Honors in Machine Learning and Signal Processing

Department of Electronics and Communication Engineering

Table-II Honors in Machine Learning and Signal Processing

S.No.	Semester	Course Code	Course Name	Category	Type	Credit	L-T-P
1	V		Modeling, Optimization and Transforms		Theory	3	3-0-0
2	V		Multirate Signal Processing		Theory	3	3-0-0
3	VI		Medical Engineering and Systems		Theory	3	3-0-0
4	VI		Computer Vision		Theory	3	3-0-0
5	VII*		Reduced order modeling, Optimization and Machine Intelligence		Theory	3	3-0-0
6	VII*		VLSI Signal Processing Architecture		Theory	3	3-0-0
7	VII*		Mini Project on Machine Learning and Signal Processing		Practical	3	0-0-6
8	VIII*		Adaptive Signal Processing		Theory	3	3-0-0
9	VIII*		Advanced Digital Signal and Image Processing		Theory	3	3-0-0
10	VIII*		Pattern Recognition and Machine Learning		Theory	3	3-0-0
11	VIII*		Mini Project on Machine Learning and Signal Processing		Practical	3	0-0-6

S J Nanda

Honors in Machine Learning and Signal Processing

Course Name: Modeling, Optimization and Transforms
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :
Unit I- Advancements in Transforms: Discrete Fourier Transform, FFT, Short time Fourier Transform (STFT), Multi Resolution Analysis, Wavelet Transform, Continuous Wavelet Transform (CWT), Inverse CWT, Discrete Wavelet Transform, Sub-band coding and implementation of DWT, Applications (signal and image compression, de-noising, detection of discontinuous and breakdown points in signals), Discrete Cosine Transform, Stockwell-transform, Frequency selective filtering with wavelet and S-transform.

Unit II- Modelling: Direct Modeling (identification), Inverse Modeling (Equalization), Classification and Clustering, Prediction/Forecasting, Auto regressive models (AR, MA, ARMA).

Unit III- Optimization: Problem formulation, Linear Programming Problems, Solution by Graphical Methods, Symmetric Dual Problems, Slack and Surplus Variables, Simplex Method, Convex- Concave Problems.

Unit IV- Data Mining Techniques: Higher Order Statistics, Principal Component Analysis, Linear Discriminant Analysis, Independent Component Analysis

COURSE OUTCOMES
CO1: To learn the advancement in transforms
CO2: To understand the mathematical modeling and optimization techniques.
CO3: To learn the data mining techniques
CO4: To explore the engineering applications of the mathematical techniques.
CO5: To develop MATLAB and other programming skills for the mathematical techniques realization.

Recommended Readings
Text Books:-
1. Digital Signal Processing: Principles, Algorithms, and Applications 4 Edition, Author: John G. Proakis, Dimitris G Manolakis Publisher: Pearson.
2. Wavelets and Signal Processing, Author: Hans-Georg Stark, Publisher: Springer
3. Stockwell, Robert Glenn, Lalu Mansinha, and R. P. Lowe. "Localization of the complex spectrum: the S transform." IEEE Transactions on Signal Processing 44.4 (1996): 998-1001.

Reference books:-
1. Engineering Optimization: Theory and Practice, Third Edition SINGIRESU S. RAO, New Age Publishers
2. Data Mining - Concepts and Techniques, Authors : Jain Pei, Jiawei Han, Micheline

Kamber, Publisher : Elsevier

Online/E resources:-

1. The Wavelet Tutorial : The Engineer's Ultimate Guide to Wavelet Analysis, Author : Robi Polikar, University of Rowan : Online : http://users.rowan.edu/~polikar/WTtutorial.html

Course Name: Multirate Signal Processing
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

Unit I- Introduction to Multirate Signal Processing; Overview of Sampling and Reconstruction, Review Discrete-Time Systems, Digital filters, FIR and IIR Filter, Oversampling techniques, DT processing of continuous time signals.

Unit II- Fundamentals Blocks of Multirate Systems, Basic building blocks – Up sampling, Down sampling, Aliasing, Interference, Reconstruction, Sampling Rate Change and filtering, Fractional sampling rate alteration, Different Applications.

Unit III- Interconnection of Multirate DSP blocks, Multiplexer and De-multiplexer functionality, Polyphase decomposition, Noble Identities, Efficient implementation of sampling rate conversion, Classification of Realization Techniques, Direct Form Realization.

Unit IV- Classification of Filterbank, Two channel maximally decimated filter bank, Signal impairments - Aliasing, Magnitude distortion, Phase distortion, M-Channel Filterbank, Uniform Filterbank, Non-Uniform Filterbank, Perfect reconstruction Filterbank, Aliasing cancellation, Tree Structure, Parallel Structure, Modulation based Methods.

Unit V- Applications of Multirate DSP - DFT-based Filterbank, Interpolated FIR filter design, Delta Sigma A/D conversion, Transmultiplexers Design, Recent Advancement in Multirate System.

COURSE OUTCOMES

- Analysis of Recent Signal Processing Techniques and Algorithms in Filterbank Systems
- Design FIR filters for multi rate signal processing, Appreciate Components of Multirate System
- Design PR and NPR Filterbank and Transmultiplexers Systems
- Characteristics of Multirate systems
- Evaluate sampling rate conversions and learn different Applications

Recommended Readings
Text Books: -

1. Vaidyanathan, Parishwad P., "Multirate systems and filter banks", Pearson Education India, 2006
2. Rabiner, Lawrence R., "Multirate digital signal processing", Prentice Hall PTR, 1996

SSNanda — Lava Bhargava

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Reference books:-

1. 1. N.J. Fliege, "Multirate digital signal processing", John Wiley 1994
2. S. K. Mitra and Y. Kuo, " Digital signal processing: a computer-based approach", McGraw-Hill, 2006.

Online/E resources:-

1. https://nptel.ac.in/courses/117/102/117102060/
2. https://onlinecourses.nptel.ac.in/noc19_ee50/

Course Name: Medical Engineering and Systems
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

Module 1: Physiological Signal Processing

Physiology: Basics of ECG Signal and its Acquisition, Electrical activity of heart, ECG Waveform, Interpretation of ECG, Introduction of EEG Signal, EEG Acquisition, Neural activity in the brain, Signal Propagation in the brain, EMG signal, EMG recording, Signal processing and Filtering of EEG, ECG, EMG etc.

Module 2: Wearable Device and Healthcare Technologies

Health monitoring with wearable sensors, Wearable electrodes of ECG, EEG & EMG, Accelerometer, Glucose sensing device, Smart healthcare components- cHealth, eHealth and mHealth. Role of IoT in Healthcare, Electronics Health Records, Concept of Bioinformatics, Security and Privacy of Health records

Module 3: Machine Learning for Health information

Data & Modelling of Health information, Basics concepts of ML, Role of ML for Healthcare, Feature Extraction of real-world signals as speech, audio, text, image, video., Pre-processing Requirements of signals, Noise and artifacts, information retrieval, Optimization, Regression, Classification, Unsupervised Learning for Health data, Pattern Recognition, Gaussian models, Time series modelling.

Module 4: Deep learning for healthcare

Basics of DL, MLP, Back Prorogation, Convolutional Neural Networks & Recurrent Neural network for digital health, Forward and Backward propagations, Architectures for sequence to sequence and sequence to vector mapping, Models for Healthcare using deep, recurrent and deep networks, LSTM, Medical Image analysis, Need for Deep Learning & Neuroimaging, Object Detection, Segmentation, Deep learning models.

Module 5: Medical Devices and Systems

Risks of Integration and Healthcare Systems Testing & Evaluation, Vitro/Vivo testing, Regulatory requirements of medical devices, Standards of medical device, quality assurance Medical Device Classification, Risk management system for medical devices, Certification of medical device, Ethical regulation of medical devices & systems, Medical Devices regulation in India, USA and other countries.

Course Outcomes:

CO1: To understand the basic concepts of various physiological signals and their processing (Knowledge)
CO2: To understand and design the medical devices and technologies for healthcare (Cognitive, Understanding)
CO3: To learn and develop the machine learning models for healthcare applications (Affective, creative)
CO4: To aware of various risk, ethical and regulatory rules for medical devices & systems (Cognitive- Analytic)

Textbooks:

References:

1. Introduction to Biomedical Engineering by John Enderle , Joseph Bronzino Academic Press
2. **Biomedical Engineering: Bridging Medicine and Technology by W. Mark Saltzman, Cambridge**
3. **Machine Learning and Analytics in Healthcare Systems: Principles and Applications (Green Engineering and Technology) by Himani Bansal, Balamurugan Balusamy, et al., CRC.**
4. **Machine Learning in Medicine by Ayman El-Baz and Jasjit S. Suri, Chapman & Hall/CRC Health Informatics,**
5. Demystifying Big Data, Machine Learning, and Deep Learning for Healthcare Analytics by Pradeep N, Sandeep Kautish, et al., Academic Press

Course Name: Computer Vision
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

Unit 1: Introduction and Overview: Overview of image processing systems, image formation and perception, continuous and digital image representation, image contrast enhancement, histogram equalization, affine transformations, model of image degradation/restoration process, Image Filtering

Unit 2: Feature Detection and Matching: Interest point detection, Edge, Blob, Corner detection; SIFT, SURF, HoG descriptors, Local Image Features and Feature Matching, RANSAC, Bag-of-words

Unit 3: Machine Learning and Deep Learning Quick course: Supervised & Unsupervised Machine Learning, Clustering , Classification, Review of Neural Networks, Convolutional Neural Network, CNN Architectures: AlexNet, VGG, InceptionNets, ResNets, DenseNets, Transfer Learning, Recurrent Neural Network, Long Short Term Memory(LSTM) , Visualization with CAM, Grad-CAM

Unit 4: CNNs for Computer Vision Tasks: Image Classification: CIFAR, MNIST, ImageNet Datasets, Object Detection: R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD; Segmentation: FCN, U-Net, Mask-RCNN

Unit 5: Recent Trends and Applications: Deep Generative Models, Generative Adversarial Networks (GANs), Attention Models, Graph Convolutional Networks, Zero-shot, One-shot, Few-shot Learning, Visual Question Answering, Image Captioning

Course Outcomes:

At the end of the course students should be able to:

CO1: Describe different image representation, their mathematical representation and different their data structures used. (Cognitive- Remembering, Understanding)

CO2: Implement feature extraction techniques for developing computer vision applications (Skills - Apply, create)

CO3: Recognize the object using the concepts of machine vision (Cognitive + Skill- Analyze)

CO4: Grasp the principles of state-of-the-art deep neural networks (Skills- Apply, Evaluate)

CO5: Develop the practical skills necessary to build computer vision applications (Skills- Apply, Evaluate)

References:

1. Computer Vision: Algorithms and Applications, by Richard Szeliski
2. Computer Vision: A Modern Approach, Forsyth and Ponce, Pearson Education.
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2008
4. Concise Computer Vision by Reinhard Klette
5. Deep Learning, by Goodfellow, Bengio, and Courville.
6. NPTEL Course Deep Learning for Computer Vision By Prof. Vineeth N Balasubramanian (IIT Hyderabad)

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Course Name: Reduced order modeling, Optimization and Machine Intelligence

Course Code :

Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

A. Reduced order modelling & large Eigen value methods-

(i) (a) Large Matrix analysis and large Eigen value problem– Groups, fields and rings; vector spaces; basis & dimensions; canonical forms; inner product spaces- orthogonalization, Gram-Schmidt orthogonalization, unitary operators, change of orthonormal basis, diagonalization; (b) Eigenvalues & eigen vectors- Gerschghorin theorem, iterative method, Sturm sequence, QR method, introduction to large eigen value problems.

(ii) Reduced order modelling of systems- Taylor's polynomial, least square approximation, Chebyshev series/polynomial, curve fitting & splines, Pade & rational approximation

B. Discrete Structures, algorithms & Combinatorial optimization- counting methods, algorithm analysis, graph algorithms, dynamic algorithms, randomized algorithms, probabilistic algorithms, combinatorial optimization

C. Digital arithmetic & machine intelligence-

(i) Number theory & computer arithmetic- unconventional number systems, residue number system, logarithmic number system, Chinese remainder theorem; fast evaluation of elementary & transcendental arithmetic functions.

(ii) Preface to AI- first order logic & inferencing, uncertainty, probabilistic reasoning systems, making decisions under uncertainty.

Suggested references (not limited to)-

1. Schaum's outline on Linear Algebra, McGraw Hill
2. Topics in Algebra, I. N. Herstein, Wiley.
3. Advanced Model Order Reduction Techniques in VLSI Design, Sheldon Tan, Lei He, Cambridge Univ. Press, 2007.
4. Model Order Reduction: Theory, Research Aspects and Applications edited by W. H. A. Schilders, Henk A. Van Der Vorst, Joost Rommes, Springer.
5. Gerald, C F; Wheatley P O; Applied Numerical Analysis, Pearson, 2017
6. Theory and Applications of Numerical Analysis, G. M. Phillips, Peter J. Taylor, Academic press
7. Discrete Structures, Schaum outline
8. Cormen, Rivest, Leiserson, Introduction to Algorithms, PHI
9. Combinatorial optimization, Papadimitriou and Steiglitz, PHI (I)
10. Israel Koren, Computer Arithmetic- Academic Press
11. Russel and Norvig- Artificial Intelligence: A Modern Approach, Pearson, 3rd Ed. 2017

Further references

1. Luigi FORTUNA, Guiseppe NUNNARI, Antonio GALLO, MODEL ORDER REDUCTION TECHNIQUES WITH APPLICATIONS IN ELECTRICAL ENGINEERING, Springer, 1992.
2. Y. Saad, Numerical methods for large Eigenvalue problems, www.umn.edu
3. Matrix Analysis & linear algebra, Meyer, SIAM
4. H. A. van der Vorst, Iterative methods for large linear systems, citeseerx.ist.psu.edu
5. Cheng et al, Symbolic analysis and reductions of VLSI circuits, Springer, 2005

Course outcomes

CO1. Is able to grasp core concepts, basic tenets of linear algebraic structures- groups, fields and rings;vector spaces (knowledge)
CO2. Is able to grasp features, properties and operations on vector spaces- orthogonalization, change of basis, diagonalization (knowledge)
CO3. Is able to learn & apply problem solving for computing eigen values and eigen vectors etc. (Thinking, skills)
CO4. Is able to demonstrate application of algorithms (Gerschgorin, Sturm sequence method, QR method) for eigen value computation/estimation and MATLAB/SCILAB validation(skills)
CO5. Is able to describe algorithms for function approximation, fitting (rational, Chebychev, Pade etc.) using MATLAB (skills)
CO6. Develops appreciation for combinatorial optimization algorithms, AI probabilistic approaches & implements through MATLAB/C++/SCILAB (skills)

Course Name: VLSI Signal Processing Architecture
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

Unit 1: Introduction to VLSI DSP Systems : Need of VLSI DSP algorithms. main DSP Blocks and typical DSP Algorithms. Fixed point /Floating point Representation; Floating point Arithmetic Implementation, Architectures of Adders/Multipliers; CORDIC, representation of DSP algorithms: Block Diagram, signal flow graph, data flow graph, dependence graph.
Unit 2: Iteration Bound Data flow graph representations, loop bound and iteration bound, longest path matrix algorithm, iteration bound of Multirate data flow graphs.
Unit 3: Pipelining and Parallel Processing: Pipelining and parallel processing of FIR digital filters, pipeline interleaving in digital filters: signal and multichannel interleaving.
Unit 4: Retiming, Unfolding and Folding: retiming techniques; algorithm for unfolding, Folding transformation, Techniques of retiming, Unfolding & Folding.
Unit 5: Systolic Array Architecture Systolic Array Architecture: Methodology of systolic array architecture, FIR based Systolic Array, Selection of Scheduling Vector, Matrix multiplication of systolic array
Unit 6: Low power Design Theoretical background , Scaling v/s power consumption, power analysis, Power reduction techniques, Power estimation approach

<u>Course Outcomes :</u>

CO1-To understand Graphical representation of DSP algorithms and Mapping algorithms into Architectures (Cognitive/Skills- Apply)
CO2-To study architecture for real time systems and parallel and pipelining for Low power design (Cognitive- Remembering)

CO3-To be aware of systolic Array architecture and methodology for developing Architectures (Cognitive- Understanding)

CO4-To know different signal processing modules as convolution technique, retiming concept, folding /unfolding Transformation and CORDIC architecture. (Cognitive- Analyse)

CO5-To implement different low power Design techniques. (Skills- evaluate)

References:

1) VLSI Digital Signal Processing System : : Design and implementation by K.K. Parhi

2) Digital Signal Processing with Field Programmable Gate Arrays Uwe Meyer-Baese , Springer.

3) FPGA-based Implementation of Signal Processing Systems. by Roger Woods, John Mcallister, WILEY

Course Name: Mini Project on Machine Learning and Signal Processing
Course Code :
Credits : 3 (L-T-P : 0-0-6)

List of Experiments/ activities

Design, verification, prototyping and implementation of hardware/ software

Circuits and systems based on software, hardware, algorithms, protocol, concepts in emerging areas such as Artificial Intelligence, Machine Learning, Deep Learning, Neural Networks, Intelligent Algorithms, Signal Processing, Image Processing, Computer Vision, Data Mining, Optimization Techniques, Transforms and related areas on Machine Learning and Signal Processing.

Course Name: Adaptive Signal Processing
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

Adaptive Filter Structures and Algorithms: Introduction to Adaptive systems, Adaptive Linear combiner, Minimum Mean-Square Error, Wiener-Hopf Equation, Error Performance Surface, LMS algorithm, Convergence of weight vector, Learning Curve, FX-LMS algorithm (Filtered X-LMS) and its application to ANC, Types of LMS, RLS algorithm, Matrix Inverse Lemma for RLS, Computational complexity of LMS and RLS, Convergence Analysis. IIR-LMS, Lattice Filter, FIR to Lattice conversion and vice-versa, Adaptive Lattice Filter Kalman Filter, Adaptive Kalman Filter Transformed domain adaptive filtering: Block Linear, Block Circular Filter Banks and multi-rate signal processing Distributed signal Processing: Incremental LMS, Diffusion LMS

Applications: Direct Modelling or System Identification, Inverse Adaptive Modelling (Equalization), Adaptive Noise Cancellation, Adaptive filters for time series and stock market prediction, Biomedical Applications (Cancellation of 50-Hz interference in Electro-Cardiography, Cancelling donor heart interference in heart-transplant electrocardiography, Cancelling Maternal ECG in Fetal Electrocardiography), Echo Cancellation in Long distance Telephone Circuits, Adaptive self-tuning filter, Adaptive line enhancer, Adaptive filters for classification and data mining.

Course Outcomes :

CO1- To learn the characteristics of adaptive system architecture and analyze Wiener-Hopf Equation. CO2- To understand the machine learning algorithms including LMS, RLS, Fx-LMS etc. CO3- To learn the adaptive structures like : Adaptive Lattice Filter, Kalman Filter, Transformed domain adaptive filtering, Filter Banks.

CO4- To explore the applications of adaptive signal techniques to System Identification, Channel Equalization, time series prediction etc.
CO5- To develop MATLAB programming skills for adaptive systems

References:

5) B. Widrow and S. D. Stearns: Adaptive Signal Processing, Prentice Hall.
6) D. G. Manolakis, V. K. Ingle, S. M. Kogon : Statistical and Adaptive Signal Processing, McGraw Hill.
7) S. S. Haykin: Adaptive Filter Theory, 4th Edition, Prentice Hall.
8) H. Sayed: Fundamentals of Adaptive Filtering, John Wiley & Sons.

Course Name: Advanced Digital Signal and Image Processing
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

Introduction to Multirate systems and filter banks, 2D systems and mathematical preliminaries, Digital Representation of Binary & Gray Scale and colour Images, Linear operations on images.
Image sampling and quantization: 2D Sampling on rectangular and nonrectangular sampling lattice, Aliasing, Lloyd-Max quantizer etc.
Image Transforms: 2D Discrete Fourier transform, DCT, DST and Hadamard ,Harr K-L Transforms & their applications to image processing.
Image restoration:Wiener filtering , smoothing splines and interpolation.
Image Enhancement Techniques: Gray scale transformation, Histogram matching and equalization, Smoothening:- Noise Removal, Averagins, Median, Min/Max. Filtering sharpening of Images using differentiation, the laplaciam, High Emphasis filtering,
Image analysis: Edge detection, Boundary Lines & Contours.
Image representation by Stochastic models: ARMA models, 2D linear prediction.
Image Segmentation & Thresholding: Multiband Thresholding, Thresholding from Textures, Selective histogram Technique.
Image Compression: Compression Techniques using K-L Transform, Block Truncation Compression. Error free Comprerssion using Huffman coding & Huffman shift coding.

COURSE OUTCOMES

CO1: Ability to understand Multirate systems, Image sampling and quantization
CO2: Ability to understand Image Transforms, Image restoration and Image Enhancement Techniques
CO3: Ability to understand Image analysis, Image Segmentation & Thresholding, Image Compression

Recommended Readings
Text Books: -

1. Digital Signal Processing- Oppenheim A.V. & Schafer R.W. PHI.
2. Digital Signal Processing-by Mitra- (TATA McGraw Hill) Publications.
3. Digital Image Processing- by Gonzalez / Woods, (Pearson Education)

Reference books: -

1. Digital Image Processing- by A.K. Jain
2. Digital Picture Processing- by Rosenfield & Kak

Online/E resources: -

1. https://nptel.ac.in/courses/117/105/117105135/

Course Name: Pattern Recognition and Machine Learning
Course Code :
Credits : 3 (L-T-P : 3-0-0)

SYLLABUS :

UNIT I

Introduction to Pattern Recognition and Machine Learning, ML design cycle, types of learning: supervised, unsupervised and reinforced, introduction to feature extraction and classification, density and discriminant functions, decision surfaces. Review of probability theory: conditional probability, Bayes theorem, random variables, density and mass functions, expectation and variance, joint distribution function of multiple random variables, multivariate normal distribution.

UNIT II

Bayesian decision theory, Bayes Classifier, Naïve Bayes classifier, Euclidian distance and Mahalanobis distance-based classifiers, minimum-error-rate classification. Parameter estimation methods, Maximum-Likelihood estimation, Gaussian mixture models, Expectation maximization method, Bayesian estimation, Hidden Markov models for sequential pattern classification: discrete hidden Markov models, continuous density hidden Markov models.

UNIT III

K-nearest neighbour classification: Simple and distance weighed voting approach. Support vector machines: linear SVM, softmargin approach for non-separable data, kernel trick to learn non-linear SVM, radial basis function, polynomial, and sigmoidal kernel. Decision tree classifier: set of questions, splitting criterion, stop-splitting rule, and class assignment rule in decision tree. Introduction to neural networks: perceptron as linear classifier and multi-layer perceptron. Regression Analysis.

UNIT IV

Feature extraction methods: statistical features, Fourier and wavelet transforms for feature extraction, Data transformation and dimension reduction: Fisher's linear discriminant analysis, Bayesian LDA, step-wise LDA, principal component analysis, kernelPCA. Optimization in feature selection. Feature visualization. Ensemble of classifiers. Evaluation the performance of a classifier: holdout, random sampling, and cross validation methods, sensitivity, specificity, confusion matrix and ROC curve. Multi-class classification. Statistical analysis for comparison of significance of multiple classifiers over multiple dataset: Template matching and context dependent classification. The curse of dimensionality.

UNIT V

Unsupervised learning and clustering. Criterion functions for clustering, Prototype-based, Graph-based, Density-based clusters. Algorithms for clustering: K means, DBSCAN, Hierarchical clustering, Cluster validation.

Course Outcomes :

CO1-The students would have exposure to different algorithms for learning pattern classification methods and would also have explore to different datasets to get a feel for ML algorithms.

CO2- The statistical and mathematical formulation underlying different algorithms would be understood.

CO3- A background needed to study more advanced topics in ML will be developed (e.g. Deep Learning, Generative Adversarial Networks, etc.).

CO4-The course would help students to build a career in industry using ML, or to be a data scientist, or to pursue research in ML.

References:

Reference Text-Books

5) R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, John Wiley, 2001
6) S. Theodoridis and K. Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009
7) C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006
8) T. Pang-Ningm, V. Kumar, M. Steinbach. Introduction to data mining. Pearson Education India, 2018.

Programming Books

5) S. Theodoridis et. al., 'Introduction to Pattern Recognition, A MATLAB Approach'. Academic Press, 2010

Course Name: Mini Project on Machine Learning and Signal Processing
Course Code :
Credits : 3 (L-T-P : 0-0-6)

List of Experiments/ activities

Design, verification, prototyping and implementation of hardware/ software

Circuits and systems based on software, hardware, algorithms, protocol, concepts in emerging areas such as Artificial Intelligence, Machine Learning, Deep Learning, Neural Networks, Intelligent Algorithms, Signal Processing, Image Processing, Computer Vision, Data Mining, Optimization Techniques, Transforms and related areas on Machine Learning and Signal Processing.