Computer Science and Engineering

M. Tech Course

July, 2018

PART I: COURSE STRUCTURE

First Year
Semester I

A. Theory							
Sl.	Code	**Subject**	Contact Periods/Week			Total	Credits
			L	T	P		
1.	CSEN5101	Advanced Data Structures	3	0	0	3	3
2.	CSEN5102	Research Methodology and IPR	2	0	0	2	2
3.	MATH5101	Advanced Discrete Mathematics and Statistical Methods	3	0	0	3	3
4.	CSEN5131- CSEN5140	Professional Elective I	3	0	0	3	3
	CSEN5131 CSEN5132 CSEN 5133 CSEN 5134 CSEN5135	Machine Learning Advanced Wireless and Mobile Networks Introduction to Intelligent Systems GPU Computing Image Processing					
5.	CSEN5141- CSEN5150	Professional Elective II	3	**0**	0	3	3
	CSEN5141 CSEN5142 CSEN5143 CSEN5144 CSEN5145	Data Science Distributed Systems Wireless Sensor Networks Digital Forensics Computational Biology					
6.	Audit Course DIMA5116 INCO5117 PDLS5118 YOGA5119	Disaster Management Sanskrit for Technical Knowledge Personality Development through Life Enlightenment Skills Stress Management by Yoga Sanskrit for Technical Knowledge	2	**0**	0	2	0

	SANS5120						
Total Theory			**16**	**0**	**0**	**16**	**14**
B. Practical							
1.	CSEN 5151	Advanced Data Structures Lab	0	0	4	4	2
2.	CSEN5181- CSEN5190	Professional Elective-I Lab	0	0	4	4	2
	CSEN5181 CSEN 5182 CSEN 5183 CSEN 5184 CSEN 5185	Machine Learning Lab Advanced Wireless and Mobile Networks Introduction to Intelligent Systems GPU Computing Lab Image Processing Lab					
Total Practical			**0**	**0**	**8**	**8**	**4**
Total of Semester			**16**	**0**	**8**	**24**	**18**

First Year

Semester II

A. Theory							
Sl.	Code	Subject	Scheme Of Studies Per Week			Total	Credits
			L	T	P		
1.	CSEN5201	Advanced Algorithms	3	0	0	3	3
2.	CSEN5202	Soft Computing	3	0	0	3	3
3.	CSEN5231- CSEN5240	Professional Elective III	3	0	0	3	3
	CSEN5231 CSEN5232 CSEN5233 CSEN5234 CSEN5235	Data Preparation and Analysis Secure Software Design & Enterprise Computing Computer Vision Theory of Computation Computational Geometry					
4.	CSEN5241- CSEN5250	Professional Elective IV	3	0	0	3	3
	CSEN5241 CSEN5242 CSEN5243 CSEN5244 CSEN5245	Human and Computer Interaction Graph Algorithms Cloud Computing Algorithms for VLSI CAD Spatial Informatics & GIS					
5.	CSEN5231- CSEN5250	Audit Course – any one subject from Elective III or Elective IV bucket	3	0	0	3	0
	Total Theory		**15**	**0**	**0**	**15**	**12**
B. Practical							
1.	CSEN5251	Advance Algorithms Lab	0	0	4	4	2
2.	CSEN5252	Soft Computing Lab	0	0	4	4	2
Total Practical			**0**	**0**	**8**	**8**	**4**
C. Sessional							
	CSEN5293	Term Paper and Seminar	0	0	4	**4**	**2**
Total Semester			**15**	**0**	**12**	**27**	**18**

Second Year
Semester III

A. Theory							
Sl.	Course Number	Subject	Scheme Of Studies Per Week			Total	Credits
			L	T	P		
1.	CSEN6131-CSEN6140	Professional Elective V	3	0	0	3	3
	CSEN6131 CSEN6132 CSEN6133 CSEN6134 CSEN6135 CSEN6136	Mobile Applications and Services Compiler for HPC Optimization Techniques Computational Complexity Fault Tolerant Computing Approximation Algorithms					
2.	CSEN6121-CSEN6130	Open Elective	3	0	0	3	3
	CSEN6121 CSEN6122 CSEN6123 CSEN6124 CSEN6125 MATH6121	Business Process Model Randomized Algorithms Embedded Systems Information & Coding Theory Quantum Computing Optimization Techniques					
Total Theory			**6**	**0**	**0**	**6**	**6**
B. Sesssional							
1.	CSEN6195	Dissertation – Phase I	0	0	20	**20**	**10**
Total Semester			**6**	**0**	**20**	**26**	**16**

Second Year
Semester IV

A. Sessional							
Sl.	Course	Subject	Scheme Of Studies Per Week			Total	Credits
			L	T	P		
1.	CSEN6295	Dissertation – Phase II	0	0	28	28	14
2.	CSEN6297	Comprehensive Viva-voce	0	0	0	0	2
Total Semester			**0**	**0**	**28**	**28**	**16**

PART II: DETAILED SYLLABUS

M. Tech. Detailed Syllabus - Semester I

Course Name : Advanced Data Structure					
Course Code: CSEN5101					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

Students undergoing this course are able to:

- Identify abstract data types and its significance; differentiate between linear and non-linear data structures for solving real world problems.
- Illustrate some of the special trees, Tries data structure and various Hashing Techniques
- Write modular programs on linear and non linear data structures for solving engineering problems efficiently.
- Understand the basic principles of different string matching algorithms and identify their advantages and disadvantages.

Module I: Review of Fundamental Concepts 10

Introduction

Arrays, lists, stacks, queues, heaps, priority queues

Dictionary operations, Abstract Data Types (ADTs)

Hashing

Hash tables, hash functions, collision resolution by chaining,

Collision resolution by open addressing, linear and quadratic probing

Double hashing, extensions and recent advances

Module II: Binary Trees **10**

BasicFeatures and Procedures

Binary tree traversal methods, total path length in binary trees

Binary search trees, insertion and deletion of keys

Worst-case and average case times for search, insertion and deletion

Special Types of Binary Trees

AVL trees, Red-Black trees, 2-3 trees, other types

Module III: Other Data Structures for Storage and Search **10**

B-Trees

Broad shallow tree structures for secondary storage

Insertion and deletion of keys in B-trees, insertion and search times

Skip Lists

Need for randomized methods, search and insertion in skip lists

Probabilistic analysis, deterministic skip lists

Module IV: Additional Topics **10**

Computational Geometry

Introductory concepts, one and two dimensional range searching

Priority search trees, priority range trees, quadtrees, k-D trees

Pattern Matching in Strings

Brute force methods, Boyer-Moore algorithm

Knuth-Morris-Pratt algorithm

Tries, Huffman codes, extensions

References:

[1] Introduction to Algorithms (3rd Ed., 2009)

T H Cormen, C E Leiserson, R L Rivest, C Stein, The MIT Press

[2] The Art of Computer Programming (latest editions)

Volume 1 (Fundamental Algorithms)

Volume 3 (Sorting and Searching)

D E Knuth, Addison Wesley

Course Name : Advanced Discrete Mathematics and Statistical Methods					
Course Code: MATH5102					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	3	**0**	**0**	**3**	**3**

Course Outcomes :

1. To understand the mathematical fundamentals that is prerequisites for a variety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.

2. To develop the understanding ofthe mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design, and concurrency.

3. To study the principles of enumeration.

4. To equip oneself with the advanced techniques used in graph theory.

MODULE I :
Probability and Statistics I : 10L

- Review of Basic Probability: Sample Space, Events, Classical Definition , Addition and Multiplication Rule, Conditional Probability
- Axiomatic definition of Probability and related problems
- Bayes' Theorem and related problems
- Expectation and Variance
- General properties of probability distributions

MODULE II :
Probability and Statistics II : 10L

- Moment generating and Characteristic functions
- Special Distributions: Binomial and Normal Distribution
- Measures of Central Tendency: Mean , Median , Mode
- Measures of Dispersion: Standard deviation and Variance
- Relation between random variables, Covariance and Correlation Coefficient
- Linear Regression equations

MODULE-III
Topics in Combinatorial Mathematics: 10 L

- Pigeon Hole Principle
- Permutations & Combinations
- Binomial Coefficients
- Recurrence Relations & Generating Functions
- Properties of Fibonacci Numbers
- Principle of Inclusion & Exclusion
- Polya's Theory of Counting, Ramsey's Theorem

MODULE IV
Advanced Graph Theory: 10 L

- Tree, Binary Tree, Spanning Tree
- Walk, Path, Cycle, Hamiltonian Graph
- The Travelling Salesman Problem
- Euler Graph, The Chinese Postman Problem , Planar Graph
- Euler's Formula for Planar Graph and Related Problems
- Examples of Non-Planar Graphs, Kuratowski's Theorem
- Matching and Augmenting Paths, Hall's Marriage Theorem and Related Problems
- Vertex Colouring, Chromatic Polynomials

Suggested Books:

1. Discrete Mathematics & Its Applications, K H Rosen, McGraw Hill
2. Introduction to Graph Theory, D G West, Prentice-Hall of India
3. Discrete Mathematics for Computer Scientists and Engineers, J L Mott, A Kandel and T P Baker, PHI
4. Introduction to Probability and Statistics for Engineers and Scientists, S.Ross, Elsevier
5. Fundamentals of Mathematical Statistics, S.C.Gupta and V.K.Kapoor, Sultan Chand and Sons

List of Electives:

Professional Elective I

CSEN5131- Machine Learning

CSEN5132- Advanced Wireless and Mobile Networks

CSEN5133- Introduction to Intelligent Systems

CSEN5134- GPU Computing

CSEN5135- Image Processing

Course Name : - Machine Learning					
Course Code: CSEN5131					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	3	**0**	**0**	**3**	**3**

COURSE OBJECTIVES

- To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes.
- To design and analyze various machine learning algorithms and techniques with a modern outlook focusing on recent advances.
- Explore supervised and unsupervised learning paradigms of machine learning.
- To explore Deep learning technique and various feature extraction strategies.

COURSE OUTCOMES

On completion of the course the student should be able to:

- Extract features that can be used for a particular machine learning approach in various IOT applications.
- To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach.
- To mathematically analyze various machine learning approaches and paradigms.

Module 1: (L10)
Supervised Learning (Regression/Classification)

- Basic methods: Distance-based methods, Nearest-Neighbors, Decision Trees, Naive Bayes
- Linear models: Linear Regression, Logistic Regression, Generalized Linear Models
- Artificial Neural Networks: Neural Network Model, Back propagation algorithm; Introduction to Radial Basis Function, Recurrent Neural Network, Convolution Neural Network
- Beyond Binary Classification: Multi-class/Structured Outputs, Ranking

Module 2: (L10)
Unsupervised Learning

- Clustering: K-means/Kernel K-means, DBScan
- Dimensionality Reduction: PCA and kernel PCA
- Matrix Factorization and Matrix Completion

Module 3 (L10)

- Components of learning
- Error and Noise; Training vs Testing: From Training to Testing,
- Dichotomies, Growth Function, Break Points, VC Dimension
- Bias-Variance Tradeoff: Bias and Variance, Learning Curves

Module 4 (L9)

- Support Vector Machines, Nonlinearity and Kernel Methods
- Overfitting: What is overfitting? Dealing with overfitting ;
- Regularization: informal and formal, Weight decay, Choosing a regularizer.
- Deep Learning

Books:

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
4. Tom Mitchell, Machine Learning, First Edition, McGraw-Hill, 1997.
5. Simon Haykin, Neural Networks and Learning Machines, Third Edition, PHI Learning, 2009.
6. Amit Konar, Computational Intelligence Principles, Techniques and Applications, Springer, 2012

Course Name : - Advanced Wireless and Mobile Networks					
Course Code: CSEN5132					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	3	**0**	**0**	**3**	**3**

COURSE OUTCOMES:

- The students should get familiar with the wireless/mobile market and the future needs and challenges.
- To get familiar with key concepts of wireless networks, standards, technologies and their basic operations
- To learn how to design and analyse various medium access protocols

MODULE 1:

INTRODUCTION: Wireless Networking Trends, Key Wireless Physical Layer Concepts, Multiple Access Technologies -CDMA, FDMA, TDMA, Spread Spectrum technologies, Frequency reuse, Challenges in Mobile Computing: Resource poorness, Bandwidth, energy etc. 1L

RADIO PROPAGATION AND MODELLING: Modelling of radio propagation channels including path-loss models, Lognormal shadowing, fading and multipath. 3L

WIRELESS CELLULAR NETWORKS: 1G and 2G, 2.5G, 3G, Cellular architecture, Frequency reuse, Handoff strategies, Interference and system capacity, Improving coverage and capacity in cellular systems, Spread spectrum Technologies. 2L

TOOLS TO EVALUATE NETWORK PERFORMANCE: Introduction to Markov Chain, Channel assignment strategies, evaluation of channel assignment strategies using Continuous Time Markov Chain. 4L

MODULE 2:

ADVANCED WIRELESS CELLULAR NETWORKS: OFDM, 4G networks, WiMAX (Physical layer, Media access control, Mobility and Networking), LTE 4L

5G networks: Network Densification, Millimetre Wave, MIMO 3L

Convex Optimization and its Application in 5G networks 3L

MODULE 3:

NETWORK AND TRANSPORT LAYER PROTOCOLS: Mobile IPv4, Mobile IPv6 and TCP over Wireless Networks: ATCP, ITCP, MTCP and others. 4L

WLAN: IEEE 802.11 Wireless LANs Physical & MAC layer, 802.11 MAC Modes (DCF & PCF) IEEE 802.11 standards, Architecture & protocols, Infrastructure vs. Adhoc Mode, Hidden Node & Exposed Terminal Problem, Problems, Fading Effects in Indoor and outdoor WLANs, WLAN Deployment issues. 2L

Cognitive Radio Networks: Analysis of Cognitive Channel Allocation Algorithms using Continuous Time Markov Chain. 4L

MODULE 4:

WIRELESS ADHOC NETWORK: Definition, Properties, Limitations, Routing Protocols: DSR, DSDV, AODV, TORA, etc. Introduction to Vehicular Adhoc Networks. 3L

WIRELESS SENSOR NETWORKS: Introduction, Application, Physical, MAC layer and Network Layer, Power Management, Tiny OS Overview. 3L

WIRELESS PANs: Bluetooth and Zigbee. 2L

SECURITY: Security in wireless Networks Vulnerabilities, Security techniques, Wi-Fi Security, DoS in wireless communication. 2L

References:

1. Stallings, William. *Wireless communications & networks*. Pearson Education India, 2009.

2. Rappaport, Theodore S. *Wireless communications: principles and practice*. Vol. 2. New Jersey: prentice hall PTR, 1996.

3. Schiller, Jochen H. *Mobile communications*. Pearson education, 2003.

4. Perkins, Charles E. *Ad hoc networking*. Vol. 1. Reading: Addison-wesley, 2001.

5. Karl, Holger, and Andreas Willig. *Protocols and architectures for wireless sensor networks*. John Wiley & Sons, 2007.

6. Boyd, Stephen. *Convex optimization*. Cambridge university press, 2004.

Course Name: Introduction to Intelligent Systems					
Course Code: CSEN 5133					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes/Learning Objectives:

- At the end of this course the students are expected to be capable of understanding the basic features / attributes that an intelligent system should have, how those attributes can be incorporated to the system.

- Beside this students should be able to know the importance of knowledge as far as intelligence is concerned and how this knowledge can be suitably represented so that it can be used to infer new knowledge.

- On completion of this course, the students also get an idea of the significance of efficient searching algorithms as far as intelligent decisions are concerned.

- Last but not the least, by the end of this course, students will be able to explore various problem solving paradigms, learning algorithms, game playing techniques, logic theorem proving etc.

Module I: [10L]

Introduction [1L]
Definition of AI, Intelligent Behavior, Turing Test, Typical AI Problems, Various AI Approaches,
Limits of AI.

Introduction to Intelligent Agents [1L]
Agents & environment, Agent Architecture, Agent Performance, Rational Agent, Nature of Environment, Simple Reflex Agent, Goal Based Agent, Utility Based Agent.

Knowledge Representation & Propositional Logic [2L]
Knowledge representation issues, Approaches to knowledge representation, Propositional Logic – its syntax & semantics, Inference rules, Application of those rules, Limitation of Propositional Logic.

Problem Solving using Single Agent Search [2L]
Introduction to State-space search, state-space search notation, search problem, Formulation of some classical AI problems as a state space search problem, Explicit Vs. Implicit State space.

Uninformed Search Techniques [4L]
Basic Principles, Evaluating parameters, BFS, DFS, Depth Limited Search, Iterative Deepening DFS, Uniform Cost Search & Bidirectional Search, Properties of various search methods & their comparative studies.

Module II: [10L]

Informed Search Methods [6L]
Basic Principles, Heuristics, Best First Search – Greedy Best First, A* Search, their Properties, Admissible & Consistent heuristic, Local Search Techniques – Hill climbing & Simulated Annealing, Comparison with other methods

Problem Solving using Two Agent Search [2L]
Adversarial Search – Game Tree, MINIMAX Algorithm, Alpha-Beta Pruning, Performance Analysis.

Constraint Satisfaction Problem [2L]
Definition of CSP, Representation of CSP, Formulation of Various popular problems as CSP, constraint graphs, Solution methods of CSP – Backtracking & Forward Checking, variable and value ordering heuristic, degree heuristic, least-constraining value heuristic, constraint propagation, dependency-directed backtracking

Module III: [10L]

Knowledge Representation & Predicate Logic [3L]
Syntax & Semantics of FOPL, Representation of facts using FOPL, Clauses, Resolution, Unification methods of inference, Default & Non-Monotonic reasoning.

Knowledge Representation using Rules [2L]
Rule based system, Horn clauses, Procedural vs. declarative knowledge, forward & backward reasoning, Introduction of logic programming using PROLOG/ LISP.

Other Representational Formalism [2L]
Inheritable knowledge, Semantic network, Inference in Semantic network, Extending Semantic Network, Frames, Slots as objects.

Probabilistic reasoning [3L]

Representing knowledge in an uncertain domain, probabilistic inference rules, Naïve Bayes Classifier, Bayesian networks – representation & syntax, semantics of Bayesian net, Fuzzy sets & fuzzy logic.

Module IV: [9L]

Planning [2L]

Introduction, Simple planning agent, Problem solving vs. planning, Logic based planning, Goal Stack planning, Planning as a search, Total-order vs. partial order planning.

Learning [5L]

Overview, Taxonomy of learning system, various learning models, learning rules, inductive learning framework, Decision tree based learning, Learning using Neural Network & Genetic Algorithm.

Natural Language Processing [1L]

Introduction, Brief idea about Syntactic processing, semantic analysis, discourse & pragmatic processing.

Expert Systems [1L]

Representing and using domain knowledge, expert system shells, knowledge acquisition.

References:

1. Artificial Intelligence A Modern Approach, Stuart Russell & Peter Norvig, Pearson Education
2. Artificial Intelligence, Ritch & Knight, TMH
3. Artificial Intelligence & Intelligent Systems, N.P.Padhy, Oxford University Press
4. Introduction to Artificial Intelligence & Expert Systems, Dan W. Patterson, PHI
5. PROLOG Programming for Artificial Intelligence, Ivan Bratko, Pearson India.

Course Name: GPU Computing					
Course Code: CSEN 5134					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

COURSE OBJECTIVES:

By attending the course, students would:

1. learn concepts in parallel programming,
2. gain the knowledge of implementation of programs on GPUs,
3. have skills for debugging and profiling parallel programs.

Module1:
Introduction: **(9L)**

A short history of supercomputing; (2L)

GPU Introduction; CPU/GPU comparison; GPU Architecture; (3L)

CUDA Introduction: Hardware overview; OpenCL / OpenACC introduction; (4L)

Module 2:
CUDA/GPU Programming : **(8L)**

Grids/Blocks and Threads: Kernels Functions; Thread organization and hierarchy; Warps / Wavefronts, Thread blocks / Workgroups. (4L)

Memory handling; global, local / shared, private, textures, Constant Memory; Strategy for reducing Global Memory Traffic; Memory and Parallelism; (4L)

Module3:
Performance Considerations: **(10L)**
Streaming multiprocessors;1D / 2D / 3D thread mapping; Dynamic Partitioning of Streaming Multiprocessors; Data Prefetching; (5L)

Synchronization: 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. (5L)

Module 4:

Advanced Topics: **(9L)**

a**) Case Studies**: Graph algorithms, Deep Learning (4L)

b) **Streams**: Asynchronous processing, tasks, Task-dependence, Overlapped data transfers, Default Stream, Synchronization with streams. Events, Event-based- Synchronization - Overlapping data transfer and kernel execution. (5L)

Suggested Additional Topics:

1. Designing GPU based systems.

2. Floating Point considerations in GPU

3. **Advanced topics**: Dynamic parallelism, Unified Virtual Memory, Multi-GPU processing, Peer access, Heterogeneous processing

4. Debugging GPU Programs. Profiling,

References:

1. Programming Massively Parallel Processors: A Hands-on Approach; David Kirk, Wen-mei Hwu; Morgan Kaufman;
2. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs; Shane Cook; Morgan Kaufman;
3. GPU Computing and Applications: Yiyu Cai, Simon See; Springer;

Course Name: Image Processing					
Course Code: CSEN 5135					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

COURSE OUTCOMES:

1. Get detail exposure to and understanding of various applications of image processing in industry, medicine, and defense.
2. Learn the digital processing algorithms and techniques in image enhancement and image restoration,
3. Able to understand various algorithms used in image compression, segmentation and morphology.
4. Acquire an appreciation for the image processing issues and techniques and be able to apply these techniques to real world problems.
5. Be able to conduct independent study and analysis of image processing problems and techniques.

Module I:

Fundamentals of Image Processing

Image Acquisition, Image Model, Sampling, Quantization, Relationship between pixels,

distance measures, connectivity , Image Geometry, Photographic film.

Histogram: Definition, decision of contrast basing on histogram, operations basing on histograms like image stretching, image sliding, Image classification. Definition and Algorithm of Histogram equalization.

Image Transforms:

A detail discussion on Fourier Transform,Wavelet transform, DFT,FFT, properties. A brief discussion on WALSH transform, WFT, HADAMARD transform, DCT.

Module II:

Image Enhancement: (by SPATIAL Domain Methods)

Arithmetic and logical operations, pixel or point operations, size operations, Smoothing filters-Mean, Median, Mode filters – Comparative study , Edge enhancement filters – Directorial filters, Sobel, Laplacian, Robert, KIRSCH, Homogeneity & DIFF Filters, prewitt filter, Contrast Based edge enhancement techniques. Low Pass filters, High Pass filters, sharpening filters.

Image enhancement (by FREQUENCY Domain Methods)

Design of Low pass, High pass, EDGE Enhancement, smoothening filters in Frequency Domain. Butter worth filter, Homomorphic filters in Frequency Domain, advantages of filters in frequency domain, comparative study of filters in frequency domain and spatial domain.

Module III:

Image compression:

Definition, A brief discussion on – Run length encoding, contour coding, Huffman code, compression due to change in domain, compression due to quantization , Compression at the time of image transmission. Brief discussion on:- Image Compression standards.

Module IV:

Image Segmentation:

Definition, characteristics of segmentation. Detection of Discontinuities, Thresholding Pixel based segmentation method. Region based segmentation methods – segmentation by pixel aggregation, segmentation by sub region aggregation, histogram based segmentation, spilt and merge technique. Use of motion in segmentation (spatial domain technique only).

Morphology:

Dilation, Erosion, Opening, closing, Hit-and-Miss transform, Boundary extraction, Region filling, connected components, thinning, Thickening, skeletons , Pruning Extensions to Gray – Scale Images, Application of Morphology in image processing.

Text Books:

1. Digital Image Processing , by Rafael C. Gonzalez and Richard E. Woods

Addision Wesley .

2. Digital Image Processing by S. Sridhar, Oxford University Press.

References:

1. Fundamentals of Electronic Image Processing by Arthyr –R – Weeks, Jr. (PHI)

2. Image processing, Analysis, and Machine vision by Milan Sonka vaclan Halavac

Roger Boyle, Vikas Publishing House.

Professional Elective II

CSEN5141- Data Science

CSEN5142- Distributed Systems

CSEN5143- Wireless Sensor Networks

CSEN5144- Digital Forensics

CSEN5145- Computational Biology

Course Name: Data Science					
Course Code: CSEN 5141					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

COURSE OBJECTIVES

1. Provide students with the knowledge and expertise to become a proficient data scientist
2. Demonstrate an understanding of statistics and machine learning concepts that are vital for data science
3. Critically evaluate data visualizations based on their design and use for communicating stories from data
4. Produce Python code to statistically analyze a dataset

COURSE OUTCOMES

On completion of the course the student should be able to:

1. Explain how data is collected, managed and stored for data science;
2. Understand the key concepts in data science, including their real-world applications and some of the popular techniques used by data scientists;
3. Implement data collection and management scripts using MongoDB

Module	Topics	Estimate
1: Data Science Process		**6L**
	Overview – Benefits and Uses, Facets of Data, Big Data Ecosystem;	3L
	Data Scientist's Role in Major Steps – Goal Setting, Data Retrieval, Data Preparation, Data Exploration, Data Modeling, Data Presentation;	3L
2: Statistics for Data Science		**8L**
	Exploratory Data Analysis (EDA) – Structured Data, Rectangular Data, Location, Variability, Data Distribution, Binary & Categorical Data, Correlation, Multiple Variables ;	3L
	Sampling Distributions – Random Sampling, Bias, Sampling Distribution & Central Limit Theorem (CLT), Bootstrap, Confidence Interval; Different Distributions –Binomial / Poisson / Exponential / Normal / Student's t / Long-Tailed;	5L
3: Algorithms for Data Science		**18L**
	Regression – Simple Linear, Multiple Linear,	3L

	Polynomial; Prediction using Regression (Logistics Regression); *[Non-linear Regression to be covered in detail in ML]*	
	Classification – K Nearest Neighbors (k-NN), Naive Bayes Classification; Evaluating Classification Models – Accuracy, Precision, Recall, Specificity, Receiver / Operating Characteristics (ROC / OCC) Curve and Area Under Curve (AUC), Precision-Recall (PR) Curve;	8L
	Unsupervised Learning – K-Means Clustering, Hierarchical Clustering & Dendrogram, Principal Component Analysis (PCA); *[PCA to be covered in detail in ML]*	7L
4: Data Visualization		**7L**
	Visual Analytics -- Definition, Roles and Lifecycle / Process / Workflow of Visualization, Common Display Types with Examples;	3L
	Visual Encoding – Guidelines, Mackinlay's Retinal Variables, Mapping Effectiveness; Some Good Practices, Recommendations & Principles related to Graphical Excellence, Some Visualization Techniques;	4L

Books:

A. "Introducing Data Science"; Davy Cielen, Arno D Meysman and Mohamed Ali; Dreamtech Press
B. "Practical Statistics for Data Scientists"; Peter Bruce and Andrew Bruce; O'Reilly Media Inc.
C. "Doing Data Science"; Cathy O'Neil and Rachel Schutt; O'Reilly Media Inc.
D. "A First Course in Probability" 8th ed.; Sheldon Ross; Pearson Education Inc.
E. "Mining of Massive Datasets" v2.1; Jure Leskovek, Anand Rajaraman and Jeffrey Ullman; Cambridge University Press

Course Name: Distributed Systems					
Course Code: CSEN 5142					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

Upon successful completion of this course students should be able to:

- CO 1: Identify the introductory distributed database concepts and its structures.
- CO 2: Describe terms related to distributed object database design and management.
- CO 3: Produce the transaction management and query processing techniques in DDBMS.
- CO 4:Relate the importance and application of emerging database technology
- CO 5: Demonstrate knowledge of the basic elements and concepts related to distributed system technologies
- CO 6: Demonstrate knowledge of the core architectural aspects of distributed systems
- CO 7: Design and implement distributed applications
- CO 8: Demonstrate knowledge of details the main underlying components of distributed systems (such as RPC, file systems)
- CO 9: Use and apply important methods in distributed systems to support scalability and fault tolerance
- CO 10: Demonstrate experience in building large-scale distributed applications

Module 1:

Distributed Systems [4L]
Introduction to distributed computing systems. DCS design goals, Transparencies, Fundamental issues

Distributed Coordination [5L]
Temporal ordering of events, Lamport's logical clocks, Vector clocks; Ordering of messages, Physical clocks, Global state detection

Module 2:

Process synchronization [6L]

Distributed mutual exclusion algorithms

Inter-process communication [6L]

Message passing communication, Remote procedure call, Transaction communication, Group communication; Broadcast atomic protocols.

Module 3:

Distributed Scheduling [5L]

Issues in Load Distributing, Classification of Load Distributing algorithm, Load Balancing vs Load Sharing, Preemptive vs Non-Preemptive transfers

Distributed file systems [2L]
Introduction, Goal, Architecture, File accessing, sharing, caching, replication.

Naming [2L]

Design Issues: Naming and Name Resolution, Name Server, Cache Consistency.

Module 4:

Distributed Databases [10L]

Storage structures for distributed data, data fragmentation, Transparency of distributed architecture, Distributed query processing, and Transaction management in distributed environment, Recovery and Concurrency control, locking protocols, Deadlock handling.

Book:

Text Books:

1. Ceri & Pellagetti: Distributed Database: Principles & Systems, TMH
2. Sukumar Ghosh: Distributed Systems: An Algorithmic Approach, CRC Press
3. Pradeep K Sinha: Distributed Operating Systems Concepts and Design, PHI

Reference:

1. Silberschatz Korth, Sudarshan: Database System Concepts, TMH
2. Connolly and Begg: Database Systems: A practical approach to design, implementation and management, Pearson
3. M. Singhal, N.G. Shivarathri : Advanced Operating Systems, McGraw Hill

Course Name: Wireless Sensor Networks					
Course Code: CSEN 5143					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

COURSE OBJECTIVES:

After the completion of this course, students should be able to:

 Understand the fundamental concepts of wireless sensor networks and have a basic knowledge of the various protocols at various layers.

 Architect, design and implement sensor networks for various application setups.

 Evaluate the performance of sensor networks and identify bottlenecks

Module1:

Introduction: **(8L)**

Basic concepts of wireless sensor networks - Motivations, Applications, Performance metrics;

History and Design factors;

Architecture of a sensor node;

Different sensing scenarios using WSN;

Challenges in implementing WSNs;

Module 2:

Medium Access Control Protocol design: **(8L)**

Characteristics of WSN MAC related properties ;

MAC performance issues ;

MAC protocols for sensor networks – Schedule based and Random Access based.

WSN protocols: synchronized, duty-cycled;

Content based and Contention free MAC protocols;

Module3:
Routing protocols for WSN : **(8L)**
Issues with the adoption of ad hoc routing protocols;

Data-centric routing ; Position-based / Geographic routing ;

Clustering-based routing algorithm, QoS based Routing Protocols.

Module 4:

Advanced Topics: **(12L)**

a**) Security** requirements in WSNs ; Different types of attacks in WNs ; Security protocols for WSNs. (3L)

b) **Time Synchronization**: Requirements and challenges; Basic Ideas; Various protocols; (3L)

c) **Coverage problem in WSNs**: OGDC coverage algorithm ; Placement problem; (3L)

d) Topology management in WSNs : Different classifications relevant algorithms ; Topology discovery, sleep-cycle management, and clustering; (3L)

Suggested Additional Topics:

1. **Introduction to Markov Chain:** Discrete time Markov Chain definition, properties, classification and analysis; MAC Protocol Analysis using Markov chains;

2. a) **Sensor Network Programming**: Node centric Programming; Macroprogramming; Dynamic reprogramming;
b) Introduction to ns-3: Description of the ns-3 core module and simulation example.

3. **Opportunistic Routing Analysis**: Analysis of opportunistic routing (Markov Chain)

4. **Real Life Deployment**; Unserwater Sensor Nodes vs Terrestrial Sensor Nodes;

5. **Power Management.**

Books:

1. W. Dargie and C. Poellabauer, “Fundamentals of Wireless Sensor Networks –Theory and Practice”, Wiley 2010.

2. Kazem Sohraby, Daniel Minoli and TaiebZnati, “Wireless Sensor Networks -Technology, Protocols, and Applications”, Wiley Interscience 2007.

3. Fei Hu and Xiaojun Cao, “Wireless Sensor Networks: Principles and Practice”, CRC Press, 2010

4. Takahiro Hara,Vladimir I. Zadorozhny, and Erik Buchmann, “Wireless Sensor Network Technologies for the Information Explosion Era”, Springer 2010

5. Holger Karl and Andreas Willig**, “**Protocols And Architectures For Wireless Sensor Networks “, Willey, 2012

6. Qian, Muller and Chen, “Security in Wireless Networks and Systems”, Willey, 2011.

7. Stojmenovic, “Wireless Sensor and Actuator Networks: Algorithms and Protocols for Scalable Coordination and Data Communication”, Willey, 2010.

Course Name: Digital Forensics					
Course Code: CSEN 5144					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

COURSE OBJECTIVES:
This course tries to accomplish the following objectives:

1) Introducing basic concepts of digital forensic science
2) Exploring the specific areas of media, network and code forensics
3) Examining the role of digital forensics in public and private investigations
4) Examining the potential benefits, limitations and risks of digital forensics
5) Increasing awareness of managerial issues raised by the use of digital forensics
6) Enabling students to create disk images, recover deleted files and extract hidden information.
7) Introducing students to the current research in computer forensics. This will encourage them to define research problems and develop effective solutions.

Module1:
Introduction: **(8L)**

Understanding the Digital Forensics Profession and Investigations; Forensics science, computer forensics, and digital forensics ; (4L)

Processing Crime and Incident Scenes; analysis of cyber-criminalistics area, holistic approach to cyber-forensics; (4L)

Module 2:
Cyber Crime Scene Analysis : **(10L)**

Understanding Storage Formats for Digital Evidence; Determining the Best Acquisition Method; Using Acquisition Tools: Linux Boot CD; Remote Network Acquisition; Understanding various acquisition tools; (6L)

Evidence Management & Presentation Basics:

Identifying Digital Evidence, Rules of Evidence, Understanding Concepts and Terms Used in Warrants; (4L)

Module3:

Details of Evidence Management & Presentation : (8L)

Determining the devices to be seized; Getting Location Description; Determining necessary tools; ; Processing an Incident or Crime Scene; Storing Digital Evidence; Managing Evidence; Obtaining a Digital Hash; (6L)

Sample Criminal Investigation; (2L)

Module 4:

Digital Forensics Analysis and Validation (12L)

Approaching Digital Forensics Cases; Analyzing and Validating Forensic Data; Addressing Data-Hiding Techniques; Understanding Steganalysis Methods; Recovering Passwords; (5L)

Network Forensics; Live Acquisition; Using Network Logs and Packet Analyzers; (3L)

E-mail and Social Media Investigations; (2L)

Legal Aspects of Digital Forensics: IT Act 2000, amendment of IT Act 2008. (2L)

Suggested Additional Topics:

1. **Mobile Forensics:** mobile forensics techniques, mobile forensics tools.

2. Recent trends in mobile forensic technique and methods to search and seizure of electronic evidence

3. Working with Windows and CLI Systemsfor File System Recovery

4. Understanding Graphic File formats and their recovery.

References:

1. File System Forensic Analysis, by Brian Carrier, Addison-Wesley
2. Handbook of Digital Forensics and Investigation, by Eoghan Casey, Academic Press
3. Guide to Computer Forensics and Investigations 5th Edition, Nelson, Phillips, Steuart, Cengage Learning, 2015
4. The Basics of Digital Forensics, John Sammons, Elsevier
5. Computer Forensics: Computer Crime Scene Investigation, John Vacca, Laxmi Publications
6. Digital Forensic Course Materials from http://mgt2.buffalo.edu/departments/mss/djmurray/mgs610/syllabus.htm

Course Name: Computational Biology					
Course Code: CSEN 5145					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

- Study of Genes, Molecule codes, DNA Structure.
- Understand Graph Algorithms for DNA Sequencing, Shortest Superstring Problem, DNA Sequence Comparison, DNA arrays as an alternative sequencing technique.
- Explore different Sequenced databases like FASTA, BLAST.

Module I:
Genes, Molecule codes, DNA Structure. DNA and Proteins. Analyzing DNA: copying, cutting and pasting, measuring, probing.

Exhaustive Search: Restriction Mapping Algorithms, Motif Finding, Finding Median String.

Module II:
Greedy Algorithms: Genome Rearrangements, Sorting by Reversals. Greedy approach to Motif Finding.

Dynamic Programming Algorithms: DNA Sequence Comparison, Edit Distance and Assignments, Longest Common Subsequence, Global Sequence Alignment, Scoring alignments, Local Sequence Alignment, Alignment with Gap Penalties, Multiple Penalties, Gene Prediction, Spliced Alignment.

Divide and Conquer Algorithms. Sorting, Sequence Alignment, Four-Russians Speedup, Constructing alignments in sub-quadratic time.

Module III:
Graph Algorithms: DNA Sequencing, Shortest Superstring Problem, DNA arrays as an alternative sequencing technique. Sequencing by Hybridization: Hamiltonian and Eulerian Path Problems. Protein sequencing and identification. Peptide sequencing problem. Spectrum Graphs: Spectral Convolution, Spectral Alignment.

Module IV:

Combinatorial Pattern Matching. Repeat Finding, Exact pattern matching, Keyword trees. Suffix trees. Heuritic similarity search, Approximate pattern matching. Sequenced databases and querying: FASTA, BLAST. Clustering and trees. Gene Expression Analysis, Hierarchical Clustering, Evolutionary trees. Distance based tree reconstruction. Reconstructing trees from additive matrices.

Evolutionary treesand hierarchical clustering. Charcter based tree reconstruction. Small and Large Parsimony problem.

References:

1. Neil C. Jones and Pavel A. Pevznel: An Introduction to

Bioinformatics Algorithms, The MIT Press, 2004.

2. Dan Gusfield: Algorithms on Strings, Trees and Sequences.
Cambridge University Press, 1999

Course Name: Disaster Management					
Course Code: CSEN 5116					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**2**

Course Objectives:
Students will be able to:
1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

	Units	**CONTENTS**	**Hours**
Module -I	1	**Introduction on Disaster** Disaster: Definition Types of Disaster • Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc. • Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures (Building and Bridge), War & Terrorism etc. • Differences, Nature and Magnitude • Factors Contributing to Disaster Impact and Severity • Repercussions of various types of Disasters o Economic Damage o Loss of Human and Animal Life o Destruction of Ecosystem o Outbreaks of Disease and Epidemics o War and Conflict Natural Disaster-prone areas in INDIA • Areas prone to o Earthquake o Floods and Droughts, o Landslides and Avalanches;	3

		○ Cyclonic And Coastal Hazards such as Tsunami; Trends of major Disasters and their Impact on India • Lessons Learnt from Recent Disasters	
	2	**Introduction to Disaster Management** What is Disaster Management Different Phases of Disasters Disaster Management Cycles Disaster Management Components • Hazard Analysis • Vulnerability Analysis • Prevention and Mitigation • Preparedness • Prediction and Warning • Response • Recovery Disaster Management Act, 2005 National Disaster Management Structure Organizations involved in Disaster Management	3
Module -II	1	**Overview on Hazard Analysis and Vulnerability Analysis** **Disaster Preparedness** • Disaster Risk Assessment, People's Participation in Risk Assessment • Disaster Risk Reduction • Preparedness Plans • Community preparedness: Emergency Exercises/ Trainings/Mock Drills	3
	2	**Disaster Prediction and Warning** • Activities ○ Tracking of disaster ○ Warning mechanisms ○ Organizational response ○ Public education ○ Communication ○ Evacuation planning • Current tools and models used for Prediction and Early Warnings of Disaster ○ Application of Remote Sensing ○ Data From Meteorological and other agencies ○ Smartphone/ Web based Apps for Disaster Preparedness and Early Warning used in different parts of Globe	3
Module -III	1	**Disaster Response** • Crisis Management: The Four Emotional Stages of Disaster ○ Heroic Phase	3

		○ Honeymoon Phase ○ Disillusionment Phase ○ Reconstruction Phase • Need for Coordinated Disaster Response ○ Search, Rescue, Evacuation, Medical Response and Logistic Management ○ Psychological Response and Management (Trauma, Stress, Rumor and Panic) • Role of Government, International and NGO Bodies	
	2	**Post-disaster Situation Awareness** • Need for Situation Awareness in Post Disaster scenario • Challenges in communication of situational data from affected areas • Need for community-driven disaster management for reliable situation awareness • Crowd-sourcing of situational data: Issues and challenges **Post-disaster Damage and Need Assessment** • Current Trends and Practices – RAPID Damage and Need Assessment • SPHERE standards in Disaster Response • ICT based techniques for Post-disaster damage and need assessment	3
Module -IV	1	**Rehabilitation, Reconstructions and Recovery** • Reconstruction and Rehabilitation as a Means of Development. • Post Disaster effects and Remedial Measures • Creation of Long-term Job Opportunities and • Livelihood Options • Disaster Resistant House Construction • Sanitation and Hygiene • Education and Awareness • Dealing with Victims' Psychology • Long-term Counter Disaster Planning	3
	2	**Disaster Mitigation** • Meaning, Concept and Strategies of Disaster Mitigation • Emerging Trends in Mitigation • Structural Mitigation and Non-Structural Mitigation • Programs of Disaster Mitigation In India	3

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies", New Royal book Company.
2. Sahni, Pardeep et.al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall of India, New Delhi.
3. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi.

Course Name : Advanced Data Structures Lab					
Course Code: CSEN 5151					
Contact hrs per week:	L	T	P	Total	Credits
	0	0	4	4	2

Course Outcomes:

At the end of this lab session, the student will

· Be able to design and analyze the time efficiency of various data structures

· Be capable to identity the appropriate data structure for a given problem

· Have practical knowledge on the applications of data structures

A tentative outline for this laboratory is given below:

- Assignments on the application of array data structure to sort a set of elements using different sorting methods (e.g., bubble sort, insertion sort, selection sort)
- Assignments on the application of array data structure to search an element in a set of elements using different searching methods (e.g., linear search, binary search)
- Implementation of stack and queue using array and linked list data structures
- Assignments on the implementation of binary tree using array and linked list and traversal of the tree
- Implementation of hashing where collision resolution is done using open addressing method
- Implementation of KMP algorithm for pattern matching
- Application of one/ two data structures in real life applications

Course Name : - Machine Learning Lab					
Course Code: CSEN5181					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	**0**	**4**	**4**	**2**

COURSE OUTCOMES:

- An understanding of fundamental concepts and methods of machine learning and its applications.
- An ability to analyze and evaluate simple algorithms for pattern classification.
- An ability to design simple algorithms for pattern classification, code them with Python programming language and test them with benchmark data sets.

List of Experiments:

1. Regression (single and Multiple Variables) linear and non-liner;
2. Logistic regression
3. Classifiers
    1. K-NN
    2. Naïve Bayes Classifier
    3. Perceptron
    4. Multi Layer Perceptron

4. Clustering Algorithms
    1. K-Means
    2. DB-Scan

5. Familiarization with a few ML Tools
    1. Excel
    2. WEKA
    3. R
    4. Python
    5. TensorFlow

6. Applications of ANN and SVM using ML tools

Course Name : - Advanced Wireless and Mobile Networks Lab					
Course Code: CSEN5182					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	**0**	**4**	**4**	**2**

COURSE OBJECTIVES:

- The students should get familiar with the various network simulators like ns2 and QualNet.
- To learn to model and simulate various network topologies
- To learn how to evaluate MAC and network protocols using network simulation software tools.
- To learn the methodology to develop new MAC and network protocols and simulate them in the network simulators.

Syllabus:

- Network Simulator (NS)
    - Installation of Network Simulator ns 2
    - Familiarization with ns 2
    - Learn programming in OTCL
    - Setup wired and wireless networks using existing protocols in OTCL
    - Observe the variation in the network performance of wireless ad hoc networks for various routing protocols
    - Observe the variation in the network performance of vehicular ad hoc networks for various routing protocols
- Real time network simulator Qualnet
    - Familiarization with the real time network simulator Qualnet.
    - Learn to setup wired and wireless networks, add applications, run scenarios, obtain results and analyze them.
    - Observe the variation in the network performance of wireless ad hoc networks for various routing protocols
    - Observe the variation in the network performance of vehicular ad hoc networks for various routing protocols

Course Name : - Introduction to Intelligent Systems Lab					
Course Code: CSEN5183					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	**0**	**4**	**4**	**2**

Course Outcomes/Learning Objectives:
At the end of this course, students are expected to get a good flavor of logical programming by using PROLOG/ LISP. Students should be able to apply those knowledge to solve some intelligent puzzles.

In this laboratory students will be familiarized with PROLOG/ LISP language. A tentative outline for this laboratory is given below:

 Introduction to PROLOG facts & rules with the help of a simple family tree; how the goals are given in PROLOG; some simple queries on the family tree

 Formation of recursive definition; how PROLOG executes the goals; simple assignments

 How PROLOG deals with problems with numbers – integers, real; with some examples

 Introduction to LIST structure; how PROLOG implements LIST; some simple assignments on LIST.

 Some more complex assignments on LIST; Introduction of Accumulators – simple assignments

 Introduction to CUT with simple assignments; implementation of Sorting algorithms

 PROLOG clauses for file operation – with simple assignments

 Implementation of Graph Search algorithms like DFS, BFS; Some application of DFS & BFS

 Implementation of some well known puzzles, like 8-queens problem, Towers-of-Hanoi problem, Missionaries & Cannibals problem etc..

 Introduction to LISP

 Some simple assignments on LISP.

References:

PROLOG Programming for Artificial Intelligence, Ivan Bratko, Pearson India.

Course Name : - GPU Computing Lab					
Course Code: CSEN5184					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	**0**	**4**	**4**	**2**

COURSE OBJECTIVES:

By attending the course, students would:

1. learn concepts in parallel programming,
2. gain the knowledge of implementation of programs on GPUs,
3. have skills for debugging and profiling parallel programs on CUDA.

Experiments will be conducted under Linux on any (say ARCUS) GPU cluster. The practicals all use these header files (helper_cuda.h, helper_string.h) which come from the CUDA SDK. They provide routines for error-checking and initialisation.

Lab 1: Application: a trivial "hello world" example
CUDA aspects: launching a kernel, copying data to/from the graphics card, error checking and printing from kernel code

Lab 2: Application: Monte Carlo simulation using NVIDIA's CURAND library for random number generation
CUDA aspects: constant memory, random number generation, kernel timing, minimising device memory bandwidth requirements

Lab 3: Application: reduction
CUDA aspects: dynamic shared memory, thread synchronization;

Lab 4: Matrix-matrix operation (CUDA)

Lab 5: Application: using the CUBLAS and CUFFT libraries

Lab 6: Matrix-matrix operation via cuBLAS (CUDA)

Lab 7: Application: tri-diagonal equations

Lab 8: pattern matching

Lab 9 and Lab 10: streams and OpenMP multithreading:

References:

1. Programming Massively Parallel Processors: A Hands-on Approach; David Kirk, Wen-mei Hwu; Morgan Kaufman.

2. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs; Shane Cook; Morgan Kaufman

3. GPU Computing and Applications: Yiyu Cai, Simon See; Springer.

4. Web Limk: https://people.maths.ox.ac.uk/gilesm/cuda/

Course Name : - Image Processing Lab					
Course Code: CSEN5185					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	**0**	**4**	**4**	**2**

Course Outcomes:

1. Students will learn to convert one image form to another image form.
2. Able to learn various kinds of image enhancement and image restoration techniques.
3. They will learn various techniques of image compression, image segmentation etc.

List of Experiments:

1. Display of Grayscale Images.

2. Histogram Equalization.

3. Non-linear Filtering.

4. Edge detection using Operators.

5. 2-D DFT and DCT.

6. Filtering in frequency domain.

7. Filtering in spatial domain.

8. Display of color images.

9. DWT of images.

10. Segmentation using watershed transform.

11. Image Compression.

12. Applications of image zooming and image shrinking etc.