Department of Computer Science and Engineering
National Institnte of Technology Calicut
NIT Campus (PO), Calicut-673601, Iudia

DCC Meeting Minutes

Datc: 15-06-2023 **Time: 02:30 PM to 03:30 PM** **Venue: CSED Seminar Hall**

Agenda Items:

1. **Ratification of the minntes of the DCC meeting heid on 05/06/2023**
2. **Action Taken Action Pending Report**
3. **Correction in MTech Senate approved Curriculum**
4. **Syllabi of MTech CS, MTech CS(IS), and MTeeh CS(AI-DA) programmes**
5. **Ratification of the eomments (seut to Dean (Acad)) on Academic Calendar AY 2023-24**
6. **Reconstitution of the sclection committee for M Tech (Self financing/ Self-sponsored) seats**

The DCC meeting started at CSED Seminar Hall at 2:30 PM. The Chairperson welcomed all members to the meeting.

Agenda ltem 1: Ratification of the mlnutes of the DCC meeting held on 05/06/2023

The DCC ratified the confirmation of the minutes of the DCC meeting held on 05/06/2023.

Ageuda ltem 2: Action Taken Action Pending Rcport

Action Taken: First year syllabus of B Tech CS was communicated to the Dean (Academic) Office.
Action pending : NIL

Agenda ltem 3: Correction in MTech approved curricuium

In the curriculum of MTech CSE, L T P O C component of the course titled "Theoretical foundations of maohine learning" is given as 3 0 2 7 4, whereas in the MTech CSE(IS) and MTech CSE(AI-DA), the same has credit distribution 3 1 0 8 4, resulting in a discrepancy. DCC recommended a uniform L T P O C of 3 1 0 8 4 for the course and directed the HOD to report the same to Dean Academic for incorporation of the necessary correction.

19/06/23

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Agenda Item 4: Syllabi of MTech CSE, MTech CSE(IS), and MTech CSE(AI-DA)

MTech Programme Coordinators presented the detailed syllabi (Annexure I) for the senate approved curricula of MTech CSE, MTech CSE(IS) and MTech CSE(AI-DA) programs. After a thorough discussion, DCC approved the syllabi.

DCC proposes that the course Research Methodology be offered by one of the departments among CSED, ECED & EED per year, in a cyclic manner, as it is a common syllabus for the circuit branches.

Agenda Item 5: Ratification of the comments (sent to Dean (Acad)) on Academic Calendar AY 2023-24

Based on the communication from Dean(Academic), a mail thread was initiated to discuss the options(Annexure II) for academic calendars for the academic year 2023-24. The comments received in the mail thread were consolidated (Annexure III) and were sent to the Dean(Academic) on 12-06-2023. DCC ratified the comments sent from the department.

Agenda Item 6: Reconstitntion of the selection committee for M Tech (Seif financing/ Sclf-sponsorcd) seats

The M Tech Coordinator proposed the following additional points / revisions related to the Admission to the M.Tech programme in CSE-AIDA (Self Financing) and the self-sponsored seats of the existing M.Tech programmes on CSE and CSE (Information Security).

(i) As per the instruction from the PG Admission Office, it has been decided to conduct the same test/interview for selection of candidates for admission to the M.Tech programme in CSE (AI and DA) (Self Financing) and the self-sponsored seats of the existing M.Tech programmes on CSE and CSE (Information Security).

(ii) A common rank list will be prepared with the priorities of the candidates shown in the list.

(iii) By considering the above points, the various committees have been constituted/ revised as follows:

Committees for the Selection process of candidates for Admission to the MTech CSE (AI and DA) Programme (Self Financing) and the self-sponsored seats of M.Tech (CSE) and M.Tech (CSE-IS)

1. Written Test (Online MCQ) [Date: 4th July 2023]

Dr. Muralikrishnan K, Dr. Lijiya A, Dr. Hiran V Nath, Dr. Anand Babu N B, Dr. Amit Praseed

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2. Interview (Online) [Date: 6th Jnly 2023]

As the selection is for all the three M.Tech programmes, all the faculty members of the department are included for the selection process.

Three committees will be formed and the interviews will be conducted in parallel.

3. General Arrangements Committee (Screening of applications, Sending Call Letters, Preparation of Results)

Dr. Gopakumar G, Dr. Anu Mary Chacko, Dr. Joe Cheri Ross, Dr. Nirmal Kumar Boran, Dr. A Sudarshan Chakravarthy [Assistance: CSED Office]

4. Technical Committee (Eduserver, Network and related services for the ONLINE Test and Interview)

Dr. Saidalavi Kalady, Dr. Pournami P N, Dr. Hiran V Nath, Dr. Jayaraj P B (Assistance: Ad Hoc Technical Staff)

The meeting ended at 03:30 PM on 15-06-2023.

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ANNEXURE - I

CS6161E MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE

Pre-requisites: NIL

L	T	P	O	C
3	0	2	7	4

Total hours: (39 Lecture Sessions + 26 Practical Sessions)

Course Outcomes:

CO1: Analyze and solve practical computing problems involving foundations of basic number theoretic and algebraic concepts and applying programming libraries for problem solving.

CO2: Analyze and solve computing problems using fundamental principles of linear spaces and analyze algorithms that use these concepts, and apply programming libraries for problem solving.

CO3: Derive algorithmic solutions for algebraic computing problems.

Module 1: (9 Lecture Sessions + 6 Practical Sessions)

Divisibility, gcd, prime numbers, fundamental theorem of arithmetic, Congruences, Fermat's theorem, Euler function, primality testing, solution of congruences, Chinese remainder theorem, Wilson's theorem, programming exercises with number theory libraries.

Module 2: (10 Lecture Sessions + 7 Practical Sessions)

Groups and subgroups, homomorphism theorems, cosets and normal subgroups, Lagrange's theorem, rings, finite fields, polynomial arithmetic, quadratic residues, reciprocity, discrete logarithms, programming exercises with number theory libraries.

Module 3: (10 Lecture Sessions + 6 Practical Sessions)

Vector spaces, basis, dimension, linear maps, rank nullity theorem, duality theorem, Eigenvalues and Eigenvectors, solution to systems of equations, solving of linear systems and Eigenvalue computation with mathematics libraries.

Module 4: (10 Lecture Sessions + 7 Practical Sessions)

Inner product spaces, orthogonality, orthogonal projections, Hermitian and unitary operators, spectral theorem for Hermitian and unitary operators, singular value decomposition (SVD), Cholesky decomposition, use of mathematical libraries for SVD and Cholesky decomposition.

References:

1. K. Ireland and R. A. Rosen, *A Classical Introduction to Modern Number Theory*, 2nd ed. Springer, 1998.
2. Niven, H.S. Zuckerman, and Montgomery, *An Introduction to the Theory of Numbers*, 3rd ed. John Wiley and Sons, New York, 1992.
3. S. Axler, *Linear Algebra Done Right*, 2nd ed. Springer, 1997.
4. V. Shoup, *A Computational Introduction to Number Theory and Algebra*, 2nd ed, US: Cambridge University Press, 2008.
5. N. Nassif, J. Erhel and B. Philippe, *Introduction to Computational Linear Algebra*, 1st ed. India: Chapman Hall / C. R. C. Press, 2015.

CS6102E ALGORITHMS AND COMPLEXITY

Pre-requisites: NIL

L	T	P	O	C
3	0	2	7	4

Total hours: (39 Lecture Sessions + 26 Practical Sessicns)

Course Outcomes:

CO1: Analyze the worst case and average case time/space complexity of an algorithm using techniques such as recurrence analysis, amortized analysis and probabilistic analysis.

CO2: Design algorithms for a given probiem using design methodologies such as divide and conquer, dynamic programming, greedy etc., and preve their correctness.

CO3: Classify problems based on their hardness, by appiying the notion of reductions.

Module 1: (9 Lecture Sessions + 16 Practical Sessions)

Anaiysis: RAM model – Notatiens, Recurrence analysis - Master's theorem and its proof - Amortized analysis - Advanced Data Structures: B-Trees, Binomial Heaps, Fibonacci Heaps, Disjoint Sets, Union by Rank and Path Compression.

Module 2: (9 Lecture Sessions + 6 Practical Sessions)

Graph Algorithms and Complexity: Matreid Theory, All-Pairs Shortest Paths, Maximum Fiow and Bipartite Matching.

Module 3: (9 Lecture Sessions + 4 Practical Sessions)

Randemized Algorithms: Fingerprinting, Pattern Matching, Graph Preblems, Algebraic Methods, Probabilistic Primality Testing, De-Randomization.

Module 4: (12 Lecture Sessions)

Complexity classes - NP-Hard and NP-complete Problems - Cook's theorem NP completeness reductions. Approximation algorithms – Pclynemial Time and Fuliy Polynomial time Approximation Schemes. Prebabilistic Complexity Classes, Probabilistic Proof Theory and Certificates.

References:

1. D. C. Kozen, *The Design and Analysis of Algorithms*, 1st ed., US: Springer, 1992.
2. T. H. Cormen, C. E. Leiserson, and R. L. Rivest, *Introduction to Algorithms*, 3rd ed., India: PHI, 2010.
3. R. Metwani and P. Raghavan, *Randomized Algorithms*, 1st ed., US: Cambridge University Press, 1995.
4. C. H. Papadimitriou, *Computational Complaxity*, 1st ed., US: Addison Wesley, 1994.

CS6103E SOFTWARE SYSTEMS LABORATORY

Pre-requisites: NIL

L	T	P	O	C
1	0	6	5	4

Total hours: (13 Lecture Sessions + 78 Practical Sessions)

Course Outcomes:

CO1: Apply scripting tools and programming languages for software development.

CO2: Use documentation tools for preparing documents, articles and presentations.

)3: Design and build web based solutions using software engineering concepts.

Theory (13 Lecture Sessions)

General purpose programming tools (e.g. Java, C++, use of GUI tools), Web programming tools (e.g. HTML, Java with applets/servlets/JSP/J2EE, CGI, Perl), Development Frameworks (Ruby on Rails, Django).

Tools for good software development process. Make/gmake, source code control systems (e.g. git), debuggers (e.g. gdb) and memory allocation debuggers, Introduction to Integrated Development Environments (e.g. eclipse).

Scripting languages (e,g. Python, Perl). Tools for text processing (e.g. AWK, Python, Lex, Yacc).

Exposure to document creation tools (e.g. Latex), plotting tools (e.g. gnuplot, Excel, pstricks).

The names in parenthesis serve as examples and not strict requirements as the contents may be adapted to software practices and trends at the time of offering the course.

Laboratory (78 Practical Sessions)

.ogramming and Data Structures - Review (12 Hours)
Web Development - Using web programming tools. Using framework. (24 Hours)
Software development tools in the Linux Environment (12 Hours)
Scripting languages - Text Processing (18 Hours)
Documentation and Plotting (12 Hours)

References

1. L. Wall, T. Christiansen and R. L. Schwartz, *Programming Perl*, 3rd ed. O'Reilly Media,2000.
2. S. Guelich, S. Gundavaram and G. Birznieks, *CGI Programming with Perl*, O'Reilly Media, 3rd ed. June 2000.
3. M. Summerfield, *Programming in Python 3*, 2nd, Addison Wesley Professional, November 2009.
4. M. Summerfield, *Rapid GUI Programming with Python and Qt*, 1st ed. Prentice Hall, 2009.
5. M. Hart. *Ruby on Rails Tutorial*, Available online at https://www.railstutorial.org/book last accessed 12/4/2018.
6. Wikibook Contributors LaTeX, Wikibooks, available at https://upload.wikimedia.org/wikipedia/commons/2/2d/LaTeX.pdf last accessed 12/4/2018
7. J. Levine, flex & and bison, *O'Reilly Media*, 1st ed., 2009.
8. B. Eckel, *Thinking in Java*, 3rd, Prentice Hall, 2002, Available online at www.bruceeckel.com last accessed 28/3/2010.
9. B. Eckel, *Thinking in C++*, 2nd ed. Vol.1 and Vol.2, Prentice Hall. 2003, Available online at www.bruceeckel.com last accessed 28/3/2010.

CS6201E FOUNDATIONS OF INFORMATION SECURITY

Pre-requisites: NIL

L	T	P	O	C
3	0	2	7	4

Total hours: (39 Lecture Sessions + 26 Practical Sessions)

Course Outcomes:

CO1: Analyze different cryptographic techniques.

CO2: Examine authentication protocols and adapt them as required.

CO3: Experiment with network security tools and interpret the results.

Module 1: (16 Lecture Sessions + 12 Practical Sessions)

Introductery Topics: Overview of number theory concepts for cryptography. Historical Ciphers - Monoalphabetic and polyalphabetic oiphers. Cryptegraphy Topics: Secret vs. Public, Secret Key - DES, Public Key - Knapsack and RSA, Cryptographic hash - SHA1, Discrete Log - Diffie Hellman.

Module 2: (13 Lecture Sessions)

Key Management Topics: Digital certificates and PKI.
Authentication topics: One way and two way authenticatien, Centralized Authentication, NeedhamSchroeder protocel.

Module 3: (10 Lecture Sessions + 14 Practical Sessions)

Network security topics: IPSec, TLS, HTTPS, DNSSEC. Overview of netwerk security toels.

Roferences:

1. B. Menezes, *Network Security and Cryptography*, 1st ed., Cengage Learning India, 2010.
2. H. Delfs and H. Knebl, *Introduction to Cryptography: Principles and Applications*, 2nd ed.Springer - Veriag, 2006.
3. M. E. Whitman and H. J. Mattord, *Principles and Practices of Information Security,* 1st ed. Cengage Learning, 2010.

CS6301E INTRODUCTION TO DATA ANALYTICS

Pre-requisites: NIL

L	T	P	O	C
3	0	2	7	4

Total hours: (39 Lecture Sessions + 26 Practical Sessions)

Course Outcomes:

CO1: Apply data analytic technique to real world problems

CO2: Organize outcomes of data analytics techniques efficiently.

CO3: Evaluate and apply ethical considerations in data analytics

Module 1: (10 Lecture Sessions + 6 Practical Sessions)

Introduction to Data Analytics- Overview of Data analytics and its importance, Introduction to Data Analytics Life Cycle, Data collection methods and sources, Data preprocessing techniques (data cleaning, integration, transformation), Handling missing data and outliers, Data sampling techniques, Review of Basic Concepts in Statistics, Probability and Linear Algebra.

Module 2: (10 Lecture Sessions + 7 Practical Sessions)

Introduction to different types of data analytics: Descriptive Analytics - Measures of central tendency and dispersion, Probability distributions, Exploratory data analysis, Correlation and covariance, Inferential analytics - Probability Distributions Hypothesis Testing, Confidence Intervals, Predictive -Regression Analysis, Time Series Analysis, Classification Techniques. Classification and regression models, Model evaluation and selection, Feature selection and dimensionality reduction, Basics of Clustering and Association Rule Mining, Practice and analysis with R

Module 3: (10 Lecture Sessions + 7 Practical Sessions)

Data Visualization - Graphical representation of data, Visualization tools and libraries (e.g., Tableau, ggplot2), Dashboard design and interactive visualization. Decision-making frameworks and models - Optimization techniques, Risk analysis and decision trees

Modulo 4: (9 Lecture Sessions + 6 Practical Sessions)

Case Study and real world applications of data analytics, Ethical consideration and data privacy - Privacy and data protection, Bias and fairness in data analytics, Ethical challenges and guidelines, Responsible data analytics practices, Emerging Trends in data analytics

References:

1. T. Hastie, R. Tibshirani, and J. Friedman, *The elements of statistical learning*, 2nd ed, Springer, 2009.
2. G James, D. Witten, T Hastie, and R. Tibshirani, *An Introduction to Statistical Learning: with Applications in R*, 1st ed. Springer, 2013
3. Mohammed J. Zaki and Wagner Meira, *Data Mining and Analysis*, 1st ed. Cambridge, 2012
4. Mark Gardener, *Beginning R: The Statistical Programming Language*, 1st ed. Wiley 2013
5. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, *Probability & Statistics for Engineers & Scientists* , 9th ed. Prentice Hall Inc.
6: Edward R. Tufte, *The Visual Display of Quantitative Information*, Graphics Pr; 2nd edition (20 April 2001); Graphics Press INC,

CS6302E THEORETICAL FGUNDATIONS OF MACHINE LEARNING

Pre-requisites: NIL

L	T	P	O	C
3	1	0	8	4

Total Lecture Sessions: 30

Course Outcomes:

CO1: Formulate machine learning problems mathematically, choose appropriate models, and identify suitable learning paradigms.

CO2: Analyze the applicability of stochastic gradient descent algorithm to varieus convex learning problems.

CO3: Estimate the sample complexity of commonly used hypothesis classes.

Module 1: PAC Learning (14 Lecture Sessions)

Agnostic probably approximately correct (PAC) learning model, less functions, true and empirical risk, uniform convergence, no-free-lunch theorem, growth functions and VC dimension, VC dimension of various classes such as hyperplanes and polynomials, the fundamental theorem of PAC learning, non-uniform PAC learning, principles underlying model selectien, validation and k-fold cross validation.

Module 2: Convex Learning (14 Lecture Sessions)

PAC learnability ef hyperplanes, linear programming and perceptron algorithms, convex loss functions, mean squared loss, hinge loss and logistic regression functions, surrogate loss functions, regularized loss functions and stability, ieamability of Convex Lipschitz bounded and smooth bounded learning problems using the stochastic gradient descent (SGD) aigorithm, sample complexity of convex learning problems.

Module 3: Applications of SGD (11 Lecture Sessions)

Support vector machines (SVM): dual formulation, SGD implementation of soft-SVM, implementation of soft SVM with kernels, linear multiclass predictors, multiclass SVM with SGD, linear predictors for bipartite ranking,

Feed-forward neural networks, expressive power and sample complexity, SGD and backpropagation.

References:

1. S. S. Schwartz and S. Ben David, *Understanding Machine Learning: From Theory To Algorithms*, 3rd ed., India: Cambridge University Press, 2015.
2. M. Mohri, A. Rostamizadeh and A. Talwalkar, Foundations ef Machine Learning, 3rd ed, India: MIT Press, 2018.
3. C. M Bishop, *Pattern Recognition and Machine Learning*, 1st ed Springer, 2006.

CS6303E TOPICS IN ARTIFICIAL INTELLIGENCE

Pre-requisites: NIL

L	T	P	O	C
3	0	2	7	4

Total hours: (39 Lecture Sessions + 26 Practical Sessions)

Course Outcomes:

CO1: Explain and illustrate various strategies and algorithms for state space search for problem solving.

CO2: Critically analyze various methods for knowledge representation and apply them for problem solving.

CO3: Implement algorithms and techniques for problem solving using the principles of Artificial Intelligence.

Module 1: (10 Lecture Sessions + 4 Practical Sessions)

Artificial Intelligence: Introduction,History and Applications; Intelligent Agents;Solving problems by Searching: Structures and Strategies for state space search- Data driven and goal driven search,Uninformed Search strategies, Informed(Heuristic) Searoh Strategies, Heuristic Functions, Locai Search Algorithms and Optimization Problems, Searching with Nondeterministic actions, Constraint satisfaction, Using heuristics in games- Minimax Search, Alpha Beta Procedure,Stochastic Games.

Module 2: (10 Locture Sessions + 6 Practical Sessions)

Knowledge representation - Knowledge based agents,Propositional calculus, First-Order Logic(Predicate Caiculus),Inference in First-Order Logic, Forward and Backward chaining, Theorem proving by Resolution, Answer Extraction, Ai Representational Schemes,, Planning,Planning and acting in the real world,Decision Making.

Module 3: (11 Lecture Sessions + 6 Practical Sessions)

Learning - Learning From Examples, Knowledge in Learning, Learning Probabilistic Models, Reinforcement Learning,Artificial Neural Networks and Deep Learning, The Genetic AlgorithmGenetic Programming, Overview of Expert System Technolegy, Introduction to Natural Language Processing.

Module 4: (8 Leoture Sessions + 8 Practical Sessions)

Languages and Programming Techniques for Ai- Introduction to PROLOG and LISP, Search strategies and Logic Programming in LISP, Production System examples in PROLOG,Introduction to ROBOTICS.

References

1. S. Russeli and P. Norvig, *Artificial Intelligence- A Modern Approach*, 2nd ed., Pearson Education, 2002.
2. G. F. Luger, *Artificial Intelligence - Structures and Strategies for Complex Problem Solving*, 4th ed. Pearson Education, 2002,.
3. E. Rich and K. Knight, *Artificial Intelligence*, 2nd ed, Tata McGraw Hill.
4. N. J Nilsson, *Artificial Intelligence a New Synthesis*, 1st ed, Elsevier,1998.
5. P. Winston and B. Horn, *LISP*, 3rd ed, Addison Wesley, 1989.
6. I. Bratko, *Prolog Programming for Artificial Intelligence*, 3rd ed, Addison Wesloy, 2000.

CS6304E MACHINE LEARNING

Pre-requisites: NIL

L	T	P	O	C
3	1	0	8	4

Total Lecture Sessions: 39

Coursc Outcomes:

CO1: Illustrate the fundamental concepts of Statistical Learning Theory required for applying Machine Learning Techniques.

CO2: Apply different estimation techniques and graphical models.

CO3: illustrate the concepts of optimal marginal hyperplanes and SVM and to build classifiers using SVM.

Module 1: (10 Lecture Sessions)

Review of Statistical Learning Theory: Learning and Generalization, PAC learning framework, Empirical Risk Minimization, Consistency of Empirical Risk Minimization. Complexity of learning problems - VC Dimension, No Free Lunch Theorem; Model selection and model estimation; Bias-variance trade-off, Regularization - Assessing Learned classifiers - Cross Validation.

Module 2: (9 Lecture Sessions)

Estimation Techniques: Mixture Densities, EM Algorithm, Approximate Inference, Variational Inference, Variational Mixture of Gaussians, Variational Linear Regression, Sampling Methods, Markov Chain Monte Carlo Sampling, Gibbs Sampling.

Module 3: (10 Lecture Sessions)

Probabilistic Graphical Models: Directed Graphical Models: Bayesian Networks, Conditional Independence, D-separation – Markov and Hidden Markov Models – Applications of Directed Graphical Models.

Undirected Graphical Models: Markov Random Fields, Conditional independence properties, Factorization Properties, Hammersiey Clifford Theorem, Inference and Learning, Application to Image de-noising, Ising Model, Gaussian MRF, Conditional Random Fields : Inference and Learning, Structural SVM.

Module 4: (10 Lecture Sessions)

Kernel Functions: Positive definite kernels, reproducing kernel Hilbert space, Representer Theorem, Mercer Theorem. Support Vector Machines: Optimal margin hyperplanes, SVM Formulation with Slack Variables, Nonlinear SVM Classifiers, Support Vector Regression, Overview Of SMO and other Algorithms.

Roferences

1. K. P. Murphy, *Machine learning: a Probabilistic Perspective*, 1st ed. MIT press, 2012.
2. C. M. Bishop, *Pattern Recognition and Machine Learning*. 1st ed. Springer, 2006.
3. R. O. Duda, P. E. Hart, and D. G. Stork, *Pattern Classification*, 1st ed. John Wiley & Sons, 2012.

CS6393E ADVANCED MACHINE LEARNING LABGRATGRY

Pre-requisites: NIL

L	T	P	O	C
1	0	6	5	4

Total hours: (13 Lecture Sessions + 78 Practical Sesslons)

Course Outcomes:

( )1: To irnplement basic dimensionality reduction technique like PCA and optimization technique like gradient descent

CO2: To appiy different probability density estimation techniques and Bayes ciassifier

CO3: To apply various data preprocessing techniques on large datasets

CO4: To design and develop efficient machine learning models using supervised and unsupervised learning techniques

Module 1: (4 Lecture Sessions + 19 Practical Sessions)

Principal Component Analysis, Gradient Descent Technique, Linear Least Square Technique

Module 2: (3 Lecture Sesslons + 19 Practical Sessions)

Maximum Likelihood Estimation (MLE), Maximum A Posteriori (MAP) estirnation, Parzen Window Density Estimation, Bayesian classifier.

Module 3: (3 Lecture Sessions + 20 Practlcal Sessions)

Data Preprocessing, Feature Extraction. Regression Techniques - Linear Regression.

Module 4: (3 Lecture Sessions + 20 Practical Sessions)

Ciassification Techniques - Logistic Regression, Decision Tree, ANN, KNN, SVM, Random Forest. Clustering Techniques - K-means, Density based.

References

1. S. Raschka and V. Mirjalil, *Python Machine Learning*, 1 st ed, Packt Publishing, 2019,
2. C. M. Bishop, *Pattern Recognition and Machine Learning*, 1st ed, Springer, 2006,
3. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern Classification*, 2nd ed, Wiley, 2000

CS6196E / CS6296E / CS6396E PROJECT PHASE I

Pre-requisites: NIL

L	T	P	O	C
0	0	4	2	2

Total Hours: 78

Course Outcomes:

CO1: Survey the literature on a domain of new research areas and compile findings on a particular topic

CO2: Organize and illustrate technical documentation with scientific rigor and adequate literal standards on the chosen topic strictly abiding by professional ethics while reporting results and stating claims

CO3: Develop and demonstrate aptitude for research and independent learning.

CO4: Demonstrate communication skills in conveying the technical documentation via oral presentations using modern presentation tools.

The objective of this phase of the project is to impart training to the students in collecting materials on a specific area of research interest *(topic)* in the broad domain of Engineering/Science from books, journals and other sources, compressing and organizing them in a logical sequence, and presenting the matter effectively both orally and in written format. The topic chosen by the student shall be approved by the project guide(s) and the evaluation committee. Based on the collected information and acquired knowledge, the student is expected to identify unresolved problems in the domain of the selected topic.

References

1. Relevant literature for the computing problem.

CS6197E / CS6297E / CS6397E PRGJECT PHASE II

Pre-requisites: CS6196E / CS6296E / CS6396E PROJECT PHASE i

L	T	P	O	C
0	0	6	3	3

Total Hours: 117

Course Outcomes:

CO1: Organize the outcome of the survey of literature as review manuscript on the selected topic of interest

CO2: Organize and illustrate technical documentation with scientific rigor and adequate literal standards on the chosen topic strictly abiding by professional ethics while reporting results and stating claims

CO3: Develop and demonstrate aptitude for research and independent learning.

CO4: Demonstrate communication skills in conveying the technical documentation via oral presentations using modern presentation tools.

The objective of this phase of the project is to impart training to the students in preparing a review manuscript based on the collected materials on the specific topic identified in the broad domain of Engineering/Science from books, journals and other sources, compressing and organizing them in a logical sequence, and presenting the matter effectively both orally and in written format. The manuscript should not be a replica of what is available in the existing literature. The manuscript prepared by the student shall be approved by the project guide(s) and the evaluation committee.

References

1. Relevant literature for the computing problem.

CS6196E / CS6298E / CS6398E PROJECT PHASE III

Pre-requisites: CS6197E / CS6297E / CS6397E PROJECT PHASE II

L	T	P	O	C
0	0	30	15	15

Total Hours: 585

Course Outcomes:

CO1: Propose solutions to the computational problem based on a focused literature survey on the topic identified

CO2: Organize and illustrate technical documentation with scientific rigor and adequate literal standards on the chosen topic strictly abiding by professional ethics while reporting results and stating claims

CO3: Develop and demonstrate aptitude for research and independent learning.

CO4: Demonstrate communication skills in conveying the technical documentation via oral presentations using modern presentation tools.

The objective of this phase of the project is to impart training to the students in proposing scientific solutions on a specific topic problem identified in the broad domain of Engineering/Science from books, journals and other sources, compressing and organizing them in a logical sequence, and presenting the matter effectively both orally and in written format. The proposed solution should not be a replica of what is contained in the syllabi of various courses of the M. Tech program. The solution proposed by the student shall be approved by the project guide(s) and the evaluation committee.

References

1. Relevant literature for the computing problem.

CS7199E / CS7299E / CS7399E PROJECT PHASE IV

Prerequisites: CS6198E / CS6298E / CS6398E / PROJECT PHASE III

L	T	P	O	C
0	0	30	15	15

Total Hours: 585

Course Outcomes:

CO1: Reflectively analyze proposed solutions to the identified computing problem.

CO2: Design and develop solutions to the problem and analyze results.

CO3: Prepare a thesis report and defend the thesis on the work done.

CO4: Augment the knowledge base in the chosen area of computing, adhering to ethical practices at every stage.

The student is expected to demonstrate the core competency aimed by this course, i.e., the development of enhancements to the knowledge base in the area of interest in computing. The secondary competencies include the management of time bound projects involving research, analysis of problem complexities, design and development of effective solutions and communication of the project's progress, adhering to ethical practices at every stage. This stage of the project evaluates the state of maturity of these competencies. The student is expected to present two reports at intermediate stages, as well as prepare and defend a thesis on his research work.

References

1. Relevant literature for the computing problem.

Research Methodology
[For M. Tech. (Circuit hranches)]

Pre-requisites: NIL

L	T	P	O	C
2	0	0	4	2

Total Lecture sessions: 26

Course Outcomes

CO1: Develop critical thinking skills and enhanced writing skills

CO2: Apply qualitative and quantitative methods for data analysis and presentation

CO3: Implement healthy research practice, research ethics, and responsible scientific conduct

Module 1: Exploring Research Inquisitiveness (7 lecture sessions)

Philosophy of Scientific Research, Role of Research Guide, Planning the Research Project, Research Process, Research Problem Identification and Formulation, Variables, Framework development, Research Design, Types of Research, Sampling, Measurement, Validity and Reliability, Survey, Designing Experiments, Research Proposal, Research Communication, Research Publication, Structuring a research paper, structuring thesis/ dissertation, Research Ethics, Social Responsibility and Research

Module 2: Research Plan and Path (12 lecture sessions)

Developing a Research Plan: Reviewing the literature- Referencing – Information sources – Information retrieval – Role of libraries in information retrieval – Tools for identifying literatures – Reading and understanding a research article – Critical thinking and logical reasoning; Framing the research problem, hypotheses, Converting research Question into a Model; Data collection- Types of data-Dataset creation- Primary and Secondary data-Scales of measurement- Sources and collection of data- Observation method- Interview method– Survey-Experiments- Processing and analysis of data-Understanding Data-statistical analysis, displaying of data-Data visualization-Data interpretation; Research design- Qualitative and Quantitative Research- Designing of experiments- Validation of experiments- Inferential statistics and result interpretation - Result publication - Publication process in peer reviewed journals

Module 3: Scientific Conduct and Ethical Practice (7 lecture sessions)

Department specific research discussions– Organizing literature– Documenting your work and results – Plagiarism– Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work-Conduct in the workplace and interaction with peers – Intellectual property: IPR and patent registration, copyrights; Current trends – Usage and ethics of AI tools in scientific research.

References:

1. Leedy, P D, *"Practical Research: Planning and Design"*, USA: Pearson, Twelfth ed., 2018
2. Krishnaswamy, K. N., Sivakumar, A. I., and Mathirajan, M., *"Management Research Methodology"*, Pearson Education, 2006.
3. Tony Greenfield and Sue Greener., Research Methods for Postgraduates, USA: John Wiley & Sons Ltd., Third ed., 2016.
4. John W. Creswell and J. David Creswell, *"Research Design: Qualitative, Quantitative, and Mixed Methods Approaches"*, USA: Sage Publications, Sixth ed., 2022

CS6104E ADVANCED OPERATING SYSTEM DESIGN

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Synthesize the design components of a modern operating System

CO2: Analyze and Implement the conceptual architecture of the OS

CO3: Apply the fundamental and extended OS concepts into designing special purpose operating systems

Moduie 1: Process management (10 iecturc sessions)

Contemporary operating-system structure: process API, Direct execution, CPU scheduling, multi-level feedback scheduling, lottery scheduling, multi CPU scheduling

Module 2: Memory management (10 lecture sessions)

Memory API, segmentation, free space management, paging, TLB, advanced page tables, swapping: mechanism and policies, VM systems

Module 3: Concurrency and Persistence (10 lecture sessions)

Thread API, locks and associated data structures, semaphore, concurrency, event-based concurrency,
Files: directories, and RAID, flie system - fast flle system (FFS), log structured flle system, journaling, Network file system, Andrew file system

Moduie 4: Special purpose OS (0 lecture sessions)

Security in operating system, distributed systems, network operating system, mobile operating system - Android kernel, boot process, file system, Dalvik and Zygote, piatform security

References:

1. Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau, "*Operating Systems: Three Easy Pieces*", 1st ed USA: Arpaci-Dusseau Books, 2018
2. Charles Crowley, "*Operating Systems: A Design-Oriented Approach*", 1st ed, USA: McGraw Hill Education, 2017
3. Russ Cox, Frans Kaashoek, and Robert Morris, "*xv6: a simple, Unix-like teaching operating system*", 1st ed MIT, 2006.
4. Abraham Silberschatz, Peter Baer Galvin, and Greg Gagne, "*Operating System Concepts*", 8th ed, USA: John Wliey and Sons, 2008.
5. Trent Jaeger, "Operating System Security", 1st ed USA: Morgan & Claypool Publishers, 2008
6. G. Meike and Lawrence Schiefer, "*Inside the Android OS: Building, Customizing, Managing and Operating Android System Services*", 1st ed USA: Addison-Wesley, 2021

CS6105E ALGORITHMS FOR BIG DATA

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze and model algorithmic questions on big data

CO2: Apply modem techniques to address such questions, and analyze resulting algorithms

CO3: Design novel solutions to algorithmic problems

Module 1: Introduction to Sketching and Streaming (10 Lecture Sessions)

Sketching/Streaming: approximate counting, distinct elements count; impossibility results; frequency moments, "Tug of War" sketch; heavy hitters, CountMin and CountSketch algorithms; Dimension reduction: random projections (Johnson–Lindenstrauss lemma); fast dimension reduction; Binary Hashing Techniques- LSH, MLH

Module 2: Linoar Algehra via Sketching (9 Lecture Sessions)

Numerical linear algebra (via sketching): regression via Sketch-And-Solve, subspace embeddings; low-rank approximation; Compressed sensing: Restricted Isometry Property (RIP), $\ell 1$ minimization; iteration hard thresholding;

Module 3: Streams for Graphs (10 Lecture Sessions)

Streaming for graphs: spanners, triangle counting; dynamic graph algorithms via `0 sampling; Distribution (statistical hypothesis) testing: uniformity testing, closeness;

Module 4: Property Testing (10 Lecture Sessions)

Property testing / sublinear-time algorithms: – monotonicity testing; – graph property estimation; – geometric probiems; Parallel computation: – MapReduce-like parallei models, sorting; – graph algorithms.

References:

1. S Muthukrishnan, *Data Streams: Algorithms and Applications (Foundations and Trends in Theoretical Computer Science)*, 1st ed Now publishers, 2005
2. R. Motwani and P. Raghavan, *Randomized Algorithms*, 1st ed ., Cambridge University Press, 2004
3. A. Bhattacharyya and Y. Yoshida, *Property Testing: Problems and Techniques*, 1st ed Springer, 2022.
4. D. P. Woodruff, *Sketching as a tool for numerical linear algebra (Foundations and Trends in Theoretical Computer Science)*, 1st ed ., Now Publishers,2014.

CS6106E BIOINFORMATICS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Define and analyze the structure of biomolecules such as DNA, RNA and Protein.

CO2: Analyze Biological information using tools and databases.

CO3: Apply various data structures to represent Biological data for efficiently solving Biological problems.

CO4: Critically analyze different Bioinformatics algorithms, and develop novel and efficient methods for Biological data analysis.

Module 1: (10 Lecture Sessions)

Introduction to molecular biology, gene structure and Information content, molecular biology tools, algorithms for sequence alignment, sequence databases and tools.

Module 2: (10 Lecture Sessions)

molecular phylogenetics, phylogenetic trees, algorithms for phylogenetic tree construction, introduction to Perl programming for bioinformatics.

Module 3: (10 Lecture Sessions)

Introduction to protein structure, algorithms for protein structure prediction, gene expression analysis, microarray, pathway analysis.

Module 4: (9 Lecture Sessions)

Pattern matching Algorithms, bio-data analysis, data mining in bioinformatics, algorithms and data structures for efficient analysis of biological Data, emerging trends in bioinformatics.

References:

1. D. E. Krane and M. L. Raymer, *Fundamental Concepts of Bioinformatics*, 1st ed, Pearson Education, 2003.
2. T. K. Attwood and D. J. Parry-Smith, *Introduction to Bioinformatics,*1st ed, Pearson Education, 2003.
3. A. M Lesk, *Introduction to Bioinformatics,*1st ed, Oxford University Press, 2002.
4. J. M. Claverie and C. Notredame, *Bioinformatics – A Beginner's Guide,* 1st ed, Wiley., 2003.
5. N. C Jones and P. A. Pevzner, *An Introduction to Bioinformatics Algorithms,* 1st ed, MIT Press, 2004.
6. Current Literature.

CS6107E TOPICS IN CGMPILER DESIGN

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Formulate new data-flow analysis to capture the information required for an optimization and build an algorithm for the optimization.

CO2: Translate intermediate code to machine code.

CO3: Evaluate the efficiency and optimality of a given optimization and suggest improvements.

Module 1: (10 Lecture Sessions)

Review of compiler phases, symbol table structure, intermediate representations. control flow analysis: basic blooks and CFG, dominators and loops.

Module 2: (10 Lecture Sessions)

Data flow analysis: reaching definitions, available expressions, and live variable analysis,
Optimizations: redundancy elimination, loop optimizations, value numbering.

Moduie 3: (10 Lecture Sessions)

Static single assignment form (SSA): SSA construction, optimizations on SSA form. register allocation, graph colouring algorithm.

Module 4: (9 Lecture Sessions)

Machine code generation: instruction selection - maximal munch and dynamic programming algorithms, code generation for target machine, code generation for run-time management.

References

1. A. V. Aho, M. S. Lam, R. Sethi, and J. D. Uilman, *Compilers: Principles, Techniques, and Tools*, Pearson Education, 2007.
2. S. Muchnick., *Advanced Compiler Implementation*, 1st ed, Morgan Kaufmann Publishers, 1997.
3. A. W. Appel and J. Palsberg, *Modern Compiler Implementation in Java*, 1st ed, Cambridge University Press, 2002.
4. Y. N. Srikant and P. Shankar, *The Compiler Design Handbook: Optimization and Machine Code Generation*, 1st ed, CRC Press, 2003.

CS6108E COMPUTER NETWORKING

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Ccurse Outcomes:

CO1: Analyze and compare new protocols in computer networks.

CO2: Evaluate performance of protocoi enhancements using modern tools.

CO3: Propose new solutions to recent problems of interest in literature and compare different possible solutions.

Module 1: (9 Lecture Sessions)

Overview of computer networks, TCP/IP protocol, Application layer prctocols, Software defined networking, content distribution, Web 2.0, overlay networks, P2P networks.

Module 2: (9 Lecture Sessions)

TCP extensions for high-speed networks, Transaction-oriented applications. New options in TCP, TCP performance issues over wireless networks, SCTP, DCCP.

Module 3: (11 Lecture Sessions)

IPv6: Why IPv6, Basic protocol, Extensions and options, Support for QoS, Security, Neighbour discovery, Auto-configuration, Routing. Changes to other protocols. Application Programming Interface for IPv6, 6bone.
IP Multicasting, Wide area multicasting, Reliable multicast. Routing layer issues, ISPs and peering, BGP, IGP, Traffic Engineering, Routing mechanisms: Queue management, Packet scheduling. MPLS, VPNs

Moduie 4: (10 Lecture Sessicns)

...AC protocols for high-speed LANS, MANs, Wireless LANs and mobile networks, VLAN. Fast access technologies. Gigabit Ethernet. Multimedia networking, Network management.

References

1. W. R. Stevens, *TCP/IP Illustrated: The Protocols, Vol. 1*: 1st ed, Addison Wesley, 1994.
2. G. R. Wright, *TCP/IP Illustrated: The Implementation Vol. 2*: 1st ed, Addison Wesley, 1995.
3. P. Loshin, *IPv6: Theory, Protecol, and Practice*, 2nd ed., Morgan Kaufmann, 2003.

CS6109E TOPICS IN IMAGE PROCESSING

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Use different modern software/tools for implementing image processing applications.

CO2: Design and build Image processing algorithms/applications that can be used in domains like Medical imaging, Satellite Imaging and Video Surveillance.

CO3: Analyzlng the performance and complexity of various techniques being used to design domain specific algorithms for improving the performance.

CO4: Propose new solutions to issues of current interest computer vision such as object detection, segmentation and classification, based on inferencas made from the literature review and analysis.

Module 1: (10 Lecture Sessions)

Introduction - Digital image representation - Fundamental steps in image processing - Elements of digital image processing systems - Digital image fundamentals - Elements of visual perception - A simple image model - Sampling and quantization - Basic relationship between pixels - Image geometry - Image transforms - Introduction to Fourier transform – Discrete Fourier transform - Some properties of 2d-fourier transform (DFT)- Other separable image transforms - Hotelling transform

Module 2: (10 Lecture Sessicns)

Image enhancement - Point processing - Spatial filtering - Frequency domain - Image restoration - Degradation model - Diagonalization of ciroulant and block circulant matrices - Inverse filtering - Least mean square filter. Image Segmentation: Thresholding: Different types of thresholding methods, Point detection, Edge detection: Different types of edge operators, Line detection, Edge linking and boundary detection, Region growing, Region splitting, Region Merging.

Module 3: (10 Lecture Sessions)

Image compression - Image compression models - Elements of information theory - Error-free compression - Lossy compression - Image compression standards.
Image reconstruction from projections - Basics of projection - Parallel beam and fan beam projection - Method of generating projections - Fourier slice theorem - Filtered back projection algorithms - Testing back projection algorithms

Module 4: (9 Lecture Sessions)

Computer Vision - Introduction to machine vision, Image Classification, Object Detection, Semantic Segmentation, Image registration, Introduction to Machine Learning, Machine learning for Computer Vision tasks, Applications in medical imaging, industry, augmented reality, robotics, autonomous vehicles.

References

1. R. C., Gonzalez and Woods R.E, *Digital Image Processing*, 1st ed. Addison Wesley, 1999.
2. Richard Szeliski, *Computer Vision: Algorithms and Applications*, 2nd ed. Springer 2022
3. A. K. Jain, *Fundamentals of Digital Image Processing*, 1st ed. Prentice Hall, Englewood Cliffs, 2002.

CS6110E PATTERN RECGGNITION

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Formulate pattern recognition tasks in relation to fundamental mathematical principles of probability theory, linear algebra and optimization.

CO2: Apply linear classifiers like logistic regression, least squares classifier and perceptron, and nonlinear classifiers like Support Vector Machines and Artificial Neural Networks.

CO4: Design and rate new pattern recognition models for problems of current interest, analyse their performances and compare with existing approaches.

Module 1: (10 Lecture Sessions)

Introduction- Introduction to statistical, syntactic and descriptive approaches, Features and feature extraction, Learning.Bayes Decision theory- introduction, continuous case, 2-category classification,Minimum error rate classification, Classifiers, discriminant functions, and decision surfaces. Error probabilities and integrals, normal density, Discriminant functions for normal density, Bayes Decision theory Discrete case.

Module 2: (10 Lecture Sessions)

Parameter estimation and supervised learning- Maximum likelihood estimation, the Bayes classifier,Learning the mean of a normal density, General bayesian learning.Nonparametric technique- Density estimation, Parzen windows, K-nearest Neighbor estimation, Estimation of posterior probabilities, K nearest neighbor rule.

Module 3: (10 Lecture Sessions)

Multiplayer neural networks- Feed forward operation and classification, Backpropagation algorithm,Error surfaces, Back propagation as feature mapping, Practical techniques for improving backpropagation, Convolutional Neural Networks and Deep Learning.

Module 4: (9 Lecture Sessions)

Linear Methods : Linear regression, logistic regression, Principal Component Analysis,Fisher's Linear Discriminant Analysis.Non-linear methods - Kernel Methods - Kernel version of PCA, LDA,SVMs Unsupervised learning and clustering- Mixture densities and identifiably, Maximum likelihood estimates, Application to normal mixtures, Unsupervised Bayesian learning, Data description and clustering, Hierarchical clustering, Low dimensional representation of multidimensional map

References:

1. C. M Bishop, *Pattern Recognition and Machine Learning,* 1st ed Springer, 2006.
2. K. S. Fu, *Syntactic Pattern Recognition and Applications,* 1st ed Prentice Hall, 1982.
3. R. O. Duda, P. E. Hart and D.G Stork, *Pattern Classification,* 2ed ed. John Wiley, 2001.

CS6211E TOPICS IN COMPUTATIONAL GEOMETRY

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Design and develop algorithms and data structures for geometric problems.

CO2: Formulate a geometric solution using randomization as a tool.

CO3: Use CGAL to implement advanced geometric problems.

Module 1: (10 Lecture Sessions)

Art Gallery problem and its associated theorems, Triangulation of a polygon and its theory, Area of a polygon. Polygon partitioning, Monotone partitioning, Trapezoidalization, Plane sweep, Partitioning to monotone mountains. Introduction to Computational Geometric Algorithms Library (CGAL) and openGL and coding of simple programs with visualization using QT.

Module 2: (10 Lecture Sessions)

Convex hull in two dimensions, Algorithms for convex hull with their complexity analysis. Implement Convex Hull algorithms and one application using CGAL & visualization using QT.
Voronoi diagram: Algorithm for construction of Voronoi diagram with its complexity analysis. Delaunay triangulation : Preliminaries and properties, Medial axis transform and its properties. Applications of Voronoi Diagram / Delaunay triangulation / Medial axis transform. Implement one application of Voronoi diagram/ Delaunay triangulation using CGAL & visualization using QT.

Module 3: (10 Lecture Sessions)

Binary space partitions : Definition, basic concepts, construction using randomized algorithm, theorems, CGAL implementation of Painter's algorithm
Robot motion planning: Workspace and configuration space, Point robot, Minkowski sums, Translational motion planning, Quadtrees: Uniform and non-uniform meshes, Quadtrees for point sets, Quadtrees to meshes.

Module 4: (9 Lecture Sessions)

Visibility Graphs: Shortest paths for a point robot, Shortest paths for a translating polygonal robot.
Interval Trees, Priority Search Trees, Segment Trees, Partition trees, Multi-level partition trees. Simplex Range Searching

References:

1. M. de Berg, M. Van Kreveld, M. Overmars, and O. Schwarzkopf, *Computational Geometry: Algorithms and Applications*, 2nd ed.(revised), Springer-Verlag, 2000.
2. S. L. Devadoss and J. O'Rourke, *Discrete and Computational Geometry*, 1st ed. Princeton University Press, 2011.
3. K. Mulmuley, *Computational Geometry: An Introduction through Randomized Algorithms*, 1st ed. Prentice-Hall, 1994.

CS6112E TOPICS IN COMPUTER ARCHITECTURE

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply different modern tools for perfermance analysis of design enhanoements and analyze the system level implications of design enhanoements.

CO2: Critically analyze and compare different architecture level design options, and design solutions.

CO3: Propose new solutions to issues of current interest, and do comparative analysis of different possibilities.

Module 1: DLP and TLP in architecture (15 Lecture sessions)

Thread level parallelism: multithreaded processors and multicore processors concept, data level parallelism (DLP) - vector architecture, design issues and implementation, graphical processing unit (GPU)- GPU architecture, programming examples using OpenMP and CUDA

Module 2: Hardware security (10 Lecture sessions)

Side channel attacks: prime+probe, flush+reload, mitigation techniques, Prefetcher based attacks, PASS-P scheduling - performance and security tradeoffs,

Module 3: State-of-the-art architectures (14 Lecture sessions)

Heterogeneous ISA architectures: scheduling mechanisms in heterogeneous ISAs, performance efficient dynamic core, energy efficient dynamic core, advanced cache replacement policies, application specific integrated circuit architectures (ASIC)

References:

1. J. L. Hennessy and D. Patterson, *Computer Architecture: A Quantitative Approach*, 6th ed., Morgan Kaufmann, 2017.
2. ACM SIGARCH *Computer Architecture* News.
3. The WWW *Computer Architecture* page. http://www.cs.wisc.edu/arch/www/ last accessed 23/3/2016.
4. J. P. Shen and M. H. Lipasti, Modern processor design: Fundamentals of superscalar architectures, 1st ed., Waveland Pr Inc, 2013.

CS6113E TOPICS IN DATABASE DESIGN

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions:39

Course Outcomes:

CO1: Analyze articles containing topics of current interest in database design.

CO2: Critically analyze Parallel, Distributed and Object oriented databases, and solve advanced problems in Internet databases with the help of Data Mining Algorithms.

CO3: Experiment with partial and temporal databases like MongoDB, Hadoop GIS, and discuss the concepts of mobile and multimedia databases.

CO4: Design, develop a database project and deploy efficient IT solutions using free and open software to help society.

Module 1: (10 Lecture Sessions)

Parallel and Distributed Databases: Architecture of Parallel Databases, Parallel Query Optimization, Distributed DBMS Architectures, Distributed Query Processing, Distributed Concurrency Control, Distributed recovery.

Module 2: (10 Lecture Sessions)

Internet Databases and Data Mining : XML –QL, Ranked Keyword searches en the Web, Data Mining, Clustering, Similarity Search over Sequences.

Module 3: (9 Lecture Sessions)

Object Oriented Database Systems: User Defined ADTs, Objects, Object Identity and Reference types, Database Design for ORDBMS, OODBMS, Comparison of RDBMS with OODBMS and ORDBMS.

Module 4: (10 Lecture Sessions)

Spatial and Deductive Databases: Spatial and Temporal Databases, Temporal Logic, Spatial Indexes, Introduction to Recursive Queries, Introduction to Mobile Databases, Main Memory and Multimedia Databases

References:

1. R. Elmasri and S. B. Navathe, *Fundamentals of Database Systems*, 3rd ed, Addison Wesley.
2. P. O'Neil and E. O'Neil , *Database Principles, Programming, and Performance*, 2nd ed, Harcourt Asia, Morgan Kaufman.
3. A. Silberschatz , H. F. Korth, and S. Sudarshan , *Database System Concepts*, 1st ed, Tata McGraw Hill, 2003.
4. J. D. Ullman, *Principles of Database Systems*, 1st ed, Galgetia Publications, 1996.
5. C. J. Date, *An Introduction to Database Systems*, 1st ed, Addison Wesley, 2000.
6. R. Ramakrishnan and J. Gehrke, *Database Management Systems*, 3rd ed, McGraw Hill, 2004.

CS6114E TOPICS IN NETWORK SYSTEMS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Totai Lecture Sessions: 39

Course Outccmes:

CO1: To design and implement the network using state of the art in network protocols and architecture.

CO2: To apply novel ideas in networking through various advanced tcpics.

CO3: To analyze the networks and to engage in advanced research.

Module 1: Internetworking (12 Lecture Sessions)

Introduction: History and Context-Packet switching, Architectural Principles, Protocol Stacks and Layering, Names, Addresses, IPv4 Addressing, IPv6 addressing, IP forwarding, IP Packets & Routers, Interdomain Routing, Routing: RIP, OSPF, & BGP, Multicast, IPv6, tunnelIng, NAT, VPN, Virtual circuits, MPLS. Open Flow, Software Defined Networking

Module 2: Congestion control (10 Lecture Sessions)

Resource Management: End-to-End Congestion Control, Fair Queueing, Router congestion control. Enterprise and Datacenter Networking: Enterprise Networking, Data Center Networking, The Incast Problem.

Module 3: Wireless Networking (10 Lecture Sessions)

Wireless Networks Overview and Architectures, Routing in Ad-hoc Networks, Making the Best of Broadcast, WiFi and Mobility.

Module 4: Application networks (7 Lecture Sessions)

Applications, Naming, and Overlays: Topology, Overlay Networks, Distributed Hash Tables, DNS and the Web, HTTP/3, Web 3.0, Policy Switching, Miscellaneous Topics: Tracing and Prototyping, Multlcast, Network Energy Issues, eBPF and BPF

References:

1. Larry Peterson and Bruce Davie, *Computer Networks: A Systems Approach*, 4th ed. (2007)
2. James F. Kurose and Keith W. Ross, *Computer Networking: A Top-Down Approach Featuring the Internat*, 5th ed. (2010)
3. W. Richard Stevens, *TCP/IP illustrated, Volume 1: The Protocols,* 1st ed.
4. W. Richard Stevens, *Unix Network Programming: Networking APIs: Sockets and XTI* (Volume 1), 1st ed
5. W. Richard Stevens, *Advanced Programming in the Unix Environment*, 1st ed, Addison-Wesley, 1993.

CS6115E TGPICS IN PARAMETERIZED ALGORITHMS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Classify problems into tractable and intractable problems.

CO2: Illustrate the techniques for the design of fixed-parameter tractable algorithms.

CO3: Design and analyze fixed-parameter tractable algorithms for some of the classical NP-Hard graph problems.

Module 1: (10 Lecture Sessions)

Review of complexity classes - P, NP, Co-NP, NP-Hard and NP-complete problems - Strategies for coping with hard algorithmic problems; Exact exponential algorithms and the notion of fixed-parameter tractability.

Module 2: (10 Lecture Sessions)

Parameterizations and Parameterized preblems- Kernelization - Formal definitions - Some simple kernels, Crown decomposition, Bounded Search trees - Vertex Cover, Feedback Vertex Set

Moduie 3: (10 Lecture Sessions)

Iterative Cempression - Illustration of the technique - Feedback vertex set - Odd Cycle Transversal - Dynamic programming over subsets – Set cover, Tree structured variants of set cover and Steiner Trees. Randomized methods in Parameterized algorithms – Simple randomized algorithm for Feedback Vertex Set, Color coding algorithm for Longest path.

Module 4: (9 Lecture Sessions)

Trees - narrow grids and dynamic programming - Path and Tree decomposition – Dynamic Programming on graphs of bounded treewidth – Treewidth and Monadic second-order logic, Graph searching, Interval and chordal graphs.

References

1. M. Cygan, F. V. Fomin, L. Kewalik, D. Lokshtanov, D. Marx, M. Piipczuk, M. Pilipczuk and S. Saurabh, *Parameterized Algorithms, Springer*, 1st ed, June 2015.
2. R. Niedermeier, *Invitation to Fixed-parameter Algorithms*, 1st ed, Oxford University Press, 2006.
3. R. G. Downey and M. R. Fellows, *Fundamentals of Parameterized Complexity*, 1st ed, Springer,2013.

CS6116E TOPICS IN PROGRAMMING LANGUAGES

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Develop formal semantics for programming language constructs.

CO2: Model Programming Language features using Lambda Calculus.

CO3: Design type systems for language safety.

CO4: Design a pregramming language (formal semantics and type system) with required constructs

Module 1: (8 Lecture Sessions)

Introduction to programming Languages. untyped arithmetic expressions - syntax and semantics, properties of the language of untyped arithmetic expressions.

Module 2: (11 Lecture Sessions)

Untyped Lambda calculus: syntax, operational semantics, evaluation strategies – programming in Lambda calculus, typed arithmetic expressions: typing relation, type safety.

Module 3: (10 Lecture Sessions)

Simply Typed lambda Calculus: typing relation, properties of the language, type safety. Extensions: basic types, derived forms, let bindings.

Module 4: (10 Lecture Sessions)

Extensions to Lambda Calculus: pairs, tuples, records, sums, variants, references, exceptions, subtyping, recursive types, polymorphism.

References

1. B. C Pierce, *Types and Programming Languages*, 1st ed. MIT Press, 2002.
2. A. B. Tucker, *Handbook of Computer Science Engineering*, 1st ed. CRC Press, 1996.
3. M. L. Scott, *Programming Languages Pragmatics*, 1st ed. Elsevier, 2004.

CS6117E TOPICS IN QUANTUM COMPUTING

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze the quantum computational model and compare with the classical models of computation with respect to computational power and algorithmic efficiency.

CO2: Illustrate and summarize well known quantum algorithms for problems like integer factorization and search.

CO3: Analyze quantum error correction and coding schemes

Module 1: (10 Lecture Sessions)

Foundations:Finite Dimensional Hilbert Spaces – Tensor Products and Operators on Hilbert Space –Hermitian and Trace Operators - Basic Quantum Mechanics necessary for the course.

Module 2: (10 Lecture Sessions)

Model of Computation:Quantum Gates and operators and Measurement – Quantum Computational Model – Quantum Complexity – Schemes for Physical realization (Only peripheral treatment expected).

Module 3: (0 Lecture Sessions)

Algorithms and Complexity Shor's Algorithm – Application to Integer Factorization – Grover's Algorithm – Quantum Complexity Classes and their relationship with classical complexity classes.

Module 4: (10 Lecture Sessions)

Coding Theory Quantum Noise – Introduction to the theory of Quantum Error Correction –Quantum Hamming Bound – Coding Schemes – Calderbank-Shor-Steane codes – Stabilizer Codes.

References

1. M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information,* 1st ed, Cambridge University Press, 2002.
2. J. Gruska, *Quantum Computing,*1st ed, McGraw Hill, 1999.
3. P. R. Halmos, *Finite Dimensional Vector Spaces*, 1st ed, Van Nostrand, 1958.
4. J. Brown, Minds, *Machines and the Multiverse: The Quast for the Quantum Computer,* 1st ed, Simon and Schuster, 2000

CS6202E COMPUTER ARCHITECTURE AND DESIGN

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze different architectural parameters for measuring performance, energy and area.

CO2: Compare different architectures with respect to performance and energy aspects

CO3: Apply software tools for designing various architecture components of a system.

Module 1: Pipeline and VLIW architecture (17 Lecture Sessions)

Review of pipeline, pipeline hazards,static and dynamic branch prediction, branch target buffer, static scheduling, dynamic scheduling, speculation, superscalar architecture, VLIW architecture.
Introduction to Thread level parallelismL simultaneous multithreading. memory hierarchy design-Cache optimization, RAM.

Module 2: Thread Level parallelism (14 Lecture Sessions)

Multithreaded processors and Multicore processors: concept, methodologies and analysis, shared memory multiprocessor architecture, cache coherence, coherence protocols, memory consistency, sequential consistency, relaxed consistency models, synchronization, hardware support for synchronization. speculative multithreading, multicore processor design and compilation issues, scheduling,
CMPs and polymorphic processors: concept, studies and analysis, OpenMP programming

Module 3: Multi-core architecture (8 Lecture Sessions)

Simulators in computer architecture: introduction, methods, ADLs, traces, dynamic compilation, multicore simulators, functional and performance simulators.

References:

1. J. L. Hennessy and D. Patterson, *Computer Architecture: A Quantitative Approach*, 6th ed., Morgan Kaufmann, 2017.
2. ACM SIGARCH *Computer Architecture* News.
3. The WWW *Computer Architecture* page. http://www.cs.wisc.edu/arch/www/ last accessed 23/3/2016.
4. J. P. Shen and M. H. Lipasti, Modern processor design: Fundamentals of superscalar architectures, 1st ed., Waveland Pr Inc, 2013.

CS6203E TOPICS IN CRYPTOGRAPHY

Pre-requisites: NIL

L	T	P	O	C
3	0	0	8	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Demonstrate knowledge of historical and modern day ciphers and principles of security behind them.

CO2: Evaluate the security of private key encryption schemes and public key encryption schemes.

CO3: Choose the appropriate encryption scheme for a given context.

Module 1: (10 Lecture Sessions)

Historical Ciphers - Modern day Ciphers. Provable Security and other varying security notions. Perfect Secrecy. One Time Pad. Practical Implementation and limitations. Private-Key Encryption - Constructing Secure Encryption Schemes - Linear and Differential Cryptanalysis. Practical implementation of block ciphers.

Module 2: (0 Lecture Sessions)

Cryptographic Techniques for Integrity - Message Authentication Codes - Hash Functions - Attacks. Practical implementation of hash functions.

Module 3: (12 Lecture Sessions)

Number theory concepts - Primality testing algorithms - Factoring algorithms - Algorithms for computing discrete logarithm. Review of RSA - Attacks on RSA. Introduction to advanced cryptosystems like Elliptic Curve Cryptosystems, Homomorphic Encryption, Threshold Encryption.

References

1. J. Katz and Y. Lindell, *Introduction to Modern Cryptography*, 2nd ed. CRC Press, 2014.
2. H. Delfs and H. Knebl, *Introduction to Cryptography Principles and Applications*, 1st ed. Springer, 2002.
3. D. R. Stinson, *Cryptography Theory and Practice*, 3rd ed. CRC Press, 2006.
4. A. J. Menezes, P. C. Oorschot and S. A. Vanstone, *Handbook of Applied Cryptography*, 1st ed CRC Press 1996.

CS6204E TOPICS IN DATA PRIVACY

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the data privacy requirements of a system.

CO2: Prepare formal specifications of the privacy requirements.

CO3: Analyze common data privacy techniques and solve simple problems using them.

Module 1: Introductory Topics (0 Lecture Sessions)

Understanding Privacy - Social Aspects of Privacy, Legal Aspects of Privacy and Privacy Regulations, Effect of Database and Data Mining technologies on privacy, Privacy challenges raised by new emerging technologies such RFID, biometrics, etc.

Module 2: Privacy Models (10 Lecture Sessions)

Privacy Models - Anonymization models: K-anonymity, l-diversity, t-closeness, differential privacy Database as a service, cloud computing

Module 3: Technology for Preserving Privacy (10 Lecture Sessions)

Using technology for preserving privacy - Statistical Database security, Inference Control, Secure Multi-party Computation and Cryptography Privacy-preserving Data mining, Hippocratic databases

Module 4: Emerging Applications (10 Lecture Sessions)

Emerging Applications - Social Network Privacy, Location Privacy, Query Log Privacy, Biomedical Privacy

References:

1. C. Dwork and A. Roth, *The Algorithmic Foundations of Differential Privacy (Foundations and Trends in Theoretical Computer Science) Vol. 9*, Nos. 3–4 (2014) 211–407, DOI: 10.1581/0400000042
2. N. Venkataramanan and A. Shriram, *Data Privacy: Principles and Practice,* 1st ed, CRC Press, 2016
3. Current Literature based research articles

CS6205E TOPICS IN INFORMATION SECURITY

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Examine and apply the fundamental techniques of information security.

CO2: Demonstrate advanced knowledge in the field of information security standards.

CO3: Detect and analyze diverse kinds of system and network related attacks using software tools.

Module 1: (14 Lecture Sessions)

Information systems - Threats, building blocks of information security, Information security management, information security risk analysis, Vulnerability, Threat and Risk, Risk Assessment and Mitigation; System security topics: Access Control - MAC. DAC, RBAC. Enforcing Access Control: Isolation and Sandboxing, Security Models: BLP, Biba, Chinese Wall and Clark Wilson - Reference Monitor.

Module 2: (14 Lecture Sessions)

Software vulnerabilities - Buffer and stack overflow, Shellcode, Malicious software - Ransomware, Viruses, Rootkits,. Entity Authentication - Password, Challenge Response, Zero Knowledge Protocols.
Network Security Topics - DoS, DDoS, Botnets, iptables/pfSense. DNS security: DNS rebinding attacks, SADDNS, Intrusion Detection Systems - DDoS detection, Malware defense.Web Security: TLS, CSS, XSRF

Module 3: (11 Lecture Sessions)

Current Trends in Information Security, benefits and Issues related to information security. Information security standards": Cobit, Cadbury, ISO 27001, OWASP, OSSTMM, etc. Introduction to BCP / DRP / Incident management, Segregation and Separation of Duties & Roles and responsibilities, IT ACT 2000

References:

1. Nina Godbele, "*Information Systems Security: Security Management, Metrics, Frameworks and Best Practices*", 2nd ed, USA: Wiley, 2017.
2. Michael Goodrich and Roberto Tamassia, "*introduction to Computer Security*", 1st ed,Pearson,, 2011
3. Ross Anderson, "*Security Engineering: A Guide to Building Dependable Distributed Systems*", 3rd ed, UK: Wiley Publications, 2021.
4. Charles Pfleege and Pearson EduShari Lawrence Pfieeger, "*Security in Computing*",5th ed, USA: Pearson Education; 2018.
5. B. Menezes, *Network Security and Cryptography,*1st ed, India: Cengage Learning, 2010.
6. D. Gollmann, *Computer Security,*3rd ed, John Wiley and Sons Ltd., 2010.
7. Michal Zalewski, "*The Tangled Web: A Guide to Securing Modern Web Applications*", 1st ed USA: No Starch Press, 2011.

CS6206E SYSTEMS SECURITY

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply security principles in developing secure systems

CO2: Analyze and interpret the functioning of malicious softwares

CO3: Identify system level and network level attacks and formulate defense strategies

Module 1: Secure System Design (8 lecture sessions)

Secure design principles, Principle of least privileges, information flow control, Linux kernel security, trusted execution environments, secure boot, SELinux

Module 2: Memory Corruption (13 Lecture Sessions)

Stack Smashing Attacks: Defenses, Stack Smashing Attack techniques, Code Injection and Reuse, Memory Corruption, Heap Overflows, Format-string Attacks, Integer Overflows, Categorization of memory error defenses, Randomization based defenses, memory errors: Definition, Detection, and Prevention, Taint-tracking, Race Conditions, CVE, CWE

Module 3: Malware analysis (10 Lecture Sessions)

Stealth, Obfuscation, Defenses for Untrusted Code, Reference Monitors, System call interception, process injection, Inline Reference Monitors, Control Flow Integrity, Binary Analysis and Instrumentation, Disassembly and Binary Analysis, Static and Dynamic Binary Translation, APT threats, malware case studies

Module 4: Network and OS Security (8 Lecture Sessions)

SSL/TLS attack: SSL stripping attack, Heartbleed attack, Beast attack Poodle attack. Processor Vulnerabilities: Meltdown & Spectre, OS Security and Access Control: File Permissions and ACLs, OS Capabilities, Mandatory Access Control, Domain and Type enforcement, Linux Capabilities, Policies for Untrusted. Code, Policy Management. Virtual Machines, Isolation and Sandboxing

References:

1. Stamp,and Mark. *Information security: principles and practice*. 2nd ed, USA: John Wiley & Sons, 2011.
2. Anderson, Ross. *Security engineering: a guide to building dependable distributed systems*. USA: John Wiley & Sons, 3rd ed., 2020.
3. Saltzer, Jerome H., and M. Frans Kaashoek, "*Principles of Computer System Design: An Introduction*", USA: Morgan Kaufmann Publishers, 1st ed, 2009.
4. Christoph Kern, Anita Kesavan, and Neil Daswani, "*Foundations of Security: What Every Programmer Needs to Know*", USA: APress, 1st ed., 2007.

CS6320E STATISTICAL FOUNDATIONS OF DATA SCIENCE

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Construct a probability model for a given data science problem specification and perform computations of probability values and statistical estimates associated with events and random variables.

CO2: Perform modeling of data science problems and computation with random vectors of multivariate Gaussian distribution.

CO3: Apply software packages for performing statistical computations of simple practical problems.

Module 1: (9 Lecture sessions)

Review of elementary probability: probability spaces, events, independence, conditional probability, Bayes theorem. MAP estimation using Bayesian statistics.

Random variables: expectation, variance and moments, density and distribution functions, weak law of large numbers, functions of random variables. modeling data science problems with probability models.

Module 2: (10 Lecture sessions)

Jointly distributed random variables, correlation and covariance, joint density and joint distribution, conditional expectation, conditional density and distribution, multivariable Gaussian distribution and its properties. .

Transform methods: moment generating functions and characteristic function, Central limit theorem (proof not expected).

Multivariate Gaussian models for data science problems and programming exercises.

Module 3: (10 Lecture sessions)

Random vectors, properties of covariance matrices, diagonalization, properties of multivariate normal density function, parameter estimation, Sampling theorem and Bessel's correction, estimation of vector means and covariance matrices, maximum likelihood estimation, estimation of multivariate Gaussian, applications to data science problems, use of software packages for multivariate estimation.

Module 4: (10 Lecture sessions)

Estimation of random variables, minimum mean squared error estimation, mean squared error minimization of Gaussian random vectors, orthogonality equations, Gauss Markov theorem, linear estimation using Gauss Markov statistics.

Introduction to MAP estimation, statistical Learning and PAC learnability, use of software packages.

References

1. A.O. Allen, *Probability, Stetistics and Queuing Theory with Computer Science Applications*, 2nd ed, Academic Press, 1990.
2. H. Stark. J.W. Woods. *Probabilitv. Random Processos and Estimation Thaorv for Enaineers.*

CS6305E ADVANCED DATA STRUCTURES AND ALGORITHMS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions:39

Course Outcomes:

CO1: Apply data structures to improve the running time of basic algorithmic questions involving data represented as graphs, lists and other data structures.

CO2: Apply probabilistic and hashing techniques for solving big-data problems and

CO2: Analyze the performance of big-data algorithms for clustering, and graph problems.

Module 1: Review of Elementary Data Structures and Algorithms (15 Lecture Sessions)

Elementary Data Structures and Algorithms: Time and space complexity analysis, proof of correctness of algorithms,searching and sorting, insertion and selection sorting, divide and conquer algorithms, quick sort, abstract data types, stack, queue, priority queues binary search trees and hashing, algorithms on graphs, spanning trees and shortest path problems.

Module 2: Hashing for Big Data (12 Lecture Sessions)

Basic probability - random variables, expectation; Standard probability distributions and their properties - Binomial, geometric, Gaussian; Concentration inequalities and applications

Hashing - chaining, open addressing; k-wise independent hash families and their constructions; Perfect hash families - FKS hashing; Bloom filters and applications; Cuckoo hashing; Locality-sensitive hashing and nearest neighbors

Module 3: Data Streams and Clustering (12 Lecture Sessions)

Data stream algorithms: sampling, counting, heavy hitters with the count-min sketch, Flajolet-Martin algorithm, AMS sketch. Graph streams - connectivity, spanning trees, spanners, sparsifiers

Clustering algorithms: hierarchical clustering, curse of dimensionality, k-means; Clustering in large graphs - random walks and applications; PageRank algorithm

References

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms* 3rd ed. US: MIT Press, 2009.
2. J. Kleinberg and E. Tardos, *Algorithm Design*, 1st ed. Pearson Education, 2013.
3. D. Kozen, *The Design and Analysis of Algorithms*, 1st ed. Springer, 1991.
4. J. Leskovec, A. Rajaraman, and J. D. Ullman, *Mining of lerge data sets*, 3rd ed. Cambridge University Press, 2020.
5. E. Upfal and M. Mitzenmacher, *Probability and Computing: Randomization and Probabilistic Techniques in Algorithms and Data Analysis*, 2nd ed. Cambridge University Press, 2017.

CS6306E ADVANCED DEEP LEARNING AND COMPUTER VISION

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Illustrate the fundamental concepts of computer vision systems.

CO2: Implement various deep learning architectures used for computer vision.

CO3: Design Deep Leaming architectures for computer vislon applications.

Module 1: (12 Lecture sessions)

Course Overview and Motivation; Computer Vision Basics : Introduction to Image Formation, Capture and Representation; Linear Filtering, Correlation, Convolution,Edge, Blobs, Corner Detection; Color, Texture, Segmentation, Scale Space and Scale Selection; SIFT, SURF; HoG, LBP, Bag-of-words, VLAD; RANSAC, Hough transform; Pyramid Matching; Optical Flow, Object Recognition.

Module 2: (10 Lecture sessions)

Review of Deep Leaming, Multi-layer Perceptrons, Backpropagation,Introduction to CNNs; Evolution of CNN Architectures: AlexNet, ZFNet, VGG, InceptionNets, ResNets, DenseNets, Visualization of Kemels; Backprop-to-image/Deconvolution Methods; Deep Dream, Hallucination, Neural Style Transfer; CAM,Grad-CAM, Grad-CAM++; Recent Methods (IG, Segment-IG, SmoothGrad), CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss); CNNs for Detection: Background of Object Detection, R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD, RetinaNet; CNNs for Segmentation: FCN, SegNet, U-Net, Mask-RCNN

Module 3: (10 Lecture sessions)

Review of RNNs; CNN + RNN Models for Video Understanding: Spatio-temporal Models, Action/Activity Recognition, Introduction to Attention Models in Vision; Vision and Language: Image Captioning, Visual QA, Visual Dialog; Spatial Transformers; Transformer Networks, Transformer model: Introduction of Attention Mechanism, Queries, Keys, and Values of Attention Network, Self-Attention and Positional Encodings, Attention-Based Sequence Encoder, Coupling the Sequence Encoder and Decoder, Cross Attention in the Sequence-to-Sequence Model, Multi-Head Attention, The Complete Transformer Network, BERT based models, Nemo, Self-supervision techniques, masked language modelling, autoregressive modelling.

Module 4: (7 Lecture sessions)

Review of Deep Generative Models: GANs, VAEs; Other Generative Models: PixelRNNs, NADE,Normalizing Flows, Applications: Image Editing, Inpainting, Superresolution, 3D Object Generation, Security; Variants: CycleGANs, Progressive GANs, StackGANs, Pix2Pix

References:

1. I. Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Leerning*,1st ed. MIT Press, 2016
2. M. Nielsen, *Neural Networks and Deep Learning*,1st ed. O'Reilly Media, Inc. 2016
3. Y. Bengio, *Learning Deep Architectures for AI, (Foundations and Trends in Machine Leaming)*, 1st ed. New Publishers, 2009

CS6307E AI IN HEALTHCARE

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify problems healthcare providers face that deep learning can solve, to bring AI technologies into the clinic, safely and ethically.

CO2: Apply the building blocks of AI to understand emerging technologies and to determine the most effective treatments.

CO3: Illustrate the current applications of AI in Radiotherapy, Cardiology, Gynecology.

Module 1: (10 Lecture Sessions)

Neural Networks, Convolutional Neural Networks, Transfer Learning, Data Augmentation, Recurrent Neural Networks, Generative Adversarial Networks (GAN), Autoencoder, VAE, DAE, Segmentation architectures – Unet, Vnet, Object detection DL architectures, Faster RCNN, Mask ;RCNN, YOLO, efficient net, centrenet, Transformers, Reinforcement Learning, Sequence model for voice data.

Module 2: (10 T Lecture Sessions)

AI in Radiotherapy - Radiotherapy treatment workflow for cancer treatment, Imaging modality for radiotherapy, Computerized Tomography, Fan Beam CT, Cone Beam CT, DICOM file structure, Removing Metal Artifices in CT images using GAN, Treatment Planning System(TPS) in radiation therapy, Atlas based segmentation, Deep Learning based segmentation, segmentation organs in CT images using UNet, Synthesising FBCT images from MR and CBCT images, Linear accelerators, Simulating the operation of a linear accelerator.

Module 3: (10 Lecture Sessions)

AI in Cardiology - processing & analyzing an echocardiogram for reducing intra observer variability, Deep learning based ultrasound processing.
AI in Cervical cancer detection, Pap smear test, VIA & HPV test. Object detection for Cropping RoI in medical images, use of self- supervision in biomedical imaging applications, Development of AI based biomedical devices for cancer detection, Mammographic analysis.

Module 4: (0 Lecture Sessions)

AI and NLP for biomedical applications. Text simplification for deaf learners. Text summarization and Text Simplification using Transformers, Lexical simplification, Syntactic simplification, development of level appropriate robot assistant Chabot for deaf learners, Large Language Models, Chat GPT.
AI and Healthcare: Smart hospitals, pertained networks, Nvidia CLARA framework for healthcare applications like Cancer detection, CT synthesis, segmenting the organs in a CT image

References:

1. Y. Bengio, I. Goodfellow and A. Courville, *"Deep Learning"*,1st ed, MIT Press, 2016.
2. Raúl Rojas, *Neural Networks: A Systematic Introduction*,1st ed, 1996
3. Geoffrey E. *Hinton, "Neurai network architectures for artificial intelligence"*,1st ed, American Association for Artificial Intelligence Menlo Park, 1968, ISBN:0-929280-15-6.
4. Adrian Rosebrock, *"Deep Learning for Computer Vision with Python", E-Book,* 1st ed, September 2017.
5. Francois Chollet, *"Deep Learning with Python", Manning Publications;* 1st ed,2017,

CS6308E TGPICS IN APPRGXIMATION ALGORITHMS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the design technique used in a given approximation algorithm.

CO2: Design and analyze approximation algorithms for NP hard problems using various combinatorial techniques, randomization and LP methods.

CO3: Apply reduction techniques of proving hardness of approximation ef simple combinatorial probiems.

Module 1: Combinatorial Methods I (10 Lecture Sessions)

Review ef NP Hardness and reductions, approximation factor, technique of lower bounding optimum, simple approximation algorithms for Vertex Cover and Set Cover. Local search: Max-Cut, Minimum Spanning Tree heuristic, Metric Steiner Tree and Metric TSP, Approximation factor preserving reduction for Steiner tree.

Module 2: Combinatorial Methods II (9 Leoture Sessions)

Layering: minimum vertex cover, feedback vertex set, Strong NP Hardness and pseudo-polynomiai-time algorithms, Knapsack. Dynamic programming: FPTAS for the Knapsack, asymptotic PTAS for Bin Packing.

Module 3: Linear Programming Methods (10 Lecture Sessions)

Linear programming: simple rounding - MAX-SAT with small clauses, Set Cover, Bin Packing, primal-duai method - set Cover, steiner forest. Introduction to Semidefinite Programming: SDP approximation algorithm for Max Cut.

Module 4: Non Approxlmability (10 Lecture Sessions)

Hardness of Approximation: Reductions from NP-complete problems, TSP, appreximation preserving reductions, PCP Theorem (no proof), gap reductions, minimum vertex cover, maximum Clique.

References

1. V. V. Vazirani, *Approximation Algorithms,* 1st ed, Springer-Verlag Berlin Heidelberg, 2003.
2. D. P. Williamson and D. B. Shmeys, *The Design of Approximation Algorithms,* 1st ed, Cambridge University Press, 2011.
3. D. S. Hochbaum (Ed), *Approxlmation Algorithms for NP-Hard Problems,* 1st ed, PWS Publishing Company, 1997.

CS6309E CGMPUTATIONAL LINEAR ALGEBRA

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions : 39

Course Outcomes:

CO1: Apply mathematical techniques like singular value decomposition to solve simple engineering applications like least squares approximation or low rank approximation of matrices.

CO2: Prove the correctness of the matrix methods used in engineering problem solving.

CO3: Design computer programs to use the mathematical techniques for solving application problems like image compression or least squares fitting.

Module 1: (10 Lecture Sossions)

Vector spaces, subspaces, linear independence, basis, dimension, inner products, orthogonality, inner product spaces, orthonormal basis, Parsavel's identity, orthegonal subspace, Gram Schmidt erthogonalization. Linear transformations, basis transformations, rank nuility theorem, solving systems of linear equations. Gaussian elimination, LU decomposition. Programming exercises with Linear equations and LU decomposition.

Module 2: (10 Lecture Sessions)

Eigenvalues and Eigenvectors, orthonormal basis transformations, Hermitian operators, projection operators, orthogonal projections, Spectral theorem for Hermitian operators, matrix norms, Frobenius inner product. Symmetric Positive semidefinite matrices and properties, Cholesky decomposition. Programming exercises with Cholesky decomposition.

Module 3: (10 Lecture Sessions)

Singular Value decemposition, Eckart Young theorem, low rank approximation, applications of singular value decomposition, Image compression, least squares approximation, clustering, principal component analysis, pseudo-inverse and properties, Programming exercises with Singular value decomposition, least square approximation and principal component analysis - solutien to big-data problems using principal component analysis.

Module 4 (9 Lecture Sessions)

Eigenvalue problems, Gershgorin's theorem, Rayleigh principle, Courant–Fischer min-max principle. programming exercises.

References

1. W. Hodger, *Numerical Linear Algebra - An Introduction, Cambridge Texts in Applied Mathematics*, 1st ed. Cambridge University Press, 2018.
2. D. S. Watkins, *Fundamentals of matrix computations, Pure and Applied Mathematics (Hoboken)*, 1st ed. John Wiley & Sons, 2010.
3. B. N. Datta, *Numarical Linear Algebra and Applications*, 1st ed. Society for industrial and Applied Mathematics (SIAM), 2010.

CS6310E COMPUTATIONAL OPTIMIZATIGN METHODS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze and soive a linear and non-linear system of equations and modeling of real worid engineering preblems as an optimization problem.

CO2. Apply nature-inspired optimization algorithms to solve real worid optimization problems.

CO3. Design and analysis of computational algorithms dealing with multiple objectives.

Module 1: (10 Lecture Sessions)

Ingredients of Optimization Problems: objective function, constraints, variable bounds. Linear Programming: standard form of linear programming probiem, canonical form, elementary operations, graphical methods, simplex method, dual simplex method, linear regression.

Moduie 2: (10 Lecture Sessions)

Beam Search, Hill Climbing, Tabu Search, Goal Programming, Gradient Descent methods, Simulated Annealing, Fuzzy Optimization.

Module 3: (10 Lecture Sessions)

Nature inspired Optimizatien Algorithms, Introduction to Meta-heuristic Optimization, Genetic Algorithms, Differential Evolution, Bee Coiony Optimization, Particle Swarm Optimization, Ant Coiony Optimization, Working Principles,Applications of Heuristic and Meta-heuristic Optimization in Data Analytics.

Module 4 (9 Lecture Sessions)

Multi-objective Optimization Problems: linear and nonlinear, convex and non-convex optimization, principles of multi-objective optimization, dominance and pareto-optimality, classical methods: weighted sum methods, weighted matrix methods, evolutionary algorithms for optimization: NSGA-II, MOPSO.

References

1. D. G. Luenberger and Yinyu Ye, *Linear and Nonlinear Programming*, 1st ed. Springer, 2016
2. A. P. Engelbrecht, *Computational Intelligence An Introduction*, 1st ed. John Wiley & Sons Ltd, 2007
3. K. Deb, *Multi-objective Optimization methods*, 1st ed. John Wiley & Sons, 2001

CS6311E TGPICS IN DATA MINING

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Illustrate the basics of data preprocessing and apply them to clean a data set

CO2: Analyze various classification techniques like - Decision Trees, Rule Based method, Nearest neighbor, ιpport Vector Machine - and implement them on sample data sets for performance evaluation.

CO3: Implement Apriori and FP-tree methods for frequent item set generation and association rule generation with proper evaluation of the rules.

CO4: Apply and evaluate the performance of various clustering techniques iike K-means, DBSCAN and Hierarchical methods on sample data sets

Module 1: (10 Lecture Sessions)

Introduction to data mining-chaiienges and tasks, Data preprocessing data analysis, measures of similarity and dissimilarity, Data visualization –concepts and techniques

Moduie 2: (10 Lecture Sessions)

Ciassification- decision tree-performance evaiuation of the classifier, comparison of different classifiers, Rule based classifier, Nearest-neighbor classifiers-Bayesian classifiers-support vector machines, Class imbalance problem

Module 3: (10 Lecture Sessions)

Association analysis –frequent item generation rule generation, evaluation of association patterns

Module 4: (9 Lecture Sessions)

Clustering - Types of clustering, Partition based, Hierarchical, Density based - Cluster evaluation. Application of data mining techniques to various domains

Referenoes

1. P. Tan, M. Steinbach, and V. Kumar, *Introduction to Data Mining*, 1st ed. Pearson Education 2006.
2. J. Han and M. Kamber, *Data Mining: Concepts and Techniques*, 2nd ed. Morgan Kaufmann, 2005.
3. T. Hastie, R. Tibshirani, and J. Friedman, *The Elements of Statistical Learning - Data Mining, Inference, and Prediotion*, 2nd ed. Springer, California, 2008.

CS6312E DISTRIBUTED COMPUTIHG AND BIG DATA

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outccmes:

CO1: Analyze a computationai problem which is distributed in nature and design approaches for solving it

CO2: Design distributed algorithms for asynchronous distributed computing systems

CO3: Design and impiement very large scaie distributed databases which support big data processing

Moduie 1: Introduction to Computing (6 Lecture Sessions)

Introduction, Parallel Vs Distributed Systems, Characteristics of Distributed Systems, Models of Computation, Happened_before and Causality Relations, Asynchronous Distributed Systems.

Module 2: Clocks and Distributed Mutual Exclusion Algorithms (15 Lecture Sessions)

Clocks (physical, logicai, vector, chain),Verifying Clock Algorithms. Clocks of Different Dimensions, Mutual Exclusion & Distributed Coordination, Using Timestamps - Lamport's Aigorithm,Token based and quorum based mutual Exclusion. Topology specific and Topology independent DME algorithms. Drinking Philosophers Problem., Dining Philosophers probiem,

Module 3: Leader Election, Giobal State and Distributed Consensus (8 Lecture Sessions)

Snapshot algorithms, Spanning tree, Globai state Detection algorithms Leader election algorithms,Distributed Consensus/agreement algorithms, Self State Stabilization algorithms, Terminatien Detection algorithms

Moduie 4: Distributed Databases and Big Data (10 Lecture Sessions)

Distributed Databases, Transactions and Concurrency control , Distributed Transactions,Distributed Recovery, Checkpointing for Recovery, Message Logging for Recovery, Big Data Processing, Introduction to Cloud Computing and virtualization.

References:

1. Vijay K. Garg., *Elements of Distributed Computing,*1st ed, Wiley & Sons, 2020
2. Vijay K. Garg., *Concurrent and Distributed Computing in Java,* 1st ed, Wiley & Sons, 2020
3. Ajay D. Kshemkalyani, Mukesh Singhai,*Distributed Computing Principles, Algorithms, and Systems* , Cambridge University Press, 2021
4. Chow R. & Jehnson T., *Distributed Operating Systems and Algorithms*, Addison Wesley, 2022
5. Tanenbaum S., *Distributed Operating Systems*, Pearson Education, 2021

CS6313E HIGH PERFORMANCE COMPUTING FOR AI

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Illustrate the neural netwerk basics and analyze commonly used networks for different AI needs.

CO2: Analyze and compare parallel computing paradigms.

CO3: Design GPU/FPGA programs for Deep Learning frameworks.

Module 1: (10 Lecture Sessions)

Introduction to Artificial Intelligence, AI workloads: Neural Networks ANN, Convolutions, CNN, Image Classification, Object detection, Region Proposal Networks, Faster RCNN, Yolo, Image segmentation, UNET, UNET++, Generative Adversarial Networks, Generators, Discriminaters, Reinforcement Learning Models, RNNs, LSTMs, Transformers, Importance of matrix operations and the need of parallel kernels in Deep learning, Deep Learning Hardware and Software.

Module 2: (10 Lecture Sessions)

Introduction to Parallel Programming; Needs for parallel computations. Homogenous parallel computing; programming models (CPU only Models), Programming with Shared Memory; Overview of the Openmp standard, Overview of the MPI standard. Point-to-peint cemmunication operatiens. Synchronous and asynchronous modes ef data transmission. Case studies: matrix computations, solving partial differential equations using OpenMP and MPI.

Module 3: (10 Lecture Sessions)

Heterogeneous parallel oomputing; Accelerators, GPUs, CUDA, Overview of CUDA C; threads, blocks and grids, warps, different GPU memories, CUDA Kernels, Operations in Deep Learning and their implementatien en CUDA. Designing High Perfermance Systems for Accelerated Machine Learning and Deep Learning Workloads. Deep Learning Software: Setting up Applicatien Envirenment for Deep Learning and HPC workloads using Centainer Platform like Docker. Introduction to PyTorch, TenserFlow (Majorly Used).

Module 4: (9 Lecture Sessions)

Deep learning on FPGA: Introduction to FPGAs, Architecture of FPGAs, Implementation of complex digital computatiens with FPGAs, FPGAs for AI, the challenges of using GPUs for deep learning, FPGAs vs. GPUs for Deep Learning, Different deep learning architectures for FPGAs, Deep Learning Accelerator scaling on FPGA Creating ASICs for AI. Pros and cons of using FPGAs for AI workload acceleration.

References:

1. Georg Hager and *Gerherd Wellein, Introduction to High Performance Computing for Scientists and Engineers*, 1st ed. Chapman & Hall / CRC Computational Science series, 2011.
2. David Kirk Wen-mei Hwu, *Programming Messively Parallel Processors, A Hends-on Approach*, 2nd ed. Morgan Kaufmann
3. Jason sanders and Edward Kandrot, *CUDA by Example: An Introduction to General-Purpose GPU Programming*, 1st ed. Addison-Wesley
4. Michael J. Quinn, *Parallel Programming in C with MPI and OpenMP*, 1st ed. McGraw-Hill
5. Palnitkar S. *Verilog HDL: a guide to digital design and synthesis.* 1st ed. Prentice Hall Professional; 2003.Y. Bengio, I. Goodfellow and A. Courville, "Deep Learning", MIT Press, 2016.
6. Wolf W. *FPGA-based system design.* 1st ed. Pearson Education India; 2004.
7. Kilts S. *Advanced FPGA design: architecture, implementation, and optimization.* 1st ed. John Wiley & Sons; 2007 Jun 18

CS6314E INTELLIGENT AGENTS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Illustrate the fundamental concepts and functions of intelligent agents.

CO2: Analyze the methodologies for agent interaction negotiation and decisien making

CO3: Apply the principles and methods of intelligent agents to practical preblems

Moduie 1: Introduction to agents and agent based systems (13 Lecture Sessions)

Motivations for agent-based computing, abstract architecture ef agents, types of agents, concepts and models of reasoning, rational decision making and handling uncertainty.

Module 2: Multi agent systems(14 Lecture Sessions)

Classifying multi-agent interactions - cooperative versus non-cooperative agents, models of negotiation, cooperation, cemmunications and reaching agreement in multiagent systems Interaction languages and protocols.

Moduie 3:Agent design and implementation (12 Lecture Sessions)

Application of intelligent agents in complex distributed problem solving, deploying agents within a simulated environment, practical reasoning strategies for distributed scenarios.

References:

1. M. Wooldrldge, *An Introduction to MuitiAgent Systems* , 2nd ed. Wiley, 2009.
2. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach* , 3rd ed. Prentice Hall, 2009.
3. Current Literature.

CS6315E: INTERNET OF THINGS

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: To illustrate the technelogy and standards relating to IeT

CO2: To design and develop domain specific IoT systems

CO3: To analyze the IoT applications and provide domain specific solutions

Module 1: Introduction to Internet of Things (8 Lecture Sessions)

Introduction to IoT, things in IeT, IoT functional blocks, IeT communication models and communication APIs, sensors, actuators, smart objects, basics of sensor networks, basics of networking and communication protocols, machine-to-machine communications, IoT network architecture & design, relationship of IoT with SDN and NFV, cloud, and fog computing

Modulo 2: Device and Communication layer (12 Lecture Sessions)

IeT access technologies, physical layer and MAC layer, LoRaWAN, IEEE 802.11ah and IEEE 805.12.4, IoT network layer: need for optimization, optimizing IP fer IoT - 6LoWPAN to 6Lo, 8TiSCH and RPL

Module 3: Application layer (12 Lecture Sessions)

IoT application layer: ioT application and transport methods, CoAP, AMQP, message queues and publish/subscribe model, MQTT, interoperability – MQTT vs. AMQP

Module 4: Domain specific IoT (7 Lecture Sessions)

Domain specific IoTs: smart lighting, smart appliances, structure healthcare monitoring, pollution monitoring, surveillance. IoT physical devices and endpoints, servers and cloud platform, data analytics for IoT - machine learning overview, case studies on illustrating IoT design

Referencos

1. Adrian McEwen and Hakim Cassimally, "*Designing the Internet of Things*", UK: Wiley Publications, 1st ed. 2014
2. Jean-Philippe Vasseur and Adam Dunkels, "*Interconnecting Smart Objects with IP: The Next Internet*", 1st ed, USA: Morgan Kaufmann Publications, 2010
3. Edward Ashford Lee and Sanjit A Seshia,"*Introduction to Embedded Systems –A Cyber–Physical Systems Approach*", 2nd ed. USA: MIT Press; 2017
4. Hanes David, Salgueiro Gonzalo, Grossetete Patrick, Barton Rob, and Henry Jerome, "*IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things*", 1st ed, UK: Pearson Education, 2017
5. Simone Cirani, Gianluigi Ferrari, Marco Picone, and Luca Veltri, "*Internet of Things: Architectures, Protocols and Standards*", 1st ed, USA: Wiley–Blackwell, 2018
6. Recent peer reviewed journal papers

CS6316E MUSIC INFORMATION RETRIEVAL

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: To illustrate fundamental concepts of music information retrieval.

CO2: To perform audie feature extraction and analysis of music.

CO3: To design and implement solutions fer a given music informatien retrieval problem.

Modulo 1: Extracting Information Frem Muslo Signais (11 Lecture Sessions)

Introduction to music Information retrieval (MIR): history and evolutlon.
Music modalities and representations: time, frequency, and sinusolds, DFT and time-frequency representatlons, audio feature extraction

Module 2: Fundamentai MiR tasks (14 Lecture Sesslons)

Pitch Detection: rhythm analysis, genre classificatien, emotion recognition, auto-tagging, music similarity, evaluation in music information retrieval.

Module 3: Advanced Tasks and Retrieval Systems (14 Lecture Sessions)

Query Retrieval, structure segmentation, chord detection and cover song identification, music recommendation systems

References:

1. M. Müller, *Fundementals of music processing: Audio, enalysis, algorithms*, applications. Vol. 5. Cham: Springer, 2015.
2. T. LI, M. Oglhara, and G.Tzanetakis, Eds, *Music data mining*, Vel. 20., Boca Raton: CRC Press, 2012.

CS6317E TOPICS IN NATURAL LANGUAGE PROCESSING

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze the applications of language modeling, information extraction, named entity recognition, information retrieval, text classification, word sense disambiguation, automatic question answering and text summarization in real world problems.

CO2: Illustrate the complexity of natural language grammatical structures with an emphasis on the English language by demonstrating various parsing techniques

CO3: Apply natural language processing (NLP) tools and libraries (such as python, nltk) and develop software tools for various NLP tasks such as tagging, parsing and text classification.

CO4: Design new solutions to issues ef current interest from recently published literature, and do a comparative analysis of different possibilities.

Module 1: Natural Language Understanding (9 Lecture Sessions)

Natural Language understanding: The study of language, Applications of NLP, Evaluating language understanding systems, Levels of language analysis, Representations and Understanding, Organization of Natural Language Understanding systems, Linguistic background: An outline of English syntax.

Module 2: Grammars and Parsing (10 Lecture Sessicns)

Grammars and parsing: grammars and sentence structure, top-down and bettom-up parsers, transition network grammars, top-down chart parsing. feature systems and augmented grammars: basic feature system for English, morphological analysis and the lexicon, parsing with features, Augmented Transition Networks.

Module 3: Grammars for Natural Languages (10 Lecture Sessions)

Grammars for Natural language: Auxiliary Verbs and Verb Phrases, Movement phenomenon in language, Handling questions in context-free grammars,Human preferences in parsing, Encoding uncertainty, Deterministic parser, Ambiguity resolution: Statistical methods, Estimating probabilities.

Module 4: Advanced Topics (10 Locture Sessions)

Part-of-Speech tagging, Probabilistic Context-free Grammars, Semantics and Logical form, Word senses and Ambiguity, Information Extraction, Named Entity Recognition, Machine Translation, Summarization, Question Answering, Recent trends in NLP.

References

1. J. Allen, *Naturel Language Understanding,* 2nd ed, Pearsen Education, 2003.
2. D. Jurafsky and J. H. Martin, *Speech and Language Processing*, 2nd ed, Pearson Education, 2009.
3. C. D. Manning and H. Schütze, *Foundations of Statistical Natural Language Processing*, 1st ed, The MIT Press, Cambridge, Massachusetts.1999.
4. Current Literature.

CS6316E NEURAL NETWORKS AND DEEP LEARNING

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Define basics of neural networks and learning rules of deep neural networks.

CO2: Analyze the mathematical, statistical and computational challenges of building stable representations for high-dimensional data, such as images and text using case studies and propose appropriate solutions.

CO3: Apply deep learning algorithms to solve simple real world problem situations. .

Module 1: (9 Lecture Sessions)

Biologically inspired computing, historical context, Perceptron Learning rule, Backpropagation, Multi-layer Perceptron model, Activation Functions – Sigmoid, Tanh, ReLU, Leaky ReLu, Loss functions, Optimization: Stochastic gradient descent, Training Neural Networks, weight initialization, batch normalization, hyper parameter optimization, parameter updates, model ensembles, dropout, Variance, Bias.

Module 2: (10 Lecture Sessions)

Convolutional Neural Networks: introduction, history, architectures, convolution layer, pooling layer, fully connected layer, Conv Net, Case study of ImageNet challenge -LeNet, AlexNet, VGG, GoogLeNet, ResNet, InceptionNet, EfficientNet etc. Regularization Techniques, Data Augmentaticn – zooming, rotation, cropping, blurring, noise addition, self-supervision techniques, Transfer Learning, freezing the input layers, fine tuning output layers.

Module 3: (10 Lecture Sessions)

Image Localisation, Image segmentation, masks, Image segmentation architectures – Unet, VNet, UNet++, Object Detection – Region Proposal Networks, Objection architectures RCNN, Fast and Faster RCNNs, Mask RCNN, YOLO, BiFPN layers, Centre Net, EfficientDet, Case study – RoI cropping in CT images and Cervical Images.

Module 4: (10 Lecture Sessions)

Sequential models, Recurrent Neural Networks, Long Short Term Memory, Gated Recurrent Units, NLP based Applications, Identifying missing words in a paragraph, text summarization
Deep Learning Hardware and Software, CPUs, GPUs, GPU architectures – Pascal, Volta, Turing & Ampere, Data Parallelism in GPU, Kernels – vector addition, vector multiplication, matrix addition, matrix multiplication, TPUs, Frameworks for Deep Learning - PyTorch, TensorFlow, Keras, Theano, Caffe, Nvidia DGX machines for DL applications.

References

1. Y. Bengio, I. Goodfellow and A. Courville, *Deep Learning*, 1st ed MIT Press, 2016.
2. Bishop C. M., *Pattern Recognition and Machine Learning*, 1st ed Springer, 2006.
3. Geoffrey E. Hinton, *Neural network architectures for artificial intelligence*, 1st ed American Association for Artificial Intelligence Menlo Park, 1988, ISBN:0-929280-15-6.
4. Adrian Rosebrock, *Deep Learning for Computer Vision with Python*, E-Book, 1st ed, September 2017.

CS6319E SPEECH INFORMATION PROCESSING

Pre-requisites: NIL

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Illustrate the fundamental concepts of Speech Processing.

CO2: Apply various Speech analysis & Modeling techniques used for building speech processing modules.

CO3: Design and build speech recognition systems using Deep Learning architectures.

Module 1: Basic Concepts (10 Lecture Sessions)

Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – acoustics of speech production; Review of Digital Signal Processing concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods.

Module 2: Speech Analysis (10 Lecture Sessions)

Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures – mathematical and perceptual – Log Spectrai Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.

Module 3: Speech Modeling (10 Lecture Sessions)

Speech Modeling: Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues.Speech Recognition: Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition ystem – acoustics and language models – ngrams, context dependent sub-word units;

Module 4: Applications and Advanced Topics (9 Lecture Sessions)

Applications and present status. Speech Synthesis: Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, subword units for TTS, intelligibility and naturalness – role of prosody, Applications and present status.

Introduction Speech Processing using Deep learning, Recurrent neural networks, parameter learning with backpropagation, vanishing and exploding gradients, Introduction to long short term memory (LSTM) networks. Introduction to convolutional neural networks.

Rcferences

1. Lawrence Rabiner and Biing-Hwang Juang, "*Fundamentals of Speech Recognition*", 1st ed. Pearson Education.
2. Daniel Jurafsky and James H Martin, "*Speech and Language Processing – An Introductien to Natural Language Processing, Computational Linguistics, and Speech Recegnition*",1st ed. Pearson Education.
3. Thomas F Quatieri, "*Discrete-Time Speech Signal Processing – Principles and Practice*",1st ed. Pearson Education.
4. Frederick Jelinek, "*Statistical Methods ef Speech Recognition*",1st ed. MIT Press.
5. Dong Yu, Li Deng, "*Autematic Speech Recognition, A Deep Learning Approach*",1st ed. Springer, 2014.

ANNEXURE – II

OPTION – I

National Institute of Technology Calicut

Academic Calendar for Monsoon Semester 2023-24 (All batches except 2023 admissions of B.Tech, B.Arch, M.Tech, M.Plan & MSc.)

Bold numbers 1 to 65 indicate instructional days

	Date	Aug-23	Date	Sep-23	Date	Oct-23	Date	Nov-23	Date	Dec-23
Sat										
Sun					1					
Mon	Enrollment Day (Mandatory Physcial Reporting) 31st July 2023				2	Gandhi Jayanti				
Tue	1	**1**			3	**33**				
Wed	2	**2**			4	**34**	1	**51**		
Thu	3	**3**			5	**35**	2	**52**		
Fri	4	**4**	1	**22**	6	**36**	3	**53**	1	Endsem
Sat	5		2		7		4		2	
Sun	6		3		8		5		3	
Mon	7	**5**	4	**23**	9	**37**	6	**54**	4	Endsem
Tue	8	**6**	5	**24**	10	**38**	7	**55**	5	Endsem
Wed	9	**7**	6	**25**	11	**39**	8	**54** #Monday TT	6	Endsem
Thu	10	**8**	7	**26**	12	**40**	9	**57**	7	
Fri	11	**9**	8	**27**	13	**41**	10	**58**	8	
Sat	12		9		14		11		9	
Sun	13		10		15		12	Deepavali	10	
Mon	14	**10**	11	**28**	16	**42**	13	**59**	11	
Tue	15	Independence Day	12	**29**	17	**43**	14	**60**	12	
Wed	16	**11**	13	**30**	18	**44**	15	**61** ##Tuesday TT	13	
Thu	17	**12**	14	MidSem	19	**45**	16	**62**	14	
Fri	18	**13** Add/Drop Late Registration	15	MidSem	20	Tathva	17	**63**	15	
Sat	19		16		21	Tathva	18		16	
Sun	20		17		22	Tathva	19		17	
Mon	21	**14**	18	MidSem	23	Maha Navami	20	**64**	18	
Tue	22	**15**	19	MidSem	24	Vijaya Dasami Dussehra	21	**65**	19	Results
Wed	23	**16**	20	MidSem	25	**46**	22	Buffer Day	20	
Thu	24	**17**	21	MidSem	26	**47**	23	End Sem	21	
Fri	25	**18**	22	MidSem	27	**48**	24	End Sem	22	
Sat	26		23		28		25		23	
Sun	27		24		29		26		24	
Mon	28	**19**	25	MidSem	30	**49**	27	Guru Nank Jayanti	25	Christmas Day
Tue	29	Onam	26	MidSem	31	**50**	28	End Sem	26	
Wed	30	**20**	27	**31**			29	End Sem	27	REX/Makeup**
Thu	31	**21**	28	Id-E-Milad*			30	End Sem	28	REX/Makeup
Fri			29	**32**					29	REX/Makeup
Sat			30						30	

1	Monsoon 2023-24 Enrolment Day (Mandatory Physical Reporting)	31.07.2023
2	First Instructional Day	01.08.2023
3	Late Registration	18.08.2023
4	Last Date for Add/Drop Courses	18.08.2023
5	Last Instructional Day	21.11.2023
6	Result Declaration	19.12.2023
7	**REX /Make Up Examination	27.12.2023 to 04.01.2024
8	*Depends on sighting of moon	28.09.2023
9	# Instructional Day with Monday Time Table	08.11.2023
10	## Instructional Day with Tuesday Time Table	15.11.2023
11	Registration to Winter 2023 and Fee Payment without fine (Online)	20.12.2023 to 30.12.2023
12	Enrolment to Winter 2023 (Physical Reporting)	01.01.2024

National Institute of Technology Calicut

Academic Calendar for Winter Semester 2023-24 (All batches except 2022-23 UG admissions)

Bold numbers 1 to 65 indicate instructional days

	Date	Jan-24	Date	Feb-24	Date	Mar-24	Date	April-24	Date	May-24
Sat										
Sun										
Mon	1	Enrollment Day (Physical Reporting)					1	**51**		
Tue	2	**1**					2	**52**		
Wed	3	**2**					3	**53** #Friday TT	1	End Sem
Thu	4	**3**	1	**22**			4	**54**	2	End Sem
Fri	5	**4**	2	**23**	1	**34**	5	**55**	3	End Sem
Sat	6		3		2		6		4	
Sun	7		4		3		7		5	
Mon	8	**5**	5	**24**	4	**35**	8	**56**	6	End Sem
Tue	9	**6**	6	**25**	5	**36**	9	If-ul-Fitr*	7	End Sem
Wed	10	**7**	7	**26**	6	**37**	10	**57**	8	
Thu	11	**8**	8	**27**	7	**38**	11	**58** #Friday TT	9	
Fri	12	**9**	9	**28**	8	Ragam	12	**59**	10	
Sat	13		10		9	Ragam	13		11	
Sun	14		11		10	Ragam	14		12	
Mon	15	**10**	12	**29**	11	**39**	15	**60**	13	
Tue	16	**11**	13	**30**	12	**40**	16	**61**	14	
Wed	17	**12**	14	**31**	13	**41**	17	**62** #Friday TT	15	
Thu	18	**13**	15	Mid Sem	14	**42**	18	**63**	16	
Fri	19	**14**	16	Mid Sem	15	**43**	19	**64**	17	
Sat	20		17		16		20		18	
Sun	21		18		17		21	Mahavir Jayanti	19	
Mon	22	**15**	19	Mid Sem	18	**44**	22	**65**	20	Results
Tue	23	**16**	20	Mid Sem	19	**45**	23	Buffer Day	21	
Wed	24	**17**	21	Mid Sem	20	**46**	24	Buffer Day	22	
Thu	25	**18** Add/Drop Late Registration	22	Mid Sem	21	**47**	25	End Sem	23	Budha Purnima
Fri	26	Republic Day	23	Mid Sem	22	Sports Day	26	End Sem	24	
Sat	27		24		23		27		25	
Sun	28		25		24		28		26	
Mon	29	**19**	26	Mid Sem	25	Holi	29	End Sem	27	
Tue	30	**20**	27	Mid Sem	26	**48**	30	End Sem	28	Rex Examinations
Wed	31	**21**	28	**32**	27	**49**			29	Rex Examinations
Thu			29	**33**	28	**50**			30	Rex Examinations
Fri					29	Good Friday			31	Rex Examinations
Sat					30					

1	Winter 2023-24 Enrollment Day (Mandatory Physical Reporting)	01.01.2024
2	First Instructional Day	02.01.2024
3	Late Registration	25.01.2024
4	Last Date for Add/Drop Courses	25.01.2024
5	Last Instructional Day	22.04.2024
6	Result Declaration	20.05.2024
7	**REX /Make Up Examination	28.05.2024 to 07.06.2024
8	SAY Examination for AY 2023-24	15.07.2024 to 27.07.2024
9	*Depends on sighting of moon	09.04.2024
10	# Instructional Day with Friday Time Table	11.04.2024 & 17.04.2024
11	Registration to Monsoon 2024 and Fee Payment without fine (Online)	15.07.2024 to 27.07.2024
12	Enrolment to Monsoon 2024 (Mandatory Physical Reporting)	29.07.2024

OPTION – II

National Institute of Technology Calicut

Academic Calendar for Monsoon Semester 2023-24 (All batches except 2023 admissions of B.Tech, B.Arch, M.Tech, M.Plan & MSc.)

Bold numbers 1 to 65 indicate instructional days

	Date	Aug-23	Date	Sep-23	Date	Oct-23	Date	Nov-23	Date	Dec-23
Sat										
Sun					1					
Mon	Enrollment Day (Mandatory Physical Reporting) 31st July 2023				2	Gandhi Jayanti				
Tue	1	**1**			3	**33**				
Wed	2	**2**			4	**34**	1	**51**		
Thu	3	**3**			5	**35**	2	**52**		
Fri	4	**4**	1	**22**	6	**36**	3	**53**	1	Endsem
Sat	5		2		7		4		2	
Sun	6		3		8		5		3	
Mon	7	**5**	4	**23**	9	**37**	6	**54**	4	Endsem
Tue	8	**6**	5	**24**	10	**38**	7	**55**	5	Endsem
Wed	9	**7**	6	**25**	11	**39**	8	Monday TT#	6	Endsem
Thu	10	**8**	7	**26**	12	**40**	9	**57**	7	
Fri	11	**9**	8	**27**	13	**41**	10	**58**	8	
Sat	12		9		14		11		9	
Sun	13		10		15		12	Deepavali	10	
Mon	14	**10**	11	**28**	16	**42**	13	**59**	11	
Tue	15	Independence Day	12	**29**	17	**43**	14	**60**	12	
Wed	16	**11**	13	**30**	18	**44**	15	Tuesday TT##	13	
Thu	17	**12**	14	MidSem	19	**45**	16	**62**	14	
Fri	18	**13** Add/Drop Late Registration	15	MidSem	20	Tathva	17	**63**	15	
Sat	19		16		21	Tathva	18		16	
Sun	20		17		22	Tathva	19		17	
Mon	21	**14**	18	MidSem	23	Maha Navami	20	**64**	18	Results/
Tue	22	**15**	19	MidSem	24	Vijaya Dasami Dussehra	21	**65**	19	"Enrollment (Physical Reporting) Winter 2023-24"
Wed	23	**16**	20	MidSem	25	**46**	22	Buffer Day	20	
Thu	24	**17**	21	MidSem	26	**47**	23	End Sem	21	
Fri	25	**18**	22	MidSem	27	**48**	24	End Sem	22	
Sat	26		23		28		25		23	
Sun	27		24		29		26		24	
Mon	28	**19**	25	MidSem	30	**49**	27	Guru Nank Jayanti	25	Christmas Day
Tue	29	Onam	26	MidSem	31	**50**	28	End Sem	26	
Wed	30	**20**	27	**31**			29	End Sem	27	REX/Makeup**
Thu	31	**21**	28	Id-E-Milad*			30	End Sem	28	REX/Makeup
Fri			29	**32**					29	REX/Makeup
Sat			30						30	

1	Monsoon 2023-24 Enrollment Day (Mandatory Physical Reporting)	31.07.2023
2	First Instructional Day	01.08.2023
3	Late Registration	18.08.2023
4	Last Date for Add/Drop Courses	18.08.2023
5	Last Instructional Day	21.11.2023
6	Result Declaration	18.12.2023
7	**REX /Make Up Examination	27.12.2023 to 04.01.2024
8	*Depends on sighting of moon	28.09.2023
9	# Instructional Day with Monday Time Table	08.11.2023
10	## Instructional Day with Tuesday Time Table	15.11.2023
11	Registration to Winter 2023 and Fee Payment without fine (Online)	08.12.2023 to 18.12.2023
12	Enrolment to Winter 2023 (Mandatory Physical Reporting)	19.12.2023

National Institute of Technology Calicut

Academic Calendar for Winter Semester 2023-24 (All batches except 2022-23 UG admissions)

Bold numbers 1 to 65 indicate instructional days

	Date	Dec-23	Date	Jan-24	Date	Feb-24	Date	Mar-24	Date	April-24	Date	May-24
Sat												
Sun												
Mon			1	**8**					1	**60**		
Tue			2	**9**					2	**61**		
Wed			3	**10**					3	**62** ##Monday TT	1	
Thu			4	**11**	1	**30**			4	**63**	2	
Fri	1		5	**12** Add/Drop Late Registration	2	**31**	1	**42**	5	**64**	3	
Sat	2		6		3		2		6		4	
Sun	3		7		4		3		7		5	
Mon	4		8	**13**	5	Midsem	4	**43**	8	**65**	6	
Tue	5		9	**14**	6	Midsem	5	**44**	9	Id-ul-Fitr*	7	
Wed	6		10	**15**	7	Midsem	6	**45**	10	Buffer Day	8	
Thu	7		11	**16**	8	Midsem	7	**46**	11	End Sem	9	
Fri	8		12	**17**	9	Midsem	8	Ragam	12	End Sem	10	
Sat	9		13		10		9	Ragam	13		11	
Sun	10		14		11		10	Ragam	14		12	
Mon	11		15	**18**	12	Midsem	11	**47**	15	End Sem	13	
Tue	12		16	**19**	13	Midsem	12	**48**	16	End Sem	14	
Wed	13		17	**20**	14	Midsem	13	**49**	17	End Sem	15	
Thu	14		18	**21**	15	Midsem	14	**50**	18	End Sem	16	
Fri	15		19	**22**	16	**32**	15	**51**	19	End Sem	17	
Sat	16		20		17		16		20		18	
Sun	17		21		18		17		21	Mahavir Jayanti	19	
Mon	18	Results Monsoon 2023-24	22	**23**	19	**33**	18	**52**	22	End Sem	20	REX Examination
Tue	19	Enrollment Day	23	**24**	20	**34**	19	**53**	23	End Sem	21	REX Examination
Wed	20	**1**	24	**25**	21	**35**	20	**54**	24	End Sem	22	REX Examination
Thu	21	**2**	25	**26**	22	**36**	21	**55**	25		23	Budha Purnima
Fri	22	**3**	26	Republic Day	23	**37**	22	**56**	26		24	REX Examination
Sat	23		27		24		23		27		25	
Sun	24		28		25		24		28		26	
Mon	25	Christmas Day	29	**27**	26	**38**	25	Holi	29		27	REX Examination
Tue	26	**4**	30	**28**	27	**39**	26	**57**	30		28	REX Examination
Wed	27	**5**	31	**29**	28	**40**	27	**58**			29	REX Examination
Thu	28	**6**			29	**41**	28	**59** #Friday TT			30	REX Examination
Fri	29	**7**					29	Good Friday			31	
Sat	30						30					

1	Winter 2023-24 Enrollment Day (Mandatory Physical Reporting)	19.12.2023
2	First Instructional Day	20.12.2023
3	Late Registration	05.01.2024
4	Last Date for Add/Drop Courses	05.01.2024
5	Last Instructional Day	08.04.2024
6	Result Declaration	06.05.2024
7	**REX /Make Up Examination	20.05.2024 to 30.05.2024
8	SAY Examination for AY 2023-24	15.07.2024 to 27.07.2024
9	*Depends on sighting of moon	09.04.2024
10	# Instructional Day with Friday Time Table	28.03.2024
11	## Instructional Day with MondayTime Table	03.04.2024
12	Registration to Monsoon 2024 and Fee Payment without fine (Online)	15.07.2024 to 27.07.2024
13	Enrolment to Monsoon 2024 (Mandatory Physical Reporting)	29.07.2024

Annexure III

Department Suggestions on the options for tho 2023-24 calendar proposed by the institute:

Option 2 Calendar: Compressing the academic calendar to not even one week of break between semesters can be very stressful to faculty, as there is very littie time to plan for the next semester course and one wouid end up in the class without any serious time to prepare the course. Hence Option 2 academic calendar is not recommendable.

Changes proposed in Option 1 Calendar:

a) September 16 Saturday and September 23 Saturday 2023 may be additionally aliotted for mid sem examination. This involves reiativeiy iess stress, as oniy facuity members having exam duty on those days (C slot exam and G slot exam) will be required to report for duty. Staff, except those related to the exam ceil, need not be given duty, as these are exam days.

b) Saturday November 18th, 2023 may be made the buffer day and may be marked as an optionai instructional day. if classes are finished, faculty need not report for duty.

c) These modifications will aiiow the end exams for Monsoon Semester to start from Monday 20th November and finish on 1st December Friday (instead of finishing on 6th December Wednesday as per the present Option1 Caiendar).

d) Result declaration may be on Tuesday 12th December 2023. (facuity wili get at least 10 days of paper valuation time). Vacation may start on that date.

e) Vacation may be from 12th December to 18th December (7 days).

f) Now, the next semester can still start on 19th December, as per Option 2 Calendar, with much iess work pressure in December.