FOUNDATIONS OF WAVELETS AND MULTIRATE DIGITAL SIGNAL PROCESSING

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PRE-REQUISITES : Exposure to Signals and systems, Some basic Engineering Mathematics

INTENDED AUDIENCE : Students of BE/ME/MSc/PhD, Both UG/PG can take this course

COURSE OUTLINE :

The word 'wavelet' refers to a little wave. Wavelets are functions designed to be considerably localized in both time and frequency domains. There are many practical situations in which one needs to analyze the signal simultaneously in both the time and frequency domains, for example, in audio processing, image enhancement, analysis and processing, geophysics and in biomedical engineering. Such analysis requires the engineer and researcher to deal with such functions, that have an inherent ability to localize as much as possible in the two domains simultaneously.This poses a fundamental challenge because such a simultaneous localization is ultimately restricted by the uncertainty principle for signal processing. Wavelet transforms have recently gained popularity in those fields where Fourier analysis has been traditionally used because of the property which enables them to capture local signal behavior. The whole idea of wavelets manifests itself differently in many different disciplines, although the basic principles remain the same.Aim of the course is to introduce the idea of wavelets. Haar wavelets has been introduced as an important tool in the analysis of signal at various level of resolution. Keeping this goal in mind, idea of representing a general finite energy signal by a piecewise constant representation is developed. Concept of Ladder of subspaces, in particular the notion of 'approximation' and 'Incremental' subspaces is introduced. Connection between wavelet analysis and multirate digital systems have been emphasized, which brings us to the need of establishing equivalence of sequences and finite energy signals and this goal is achieved by the application of basic ideas from linear algebra. Towards the end, relation between wavelets and multirate filter banks, from the point of view of implementation is explained

ABOUT INSTRUCTOR :

Prof. Vikram M. Gadre is currently a Professor at Department of Electrical Engineering, IIT Bombay. He received his Undergraduate degree, along with President’s Gold Medal for cumulative performance during his B.Tech, from IIT Delhi in 1989. He received his PhD degree in Electrical Engineering from Indian Institute of Technology, Delhi in 1994.His research interests are Communication and signal processing, with emphasis on multiresolution and multi-rate signal processing, especially wavelets and filter banks: theory and applications. He is known for his unique way of teaching for which he received Award for Excellence in Teaching four times from IIT Bombay.His other recognitions and awards include: S.S.I. Varshney Award from the Systems Society of India (S.S.I) (2011), IIT Bombay Research Paper Award (2008), Felicitation from Society for Cancer Research and Communication (SCRAC), India (2006), Sixth SVC Aiya Memorial Award for Telecom Education from IETE Pune Centre (2005), 11th IETE Prof K Sreenivasan Memorial Award(2004), INAE Young Engineer Award from the Indian National Academy of Engineers (2001), Student Journal Award of the IETE(1994), Adarsh Ratna Bhagat Award from National Service Scheme,IIT Delhi(1992)

COURSE PLAN :

Week 1: Introduction
- Origin of Wavelets
- Haar Wavelet
- Dyadic Wavelet
- Dilates and Translates of Haar Wavelets
- L2 norm of a function

Week 2: Piecewise Constant Representation of a Function
- Ladder of Subspaces
- Scaling Function of Haar Wavelet
- Demonstration: Piecewise constant approximation of functions
- Vector Representation of Sequences
- Properties of Norm
- Parseval's Theorem

Week 3: Equivalence of functions & sequences
Angle between Functions & their Decomposition
Additional Information on Direct-Sum
Introduction to Filter Bank
Haar Analysis Filter Bank in Z-domain
Haar Synthesis Filter Bank in Z-omain

Week 4: Moving from Z-domain to frequency domain
Frequency Response of Haar Analysis Low pass Filter bank
Frequency Response of Haar Analysis High pass Filter bank
Ideal Two-band Filter bank
Disqualification of Ideal Filter bank
Realizable Two-band Filter bank
Demonstration: DWT of images

Week 5: Relating Fourier transform of scaling function to filter bank
Fourier transform of scaling function
Construction of scaling and wavelet functions from filter bank
Demonstration: Constructing scaling and wavelet functions
Conclusive Remarks and Future Prospects