The University Of Sheffield.

Electronic & Electrical Engineering.

EEE6209 ADVANCED SIGNAL PROCESSING

Credits: 15

Course Description including Aims

This unit focuses on introducing advanced signal processing methods and technologies and their applications. The aims are:

1. Provide an understanding of advanced filter design concepts and applications.
2. Extend filter design into scenarios where sampling rate conversions, poly-phase filter banks and adaptive filtering are required.
3. Develop the concept of transforms and transform domain processing.
4. Develop the concept of random signals and processes and their analysis and apply them to the area of adaptive filtering with various applications.
5. Introduce the extension of above into multidimensional signal processing.

Outline Syllabus

Multi-rate signal processing, filter bank theory, signal transforms, wavelets, multi-dimensional signal processing (2D and 3D), Multi resolution analysis, random signal and process analysis and adaptive filtering theory. The coursework component of this unit aims to provide an understanding of using software tools, such as MATLAB, in solving problems and implementing signal processing algorithms.

Time Allocation

30 lectures, 2 coursework support sessions, 2 programming sessions and 2 problem solving classes

Recommended Previous Courses

Digital signal processing - - Mathematical background for signal and systems analysis – LTI systems, convolution, impulse response, the concept of transforms, the Fourier Transform, FIR filters and design, analog-to-digital conversion, MATLAB programming

Assessment

2 hours formal examination 3/4 questions (75%) plus coursework based assessment (25%)

Recommended Books

1. Digital Signal Processing : Concepts and Applications -- Mulgrew, Grant and Thompson.
2. Digital Signal Processing - J. Proakis & D. Manalokis (Prentice Hall).
3. Wavelets & Subband coding -- M. Vetterli & J. Kovacavic. (available online at http://www.waveletsandsubbandcoding.org/)
4. Discrete-time Signal Processing – A. Oppenheim and R. Schafer

Objectives

By the end of the unit, a candidate will be able to demonstrate the ability to:

1. Design filters appreciating time and frequency domain performance, computational complexity and other implementation-related issues.
2. Carry out filter design and implementation for sampling rate conversions including decimation (d), interpolation (i), and a rational factor (i/d).
3. Understand the polyphase representations of filter banks, formulate different filter bank design provide the corresponding solutions and application of designing wavelet transforms.
4. Understand the concept of transforms, design, implement and use signal transforms in various applications.
5. Perform analysis and compute statistics of random signals.
6. Understand the Wiener filter solution and the least mean square type adaptive algorithms and apply them to solve adaptive filtering problems.
7. Extend above techniques for multi-dimensional signal processing.
8. Use MATLAB in designing and implementing the above concepts and using them in suitable applications.

Detailed Syllabus

1) Linear time invariant systems, filters, convolution, impulse response, step response, frequency response, time-domain parameters, frequency domain parameters, filter design, moving average filters, recursive implementation, multistage moving average filters, complexity, 2D and higher dimensional filters and applications.
2) Decimation, Interpolation, Sampling rate conversion (by integer and non-integer factors), anti-aliaisng filters, anti-imaging filters, multistage sampling, complexity calculation and reduction, applications.
3) Transforms, basis functions, orthogonality, matrix representation, Parseval's theorem, discrete Cosine Transform (DCT), 2D and higher dimensional transforms, transform applications
4) Filter banks, wavelets, dyadic decomposition, wavelet packets, orthogonal and biorthogonal wavelets, subband coding. Wavelets on multidimensional signals, lifting, low complexity transform solutions, wavelet domain processing, multi-resolution analysis, applications.
5) Random processes, averages and spectral representations, autocorrelation and autocovariance, correlation and dependence, power spectral density, alernative representations of a random process.
6) Random signals and discrete linear systems, cross-correlation between the input and the output of a filter, filter noise calculations (quantization noise, dynamic range).
7) Wiener filters, algorithms for adaptive filtering, applications

UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1m / SM1fl	Module aims to provide detailed understanding on transforms-based multi-resolution representation and processing, random signal analysis and adaptive filtering. Assessment –final exam
SM2m	Understanding of random signals and systems and apply them to adaptive filtering and transform domain applications.

	Assessment –Final exam
SM2fl	Most recent development in the area of transforms, transform domain processing and multiresolution analysis are introduced in this module.Assessment Final exam
EA2fl	Through the coursework students are expected to apply the knowledge to new applications Assessment Coursework report
EA3m / EA3fl	Students use MATLAB for implementing the algorithms to try examples
	Assessment – Coursework
EA5m	Through the coursework students are expected to apply the knowledge to new applications
	Assessment –Coursework report
SM4m	Most recent development in the area of transforms, transform domain processing and multiresolution analysis are introduced in this module.
	Assessment – Final exam
D2fl	Students are expected to apply the knowledge into designing a solution for a problem with different unfamiliar signal scenarios.
	Assessment - Coursework