Adaptive Filtering & Linear Algebra

steepest ascent

SYLLABUS

Review: Signal Processing Review
- Signal, systems and applications
- Linear Algebra/Matrix DSP systems

Review: Matrix Methods
- Matrices and linear algebra
- Matrix additions and multiplies
- Vectors
- Row and Column vectors
- Transpose matrices
- Complex matrices
- Hermitian transpose

Matrix properties
- The identity matrix
- Symmetric matrices
- Diagonal matrices
- Triangular matrices (upper and lower)
- Positive definite matrices
- Condition numbers
- Orthogonal Matrices
- Matrix inverse

Defining DSP Systems with Matrices
- FIR and IIR filters
- The DFT and IDFT
- OFDM Implementations
- Farrow filters for resampling
- Covariance matrices and properties
- Adaptive Filters
- Interleaving
- Hadamard matrices
- MIMO implementations / Smart Antennas
- Adaptive beamforming

Adaptive Filters
- Overdetermined system
- The method of least squares (pseudoinverse)
- The Wiener Hopf solution
- Gradient based methods
- Least mean square (LMS) methods
- Recursive least squares (RLS)
- RLS versus LMS
- Kalman implementations

Adaptive DSP Applications
- System Identification
- Inverse System Identification
- Noise cancellation
- Predictive Systems
- Multichannel systems
- Oversampling DSP systems

Complex Arithmetic Adaptive Systems
- The basic QAM RF system and baseband model
- Complex FIR filters for baseband IQ modelling
- Complex adaptive FIR Filters
- Complex arithmetic requirements
- Working with complex matrices

Linear Systems of Equations
- Simultaneous equations
- Linear set of equations
- Solution by Gaussian elimination
- Gaussian elimination with pivoting
- Underdetermined sets of equations
- Overdetermined sets of equations
- LU Decomposition
- Cholesky (LL^T Decomposition)
- Eigenvalue decomposition
- Singular value decomposition (SVD)

Matrix Inverse Methods
- Square sets of simultaneous equations
- Defining and calculating the matrix inverse
- Inverse of a diagonal matrix
- Method of backsubstitution
- Inverse of a triangular matrix and LU decomposition
- Practical Implementation on DSP processors

The QR Algorithm
- The QR Decompositions
- Orthogonality of Q; Upper Triangular nature of R
- Relation to Cholesky decomposition
- Householder decomposition
- Givens rotation based decomposition
- Systolic / parallel array for Givens based QR
- Solving linear sets of equations

QR/Cholesky Applications Smart Antenna
- High speed adaptive filters
- Adaptive least squares equalisation
- Adaptive beamforming methods
- Smart Antennas
- MIMO (multiply in-multiple out)
- Processing speed requirements

Real Time Arithmetic Requirements
- Overflow and underflow issues
- Multiply and addition requirements
- Floating point and fixed point implementations
- How many bits? (... certainly more than 16!)
- Square root and divide in QR
- *"Square root free"* methods for QR
- Using CORDIC to calculate sine and cosine
- Numerical integrity and round off noise
- Wordlength requirements
- Floating point implementations and issues
- DSP processors versus FPGAs.

Case Studies
- Baseband RF Channel Identification
- Baseband Acoustic System Identification
- QR using FPGA logic
- Complex channel equalisation
- FPGA implementation of Adaptive Systems
- QR arithmetic implementation using CORDIC
- Backsubstitution on co-processors
- MIMO Channel modelling, 802.11n, 3G SCM

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