SYLLABUS BOOKLET

PhD Course work courses
(Seven Level Courses)
(Computer Science and Engineering)

Department Postgraduate Committee (DPGC)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
(BANARAS HINDU UNIVERSITY)
VARANASI-221005
INDIA

Introduction:

The Department of Computer Science and Engineering was established in July 1983. The department offers following programmes:

1. 4-Years B.Tech. programme in Computer Sc. & Engineering
2. 5 Years Integrated Dual Degree (B.Tech. and M.Tech.) programme in Computer Sc. & Engineering and
3. Ph.D. degree in various specializations of Computer Sc. and Engineering.

Computer Sc. & Engineering is the most sought-after branch for the JEE selected students that come to the Institute. Our graduates have distinguished themselves in higher studies at the top Universities. They also occupy positions of eminence in the computer industry. Our Alumni remain in constant touch with us and are contributing in the development of the department. Placements for our graduates are the best in the Institute. The faculty members of the department have international experience and training.

The departmental research is focused in the areas of Artificial Intelligence, Neuro Computing, Parallel Processing, Software Engineering, Image Processing and Computer Vision, Medical Image Processing, Pattern Recognition, Datamining and Webmining, Biometrics, semantic web, Natural Language Processing (NLP), Machine Learning, and Information Extraction. Besides plan funding, the Department attracts financial inputs through externally funded projects.

Programme Objective:

The basic objective of the programme offered by the Dept. is to train the students in the area of Computer Science and Engineering and its streams at various levels UG/PG. Apart from learning the concepts of development of skills related to the discipline, the courses are designed in such a way that covers most of the basic as well as advanced courses required for pursuing PhD research in a specific area.

Curriculum Overview:

The PhD course work courses are designed in such a way that facilitates the start of the research in following areas of Computer Science and Engineering:

Artificial Intelligence, Neuro Computing, Parallel Processing, Software Engineering, Image Processing and Computer Vision, Medical Image Processing, Pattern Recognition, Data mining and Webmining, Biometrics, semantic web, Natural Language Processing (NLP), Machine Learning, and Information Extraction, Computer Networks , and wireless sensor networks etc.

List of Courses for Ph.D. Level Course Work
(Computer Science and Engineering)

S. N.	Course Code	Course Name	Credits	Credit breakup L-T-P-A
1.	CS-7001	Selected Topics in Machine Learning	11	3-0-0-2
2.	CS-7002	Bio inspired Computation	11	3-0-0-2
3.	CS-7003	Software Metrics	11	3-0-0-2
4.	CS-7004	Digital Video Processing	11	3-0-0-2
5.	CS-7005	Biometrics	11	3-0-0-2
6.	CS-7006	Image Processing & Computers Vision	11	3-0-0-2
7.	CS-7007	Advanced Parallel Algorithms	11	3-0-0-2
8.	CS-7008	Advanced Computational Mathematics	11	3-0-0-2
9.	CS-7009	Advanced Simulation & Modeling	11	3-0-0-2
10.	CS-7010	Pattern Recognition	11	3-0-0-2
11.	CS-7011	High Performance Computing	11	3-0-0-2
12.	CS-7012	Computational Aspects of Bioinformatics	11	3-0-0-2
13.	CS-7013	Selected Topics in Social Network Analysis	11	3-0-0-2
14.	CS-7014	Advanced Topics in Multimedia & Application	11	3-0-0-2
15.	CS-7015	Advanced Knowledge Based Systems	11	3-0-0-2
16.	CS-7016	Researches Software Implementation	11	0-0-6-5
17.	CS-7017	Research Tools Programming Practice	11	0-0-6-5
18.	CS-7018	Advanced Topics in Data Mining	11	3-0-0-2
19.	CS-7019	Recent Topics in Computer Networking	11	3-0-0-2
20.	CS-7020	Cloud Computing	11	3-0-0-2
21.	CS-7021	Advanced Topics in Algorithms	11	3-0-0-2
22.	CS-7022	Cognitive Computation	11	3-0-0-2

23.	CS-7023	Computer and Scripting – I	11	3-0-0-2
24.	CS-7024	Computer and Scripting – II	11	3-0-0-2
25.	CS-7025	Selected Topics in Artificial Intelligence	11	3-0-0-2
26.	CS-7026	Selected Topics in Natural Language Processing	11	3-0-0-2
27.	CS-7027	Selected Topics in Mobile Computing	11	3-0-0-2
28.	CS-7028	Selected Topics in Wireless Network	11	3-0-0-2
29.	CS-7029	Selected Topics in Augmented Reality and Virtual Reality	11	3-0-0-2
30.	CS-7030	Information Retrieval	11	3-0-0-2

Credit calculation: C = 3 L + 2 T + P + A (As per PG Ordinance)

L= No. of hours of Lectures per week, T=No. of Tutorials per week, P= no of practical hours per week, A= No. of hours of additional work per week

Selected Topics in Machine Learning

1. GENERAL
1.1 TITLE:: Selected topics in Machine Learning
1.2 *COURSE NUMBER (if known):: CS-7001
1.3 CREDITS:: 3-0-0-2
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Probability and Statistics, Engineering Maths
2. OBJECTIVE:: The course will provide the concepts of Selected topics in Machine Learning.
3. COURSE TOPICS::
Unit 1: Introduction
to Machine Learning, Probability Theory, Model Selection, The Curse of Dimensionality, Decision Theory, Information Theory

Unit 2: Probability Distributions: Binary Variables, Multinomial Variables, The Gaussian distribution, The Exponential Family, Nonparametric Methods

Unit 3: Linear Models for Regression: Linear Basis Function Models, The Bias-Variance Decomposition , Bayesian Linear Regression ,Bayesian Model Comparison, The Evidence Approximation, Limitations of Fixed Basis Functions

Unit 4: Linear Models for Classification L: Discriminant Functions, Probabilistic Generative Models, Probabilistic Discriminative Models , The Laplace Approximation,, Bayesian Logistic Regression

Unit 5: Neural Networks and Kernel Methods

4. READINGS
4.1 TEXTBOOK:: Christopher M. Bishop. 2006. *Pattern Recognition and Machine Learning (Information Science and Statistics)*. Springer-Verlag New York, Inc., Secaucus, NJ, USA.
4.2 *REFERENCE BOOKS:: As prescribed by the instructor
5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::
6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE:: Understanding of Machine Learning
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::
10. *ANY OTHER REMARKS::

Bio-inspired Computation

1. GENERAL
1.1 TITLE:: **Bioinspired Computation**
1.2 *COURSE NUMBER (if known):: CS-7002
1.3 CREDITS:: [3-0-0-2] 11 Credit
1.4 SEMESTER-OFFERED:: PhD Course work I/II
1.5 PRE-REQUISITES:: Basic Knowledge of Probability and Computational Methods, Some Experience in Programming.

2. OBJECTIVE:: Student will have working knowledge of Evolutionary Theory and Algorithms and able to explain how biological systems exploit natural processes. The main focus will be on the details of the techniques such as ACO, PSO and artificial neural System and related learning algorithms.

3. COURSE TOPICS::

Unit-I: Evolutionary Computation:

Foundation of Evolutionary theory, Evolutionary Strategies, Evolutionary programming, Evolutionary Algorithms, Evolutionary Algorithm Case Study, Genetic Algorithm, Genetic Representations, Initial Population, Fitness Function, Selection and Reproduction, Genetic Operators(Selection, Crossover, Mutation), Artificial Immune Systems, Other Algorithms Harmony Search, Honey-Bee Optimization, Memetic Algorithms, Co-evolution, Multi-Objective Optimization, Artificial Life, Constraint Handling

Unit-II: Neural Networks:

Neural Networks: Neuron Models, Neuron Architecture, Mathematical Model of Neural Networks, , Artificial Neural Network Learning Methods and Learning Strategies, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Activation Functions, Pattern Classification and Linear Separability, Single and Multilayer Perceptron Network, Self-Organizing Map (Kohonen network), Hopfield Network, Back Propagation Network, Radial Basis function Network

Unit III: Collective Systems

Collective Behavior and Swarm Intelligence, Particle Swarm Optimization and Ant Colony Optimization, Artificial evolution of Competing Systems, Artificial Evolution of cooperation and competition. Recent topics from research papers.

4. READINGS
4.1 TEXTBOOK::

- Dario Floreano, Claudio Mattiussi, “Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies”, MIT Press, 2008.
- Eberhart, E. and Y. Shi., “Coputational Intelligence: Concepts and Implementations”, Morgan Kauffmann, San Diego, 2007.

4.2 *REFERENCE BOOKS::

- D. E. Goldberg, “Genetic algorithms in search, optimization, and machine learning”, AddisonWesley, 1989
- R. C. Ebelhart et al., “Swarm Intelligence”, Morgan Kaufmann, 2001.
- M. Dorigo and T. Stutzle, “Ant Colony Optimization”, A Bradford Book, 2004.
- Leandro Nunes De Castro, Fernando Jose Von Zuben, “Recent Developments in Biologically Inspired Computing”, Idea Group Publishing, 2005.
- Kenneth DeJong, Evolutionary Computation A Unified Approach, 2006.
- Gusz Eiben and Jim Smith, Introduction to Evolutionary Computing, 2007.
- Simon O. Haykin, “Neural Networks and Learning Machines”, Third Edition, Prentice Hall, 2008.
- A.E. Elben and J. E. Smith, “Introduction to Evolutionary Computing”, Springer, 2010.

5. OTHER SESSIONS
5.1 *TUTORIALS:: No
5.2 *LABORATORY:: No
5.3 *PROJECT:: Yes

6. ASSESSMENT (indicative only)
6.1 HA:: [5% GRADE]
6.2 QUIZZES-HA:: [5% GRADE]
6.3 PERIODICAL EXAMS:: [20% GRADE]
6.4 *PROJECT:: [0% GRADE]
6.5 FINAL EXAM:: [60% GRADE]

7. OUTCOME OF THE COURSE::

After this course, Student will be able to design and implement simple bio-inspired algorithms like Evolutionary Algorithms, Neural System and Collective intelligence systems.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 5-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Any Department

10. *ANY OTHER REMARKS:: None

Software Metrics

1. GENERAL
1.1 TITLE:: **Software Metrics**
1.2 *COURSE NUMBER (if known):: CS-7003
1.3 CREDITS:: [3-0-0-2] 11 Credits
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Knowledge and exposure to probability and linear programming is necessary, reasonable background in algorithms and discrete mathematics would be needed.
2. OBJECTIVE:: The goal is obtaining objective, reproducible and quantifiable measurements, which may have numerous valuable applications in schedule and budget planning, cost estimation, quality assurance testing, software debugging, software performance optimization, and optimal personnel task assignments.
COURSE TOPICS::
Unit-I: Basics of measurements, Metrics data collection and analysis, measuring internal attributes: Size & structure, measuring external product attributes.
Unit-II: Software reliability. Resource measurement: productivity, teams and tools. Process predictions. Planning and measurement program.
Unit-III: Measurement in practice. Empirical research in software engineering. A case study.
Unit-IV: Selected topics from research papers.
4. READINGS
4.1 TEXTBOOK::
1. Software Testing Fundamentals: Methods and Metrics, Marnie, Wiley.
2. Software Metrics, Second Edition, Fenton, CRC.

4.2 *REFERENCE BOOKS::
1. Applying software metric, Paul Oman, Wiley & Sons

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT:: Different Projects are Given to each student or group of students .
6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE:: Metrics have become an integral part of the software development process. Valuable applications in schedule and budget planning cost estimation, quality assurance testing, software debugging, software performance optimization, and optimal personnel task assignments.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::None
10. *ANY OTHER REMARKS:: None

Digital Video Processing

1. GENERAL
1.1 TITLE:: **Digital Video Processing**
1.2 *COURSE NUMBER (if known):: **CS-7004**
1.3 CREDITS:: 3-0-0-2: 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Engineering Maths

2. OBJECTIVE:: To impart knowledge to the students in the field of Digital Video Processing

3. COURSE TOPICS::

Unit-I

Basic steps of Video Processing: Analog Video, Digital Video, Time-Varying Image Formation models: Three-Dimensional Motion Models, Geometric Image Formation, Photometric Image Formation, Sampling of Video signals, Filtering operations.

Unit-II

Motion Estimation: Optical flow, General Methodologies, Pixel Based Motion Estimation, Block-Matching Algorithm, Mesh based Motion Estimation, Global Motion Estimation, Region based Motion Estimation, Multi resolution motion estimation, Application of 2D motion estimation, Parametric motion models.

Unit-III

Optical Flow methods, Motion-compensated filtering, Video processing operations including noise reduction, restoration, super resolution, de-interlacing and video sampling structure conversion, and compression (frame-based and object-based methods), Video quality assessments.

Unit-IV

Video segmentation, motion segmentation, tracking, optimization
Topics from latest research papers.

4. READINGS
4.1 TEXTBOOK:: As advised by course instructor

(1) Digital Video Processing – M. Tekalp, Prentice Hall International
(2) Handbook of image and video processing, Bovik
(3) The Essential Guide to Video Processing, Bovik

4.2 *REFERENCE BOOKS::

(1) Video processing and communication – Yao Wang, Joem Ostermann and Ya-quin Zhang. 1st Ed., PH int.
(2) Digital Video Processing by Tekalp
(3) Topics from latest research papers

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]

7. OUTCOME OF THE COURSE:: Students will have the knowledge of the field of digital video processing.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::

10. *ANY OTHER REMARKS:: None

Biometrics

1. GENERAL
1.1 TITLE:: **Biometrics**
1.2 *COURSE NUMBER (if known):: CS-7005
1.3 CREDITS:: [3-0-0-2] 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Image Processing
2. OBJECTIVE: This course concentrates on the unique advantages that biometrics brings to computer security, but also addresses challenging issues such as security strength, recognition rates, and privacy, as well as alternatives of passwords and smart cards.
3. COURSE TOPICS:
Unit-I: Introduction to Biometrics, Review of related theories/terms, Face Recognition
Unit-II: Iris Recognition, Fingerprint Recognition, Voice/Speaker recognition, Other Biometrics, Multimodal Biometrics.
Unit-III: Privacy and other issues in biometrics, Applications of biometrics & future trends.
Unit-IV: Selected topics from research papers.

4. READINGS
4.1 TEXTBOOK::
Anil K Jain, Patrick Flyn, Arun A Ros, "Handbok of Biometrics", Springer, 208
Biometrics, J. D. Woodward, N. M. Orlans, P.T. Higgins, McGraw-Hill Osborne Media, 2002.
4.2 *REFERENCE BOOKS::
Samir Nanavati, Michael Thieme, Raj Nanavati, "Biometrics – Identiy Verifcation in a Networked World",
Paul Reid, "Biometrics for Network Security", Pearson Education
3. John R Vaca, "Biometric Technologies and Verifcation Systems",
5. OTHER SESSIONS
5.1 *TUTORIALS:: No
5.2 *LABORATORY:: No
5.3 *PROJECT:: Yes
6. ASSESSMENT (indicative only)
6.1 HA:: [0% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [0% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE: Students will gain knowledge in the building blocks of this field: pattern recognition, security and privacy, and secure systems design. The formal component of the course will involve a research project, writing a research paper, and making a presentation on a subject.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: -
10. *ANY OTHER REMARKS:: None

Image Processing and Computer Vision

1. GENERAL

1.1 TITLE:: **Image Processing and Computer Vision**

1.2 *COURSE NUMBER (if known):: CS-7006

1.3 CREDITS:: [3-0-0-2] 11

1.4 SEMESTER-OFFERED:: PhD Course work

1.5 PRE-REQUISITES::

2. OBJECTIVE::

Introduce the student to analytical tools and methods which are currently used in digital image processing and computer vision as applied to image information for human viewing. Then apply these tools in the laboratory in image restoration, enhancement, segmentation, feature extraction, pattern recognition, compression and other computer vision related tasks.

1. COURSE TOPICS::

UNIT-I

1. Introduction

Image acquisition process, Sampling & quantization, Pixel neighbourhood properties (connectivity, path), Concept of matrices (Eigen values, diagonalization etc.), Image transforms (Unitary Transform and properties, 2D Fourier Transform, 2D FFT, Discrete Fourier Transform (DFT), Properties of DFT, 2D DCT and properties, Walsh-Hadamard Transform, K-L Transform, Principal Component Analysis (PCA), Wavelet transform (Definition, Properties, Mathematical function, Mother wavelets)

Selected topics from recent research papers.

UNIT-II

2. Image enhancement and restoration

Image Enhancements: Point processing functions, Piece-wise linear functions, Histogram base methods (histogram equalization, specification and modification), Bit extraction, and other topics.

Restoration (in spatial domain): Image restoration and degradation model, Noise types (Gaussian, Rayleigh, Poisson, other) and their pdfs (Probability Distribution Functions), Averaging Filter (Mean Filters (Arithmetic, Geometric & Harmonic), Inverse filtering, Weiner Filter, Tikhonov Regularization, LMMSE filters, constrained least squares filters, Other related optimization problems.

UNIT-III

3. Edge Detection: Mathematical concepts, Operators based on first order derivative (Roberts, Prewitt and Sobel), Laplacian (Second order derivative based edge detection),LOG
4. Image Segmentation:

Thresholding based (Local, Global, Adaptive), Region based (Region split & merge, Region growing), Cluster based (K-means, Fuzz c-means), Contour based (Snakes' method), Graph based (book/literature)

UNIT-IV

5. Feature extraction: Spatial Features, Amplitude, Transform based features, Fourier Descriptors (FDs), Histogram based statistical features, Based on statistical moments (e.g., mean, variance, kurtosis, etc), Shape/geometry based features & moment based features(Radii, perimeter, area, compactness, max boundary rectangle, orientation etc.), Texture features (GLCM and texture features, Gabor features), Color features

6. Object representation and description

Boundary representation: Chain codes, Polygon approximations, Signatures, Boundary segments, Skeletons

Boundary description: Shape numbers, FDs, Statistical moments

Region representation: Data structures used for representing region (quad tree, RLE, projection)

Region description: Topological description, Texture, Moments, Principal components

UNIT-V

7. Object recognition
    a. Patterns & pattern classification
    b. Recognition based on decision theoretic methods
    c. Structural methods
8. Framework of a computer vision
9. Selected topics from recent research papers

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4. READINGS

4.1 TEXTBOOK::

1. Fundamental of image processing by R.C. Gonzalez
2. Digital image processing by A.K. Jain

4.2 *REFERENCE BOOKS::

1. Image Processing and Analysis by Milan Sonka
2. Selected Research papers from international journal

5. OTHER SESSIONS

5.1 *TUTORIALS::

5.2 *LABORATORY:: 02 Hours Implementation of Algorithms

5.3 *PROJECT:: Projects related to computer vision

6. ASSESSMENT (indicative only)

6.1 HA:: [10% GRADE] 6.2 QUIZZES-HA:: [GRADE] 6.3 PERIODICAL EXAMS:: [30% GRADE] 6.4 *PROJECT:: [10% GRADE] 6.5 FINAL EXAM:: [50% GRADE]

7. OUTCOME OF THE COURSE::

To understand (i.e., be able to describe, analysis and reason about) how digital images are represented, manipulated, encoded and processed, with emphasis on algorithm design, implementation and performance evaluation.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 5-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Maths and Computing, Biomedical Engg., ECE, EE

10. *ANY OTHER REMARKS:: None

Advanced Parallel Algorithms

1.GENERAL
1.1 TITLE:: Advanced **Parallel Algorithms**
1.2 *COURSE NUMBER (if known):: CS-7007
1.3 CREDITS:: [3-0-0-2] 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Data Structures, Algorithms, Graph Theory

2. OBJECTIVE:: The course will highlight parallel algorithmic thinking for obtaining good speed-ups with respect to serial algorithms. The main objective of the class presentations and the written homework will be to study the main theory of parallel algorithms. This includes the design and analysis of parallel algorithms--primarily standard asymptotic analysis. The main objective of the programming assignments will be to reduce this knowledge to practice for improved understanding. One highlight will be achieving hard speedups for the more advanced parallel algorithms studied,

COURSE TOPICS::

Unit-I: PRAM Algorithms: Introduction, selection, merging, sorting, graph problems, Computing the Convex Hull, lower bounds etc.

Unit-II: Mesh Algorithms: Computational Model, Packet Routing, selection, merging, sorting, graph problems.

Unit-III: Hypercube Algoithms: Computational Model, PPR Routing, selection, merging, sorting, graph problems. Parallel programming languages, case studies.

Unit-IV: Selected topics from research papers

READINGS
4.1 TEXTBOOK::

Introduction to Parallel Computing: Design and Analysis of Algorithms by Ananth Grama (Author), George Karypis (Author), Vipin Kumar (Author), Anshul Gupta (Author), 2nd Edison-Wesley.

a. *REFERENCE BOOKS::
   Study and Design of Parallel Algorithms for Interconnection Networks: Parallel Algorithm Design by Prasanta K. Jana, Sudhanshu K. Jha

   Efficient Parallel Algorithms by Wojciech Rytter

5. OTHER SESSIONS
5.1 *TUTORIALS:: No
5.2 *LABORATORY:: No
5.3 *PROJECT::Yes

6. ASSESSMENT (indicative only)
6.1 HA:: [0% GRADE]
6.2 QUIZZES-HA:: [0% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]

6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]

7. OUTCOME OF THE COURSE:: This course examines a variety of issues in the design of parallel algorithms such as: what algorithms and data structures should be used when programming parallel computers; how can the quality of these algorithms be analyzed; what are the factors that influence the performance of algorithms on parallel machines. The students will study features of some parallel programming paradigms in the abstract and will learn important aspects in algorithm implementation by completing several programming projects.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::None

10. *ANY OTHER REMARKS:: None

Advanced Computational Mathematics

1. GENERAL
1.1 TITLE:: Advanced Computational Mathematics
1.2 *COURSE NUMBER (if known):: CS-7008
1.3 CREDITS:: 3-0-0-2 (11 Credits)
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Engineering Maths
2. OBJECTIVE:: To impart knowledge to research students in the selected field of mathematics useful for carrying out their research

3. COURSE TOPICS::
Topics are indicative in nature. Supervisor may add or delete a topic as per requirements of research topic. However, a student must be familiar with most of the following topics.

UNIT-I: Introductory Topics

ALGEBRA, VECTORS AND GEOMETRY:
*Solution of equations *Linear algebra : Determinants, matrices * Vector algebra & solid geometry
CALCULUS:
*Differential calculus and its applications *Partial calculus and its applications *Integral calculus and its applications
*Multiple integrals and beta, gamma functions *Vector calculus and its applications
SERIES:
*Infinite series *Fourier series

UNIT-II

DIFFERENTIAL EQUATIONS:
*Differential equations of first order *Applications of differential equations of first order *Linear differential equations *Applications of linear differential equations *Differential equations of other types *Series solution of differential equations and special functions *Partial differential equations *Applications of partial differential equations

UNIT-III

Probability, random variables and stochastic processes:

Fundamentals of probability and statistics: The Concept of a Random Variable, functions of one and two random variables, probability distribution functions, statistics.

Stochastic Processes: General concepts, Random Walks and Other Applications, Spectral Representation, Spectrum Estimation, Mean square estimation, Entropy. Markov Chains, Markov Processes and Queueing Theory.

UNIT-IV

NUMERICAL TECHNIQUES: (Selected topics)
*Empirical laws and curve-fitting *Statistical methods *Probability and distributions *Sampling and interface *Finite differences and interpolation *Numerical differentiation and integration *Difference equations *Numerical solution of ordinary differential equations *Numerical solution of partial differential equations *Linear programming

Unit-V

Calculus of variations, Euler-Lagrange minimization and other topics

Selected topics as per requirement of research as designed by the faculty advisor/ supervisor

4. READINGS
4.1 TEXTBOOK::

1. Higher Engineering Mathematics: BS Grewal

2. Probability, random variables, and stochastic processes: A. Papoulis, S. Unnikrishna Pillai, MacGraw Hill
4.2 *REFERENCE BOOKS::

Advanced **Engineering Mathematics by** Erwin **Kreyszig**.

5. OTHER SESSIONS
5.1 *TUTORIALS:: nil
5.2 *LABORATORY:: nil
5.3 *PROJECT::nil

5.4 Additional Work: Assignments

6. ASSESSMENT (indicative only)
6.1 HA:: [10% GRADE]
6.2 QUIZZES-HA:: [0% GRADE]

6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [0% GRADE]
6.5 FINAL EXAM:: [50% GRADE]

7. OUTCOME OF THE COURSE:: At the end of the course a student should be familiar with all fundamental topics in mathematics so that it can be applied and used in their research wherever required.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: None

10. *ANY OTHER REMARKS:: None

Advanced Simulation and Modeling

1. GENERAL
1.1 TITLE:: Advanced Simulation and Modeling
1.2 *COURSE NUMBER (if known):: CS-7009
1.3 CREDITS:: 3-0-0-3
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Algorithms, Computer Programming, Probability and statistics
2. OBJECTIVE:: To learn the methodologies and tools for simulation and modeling of a real time problem/ mathematical model.
In this course, modeling and simulation (M&S) methodologies considering both practical and theoretical aspects – Primarily in the context of defense industry and game programming will be studied in details. • By taking the lecture, you will be supported with sufficient knowledge about – A wide range of M&S concepts that will lead you to develop your own M&S applications.
3. COURSE TOPICS::
UNIT-I
Introduction To Modeling & Simulation – What is Modeling and Simulation? – Complexity Types – Model Types – Simulation Types – M&S Terms and Definitions
Input Data Analysis – Simulation Input Modeling – Input Data Collection • Data Collection Problems • Practical Suggestions • Effect of Period of Time – Input Modeling Strategy • Histograms • Probability Distributions • Selecting a Probability Distribution • Evaluating Goodness of Fit
Unit-II
Random Variate Generation – Random Numbers – Random Number Generators – Random Variate Generation • Factors to be considered • General principles –Inverse Transform Method –Acceptance-Rejection Method –Composition Method –Relocate and Rescale Method • Specific distributions
Output Data Analysis – Introduction • Types of Simulation With Respect to Output Analysis • Stochastic Process and Sample Path • Sampling and Systematic Errors • Mean, Standard Deviation and Confidence Interval – Analysis of Finite-Horizon Simulations • Single Run • Independent Replications • Sequential Estimation – Analysis of Steady-State Simulations • Removal of Initialization Bias (Warm-up Interval) • Replication-Deletion Approach • Batch-Means Method
UNIT-III
Comparing Systems via Simulation – Introduction – Comparison Problems • Comparing Two Systems • Screening Problems • Selecting the Best • Comparison with a Standard • Comparison with a Fixed Performance
Discrete Event Simulations – Introduction • Next-Event Time Advance • Arithmetic and Logical Relationships • Discrete-Event Modeling Approaches – Event-Scheduling Approach – Process-Interaction Approach

Unit-IV
Entity Modeling – Entity Body Modeling – Entity Body Visualization – Entity Body Animation – Entity Interaction Modeling – Building Modeling
Distributed Simulation – High Level Architecture (HLA) – Federation Development and Execution Process (FEDEP) – SISO RPR FOM
Behavior Modeling – General AI Algorithms • Decision Trees • Neural Networks • Finite State Machines • Logic Programming • Production Systems – Path Planning • Off-Line Path Planning • Incremental Path Planning • Real-Time Path Planning – Script Programming • Script Parsing • Script Execution

Unit-V
Optimization Algorithms – Genetic Algorithms – Simulated Annealing
Examples: Sensor Systems Modeling – Human Eye Modeling – Optical Sensor Modeling – Radar Modeling

4. READINGS
4.1 TEXTBOOK::
[1] Jerry Banks, "Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice", John Wiley & Sons, Inc., 1998.
[2] George S. Fishman, "Discrete-Event Simulation: Modeling, Programming and Analysis", Springer-Verlag New York, Inc., 2001.
4.2 *REFERENCE BOOKS::
[1] Andrew F. Seila, Vlatko Ceric, Pandu Tadikamalla, "Applied Simulation Modeling", Thomson Learning Inc., 2003.
5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::
6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE:: • Develop a small-scale M&S project • The project will include: – Documentation, – Implementation and – A class presentation.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::
10. *ANY OTHER REMARKS::

Pattern Recognition

1. GENERAL

1.1 TITLE:: **Pattern Recognition**

1.2 *COURSE NUMBER (if known):: CS-7010

1.3 CREDITS:: [3-0-0-2] 11 Credits

1.5 PRE-REQUISITES::

Algorithms, Probability theory.

2. OBJECTIVE::

This course deals with pattern recognition which has several important applications. For example, multimedia document recognition (MDR) and automatic medical diagnosis are two such.

1. COURSE TOPICS::

Unit-I

Pattern & Pattern classes, Pattern recognition Design Cycle, Feature Extraction: Feature processing & normalization, Learning (Supervised, Unsupervised, Reinforced).
Preliminary concepts and pre-processing phases, coding, normalization, filtering, linear prediction, Feature extraction and representation thresholding, contours, regions, textures, template matching, Hidden Markov Models, Taxonomy of pattern classifiers
Performance measurement metrics: Confusion matrix, Accuracy, Precision, Recall, ROC curve, Area Under Curve (AUC), Confidence intervals.
Data partitioning (K-fold cross validation, Leave one out , Leave m-out)

Unit-II

Data structure for pattern recognition, statistical pattern recognition, clustering Technique and application. Study of pattern classifiers: Supervised and unsupervised.

Unit-III

Pattern Classifiers: Statistical: Bayesian theorem, Bayesian classifier: Minimum distance, Maximum likelihood), Naïve Bayes, Linear Discriminant Analysis, k- nearest neighbour (K-NN), Artificial Neural Network etc. and Case studies.

UNIT-IV

Clustering techniques and algorithms
Deep learning
Selected topics from research papers

Unit-V

Selected topics from research papers and reference books

4. READINGS

4.1 TEXTBOOK::

1. R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001.
2. K. Fukunaga, Statistical pattern Recognition; Academic Press, 2000.
3. Devi V.S.; Murty, M.N., Pattern Recognition: An Introduction, Universities Press, Hyderabad, 2011

4.2 *REFERENCE BOOKS::

1. S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009.

4. OTHER SESSIONS
   5.1 *TUTORIALS:: No 5.2 *LABORATORY:: 0 5.3 *PROJECT:: Mini projects 5.4 Additional work: lab 2 hours

6. ASSESSMENT (indicative only)
6.1 HA:: [10% GRADE] 6.2 QUIZZES-HA:: [0% GRADE] 6.3 PERIODICAL EXAMS:: [30% GRADE] 6.4 *PROJECT:: [10% GRADE] 6.5 FINAL EXAM:: [450% GRADE]
7. OUTCOME OF THE COURSE::
The students shall after the course be able to
* design systems and algorithms for pattern recognition , with focus on sequences of patterns that are analyzed using, e.g., hidden Markov models (HMM).
* analyse classification problems probabilistically and estimate classifier performance.
* understand and analyse methods for automatic training of classification systems.
* apply Maximum-likelihood parameter estimation in relatively complex probabilistic models, such as mixture density models and hidden Markov models.
*Study and implementation of various supervised and un-supervised classifiers
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 50
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: MnC, Biomedical Engg., EE, ECE
10. *ANY OTHER REMARKS:: None

HIGH PERFORMANCE COMPUTING (CS-7011)

1.GENERAL
1.1 TITLE:: HIGH PERFORMANCE COMPUTING
1.2 *COURSE NUMBER (if known):: CS-7011
1.3 CREDITS:: [3-0-0-2] 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Computer Architecture, Algorithms

2. OBJECTIVE:: The principal objective of this course is to introduce students to the use of high performance computing systems in science and engineering.

COURSE TOPICS::

Introduction
Parallel Architectures: RISC, CISC, Superscalar, VLIW, Vector processors, Multicore architecture etc.
Parallel Algorithms: PRAM, Mesh, Hypercube, Butterfly, Binary tree
Parallel Programming: MPI, OPENMP, CUDA
Related research papers

READINGS
4.1 TEXTBOOK::

Introduction to Parallel Computing: Design and Analysis of Algorithms by Ananth Grama (Author), George Karypis (Author), Vipin Kumar (Author), Anshul Gupta (Author), 2nd Edison-Wesley.

b. *REFERENCE BOOKS::

1. Parallel Programming by B. Wilkinson and M. Allen (Pearson Education, 2009)
2. Principles of Parallel Programming by C. Lin and L. Snyder (Pearson Education, 2010)
3. Advanced Computer Architecture by K. Hwang (TMH,2005)
4. Parallel Computing by M.J.Quinn (TMH, 2002)
5. Fundamentals of Computer Algorithms by E. Horowitz, S. Sahni and S. Rajasekaran (Galgotia Publishing House, 2007)

5. OTHER SESSIONS
5.1 *TUTORIALS:: No
5.2 *LABORATORY:: No
5.3 *PROJECT::Yes

6. ASSESSMENT (indicative only)
6.1 HA:: [0% GRADE]
6.2 QUIZZES-HA:: [0% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [20% GRADE]
6.5 FINAL EXAM:: [40% GRADE]

7. OUTCOME OF THE COURSE:: After the course students will be able to

- analyze a given problem for possibilities of parallel computations
- select algorithms and hardware for the solution of high performance applications
- program computers with shared and distributed memory architectures
- run parallel programs on different hardware architectures and software environments

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::None

10. *ANY OTHER REMARKS:: None

Computational Aspects of Bioinformatics

1. GENERAL
1.1 TITLE:: **Computational Aspects of Bioinformatics**
1.2 *COURSE NUMBER (if known):: CS7012
1.3 CREDITS:: [3-0-0-2] 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Data Structures, Algorithms, Programming

2. OBJECTIVE:: To introduce the students about development of algorithms for solving the problems related to bioinformatics such as mapping DNA, Sequencing DNA, Comparing Sequences, Predicting genes, Finding Signals, Identifying Proteins, Repeat Analysis, DNA Arrays, Genome Rearrangements, Molecular Evolution.

3. COURSE TOPICS::

Unit-I: Basics Of Bioinformatics

Molecular Biology Primer : What Is Life Made Of? , What Is the Genetic Material? , What Do Genes Do? What Molecule Codes for Genes? , How Do Individuals of a Species Differ?, How Do Different Species Differ? , Why Bioinformatics?

DNA and Chromosome : The structure and function of DNA ,Chromosomal DNA and its packaging in the chromatin fiber , DNA replication repair and recombination ,how to cell read to genome : from DNA to protein ,RNA : Comparison with DNA, Structure Synthesis ,Types of RNA ,RNA translation, Protein :Protein structure and function ,Protein synthesis : Chemical synthesis ,Biosynthesis ,Cellular function :Enzymes ,Cell signalling and ligand binding ,Structural protein ,Protein disorder , Proteomics

Exhaustive Search: Restriction Mapping , Impractical Restriction Mapping Algorithms, A Practical Restriction Mapping Algorithm, Regulatory Motifs in DNA Sequences , Profiles , The Motif Finding Problem , Search Trees , Finding Motifs, Finding a Median String.

UNIT-II: Gene-Gene Interaction :Sample size requirement method,Matched case control design, The case sibling, Case Parent, Computing methods:Bayes classifier ,Neural Network, Random Forest, Multifactor dimensionally Reduction, Cellular Automata, Symbolic Discriminating Analysis ,Protein- Protein Interaction: Methods based on genomic content and structure, Co –Locations, Phylogenetic Profiles, Gene Fusion

Software Tools : GENIE, GWGGI ,STRING10

Unit-III: Dynamic Programming Algorithms : The Power of DNA Sequence Comparison, The Change Problem Revisited , The Manhattan Tourist Problem , Edit Distance and Alignments , Longest Common Subsequences , Global Sequence Alignment , Scoring Alignments, Local Sequence Alignment , Alignment with Gap Penalties, Multiple Alignment , Gene Prediction , Statistical Approaches to Gene Prediction, Similarity-Based Approaches to Gene Prediction , Spliced Alignment.

UNIT-IV: Divide-and-Conquer Algorithms : Divide-and-Conquer Approach to Sorting, Space-Efficient Sequence Alignment , Block Alignment and the Four-Russians Speedup , Constructing Alignments in Subquadratic Time.

Unit V: Combinatorial Pattern Matching: Repeat Finding , Hash Tables , Exact Pattern Matching , Keyword Trees , Suffix Trees, Heuristic Similarity Search Algorithms , Approximate Pattern Matching , BLAST: Comparing a Sequence against a Database..

Unit-VI: Hidden Markov Models : CG-Islands and the "Fair Bet Casino" , The Fair Bet Casino and Hidden Markov Models, Decoding Algorithm , HMM Parameter Estimation , Profile HMM Alignment.

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4. READINGS : Introduction to bioinformatics Book by Arthur M.lesk

Bioinformatics Sequence and Genome Analysis Book By Arthur David W.Mount

Pyhton programming for Biology book By Tim J.Stevens and Wayne Boucher

4.1 TEXTBOOK

By NEIL C. JONES AND PAVEL A. PEVZNER, The MIT Press Cambridge.
http://www.math-info.univ-paris5.fr/~lomn/Cours/BC/Publis/Complements/introductiontoBioinformaticsAlgorithms.pdf
4.2 *REFERENCE BOOKS::

5. OTHER SESSIONS
5.1 *TUTORIALS:: No
5.2 *LABORATORY::No
5.3 *PROJECT::Yes

6. ASSESSMENT (indicative only)
6.1 HA:: [10% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [0% GRADE]
6.5 FINAL EXAM:: [50% GRADE]

7. OUTCOME OF THE COURSE:: Understanding and development of developing algorithms for solving bioinformatics problems such as mapping DNA, Sequencing DNA, Comparing Sequences, Predicting genes, Finding Signals, Identifying Proteins, Repeat Analysis, DNA Arrays, Genome Rearrangements, Molecular Evolution.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: None

10. *ANY OTHER REMARKS:: None

Selected Topics in Social Network Analysis

1. General

1.1 Title: Selected Topics in Social Network Analysis
1.2 Course Number: CS-7013
1.3 Credits: [3-0-0-2] **11**
1.4 Semester offered: PhD Course work
1.5 Prerequisite: Data mining, Data Structure and Algorithm, Probability and statistical analysis.

2. Objective: To enhance the research interest in field of social network analysis.

3. Course Topics:

Unit-I: Introduction to SNA, nodes Edges and Network Measure, Networks Structures, Network Visualization, tie strength, trust, understanding structure through user attributes and behavior. Unit-II: Building Networks, entity Resolution and Link Prediction, Propagation in Networks.
Unit-III: Community Maintained Resources, location based social interaction, social information filtering, social media in public sector, business use of social media, privacy.
Unit-IV: Selected topics from research papers/ reference books as advised by the course instructor

4. Readings

4.1 Text books:

1. "Analyzing the Social Web", Jennifer Golbeck, Morgan Kauffmann.

4.2 *REFERENCE BOOKS::

5. OTHER SESSIONS
5.1 *TUTORIALS:: None
5.2 *LABORATORY:: None
5.3 *PROJECT:: Yes

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE:: Learning of basic technical concepts of the subject.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::
10. *ANY OTHER REMARKS::

Advanced Topics in Multimedia and Applications

1. GENERAL
1.1 TITLE:: Advanced Topics in Multimedia and Applications
1.2 *COURSE NUMBER (if known):: CS-7014
1.3 CREDITS:: [3-0-0-2] 11 Credits
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES::

- Any programming language.
- Knowledge in Computer Network and Operating System.

2. OBJECTIVE::
Multimedia has become an indispensable part of modern computer technology. In this course, students will be introduced to principles and current technologies of multimedia systems. Issues in effectively representing, processing, and retrieving multimedia data such as sound and music, graphics, image and video will be addressed. The students will gain hands-on experience in those areas by implementing some components of a multimedia streaming system as their term project. Latest Web technologies and some advanced topics in current multimedia research will also be discussed.
3. COURSE TOPICS::
Unit-I: Introduction to multimedia coding standards- JPEG, MPEG, digital audio compression.

Unit-II: Multimedia Communication – B-ISDN, ATM, multimedia networks, synchronization techniques. Multimedia storage and retrieval- Disk scheduling in multimedia I/O systems, streaming RAID, design of video-object databases, query-by-content.

Unit-III: Structural multimedia authoring, active learning through multimedia, designing on-demand multimedia service. Transport and display of multimedia conferences, distributed collaborative multimedia, case studies.

Unit-IV: Selected topics from reference books and research papers

4. READINGS
4.1 TEXTBOOK::

1. Multimedia: Concepts and Practice, Stephen McGloughlin, November 2000, Prentice Hall
2. Digital Multimedia, Nigel Chapman and Jenny Chapman, Wiley, 2000.
3. Multimedia Systems, Standards, and Networks, A. Puri, T. Chen (editors.), Marcel Dekker, 2000
4. Multimedia Database Management Systems, Guojun Lu, Artech House Publishers, October 1999.
5. Multimedia: Computing, Communications and Applications, R. Steinmetz and K. Nahrstedt, Prentice Hall, 1997.

4.2 *REFERENCE BOOKS::

1. Multimedia Systems Design, P. K. Andleigh & K. Thakrar, Prentice Hall, 1996.
2. Image and Video Compression Standards: Algorithms and Architecture, V. Bhaskaran and K. Konstantinides, 2nd ed., Kluwer Academic Publishers, 1997.
3. Compressed Video over Networks, Ming-Ting Sun, Amy R. Reibman (editors.), Marcel Dekker, 2000

4. Internetworking Multimedia, Jon Crowcroft, Mark Handley and Ian Wakeman, Taylor and Francis, Morgan Kaufmann Publishers, 1999.

5. OTHER SESSIONS
5.1 *TUTORIALS:: No 5.2 *LABORATORY:: No 5.3 *PROJECT:: Yes
6. ASSESSMENT (indicative only)
6.1 HA:: [10% GRADE] 6.2 QUIZZES-HA:: [0% GRADE] 6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE] 6.5 FINAL EXAM:: [50% GRADE]
7. OUTCOME OF THE COURSE::
The ability to: describe different realisations of multimedia tools and the way in which they are used; analyse the structure of the tools in the light of low-level constraints imposed by the adoption of various QoS schemes (i.e. bottom up approach); analyse the effects of scale and use on both presentation and lower-level requirements (ie top down approach); state the properties of different media streams; compare and contrast different network protocols and to describe mechanisms for providing QoS guarantees in the network.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: None 10. *ANY OTHER REMARKS:: None

Advanced Knowledge Based Systems

1. GENERAL
1.1 TITLE:: **Advanced Knowledge Based Systems**

1.2 *COURSE NUMBER (if known):: CS-7015
1.3 CREDITS:: [3-0-0-2] 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Artificial Intelligence

2. OBJECTIVE:: The course will provide the concepts of Advanced Knowledge Based Systems.

3. COURSE TOPICS::

Unit-I: Architecture of Knowledge Based systems, Basic components, Knowledge, Reasoning and Interfaces. Deduction, Inductive and abdicative methods of reasoning. Model based and Case based Reasoning. Non Monotonic logic, Temporal logic, justification, belief, desire and intention (BDI). Theory of arguments.

Unit-II: Knowledge acquisition: Models of Knowledge acquisition and symbolic Machine learning, Analogical, explanation based, example based Induction etc.

Unit-III: Knowledge Management: Knowledge creation, Capture, assimilation, dissimilation and storage of data. Integration of Software Engineering with KBS. Application of KBS to Medical diagnosis, management, decision making etc.

Unit-IV

Selected topics from research papers.

4. READINGS
4.1 TEXTBOOK:: As prescribed by the instructor
4.2 *REFERENCE BOOKS:: As prescribed by the instructor
5. OTHER SESSIONS
5.1 *TUTORIALS:: No
5.2 *LABORATORY:: No
5.3 *PROJECT:: Yes
6. ASSESSMENT (indicative only)
6.1 HA:: [10% GRADE]
6.2 QUIZZES-HA:: [10% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [50% GRADE]
7. OUTCOME OF THE COURSE::
Understanding of knowledge based systems.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: None
10. *ANY OTHER REMARKS:: None

Research Software Implementation

1. GENERAL
1.1 TITLE:: **Research Software Implementation**

1.2 *COURSE NUMBER (if known):: CS-7016
1.3 CREDITS:: 0-0-6-5: 11 Credits
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Fundamental of concepts of intended field of research and programming languages

2. OBJECTIVE:: The objective of this course, which is practical in nature, is to impart knowledge to the research scholars for the development of various research software/ tools/ project in the field of research.

3. COURSE TOPICS::

Topics to be decided by the research advisor/ supervisor.

Objective is the design and development of a research software/ tools/ project in the field of research.

A student may be asked to work on a semester long research based project and their implementation.

The problem is to be identified from the current field of research.

4. READINGS
4.1 TEXTBOOK:: As suggested by the supervisor.
4.2 *REFERENCE BOOKS:: As suggested by the supervisor.

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: 6 hours/ week
5.3 *PROJECT:: 6 hours/ week

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE:: At the end of the course the student should be able to implement a research software/ tool/ project.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::===
10. *ANY OTHER REMARKS:: None

Research Tools Programming Practice

1. GENERAL
1.1 TITLE:: Research Tools Programming Practice
1.2 *COURSE NUMBER (if known):: CS-7017
1.3 CREDITS:: 0-0-6-5: 11 Credits
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Fundamental of concepts of intended field of research and programming languages

2. OBJECTIVE:: The objective of this course, which is practical in nature, is to impart knowledge to the research scholars in the various research tools, software tools, programming languages and open source tools in the intended field of research.
3. COURSE TOPICS::
The objective is to impart knowledge to the research scholars in the various research tools, software tools, programming languages and open source tools in the intended field of research.
The student may be asked to explore 3-4 software tools/ packages and do some experimental work.
Some examples of Software tools: Weka, MATLAB, Statistical and data analysis tool boxes such as (SPSS/Statistica and OriginLab), Network simulator, Sensor network related software tools, Data mining tools, Wavelet tool box, Neural network tool box, Fuzzy Tool box, Image Processing and Vision Tool boxes in MATLAB, Open source packages such as OpenMPI, OpenCV, OpenGl, Machine learning tool boxes etc.
Some assignments may also be designed for implementation in Python, C/C++, Java Programming Language. Student should be able to work on Linux environment.
Knowledge of LaTeX, EndNote is also required for report/ research paper writing.
The list of experiments/ projects to be provided by the supervisor.
4. READINGS
4.1 TEXTBOOK:: As suggested by the supervisor.
4.2 *REFERENCE BOOKS:: As suggested by the supervisor.
5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: 6 hours/ week
5.3 *PROJECT:: 6 hours/ week
6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE:: At the end of the course the student should be able to implement a research software/ tool/ project.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::===
10. *ANY OTHER REMARKS:: None

Advanced Topics in Data Mining

GENERAL
1.1 TITLE:: **Advanced Topics in Data Mining**
1.2 *COURSE NUMBER (if known):: CS-7018
1.3 CREDITS:: [3-0-0-2] 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Data Structure, Algorithms, Probability and Statistical Analysis, Database.
2. OBJECTIVE:: To give knowledge about fundamentals of data mining

3. COURSE TOPICS::

Unit-I:
Introduction: Data Mining, , Motivation, Application, Data Mining—On What Kind of Data?, Data Mining Functionalities, Data Mining Task Primitives, Major Issues in Data Mining.
Data pre-processing: Descriptive Data Summarization, Data Cleaning, Data Integration and Transformation, Data Reduction, Data Discretization and Concept Hierarchy Generation.
Unit-II:
Association Rule: Mining Frequent Patterns, Associations, and Correlations: Basic Concepts and a Road Map, Association Rules, the Apriori Algorithm
Classification and Prediction:
Classification: Classification, Issues Regarding Classification, Classification by Decision Tree Induction, Bayesian Classification, Rule-Based Classification, Metrics for Evaluating Classifier Performance, Holdout Method and Random Sub sampling
Prediction: Prediction, Issues Regarding Prediction, Accuracy and Error Measures, Evaluating the Accuracy of a Classifier or Predictor.
Unit-III:
Clustering: Cluster Analysis, Agglomerative versus Divisive Hierarchical Clustering, Distance Measures in Algorithmic, Evaluation of Clustering.
Unit-IV: Selected topics from research papers.
4. READINGS
4.1 TEXTBOOK::
"Data Mining: Concepts and Techniques", Second Edition Jiawei Han and Micheline Kamber.
4.2 *REFERENCE BOOKS:: As per instructor choice
5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT:: Projects related to data mining
6. ASSESSMENT (indicative only)
6.1 HA:: [10% GRADE]
6.2 QUIZZES-HA:: [GRADE]
6.3 PERIODICAL EXAMS:: [30% GRADE]
6.4 *PROJECT:: [10% GRADE]
6.5 FINAL EXAM:: [50% GRADE]
7. OUTCOME OF THE COURSE::
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-30

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Maths and Computing, ECE, EE
10. *ANY OTHER REMARKS:: None

Recent Topics in Computer Networking

1. GENERAL

1.1 TITLE:: **Recent Topics in Computer Networking**

1.2 *COURSE NUMBER (if known):: CS-7019

1.3 CREDITS:: [3-0-0-2]: 11 Credits

1.4 SEMESTER-OFFERED:: PhD

1.5 PRE-REQUISITES:: Computer Networks

2. OBJECTIVE:: This course provides students with an opportunity to explore the research issues in recent computer networks and its close relative, sensor networks. Many traditional areas of computer science and engineering are impacted by the constraints and demands of computer networks. Various aspects of computer networking will be covered including the wireless communication, mobile ad-hoc networks, network protocols, routing in wireless and mobile networks, software defined networks, and network virtualization. This course has no official prerequisites. However, it is implicitly expected that the students have already gone through the basic courses on computer networks.

3. COURSE TOPICS::

Unit 1: Review of the Internet architecture, layering, wireless channel models, channel diversity, time diversity, frequency diversity , and antenna diversity, and multiplexing.

Unit 2: Routing mechanisms in wireless and mobile network, congestion control mechanisms, resource allocation schemes, ad-hoc networks, mobility in networks, mobile IP, security related issues.

Unit 3: Advanced topics in networking: Network Virtualization, Networking with virtual machines, software switches, network function virtualization.

Unit 4: Software Defined Networking, evolving network requirements, Complex traffic patterns, Traditional network architecture, SDN requirement, architecture and characteristics, SDN and NFV related standards, SDN data planes, Data plane functions and protocols, Flow table structure.

Unit 5: SDN control plane architecture and functions, southbound and northbound interface, Cooperation and coordination among controllers, Centralized and distributed controllers, SDN Application plane architecture, network service abstraction layer, abstractions in SDN,

Traffic engineering, measurement, monitoring and security.

Unit 6: Selected topics from reference books and research papers.

4. READINGS

4.1 TEXTBOOK::

1) Fundamentals of Wireless Communications -David Tse, 2004

2) James Kurose and Keith Ross, "Computer Networking, A Top-Down Approach".

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [0% GRADE]
6.2 QUIZZES-HA:: [10% GRADE]
6.3 PERIODICAL EXAMS:: [30% GRADE]
6.4 *PROJECT:: [30% GRADE]
6.5 FINAL EXAM:: [30% GRADE]

7. OUTCOME OF THE COURSE:: A primary focus of this course is to explore the high level facilities, system architecture, and protocols of the computer networks, with emphasis on recent trends in networking.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Department of Electronics Engineering, Department of Electrical Engineering, Department of Mathematical Sciences

10. *ANY OTHER REMARKS::---

Cloud Computing

1. GENERAL

1.1 TITLE:: **Cloud Computing**

1.2 *COURSE NUMBER (if known):: CS-7020

1.3 CREDITS:: [3-0-0-2] 11 credits

1.4 SEMESTER-OFFERED:: PhD Course work

1.5 PRE-REQUISITES:: Computer networks, operating system, algorithms

2. OBJECTIVE:: This course covers a series of current cloud computing technologies, including technologies for Infrastructure as a Service, Platform as a Service, Software as a Service, and Physical Systems as a Service.

The course is also highly project oriented, involving hand-on exploration of existing technologies as well as development of new technologies.

1. COURSE TOPICS::

Unit-I: Introduction to Cloud Computing, History of Cloud Computing, Cloud service providers, Pros and Cons of Cloud Computing, Benefits of Cloud Computing, Cloud computing vs. Cluster computing vs. Grid computing, Cloud Computing Architecture, Service Models (XaaS), Infrastructure as a Service(IaaS), Platform as a Service(PaaS), Software as a Service(SaaS).

Unit-II: Deployment Models, Public cloud, Private cloud, Hybrid cloud, Community cloud, Cloud security

Unit-III: Case Study on Open Source & Commercial Clouds: Eucalyptus, Microsoft Azure, Amazon EC2.

Unit-IV

Selected topics from research papers

4. READINGS

4.1 TEXTBOOK::

Cloud Computing (Wind) by Dr. Kumar Saurabh, 2nd Edison, Wiley India

4.2 REFRENCE BOOKS:: Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2011

Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012

5. OTHER SESSIONS

5.1 *TUTORIALS::No 5.2 *LABORATORY:: No 5.3 *PROJECT:: Yes

6. ASSESSMENT (indicative only)

6.1 HA:: [5% GRADE] 6.2 QUIZZES-HA:: [5% GRADE] 6.3 PERIODICAL EXAMS:: [30% GRADE] 6.4 *PROJECT:: [10% GRADE] 10%

6.5 FINAL EXAM:: [50% GRADE]

7. OUTCOME OF THE COURSE:: Applying key comparative methodologies to assess the comparative advantages and disadvantages of public vs. private computing clouds

Applying relevant methods to assess the important security and sustainability challenges involved in adopting various cloud architectures and making informed decisions for the organizations

8. *EXPECTED ENROLLMENT FOR THE COURSE::1-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: None
10. *ANY OTHER REMARKS:: None

Advanced Topics in Algorithms

1. GENERAL
1.1 TITLE:: Advanced Topics in Algorithms
1.2 *COURSE NUMBER (if known):: CS7021
1.3 CREDITS:: 3-0-0-2
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Data Structures, Algorithms
2. OBJECTIVE:: To impart knowledge related to advanced topics in algorithms
3. COURSE TOPICS::
Unit-I:
Review of Algorithmic paradigms: Divide and Conquer, Greedy, Dynamic, Programming, Branch-and-bound; Asymptotic complexity.
Unit-II:
Graph Algorithms: Shortest paths, MST etc.
Unit-III
Lower bound theory; NP-completenses.
Unit-IV
Approximation algorithms; Randomized algorithms; Parallel algorithms.
Unit-V:
Selected topics from related Research Papers
4. READINGS
4.1 TEXTBOOK::

1) T. H. Cormen, C. L. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, 2nd edition, Prentice-hall of India Pvt. Ltd. (2007)
(2) J. Kleinberg and E. Tardos, Algorithm Design, Addison-Wesley, (2008)
(3) Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press, (1995)
(4) Vijay Vazirani, Appromation Algorithms, Springer, (2004)
(5) E. Horozitz, S. Sahni and S. Rajshekhran, Fundamentals of Computer Algorithms, Galgotia Publications, 2007

4.2 *REFERENCE BOOKS::
As prescribed by the instructor
5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::
6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [60% GRADE]
7. OUTCOME OF THE COURSE::
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::

10. *ANY OTHER REMARKS:: --

Cognitive Computation

1. GENERAL
1.1 TITLE:: Cognitive Computation
1.2 *COURSE NUMBER (if known):: CS-7022
1.3 CREDITS:: 3-0-0-2: 11 Credits
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Data Structures, Programming

2. OBJECTIVE:: Cognitive computing refers to systems that learn at scale, reason with purpose, and interact with humans naturally. The objective is to learn the various recent methods in this field.

3. COURSE TOPICS::

Unit-I

Introduction to Cognitive Systems and computation, Knowledge based AI: Cognitive systems, Different modes of Computing: Turning machine Lambda, Calculus, Hyper Computing, Super Computing, Pan Computing and Interactive Computing.

Unit-II

Cognitive Functioning: Learning, Memorising, Adaptation, Self Origination, Control, Thinking, Reasoning, Decision Making & Judgement.

Unit-III

Mental States: Belief Desire Intention (BDI) emotion and feeting.
Computation of Cognitive Functioning in machines: Robotics, Human-Robotics Interaction, Hepatic.

Unit-IV

Perception and sensing: Hardware machines of vision and audition with reference to human and machine.

Unit-V

Cognitive function measurement tools and software.
Selected topics from research papers.

4. READINGS
4.1 TEXTBOOK:: As prescribed by the instructor.
4.2 *REFERENCE BOOKS:: As prescribed by the instructor.

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT:: 10%

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [40% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [50% GRADE]
7. OUTCOME OF THE COURSE::

8. *EXPECTED ENROLLMENT FOR THE COURSE::
9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::
10. *ANY OTHER REMARKS::

Computer and Scripting – I

1. GENERAL
1.1 TITLE:: Computer and Scripting – I
1.2 *COURSE NUMBER (if known):: CS-7023
1.3 CREDITS::3-0-0-2: 11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: None.

2. OBJECTIVE:: The objective of the Computer Scripting (I and II) course is to introduce the students coming from non-computer science background (such as Humanities, Social Sciences or Biological Sciences etc.) to basic programming.

3. COURSE TOPICS::
The course content can be divided broadly into three categories:
(A) Introduction to Shell and simple shell programming:
Simple and advanced shell commands for file and director organization, cut, copy and paste, search and regular expression.
Concept of shell programming: linear execution, running a shell script on multiple file
- use of for loop for simple tasks
- backquote operator in shell script
- echo command
- concept of a variable

(B) Perl programming
DATA:
- Scalar, array, associative array (hash)

Constructs:
- if, while, for, foreach

string manipulations:
- regular expression,
- matching with $1, $2, etc.
- push, split, sort, reverse, length

file handling:
- file handle, file open, close
- tie, associating with GDBM_file

Perl special variables:
- $., $’, $', $_, @_

Subroutine
- Passing of parameters,
- Variables: my, local, global

Note: In this category, Perl may be replaced by Python if the instructor considers that more useful and appropriate. In that case, the sub-topics may be changed accordingly.
(C) Miscelleneous
Good programming practice:
- Naming of variables
- Modularity

Documentation
Test Data
Debugging techiques

4. READINGS

4.1 TEXTBOOK::

1. Forouzan and Richards. Unix and Shell Programming: A Textbook.
2. Schwartz and Christiansen. Learning Perl.
3. Wall, Christiansen and Schwartz. Programming Perl.

4.2 *REFERENCE BOOKS:: As suggested by the instructor.

5. OTHER SESSIONS

5.1 *TUTORIALS::

5.2 *LABORATORY::

5.3 *PROJECT::

6. ASSESSMENT (indicative only)

6.1 HA::

6.2 QUIZZES-HA::

6.3 PERIODICAL EXAMS:: 40%

6.4 *PROJECT::

6.5 FINAL EXAM:: 60%

7. OUTCOME OF THE COURSE::

Students should be able to do basic programming so that they can implement ideas on their own, rather than waiting to find someone who can do it for them.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 1-10

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Humanistic studies

10. *ANY OTHER REMARKS::---

Computer and Scripting – II

1. GENERAL
1.1 TITLE:: Computer and Scripting – II
1.2 *COURSE NUMBER (if known):: CS-7024
1.3 CREDITS:: 3-0-0-2:11
1.4 SEMESTER-OFFERED:: PhD Course work
1.5 PRE-REQUISITES:: Computer and Scripting - I

2. OBJECTIVE:: The objective of the Computer Scripting (I and II) course is to introduce the students coming from non-computer science background (such as Humanities, Social Sciences or Biological Sciences etc.) to basic programming.
3. COURSE TOPICS::
Data Structure
    Arrays, Hashes, Ques, Stacks, Tree structure, graph
    Linear search and binary search
Basic Database
    Relational Database and Mysql
    Connecting Mysql to Perl
Basic Understanding of Object Orientation Programming
LaTeX
4. READINGS
4.1 TEXTBOOK::
1. Langsam and Tanenbaum. Data Structures Using C and C++.
2. Cormen and Leiserson. Introduction to Algorithms.
3. Elamsri and Navathe. Fundamentals of Database Systems.
4. Kottwitz. LaTeX Beginner's Guide.
4.2 *REFERENCE BOOKS:: As suggested by the instructor.
5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::
6. ASSESSMENT (indicative only)
6.1 HA::
6.2 QUIZZES-HA::
6.3 PERIODICAL EXAMS:: 40%
6.4 *PROJECT::
6.5 FINAL EXAM:: 60 %
7. OUTCOME OF THE COURSE::
Students should become familiar with the basics of data structures, algorithms, databases and LaTeX, so that they are able to do basic programming so that they can implement ideas on their own (as well as write a document in LaTeX), rather than waiting to find someone who can do it for them.
8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::
10. *ANY OTHER REMARKS::

Selected Topics in Artificial Intelligence

1. GENERAL
1.1 TITLE:: Selected Topics in Artificial Intelligence
1.2 *COURSE NUMBER (if known):: CS-7025
1.3 CREDITS:: 11
1.4 SEMESTER-OFFERED:: Even
1.5 PRE-REQUISITES:: Computer Programming, Data Structures, Algorithms, Discrete Maths

2. OBJECTIVE::

To make conversant with fundamentals of AI with the help of a running practical application connecting all the covered topics. To prepare students to do research in AI.

3. COURSE TOPICS::

- **Unit 1**
  - Introduction (1 lecture)
    - [What is AI, Areas, Current uses (captcha, recommendation systems)].
  - Review of Mathematical Logic (4 lectures)
    - Propositional Logic: Logical implication. Finite models and truth values.
    - Predicate Calculus: Infinite models and truth values.
    - Representing Knowledge about the World [Domain: General, blocks world]
  - Logical Reasoning (3 lectures)
    - Logical consequence
    - Relation with deduction: Soundness and completeness
    - Resolution refutation procedure
- **Unit 2**
  - Machine Learning (5 lectures)
    - Symbolic learning (1 lecture)
      - Transformation based learning [Domain: POS tagging]
    - Probabilistic learning (4 lectures)
      - Markov Models, Hidden MM, Viterbi [Domain: Word prediction in speech, POS tagging, Chunking]
    - Rule based systems (3 lectures)
      - [Domain: Natural Language Parsing, CFG].
  - Natural Language (NL) Semantics (3 lectures)
    - Connecting with Logic [Domain: NL and KR]
    - Phrase structure -> Dependency structure -> Logic.
- **Unit 3**
  - Search (4 lectures)

        - Hill climbing, Best first, A*
        - Game tree search, min-max
    - Other topics (depending on time available: 5 lectures)
        - Constraint Satisfaction/Planning
        - Applications [Expert systems, vision]
        - Philosophical issues, History of AI.
- **Unit 4**
    - Another application of AI (5 to 7 lectures)
        - Building a natural language interface for relational databases

NOTE: A crucial aspect of the course is a serial assignment, which connects knowledge representation (and reasoning), with NLP. For example, in the serial assignment, natural language commands in a blocks world (or similar domain) are analyzed, interpreted and are carried out by machine. Students get to build a system.

In additional to the above, students will have to:

(a) Study some additional topics as told by the teacher on their own.

(b) Present a term paper and/or project at the end of the course.

4. READINGS
4.1 TEXTBOOK::

(a) Artificial Intelligence. Elaine Rich and Kevin Knight. McGraw Hill.

(b) Artificial Intelligence: A Modern Approach. Stuart Russell and Peter Norvig. Pearson.

4.2 *REFERENCE BOOKS::

As instructed by the teacher.

5. OTHER SESSIONS
5.1 *TUTORIALS:: None
5.2 *LABORATORY:: One laboratory session for practice and practical assessments etc.
5.3 *PROJECT:: None

6. ASSESSMENT (indicative only)
6.1 HA::
6.2 QUIZZES-HA::
6.3 Class and Lab Assignments:: 10% GRADE
6.4 PERIODICAL EXAMS:: 30% GRADE
6.5 *PROJECT:: 20% GRADE
6.6 FINAL EXAM:: 40% GRADE

7. OUTCOME OF THE COURSE::

Students will become familiar with the basic ideas on which AI is based. In addition, they will have practiced what they have learnt through a serial example. The serial assignment between two core

areas allows the student to see the connectedness of areas. By building an end to end system, the student, hopefully, sees glimpse of deep issues related to symbols and their meaning. At the end, they should be able to work on a research and development project in the general area of AI. The project and the term paper will prepare them for this.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: ---

10. *ANY OTHER REMARKS:: No

Selected Topics in Natural Language Processing

1. GENERAL
1.1 TITLE:: Selected Topics in Natural Language Processing
1.2 *COURSE NUMBER (if known):: CS-7026
1.3 CREDITS:: 11
1.4 SEMESTER-OFFERED:: Odd
1.5 PRE-REQUISITES:: Programming, Data Structures and Algorithms

2. OBJECTIVE::

1. To introduce students to language, linguistics, NLP/CL and allied areas. 2. To make students familiar with some of the NLP approaches and algorithms. 3. To prepare students to be NLP developers and/or researchers in their future career.

3. COURSE TOPICS::

UNIT-1: Introduction to NLP. Language Structure and Analyzer - Overview of language, requirement of computational grammar. Words and their Analysis. Tokenization. Stemming. Morphological Analysis. POS tagging.

UNIT-2: Local word grouping. Paninian Grammar - The semantic model, Free word order and vibhakti, Paninian theory, Active, Passive, Central. Paninian Parser - Core parser, constraint parser, preference over parses, lakshan charts, sense disambiguation. Machine Translation.

UNIT-3: Lexical functional grammar, LFG and Indian languages, Tree Adjoining Grammar, Comparing TAG and PG. Automatic parsing: rules based and statistical. Introduction to some other NLP applications, depending on availability of time.

UNIT-4: Some applications of machine learning in NLP such as Shallow Discourse Parsing. Statistical machine translation.

In additional to the above, the students will have to:

(a) Study on their own some additional topics as suggested by the teacher.

(b) Present a term paper and/or project at the end of the course.

4. READINGS
4.1 TEXTBOOK::

A. Speech and Language Processing by Jurafsky and Martin

B. Natural Language Processing: A Paninian Perspective by Akshar Bharati, Vineet Chaitanya and Rajeev Sangal

4.2 *REFERENCE BOOKS::

A. Foundations of Statistical Natural Language Processing by Chris Manning and Hinrich Schutze

B. The Handbook of Computational Linguistics and Natural Language Processing by Alexander Clark, Chris Fox and Shalom Lapic

C. The Oxford Handbook of Computational Linguistics edited by Ruslan Mitkov

5. OTHER SESSIONS
5.1 *TUTORIALS:: One tutorial session for clearing doubts and class assignments etc.
5.2 *LABORATORY:: None
5.3 *PROJECT:: A project towards the end of the course

6. ASSESSMENT (indicative only)
6.1 HA::
6.2 QUIZZES-HA:: 10%
6.3 Class Assignments::
6.4 PERIODICAL EXAMS:: 30% GRADE
6.5 *PROJECT:: 20%
6.6 FINAL EXAM:: 40% GRADE

7. OUTCOME OF THE COURSE::

1. Understand NLP problems and survey the literature about that problem 2. Propose a new or adapted technique for solving that problem 3. Evaluate and compare the results with other approaches 4. Implement the technique as a tool usable by others. 5. Do a project in NLP, along with a term paper.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: All departments

10. *ANY OTHER REMARKS::

Selected Topics in Mobile Computing

1. GENERAL
1.1 TITLE:: Selected Topics in Mobile Computing
1.2 *COURSE NUMBER (if known):: CS-7027
1.3 CREDITS:: [3-0-2]: 11 Credits
1.4 SEMESTER-OFFERED:: PhD
1.5 PRE-REQUISITES:: Computer Networks

2. OBJECTIVE:: This course provides students with an opportunity to explore the research issues in mobile computing and its close relative, pervasive and ubiquitous computing. Many traditional areas of computer science and engineering are impacted by the constraints and demands of mobile computing. A primary focus of this course is to explore the high level facilities, system architecture, and protocols of the mobile system.

3. COURSE TOPICS::

Unit 1: Definition, scope, essential elements of ubiquitous, pervasive, and mobile computing. Architecture for mobile computing: new devices and communications; and software architectures.

Unit 2: Automatic Identification and Data Capture (AIDC): Introduce the following technologies in an AIDC solution: Bar Code Technologies, Radio Frequency Identification (RFID) and Data Communications Technologies, Card Technologies, including Magnetic Stripe Cards, Magnetic Ink Character Recognition (MICR), Optical Character Recognition (OCR), Optical Mark Recognition (OMR), Electronic Article Surveillance (EAS), Emerging technologies – voice and vision systems, Biometric Identification – Fingerprint, retinal scan or voice, Contact Memory, Machine Vision Technologies, Real Time Locating Systems.

Unit 3: Security and Fraud Detection in Mobile Computing: Introduction , Mobile Security Problems , Mobile Security Management Plan , Intrusion Detection Systems (IDS) , Securing Data Transfer in Digital Mobile Systems , Securing Wireless Ad Hoc Networks , Authentication of Mobile Users , Subscription and Fraud Detection in Mobile Phone Systems.

Unit 4: Dominating-Set-Based Routing in Mobile Computing: Introduction , Formation of a Connected Dominating Set, Unicast Routing Protocols, Broadcasting Protocols, and Multicasting Protocols for mobile computing.

Unit 5: Selected topics from reference books and research papers.

4. READINGS
4.1 TEXTBOOK::

1) Ubiquitous Computing Fundamentals, Ed. John Krumm. ISBN: 1420093606. Chapman & Hall/CRC 2009.

2) Pervasive Computing and Networking, Mohammad S. Obaidat and et al., ISBN: 978-0-470-74772-8, Wiley 2011.

3) Mobile Computing: Technology, Application and Service Creation, Asoke K. Talukder, Tata McGraw - Hill Education, 2004.

4.2 *REFERENCE BOOKS::

1) Wireless Sensor Networks: An Information Processing Approach - Feng Zhao and Leonidas Guibas, Morgan Kaufmann Publishers, 2004

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [5% GRADE]
6.2 QUIZZES-HA:: [5% GRADE]
6.3 PERIODICAL EXAMS:: [30% GRADE]
6.4 *PROJECT:: [10% GRADE]
6.5 FINAL EXAM:: [50% GRADE]

7. OUTCOME OF THE COURSE:: A primary focus of this course is to explore the high level facilities, system architecture, and protocols of the ubiquitous system.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Department of Electronics Engineering, Department of Electrical Engineering, Department of Mathematical Sciences

10. *ANY OTHER REMARKS::

Selected Topics in Wireless Networks

1. GENERAL
1.1 TITLE:: Selected Topics in Wireless Networks
1.2 *COURSE NUMBER (if known):: CS-7028
1.3 CREDITS:: [3-0-2]: 11 Credits
1.4 SEMESTER-OFFERED:: PhD
1.5 PRE-REQUISITES:: Computer Networks

2. OBJECTIVE:: This course provides students with an opportunity to explore the research issues in wireless networks and its close relative, sensor networks. Many traditional areas of computer science and engineering are impacted by the constraints and demands of wireless networks. Various aspects of wireless networking will be covered including: fundamentals of wireless PAN/LAN/MAN standards, mobile ad-hoc networks, wireless sensor networks, wireless multimedia sensor networks, routing in wireless and mobile networks and Software defined networks. This course also covers foundations of modern networking such as SDN, NFV, QoE, IoT and Cloud. This course has no official prerequisites. However, it is implicitly expected that the students have already gone through the basic courses on computer networks.

3. COURSE TOPICS::

Unit 1: Overview: Wireless vs. Wired -- key differences, types of wireless networks and design constraints, emerging applications. Fundamentals of Ad-hoc and sensor networks, wireless PAN, LAN, MAN, and mesh networks.

Unit 2: Wireless PHY layer and MAC layer: path modeling, modulation. Centralized and Distributed MAC protocols in wireless networks. Near field communication (NFC), Bluetooth classic, Bluetooth Low Energy (BLE), WiFi, and WiFi Direct.

Unit 3: Network layer and Transport layer: Ad-hoc networks, routing, TCP for wireless, Congestion control mechanisms for Ad-hoc networks.

Unit 4: Network Functions Virtualization (NFV): Introduction of NFV, Relationship between NFV and SDN, ETSI NFV ISG Specifications, Concepts, Architecture, Requirements, and Use cases of NFV. SDN control plane architecture and functions, southbound and northbound interface, SDN routing, ITU-T Model, OpenDaylight architecture, OpenDaylight Helium, REST, REST constraints, example REST API, Cooperation and coordination among controllers, Centralized and distributed controllers, High availability clusters, Federated SDN networks, Routing and QoS between domains.

Unit 5: Selected topics from reference books and research papers.

4. READINGS
4.1 TEXTBOOK::

1) Wireless Communications - Andreas F. Molisch, John Wiley and Sons, 2005 (Indian Edition)

2) Protocols and Architectures for Wireless Sensor Networks - Holger Karl and Andreas Willig, John Wiley and Sons, 2005

3) Foundations of modern networking- SDN, NFV, QoE, IoT, and Cloud, William Stallings, 2016.

4.2 *REFERENCE BOOKS::

1) Wireless Sensor Networks: An Information Processing Approach - Feng Zhao and Leonidas Guibas, Morgan Kaufmann Publishers, 2004 (Indian Edition)

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [5% GRADE]
6.2 QUIZZES-HA:: [5% GRADE]
6.3 PERIODICAL EXAMS:: [30% GRADE]
6.4 *PROJECT:: [10% GRADE]
6.5 FINAL EXAM:: [50% GRADE]

7. OUTCOME OF THE COURSE:: A primary focus of this course is to explore the high level facilities, system architecture, and protocols of the wireless networks, with emphasis on current and next-generation wireless networks.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Department of Electronics Engineering, Department of Electrical Engineering, Department of Mathematical Sciences

10. *ANY OTHER REMARKS::

Selected Topics in Augmented Reality and Virtual Reality

1. GENERAL
1.1 TITLE:: Selected Topics in Augmented Reality and Virtual Reality
1.2 *COURSE NUMBER (if known):: CS-7029
1.3 CREDITS:: [3-0-2]: 11 Credits
1.4 SEMESTER-OFFERED:: PhD
1.5 PRE-REQUISITES:: Data Structure

2. OBJECTIVE:: This course provides students with an opportunity to explore the research issues in Augmented Reality and Virtual Reality (AR &VR). It also makes the students know the basic concept and framework of virtual reality.

3. COURSE TOPICS::

Unit 1: Introduction of Virtual Reality: Fundamental Concept and Components of Virtual Reality. Primary Features and Present Development on Virtual Reality.

Unit 2: Multiple Models of Input and Output Interface in Virtual Reality: Input -- Tracker, Sensor, Digital Glove, Movement Capture, Video-based Input, 3D Menus & 3DScanner etc. Output -- Visual /Auditory / Haptic Devices.

Unit 3: Visual Computation in Virtual Reality: Fundamentals of Computer Graphics. Software and Hardware Technology on Stereoscopic Display. Advanced Techniques in CG: Management of Large Scale Environments & Real Time Rendering.

Unit 4: Interactive Techniques in Virtual Reality: Body Track, Hand Gesture, 3D Manus, Object Grasp.

Unit 5: Development Tools and Frameworks in Virtual Reality: Frameworks of Software Development Tools in VR. X3D Standard; Vega, MultiGen, Virtools etc.

Unit 6: Application of VR in Digital Entertainment: VR Technology in Film & TV Production. VR Technology in Physical Exercises and Games. Demonstration of Digital Entertainment by VR.

Unit 7: Augmented and Mixed Reality, Taxonomy, technology and features of augmented reality, difference between AR and VR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality, wireless displays in educational augmented reality applications, mobile projection interfaces, marker-less tracking for augmented reality, enhancing interactivity in AR environments, evaluating AR systems.

4. READINGS
4.1 TEXTBOOK::

1) Burdea, G. C. and P. Coffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2003/2006.

2) Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, 2013.

4.2 *REFERENCE BOOKS::

1) Alan Craig, William Sherman and Jeffrey Will, Developing Virtual Reality Applications, Foundations of Effective Design, Morgan Kaufmann, 2009.

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [5% GRADE]
6.2 QUIZZES-HA:: [5% GRADE]
6.3 PERIODICAL EXAMS:: [30% GRADE]
6.4 *PROJECT:: [10% GRADE]
6.5 FINAL EXAM:: [50% GRADE]

7. OUTCOME OF THE COURSE:: This course provides students with an opportunity to explore the research issues in Augmented Reality and Virtual Reality (AR&VR).

8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST:: Department of Electronics Engineering, Department of Electrical Engineering, Department of Mathematical Sciences

10. *ANY OTHER REMARKS::

Information Retrieval

1. GENERAL
1.1 TITLE:: Information Retrieval
1.2 *COURSE NUMBER (if known):: CS-7030
1.3 CREDITS:: [3-0-2]: 11 Credits
1.4 SEMESTER-OFFERED:: PhD
1.5 PRE-REQUISITES:: Data Structure, Algorithms
2. OBJECTIVE:: This course provides students with an opportunity to learn the basics of information retrieval and web search and explore the research issues therein.
3. COURSE TOPICS::
Unit 1: Introduction, Basic IR system structure; Retreival Techniques: Boolean retrieval, term-vocabulary, postings-lists, Dictionaries, Inverted Indices; Preprocessing steps: Tokenization, Stemming, Stopword removal, Term Weighting; Index Compression: Data Compression Techniques, Huffman Coding, Arithmetic Coding, compressing posting lists.
Unit 2: Retrieval Models: Vector Space Model, Probabilistic Model, Language Models: Evaluation:
Standard Test Collection, concept of relevance, Precision-Recall based metrics, Reciprocal Rank, DCG; Relevance Feedback and Query Expansion: Rocchio algorithm; Text Classification: Naïve Bayes, Text Clustering: Flat Clustering, Hierarchical Clustering.
Unit 3: Web Search: Structure of Web, Web Graph, Hidden Web, User intent, Web crawl; Link Analysis: Web as a graph, PageRank, Hubs and Authorities; Social Search: Community-based search activities, Question Answering, Collaborative Searching; XML Retrieval: Basic concepts, Challenges, Evaluation.
4. READINGS
4.1 TEXTBOOK::

1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, *Introduction to Information Retrieval*, Cambridge University Press. 2008.
2. Baeza-Yates and Ribeiro-Neto, *Modern Information Retrieval*, Addison Wesley, 1999.

4.2 *REFERENCE BOOKS::

1. Bruce Croft, D. Metzler, T. Strohman, *Search Engines Information Retrieval in Practice* ,Pearson, 2009.
2. Stefan Büttcher, Charles L. A. Clarke and Gordon V. Cormack, *Information Retrieval Implementing and Evaluating Search Engines,* MIT Press, 2010.

5. OTHER SESSIONS

5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: A few experiments will be given involving implementation of algorithms.
5.3 *PROJECT::
6. ASSESSMENT (indicative only)
6.1 HA:: [5% GRADE]
6.2 QUIZZES-HA:: [10% GRADE]
6.3 PERIODICAL EXAMS:: [35% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [50% GRADE]
7. OUTCOME OF THE COURSE:: This course provides students with an opportunity to explore the research issues in Information Retrieval and Web Retrieval.
8. *EXPECTED ENROLLMENT FOR THE COURSE::

9. *DEPARTMENTS OTHER THAN YOUR OWN TO WHICH THIS COURSE WOULD BE OF INTEREST::
Department of Mathematical Sciences.
10. *ANY OTHER REMARKS::