COURSES FOR Ph. D. Program

Core Courses

CODE	COURSE NAME	L	T	P	CR	CH
RP 799	Research and Publication Ethics	2	0	0	2	2
CS704	Doctoral Research Methodology	4	0	0	4	4

Elective Courses

CODE	COURSE NAME	L	T	P	CR	CH
EL 703	Biomedical Signal Processing	3	0	0	3	3
EL 704	Bioinspired Systems and Engineering	3	0	0	3	3
BE 705	Advanced Bioelectronics Devices	3	0	0	3	3
BE 706	Neuroengineering	3	0	0	3	3
BE 707	Biomedical Image Processing	3	0	0	3	3
BE 708	Neuro-Fuzzy Systems	3	0	0	3	3
BE 709	Artificial Vision	3	0	0	3	3
EL 710	Analog and Digital Circuits	4	0	0	4	4
EL 713	Advanced Data Communication	4	0	0	4	4
EL 701	BIOMEMS and Nanotechnology:	3	0	0	3	3
EL 702	Intelligent Sensor Systems	3	0	0	3	3
EL 711	Microwave Devices, Circuits and Measurements	4	0	0	4	4
EL 712	Electromagnetic Theory and Antennas	4	0	0	4	4
EL 714	Signals and Circuits	3	0	0	3	3
EL 715	Sparse Representations in Signal and Image Processing	3	0	1	4	5
EL 716	Linear Algebra and Convex Optimization	3	0	0	3	3
EL 717	Digital Image Processing	3	0	1	4	5
EL 718	Machine Vision	3	0	1	4	5

COURSES FOR Ph. D. Program

EL 701 BIOMEMS AND NANOTECHNOLOGY : 3 0 0 0 3

Introduction to micro-electro mechanical systems (MEMS), MEMS sensor, intelligent sensors using MEMS: micro pump, micro cantilever beam; DNA Biosensors, multi-biosensors Lab-on-a chip, micromachining of bioanalytical devices, microarray Biosensors, nanosensors, nanoarrays and nanodevices, biochips; simulation technique for DNA nanodevices; E-nose, E-tongue; artificial autitory chips artificial vision chips, artificial audio/ visual integrated systems based on brain information processing.

Books/References:

1. Massimo Grattarola, Giuseppe Massobrio, "Bioelectronics Handbook, MOSFETs, Biosensors & Neurons", McGraw Hill.
2. J Cheng, L. Kricka, " Biochip Technology", Taylor and Francis
3. H. Markov, "Advanced Semiconductor and Organic Nanotechnology" , Academic Press.
4. Ruddy Ratner, " Biomaterial Science", Academic Press.
5. K E Drexler, "Nanosystems: Molecular Machinery – manufacturing and Computation", John Wiley and Sons
6. "Understanding Nanotechnology: Scientific American", Warner Books.
7. J W Gardner, V K Vardhan, O OAwadelkarim, " Microsensors, MEMS and Smart Devices", John Wiley and Sons.
8. William Illsay Atkinson, " Nanocosom: Nanotechnology and the Big Changes coming from the Inconceivably Small", AMACOM.
9. J A Pelesko, David H Bernstein, " Modeling MEMS and NEMS", CRC Press.
10. NadimMaluf, " An Introduction to Microelectromechanical System Design Engineering", Artech House.
11. Stephen D Senturia, "Microsystem Design", KAP

EL 702 INTELLIGENT SENSOR SYSTEMS 3 0 0 3 3

SENSORS: Primary sensing principles and measurement variable, Sensor performance characteristics and terminology.
INSTRUMENTATION: Transducer measurement circuits, Signal conditioning circuits, Data Conversion: DAC, ADC, Virtual instrumentation with LabVIEW

PATTERN ANALYSIS: Introduction to Statistical Pattern recognition Dimensionality reduction, Classification, Validation, Data analysis with MATLAB
INTELLIGENT SENSORS SYSTEMS: Structure, definitions and concepts, Advanced processing and control techniques, Smart Sensors, Case study: the "electronic nose". The future of intelligent sensors systems.

Books/References:

1. R H Bishop, "Learning with LabVIEW", Addison Wesley, 1999
2. D Hanselman and B Littlefield, "Mastering MATLAB 5", Prentice Hall, 1998
3. R O Duda, P E Hart and D G Stork, "Pattern Classification", Wiley 2001
4. J Brignell and N White, "Intelligent Sensor Systems", Revised Ed. IOP 1996
5. R Frank, "Understanding Smart Sensors", 2nd Ed. Artech 2000
6. R. Pallas-Areny and J G Webster, "Sensors and Signal Conditioning", Wiley, 1991

EL 703 BIOMEDICAL SIGNAL PROCESSING 3 0 0 3 3

Biomedical Signals: Genesis of bioelectric potential, ECG, EEG, EMG and their monitoring and measurements: overview of analog signal analysis: time-and frequency – domain representation of signal, Fourier series and Fourier transform, linear system, correlation, convolution and filtering: random signal – correlation and spectral representation.

Digitization of Signal: Sampling theorem and A/D conversion: quantizing effects, aliasing artifacts in biomedical signals.

Discrete transforms: Discrete – time Fourier theorem, DFT and FFT; z-transform and properties.

Digital Filters: FIR and IIR filter, biomedical applications of digital filtering – removal power line interference from ECG data, reducing ECG artifact from EMG data.

ECG Pre-processing, wave form recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory, ECG compression, Evoked potential estimation.

EEG: evoked responses, averaging techniques, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages, epilepsy detection.

EMG: wave pattern studies, biofeedback.

Books/References:

1. E N Bruce, " Biomedical Signal Processing and Signal Modeling", John Wiley and Sons.
2. MetinAkay, " Nonlinear Biomedical Signal Processing Dynamics, Analysis and Modeling", John Wiley and Sons.
3. MetinAkay, " Nonlinear Biomedical Signal Processing Fuzzy Logic, Neural Networks and New Algorithms", John Wiley and Sons
4. W. J. Tompkms, "Biomedical Digital Signal Processing: C language examples and Laboratory Experiments for IBM PC", Prentice Hall

5. S. K. Mitra, “Digital Signal Processing A Computer base Approach”, McGraw Hill, 2nd Ed. 2001
6. John G Proakis, Dimitria G. Manolakis, “Digital Signal Processing: Principles, Algorithms and Application”, 3rd Ed. Prentice Hall, 1995
7. J D Bronzino, “Biomedical Engineering Handbook”, CRC Press
8. A C Guyton, “Textbook of Medical Physiology”, Prism Books (Pvt) ltd.
9. F H Martini, “Fundamentals of Anatomy and Physiology”, Prentice Hall.

EL 704 BIOINSPIRED SYSTEMS AND ENGINEERING 3 0 0 3 3

Biologically inspired artificial devices: artificial Heart and circulatory assist devices, artificial lungs, artificial kidney, artificial cell, artificial muscle.

Artificial vision: Computer vision – word recognition, feature extraction based on biological visual system, stereo vision; speech recognition.

Biologically inspired systems: Robotic systems and devices, acoustical systems, computing system such as neural network, bioinspired exploration, bioinspired computer architectures.

Books/References:

1. M Farkas, “ Dynamical Model in Biology”, Academic Press
2. B Webb, T R Consi, “ Biorobotics”, AAAI Press
3. Karl Williams, “Insectronics”, McGraw Hill
4. Karl Willams, “Amphoibionics: Built your own biologically inspired Reptilian Robot”, McGraw Hill
5. G Schmid, “BioinspiredNanoscale Hybrid System: Conference Proceeding Held on Nov 02, Amazon.
6. J D Bronzino, “Biomedical Engineering Handbook”, CRC Press.

BE 705 ADVANCED BIOELECTRONIC DEVICES 3 0 0 3 3

Metal: Oxide – Semiconductor (MOS), MOS structure, Model of operation, Metal Oxide Semiconductor Field effect Transistor (MOSFET).

Electrolyte – Insulator – Semiconductor (EIS): EIS Structure, Site binding Theory, Electrical double layer theory.

MOSFET based Bioelectronic devices: Biosensor overview, Ion Sensitive Field Effect Transistor (ISFET), Enzyme Field Effect Transistor (ENFET), Chemical Field Effect Transistor (CHEMFET), Reference Field Effect Transistor (REFET), Immune Field Effect Transistor (IMFET), Organic Thin Film Transistor (TFT), Cell-Based Biosensors & Sensors of Cell Metabolism, Light Addressable Potentiometric Sensors (LAPS), Interfacing of Biological

Systems with Electronic Systems, Non-conventional bioelectronic devices, conducting polymer based ISFET.

Modeling & Simulation: SPICE and Electrochemical models of ISFET & CHEMFET.

Books/References:

1. Massimo Grattarola, Giuseppe Massobrio, "Bioelectronics Handbook, MOSFET's, Biosensors & Neurons", McGraw Hill.
2. H Markov, "Advanced Semiconductor and Organic Nanotechnology", Academic Press.
3. Ruddy Ratner, "Biomaterial Science", Academic Press.
4. J D Bronzion, "Biomedical Engineering Handbook", CRC Press.
5. G Ramsa, "Commercial Biosensors: Applications to Clinical, Bioprocess and Environmental Samples", Wiley-interscience.
6. A J Cunningham, "Introduction to Bioanalytical Sensors", Wiley-Interscience.
7. U Bilitewski, A Turner, "Biosensors in Environmental Monitoring", Taylor Francis.
8. J. Cheng, L Kricka, "Biochip Technology", Taylor and Francis.
9. R Glaser, "BioPhysics", Spring.

BE 706 NEUROENGINEERING 3 0 0 3 3

Biology of the neuron, biophysical description of the action potential, synapses, neuron as a threshold device, networks, neuroelectronics junctions, silicon neurons, SPICE modeling of Silicon neurons, Neural coding, models and methods, goal functions and time dependent learning rules, neural interfaces, EEG recording for brain computer interface applications, coding and decoding of neural information in bi-directional neural interfaces, Neuroengineering of mind: neural models of higher functions, large scale brain models, neural modeling and neural coding in the brain.

Books/References:

1. Massimo Grattarola, GuiseppeMossobrio, "Bioelectronics Handbook, MOSFETs, Biosensors & Neurons", McGraw Hill.
2. J C Nicholls, A R Martin, B G Wallace, Sunderland, Mass, "From Neuron to Brain", Sinauer Associates.
3. C Mead, "Analog VLSI and Neural System", Addison Wesley.
4. MetinAkay, "Neural Engineering", Vol-1-6, Wiley/IEEE Press.

BE 707 BIOMEDICAL IMAGE PROCESSING 3 0 0 3 3

Medical imaging: X-ray imaging, computer assisted tomography magnetic resonance imaging, nuclear magnetic resonance imaging.

Image enhancement: Fundamental enhancement techniques, medical image enhancement with nonlinear filters.

Segmentation: Image segmentation basics, medical image segmentation by clustering, fuzzy clustering, segmentation by neural network, deformable modules and gradient vector flaw deformable modules, case studies of segmentation of brain heart etc.

Image reconstruction from projections: Principle of tomography, algebraic and Fourier domain reconstruction technique.

Image registration: Physical basics of spatial distortion in medical images, fundamental of registration; application of image registration for image guided surgery.

Medical image compression: Fundamental and standards of image compression, issues related with medical image compression: medical image.

Books/References:

1. K. Shun, M F Insana, "Ultrasonic Imaging and Signal Processing", SPIE
2. J D Bronzion, "Biomedical Engineering Handbook", CRC Press
3. W J Tompkms, "Biomedical Digital Signal Processing: C Language Examples and Laboratory Experiments for IBM PC", Prentice Hall
4. "Digital Processing of Biomedical Image", Plenum Publisher.
5. Richard A. Robb, "Biomedical Imaging, Visualization and Analysis", Wiley-Liss.
6. A Cichocki, Shun-ichiAmari, "Adaptive Blind Signal and Image Processing", Wiley and Sons.
7. Stephen T C Wong, "Medical Image Database", KAP
8. A K Jain, "Fundamentals of Digital Image Processing",
9. IssacBankman, "Handbook of Medical Imaging and Processing".

BE 708 NEURO-FUZZY SYSTEMS 3 0 0 3 3

Fuzzy Systems: Fuzzy sets, operations on Fuzzy sets, Fuzzy logic, Linguistics variables, membership functions, Fuzzy rules and reasoning, Fuzzy inference systems, Fuzzy logic controller, Fuzzyfication, Fuzzy operations, Fuzzy implication, Fefuzzification, Fuzzy clustering, Applications of Fuzzy systems.

Neural Network: Introduction to neural network, neuron model, simple neuron & firing rules, neural architectures: Feed forward networks, Feed back networks, Radial Basis network, perceptions, adaptive networks, Learning methods, transfer functions, back propagation, the delta learning, clustering, applications of artificial neural networks(ANNs).

Fuzzy Neural Networks (FNNs): Integration of fuzzy logic and neural networks, Fuzzy neurons, hybrid neural nets, adaptive – networks – based Fuzzy Inference systems (ANFIs), Computation of fuzzy logic inferences by hybrid neural net. Trainable neural nets for fuzzy IF-THEN rules, Implementation of fuzzy rules by regular FNN, neuro fuzzy inference, Neuro-fuzzy classifiers, clustering, FULLINS, Applications of fuzzy neural systems.

Books/References:

1. Fuller, Robert, "Introduction to Neuro Fuzzy Systems", Springer-Verlog, 2000

2. Jyh-Shing Roger Janny, Chuer Tsai Sun, EijiMizutasni, "Neuro fuzzy and Soft Computing", Prentice Hall, 1997.
3. www.mathworks.com, "Neural Network Toolbox User's Guide".
4. www.mathworks.com, "Fuzzy Logic Tool Box User's Guide".

BE 709 ARTIFICIAL VISION 3 0 0 3 3

Introduction to vision, Basics of picture processing, Binary and grey scale images, Biological eyes compared to cameras and VLSI sensors; Types of camera for Machine Vision and their principles, different types of eyes; Optics; theoretical signal processing limits in eyes and cameras; the Sampling Theorem:

Colour Image Models: Colour models, colour representation, colour matching, histogram, colour difference measures, colour vision model and properties.

Preprocessing concepts – Digital image, Geometrical correction, Grey scale modification, Sharpening and smoothing the images.

Edge detection and line funding – Spatial differentiation, Extraction of line descriptions.

Softwares: Measurement and pattern recognition applications with examples – Two and three dimensional measurements, Fourier transform for pattern recognition applications, image operation studies, interfacing a robot with a vision system.

Books/References:

1. Kim L Boyer, SudeepSarkar, "Perceptual Organization for Artificial Vision Systems" (Kluwer International Series in Engineering and Computer Science, 546)
2. Oliver Faugeras, "Three Dimensional Computer Vision (Artificial Intelligence).
3. David J Fleet, "Measurement of Image Velocity", Kluwer Academic Publisher/ March.
4. J R Parker, "Algorithms for Image Processing and Computer Vision", November 8, 1996
5. R C Gonzalez, "Digital Image Processing using MATLAB", Pearson, 2004.
6. J C Russ, "The Image Processing Handbook", Fourth Edition.
7. A K Jain, "Fundamental of Image Processing", Pearson, 2004.

EL 710 Analog and Digital Circuits 4 0 0 4 4

Overview of analog devices: Bipolar junction transistors, FET devices. Linear integrated devices: operational amplifiers and its characteristics, Op-amp applications, timer ICs.
Digital systems: Review of Boolean algebra, logic technology, minimization techniques, combinational and sequential circuits, multiplexers, de-multiplexers and their applications, state machine models: FSM, ASM. Memory devices, clock generators, error detection and correction circuits, PLDs, FPGAs, CPLDs, ADCs, DACs,
Power semiconductor devices: DIAC, TRIAC, BJT, MOSFET, IGBT, GTO, drive circuits, PSD protection circuits: snubbers.

Books/References:

1. Operating Amps and Linear Integrated Circuits by Ramakant A. Gayakwad (PHI)
2. Integrated Electronics: Analog and Digital Circuits and Systems. by Millman and Halkias (Tata McGraw Hill)
3. Digital Systems-Principles and Applicati**ons** by R. J. Tocci and N. S. Widmer (PHI)
4. Power Electronics: Converters, Applications, and Design by Ned Mohan, Tore M. Undeland, and William P. Robbins (John Wiley)

EL 711 Microwave Devices, Circuits and Measurements 4 0 0 4 4

Microwave transistor, microwave tunnel diode, varactor diode, Schottky diode, MESFET: Principle of operation, MOS structure, MOSFET microwave applications, Charge Coupled Devices (CCD), transferred electron devices: Gunn diode, LSA diode, modes of operation, microwave generation and amplification; avalanche effect devices: Read diode, IMPATT diode; klystron: velocity modulation process, bunching process, output power and beam loading; reflex klystron: power output and efficiency; traveling wave tubes, magnetron.
Microwave waveguide components: attenuators, phase shifters, matched loads, detectors and mounts, slotted-sections, E-plane tee, H-plane tee, hybrid tees, directional couplers, tuners, circulators and isolators, quarter wavelength transformer, multi section transformer matching section; lumped planar components: capacitor, inductor and balun; power dividers, directional couplers, analysis of these components using the S-parameters, microwave planar filters, planar non reciprocal devices, signal generators: fixed frequency, sweep frequency and synthesized frequency oscillators; frequency meters, VSWR meters, measurements of frequency, attenuation, VSWR and impedance; cavity measurements: Q-factor, bandwidth; dielectric and magnetic properties of materials: cavity and waveguide methods; measurements of power: calorimetric and microwave bridges; microwaves in process control instrumentation, microwave waste disposal, microwave in agriculture and medicine, hyperthermia etc., microwave heating, microwave absorbers**.**

Books/References:

1. Physics of Semiconductor Devices by S. M. Sze and K. K. Ng. (John Wiley)
2. Microwave Devices and Circuits by S. Y. Liao (Pearson Education)
3. Antennas by J. D. Kraus (McGraw Hill)

EL 712 Electromagnetic Theory and Antennas 4 0 0 4 4

Maxwell's equations, electromagnetic radiation, plane waves in dielectric and conducting media, reflection and refraction of waves, transmission lines, smith chart and its applications, rectangular wave guide, rectangular cavity, modes in waveguides and cavities, dielectric filled wave guides, dielectric slab guide, surface guided waves, non-resonant dielectric guide, modal expansion of fields and its applications**.**
Antenna characteristics: radiation patterns, directive gain, side lobe, back lobe, polarization, co-polarization and cross polarization level, , frequency reuse, beam width, input impedance, bandwidth, efficiency, antenna types: wire, loop and helix antennas, aperture antenna - slot, waveguide and horn antenna; parabolic reflector antenna, microstrip antenna: rectangular and

circular patch, feed for microstrip antennas: probe feed, microstrip line feed, aperture feed, electromagnetically fed microstrip patch; circularly polarized microstrip antennas, wide band and multi-frequency antennas, planar array, phased array and adaptive antenna, feed network of microstrip antenna array, antenna for mobile communication: handset antenna and base station antenna.

Books/References:

1. Electromagnetic Theory by J. A. Stratton (IEEE Press)
2. Microstrip Antenna Theory and Design by J. R. James, P. S. Hall and C. Wood (IEE Publication)\
3. Antennas by J. D. Kraus (McGraw Hill).

EL 713 Advanced Data Communication 4 0 0 4 4

Data Transmission: Analog and Digital transmission, Transmission Impairments, Wireless Transmission Media, Guided transmission media.

Data Signaling: Encoding of Digital Data to Digital signal, Digital Data to Analog Signal, Analog Data to Analog signal and Analog Data to Digital Signal. Spread Spectrum Signaling, Data Communication Interface, Data Link control - stop & wait protocol, sliding window protocol, select & reject ARQ etc., multiplexing.

Data Communication Networks: Circuit Switched Networks, Packet Switched Networks, Asynchronous Transfer Mode (ATM) Networks, Local Area Networks – OSI model, TCP/IP Protocol, Medium Access Control (MAC), Star topology, Ring Topology, Wireless LAN, Wide Area Networks, Fiber Optic Networks, ISDN - ISDN Channels & Interface, All Optical Networks-WDM Optical Networks.

Books/References:

1. William Stallings: Data and Computer Communication.
2. Murthy &Guruswamy: WDM Optical Networks.
3. Martin S Roden: Digital Communication Systems Design.

EL 714 SIGNALS AND CIRCUITS 3 0 0 3 3

(Approved by 5th Academic Council held on 09–05- 08 Res. No.AC.05/2008/1/15)

1. **Introduction to Signals and Systems:** Signals and systems as seen in everyday life, and in various branches of engineering and science: electrical, mechanical, hydraulic, thermal, biomedical signals and systems as examples. Extracting the common essence and requirements of signal and system analysis from these examples.

2. **Signal Characteristics:** Energy and power signals, signal properties: periodicity, absolute integrability, Some special signals of importance: the unit step, the unit impulse,

the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals.

3. **Periodic and Aperiodic signals:** Frequency response and its relation to the impulse response, Fourier series representation, the Fourier Transform, magnitude and phase response, analog circuits – RLC, Passive integrator, differentiator, Discrete fourier Transform (DFT).

4. **The Laplace Transform:** Laplace transform of continuous time signals and systems: Laplace domain analysis, solution to differential equations and system behaviour.

5. **The Sampling Theorem:** Spectra of sampled signals, Reconstruction: ideal interpolator, zero-order hold, first – order hold, and so on. Aliastingand its effects. Relation between continuous and discrete time systems, basic digital circuits, A/D & D/A conversion.

6. **Applications of signals and systems theory:** Modulation and demodulation, filtering and Applications of signal and system theory: filtering-low-pass, high-pass, band-pass and band-elimination filters, examples like noise filtering and elimination of power line components from the ECG signals.

7. **Statistical signal analysis:** Statistical signal analysis, Probability, average, variance, standard deviation, correlation, time-series analysis.

Books/References:

1. A V Oppenheim, AS Willsky and I T Young, "Signals and Systems", Prentice-Hall, 1983.
2. R F Ziemer, W H Tranter and D R Fannin, "Signals and Systems – continuous and Discrete:, 4th Ed. Prentice – Hall, 1998
3. Douglas K Lindner, "Introduction to Signals and Systems", McGraw Hill International Edition: c 1999
4. Simon Haykin, Barry Van Veen, "Signals and Systems", John Wiley and Sons (Asia) Pvt. Ltd., 1998
5. Robert A Gabel, Richard A Roberts, " Signals and Linear Systems", John Wiley and Sons (Asia) Pvt. Ltd., 1995
6. M J Roberts, " Signals and Systems – Analysis using Transform methods and MATLAB", Tata McGraw Hill Edition, 2003.
7. I J Nagarth, S N Sharan, R Ranjan, S Kumar, "Signals and Systems", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2001
8. Ashok Ambardar, " Analog and Digital Signal Processing", Second Edition, Brooks/Cole Publishing Company

EL 715: Sparse Representations in Signal and Image Processing
(Approved by 24th Academic Council meeting, held on 04/06/2015 vide Resolution No: AC.24/2015/1/3.1)

EL 715: Sparse Representations in Signal and Image Processing ***L-T-P: 3-0-1 CH 5***

Course Contents:

Introduction: Sparse signal, Signal representations, Sparse representation of signals.

Sparse representation: Discrete cosine transforms, Discrete Fourier transform, Discrete wavelet transform, Dictionary learning for sparse representation.

Sampling sparse signals: Sparsity, Incoherence, Dictionary, Restricted isometry property.

Sparse Solution: Sparse Solution via Linear Programming, Under-determined systems of linear equations, ℓ^0, ℓ^1, ℓ^2 and ℓ^p Solutions, Approximate sparse solution, Error correction via linear programming, Signal recovery from random projections.

Recovery Algorithms: Matching Pursuit, OMP, Primal-dual interior point methods, Log barrier method, Gradient projection method, and Fast Algorithms for sparse solutions.

Applications: Image Compression, Denoising, Super-resolution, Face Recognition, MRI, Feature Selection, Sparsity-Based Clustering, Missing, Incomplete, Corrupted Features.

Text Book:

1. M. Elad, Sparse and Redundant Representations: From Theory to Applications in Signal and Image Processing, Springer, 2010.
2. J. L. Starck, F. Murtagh and J. M. Fadili, Sparse Image and Signal Processing: Wavelets, Curvelets, Morphological Diversity, CUP, 2010.
3. S. Boyd and L. Vandenberghe, Convex Optimization, CUP, 2004.

References

As there is no specific text book for the course, the recommended references for this course may also include:

4. Lustig, Donoho, Santos and Pauly - Compressed Sensing MRI, MRM 2007.
5. Donoho and Elad - Optimally Sparse Representation in General (nonorthogonal) Dictionaries via L1 Minimization, PNAS 2003.
6. G. Strang, Linear Algebra and Its Applications, 4th Ed., Cengage, 2006.
7. Duarte, Davenport, Takhar, Laska, Sun, Kelly, Baraniuk - Single Pixel Imaging via Compressive Sampling, IEEE SPM 2008.
8. Wright, Ma, Saipro, Mairal, Huang, Yan - Sparse Representation for Computer Vision and Pattern Recognition, Signal Processing Magazine 2010.
9. Tropp and Gilbert - Signal Recovery from Random Measurements via Orthogonal Matching Pursuit - IT 2007.
10. Mairal, Elad and Sapiro - Sparse Representation for Color Image Restoration - IEEE IP 2008.
11. Yang, Wright, Huang and Ma - Image Superresolution via Sparse Representation - IEEE IP 2010.

EL 716: Linear Algebra and Convex Optimization L-T-P: 3-0-0 CH 3

Course Contents:

Linear equations and matrices: Systems of linear equations, Homogeneous systems, Matrix algebra.

Vector Spaces: Real vector spaces, Euclidean space, Subspaces, Span, Range and Null space Linear dependence and Linear independence, Basis and Dimension, Rank of a Matrix, Rank Nullity theorem.

Orthogonality: Orthogonality, Inner product spaces, Orthogonality, Gram-Schmidt process, Norms, Orthonormal basis.

Eigenvalues and Eigenvectors: Eigenvalue-Eigenvector pairs, Characteristic equation, Eigenspaces and geometric multiplicity.

Linear Transformations: Kernel and range, Matrix of linear transformation, Operations on linear transformations, Dual Spaces.

General Matrices: The matrices AA^T and A^TA, Singular Values, Singular Value Decomposition, Pseudo-inverse and the Geometry of Pseudo-inverse.

Introduction to Convex Optimization: Convex sets, convex functions, Convexity, Conjugate function, conjugate sets, Hyperplanes, Norm-balls, Formulation of convex optimization problems.

Duality Theory: Weak and strong duality, Lagrangian dual function, KKT conditions.
Convex optimization algorithms: Barrier interior point method, Primal-dual interior point methods, Conjugate gradient-projection method.

Text Book:

1. Gilbert Strang, Introduction to Linear Algebra, Fourth Edition, Wellesley-Cambridge Press, Wellesley, MA, 2009, ISBN 978-09802327-14
2. Boyd, Stephen P.; Vandenberghe, Lieven (2004). Convex Optimization, Cambridge University Press.ISBN 978-0-521-83378-3. Retrieved October 15, 2011.
3. Edwin K. P. Chong, Stanislaw H. Zak, An Introduction to Optimization, Fourth Edition, Wiley-India, 2013, ISBN: 978-1-118-27901-4.

Reference Books:

1. Stephen H. Friedberg and Arnold J. Insel, Linear Algebra, 4th Edition, Pearson, 2003.
2. Dimitri P. Bertsekas, Convex Optimization Theory Athena Scientific, 2009.
3. Nesterov, Introductory Lectures on Convex Optimization: A Basic Course, Springer, 2003.
4. David G. Luenberger, Optimization by Vector Space Methods, Wiley, 1997.

5. Ben-Tal and Nemirovski, Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications, MPS-SIAM Series on Optimization, 2001.

EL 717: Digital Image Processing **L-T-P: 3-0-1 CH 5**

Course Contents:

Introduction: Digital image fundamentals, Brightness, Contrast and grey levels, Fundamentals steps in image processing.

Intensity Transformation and Spatial Filtering: Intensity Transformation, Histogram equalization, Histogram matching, Smoothening and Sharpening spatial filters.

Image Transforms: Introduction, Two-dimensional orthogonal and unitary transforms, Basis Images, Two-dimensional discrete Fourier transform, Cosine transform, Sine transform, Hadamard transform, Haar transform, KL transform, Wavelet transform.

Image Restoration: Noise models, Mean filters, Order-Statistics filters, Inverse filter, Wiener filter, Estimation of Degradation functions, Restoration from projections.

Image Compression: Fundamental Redundancy, Image Compression Models, Coding Theorems, Entropy, Error-Free Compression, Lossy Compression, LZW coding, Transform Coding, JPEG-2000 encoding, Lossless predictive coding, Lossy predictive coding .

Image Segmentation: Point, line detection, Edge detection, Boundary detection based techniques, Thresholding, Iterative thresholding, Region-based segmentation.

Morphological Image Processing: Erosion, Dilation, Opening, Closing, Hit-or-Miss Transform, Boundary Detection, Hole filling, Connected components, Convex hull, thinning, Thickening, Skeletons, Pruning, Morphological Reconstruction.

Text Books:

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson , Third Edition, 2009.
2. Anil K. Jain, Fundamentals of Digital Image Processing, Pearson, 2013.

Reference Books:

1. Rafael C. Gonzalez, Richard E. Woods, & Stevev L. Eddins, Digital Image Processing using Matlab, Prentice-Hall, 1st edition, 2003, ISBN: 0130085197.
2. Kenneth R. Castelman, Digital Image Processing, Prentice-Hall, 1996.
3. William K. Pratt, Digital Image Processing, John Wiley & Sons Inc., 3rd edition, 2001.
4. S. Ahmed, Image Processing, McGraw -Hill, 1994.
5. S.J. Solari, Digital Video and Audio Compression, McGraw-Hill, 1997.

EL 718: Machine Vision **L-T-P: 3-0-1 CH 5**

Course Contents:

Introduction to Machine Vision: Fundamental concept, Image Geometry, Parts of machine vision system, Levels of Computation.

Image Segmentation: Deformable curves and surfaces, Edge-based - voting, optimization, perceptual grouping, Pixel-based – clustering, Texture Segmentation, Snakes and active contours.

Feature Extraction: Geometric features - lines, circles, ellipses, Blobs, Edges - Canny; Line detectors, Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.

Shape Representation and Boundary descriptors: Shape from shading, Shape from monocular images, surface geometry, Boundary descriptors.

Object Recognition: System Components, Complexity of Object Recognition, Matching, Classification, Template Matching.

Image Formation Models: Monocular imaging system, Orthographic & Perspective Projection, Camera model and Camera calibration.

3D vision, Geometry: Methods for 3D vision, Projection schemes, Shape from shading, Photometric stereo, Shape from texture, Active range finding – Surface representations, 3D object recognition, and 3D reconstruction.

Motion Analysis: Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion.

Text Books:

1. R. Jain, R. Kasturi and B. G. Schunck, Machine Vision, McGraw-Hill, 1995.
2. D. A. Forsyth and J. Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003.
3. Dana H. Ballard & Christopher M. Brown, Computer Vision, Prentice-Hall, 1982.

Reference Books:

1. B. Horn, Robot Vision, MIT Press, 1986.
2. Robert M. Haralick & Linda G. Shapiro, Computer & Robot Vision, Addison-Wesley, 1993.
3. Anil K. Jain, Fundamentals of Digital Image Processing, Pearson, 2013.
4. Rafael C. Gonzalez, Richard E. Woods, & Stevev L. Eddins, Digital Image Processing using Matlab, Prentice-Hall, 1st edition, 2003, ISBN: 0130085197.

5. Tom M. Mitchell, Machine Learning, McGraw-Hill, 1997.
6. E.R. Davies, Machine Vision - Theory Algorithms Practicalities, 3rd Ed., Elsevier, 2005.

Course Structure and Syllabi

Core Course : RP799: Research and Publication Ethics (L-2, T-0, P-0, CH-2, CR-2)

The course on Research and Publication Ethics be offered compulsorily to all Ph.D. students as course work of the Ph.D. programme w.e.f. the academic session 2020-21.

About the course:

The course has total of 6 units focusing on basics of philosopy of science and ethics, research integrity, publication ethics. Hands-on sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases open access publications research metrics(citations, h-index, Impact Factor, etc.) and plagiarism tools will be introduced in this course.

Evaluation:

Continuous assessment will be done through tutorials, assignments, quizzes and group discussions. Weightage will be given for active participation. The final written examination will be conducted at the end of the course.

Unit 1: Philosophy and Ethics

1. Introduction to philosophy, definition, nature and scope, concept, branches
2. Ethics, definition, moral philosophy, nature of moral judgements and reactions

Unit 2: Scientific conduct

1. Ethics concerning science and research
2. Intellectual honesty and research integrity
3. Scientific misconduct, falsification, fabrication and plagiarism
4. Redundant publications, duplicate and overlapping publications and salami slicing
5. Selective reporting and misrepresentation of data

Unit 3: Publication Ethics

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Unit 4: Open access publishing

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

Unit 5: Publication misconduct

A. Group Discussions (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit 6: Data Base and research Metrics

A. Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

References

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MacIntyre, Alasdair (1967) *A Short History of Ethics.* London.

P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865

National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. National Academies Press.

Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences*, 1–10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm

Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179–179. https://doi.org/10.1038/489179a

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