(COIMBATORE)

M.TECH DATA SCIENCE

CURRICULUM 2020

GENERAL INFORMATION

Course Outcome (CO) – Statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

Program Outcomes (POs) – Program Outcomes are statements that describe what students are expected to now and be able to do upon graduating from the Program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. NBA has defined the Program Outcomes for each discipline.

PROGRAM OUTCOMES FOR ENGINEERING

- **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
- **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

SEMESTER I

Cat.	Code	Title	L T P	Credit
FC	20MA604	Computational Linear Algebra and Optimization for Data Sciences	3 0 1	4
SC	20DS611	Introduction to Machine Learning	2 0 1	3
FC	20DS601	Algorithms and Structures for Data Science	2 0 1	3
SC	20DS612	Real Time Operating System for Embedded Computing	2 0 1	3
SC	20DS613	Embedded Computing for Data Science	2 0 1	3
SC	20RM600	Research Methodology	2 0 0	2
HU	18HU601	Amrita Value Programs		P/F
HU	18HU602	Career Competency - I		P/F
		TOTAL		18

SEMESTER II

Cat.	Code	Title	L T P	Credit
SC	20DS614	Machine Learning for Signal Processing and Pattern Classification	2 0 1	3
FC	20DS602	Probabilistic Graphical Models	2 0 1	3
SC	20DS615	Scientific Computing	2 0 1	3
SC	20DS616	Computer Networks and IOT	2 0 1	3
E		Elective-I	2 0 1	3
E		Elective-II	2 0 1	3
HU	18HU603	Career Competency - II	0 0 1	1
		TOTAL		19

SEMESTER III

Cat.	Code	Title	L T P	Credit
SC	20DS617	Big Data Framework for Data Science	2 0 1	3
E		Elective-III	2 0 1	3
E		Elective-IV	2 0 1	3
P	20DS798	Dissertation	0 0 8	8
		TOTAL		17

SEMESTER IV

Cat.	Code	Title	L T P	Credit
P	20DS799	Dissertation	0 0 12	12
		TOTAL		12

		Total Credits		66

List of Courses

Foundation Core

Course Code	Course	L T P	Credits
20MA604	Computational Linear Algebra and Optimization for Data Sciences	3 0 1	4
20DS601	Algorithms and Structures for Data Science	2 0 1	3
20DS602	Probabilistic Graphical Models	2 0 1	3

Subject Core

Course Code	Course	L T P	Credits
20DS611	Introduction to Machine Learning	2 0 1	3
20DS612	Real Time Operating System for Embedded Computing	2 0 1	3
20DS613	Embedded Computing for Data Science	2 0 1	3
20DS614	Machine Learning for Signal Processing and Pattern Classification	2 0 1	3

20DS615	**Scientific Computing**	**2 0 1**	**3**
20DS616	**Computer Networks and IOT**	**2 0 1**	**3**
20DS617	**Big Data Framework for Data Science**	**2 0 1**	**3**
20RM600	**Research Methodology**	**2 0 0**	**2**

PROFESSIONAL ELECTIVES				
Cat	**Code**	**Title**	**L T P**	**Credits**
E	**20DS701**	**Digital Control Systems**	**2 0 1**	**3**
E	**20DS702**	**Multivariable Control Systems**	**2 0 1**	**3**
E	**20DS703**	**Deep Learning in Genomic and Biomedicine**	**2 0 1**	**3**
E	**20DS704**	**Deep Learning for Biomedical Data Analysis**	**2 0 1**	**3**
E	**20DS705**	**Speech Processing**	**2 0 1**	**3**
E	**20DS706**	**Deep Learning for NLP**	**2 0 1**	**3**
E	**20DS707**	**Social Media Analytics**	**2 0 1**	**3**
E	**20DS708**	**Deep Learning for Visual Recognition**	**2 0 1**	**3**
E	**20DS709**	**Deep Learning for Cyber security**	**2 0 1**	**3**
E	**20DS710**	**Computational Fluid Dynamics**	**2 0 1**	**3**
E	**20DS711**	**Deep Learning Essential for Self-Driving Car**	**2 0 1**	**3**
E	**20DS712**	**Introduction to Additive Manufacturing**	**2 0 1**	**3**
E	**20DS713**	**Unmanned Aerial Vehicles and Essential Control**	**2 0 1**	**3**
E	**20DS714**	**Computational Robotics and Robotic Operating System**	**2 0 1**	**3**
E	**20DS715**	**Complex Systems in Engineering, Finance & Biology: Modelling & Analysis**	**2 0 1**	**3**
E	**20DS716**	**Introduction to Data Analysis**	**2 0 1**	**3**

SYLLABUS

SEMESTER I

20MA604COMPUTATIONAL LINEAR ALGEBRA AND OPTIMIZATION FOR DATA SCIENCESL-T-P-C: 3-0- 1- 4

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra, calculus and optimization theory needed for subsequent study.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- At the same time, it will provide an appreciation of the wide application of these disciplines within the scientific field.
- Another goal of the course is to provide connection between the concepts of linear algebra, differential equation and optimization theory.

Course Outcomes

CO1: Use computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors, orthogonality and diagonalization. (Computational and Algebraic Skills).
CO2: Use visualization, spatial reasoning, as well as geometric properties and strategies to model, solve problems, and view solutions, especially in R2 and R3.
CO3: Conceptually extend these results to higher dimensions. (Geometric Skills) and critically analyse and construct mathematical arguments that relate to the study of introductory linear algebra. (Proof and Reasoning).

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	--	--	--	3	2	3	3
CO2	3	3	3	3	3	2	--	--	3	2	3	3
CO3	3	2	3	3	3	--	--	--	3	2	3	3

Syllabus

Matrices and Gaussian Elimination – Introduction, Geometry of Linear Equations, Gaussian Elimination, Matrix multiplication, Inverses and Transposes, Special matrices and applications. Vector spaces and Linear equations– Vector spaces and subspaces, linear independence, basis and dimension, the four fundamental subspaces. Orthogonality - Perpendicular vectors and orthogonal subspaces, inner products and projections onto lines, projections and least square applications, orthogonal basis, orthogonal spaces, orthogonal matrices, Gram Schmidt orthogonalization, FFT. Eigenvalues and Eigenvectors – Introduction, diagonal form of a matrix, difference equations and the powers of A^k, Positive Definite Matrices - Minima, Maxima and saddle points, tests for positive definiteness, semi-definite and indefinite matrices, Singular Value Decomposition, iterative methods for Ax = b, applications in sparse signal and image processing. Introduction - mathematical optimization, least-squares and linear programming, convex and nonlinear optimization. Convex sets, Convex optimization problems - optimization problem in standard form, convex optimization problems, quasi-convex

optimization, linear optimization, quadratic optimization, generalized inequality constraints, semi definite programming, vector optimization. Duality, Approximation and fitting, Statistical estimation, Geometric problems, Unconstrained minimization- gradient descent method, steepest descent method, Newton's method. Equality constrained minimization - equality constrained minimization, eliminating equality constraints, Newton's method with equality constraints, infeasible start Newton method, implementation. Interior-point methods -inequality constrained minimization, logarithmic barrier function and central path, barrier method, L1 Norm Optimization methods,
Alternating direction method of multipliers (ADMM), Applications in Signal and Image Processing.

Textbooks / References

Gilbert Strang, "Linear Algebra and its Applications", Third Edition, Harcourt College Publishers, 1988.
Gene H. Golub and V. Van Loan, "Matrix Computations", Third Edition, John Hopkins University Press, Baltimore, 1996.
David C. Lay, "Linear Algebra and Its Applications", Pearson Addison Wesley, 2002.
Stephen P. Boyd and Lieven Vandenberghe d, Convex Optimization, Cambridge University press, 2004
Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, New Delhi, 2004.
Edwin K.P. Chong and Stanislaw H. Zak, "An Introduction to Optimization" Second Edition, Wiley-Interscience Series in Discrete Mathematics and Optimization, 2004.
M. Asghar Bhatti, "Practical Optimization Methods: With Mathematica Applications", Springer Verlag Publishers, 2000.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (8 assignments with equal credit)	20
Quiz (6 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS611 INTRODUCTION TO MACHINE LEARNING L-T-P-C: 2-0- 1- 3

Course Objectives

- This course dives into the basics of Machine Learning using various tools such as Weka and LibSVM and implementations of Machine Learning algorithms using Python and MATLAB.
- The students will learn about Supervised Vs Unsupervised Learning, investigate how Statistical Modelling relates to Machine Learning, and do a comparison of each.
- The students will enrich with the hands-on experience to implement various machine learning algorithms.

Course Outcomes

CO1: To understand the fundamentals of patterns recognition and to implement clustering concepts and feature extraction techniques.
CO2: To implement the Kernel methods using different machine learning packages such as, Weka and LibSVM.
CO3: Understand and apply various algorithms for pattern recognition and gain knowledge on how to apply classifier to a particular application.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	--	--	3	3	--	3
CO2	3	3	3	3	3	3	--	--	3	3	--	3
CO3	3	3	3	3	3	3	--	--	3	3	--	3

Syllabus

The need for Machine Learning – Supervised learning – Unsupervised Learning – Linear regression and Feature selection – Linear Classification – Support Vector Machines – Clustering – Dimensionality Reduction – Graphical – Artificial Neural Networks – Dimensionality Reduction - Combining classifiers - regularization, clustering - Spectral clustering, Reinforcement Learning - Markov models - Large Scale Machine Learning - Applications - Introduction to Deep Learning – Deep Learning Architectures – LSTM – CNN – RNN – Hyper parameter tuning – Decision Trees – Machine Learning applied to medical data – ECG – EEG – Deep Learning applications in medical data – EEG – ECG.

Textbooks / References

Pattern Recognition and Machine Learning. Bishop, C. M. Springer (2010).

Introduction to Machine Learning with Python. Mueller, A. C. & Guido, S. O'REILLY' Publishers (2016).

Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms. Buduma, N. & Locascio, N. O'REILLY' Publishers (2017).

Introduction to Machine Learning, 2nd Edition. Alpaydin, E. MIT Press (2009).

Soman, K. P., Loganathan, R., & Ajay, V. (2009). Machine learning with SVM and other kernel methods. PHI Learning Pvt. Ltd.

Ethem Alpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)‖, Third Edition, MIT Press, 2014

Stephen Marsland, ―Machine Learning – An Algorithmic Perspective‖, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.

Tom M Mitchell, ―Machine Learning‖, First Edition, McGraw Hill Education, 2013.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS601ALGORITHMS AND STRUCTURES FOR DATA SCIENCE L-T-P-C: 2-0- 1- 3

Course Objectives

- This course aims at introducing the concept of data structure hierarchy.
- It will also expose the students to the basic and higher order data structures.
- Further the students will be motivated to apply the concept of data structures to various engineering problems.

Course Outcomes

CO1: To choose an appropriate data structure as applied to a specified problem.
CO2: To introduce various techniques for representation of the data in the real world.
CO3: To develop application using data structures
CO4: To improve the logical ability

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	--	--	--	3	2	3	3
CO2	3	3	3	3	3	--	--	--	3	2	3	3
CO3	3	2	3	3	3	--	--	--	3	2	3	3
CO4	3	3	3	2	3	--	--	--	3	2	3	3

Syllabus

Algorithm Analysis - Methodologies for Analyzing Algorithms, Asymptotic Notation, A Quick Mathematical Review, Case Studies in Algorithm Analysis, Amortization, Experimentation .Basic Data Structures - Stacks and Queues, Vectors, Lists, and Sequences, Trees, Priority, Queues and Heaps, Dictionaries and Hash Tables. Search Trees and Skip Lists - Ordered Dictionaries and Binary Search Trees, AVL Trees. Bounded-Depth Search Trees, Splay Trees, Skip Lists. Sorting, Sets, and Selection - Merge-Sort, Abstract Data Type, Quick-Sort, A Lower Bound on Comparison-Based Sorting, Bucket-Sort and Radix-Sort, Comparison of Sorting Algorithms, Selection. Fundamental Techniques - The Greedy Method, Divide-and-Conquer, Dynamic Programming.Graphs - Abstract Data Type Data Structures for Graphs, Graph Traversal. Directed Graphs , Weighted Graphs, Single-Source Shortest Paths, All-Pairs Shortest Paths, Minimum Spanning Trees, Network Flow and Matching, Flows and Cuts. Additional Topics- Computational Geometry, Range Trees, Priority Search Trees, Quadtrees and k-D Trees, the Plane Sweep Technique, Convex Hulls. NP-Completeness - P and NP, NP-Completeness, Important NP-Complete Problems.

Textbooks / References

Michael T. Goodrich and Roberto Tamassia, "Algorithm Design Foundations, Analysis and Internet Examples", John Wiley and Sons, 2003.
Michael T. Goodrich and Roberto Tamassia, "Data Structures and Algorithms in C++", John Wiley and Sons, 2003.
Michael T. Goodrich and Roberto Tamassia, "Data Structures and Algorithms in Java", Fourth Edition, John Wiley and Sons, 2004.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS612 REAL TIME OPERATING SYSTEM FOR EMBEDDED COMPUTING L-T-P-C:2-0-1-3

Course Objective

- The course will provide an introductions to limitations of the micro controls for some of the real-time applications and need of RTOS
- The students will understand the various computational resources which are very much necessary for the time critical operations and applications

- The course will provide the implementation of RTOS system using open source microcontrollers and RTOS software platforms.

Course Outcome

CO 1: Introducing the limitations of micro-controllers in embedded system based on the computing resources
CO 2: Understanding timing sub-system in micro-controllers
CO 3: Understanding and implementation of time and priority management using Free-RTOS and Atmega328

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	1	1	1	3	3	2	2	1	1
CO2	3	3	3	2	2	--	--	--	1	3	3	3	3	3
CO3	3	3	3	3	3	--	--	--	1	--	3	3	3	3

Syllabus
Programming languages intended for real time systems, Introduction to Real time operating system (RTOS), System support: scheduling, resource handling, Design and analysis of real time system software, Modelling and verification of real time systems, Reliability and fault tolerance, Interrupts, Fault recovery, Distributed real time systems, Real time communication, Real time systems for multiprocessor systems

Textbooks / References
Liu, Jane W. S., Real-time systemsUpper Saddle River, N.J.: Prentice Hall, cop. 2000
Rajib Mall, "Real-Time Systems: Theory and Practice," Pearson, 2008.
Jane W. Liu, "Real-Time Systems" Pearson Education, 2001.
Krishna and Shin, "Real-TIme Systems," Tata McGraw Hill. 1999.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS613 EMBEDDED COMPUTING FOR DATA SCIENCE L-T-P-C:2-0-1-3

Course Objective

- The course will provide the importance and applications of embedded systems in modern applications
- The course will paves the way for understanding the various sources of data stream from a embedded system point of view and recording this data streams for processing
- This will enable the students to develop various system and analyse the data from the developed system for decision making.

Course Outcome

CO 1: Fundamentals of micro-controller architecture and programming and sources of data
CO 2: Introducing Arduino microcontroller and programming environment and data streaming using various sensors
CO 3: Real-time application development for automating Aquaponics farming system and various case studies from healthcare, agriculture and automation

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	1	--	3	3	2	2	1	1
CO2	3	3	2	2	2	1	1	--	1	3	3	3	3	3
CO3	3	3	3	3	3	1	1	1	1	2	3	3	3	3

Syllabus
Introduction to Embedded systems, hardware/software code sign, Embedded micro controller cores, embedded memories,Basic electronics using Arduino and raspberry pi, Examples of embedded systems, sensors and interfacing techniques, Real-time concepts, real-time operating systems, Required RTOS services/capabilities (in contrast with traditional OS). Digital Systems- Design of P, PI, and PID controllers. State space and filtering systems. Motor Controls. Communication systems- System design and simulation on Simulink. Signal processing systems- Hardware based on DSP Chips and Microcontrollers, Development environments of microcontrollers and DSP processors. Software development for data acquisition, fundamentals of wireless networks for embedded system, Interfacing and Integration of microcontroller based systems. Examples of Industrial process automation, software development using python, introduction to data streams and analytics. Data visualization using python tools,Machine learning techniques on sensor data streams

Textbooks / References
D. Gajski, F. Vahid, S. Narayan, and J. Gong."Specification and Design of Embedded Systems", PEARSON Education, 1994
Syaunstrup and W. Wolf. "Hardware Software Co-design: Principles and Practice", Kluwer, Academic Publishers, 1997
Python Programming with Raspberry Pi Paperback – Import, 28 Apr 2017 by Sai Yamanoor and Srihari Yamanoor

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20RM600	**RESEARCH METHODOLOGY**	**L-T-P-C: 2-0- 0- 2**

Syllabus
Unit I:
Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach,

Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.

Unit II:
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:
Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.

Textbooks / References

Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011
C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers
Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011
T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6 edition July 2012.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

SEMESTER II

20DS614MACHINE LEARNING FOR SIGNAL PROCESSING AND PATTERN CLASSIFICATION
L-T-P-C: 2-0- 1- 3

Course Objectives

- This course dives into the basics of Machine Learning for signal processing and pattern classification.
- This course helps to learn different feature extraction approaches from various signals.
- Students will learn to implement various pattern recognition tasks using machine learning / deep learning algorithms.
- Students will learn to use pre-trained models for deep learning.

Course Outcomes

CO1: To apply advanced optimization based de-noising methods to recover original signal.
CO2: To implement advanced decomposition methods such as, Empirical Wavelet Transform, Variational Mode Decomposition, Empirical Mode Decomposition and analyse the signal.
CO3: To implement the Kernel methods using different machine learning packages such as, Weka, LibSVM and GURLS. And also to implement deep learning architectures for signal classification.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	--	--	3	3	--	3
CO2	3	3	3	3	3	2	--	--	3	3	--	3
CO3	3	3	3	3	3	2	--	--	3	3	--	3

Syllabus

Introduction to real world signals - speech, image. Feature extraction and front-end signal processing - information rich representations, robustness to noise and artifacts, signal enhancement, bio inspired feature extraction. Basics of pattern recognition, Discriminative modelling - support vector machines, neural networks and back propagation. Introduction to deep learning - convolutional and recurrent networks, pre-training and practical considerations in deep learning, understanding deep networks. Clustering methods and decision trees. Applications in computer vision and speech recognition.

Textbooks / References

Pattern Recognition and Machine Learning, C.M. Bishop, 2nd Edition, Springer, 2011.

Deep Learning, I. Goodfellow, Y, Bengio, A. Courville, MIT Press, 2016.

Digital Image Processing, R. C. Gonzalez, R. E. Woods, 3rd Edition, Prentice Hall, 2008. d.

Fundamentals of speech recognition, L. Rabiner and H. Juang, Prentice Hall, 1993.

Deep Learning: Methods and Applications, Li Deng, Microsoft Technical Report.

Automatic Speech Recognition - Deep learning approach - D. Yu, L. Deng, Springer, 2014.

Computer Vision: Algorithms and Applications, R. Szeliski, Springer, 2010

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS602 PROBABILISTIC GRAPHICAL MODELS L-T-P-C: 2-0- 1- 3

Course Objectives

- The main objective of the course is to introduce the fundamental concepts of probabilistic graphical models.
- To explore the applications of probability theory and graphical models in data analysis.
- To provide connection between the concepts of mathematics and computational thinking with probabilistic graphical models.

Course Outcomes

After completing this course, the students will be able to
CO1: Model engineering problems using the fundamental concepts of probability
CO2: Apply the concept of probabilistic graphical models to solve problems pertinent to data science.
CO3: Analyse different probabilistic models developed for describing a given system.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	3	--	--	3	3	--	3
CO2	3	3	3	2	3	3	--	--	3	3	--	3
CO3	3	3	3	2	3	3	--	--	3	3	--	3

Syllabus

Samples, Events, Event space, Probability Space, Random Variables, Independence and Conditional Independence, Conditional Probability, Joint Probability, Bayes' theorem Joint and Marginal Probability, Estimation Theory - Maximum Likelihood Estimators. Probabilistic Graphical Models: Direct and undirected model, Inference from Direct and undirected graphical model, Structured and Unstructured graphical models, Partition Function, D-Separation, Energy based models, Factor Graphs, Sampling from Graphical Models. Monte-Carlo Methods: Markov Chain and Monte-Carlo methods, Gibbs Sampling, Approximate Inference – Expectation Maximization, MAP Inference. Special cases: HMM, CRF, Kalman Filter.

Textbooks / References

Koller, Daphne, and Nir Friedman. Probabilistic graphical models: principles and techniques. MIT press, 2009.
Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT press 2016

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS615 SCIENTIFIC COMPUTING L-T-P-C: 2-0- 1- 3

Course Objectives

- This course helps students to understand the latest computational techniques.
- This course helps students to understand the concept of partial differential equations and the ways to solve those equations.
- This course aims to help students to implement the computational methods using MATLAB and Python.

Course Outcomes

After completing this course, the students will be able to

CO1: Develop a basic understanding of computational schemes used to solve differential equations.

CO2: Analyse problems pertinent to data science using novel computational techniques.

CO3: Model different engineering/physical/natural systems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	--	--	3	3	--	3
CO2	3	3	3	3	3	2	--	--	3	3	--	3
CO3	3	3	3	3	3	2	--	--	3	3	--	3

Syllabus

Root finding: Functions and polynomials, zeros of a function, roots of a nonlinear equation, bracketing, bisection, secant, and Newton-Raphson methods. Interpolation, splines, polynomial fits, Chebyshev approximation. Numerical Integration and Differentiation: Evaluation of integrals, elementary analytical methods, trapezoidal and Simpson's rules, Romberg integration, Gaussian quadrature and orthogonal polynomials, multidimensional integrals, summation of series, Euler-Maclaurin summation formula, numerical differentiation and estimation of errors. Ordinary differential equations: Lipschitz condition, solutions in closed form, power series method. Numerical methods: error analysis, stability and convergence, Euler and Runge-Kutta methods, multistep methods, Adams-Bashforth and Adams-Moulton methods, Gear's open and closed methods, predictor-corrector methods.

Numerical solution of PDEs: relaxation methods for elliptic PDEs, Crank-Nicholson method for parabolic PDEs, Lax-Wendroff method for hyperbolic PDEs. Calculus of variations and variational techniques for PDEs, integral equations. Finite element method and finite difference time domain method, method of weighted residuals, weak and Galerkin forms, ordinary and weighted/general least squares. Fitting models to data, parameter estimation using PDEs. Iterative methods for Solution of linear matrix equations.

Textbooks / References

Kutz, J. Nathan, Data-Driven Modeling & Scientific Computation: Methods for Complex Systems & Big Data, Oxford University press,

Arfken, G.B., and Weber, H.J., Mathematical Methods for Physicists, Sixth Edition, Academic Press, 2005.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS616 COMPUTER NETWORKS AND IOT L-T-P-C: 2-0- 1- 3

Course Objectives

- The primary course objective is to provide the importance of computer networks.
- Enable the student to understand the fundamental networking principles, standards, protocols and technologies.
- The course also provide insights into concepts of the internet of things and its various applications.
- The course will enrich the students with hands on experience in creating physical networks and developing network applications using Raspberry-PI.
- The course also provides an introduction to the modern software defined networks and its applications.

Course Outcomes

CO1: Fundamentals of building IOT applications using Raspberry-PI.
CO2: Understanding fundamentals of building IOT based machine learning application.
CO3: Understanding data processing and visualization for IOT system using open source IOT platforms (Things Speak,IBM Watson etc.)

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2	---	3	2	3	3
CO2	2	2	3	2	3	2	2	---	3	2	3	3
CO3	2	3	3	2	3	2	2	---	3	2	3	3

Syllabus

This course starts with the basics of computer networks and basic requirements to setup a network .The course take through discussion of current problems faced in networking and how to resolve it. The remaining portion covers the OSI Layers, Protocols, Web technologies, IOT Architectures, Introducing IOT frameworks and cloud platforms for IOT. The practical aspects of the subject will be covered through a specially made embedded board called ESP32 development board for IOT along with open source cloud platforms for data management and visualization

Introduction to computer Networks, Building a Network, Network Architecture, Implementing Network Software, Introduction to web technologies for IOT, Introduction to cloud services and platforms for IOT, Building IOT Application using ESP32 development board, Web programming and Database management, IOT application development using Arduino, Raspbery-PI and ESP32.

Textbooks / References

CISCO Semester 1 and 2,"Networking Course" Reference Material.
Computer networks a Systems Approach By Larry .L.Peterson and Bruce.S.Davie
Raspberry PI Networking Cookbook
An Introduction to Computer Networks By Peter L Dordal
Fiction Programming the Raspberry Pi- Getting Started with Python - Simon Monk

Andrew S. Tanenbaum, "Computer Networks", Fourth Edition, Prentice Hall PTR, 2002.
Designing the Internet of Things (Paperback)by Adrian McEwen,HakimCassimally
Stan Openshaw and Ian Turton, "High-Performance Computing and the Art of Parallel Programming", O'Rielly Press, 2000.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

SEMESTER III

20DS617 BIGDATA FRAMEWORK FOR DATASCIENCE L-T-P-C: 2-0- 1- 3

Course Objectives

- The primary course objective is to provide the importance of functional programming.
- The course aims to implement various big data concepts using Scala programming language, which is a functional programming language.
- This course helps student to solve various real time problems using big data concepts.

Course Outcomes

CO1: Understand Functional representations.
CO2: Model Computations as a Map-Reduce problem.
CO3: Imbibe the programming skill to use Spark for Big data manipulation

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	3	2	--	--	3	3	3	3
CO2	3	3	3	3	3	2	--	--	3	3	3	3
CO3	2	3	3	3	3	2	--	--	3	3	3	3

Syllabus

New generation Big data using Functional Programming in Scala: Basic Syntax- type inference and static types-function types and value types, closures. Immutability and immutable types-generic type Parameters-Recursive arbitrary collections-cons list- Iterative arbitrary collections-Arrays-Tail recursion- factorial example-functional abstractions with examples-square root, fixed point, sequence summations. Higher order functions- MapReduce Template-Pattern Matching syntax. Similar higher order (Cons) List operations on arbitrary Collections-filter, fold, partition, span. Basic entity classes and object in Scala. Apache Spark: - Resilient Distributed Data Sets-Creating RDDs, Lineage and Fault tolerance, DAGs, Immutability, task division and partitions, transformations and actions, lazy evolutions and optimization - Formatting and housing data from spark RDDs-Distributed File systems HDFS and Tachyon-Persistance. Setting up a standalone Spark cluster-: spark-shell, basic API, ModulesCore-Key/Value pairs and other RDD features, MLlib-examples for bi-class SVM and logistic regression, Streaming and stream context, GraphX- streaming work count and page rank example. Data Frames and Datasets. Creating data frames from RDDs. Using Spark SQL to query data frames. NoSQL aggregate data bases. Graph data bases and querying them. Some analytics case studies: - Server Log data, Wikipedia dump text, Financial data, image data (using Cifar and Mnist), Matrix/ Vector multiplication and factorization using MapReduce.

Textbooks / References

Learning Spark: Lightning-Fast Big Data Analysis 1st Edition by Holden Karau , Andy Konwinski, Patrick Wendell, MateiZaharia

Programming in Scala: A Comprehensive Step-by-Step Guide Third Edition by Martin Odersky, Lex Spoon, Bill Venners.

High Performance Spark: Best Practices for Scaling and Optimizing Apache Spark 1st Edition, by Holden Karau, Rachel Warren

Scala for the Impatient 2nd Edition, by Cay S. Horstmann

Spark: The Definitive Guide: Big Data Processing Made Simple 1st Edition, Kindle Edition by Bill Chambers, MateiZaharia.

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

ELECTIVES

20DS701 DIGITAL CONTROL SYSTEM L-T-P-C: 2- 0 - 1 -3

Course Objectives

- The course will lay down the basic concepts and techniques of digital control system used for various applications with help of linear algebra and probability theory.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind the control system.
- It will help the students to perceive the control system in engineering system with help of digital control system implementations.
- Another goal of the course is to implement the control system with concepts from linear algebra and probability theory in real-time engineering systems.

Course Outcomes

CO1: To introduce data driven control system theory based on linear algebra and probability theory

CO2: To simulate real life control situations for engineering systems

CO3: To apply the concepts of digital control system in drones and autonomous car

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3			3				3		3	3
CO2	3	3	1	1	3	1			2	1	3	3
CO3	3	2	3	3	3	1	1	1	3	2	3	3

Syllabus

Introduction to digital control - Emulation of analogue controllers - Sampling and reconstruction.- Stability analysis techniques - Digital controller design - Digital filter structures and quantization effects - Adaptive inverse control.

Text Books / References

Jacquot, Raymond G. Modern digital control systems. Routledge, 2019.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Examination	30

20DS702	**MULTIVARIABLE CONTROL SYSTEMS**	**L-T-P-C: 2- 0 -1- 3**

Course Objectives

- This course covers methods for the analysis and control of systems with multiple inputs and outputs, which are ubiquitous in modern technology and industry.
- The course will take the students to various engineering and industrial applications which deal with multivariate control systems.
- Students will also be motivated to solve the problems in engineering applications with above theoretical knowledge

Course Outcomes

CO1: Understand, Construct and analyse a discrete-time model for a dynamic system.

CO2: Observe and analyse a multivariable dynamic system and design an appropriate controller for the system.

CO3: To enable the students to Assess / Evaluate the stability, performance and robustness of a closed-loop system.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3			3				3		3	3
CO2	3	3	1	1	3	1			2	1	3	3
CO3	3	2	3	3	3				3	2	3	3

Syllabus

Continuous-time state-space systems - Discrete-time state-space systems – Stability - Observability and controllability - State-feedback control - Output-feedback control - Linear quadratic regulation.

Textbooks / References

Albertos, Pedro, and Sala Antonio. Multivariable control systems: an engineering approach. Springer Science & Business Media, 2006.

Tzafestas, Spyros G., ed. Multivariable control: new concepts and tools. Springer Science & Business Media, 2012.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Examination	30

20DS703 DEEP LEARNING IN GENOMICS AND BIOMEDICINE L-T-P-C: 2- 0 -1- 3

Course Objectives

- The course will lay down the basic concepts and techniques of Deep learning in Genomics and Biomedicine
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- It will provide an appreciation of the wide application of these disciplines within the scientific field
- Goal of the course is to provide connection between the concepts of Deep learning in Genomics and Biomedicine

Course Outcomes

CO1: To develop an understanding of the basic concepts and techniques of Deep learning in Genomics and Biomedicine
CO2: To provide an appreciation of the wide application of these disciplines within the scientific field.
CO3: To provide connection between the concepts of Deep learning in Genomics and Biomedicine
CO4: To develop an insight into the applicability of Deep learning in the field of Genomics and Biomedicine
CO5: To enable the students to understand the use of Deep learning in Genomics and Biomedicine
CO6: To equip the students to understand the role of Deep learning in Genomics and Biomedicine

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3	2			3	2	3	3
CO3	3	2	3	3	3				3	2	3	3
CO4	3	3	3	2	3				3	2	3	3
CO5	3	2	3	3	3				3	2	3	3
CO6	3	3	3	3	3	2			3	2	3	3

Syllabus

Introduction to Machine Learning - Genomics – DenseNets and Convolutional Nets for Genomics - Recurrent NN –Autoencoders and representation learning - Generative Models –Drug Discovery and protein structure: - imaging and electronic medical records-MoleculeNet – One shot Learning drug discovery - Case Studies

Textbooks / References
Based on latest research papers

Evaluation Pattern

Assessment	Weightage(%)
Assignments(6 Assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
MidTerm Periodical	15
End Semester Exam	30

20DS704 DEEP LEARNING FOR BIOMEDICAL DATA ANALYSIS L-T-P-C: 2- 0 -1- 3

Course Objectives

- This course provides the foundations essential for the deep learning.
- This course develops the practical skill required to implement the deep learning algorithms.
- This course develops the skill to apply data driven techniques in the biomedical domain.

Course Outcomes

CO 1: To understand the fundamentals of Deep Learning.
CO 2: To implement different deep learning architectures for point of care disease diagnosis.
CO 3: To expose the different case studies from the recent literature.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3				3				3	3		3	3	3
CO2	3	3	3	3	3	2	2	2	3	3		3	3	3

CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	3

Syllabus

Introduction to Deep Learning - Convolutional Neural Networks - Convolutional Neural Networks: Architectures – Convolution / pooling layers – Understanding and Visualizing Convolutional Neural Networks . Lenet, Alexnet, Googlenet for visual perception tasks- Point of care disease diagnosis using CNN – Capsule Network- Generative Adversarial Networks - Case Studies based on latest research papers.

Textbooks / References

Simonyan, Karen, Andrea Vedaldi, and Andrew Zisserman. "Deep inside convolutional networks: Visualising image classification models and saliency maps." *arXiv preprint arXiv:1312.6034* (2013).

Zeiler, Matthew D., and Rob Fergus. "Visualizing and understanding convolutional networks."*Computer vision–ECCV 2014*.Springer International Publishing, 2014.818-833.

Domingos, Pedro. "A few useful things to know about machine learning." *Communications of the ACM* 55.10 (2012): 78-87.

David Foster, Generative Deep Learning, O'Reilly, 1st edition, 2019.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Term Periodical	15
End Semester Examination	30

20DS705	**SPEECH PROCESSING**	**L-T-P-C: 2- 0 -1- 3**

Course Objective

- To develop an understanding on the acoustics of speec h production**.**
- To analyze the characteristics of different sounds in the Indian context.
- To develop an understanding on the speech modelling in different environments.

Course Outcome

CO1: Understanding the acoustics of speech production and perception.
CO2: Analyze Characteristics of Different sounds in the Indian context.
CO3: Qualitative analysis of speech collected in different environments and noisy conditions for robust speech modelling.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	3	---	---	3	2	3	3
CO2	3	3	3	3	3	2	---	---	3	2	3	3
CO3	3	2	3	3	3	---	---	---	3	2	3	3

Syllabus

Overview of Speech Processing Systems, Speech Production, Speech Perception, Speech Signal Characteristics, Sounds (Syllables, Phonemes, etc.), Properties of speech sounds. Speech signal processing, Short time processing of speech- Time Domain parameters, Frequency domain parameters, Tie-Frequency representation (Spectrograms), Cepstral Analysis, MFCC, Linear Prediction Analysis, speech modelling, Basic speech models, Gaussian mixture modelling of speech, Hidden markov models, model adaptations, DNN models (DBN, TDNN, LSTM, etc.) used for speech modelling- Development of speech systems, Speech synthesis (diphones and syllable based unit selection systems, parametric synthesis systems), Speaker recognition/Verification systems, Development of speaker verification/recognition systems.

Textbooks / References

L. Rabiner, Biing-Hwang Juang and B. Yegnanarayana,"Fundamentals of Speech Recognition",Pearson Education Inc.2009

Douglas O'Shaughnessy,"Speech Communication",University Press,2001

Thomas F Quatieri,"Discrete Time Speech Signal Processing", Pearson Education Inc.,2004

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Sem Periodical	30

20DS706	**DEEP LEARNING FOR NLP**	**L-T-P-C: 2- 0 -1-**

Course Objectives

- This course aims to provide an insight into the concepts of natural language processing and NLP applications.
- This course helps the students to implement NLP applications using deep learning algorithmsThis course helps to understand various word/text representation algorithms.
- This course discusses the latest methods used in the field of NLP such as attention mechanism, transformer networks and BERT.

Course Outcomes

CO1: Understand different word/text representation methods.
CO2: Understand various NLP applications and how each application can be modelled in machine learning/deep learning perspective.
CO3: To use different deep learning architectures to solve real-time NLP problems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	--	--	2	2	--	3
CO2	3	3	3	3	3	2	--	--	2	2	--	3
CO3	3	3	3	3	3	2	--	--	2	2	--	3

Syllabus

Introduction - Words - Regular Expressions - N-grams - Language modelling - Python for NLP - Part-of-Speech Tagging - Named Entity Recognition - Topic classification - Morphological analysis - Syntactic Parsing - Dependency Parsing - The Representation of Meaning - Computational Semantics - Lexical Semantics - Vector space models - Bag-of-Words - Term Frequency - Inverse Document Frequency

Word Vector representations: word2vec, GloVe -Advanced word vector representations: FastText, BERT - Neural language models - Recurrent Neural Network - Long Short Term Memory Networks - Encoder-decoder architecture - Attention mechanism - Transformer networks - Convolutional Neural Networks for text classification - Machine Translation - Question answering - Text summarization.

Textbooks / References

Jurafsky D, Martin JH. Speech and Language Processing. 3rd edn Englewood Cliffs, NJ: Prentice-Hall
Manning C, Schuetze H. Foundations of Statistical Natural Language Processing. Cambridge, MA: MIT Press, 1999.
Eisenstein, Jacob. Introduction to natural language processing. MIT press, 2019.
Collobert, R., Weston, J., Bottou, L., Karlen, M., Kavukcuoglu, K., &Kuksa, P. (2011).Natural language processing (almost) from scratch.Journal of Machine Learning Research, 12(Aug), 2493-2537.
Goldberg, Yoav. "A primer on neural network models for natural language processing." Journal of Artificial Intelligence Research 57 (2016): 345-420.
Vaswani, Ashish, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Łukasz Kaiser, and Illia Polosukhin. "Attention is all you need." In Advances in neural information processing systems, pp. 5998-6008. 2017.
Yoav Goldberg, Neural Network Methods for Natural Language Processing, Synthesis Lectures on Human Language Technologies, Morgan & Claypool Publishers, 2017

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30

20DS707 SOCIAL MEDIA ANALYTICS L-T-P-C: 2- 0 -1- 3

Course Objective

- To understand the domain of Social media data analysis and its related problems.
- To understand challenges involved in social media data analytics.
- To understand and implement various algorithms and approaches used for analysis

Course Outcome

- Understanding the challenges and associated data in the social media analytics
- Developing machine learning and deep learning model for social media data analysis
- Build the problem solving ability to participate in the open challenge tasks such as sentiment analysis, fake news identification and emotion detection

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	---	---	1	3	3	3
CO2	3	3	3	3	3	3	---	---	3	3	3	3
CO3	3	3	3	3	3	3	---	---	3	3	3	3

Syllabus

Introduction to Text Analytics- Text Analytics in Social Media - Python and R- Collecting and Extracting Social Media Data - Vector Space Models of Semantics- Data Analysis, Visualization, and Exploration - Sentiment Analysis with Social media data - Author profiling in Social media data- Network Analysis with R . - Code-mixed data analytics -Topic modelling - Influence and Centrality in Social Networks -Geospatial social data mining - Shingling of Documents -Mining Data Streams, The Stream Data Model, Sampling Data in Stream, Filtering Streams, Link Analysis, Page Rank, Topic-Sensitive Page Rank, Link Spam, hubs and Authorities, Frequent Itemsets- Mining Social network Graphs

Textbooks / References

Jure Leskovec, AnandRajaraman, Jeffrey D Ullman, “Mining of Massive Datasets”, 2014.

Charu C. Aggarwal, “Social Networking Analytics”, Kluwer Academic Publishers, 2011.

Charu C. Aggarwal, Cheng Xiang Zhai, “Mining Text Data”, Springer, 2012.

Cheng, Zhiyuan, James Caverlee, and Kyumin Lee. "You are where you tweet: a content-based approach to geo-locating twitter users." Proceedings of the 19th ACM international conference on Information and knowledge management.ACM, 2010.

Evaluation Pattern

Assessment	Weightage (%)

Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Sem Periodical	30

20DS708 DEEP LEARNING FOR VISUAL RECOGNITION L-T-P-C:2-0-1-3

Course Objectives

- This course provides the foundations essential for the deep learning.
- This course develops the practical skill required to implement the deep learning algorithms.
- This course develops the skill to apply data driven techniques in the computer vision applications.

Course Outcomes

CO 1: To understand the fundamentals of Deep Learning.
CO 2: To develop practical Engineering tricks for training and fine-tuning the networks by developing the skill to use multiple packages required to build deep learning based AI systems.
CO 3: To gain knowledge of standard deep convolutional architectures and use the pre-trained model for transfer learning.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3				3				3	3		3	3	3
CO2	3	3	3	3	3	2	2	2	3	3		3	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	3

Syllabus

Image Classification: Data driven approach – k- Nearest Neighbor - Linear Classification: Support Vector Machine – softmax – Optimization: Stochastic Gradient Descent – Backpropagation – Neural Network Architecture: model of a biological neuron – activation functions – neural net architecture – preprocessing – weight initialization - batch normalization – regularization – loss functions- Learning and Evaluation – Convolutional Neural Networks: Architectures – Convolution / pooling layers – Understanding and Visualizing Convolutional Neural Networks . Lenet, Alexnet, Googlenet for visual perception tasks.

Textbooks / References

Domingos, Pedro. "A few useful things to know about machine learning." *Communications of the ACM* 55.10 (2012): 78-87.

Li Fei-Fei (Stanford), Rob Fergus (NYU), Antonio Torralba (MIT), "Recognizing and Learning Object Categories" (Awarded the Best Short Course Prize at ICCV 2005).

Baydin, AtilimGunes, Barak A. Pearlmutter, and Alexey AndreyevichRadul. "Automatic differentiation in machine learning: a survey." *arXiv preprint arXiv:1502.05767* (2015).

Bengio, Yoshua. "Practical recommendations for gradient-based training of deep architectures." *Neural Networks: Tricks of the Trade*. Springer Berlin Heidelberg, 2012. 437-478.

LeCun, Yann A., et al. "Efficient backprop." *Neural networks: Tricks of the trade*. Springer Berlin Heidelberg, 2012. 9-48.

Simonyan, Karen, Andrea Vedaldi, and Andrew Zisserman. "Deep inside convolutional networks: Visualising image classification models and saliency maps." *arXiv preprint arXiv:1312.6034* (2013).

Zeiler, Matthew D., and Rob Fergus. "Visualizing and understanding convolutional networks." *Computer vision–ECCV 2014*. Springer International Publishing, 2014. 818-833.

Springenberg, Jost Tobias, et al. "Striving for simplicity: The all convolutional net." *arXiv preprint arXiv:1412.6806* (2014).

Russakovsky, Olga, et al. "Imagenet large scale visual recognition challenge." *International Journal of Computer Vision* 115.3 (2015): 211-252.

Mahendran, Aravindh, and Andrea Vedaldi. "Understanding deep image representations by inverting them." *Computer Vision and Pattern Recognition (CVPR), 2015 IEEE Conference on*. IEEE, 2015.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Term Periodical	15
End Semester Examination	30

20DS709	**DEEP LEARNING FOR CYBERSECURITY**	**L-T-P-C:2-0-1-3**

Course Objectives

- Understanding the fundamentals of cyber security
- Understand the fundamentals of deep learning
- Understand how deep learning can be used for problems in cybersecurity

Course Outcome

CO1: Understand the fundamentals of deep learning
CO2: Understand and explore the challenges in cybersecurity data
CO3: Applying the deep learning algorithms for cybersecurity applications

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	3	3	2	3	3	---	---	3	3	---	3
CO2	3	3	3	2	3	3	---	---	3	3	---	3
CO3	3	3	3	2	3	3	---	---	3	3	---	3

Syllabus

Introduction – Vocabulary- Concepts: History , Crash Course in Number Theory -Properties of Mod- Calculator algorithms- Simple cryptosystems- Modern stream ciphers- Running time of algorithms- AES- Public key cryptography- RSA- Signatures-Hash functions- Finite fields- Discrete log cryptosystems - Diffie Hellman key exchange- ElGamal message exchange- Massey Omura message exchange- ElGamal signature system- Elliptic curves- Elliptic curve cryptosystems. Deep learning overview, applying deep learning for anomaly detection, Malware, spam detection, Phishing detection

Textbooks / References

Kaufman, C., Perlman, R. and Speciner, M., "Network Security: Private Communication in a Public World ", 2nd edition, Prentice Hall 2002.

W. Stallings: "Cryptography and Network Security: Principles and Practices", 4th edition, Prentice Hall, 2000.

D. R. Stinson: "Cryptography: Theory and Practice", third ed., CRC Press, 2005.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Sem Periodical	30

20DS710	**COMPUTATIONAL FLUID DYNAMICS**	**L-T-P-C:2-0-1-3**

Course Objectives

- This course provides the strong foundation of computational schemes essential to understand the basics of fluid dynamics.
- This course equip the students with the skills on tools essential for data driven modelling in fluid dynamics.

Course Outcomes

CO 1: To provide a basic understanding of computational schemes to be used for solving partial differential equations.

CO 2: To equip the student to develop models of different canonical fluid mechanics problems.
CO 3: To develop an understanding of data driven modelling in fluid mechanics.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3				3				3	3		3	3	3
CO2	3	3	3	3	3	2	2	2	3	3		3	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	3

Syllabus

Introduction to CFD and principles of conservation, continuity equation, Navier stokes equation, energy equation and general structure of conservation equations. Numerical Solution of ODEs, methods for parabolic equations, methods for elliptic equations, methods for hyperbolic equations, systems of equations, Aerodynamics-Hydrodynamics with Python, Application in unmanned aerial vehicles, Autonomous cars.

Textbooks / References

T.J Chung, Computational fluid dynamics, Cambridge university press, 2002.

H.K. Versteeg&W.Malalasekera, An introduction to Computational fluid dynamics, Longman scientific and Technical, 1995.

Leona Barbara, CFD Python:12 steps to Navier-Stokes, Online course material.

Leona Barbara, Aero Python: Aerodynamics-Hydrodynamics with Python, online course material.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Term Periodical	15
End Semester Examination	30

20DS711 DEEP LEARNING ESSENTIALS FOR SELF -DRIVING CAR L-T-P-C:2-0-1-3

Course Objectives

- This course provides the strong foundation for Computer Vision applications in self-driving car.
- This course equip the students with the skills on tools used for Deep Learning applications.
- This course provides the hands-on skill required for the Computer Vision applications.

Course Outcomes

CO 1: To apply Computer Vison and Deep Learning techniques to build automotive-related algorithms.
CO 2: To use essential Computer Vision techniques to computer vision tasks in self drving car such as identification of lane lines on a road.
CO 3: To understand, build and train Convolutional Neural Networks with Keras.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2		3	3	3		3	3	3	2	3	3	3
CO2	3	2		3	3	3			3	3	2	3	3	3
CO3	3	3	3	3	3	3			3	3	2	3	3	3

Syllabus

Introduction to self driving technology, fundamentals of deep learning, introduction and overview of Python, Machine Learning with Python, Neural Networks with Python, Introduction to tensor-flow and kerasdeeplearning platforms, Fundamentals of building a driverless vehicles from a conventional car, introduction to embedded platforms for self driving car software development, Integration of various sensors to self driving cars, Navigation and obstacle avoidance using deep learning.

Textbooks / References

Driverless: Intelligent Cars and the Road Ahead (MIT Press) Hardcover– September 23, 2016 by HodLipson , Melba Kurman .
Deep Learning: An MIT Press book, by Ian Goodfellow and YoshuaBengio and Aaron Courvill.
Stanley: The Robot that Won the DARPA Grand Challenge.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Term Periodical	15
End Semester Examination	30

20DS712 INTRODUCTION TO ADDITIVE MANUFACTURING L-T-P-C:2-0-1-3

Course Objectives

- This course will equip the students to understand about the basics of Additive manufacturing used in various industry applications.
- It will also impart the knowledge of basics of digital manufacturing and its importance in current era.
- Further it will expose the students to additive manufacturing technology using 3-D printing.

Course Outcomes

CO 1: To understand the additive manufacturing technology trends in decades for product development and innovation.

CO 2: To demonstrate comprehensive knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
CO 3: To understand the various software tools, processes and techniques that enable advanced/additive manufacturing and personal fabrication.
CO 4: To understand the hardware and software development of 3D printers.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	--	--	--	--	2	2	--	--	3	--	3	3	3
CO2	3	--	--	--	--	2	2	--	--	3	--	3	3	3
CO3	3	3	3	--	3	3	3	2	3	2	3	3	3	3
CO4	3	3	3	3	3	3	3	2	3	2	3	3	3	3

Syllabus

Historical evolution of rapid prototyping technology in the CAD/ CAM hierarchy, Fundamental steps in rapid prototype, ASTM F42 standard terminology and main varieties of machine technologies used internationally, Advantages and disadvantages of main RP technologies, Guidelines for safe operation of RP machines and handling of associated RP materials, Stereolithography apparatus (SLA), Fused deposition modelling (FDM), Multi-jet modelling (MJM), Selective laser sintering (SLS), Three-dimensional printing (3DP), Additive Manufacturing data file formats and manipulation, Stereo lithography (STL) file export and import procedures/ translation to RP machines driven with varied proprietary software , STL file problems and repair techniques, Clean-up, finishing, surface coatings and quality assurance methods in RP technologies, Secondary applications ,Metal Casting processes, Silicone mould making and resin casting process, Rapid tooling for manufacturing, General uses, benefits and industry specific applications for Additive Manufacturing

Textbooks / References

Ian Gibson, David W. Rosen, Brent Stucker , *"Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing",* Springer,2009.

Ali K. Kamrani, Emad Abouel Nasr , *"Engineering Design and Rapid Prototyping",* Sringer, 2010.

Brian Evans, *"Practical 3D Printers: The Science and Art of 3D Printing",*Apress,2012.

Hod Lipson, Melba Kurman, *" Fabricated: The New World of 3D Printing",* John Wiley & Sons, 2013.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Term Periodical	15
End Semester Examination	30

20DS713 UNMANNED AERIAL VEHICLES AND ESSENTIAL CONTROL L-T-P-C:2-0-1-3

Course Objectives

- The main aim of this course is to understand the basics of Unmanned Arial Vehicles (Drones) and its various applications.
- The course will also impart the knowledge of how to fly a drone by considering the rules and regulations to the specific country.
- Further the students will be introduced to the safety measures to be taken during flight.

Course Outcomes

CO1: To introduce the various types of frame design used for the UAV and to accommodate the electronics over the frame to fly UAV.
CO2 : To make the students understand the basic working principal behind the electronic components used and its specification to build a drone from scratch.
CO3: To enable the students to identify and understand various functional modules of the controller using a pre-programmed controller used in the UAV.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2	--	3	2	3	3
CO2	2	2	3	2	3	2	2	--	3	2	3	3
CO 3	2	3	3	2	3	2	2	--	3	2	3	3

Syllabus

This course includes UAV components, command and control (C2) communication systems, basics of flight, regulatory and regulations, safety and societal considerations. Laboratory activities provide opportunity for students to gain hands-on experience in working with UAVs, Design aspects of drone, Drone control experiments using MATLAB and parrot drones, PID control for drones, State space controls for drone

Textbooks / References

ASA Test Prep. Remote Pilot Test Prep — UAS: Study & Prepare. Wellfleet Press, 2016. 978-1577151326

Austin, Unmanned Aircraft Systems: UAVS Design, Development and Deployment. Wiley, 2010. 978-0- 470-05819-0

Baichtal, Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs. Que Publishing, 2016. 978-0789755988

Beard & McLain, Small Unmanned Aircraft: Theory and Practice. Princeton University Press, 2012. 978-0691149219

Cares &Dickmann, Operations Research for Unmanned Systems. Wiley, 2016. 978-1-118-91894-4

UAS110 Syllabus - Page 3 Chao & Chen, Remote Sensing and Actuation Using Unmanned Vehicles. Wiley, 2012. 978-1-118- 12276-1

Cheng, Aerial Photography and Videography Using Drones. Peachpit Press, 2015. 978-0-13-412277-9

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Examination	30

20DS714 COMPUTATIONAL ROBOTICS AND ROBOTIC OPERATING SYSTEML-T-P-C:2-0-1-3

Course Objectives

- The course will provide an introduction to Robotic Operating System platform.
- The course will enrich the students with various module developments in ROS for Robot control, Navigation and environment mapping.
- The course will also deliver the multiple robot communication and control using ROS.
- The final goal of the course will be designing a ROS module for the robotic system designed by the student.

Course Outcomes

CO1: To develop simple applications to control robot motion.
CO2: To master the basics of ROS module development for robots.
CO3: To program the robots to perform simple and specific tasks.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	3	3	--	--	3	3	3	3
CO2	3	2	3	2	3	2	--	--	3	3	3	3
CO3	3	2	3	2	3	3	--	--	3	3	3	3

Syllabus

ROS concepts - Preliminaries – Publishing a topic – Subscribing to a topic – Latched topics – Defining message types – Mixing Publishers and subscribers – Services – Defining a service – Implementing a service – Using a service – Actions – Definition of an Action – Implementing a basic action server – Robots and Simulators – Sub systems – Actuation: Mobile platform – Actuation manipulator arm – Cameras and Scanners.

Text Books / References

'Programing Robots with ROS', M. Quigley, B. Gerkey, and W. D. Smart, Oreilly Publishers, 2015.
'ROS Robotics by example', Fairchild & Harman, PACKT Publishing, 2016

'Introduction to Robotics', T. Bajd, M. Mihelj and M. Munih, Springer Briefs in Applied Sciences and Technology, 2013
'Introduction to AI Robotics', Robin Murphy, MIT Press, 2000

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Examination	30

20DS715COMPLEX SYSTEMS IN ENGINEERING, FINANCE & BIOLOGY: MODELLING & ANALYSIS L-T-P-C: 2-0-1-3

Course Objectives

- The course will lay down the basic concepts of complex system theory required to model and analyse various physical systems
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- It will help the students to perceive the engineering problems using the fundamental concepts in engineering, finance and biology
- Another goal of the course is to provide connection between the concepts of complex system theory, mathematics and computational thinking

Course Outcomes

CO1: To enable the students to create mathematical models of physical and engineering systems
CO2: To introduce state of the art techniques to analyze data obtained from nonlinear systems
CO3: To apply the concepts of complex system theory to predict transitions that happen in physical and Engineering systems

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	2	--	--	--	--	2	2	2
CO2	3	3	2	2	3	--	--	--	--	2	2	2
CO3	3	3	2	3	2	--	--	--	--	2	2	2

Syllabus

Definition of a complex system- Complex systems in engineering- Complex systems in nature & society- Modelling of complex systems-Introduction to dynamical system theory- standard models in dynamical systems-transitions in dynamical systems-bifurcations- Maps and flows- Chaos- Routes to chaos.

Analysis of chaotic data from experiments-basics of time series analysis-standard models in time series analysis-nonlinear time series analysis- phase space reconstruction- precursors to predict transitions in complex systems-critical slowing down- precursors based on recurrence-precursors based on multifractal formalism.

Emergence of order in complex systems-transitions as pattern formation-spatial early warning signals-complex networks-network properties as early warning measures-Networks in natural and engineering systems-Networks in biology-Networks in finance.

Applications in remote sensing- Applications in cyber security- Applications in physiology- Applications in finance-future of complex system theory.

Textbooks / References

N. Boccora, Modelling of Complex Systems, 2nd Edition, Springer 2010.

S. Strogatz, Nonlinear Dynamics and Chaos with applications to Physics, Biology, Chemistry & Engineering, 2nd Edition, Westview Press 2014.

H. D. I. Abarbanel, Analysis of Observed Chaotic Data, Springer 1997.

R. C. Hilborn, Chaos and Nonlinear Dynamics: An Introduction for Scientists and Engineers, Oxford University Press 1994.

R. H. Shumway and D. S. Stoffer, Time Series Analysis and Its Applications, 3rd Edition, Springer 2011.

D. Sornette, Critical Phenomena in Natural Sciences, Springer 2000.

M. Cross and H. Greenside, Pattern Formation and Dynamics in Non-equilibrium Systems, Cambridge University Press 2009.

R. P. Sattoras, M. Rubi and A. D. Guilera (Eds), Statistical Mechanics of Complex Networks, Springer 2003.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(6 assignments with equal credit)	20
Quiz(4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Sem Periodical	30

20DS716 INTRODUCTION TO DATA ANALYSIS L-T-P-C: 2-0- 1- 3

Course Objectives

- The course will introduce the students to the basic concepts of data analysis
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- It will help the students to analyse the engineering problems using the fundamental concepts in data analysis

- Another goal of the course is to provide connection between the concepts of data analysis, mathematics and computational thinking

Course Outcomes

CO1: Analyse the data generated by experiments and simulation

CO2: Develop models for the systems of interest from the observed data

CO3: Evaluate the efficacy of different data driven models developed in order to predict the behaviour of the system

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	3	--	--	--	2	2	2	2
CO2	2	2	3	2	3	--	--	--	2	2	2	2
CO3	2	2	3	2	3	--	--	--	2	2	2	2

Syllabus

The need for data analysis – variables and data – graphs and distributions – measures of center and spread – normal distribution – z-scores – correlation – functions –hypothesis testing – confidence interval and errors – t-test – chi-square test – goodness of fit – test for independence – ANOVA – introduction to design of experiments - random samples – sample statistics and population statistics – regression analysis – regression models – method of least squares –data reduction – Time Series Analysis – AR models – ARMA models – ARIMA models – Basics of nonlinear TSA.

Textbooks / References

Basic skills in Statistics: A Guide for Healthcare Professionals. Cook, A., Netuveli, G. and Sheikh, A.Class Publishing (London) (2004).

Basic Statistics: Understanding conventional methods and modern insights. Wilcox, R. R. Oxford University Press (2009).

Basic Statistics for the behavioural sciences. 6th edition. Heiman, G. W. Wadsworth (2011).

Introduction to Time Series and Forecasting (Springer Texts in Statistics) 2nd Edition. Brockwell, P. J. & Richard, A. D (1991).

Introduction to Engineering Statistics and Six Sigma. Allen, T. T. Springer – Verlag (London) (2006).

Statistical Design and Analysis of Experiments: With Applications to Engineering and Science. 2nd Edition.Mason, R. L., Gunst, R. F. and Hess, J. L. Wiley-Interscience (2003).

Time Series: Theory and Methods (Springer Series in Statistics) 2nd edition. Brockwell, P. J. & Richard, A. D (1991).

Evaluation Pattern

Assessment	Weightage (%)
Assignments (6 assignments with equal credit)	20
Quiz (4 Quizzes with equal credit)	35
Mid Sem Periodical	15
End Semester Exam	30