GIAN Course on

Theory and Application of Wavelets and Framelets

28 December 2017 – 04 January 2018

Overview

As the major tool for multiscale data analysis, wavelets have a wide scope of applications in mathematics, engineering, physics, sciences, and industries. For example, wavelets have been adopted in JPEG-2000 standard for image compression, and wavelet subdivision algorithms have been used in animation movie industry. Being a multidisciplinary research area, wavelets and framelets are very effective for representing various functions and data. The great success of wavelets and framelets largely lies in their many desired properties such as multiscale structure, sparse representation, efficient approximation schemes, good time-frequency localization, and fast computational algorithms. In comparison to traditional wavelets, framelets have the desired properties of redundancy for robustness and flexibility for adaptive custom design. The current developments on wavelet theory are focusing on framelet aspects and their applications in high-dimensional data analysis. For example, algorithms using framelets currently provide the-state-of-the-art results in image processing, and are popular in geometric modelling processing.

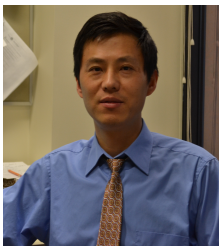
Objectives

Introduce the algorithms and basic theory of wavelets and framelets to students and interested researchers. This will equip the students and researchers the basic knowledge on wavelet theory, teach them how to develop and implement their own fast framelet/wavelet transforms, and introduce them to design their own wavelets and framelets for their own purposes. Bring the students and researchers to the wide scope of applications using wavelets and framelets. There are numerous applications of wavelets and framelets and we mainly concentrate on their applications to signal/image processing and geometric modelling. Throughout the lectures and tutorials, the students and researchers will become familiar with how to concretely use/implement wavelets and framelets to solve some practical problems in applications. Present some most recent developments on wavelets and framelets. This allows the students and researchers to become aware what are the current frontiers of wavelet theory and what are the possible further developments and applications of wavelets and framelets. The students' knowledge about the course content will be raised to the level such that they will be able to use wavelets and framelets for their own applications and research.

Modules A: **Fast Framelets and Wavelet Transforms**	**Topics of Lecture:** • A short naïve introduction to wavelets for everyone: What is a wavelet? • Perfect reconstruction, sparsity and vanishing moments of framelet and wavelet transforms • Multilevel structure of framelet/wavelet transforms and their variants • How to implement fast framelet and wavelet transforms for practical data • How to process wavelet or framelet coefficients: wavelet shrinkage **Topics of Tutorial:** • Introduction to framelet and wavelet transforms • Demonstration and examples on wavelet transforms using matlab toolbox • Explore framelet transforms and discuss their differences to wavelets • Wavelet applications to the signal denoising problem

Modules B: **Mathematical Theory of Wavelets and Framelets**	**Topics of Lecture:** • Frames and bases in Hilbert spaces, in finite dimensional spaces, and in shift-invariant spaces • Sampling theorems in shift-invariant spaces for signal processing • Multiresolution analysis and orthogonal wavelets • Compactly supported Daubechies orthogonal wavelets • Refinable functions and theory of tight framelets • Basic desirable properties of wavelets and framelets **Topics of Tutorial:** • Explore sampling theorems in shift-invariant spaces generated by B-splines • Design and implement orthogonal wavelets • How to design and implement tight framelet filter banks • Use subdivision schemes and cascade algorithms to plot wavelets and refinable functions
Modules C: **Applications of Wavelets and Framelets**	**Topics of Lecture:** • Tensor production and high-dimensional wavelets and framelets • Introduction of subdivision schemes and cascade algorithms • Wavelet subdivision for computer graphics and geometric modeling • Dual-tree complex wavelet transform and directional complex tight framelets **Topics of Tutorial:** • Explore tensor product wavelet/framelet algorithms for high-dimensional data • Image models and wavelet-based algorithms for image processing • Use subdivision schemes to generate subdivision curves for geometric modeling • Applications of directional framelets and wavelets to image processing • Problem solving session with examples in image processing
You Should Attend If…	• You are students at all levels (BTech/MSc/MTech/PhD/Post Doc) or Faculty from reputed academic institutions and technical institutions. • You are executives, engineers and researchers from manufacturing, service and government organizations including R&D laboratories.
Max. No. of Participants	50
Fees	**Participants from abroad: US $200** **MSc/M.Phil/B.Tech/M. Tech. Students: Rs. 1,000/-** **Ph.D. Student/ Post Doctoral Participants: Rs. 2,000/-** **Faculty Participants: Rs. 2,500/-** **Government Research Organization Participants: Rs. 3,000/-** **Industry Participants: Rs. 5,000/-** The above fee includes lunch, instructional materials, 24 hours internet facility.
Accommodation	The participants may be provided with hostel accommodation, depending on availability, on payment basis. For any query, please send an email to nirajshukla@iiti.ac.in.

The Faculty



Prof. Bin Han is a full professor of mathematics at the Department of Mathematical and Statistical Sciences in the University of Alberta, Canada. The research area of Bin Han includes applied harmonic analysis, wavelet analysis and their applications in computer graphics, image/signal processing, and numerical algorithms. Bin Han serves as an editor for four academic SCI journals including Applied and Computational Harmonic Analysis and Journal of Approximation Theory. Bin Han is an author of more than 85 papers in top academic SCI journals and is the author of the book: *Framelets and wavelets: algorithms, analysis, and applications.* According to SCI citation for recent 10-year work, he is ranked within top 200 in mathematics with several of his papers cited 299, 132 and 118 times. He has been invited to present many invited talks including five plenary talks in major international conferences in the area of wavelets, approximation theory, and applied and computational harmonic analysis. For example, he presented a 1-hour plenary talk in the 13th International Conference on Approximation Theory in March 2010 at San Antonio, USA. He served as the director of the Applied Mathematics Institute at the University of Alberta from 2012 to 2015. He has supervised 5 PhD students, 4 MSc students, and 5 postdoctoral fellows. For more details, please visit https://sites.ualberta.ca/~bhan/.

Dr. Niraj K. Shukla is working as an Assistant Professor in Discipline of Mathematics, IIT Indore. His research interest is Wavelet, Frame and Harmonic Analysis.

For more details, please visit http://iiti.ac.in/people/~nirajshukla/.

Duration:

December 28, 2017-
January 04, 2018

Course Co-ordinator

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Course Web-page:
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Registration Link:
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