empowered a new generation of scholars, providing them with invaluable guidance and fostering their development. As Head of Department from 2000 to 2006, Professor Lee was instrumental in expanding the Applied Mathematics and Quantitative Finance undergraduate programmes to address the evolving demands of industry and academia.

### **A Direct Time-frequency Method for Component Recovery of Multi-component Non-stationary Signals**

*Jiang Qingtang*

*University of Missouri at St. Louis, USA*

Recently a direct time-frequency method to recover a component of a multi-component non-stationary signal is proposed. More precisely, a component is recovered by simply plugging the corresponding ridge of the signal separation operator (SSO), a variant of the short-time Fourier transform, to SSO. In this talk, firstly, we will show how this approach results in a more accurate component recovery formula when a linear chirp local approximation is applied. Secondly, we will discuss how the SSO approach leads to our most recently developed time-scale-chirp\_rate (TSC\_R) and time-frequency-chirp\_rate (TFC\_R) method to separate multi-component signals even with crossover instantaneous frequency curves. Our TSC\_R (TFC\_R resp.) maps a signal into a 3-dimensional space of time, scale and chirp-rate (time, frequency and chirp-rate resp.), as opposed to the traditional 2-dimensional space of time and scale (time and frequency resp.). Demonstrative examples will also be presented.

# Abstracts

## Generalizations of Poisson's Summation Formula

Wayne Lawton  
Siberian Federal University, Russia

Dirac's comb on  $\mathbb{R}^d$  is the sum of point measures at integer lattice points. Poisson's summation formula, which says that it equals its Fourier transform, has diverse applications from analytic number theory to signal processing. We discuss generalizations including almost periodic measures and Fourier quasicrystals.

## Barron Space for Graph Convolution Neural Networks

Sun Qiyu  
University of Central Florida, USA

In this talk, we introduce a Barron space of functions on a compact domain of graph signals, discuss its various properties, such as reproducing kernel Banach space property and universal approximation property. We will also discuss well approximation property of functions in the Barron space by outputs of some graph convolution neural networks, and learnability of functions in the Barron space from their random samples.

## Computing Proximity Operators of Scale and Signed Permutation Invariant Functions

Shen Lixin  
Syracuse University, USA

This presentation focused on computing proximity operators for scale and signed permutation invariant functions. A scale-invariant function remains unchanged under uniform scaling, while a signed permutation invariant function retains its structure despite permutations and sign changes applied to its input variables. Noteworthy examples include the  $\ell_0$  function and the ratios of  $\ell_1/\ell_2$  and its square, with their proximity operators being particularly crucial in sparse signal recovery. We delve into the properties of scale and signed permutation invariant functions, delineating the computation of their proximity operators into three sequential steps: the  $w$ -step,  $r$ -step, and  $d$ -step. These steps collectively form a procedure termed as WRD, with the  $w$ -step being of utmost importance and requiring careful treatment. Leveraging this procedure, we present a method for explicitly computing the proximity operator of  $(\ell_1/\ell_2)^2$  and introduce an efficient algorithm for the proximity operator of  $\ell_1/\ell_2$ .

# Abstracts

## **Splines and Wavelets for Biomedical Imaging Data Analysis**

*Wang Yu-Ping*  
*Tulane University, USA*

In this talk, I will first give a brief review of my work on splines and wavelets at NUS Centre for Wavelets, Approximation and Information Processing back in 1996-1999, where I proposed scale-space theory derived from B-splines and a class of differential wavelets. Then, I will present two successful applications of splines and wavelets for biomedical imaging data analysis after moving to USA. The first application is to apply splines for fast and accurate estimation of motion of the heart based on tagged MRI data for improved diagnosis of cardiovascular diseases. The second application is to use the differential wavelets to enhance chromosome images, leading to better classification of chromosomes for prenatal diagnosis and cancer research. Finally, I will introduce my current work at Tulane University on the integration of multi-modal brain imaging and genomics data for precision medicine.

## **Panel Discussion**

### **From Academia to Industry: Charting the Journey from Graduate Studies to Professional Success**

*Liu Bao, Apple, USA*  
*Tham Jo Yew, ESP xMedia Pte. Ltd., Singapore*  
*Xia Tao, Piotech Inc, USA*  
*Yang Gan, NXP Semiconductors, USA*

The leap from higher education to industry is a pivotal stage for many graduate students. Emphasising the necessity of an interdisciplinary approach and the application of the robust analytical skills honed during graduate studies, this panel discussion offers a comprehensive exploration of the journey that awaits MSc and PhD graduates who are looking to bridge the gap between academic accomplishment and professional fulfilment in the industry. Panellists will provide candid reflections on their personal pathways, highlighting the obstacles they encountered and the successes they achieved within various industrial domains. Attendees of the session will be encouraged to engage with live inquiries and raise pertinent topics for discussion. Discussions will revolve around the symbiotic relationship between advanced academic preparation and industry expectations, strategic planning for entering the corporate sector, the diverse opportunities ranging from employment in small to large-scale organisations to the launch of deep tech ventures, as well as the innovative trends and fruitful careers found in today's industrial research and development.