Curriculum and Syllabus for
M.TECH
DIGITAL SIGNAL PROCESSING – R2015
# FIRST SEMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course</th>
<th>Lecture Hours</th>
<th>Tutorial Hours</th>
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<td>AVD611</td>
<td>Advanced Signal Analysis and Process</td>
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# SECOND SEMESTER

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THIRD SEMESTER

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ELECTIVE COURSES

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<tr>
<th>Course Code</th>
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<tr>
<td>AVD861</td>
<td>Speech Signal Processing And Coding</td>
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<td>AVD862</td>
<td>Information Theory and Coding</td>
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<td>AVD863</td>
<td>Soft Computing And Its Application In Signal Processing</td>
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<td>AVD864</td>
<td>Computer Vision</td>
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<tr>
<td>AVD865</td>
<td>Multimedia Processing</td>
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<tr>
<td>AVD866</td>
<td>Virtual Reality</td>
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<tr>
<td>AVD867</td>
<td>Pattern Recognition and Machine Learning</td>
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<tr>
<td>AVD868</td>
<td>VLSI Signal Processing</td>
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## SEMESTER I

### AVD611 ADVANCED SIGNAL ANALYSIS AND PROCESSING (3-0-0) 3 credits

Continuous-time and discrete-time signals and systems; LTI systems/convolution/Difference equations, Spectral analysis: Frequency domain representation –FS/FT/DTFT/DTFT/DTFS/DFT, Decimation in Time, Decimation in Frequency FFT algorithms; Sampling and reconstruction, Quantization, Decimation and Interpolation; Z-transform; Digital filters: FIR and IIR filters, Digital-filter realizations and design; Finite length effects Time Frequency representations; Nonstationary Processes; Discrete Wavelet Transforms; Discrete Time-Frequency Transforms; Introduction to adaptive signal processing , compressive sensing and its applications to DSP

**Text/Reference Books:**


### AVD612 MATHEMATICAL METHODS FOR SIGNAL PROCESSING (3-0-0) 3 credits


Bayesian: MMSE/MAP/IMMSE

Optimization : Langrage multiplier, Matched filter, Gradient descent-derivative, convex/nonconvex sets and optimization, Kehn-Tucker method, linear programming/dynamic programming.

**Text/Reference Books:**

6. Prof. J. Reilly’s online course notes on Matrix Computations http://www.ece.mcmaster.ca/~reilly/html/gradcourse/graduate_courses.html

AVD613 COMMUNICATION SYSTEM - I (3-0-0) 3 credits

This course gives an introduction to the relevant mathematical topics for understanding the following subject namely Digital Communication, Estimation and Detection theory and Statistical Signal Processing which includes adaptive filter theory. The topics covered in this course are as given below

3. PSD/ACF of digitally transmitted signals, matched filter, Baseband representation of narrow band signals, Vector Phase representation of digitally transmitted signals

Text/Reference Books

AVD614 IMAGE AND VIDEO PROCESSING (3-0-0) 3 credits

Human visual system and image perception; monochrome and colour vision models; image digitization, display and storage; 2-D signals and systems; image transforms- 2D DFT, DCT, KLT, Harr transform and discrete wavelet transform; image enhancement: histogram processing, spatial-filtering, frequency-domain filtering; image restoration: linear degradation model,
inverse filtering, Wiener filtering; image compression: lossy and lossless compression, image compression standards, image analysis: edge and line detection, segmentation, feature extraction, classification; image texture analysis; morphological image processing: binary morphology- erosion, dilation, opening and closing operations, applications; basic gray-scale morphology operations; colour image processing: colour models and colour image processing Fundamentals of digital video processing- Coverage includes spatio-temporal sampling, motion analysis, parametric motion models, motion-compensated filtering, and video processing operations.

Text/Reference Books:


<table>
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<tr>
<th>E01</th>
<th>ELECTIVE I</th>
<th>(3-0-0) 3 credits</th>
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<tr>
<td>AVD631</td>
<td>MATHEMATICAL METHODS FOR SIGNAL PROCESSING LAB</td>
<td>(0-0-1) 1 credit</td>
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- Lab Experiments are based on algorithms covered in the course

| AVD632 | IMAGE AND VIDEO PROCESSING LAB | (0-0-1) 1 credit |

- Lab Experiments are based on algorithms covered in the course
SEMESTER II

<table>
<thead>
<tr>
<th>AVD621</th>
<th>STATISTICAL SIGNAL PROCESSING</th>
<th>(3-0-0) 3 credits</th>
</tr>
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</table>

Estimation Theory, Maximum Likelihood estimation (MLE): exact and approximate methods (EM, alternating max, etc), Cramer-Rao lower bound (CRLB), Minimum variance unbiased estimation, best linear unbiased estimation, Bayesian inference & Least Squares Estimation, Basic ideas, adaptive techniques, Recursive LS, etc, Kalman filtering (sequential Bayes), Finite state Hidden Markov Models: forward-backward algorithm, Viterbi (ML state estimation), parameter estimation (f-b + EM), Monte Carlo methods: importance sampling, MCMC, particle filtering, applications in numerical integration (MMSE estimation or error probability computation) and in numerical optimization (e.g. annealing)

Detection Theory: Likelihood Ratio testing, Bayes detectors, Minimax detectors, Multiple hypothesis tests Neyman-Pearson detectors (matched filter, estimator-correlator etc), Wald sequential test, Generalized likelihood ratio tests (GLRTs), Wald and Rao scoring tests, Applications


Text/Reference Books:

<table>
<thead>
<tr>
<th>AVD622</th>
<th>DIGITAL SIGNAL PROCESSORS FOR REAL TIME APPLICATIONS</th>
<th>(3-0-0) 3 credits</th>
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Computational characteristics of DSP algorithms and applications; their influence on defining a generic instruction-set architecture for DSPs.
Architectural requirement of DSPs: high throughput, low cost, low power, small code size, embedded applications. Techniques for enhancing computational throughput: parallelism and pipelining.
Data-path of DSPs: multiple on-chip memories and buses, dedicated address generator units, specialized processing units (hardware multiplier, ALU, shifter) and on-chip peripherals for communication and control.
Control-unit of DSPs: pipelined instruction execution, specialized hardware for zero-overhead looping, interrupts.
Architecture of Texas Instruments fixed-point and floating-point DSPs: brief description of TMS320 C5x /C54x/C3x DSPs; Programmer’s model.
Architecture of Analog Devices fixed-point and floating-point DSPs: brief description of ADSP 218x / 2106x DSPs; Programmer’s model.
Advanced DSPs: TI’s TMS 320C6x, ADI’s Tiger-SHARC, Lucent Technologies’ DSP 16000 VLIW processors.
Applications: a few case studies of applications of DSPs in communication and multimedia.
Introduction to FPGA, RTOS, OS, Basics of Embedded systems

Text/Reference Books:
3. Texas Instruments TMSC5x, C54x and C6x Users Manuals.

<table>
<thead>
<tr>
<th>AVD623</th>
<th>COMMUNICATION SYSTEM II</th>
<th>(3-0-0) 3 credits</th>
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</table>
4. Introduction to TDM, FDM, Spread spectrum techniques, OFDM communication systems.

Text/Reference Books:

<table>
<thead>
<tr>
<th>E02</th>
<th>ELECTIVE II</th>
<th>(3-0-0) 3 credits</th>
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<table>
<thead>
<tr>
<th>E03</th>
<th>ELECTIVE III</th>
<th>(3-0-0) 3 credits</th>
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<tr>
<th>AVD641</th>
<th>DSP HARDWARE LAB</th>
<th>(0-0-1) 1 credit</th>
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- Lab Experiments are based on algorithms covered in the course
<p>| AVD851 | SEMINAR | (0-0-0) 2 credits |</p>
<table>
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<tr>
<th>Course</th>
<th>Project Work Phase</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AVD852</td>
<td>Phase I</td>
<td>17 credits</td>
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<tr>
<td>AVD853</td>
<td>Phase II</td>
<td>18 credits</td>
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ELECTIVE COURSES

AVD861 | SPEECH SIGNAL PROCESSING AND CODING | (3-0-1) 4 credits
Introduction: speech production and perception, information sources in speech, linguistic aspect of speech, acoustic and articulatory phonetics, nature of speech, models for speech analysis and perception; Short-term processing: need, approach, time, frequency and time-frequency analysis; Short-term Fourier transform (STFT): overview of Fourier representation, non-stationary signals, development of STFT, transform and filter-bank views of STFT; Cepsrum analysis: Basis and development, delta, delta-delta and mel-cepstrum, homomorphic signal processing, real and complex cepstrum; Linear Prediction (LP) analysis: Basis and development, Levinson-Durbin's method, normalized error, LP spectrum, LP cepstrum, LP residual; Sinusoidal analysis: Basis and development, phase unwrapping, sinusoidal analysis and synthesis of speech; Speech coding: Need and parameters, classification, waveform coders, speech-specific coders, GSM, CDMA and other mobile coders; Applications: Some applications like pitch extraction, spectral analysis and coding standard.

Text/Reference Books:
1. Digital Processing of Speech Signals Pearson Education, L.R. Rabiner and R.W. Schafer, Delhi, India, 2004

AVD862 | INFORMATION THEORY AND CODING | (3-0-0) 3 credits
Error control coding – Block codes Definitions and Principles: Hamming weight, Hamming distance, Minimum distance decoding - Single parity codes, Hamming codes, Repetition codes - Linear block codes, Cyclic codes - Syndrome calculation, Encoder and decoder – CRC
Convolutional codes – code tree, trellis, state diagram - Encoding – Decoding: Sequential search and Viterbi algorithm – Principle of Turbo coding, LDPC codes

Text/Reference Books:
1. Information Theory and Coding, Norman Abramson, McGrawHill,1963
3. Introduction to Error Control Codes, S Gravano, Oxford University Press 2007

AVD863 | SOFT COMPUTING AND ITS APPLICATION IN SIGNAL PROCESSING | (3-0-1) 4 credits
Soft Computing: Introduction, requirement, different tools and techniques, usefulness and applications.
Artificial Neural Network: Introduction, basic models, Hebb's learning, Adaline, Perceptron, Multilayer feed forward network, Back propagation, Different issues regarding convergence of Multilayer Perceptron, Competitive learning, Self-Organizing Feature Maps, Adaptive Resonance Theory, Associative Memories, Applications.
Rough Set: Introduction, Imprecise Categories Approximations and Rough Sets, Reduction of Knowledge, Decision Tables, and Applications.
Hybrid Systems: Neural-Network-Based Fuzzy Systems, Fuzzy Logic-Based Neural Networks, Genetic Algorithm for Neural Network Design and Learning, Fuzzy Logic and Genetic Algorithm for Optimization, Applications.
Applications of soft computing to signal processing

Text/Reference Books:
6. Neuro-Fuzzy and Soft Computing, Jang, Sun, & Mizutani, PHI.

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<th>AVD864</th>
<th>COMPUTER VISION</th>
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<tr>
<td></td>
<td>Image Formation Models, Monocular imaging system, Orthographic &amp; Perspective Projection, Camera model and Camera calibration, Binocular imaging systems</td>
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<td></td>
<td>Image Processing and Feature Extraction, Image representations (continuous and discrete), Edge detection, Motion Estimation, Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion Shape Representation and Segmentation, Deformable curves and surfaces, Snakes and active contours, Level set representations, Fourier and wavelet descriptors</td>
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<td>• Medial representations, Multiresolution analysis Object recognition, Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal component analysis, Shape priors for recognition</td>
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Text/Reference Books:

**AVD865** | **MULTIMEDIA PROCESSING** (3-0-0) 3 CREDITS
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The course focuses on international standards related to image/video/audio formulated by ISO/IEC/ITU. Short-term Fourier Transform & Continuous Wavelet Transform, CWT and its discretization, Discrete Wavelet Transforms, 2 - D Wavelet Transforms, Coding Techniques in 2 - D Wavelet Transforms. Emphasis will be on the family of MPEG 1/2/4 (Moving Picture Experts Group), H.26x (x = 1, 2, 3), JPEG/JPEG-LS/JPEG2000 (Joint Photographic Experts Group), JPEG 1/2 (Joint Binary Image Group), H.264/MPEG-4 Part 10 AVC (Advanced Video Coding) and the emerging H.265 standard (HEVC). Other standards such as WMV-9 (Windows Media Video) of Microsoft and AVS China (Advanced Video Standard) and their similarities/differences with H.264 will also be presented, also audio coding AC3, AAC, AAC + SBR, G.72x–series, MPEG-1, 2, 4 audio. Course will be supplemented with ftp/web sites, software, standards documents, test sequences etc. Industry worldwide is very active in developing products (software/hardware) based on these standards with emphasis on the latest standard H.264. Some of these are digital TV, HDTV, HD-DVD, set-top-box, handheld devices with multimedia capabilities, digital cameras, camcorders, electronic games, IPTV, video streaming, iPods etc. Motion Estimation: Matching Criteria, Generalised Matching, Generalised Deformation Model in Motion Estimation, Synchronization of Media Multimedia Content Representation and Retrieval, Video Content Representation, Content-based Video: Motion Representation, Content-based Video: Low to High-level Representation, Content Retrieval Schemes

**TEXT/REFERENCE BOOKS:**


**AVD866** | **Virtual Reality** (3-0-0) 3 credits
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1. **Introduction:** What is VR, applications, basic components of VR, Success stories of VR and challenges, VR hardware, visualization, VR content generation and storing?
2. **Human Senses and VR:** Discussion on how human senses correlates to VR such as Visual system, Auditory System, Olfaction, Gustation etc.
3. **Three dimensional geometry theory:** coordinate system, Vectors, Line, plane transformation etc.
4. **The rendering pipeline:** Geometry and vertex operations, culling and clipping, screen mapping, scan conversion or rasterization, fragment processing, texturing etc.
5. **Image based rendering:** General approaches to IBR, acquiring images for IBR, mosaicing, making panoramic images etc.
6. **Computer vision in VR:** The mathematical language of geometric computer vision, cameras, CV application in VR, Virtual Worlds using Computer Vision.
7. **Stereopsis:** parallax, HMD, active, passive and other stereoscopic systems etc
8. **Navigation and Movement in VR**: computer animation, moving and rotating in 3D, robotic motion, inverse kinematics etc

**Laboratory**: Introductory training in scripting and Vizard software demo on modeling. There will be lab exercises given to students for better understanding of the course.

**Project**: Two projects will be given to students that need to be simulated using python/c/opengl/vrml etc.

1. The first project is a short individual project that will focus on creating a simple VR environment to get everyone familiar with the available software and give you a sense of the scope of the projects that you can create.
2. The second project will focus on creating a more complicated virtual world. This second project can either be done as individuals or in groups of two. Groups of two are responsible for CLEARLY delineating each persons role in the project.

**References**:
2. Vizard Teacher in a Book from Vizard, 2008
3. IEEE conferences and Journals on Graphics, VR and computer vision.

<table>
<thead>
<tr>
<th>AVD867</th>
<th>PATTER RECOGNITION AND MACHINE LEARNING</th>
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**Text/Reference Books**:
AVD868 | VLSI DIGITAL SIGNAL PROCESSING | (3-0-0) 3 credits

Introduction to Digital Signal Processing; Need of VLSI DSP algorithms. Introduction to VLSI Technology and DSP Technology requirements; main DSP Blocks and typical DSP Algorithms.
Number Representation: Fixed point Representation Floating point Representation; Binary Adders; Binary Multiplier; Binary Dividers; Floating point Arithmetic Implementation: CORDIC architectures; Multiply Accumulator unit; Computation of Special functions using MAC cells.
Bit level arithmetic structures- parallel multipliers, interleaved floor plan and bit plan based digital filters. Bit serial multipliers. Bit serial filter design and implementation. Canonic signed digit arithmetic, Distributed arithmetic.
Synchronous pipelining and clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs.
Pipelining and parallel processing for IIR filters. Low power IIR filter design using pipelining and parallel processing, Pipelined adaptive digital filters.
Systolic Array Architectures and fast convolution algorithms.

Reference Books