31/c

DELHI TECHNOLOGICAL UNIVERSITY

SCHEME OF TEACHING AND EVALUATION M.TECH DATA SCIENCE

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1st year, 6 for M. Tech. 2nd year), C – credit of the course (4/3/2), MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	DSC501	Mathematical Foundations of Computer Science	Core	4	3	0	2	15	25	20	40	-	17
	2	DSC503	Data Management and Ethics	Core	4	3	0	2	15	25	20	40	-	
Group B	3	DSC5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	DSC5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	DSC5201/5203/..... / UEC5201/5203/.....	Elective 3	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	DSC502	Data Preparation & Analysis	Core	4	3	0	2	15	25	20	40	-	17
	2	DSC504	Machine Learning	Core	4	3	0	2	15	25	20	40	-	

Group D	3	DSC5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	DSC5302/5304/.....	Elective 5	Elective	3	3	0	0	20	0	30	50-	-	
	5	DS5202/5204/..... / UEC5202/5204/.....	Elective 6	Elective	2	2	0	0	20	0	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRE	MTE	'ETE	PRE	Total Credits
	Track 1													**12**
Group E	1	DSC651	Research Project	Core	12	0		12	0	0	-	100	-	
	Track 2													
	1	DSC601	Major Project I	Core	3				0	0	40	60	-	
	2	DSC6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	**12**
	3	DSC6301/6303/.....	Elective 8	Elective	3	3	0	0	20	0	30	50	-	
	4	DSC6201/6203/.....	Elective 9	Elective	2	2/0	0	0/4	20/0	0/40	30/0	50/0	0/60	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRE	MTE	'ETE	PRE	Total Credits
Group F	**Track 1**													
	1	DSC652	Research Project	Core	12	0		12	0	0	-	100	-	**12**
	Track 2													
	1	DSC602	Major Project II	Core	12	0		12	0	0	40	60	-	**12**

LIST OF ELECTIVES:													
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 1	1	DSC5401	Programming Languages	Elective	4	3	0	2	15	25	20	40	-
	2	DSC5403	Advanced Database Management Systems		4	3	0	2	15	25	20	40	-
	3	DSC5405	Advanced Operating System		4	3	0	2	15	25	20	40	-
	4	DSC5407	Advanced Data Structures		4	3	0	2	15	25	20	40	-
	5	DSC5409	Data Warehousing Data Mining		4	3	0	2	15	25	20	40	-
	6	DSC5411	Software Project Management		4	3	0	2	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 2	1	DSC5301	Project Work	Elective	3	0	0	-	-	40	-	-	60
	2	DSC5303	Artificial Intelligence		3	3	0	0	20	-	30	50	-
	3	DSC5305	Information Retrieval		3	3	0	0	20	-	30	50	-
	4	DSC5307	Artificial Neural Networks		3	3	0	0	20	-	30	50	-
	5	DSC5309	Business Analytics		3	3	0	0	20	-	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 3	1	DSC5201	SEMINAR	Elective	2	2	0	0	2	-	100	-	-
	2	DSC5203	Research Methodology		2	2	0	0	20	-	30	50	-
	3	DSC5205	Data Visualization		2	2	0	0	20	-	30	50	-
	4	DSC5207	Stress Management		2	2	0	0	20	-	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 4	1	DSC5402	Web Analytics and Development	Elective	4	3	0	2	15	25	20	40	-
	2	DSC5404	Pattern Recognition		4	3	0	2	15	25	20	40	-
	3	DSC5406	Deep Learning		4	3	0	2	15	25	20	40	-
	4	DSC5408	Big Data Analytics		4	3	0	2	15	25	20	40	-

	5	DSC5410	Empirical Software Engineering		4	3	0	2	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 5	1	DSC5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	-	60
	2	DSC5304	Optimization Techniques		3	3	0	0	20	-	30	50	-
	3	DSC5306	Data Security & Privacy		3	3	0	0	20	-	30	50	-
	4	DSC5308	Distributed Systems		3	3	0	0	20	-	30	50	-
	5	DSC5310	Natural Language Processing		3	3	0	0	20	-	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
	1	DSC5202	Predictive Modelling	Elective	2	2	0	0	20	-	30	50	-
	2	DSC5204	Operational Research		2	2	0	0	20	-	30	50	-
	3	DSC5206	Research Paper Writing		2	2	0	0	20	-	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 7	1	DSC6401	Advanced Machine Learning	Elective	4	3	0	2	15	25	20	40	-
	2	DSC6403	Cloud Computing		4	3	0	2	15	25	20	40	-
	3	DSC6405	Internet of Things		4	3	0	2	15	25	20	40	-
	4	DSC6407	Multimedia Applications		4	3	0	2	15	25	20	40	-
	5	DSC6409	GPU Computing		4	3	0	2	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 8	1	DSC6301	Intellectual Property Rights	Elective	3	3	0	0	20	-	30	50	-
	2	DSC6303	Recommender Systems		3	3	0	0	20	-	30	50	-
	3	DSC6305	Security Analytics		3	3	0	0	20	-	30	50	-
	4	DSC6307	Software Quality & Metrics		3	3	0	0	20	-	30	50	-
	5	DSC6309	Swarm and Evolutionary Computing		3	3	0	0	20	-	30	50	-

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	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	DSC6201	Soft Computing	Elective	2	2	0	0	20	-	30	50	-
	3	DSC6203	Search Based Software Engineering		2	2	0	0	20	-	30	50	-
	5	DSC6205	Statistical Tools		2	0	0	4	-	40	-	-	60

SEMESTER I

DSC501 Mathematical Foundations of Computer Science

This course contains topics of Introduction to Probability theory, Through set and Relative Frequency: Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability and Axioms, Probability as a Relative Frequency, Joint and Conditional Probability, Random Variables, Distribution Function, Density Function. Random Samples, sampling distributions, Methods of moments and maximum likelihood. Covariance and correlation, Statistical Inference: Introduction of multivariate statistical models: Classification and regression, principal component analysis, overfitting problem. Graph theory: Isomorphism, planar graphs. permutations and combinations. Computer science and engineering application: software engineering, data mining, machine learning. Recent Trends

Text Books:

1. J. Vince, "Foundation Mathematics for Computer Science", Springer, 2015.
2. Ronald Walpole, Raymond Myers, Sharon Myers, Keying Ye, "Probability and Statistics for Engineers and Scientists", Prentice Hall International, 2016.
3. Joseph F. Hair, William C. Black, Barry J. Babin, Rolph E. Anderson, "Multivariate Data Analysis", Prentice Hall, 2010.
4. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh, "An Introduction to Probability and Statistics", 3rd Edition, Wiley, 2015.

Reference Books:

1. H.C. Taneja, "Statistical methods for Engineering and Sciences", I.K. International.

DSC503 Data Management and Ethics

The objective of the course is to introduce data management concepts and ethical practices. Database system concepts and its architecture, Data models schema and instances, Data independence and database language and interface, Data definition languages, DML. Relational Data Model and Language. Data Base Design: Functional dependencies, normal forms, 1NF, 2NF, 3NF and BCNF, multi-valued dependencies fourth normal form, join dependencies and fifth normal form. Inclusion dependencies, lossless join decompositions, normalization using FD. Transaction processing concepts: Transaction processing system, schedule and recoverability, Testing of serializability, Serializability of schedules, conflict & view serializable schedule, recovery from transaction failures, deadlock handling. Concurrency Control Techniques: Locking Techniques for concurrency control, time stamping protocols for concurrency control, Database Security Issues. Ethics and Data Management:- Data ethics, Need for Data ethics, Data ownership and privacy, The Five Cs (Consent, Clarity Consistency and Trust, Control and Transparency, Consequences), Implementing 5Cs, Ethics and Security Training, Developing Guiding Principles, Building Ethics into a Data-Driven Culture. Ethical issues related to data collection and storage:- ethical responsibilities of a company to its customers. Ethical responsibilities of employees to the company and its customers, Ethical responsibilities of customers to the company. Database Administrator's Code of Ethics:- Database Administrator, Need of Database Administrator, Existing DBA Code of Ethics, Areas of improvisation in existing code of ethics. Data Ethics Case studies: Academic Data Standards.

Text Books:

1. R. Elmasri, S. B. Navathe, R. Elmasri and S. B. Navathe, "Fundamentals of Database Systems", Addision Wesley, 2000.
2. A. Silberschatz, H. F. Korth and S. Sudarshan, "Database System Concepts", McGraw Hill, 7th edition, 2019.
3. M. Loukides, H. Mason and D. J. Patil, "Ethics and data science", O'Reilly Media, 2018
4. L. Turner, A. B. Weickgenannt and M. K. Copeland, "Accounting information systems: the processes and controls", John Wiley & Sons, 2016.

DSC5401 Programming Languages

The objective of the course is to introduce programming fundamentals through Python language. Planning the Computer Program, Techniques of Problem Solving, Overview of Programming: Structure of python program, basic elements of python program. Introduction to Python: Python Interpreter, Using Python as calculator, Python shell, Indentation. Atoms, Identifiers and keywords, Literals, Strings, Operators. Creating Python Programs: Input and Output Statements, Control statements, Defining Functions, default arguments, Errors and Exceptions. Iteration and Recursion, Strings and Lists, Object Oriented Programming: Introduction to Classes, Objects and Methods, Standard Libraries. Data Structures: Arrays, list, set, stacks and queues. Searching and Sorting.

Text Books:

1. T. Budd, "Exploring Python", First Edition, Tata McGraw Hill, 2011.
2. Downey, J. Elkner and C. Meyers. "How to think like a computer scientist learning with Python", 5th edition, Freely Available Online, 2012.

DSC5403 Advanced Database Management System

Relational Databases: Integrity Constraints revisited, Extended ER diagram, Relational Algebra & Calculus, Functional, Muiltivalued and Join Dependency, Normal Forms, Rules about functional dependencies. Advanced Transaction Processing: Nested and Multilevel Transactions, Compensating Transactions and Saga, Long Duration Transactions, Weak Levels of Consistency, Transaction Work Flows, Transaction Processing Monitors, Schedules, Serializability, conflict and view Query Processing: General strategies for query processing, transformations, expected size, statistics in estimation, query improvement, view processing, query processor. Query Optimization: Indexing and Query Optimization, Limitations of Relational Data Model, Null Values and Partial Information. Parallel and Distributed Databases: Distributed Data Storage – Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Distributed Transaction Modeling and concurrency Control, Distributed Deadlock, Commit Protocols, Design of Parallel Databases, Parallel Query Evaluation. Active Database and Real Time Databases: Triggers in SQL, Event Constraint and Action: ECA Rules, Query Processing and Concurrency Control, Compensation and Databases Recovery.

Text Books:

1. R. Elmasri and S. B. Navathe, "Fundamentals of Database Systems", 4th edition, Pearson Education, 2007.
2. H. G. Molina, J. Ullman and J. Widom, "Database Systems, The complete book", 2nd edition, Pearson, 2001.

Reference Books:

1. C. J. Date, A. Kannan and S. Swaminathan, "An Introduction to Database Systems", 8th edition, Pearson Education, 2007.
2. A. Silberschatz, H. F. Korth and S. Sudarshan, "Database System Concepts", McGraw Hill, 7th edition, 2019.

DSC5405 Advanced Operating System

The objective of the course is to learn various concepts related to operating systems. Operating system concepts: history, evolution and philosophy of operating systems. Concurrent processes, process coordination and synchronization, CPU scheduling, deadlocks, memory management, virtual memory, secondary storage and file management, device management, security and protection, networking, and distributed and real-time systems.

Text Books:

1. A Silberschatz, P. B. Galvin and G. Gagne, "Operating Systems Concepts", 8th edition, John Wiley Publications, 2008.
2. A. S. Tanenbaum, "Modern Operating Systems", 3rd edition, Pearson Education, 2007.
3. W. Stallings, "Operating Systems, Internals & Design Principles", 5th edition, Prentice Hall of India, 2008.

DSC5407 Advanced Data Structures

This course covers topics of Review of Elementary data structures, Sparse matrices, Advanced Data Structures: data structures for combinatorial, Operations on Disjoint Divide and Conquer approach, Graph Algorithms: Definitions and Algorithms, Greedy Method and Dynamic Programming, Dynamic Programming, Advanced Algorithms: NP Complete problems, Approximation algorithms for NP complete problem, Algorithms for matching, Flow and circular problems, Bio Inspired Algorithm- Genetic Algorithm, Particle Swam, Artificial Bee Colony, Firefly Algorithm, Bat Algorithm.

Text Books:

1. T. H. Cormen, C. E. Leiserson and R. L. Rivest, "Introduction to Algorithms", MIT Press, 2009.
2. R. E. Tarjan, "Data Structures and Network algorithms", SIAM Regional Conference series in Applied Mathematics, 1987.
3. A. Aho, J. Ullman and J. Hopcroft, "The Design and Analysis of Computer algorithms", Addison Wesley, 1974.
4. S. Dasgupta, C. H. Papadimitriou, and U. V. V Azirani, "Algorithms", Tata McGraw Hill, 2017.
5. Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, "Data Structures using C and C++", Pearson, 2006.

DSC5409 Data Warehousing and Data Mining

This course contains topics of Data Warehousing, Data Warehouse Architecture, Design, Implementation & Maintenance, Data Mining Concepts, Mining Association Rules in Large Databases, Classification and Prediction, Cluster Analysis in Data Mining, Mining Complex Types of Data: Multidimensional Analysis and Descriptive Mining of Complex Data Objects, Mining Spatial Databases, Mining Multimedia Databases, Mining Time Series and Sequence Data, Mining Text Databases, Applications, Trends in Data mining, spatial mining, and Web Mining.

Text Books:

1. P. Ponniah, "Data Warehousing Fundamentals", John Wiley, 2001.
2. M. H. Dunham, "Data Mining Introductory & Advanced Topics", Pearson Education, 2011.
3. H. Kamber, M. Kaufman and J. Pie, "Data Mining Concepts & Techniques", 3rd edition, Morgan Kaufmann, 2012.

DSC5411 Software Project Management

This course contains topics of Project Management concepts, Process Framework, Project Planning Software Life Cycle Models, Artifacts of the Project Management Process, Cost and Scheduling Estimation Models, Gantt Chart, CPM and PERT, Project Management Techniques, Project Closure, Software Project Management Renaissance, Advance Topics in Software Project Management

Text Books:

1. W. S. Humphrey, "Managing the Software Process", Pearson Education, 1990.
2. W. Royce, "Software Project Management", Pearson Education, 2002.
3. P. Jalote, "Software Project Management in Practice", Pearson Education, 2002.
4. B. Hughes, "Software Project Management", Tata McGraw Hill, 1995.

DSC5303 Artificial Intelligence

This course covers topics of AI Problems, Task Domains of AI, AI Techniques, Basic Problem solving Method: state space search, problem characteristics, Heuristic search Techniques, Knowledge Representation Knowledge Representation: using Predicate Logic: Unification, resolution. Natural deduction, using Rules, Structured Knowledge Representation, Programming Languages: Prolog or Lisp, Symbolic Reasoning under uncertainty, Statistical Reasoning, Concept of learning, learning in problem solving, learning by inductions, genetic algorithm, , Neural Network, Genetic theorem, Expert Systems Research issues in different domains.

Text Books:

1. J E. Rich. K. Knight, "Artificial Intelligence", Tata McGraw Hill, 2nd edition, 1992.
2. N.J. Nilsson, "Principles of AI", Narosa Publ. House, 1990.
3. D.W. Patterson, "Introduction to AI and Expert Systems", PHI, 1992.
4. M. Negnevitsky, "Artificial Intelligence: A Guide to Intelligent Systems", 2nd edition, Addison-Wesley, 2005

DSC5305 Information Retrieval

This course contains topics of Introduction and Search engine architecture, Search engine architecture, Retrieval models, Retrieval evaluation, classical evaluation metrics, e.g., Mean Average Precision, and modern advance, e.g., interleaving. Relevance feedback, Link analysis and Search applications, recommendation, personalization, and online advertising.

Text Books:

1. C. D. Manning, P. Raghavan and H. Schutze. "Introduction to Information Retrieval", Cambridge University Press, 2008.

DSC5307 Artificial Neural Networks

Introduction: A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks Learning Process: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process. Convolutional Neural Network. **Single Layer Perceptron:** Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate Annealing Techniques, Perceptron –Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment Multilayer Perceptron: Back Propagation Algorithm XOR Problem, Heuristics, Output Representation and Decision Rule, Computer Experiment, Feature Detection. **Back Propagation:** Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues, and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning.

Text Books:

1. Simon S. Haykin, "Neural Networks", Pearson, 3rd Edition, 2009.
2. B. Yegnanarayana, "Artificial Neural Networks", Prentice Hall of India Pvt. Ltd 2005.
3. L. M. Fu, "Neural Networks in Computer Intelligence", TMH 2003.
4. J. A. Freeman and D. M. Skapura, "Neural Networks", Pearson Education 2004.

DSC5309 Business Analytics

Introduction and Data Visualization: Decision making, Business analytics defined, Big data, Business analytics in practice. Data Visualization: Overview, Tables, Charts, Advanced data visualization, data dashboards. Spreadsheet Models and Linear Optimization Models: Building good spreadsheet models, what if analysis, excel functions for modeling, auditing spreadsheet models. Linear optimization models: Minimization problem, solving the par. Inc problem, maximization problem, special cases of linear program outcomes, sensitivity analysis, general linear programming notation. Integer Linear Optimization Models and Nonlinear optimization Models: Types of Integer linear optimization models, eastborne realty example, solving using excel solver, application involving binary variables, modeling flexibility provided by binary variables, generating alternatives. Nonlinear optimization models: a production application, local and global optima, a location problem, Markowitz portfolio model, forecasting adoption of a new product. Monte Carlo Simulation and Decision Analysis: Monte Carlo Simulation: Risk Analysis for Santonics LLC, Simulation modeling for land Shark Inc., Simulation considerations. Decision analysis: Problem Formulation
Business Analytics Applications: Why resource constraints are important to support business analytics: introduction, business analytics personnel, business analytics data. Prescriptive Analysis: Prescriptive modeling: non-linear optimization. Measures & metrics and Performance Management.

Text Books:

1. J. D. Camm, J. J. Cochran, M. J. Fry, J. W. Ohlmann, D. R. Anderson, D. J. Sweeney and T. A. Williams, "Essentials of Business Analytics", Cengage Learning, 2nd edition, 2015.
2. R. N. Prasad and Seema Acharya, Fundamentals of Business Analytics, Wiley, 2011.
3. C. M. Starkey, D. G. Schniederjans and M. J. Schniederjans, "Business Analytics: Principles, Concepts and Applications", Pearson, 2014.

Reference Books:

1. J. Liebowitz, "Business Analytics: An Introduction", Auerbach Publications, 2013.
2. D. R. Hardoon and G. Shmueli, "Getting Started with Business Analytics", CRC Press, Taylor & Francis, 2016.
3. P. H. Rao, "Business Analytics: An Application Focus", Prentice Hall India, 2014.
4. J. K. Sharma and P. K. Khatua, Business Statistics, Pearson, 2012

DSC5201 Seminar

Presentation based on recent topics

DSC5203 Research Methodology

This course contains topics of Foundation of Research and Problem Definition, Meaning, Objective and Importance of research, Types of research, steps involved in research, identification of research problem and its formulation. Research Design, Methods of research design, research process and steps involved, Literature Survey. Data Collection and Analysis, Reporting of Research, Types of research report, Referencing and referencing styles, Indexing and citation of Journals, Reference management software like Mendeley, Intellectual property, Plagiarism.

Text Books:

1. C. R. Kothari and G. Garg, "Research Methodology Methods and Techniques", 3rd edition, New Age International, 2019.
2. D. Cooper and P. Schindler, "Business Research Methods", 9th edition, Tata McGraw Hill, 2006.
3. J. W. Creswell, "Research design: Qualitative, quantitative, and mixed methods approaches", Sage publications, 2013.

DSC5205 Stress Management

This course aims at learning the techniques to manage stress. Understanding the nature of Stress: meaning of stress, the body's reactions to stress, sources of stress across the lifespan, adaptive and maladaptive behavior, individual and cultural differences. Strategies of stress management and prevention: challenging stressful thinking, problem solving and time management, psychological and spiritual relaxation methods, physical methods of stress reduction, preparing for the future: college and occupational stress, care of the self: nutrition and other lifestyle issues, stress and conflict in relationships. Strategies of synthesis and prevention: resilience and stress, optimal functioning, making changes last.

Text Books:

1. J. A. Kottler and D. D. Chen, "Stress management and prevention: Applications to daily life", 2nd edition, London and New York: Routledge.

DSC5207 Data Visualization

This course intends to learn basics of information visualization, scientific visualization, to learn key techniques for data visualization, technological advancements of data visualization, detailed view of visual perception, the visualized data and distorting techniques. The introduction part discuss about the visual perception introduction, visual reference model, visual mapping, information overloads. Creation of visual representations, visualization systems will be covered in next part. Visualization of groups, trees, graphs, clusters, networks and software. Visualization of volumetric data, vector fields, processes, simulators, visualization of maps, graphic information, GIS systems, collaborative visualizations. Recent trends in various perception techniques, various visualization techniques, data structures used in the data visualization.

Text Books:

1. M.O. Ward, G. Grinstein and D. Keim, "Interactive data visualization: foundations, techniques, and applications", CRC Press, 2010.
2. E. Tufte, "The visual display of quantitative information", Graphics Press, 2001.

SEMESTER II

DSC502 Data Preparation & Analysis

Introduction: Data Collection Strategies, Data Collection from Repositories, Mining Data from Software Repositories: Configuration Management Systems, Importance of Mining Software Repositories. Common Types of Software Repositories, Version Control Systems, Bug Tracking Systems, Open Source Repositories. Types of Variables: Independent and Dependent Variables, Categorical vs Numerical, Nominal Variables, Ordinal Variables, Interval Variables, Ratio Variables; Identifying the dependent and independent variables, Confidence levels. Data Preparation-I: Descriptive Statistics: Summarizing and describing a collection of data, Univariate and bivariate analysis, Mean, mode and standard deviation, Percentages and Ratios, Histograms, Identifying randomness and uncertainty in data inferential Statistics: Drawing inference from data, Modeling assumptions, Identifying Patterns, Regression analysis, T-test, Analysis of Variance, Correlations, Chi-square Measures of central tendency, measures of dispersion, data distribution, histogram analysis, normalization, outlier analysis, correlation analysis. Data Preparation-II: Attribute Reduction Methods: Univariate Analysis, Correlation-based Feature Selection, Attribute Extraction: Principal Component Analysis.
Case studies for data preparation and analysis.

Text Books

1. M. Kuhn, and K. Johnson, "Applied Predictive Modelling", Springer Verlag, 2013
2. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2016.

Reference Books

1. K. S. Sharma, "Predictive Modeling with SAS Enterprise Miner: Practical Solutions for Business Applications", 2nd edition, SAS Institute, 2013.
2. J. Strickland, "Predictive Modeling and Analytics", 2014.

DSC504 Machine Learning

The objective is to make the student understand the different supervised, unsupervised and reinforcement learning algorithms and choose the appropriate machine learning tool for different real-world examples. This course contains topics Machine Learning, Types of Machine Learning:Supervised, Unsupervised Learning, Reinforcement Learning, Categories of Supervised Learning; Predictive Modeling, Steps in Model Prediction: Metric Data Analysis, Attribute Reduction, Hypothesis Testing, Performance Evaluation Measures, Model Development, Model Development, Model Validation, Model Comparison Tests, Decision Trees (ID3, C4.3, CART), Artificial Neural Networks (Single-Layer Networks, Multi-layer Perceptron), Nearest Neighbour, Computing Distance, Support Vector Machines Dimensionality Reduction. Research applications.

Text Books:

1. T. Mitchell, "Machine Learning", McGraw Hill, 1997.
2. S. Shalev-Shwartz, S. Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014.
3. J. D. Kelleher, B. M. Namee, A. D'Arcy, "Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies", MIT Press, 2015.

DSC5402 Web Analytics and Development

This course intends to explore use of social network analysis to understand growing connectivity and complexity in the world ranging from small groups to WWW. Introduction: Social Network and Web data and methods, Graphs and Matrices, Basic measures for individuals and networks, Information Visualization. Web Analytics Tools: Click Stream Analysis, A/B testing, Online Surveys. Web Search and Retrieval: Search Engine Optimization, Web Crawling and indexing, Ranking Algorithms, Web traffic models. Making Connections: Link Analysis, Random Graphs and Network evaluation, Social Connects, Affiliation and identity. Connection: Connection Search, Collapse, Robustness, Social involvements and diffusion of innovation.

Text Books:

1. D. Hansen, B. Shneiderman and M. A. Smith, "Analyzing social media networks with NodeXL: Insights from a connected world", Morgan Kaufmann, 2011.
2. A. Kaushik, "Web analytics 2.0: The Art of Online Accountability", 2009.
3. D. Easley and J. Kleinberg, "Networks, crowds, and markets: Reasoning about a highly connected world. Significance", New York: Cambridge University Press.
4. S. Wasserman and K. Faust, "Social network analysis: Methods and applications", New York: Cambridge University Press, 1994.
5. P. R. Monge, N. S. Contractor, P. S. Contractor, R. Peter and S. Noshir, "Theories of communication networks", New York: Oxford University Press, USA, 2003.

DSC5404 Pattern Recognition

Introduction to Pattern Recognition, Feature Detection, Classification, Review of Probability Theory, Conditional Probability and Bayes Rule, Random Vectors, Expectation, Correlation, Covariance, Review of Linear Algebra, Linear Transformations. Decision Theory, ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant, Sufficient Statistics, Coping with Missing or Noisy Features. Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent. Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Density Estimation, Parzen Estimation. Unsupervised Learning, Clustering, Vector Quantization, K-means, Mixture Modelling, Expectation-Maximization. Hidden Markov Models, Viterbi Algorithm, Baum-Welch Algorithm, Linear Dynamical Systems, Kalman Filtering, Bayesian Networks.

Text Books:

1. R. O. Duda, P. Hart and D. Stork, "Pattern Classification", Second Edition, Wiley, 2000.
2. C. M. Bishop, "Pattern Recognition and Machine Learning'. Springer, 2007.
3. C. M. Bishop, "Neural Networks for Pattern Recognition", Oxford University Press, 1995.
4. S. Theodoridisand and K. Koutroumbas, "Pattern Recognition", 4th edition. Academic Press, 2008.
5. T. Hastie, R. Tibshirani and J. Friedman, "The Elements of Statistical Learning", Springer, 2009.

DSC5406 Deep Learning

Introduction to K-Nearest Neighbors, Deep Feedforward Networks, Regularization of deep learning, Optimization for training deep models, convolutional networks, recurrent networks, Applications. Convolutional Neural Networks: Invariance, stability Properties of CNN representations: invertibility, stability, invariance. Variants of the Basic Convolution Function ,history of CNN and deep learning Recurrent and Recursive Nets: Recurrent and Recursive Nets, Unfolding Computational Graphs, Recurrent Neural Network, Bidirectional RNNs, Deep Recurrent Networks , Recursive Neural Networks , The Challenge of Long-Term Dependencies , Echo State Networks, Leaky Units and Other Strategies for Multiple, Time Scales , The Long Short-Term Memory and Other Gated RNNs, optimization for Long-Term Dependencies, Explicit Memory. Linear Factor Model and Autoencoder: Linear Factor Models, Probabilistic PCA and Factor Analysis Independent Component Analysis (ICA), Slow Feature Analysis, Sparse Coding, Autoencoders, Undercomplete Autoencoders, Regularized Autoencoders, Stochastic Encoders and Decoders, Applications of Autoencoders. Deep Supervised Learning: Introduction to Deep Supervised Learning, Convolution & Pooling, Dropout, Transfer Learning Transfer Learning Scenarios, Applications of Transfer Learning, transfer Learning Methods, Fine Tuning and Data Augmentation, Related Research Areas.

Text Books:

1. I. Goodfellow, Y. Bengio and A.Courville, "Deep Learning", MIT Press, 2015.
2. A. Gibson and J Patterson, "Deep Learning", O'Reilly Media, Inc., 2017.

3. Russell, Norvig, "Artificial Intelligence: A Modern Approach", 3rd edition, Prentice Hall, 2010.
4. R.O. Duda, P.E. Hart, and D.G. Stork, "Pattern Classification", Wiley, 1973.
5. A. M. Bishop, "Neural Networks for Pattern Recognition", Oxford University Press, 1995.

DSC5408 Big Data Analytics

Introduction to Big Data, Clustering and Classification: Advanced Analytical Theory and Methods: Overview of Clustering, K-means, Use Cases – Overview of the Method, Determining the Number of Clusters, Diagnostics, Reasons to Choose and Cautions, Classification: Decision Trees Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes Theorem, Naïve Bayes Classifier, Association and Recommendation System: Advanced Analytical Theory and Methods-Association Rules, Classification: Decision Trees, Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms, Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier, Stream Memory, NoSQL Data Management For Big Data And Visualization: NoSQL Databases: Schema-less Models: Increasing Flexibility for Data Manipulation-Key Value Stores- Document Stores, Tabular Stores, Object Data Stores, Graph Databases Hive, Sharding, Hbase, Analyzing big data with twitter, Big data for E-Commerce Big data for blogs, Review of Basic Data Analytic Methods using R.

Text Books:

1. C. Eaton and D.deroos et al., "Understanding Big data ", McGraw Hill, 2012
2. A. Rajaraman and J.D. Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
3. B. Lublinsky, K. T. Smith and A.Yakubovich, "Professional Hadoop Solutions", Wiley, 2015.
4. T. White, "HADOOP: The definitive Guide", O Reilly 2012.

DSC5410 Empirical Software Engineering

The goal of the course is to instill the concepts and applications of empirical software engineering. Introduction: What Is Empirical Software Engineering? Overview & Types of Empirical Studies, Empirical Study Process, Ethics, Importance and Basic Elements of Empirical Research, Some Terminologies, Systematic Literature Review, Software Metrics, Experimental Design, Mining Data from Software Repositories, Data Analysis and Statistical Testing, Model Development and Interpretation, Validity Threats, Reporting Results, Mining Unstructured Data, Case Study & Tools.

Text Books:

1. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2016.
2. B. Boehm, H. D. Rombach, M. V. Zelkowitz, "Foundations of Empirical Software Engineering: The Legacy of Victor R. Basili", Springer, 2010.

DSC5302 **Minor Project**

DSC5304 **Optimization Techniques**

Basics of Optimization Techniques: Historical Development, Engineering application of Optimization, Formulation of design problems as mathematical programming problems, classification of optimization problems, Constrained and Un-constrained Optimization. Linear Programming Problem: Convex Sets, Hyper plane, Graphical method, Simplex method, Revised simplex method, Duality in linear programming (LP), Sensitivity analysis, other algorithms for solving LP problems, Transportation, assignment and other applications. Non-Linear Programming Problem: Quadratic Forms, Convex Non-linear Programming Problem, Method of Lagrange multipliers, Kuhn–Tucker Theory, Convex Quadratic Programming Problem, Separable Programming, Geometric Programming, Polynomial Programming Problem. Dynamic Programming: Introduction, Forward and Backward dynamic Programming, Recursive Relations, Search Techniques, Uniform, Sequential, and Fibonacci search Techniques, Univariate search methods, Steepest Descent method, Conjugate Directions method, Flecture Reev Methods. Queuing Systems: Introduction, Characteristics of Queuing Models, Models for arrival and service time, Kendall's notation for representing Queuing Models, Birth and Death Processes Advanced Techniques of Optimization: Introduction, Particle Swarm Optimization, Bacteria Foraging, Ant Colony Optimization, and Genetic algorithms for optimization and search.

Text Books:

1. S. S. Rao, "Engineering optimization: Theory and practice", New Age International (P) Limited, 3rd edition, 1998.
2. J. C. Pant, "Introduction to Optimization Operations Research", Jain Bros, 7th edition, 2008.
3. K.V. Mital and C. Mohan, "Optimization Methods in Operations Research and systems Analysis", New Age International (P) Limited, Publishers, Third Edition, 1996.

Reference Books:

1. H.A. Taha, "Operations Research: An Introduction", PHI Pvt. Ltd.
2. Kwang Y.Lee and El-Sharkawi, "Modern Heuristic Optimisation Techniques", Wiley Publication.

DSC5306 Data Security & Privacy

This course contains topics of Introduction to Data Security, Conventional Encryption Principles, Conventional encryption algorithms, cipher block modes of operation, Modern Block Ciphers, Public-key cryptography Principles, Latest Trends and solutions in Information Security, IP Security, Web Security: Secure Socket Layer (SSL) and transport layer security, TSP, Secure Electronic Transaction (SET), Electronic money, WAP security, firewall design principals, Virtual Private Network (VPN) security.

Text Books:

1. W. Stallings, "Cryptography and Network Security", William Stallings, Seventh Edition, PHI, 2017.
2. C. A. Jan, "Basic Methods of Cryptography", Cambridge University Press, 2000.
3. T. Calabrese, "Information Security Intelligence: Cryptographic Principles & Applications", Thomson Learning., 2003.
4. W. Mao, "Modern Cryptography: Theory and Practice", Pearson Education, 2003.
5. D. Elizabeth, R. Denning, "Cryptography and Data Security", Addison Wesley, 1992.

DSC5308 Distributed Systems

This course covers topics of Distributed System Models, Transparency, Scalability, Inter-process Communication, Middleware, issues in design of Distributed systems: current & future, Communications, Process and Synchronization, Serializability, Resource Allocation, Distributed Shared Memory, Process Scheduling, Load Balancing & Load Sharing, Mutual Exclusion, Election algorithms. Distributed File Systems Overview of security techniques, Cryptographic algorithms , Digital signatures, Cryptography pragmatics.

Text Books:

1. S. Taenbaum and M. V. Steen, "Distributed Systems: Principles and Paradigms", Prentice Hall, 2015.
2. G. Coulouris, J. Dollimore and T. Kindberg, "Distributed Systems Concepts and Design", Addison Wesley, 1994.
3. Kshenkalyani and M. Singhal, "Distributed Computing", Cambridge University Press, 2008.

DSC5310 Natural Language Processing

This course contains topics Phases in natural language processing, applications. Words and Word Forms, Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields. Morphology, acquisition models, Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality, Web 2.0 Applications.

Text Books:

1. D. Jurafsky and J. H. Martin, "Speech and Language Processing", 2nd edition, Pearson Education, 2009.
2. James, "Natural Language Understanding", 2nd edition, Pearson Education, 1994.
3. Bharati, R. Sangal and V. Chaitanya, "Natural Language Processing: A Paninian Perspective", PHI, 2000.
4. T. Siddiqui and U.S. Tiwary, "Natural Language Processing and Information Retrieval", OUP, 2008.

DSC5202 Predictive Modelling

The course aims at introducing the framework of predictive modeling process to students. Introduction: classification & prediction, key ingredients of predictive models, goals of a regression analysis, regression models, data in a regression analysis. Data preparation: analyzing the metric data, outlier analysis, correlation analysis, attribute reduction methods, attribute extraction. Statistical tests: categories, one-tail and two-tail, Type I and Type II errors, interpreting significance results. Model Development: data partition, attribute reduction, model construction, model validation, hypothesis testing, results interpretation, cross-validation. Hypothesis testing and model-comparison tests. Model evaluation: performance measures for categorical and continuous dependent variables, ROC analysis.

Text Books:

1. M. Kuhn and K. Johnson, "Applied Predictive Modelling", Springer Verlag, 2013.
2. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC Press, 2016.
3. E.E. Frees, E.W. Derrig, and G. Meyers, "Predictive Modeling Techniques in Actuarial Science", Vol. I: Predictive Modeling Techniques. Cambridge University Press, 2014.

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DSC5204 Operational Research

This course aims at familiarizing the students with quantitative tools and techniques, which are frequently applied to business decision-making. Introductory linear algebra: system of linear equations, matrices, rank and determinant of a matrix, linearly dependent and independent vectors, basis of a matrix. Linear programming: optimization problems, introduction to LP formulation, convex sets, extreme points, geometry of linear programs, basic feasible solutions, neighborhoods, local and global optima, profitable column, pivoting, simplex algorithm, graphical method. Duality: definition of the dual problem, primal-dual relationships, economic interpretation of duality, complementary slackness conditions. Transportation models: transportation algorithm, assignment model, hungarian method. Queuing models: elements of queuing model, exponential distribution, poisson distributions, poisson queuing models, single server model, multiple server model.

Text Books:

1. G. Hadley, "Linear Programming", Narosa, 2002.
2. H. A. Taha, "Operations Research-An Introduction", Prentice Hall, 8th Edition, 2008.
3. A. Ravindran, D. T. Phillips and J. J. Solberg, "Operations Research-Principles and Practice", John Wiley & Sons, 2005.

DSC5206 Research Paper Writing

The primary objective of the course is to make one aware of the basics and structure of formal research writing. Introduction: Concept of research writing and its importance, types of a study and its process. Systematic Literature Review: Basic concepts, planning, conducting, reporting. Research paper writing: abstract, introduction, related work, experiment design, research methods, research results, discussion & interpretation of results, validity evaluation, conclusions & future work, acknowledgement, references, index. Research ethics and misconduct.

Text Books:

1. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2013.
2. M. Cargill and P. O'Connor, "Writing Scientific Research Articles: Strategy and Steps", 2nd edition, Wiley Blackwell, 2013.
3. J. Mugah, "Essentials of Scientific Writing", AuthorHouse, 2016.

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SEMESTER III

DSC6401 Advanced Machine Learning

Introduction to Resampling Techniques for Imbalanced Data. Bayesian Learning: Introduction, Summarizing posterior distributions, Bayesian model selection, Hierarchical Bayes, Empirical Bayes, Bayesian decision theory, Naïve Bayes. Ensemble Learning: Bagging, Random Forests, Tree based methods, Boosting methods, boosting fits an additive model, forward stagewise additive modeling, exponential loss and adaboost. Text Mining- information extraction, retrieval, clustering, text summarization, Natural Language Processing; Applications of Text Mining: Introduction, Association rules, Cluster analysis, Self-organizing maps, Principal components, curves and surfaces, non-negative matrix factorization, independent component analysis, multidimensional scaling, nonlinear dimension reduction, the googlePagerank algorithm. Deep Learning and Applications.

Text Books:

1. T. Mitchell, "Machine Learning", McGraw Hill, 1997.
2. S. Shalev-Shwartz, S. Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014.
3. J. D. Kelleher, B. M. Namee, A. D'Arcy, "Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies", MIT Press, 2015.

DSC6403 Cloud Computing

The goal of this course is to introduce the concepts and applications of cloud computing. Overview of Computing Paradigm and introduction to cloud computing: Recent trends in computing, Evolution of Cloud Computing, Cloud service providers, Properties, Characteristics & Disadvantages, Cloud computing vs. Cluster computing vs. Grid computing, Role of Open Standards. Cloud computing architecture, Role of networks and web services in cloud computing, Service models, Deployment Models. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Service management in Cloud Computing, Cloud Security.

Text Books:

1. B. Sosinsky, "Cloud Computing Bible", Wiley, 2010.
2. R. Buyya, J. Broberg, A. M. Goscinski, "Cloud Computing: Principles and Paradigms", Wiley, 2011.
3. N. Antonopoulos, L. Gillam, "Cloud Computing: Principles, Systems and Applications", Springer, 2012.
4. R. L. Krutz, R. D. Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Wiley, 2010.

DSC6405 Internet of Things

Introduction to Internet of Things: Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, Iot Communication APIs IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols, Embedded Systems, IoT Levels and Templates Domain Specific IoTs – Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle. IoT and M2M: Software defined networks, network function virtualization, difference between SDN and NFV for IoT Basics of IoT System Management with NETCOZF, YANG- NETCONF, YANG, SNMP NETOPEER. Introduction to Python: Language features of Python, Data types, data structures, Control of flow, functions, modules, packaging, file handling, data/time operations, classes, Exception handling Python packages – JSON, XML, HTTPLib, URLLib, SMTPLib. IoT Physical Devices and Endpoints: Introduction to Raspberry PI-Interfaces (serial, SPI, I2C) Programming – Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, and reading input from pins. IoT Physical Servers and Cloud Offerings: Introduction to Cloud Storage models and communication APIs Webserver – Web server for IoT, Cloud for IoT, Python web application framework designing a RESTful web API.

Text Books:

1. Bahga and V. Madisetti, "Internet of Things – A Hands-on Approach", Universities Press, 2015.
2. M. Richardson and S. Wallace, Getting Started with Raspberry Pi, O'Reilly (SPD), 2014.
3. J. Holler, V. Tsiatsis, C. Mulligan, S. Avesand, S. Karnouskos and D. Boyle, "From Machine-toMachine to the Internet of Things: Introduction to a New Age of Intelligence", 1st edition, Academic Press, 2014.
4. B.S. Reiter and F.Michahelles, "Architecting the Internet of Things", Springer, 2011.
5. W. Stallings, "Foundations of modern networking: SDN, NFV, QOE, IOT, and cloud" publisher: Addison-Wesley, 2015.

DSC6407 Multimedia Applications

This course contains topics of Introduction to Multimedia Systems Architecture and Components, Multimedia Distributed Processing Model, Synchronization, Orchestration and Quality of Service Architecture. Usage of Text in Multimedia, Families and Faces of Fonts, Outline Fonts, Bitmap Fonts International Character Sets and Hypertext, Digital Fonts Techniques. Audio and Speech , Images and , Multimedia and Hypermedia, Hypermedia Presentation.

Text Books:

1. T. Vaughan, "Multimedia: Making it work", Tata McGraw-Hill, 9th edition, 2017.
2. R. Aggarwal, B. B Tiwari, "Multimedia Systems", Excel Publication, 2007.
3. Z. Li & M.S. Drew, "Fundamentals of Multimedia", Pearson Education, 2009.
4. D. Hillman, "Multimedia Technology and Application", Galgotia Publication, 2000.

DSC6409 GPU Computing

This course intends to learn parallel programming with Graphics Processing Units (GPUs). Introduction includes History, Graphics Processor, Graphics Processing Units, GPGPUs, Clock speeds, CPU/GPU comparisons, Heterogeneity, Accelerators, Parallel Programming, CUDA OpenCL/ OpenACC, Hell World Computation Kernels, Launch parameters, Tread hierarchy, Warps/ Wavefronts, Thread blocks/ Workgroups, Streaming multiprocessors, 1D/ 2D/ 3D thread mapping, Device properties, Simple programs. Memory includes Memory hierarchy, DRAM/ global, local/ shared, private. Local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Program switch matrices, Performance evaluation with different measures. Synchronization includes memory consistency, barriers (local versus global), Atomics, Memory fence, Prefix sum, Reduction, Programs for concurrent data structures such as Worklists, Linked-lists, Synchronization across CPU and GPU. Functions include Device Functions, Host Functions, Kernels functions, Using libraries (such as Thrust) and developing libraries. Support includes Debugging GPU Programs, Profiling, Profile tools, and Performance aspects. Streams include Asynchronous processing, tasks, Task-dependence, Overlapped data transfers, Default Streams, Synchronization with streams, Events, Event-based-Synchronization-Overlapping data transfer and kernel execution, pitfalls. Case Studies related to Image Processing, Graph algorithms, Simulations, Deep Learning. Advanced topics covers Dynamic Parallelism, Unified Virtual Memory, Multi-GPU processing, Peer access, Heterogeneous processing.

Text Books:

1. D. B. Kirk and W. H. Wen-Mei, "Programming Massively Parallel Processors: A Hands-on Approach", Morgan Kaufmann, 2010 (ISBN: 978-0-12-415992-1).
2. S. Cook, "C. U. D. A. "Programming: A Developer's Guide to Parallel Computing with GPUs", Applications of GPU Computing, 2012 (ISBN: 978-0-12-415933-4).

DSC6301 Intellectual Property Rights

This course contains topics of Introduction to IPR Overview & Importance IPR in India – Genesis and Development IPR in abroad Some Important examples of IPR Patents and their definition; Protectable subject matter--patentable invention, Procedure for obtaining patent, Provisional and complete specification Rights conferred on a patentee, transfer of patent; granting; infringement; searching & filing, Copyrights, Trademarks, relationship between unfair competition and intellectual property laws, Research and Intellectual Property Rights, Management Licensing and Enforcing Intellectual Property Industrial Designs: research and rights managements; legal issues, enforcement; Case studies in IPR.

Text Books:

1. B.L. Wadehra, "Law Relating to Intellectual Property", fourth edition, Universal law publishing co. pvt. Ltd, 2007.
2. A. Parulekar, S. D' Souza, "Indian Patents Law –Legal & Business Implications", Macmillan, 2006.
3. P. Narayanan, "Law of Copyright and Industrial Designs", Eastern law House, 2010.

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DSC6303 Recommender Systems

This course intends to learn techniques for making recommendations, including non-personalized, content-based and collaborative filtering, automation of variety of choice-making strategies with the goal of providing affordable, personal and high-quality recommendations. Introduction includes Overview of Information Retrieval, Retrieval Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Recommender systems functions, Matrix operations, covariance matrices, Understanding rating, Applications of recommendation systems, Issues with recommender system. Content-based Filtering includes High level architecture of content-based systems, Advantages and drawbacks of content based filtering, Item profiles, Discovering features of documents, pre-processing and feature extraction, Obtaining item feature form tags, Methods for learning user profiles, Similarity based retrieval, Classification algorithms. Collaborative Filtering includes User-based recommendation, Item-based recommendation; Model based approaches, Matrix factorization, Attacks on collaborative recommender systems. Hybrid approaches including Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies. Evaluating Recommender System includes Introduction, General properties of evaluation research, Evaluation designs: Accuracy, Coverage, Confidence, Novelty, Diversity, Scalability, Evaluation historical datasets, Offline evaluations. Types of Recommender Systems including Recommender systems in personalized web search, Knowledge-based recommender system, Social tagging recommender systems, Trust-centric recommendations, Group recommender systems.

Text Books:

1. D. Jannach, M. Zanker and A. Felfernig, "Recommender Systems: An Introduction", 1st edition. Cambridge University Press, 2010.
2. C. C. Aggarwal, "Recommender Systems", Cham: Springer International Publishing, 1st edition, 2016.
3. F. Ricci, L. Rokach and B. Shapira, "Introduction to Recommender Systems Handbook", Springer, Boston, MA, 1st edition, 2011.
4. N. Manouselis, H. Drachsler, K. Verbert and E. Duval, "Recommender systems for learning", Springer Science & Business Media, 2012.

DSC6305 Security Analytics

The objective of the course is to use analytics techniques to detect security vulnerabilities and prevent security attacks in the best possible manner. Precrime Data Mining: Rivers of Scraps, Data mining, investigative data warehousing, link analysis, software agents, text mining, neural networks, machine learning, precrime, September 11, 2001, Criminal Analysis and Data mining. Investigative Data Warehousing: Data Testing, Data Warehouse, Demographic data, Real estate and auto data, credit data, critical data, government data, Internet data, XML, Data preparation, Interrogating the data, data integration, security and privacy, Choicepoint, Tools for data preparation, Standardizing criminal data. Link Analysis and Intelligent Agents, Machine Learning Profiles: Machine learning: Decision Trees, case studies,Criminal Patterns: Money as Data, Financial crimes, money laundering, Insurance crimes, Telecommunication crimes, case studies, Identity crimes, Detecting crimes, Intrusion Detection: Intrusion MOs, Intrusion Patterns, Anomaly and Misuse detection, intrusion detection systems, Case study, Types of IDs, Misuse IDs, Anomaly IDs, Multiple based IDs, Data mining IDs, Advanced IDs, Forensic considerations, Early warning systems, Internet resources.

Text Books

1. J. Mena, "Investigative Data Mining for Security and Criminal Detection", Butterworth-Heinemann, 2002.
2. D. Barbara and S. Jajodia, "Applications of Data Mining in Computer Security", Springer, 2012.
3. Chen, W.W.S. Statistical Methods in Computer Security, Marcel-Dekker, 2005.
4. W. Stallings, Cryptography and Network Security, Pearson Education, Sixth Edition, 2013.

DSC6307 Software Quality & Metrics

The primary objective of the course is to make one understand software quality concepts and associated metrics to deliver good quality maintainable software. Introduction to software quality: What is software quality? software quality attributes, elements of a quality system, software quality models. Software metrics, their categories and application areas, measurement scales, analyzing metric data, metrics for measuring size, structure and software quality. Software maintenance: categories, challenges, maintenance of object-oriented software, software rejuvenation, estimation of maintenance effort, configuration management, regression testing. Case study pertaining to software quality improvement.

Text Books:

1. Y. Singh, R. Malhotra, "Object-Oriented Software Engineering", PHI Learning, 2012.
2. S.H. Kan, "Metrics and Models in Software Engineering", Second Edition, Pearson Education, 2003.
3. A. Basu, "Software Quality Assurance Testing and Metrics", PHI Learning, 2015.

3/C

DSC6309 Swarm and Evolutionary Computing

The course is designed to introduce the basic concepts of evolutionary and swarm computing along with their applications. Introduction to Evolutionary Computing: Components, global optimization, evolution strategies, fitness functions, learning classifier systems, parameter control, multi-modal problems. Swarm Intelligence: Its application to optimization problems, particle swarm optimization. Genetic Algorithm: Basics, reproduction, cross-over and mutation, Genetic algorithm convergence, Genetic programming. Hybrid Methods and Multi-objective Evolutionary Algorithms: Variants of Particle Swarm optimization and Genetic Algorithm, their hybridization, hybrid Multi-objective Optimization algorithms. Other recent algorithms: Cockoo search algorithm, Artificial Bee Colony Optimization, Ant Colony Optimization, Fire-fly algorithm, Bacterial Foraging, Application to the travelling salesman problem. Application to real world optimization problems.

Text Books:

1. P. Engelbrech, "Computational Intelligence", Second Edition, John Wiley & Sons, 2008.
2. M. Mitchell, "An Introduction to Genetic Algorithm", MIT Press, 1996.
3. D. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Addison-Wesley, 1989.
4. A.E Eiben, J.E. Smith, "Introduction to Evolutionary Computing", Second Edition, Springer, 2007.
5. K. DeJong, "Evolutionary Computation: A Unified Approach", MIT Press, 2006.

DSC6201 Soft Computing

This course contains topics of Soft Computing & Artificial Intelligence, Applications of Soft Computing, AI Search Algorithm, Predicate Calculus, Rules of Interference, Semantic Networks, Frames, Objects, Hybrid Models. Artificial Neural Networks, Back propagation Networks, Applications of NN. Fuzzy Logic and Fuzzy Sets, Fuzzy Arithmetic, Neuro - Fuzzy Modeling, Genetic Algorithms and Swarm Optimizations: Fitness Computations, Evolutionary Programming, Genetic Programming Parse Trees, Variants of GA, Applications.

Text Books:

1. S. Patnaik, B. Zhong, "Soft Computing Techniques in Engineering Applications", Springer, 2014.
2. H. J. Krogh, R.G. Palmer, "Introduction to the Theory of Neural Computation", Addison-Wesley, 1991.
3. M. Mitchell, "An Introduction to Genetic Algorithm", PHI, 1998.
4. S. Kaushik, "Artificial Intelligence", Cengage Learning, 2007.
5. J. A. Anderson, "An Introduction to Neural Networks", MIT Press, 1997.
6. G. J. Klir & B. Yuan, "Fuzzy Sets & Fuzzy Logic", PHI, 1996.

DSC6203 Search Based Software Engineering

This course aims to introduce students to a wide range of search based software engineering terminology, techniques, and processes. Topics covered in this course are as following: Search Based Software Engineering Introduction, methods, search based algorithms, automated test case generation introduction, search based approaches to automated test data generation, test data generation using genetic algorithms, PSO, ABC, test data generation tools.

Text Books:

1. Y. Singh, "Software Testing", U. S., New York: Cambridge University Press, 2012.
2. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2016.

Supported Readings:

1. M. Harman, and P. McMinn, "A theoretical and empirical study of search-based testing: Local, global, and hybrid search," IEEE Transactions on Software Engineering, vol. 36, no. 2, pp. 226–247, 2010.
2. W. Afzal, R. Torkar, and R. Feldt, "A systematic literature review of search-based software testing for non-functional system properties," Information and Sofstware Technology, vol. 51, no. 6, 957–976, 2009.

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DSC6205 Statistical Tools

This course contains review and applications of statistical tools. Introduction to statistical tests and statistical concepts with various tools such as WEKA, SPSS, R, Python and MATLAB

Text Books:

1. Ian H. Witten, Eibe Frank , M. Hall, "DATA MINING, Practical Machine Learning Tools and Techniques, "Morgan Kaufmann Series in Data Management Systems, 2011.
2. V.K. Rohatgi, A.K. Md.E.Saleh, "An Introduction to Probability and Statistics", Wiley, 2008.
3. S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Fifth Edition, Academic Press, 2014.