CURRICULUM AND SYLLABUS FOR

M.TECH IN ELECTRONICS

WITH SPECIALIZATION IN

SIGNAL PROCESSING

of Cochin University of Science & Technology (CUSAT)

at

Govt. Model Engineering College, Thrikkakara

(Managed by IHRD, Govt. of Kerala)
# Proposed Course Structure for M.Tech in Electronics with Specialization in Signal Processing

## First Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of Course</th>
<th>Internal Marks</th>
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<tbody>
<tr>
<td>SP101</td>
<td>Fundamentals of Spectral estimation</td>
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<td>SP102</td>
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List of Electives

**First Semester**

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Module 1:  
**Fundamentals of Discrete Time Signal Processing:**
Mathematical representation of Signals, Transform Domain representation of Continous and Discrete signals, Fourier Series and Fourier Transforms, Sampling, DFT, Z Transform, Representing narrow band signals, Discrete Time systems, Analysis of LTI Systems, Response to Periodic inputs, Correlation analysis and spectral density, Minimum phase and system invertibility, All pass systems, Minimum phase and all pass decomposition, Spectral factorization.

Module 2:  
**Random variables, vectors and sequences:**

Module 3  
**Linear signal models:** Linear non parametric signal models, parametric pole zero signal models, Mixed Processes and the Wold decomposition, all-pole models, Linear Prediction, Autoregressive models, all zero models, Moving average models, pole-zero models, Auto regressive Moving Average Models.

Module 4  
**Non Parametric spectral estimation:** Spectral analysis of deterministic signals, Estimating auto correlation of stationary random signals, estimating power spectrum of stationary random signals-periodogram, Blackmann Tukey method, Welch Bartlett method.

Module 5  
**Parametric Model Based spectral analysis:** Spectral analysis based on AR, MA or ARMA, relation between model parameters and the auto correlation sequence, Power spectrum estimation using an AR model- the Yule Walker method.

**Text Book:**

**References:**
1. Introduction to spectral analysis, Stoica, R L Moses, Prentice Hall  
Module 1

**MSI and LSI circuits and their applications:** Arithmetic circuits, comparators, Multiplexers, Code Converters, XOR & AOI Gates, Wired Logic, Bus-oriented structures, Tri-state bus systems, Propagation Delay

Module 2

**Sequential Circuit Design:** Clocked Synchronous State Machine Analysis, Mealy and Moore machines, Finite State Machine design procedure –state diagrams, state tables, state reduction methods, state assignments. Incompletely specified state machines, implementing the states of FSM

Module 3

**Designing with Programmable Logic Devices:** Read Only Memories, Programmable Array Logic, Programmable Logic Arrays, PLA minimization and PLA folding, Other Sequential PLDs, Design of combinational and sequential circuits using PLDs. XILINX FPGAs – Configurable Logic Block (CLB), Input/ Output Block(IOB), Programmable Interconnection Points(PIP), XILINX CPLDs

Module 4

**Asynchronous sequential circuits:** Derivation of excitation table, Race conditions and cycles, Static and dynamic hazards, Methods for avoiding races and hazards, essential hazards, Designing with SM charts – State machine charts, Derivation of SM charts, and Realization of SM charts.

Module 5

**Advanced Topics in Boolean algebra:** Shannon’s Expansion Theorem, Consensus Theorem, Reed Muller Expansion, Design of Static Hazard free and dynamic hazard free logic circuits, Threshold logic, Symmetric functions

TEXT BOOKS


REFERENCES

SP 103 Digital Communication Techniques

Module I:
Random Variables and processes: Review of random variable: Moment generating function, Chernoff bound, Markov’s inequality, Chebyshev's inequality, Central limit theorem, Chi square, Rayleigh and Rician distributions, correlation, Covariance matrix- Stationary processes, wide sense stationary processes, ergodic process, cross correlation and autocorrelation functions- Gaussian process

Module II:
Communication over Additive Gaussian noise channels: Characterization of communication signals and systems- signal space representation-connecting linear vector space to physical waveform space- scalar and vector communication over memory less channels. Optimum waveform receiver in additive white gaussian noise (AWGN) channels

Module III:
Cross correlation receiver, Matched filter receiver and error probabilities. Optimum receiver for signals with random phase in AWGN channels-optimum receiver for binary signals- optimum receiver for M-ary orthogonal signals- probability of error for envelope detection of M-ary orthogonal signals, Optimum waveform receiver for colored gaussian noise channels- Karhunen-Loeve expansion approach, whitening

Module IV:
Digital communication over fading channels Characterization of fading multipath channels- Statistical models for fading channels- Time varying channel impulse response- narrow band fading models- wideband fading models- channel correlation functions- key multipath parameters- Rayleigh and Ricean fading channels, Optimum non-coherent receiver in random amplitude, random phase channels- performance of non-coherent receiver in random amplitude, random phase channels- performance in Rayleigh and Rician channels- performance of digital modulation schemes such as BPSK, QPSK, FSK, DPSK etc over wireless channels

Module V:
Communication over band limited channels: Communication over band limited channels- Optimum pulse shaping- Nyquist criterion for zero ISI, partial response signaling- equalization techniques- zero forcing linear equalization- decision feedback equalization

Text Book:

Reference Books:
SP 104 Multidimensional signal processing

Module 1
Multidimensional Discrete signals and Multidimensional systems: Frequency domain characterization of multidimensional signals and systems, sampling two dimensional signals, processing continuous signals with discrete systems,

Discrete Fourier analysis of multidimensional signals: Discrete Fourier series representation of rectangularly periodic sequences, Multidimensional DFT, definition an properties, Calculation of DFT, Vector radix FFT, Discrete Fourier transforms for general periodically sampled signals, relationship between M dimensional and one dimensional DFTs.

Module 2
Design and implementation of two dimensional FIR filters: Implementation, Design using windows, Optimal FIR filter design- least squares design, Design of cascaded and parallel 2 D FIR filters, Design and implementation of FIR filters using transformations

Module 3
Multidimensional Recursive systems: Finite order difference equations- realizing LSI systems using difference equations, recursive computability, boundary conditions, ordering the computation of output samples, Multidimensional Z Transforms, stability of 2 D recursive systems, stability theorems, Two dimensional complex cepstrum.

Module 4
Design and implementation of two dimensional IIR filters: classical 2 D IIR filter implementations, Iterative implementation of 2 D IIR filters, signal flow graphs- circuit elements and their realizations, state variable realizations, Space domain Design techniques- Shank's method, Descent methods, Iterative pre-filtering design method, Frequency domain design techniques, stabilization techniques.

Module 5
2 dimensional Inverse problems: Constrained iterative signal restoration; iterative techniques for constrained deconvolution and signal extrapolation, reconstructions from phase or magnitude, Reconstruction of signals from their projections: Projection slice theorem, Discretization of the Reconstruction problem, Fourier domain reconstruction algorithms, Convolution/ back-projection algorithms, iterative reconstruction algorithms, Fan beam algorithms, Projection of discrete signals.

Text Book

References
1. Digital Signal and Image Processing- Tamal Bose, John Wiley publishers.
2. Two dimensional signal and Image Processing- J S Lim, Prentice Hall.
Module 1
Introduction to Biomedical Signals - Examples and acquisition of Biomedical signals - ECG, EEG, EMG etc. - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio potentials

Module 2
Review of linear systems - Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals - Processing of Random & Stochastic signals - spectral estimation - Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments

Module 3

Module 4

Module 5

Text Book
2. Biosignal and Biomedical Image Processing, Marcel Dekker, Semmlow, 2004

Reference Books:
2. Bioelectrical Signal Processing in Cardiac & Neurological Applications, Sörnmo, Elsevier
4. Introduction to Biomedical Engineering, 2/e, Enderle, Elsevier, 2005
SP 106 Multirate Signal Processing

Module 1

Basic Sampling alteration schemes: Time-Domain Representation of Down-Sampling and Up-Sampling, Frequency-Domain Characterization of Down-Sampling and Up-Sampling, Decimation and Interpolation-Identities, Cascading, Sampling-Rate Alteration Devices, Polyphase Decomposition, Multistage Systems.

Module 2
Filters in Multirate Systems: Spectral Characteristics of Decimators and Interpolators, Filter Specifications for Decimators and Interpolators, Computation of Aliasing Characteristics, Sampling Rate Alteration of Band pass Signals

FIR Filters for Sampling Rate Conversion Direct Implementation Structures for FIR Decimators and Interpolators, Poly-phase Implementation of Decimators and Interpolators, Memory Saving Structures for FIR Poly-phase Decimators and Interpolators, Computational Efficiency of FIR Decimators and Interpolators

Module 3
IIR Filters for Sampling Rate Conversion: Direct Implementation Structures for IIR Filters for Decimation and Interpolation, Computational Requirements for IIR Decimators and Interpolators, IIR Filter Structures Based on Polyphase Decomposition.

Sampling Rate Conversion by a Fractional Factor: Sampling Rate Conversion by a Rational Factor, Spectrum of the Resampled Signal, Polyphase Implementation of Fractional Sampling Rate Converters, Rational Sampling Rate Alteration with Large Conversion Factors, Sampling Rate Alteration by an Arbitrary Factor, Fractional-Delay Filters

Module 4
Lth-Band FIR Digital Filters
Lth-Band Linear-Phase FIR Filters: Definitions and Properties, Polyphase Implementation of FIR Lth-Band Filters, Separable Linear-Phase Lth-Band FIR Filters, Minimum-Phase and Maximum-Phase Transfer Functions, Halfband FIR Filters

Complementary FIR Filter Pairs
Definitions of Complementary Digital Filter Pairs, Constructing High pass FIR Filters, Analysis and Synthesis Filter Pairs, FIR Complementary Filter Pairs

Module 5
Multirate FIR Filter Banks: Two Channel FIR Filter bank, Alias free filter banks, Perfect reconstruction and Near Perfect reconstruction, Orthogonal Two channel FIR filter bank, Tree structured Multi-channel filter banks, Filter banks with equal pass bands, Octave Filter banks.

Text Book

Reference
SP 107 Digital signal processors

Module 1
DSPs and Conventional Microprocessors, Circular Buffering, Architectural features of DSP- Von Neumann, Harvard, Super Harvard architectures, Fixed vs. Floating point DSP processors, Programming in C vs Programming in assembly, speed benchmarks for DSPs, Multiprocessing for high speed DSP applications.

Module 2
TMS 320 C 55 x Digital Signal Processor: Architecture overview, Buses, memory maps, software development tools- C compiler, assembler, linker, Code Composer studio, Addressing modes and instruction set, pipelining and parallelism in TMS 320C 55X, Mixed C and Assembly programming

Module 3
TMS 320 C 6x: Architecture, Functional Units, Fetch and Execute Packets, Pipelining, Registers, Linear and Circular Addressing Modes, Indirect Addressing, Circular Addressing, TMS320C6x Instruction Set, Assembly Code Format, Types of Instructions, Assembler Directives, Linear Assembly, ASM Statement within C, C-Callable Assembly Function, Timers, Interrupts, Multichannel Buffered Serial Ports, Direct Memory Access, Memory Considerations, Fixed- and Floating-Point Formats, Code Improvement, Constraints

Module 4
SHARC Digital Signal Processor: - Architecture - IOP Registers - Peripherals - Synchronous Serial Port - Interrupts -Internal/External/Multiprocessor Memory Space - Multiprocessing - Host Interface - Link Ports

Module 5
Some Practical applications of Digital Signal Processors: Sine wave generators, Noise generators, DTMF Tone detection, Adaptive echo cancellation, Acoustic echo cancellation, Speech enhancement

Text Books:
1. Digital Signal Processing: A Practical guide for Engineers and scientists, Steven W Smith, Newness(Elsevier), 2003
2. Digital Signal Processing and applications with the C6713 and C6416 DSK, Rulf Chassaing, Wiley-Interscience, 2005

References:
1. Digital Signal Processing Implementation using the TMS320C6000 DSP Platform, 1st Edition; Naim Dahnoun
5. A Simple approach to Digital Signal processing, 1st Edition, Kreig Marven & Gillian Ewers; Wily Interscience
SP 108 Digital Control Systems

Module 1

**Sampling process:** Sampling process - continuous and sampled signal, uniform impulse sampling - time domain and frequency domain analysis, aliasing, sampling theorem, data reconstruction, zero order hold, first order hold.

Module 2

**Z Transform methods:** Z transform definition - theorem, inverse Z Transform, mapping s plane to Z plane, linear constant coefficient difference equation, solution by recursion and Z transform method, principles of discretization.

Module 3

**Design of digital control systems:** Digital Control systems, pulse transfer function, Z Transform analysis of closed loop and open loop systems, steady state accuracy, characteristic equation, stability, tests for stability, frequency domain analysis, Bode diagrams - gain margin, phase margin, root locus techniques

Module 4

**Design of Digital Control Systems:** Cascade and feedback compensation using continuous data controllers, digital controller - design using bilinear transformation, root locus based design, digital PID controllers, Dead beat control design.

Module 5

**State variable methods:** State variable techniques for digital control systems, state space models - algebraic transformation-canonical forms, interrelations between Z Transform models and state variable models, controllability, observability, stability, response between sampling instants using state variable approach, state feedback, pole placement using state feedback, dynamic output feedback, SISO systems, effect of finite word length on controllability and closed loop placement, case study examples using MATLAB/clones.

**Texts/References**

3. Discrete time control systems, Katsuhito Ogata, Prentice Hall
4. Digital Control systems, Constantine H Houpis and Gary B Lamont, McGraw Hill
Module 1
Adaptive systems: definitions and characteristics, Open and Closed loop adaptation, Adaptive linear combiner, Performance function, Gradient and minimum mean square error, performance function, Gradient and minimum mean square error, Alternate expressions of gradient

Module 2
Theory of adaptation with stationary signals: Input correlation matrix, Eigen values and eigen vectors of the i/p correlation matrix
Searching the performance surface: Basic ideas of gradient search, Stability and rate of convergence, Learning curve, Newton's method, Steepest descent method, Comparison

Module 3
Gradient estimation and its effects on adaptation: Gradient component estimation by derivative measurement, performance penalty, Variances of the gradient estimate, effects on the weight – vector solution, Excess mean square error and time constants, misadjustments, total misadjustments and other practical considerations.

Module 4

Module 5
Applications of Adaptive signal processing: Adaptive modeling of a multi-path communication channel, adaptive model in geophysical exploration, Inverse modeling, Adaptive interference canceling: applications in Bio-signal processing

Text Book:
1. Adaptive signal processing: Widrow and Stearns, Pearson

References
3. Adaptive filtering primer with MATLAB – A Poularikas, Z M Ramadan, Taylor and Francis Publications
SP 202 VLSI Architectures for DSP

Module 1
Pipelining and parallel processing - pipelining of FIR filters, Parallel processing, pipelining and parallel processing for low power.
Retiming - definitions and properties, solving system of inequalities, retiming techniques.
Unfolding - algorithm for unfolding, properties of unfolding, critical path, unfolding and retiming, applications
Folding - folding transformation, register minimization techniques, register minimization in folded architectures.

Module 2
Fast convolution – Cook Toom Algorithm, Winograd Algorithm, Iterated convolution, Cyclic convolution
Algorithmic strength reduction in filters and transforms - Parallel FIR filters, DCT and IDCT, Pipelined and parallel recursive and adaptive filters- pipeline interleaving in Digital filters, Pipelining in IIR digital filters, Parallel processing for IIR filters, Low power IIR filter design using pipelining and parallel processing.

Module 3
Scaling and round off noise – scaling and round off noise, state variable description of digital filters, scaling and round off noise computation, round off noise in pipelined IIR filters, Round off noise computation using state variable description, slow down, retiming and pipelining

Module 4
Digital lattice filter structures - Schur algorithm, Digital basic lattice filters, Derivation of one multiplier Lattice filter, Derivation of scaled-normalized lattice filter, Round off noise calculation in Lattice filters.
Bit level arithmetic architectures - parallel multipliers, interleaved floor plan and bit plane based digital filters, bit serial filter design and implementation, Canonic signed digital arithmetic.

Module 5
Synchronous, wave and asynchronous pipelines - Synchronous pipelining and clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs, Wave pipelining, asynchronous pipelining

Text Book

References
SP 203 Digital Image processing

Module 1

**Digital Image fundamentals**: representation, elements of visual perception, simple image formation model, image sampling and quantization, basic relationship between pixels, imaging geometry.

**Review of Matrix theory results**: Row and Column ordering, Doubly Block Toeplitz for 2D linear convolution, Doubly Block Circulant Matrices for circular convolution, Kronecker products, Unitary and orthogonal matrices.

**Unitary Transforms for Image processing**: General Unitary Transforms, DFT, DCT, DST, Hadamard Transform, Haar Transform, Karhunen Loeve Transform.

Module 2

**Image Enhancement**: Spatial Domain Methods: point processing - intensity transformations, histogram processing, image subtraction, image averaging. Spatial filtering- smoothing filters, sharpening filters, Frequency Domain methods- low pass filtering, high pass filtering, homomorphic filtering, generation of spatial masks from frequency domain specifications

Module 3


Module 4


Module 5

**Image Segmentation**: Detection of discontinuities- point, line, edge and combined detection, edge linking and boundary description, local and global processing using Hough Transform- Thresholding, Region oriented segmentation – basic formulation, region growing by pixel aggregation, region splitting and merging, use of motion in segmentation.

**Color Image Processing**: color models- RGB, CMY, YIQ, HIS, Pseudo coloring, intensity slicing, gray level to color transformation.

**Text Book**


**References**

3. Two dimensional signal and Image Processing- J S Lim, Prentice Hall.
Module 1

Spatial Signals: Signals in space and time. Spatial frequency, Direction vs. frequency. Wave fields. Far field and Near field signals

Module 2


Module 3


Module 4


Module 5

Higher order statistics in Signal Processing: Moments, Cumulants and poly spectra, Higher order moments and LTI systems

Text Book


References

2. Array Signal Processing [Connexions Web site].February 8, 2005. Available at:
   http://cnx.rice.edu/content/col10255/1.3/
SP 205 Signal Compression Techniques

Module 1


Module 2

Rate distortion theory: Rate distortion function R(D), Properties of R(D); Calculation of R(D) for the binary source and the Gaussian source, Rate distortion theorem, Converse of the Rate distortion theorem, Quantization - Uniform & Non-uniform - optimal and adaptive quantization, vector quantization and structures for VQ, Optimality conditions for VQ, Predictive Coding - Differential Encoding Schemes

Module 3

Mathematical Preliminaries for Transforms, Karhunen Loeve Transform, Discrete Cosine and Sine Transforms, Discrete Walsh Hadamard Transform, Lapped transforms - Transform coding - Subband coding - Wavelet Based Compression - Analysis/Synthesis Schemes

Module 4


Module 5

Audio Compression standards: MPEG, Philips PASC, Sony ATRAC, Dolby AC-3,


Text books

Reference books
Module 1

Continuous Wavelet Transform: Continuous time frequency representation of signals, The Windowed Fourier Transform, Uncertainty Principle and time frequency tiling, Wavelets, specifications, admissibility conditions, Continuous wavelet transform, CWT as a correlation, CWT as an operator, Inverse CWT.

Module 2

Discrete wavelet Transform: Approximations of vectors in nested linear vector spaces, Example of an MRA, Formal definition of MRA, Construction of a Wavelet basis for MRA, Digital filtering interpretations- Decomposition and Reconstruction filters, examples of orthogonal basis generating wavelets, interpreting orthogonal MRA for Discrete time signals, Mallat algorithm Filter bank implementation of DWT.

Module 3

Alternative wavelet representations- Biorthogonal Wavelets: biorthogonality in vector space, biorthogonal wavelet bases, signal representation using biorthogonal wavelet system, advantages of biorthogonal wavelets, biorthogonal analysis and synthesis, Filter bank implementation, Two dimensional Wavelets, filter bank implementation of two dimensional wavelet transform.

Module 4

Lifting scheme: Wavelet Transform using polyphase matrix factorization, Geometrical foundations of the lifting scheme, lifting scheme in the z-domain, mathematical preliminaries for polyphase factorization, Dealing with Signal Boundary.

Module 5

Applications: Image Compression: EZW Coding, SPIHT, Wavelet Difference Reduction Compression Algorithm, Denoising, speckle removal, edge detection and object isolation, audio compression, communication applications – scaling functions as signaling pulses, Discrete Wavelet Multitone Modulation.

Text Book
1. Insight into wavelets: From theory to Practice- K P Soman and K I Ramachandran, Prentice Hall of India
2. Wavelet Transforms: Introduction to theory and applications- R M Rao and A S Bopardikar, Pearson

References
3. Wavelets and Multiwavelets- F Keinert, SIAM, Chapman and Hall/CRC, 2004
4. Ten Lectures on Wavelets- Ingrid Daubechies, SIAM, 1990
SP 207 Artificial Neural Networks

Module 1
Introduction to ANNs: Classical AI and Neural Networks, Human brain and the biological neuron, Artificial Neurons, Neural Networks and architectures, feed forward and feedback architectures, geometry of binary threshold neurons and their networks, Supervised and unsupervised learning, concepts of generalization and fault tolerance
Supervised learning: Perceptrons and LMS, Back propagation Neural Networks, Fast variants of Back propagation

Module 2
Statistical pattern recognition perspective of ANNs: Bayes theorem, Implementing classification decisions with the Bayes theorem, interpreting neuron signals as probabilities, Multilayered networks, error functions, posterior probabilities, error functions for classification problems, Support vector machines, RBFNNs, regularization theory, learning in RBFNNs, Image classification application, PNNs

Module 3

Module 4
Fuzzy Systems: Fuzzy sets, Membership functions, Measures of fuzziness, Fuzzification and defuzzification, Fuzzy relations, Neural Networks and Fuzzy logic, Fuzzy neurons, Fuzzy perceptron, Fuzzy classification networks using Backpropagation, Fuzzy ART

Module 5

Text Book
1. Neural Networks, A Classroom approach, Satish Kumar, Tata McGraw Hill, 2004

References
1. Introduction to Artificial Systems, J M Zurada, Jaico Publishers
2. Neural Networks –A Comprehensive Foundation, Simon Haykins, PHI
4. Fuzzy Logic with Engineering Applications, Timothy J. Ross: TMH
6. Fuzzy Logic and Genetic Algorithms, Rajasekharan & Pai Neural Networks, PHI
8. Artificial Neural Networks, Yegnanarayana, PHI, 1999
SP 208 Advanced Microprocessor Architectures

Module 1
Introduction to general structure of advanced microprocessors, Discussions on bus architecture, instruction sets, interrupts, shared data problem, interrupt latency, memory hierarchy, pipelining and RISC principles.

Module 2
Instruction Pipeline, Design consideration and performance models, Dependency detection and resolution, Branch handling strategies, Static and dynamic pipeline, Scheduling techniques

Module 3
Vector processor: Memory processor interface, vectorization techniques, Performance issues, Advanced Pipelined Processor, Superpipelined processor, Superscaled processor: Instruction scheduling, Software pipelining, VLIW.

Module 4
Cache Memory, Organization, Cache addressing, Multilevel caches, Virtual Memory, Paged, segmented and paged organizations Address translation: Direct page table translation, Inverted page table, Table look aside buffer, Virtual memory accessing rules.

Module 5

TEXT BOOKS
2. Advanced Microprocessors”, (Computer Engineering Series)Daniel Taback; Mc-Graw Hill

REFERENCES
1. Architecture of high performance computers, Volume-1, RN Ibbett and N P Topham
Module 1

Module 2
Speech Analysis :- Short-Time Speech Analysis, Time domain analysis- Short time energy, short time zero crossing Rate, ACF. Frequency domain analysis- Filter Banks, STFT, Spectrogram, Formant Estimation & Analysis, Cepstral Analysis

Module 3
Parametric representation of speech :- AR Model, ARMA model. LPC Analysis- LPC model, Auto correlation method, Covariance method, Levinson-Durbin Algorithm, Lattice form, LSF, LAR, MFCC, Sinusoidal Model, GMM, HMM

Module 4
Speech coding :- Phase Vocoder, LPC, Sub-band coding, Adaptive Transform Coding, Harmonic Coding, Vector Quantization based Coders, CELP

Module 5
Speech processing :- Fundamentals of Speech recognition, Speech segmentation. Text-to-speech conversion, speech enhancement, Speaker Verification, Language Identification, Issues of Voice transmission over Internet

Text Books

Reference
4. Fundamentals of Speech Recognition, Rabiner and Juang, Prentice Hall, 1994