Master of Technology

In

Computer Science and Engineering

(Artificial Intelligence)

Course Structure & Syllabus

Department of Computer Science and Engineering

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

Course Structure of M. Tech. Computer Science and Engineering (Artificial Intelligence)

SEMESTER-I

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	CS-651	Artificial Intelligence and Intelligent Systems	4	0	0	4	4
2	CS-652	Machine Learning	4	0	0	4	4
3	CS-653	Natural Language Processing	4	0	0	4	4
4	CS-7MN	Programme Elective-I	4	0	0	4	4
5	CS-7MN	Programme Elective-II	4	0	0	4	4
6	CS-654	AI based Programming Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective-I & II: List of Programme Electives is given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	CS-661	Deep Learning	4	0	0	4	4
2	CS-662	Big Data Analytics	4	0	0	4	4
3	CS-663	Speech Information Processing	4	0	0	4	4
4	CS-7MN	Programme Elective-III	4	0	0	4	4
5	CS-7MN	Programme Elective-IV	4	0	0	4	4
6	CS-664	Deep Learning and Data Analytics Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective –III & IV: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	CS-800	M.Tech. Dissertation	--	20
	Total			**20**

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	CS-800	M.Tech. Dissertation	--	20
	Total		**--**	**20**

Total Credit of the Programme = 84

Annexure

List of Programme Electives

Programme Elective-I

CS-716	Cognitive Systems
CS-717	Neural Network and Fuzzy Logic
CS-718	Game Theory and Applications
CS-719	Data Mining

Programme Elective-II

CS-726	Probabilistic Graphical Models
CS-727	Digital Image Processing
CS-728	Information Retrieval
CS-729	Machine Translation

Programme Elective-III

CS-736	Computer Vision
CS-737	Network Science and Modelling
CS-738	Spatial and Temporal Computing
CS-739	Evolutionary Computing

Programme Elective-IV

CS-746	Cryptography and Security Analytics
CS-747	IPR in Artificial Intelligence
CS-748	Affective Computing and Interaction
CS-749	Internet of Things

Course Name: **Artificial Intelligence and Intelligent Systems**
Course Code: **CS-651**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about Artificial Intelligence.
- To give understanding of the main abstractions and reasoning for intelligent systems.
- To enable the students to understand the basic principles of Artificial Intelligence in various applications.

Course Content

Introduction: Overview of AI problems, AI problems as NP, NP-Complete and NP Hard problems. Strong and weak, neat and scruffy, symbolic and sub-symbolic, knowledge-based and data-driven AI. Search Strategies: Problem spaces (states, goals and operators), problem solving by search, Heuristics and informed search, Minmax Search, Alpha-beta pruning. Constraint satisfaction (backtracking and local search methods). Knowledge representation and reasoning: propositional and predicate logic, Resolution and theorem proving, Temporal and spatial reasoning. Probabilistic reasoning, Bayes theorem. Totally-ordered and partially-ordered Planning. Goal stack planning, Nonlinear planning, Hierarchical planning. Learning: Learning from example, Learning by advice, Explanation based learning, Learning in problem solving, Classification, Inductive learning, Naive Bayesian Classifier, decision trees. Natural Language Processing: Language models, n-grams, Vector space models, Bag of words, Text classification. Information retrieval. Agents: Definition of agents, Agent architectures (e.g., reactive, layered, cognitive), Multi-agent systems- Collaborating agents, Competitive agents, Swarm systems and biologically inspired models. Intelligent Systems: Representing and Using Domain Knowledge, Expert System Shells, Explanation, Knowledge Acquisition. Key Application Areas: Expert system, decision support systems, Speech and vision, Natural language processing, Information Retrieval, Semantic Web.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Solve basic AI based problems.
CO2: Define the concept of Artificial Intelligence.
CO3: Apply AI techniques to real-world problems to develop intelligent systems.
CO4: Select appropriately from a range of techniques when implementing intelligent systems.

Books and References

1. Artificial Intelligence by Elaine Rich, Kevin Knight and Shivashankar B Nair, Tata McGraw Hill.
2. Introduction to Artificial Intelligence and Expert Systems by Dan W. Patterson, Pearson Education.
3. Artificial Intelligence: A Modern Approach by S. Russell and P. Norvig, Prentice Hall.

Course Name: **Machine Learning** Course Code: **CS-652** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the concepts of machine learning.
- To introduce the fundamental concepts of distributed nature of operating system, network, data and processes.
- To enable the students to understand the concepts of computing environment where computations do not take place at one system and accordingly enable them to solve related problems.

Course Content

Introduction to Machine Learning, Problems, data, and tools, Visualization tools, Decision Tree Learning, Artificial Neural Networks, Bayesian Learning, Deep Learning, Instance-Based Learning, Regression Techniques, Linear regression, SSE, gradient descent, closed form, normal equations, features, Overfitting and complexity, training, validation, test data, Classification problems, decision boundaries, nearest neighbor methods, Probability and classification, Bayes optimal decisions, Naive Bayes and Gaussian class-conditional distribution, Linear classifiers: Bayes Rule and Naive Bayes Model, Logistic regression, online gradient descent, Kernel Methods, Radial Basis Function Networks, Support Vector Machines, Genetic Algorithms, Reinforcement Learning, Ensemble methods: Bagging, random forests, boosting Unsupervised learning: clustering, k-means, hierarchical agglomeration, Latent space methods, PCA, Text representations, naive Bayes and multinomial models, clustering and latent space models, VC-dimension, structural risk minimization, margin methods and support vector machines (SVM), Machine Learning Applications.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Develop an understanding what is involved in learning models from data.

CO2: Understand a wide variety of learning algorithms.

CO3: Apply principles and algorithms to evaluate models generated from data.

CO4: Apply the algorithms to a real-world problem.

Books and References

1. Introduction to Machine Learning by Ethem Alpaydin, PHI Learning.
2. Machine Learning: An Algorithmic Perspective by Stephen Marsland, Chapman and Hall/CRC.
3. Pattern Recognition and Machine Learning by Christopher M. Bishop, Springer.
4. Machine Learning by Tom Mitchell, McGraw Hill Education.

Course Name: **Natural Language Processing**
Course Code: **CS-653**
Course Type: **Core**

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To learn about the concepts and principles of natural language processing.
- To explore both theoretical and practical issues of natural language processing.
- To develop skills of finding solutions and building software using natural language processing techniques.

Course Content

Introduction: Knowledge of Natural Language Processing, Ambiguity, Models and Algorithms, Text representation in computers, encoding schemes, Regular expressions, Finite State Automata, word recognition, lexicon. Grammar and NLP Stages NLP grammar, POS and POS schemes, Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, named entities, multi word expressions, lexical analyzer, Parsing, Stemming, Smoothing and Interpolation Names Entity Recognition. Semantics- Meaning representation, semantic analysis, lexical semantics, WordNet, Word Sense Disambiguation- Selectional restriction, machine learning approaches, and dictionary based approaches. Pragmatics: Discourse, Reference Resolution, Reference Phenomena, Syntactic and Semantic Constraints on Coreference, Preferences in Pronoun Interpretation, Text Coherence and Inference Based Resolution Algorithm, Corpora: elements in balanced corpus, Concordance and corpora, characteristics of Gold Standard Corpora. TreeBank, PropBank, WordNet, VerbNet etc. Resource management with XML, Management of linguistic data with the help of GATE, NLTK. Parallel Corpus, Comparable corpus, Inter-Annotator Agreement Tests, kappa statistics. Corpus annotation tools. N-GRAMS: Counting words in Corpora, N-Gram probabilities, Training and Test sets, Evaluating N-Gram Perplexity. Machine Translation and Performance Metrics Machine Translation issues, MT Evaluation, automatic evaluation BLEU, METEOR, ORANGE, Information Retrieval: Vector space model, term weighting, homonymy, polysemy, synonymy, improving user queries.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand concept of natural language processing.
CO2: Understand various research issues in natural language processing.
CO3: Apply various tools and techniques in natural language processing.

Books and References

1. Speech and Language Processing by Daniel Jurafsky and James H. Martin, Prentice Hall.
2. Language as a Cognitive Process by T. Winograd, Addison-Wesley.
3. Natural Language Understanding by James Allen, the Benajmins/Cummings.
4. Natural language processing: a Paninian perspective by A. Bharati, R. Sangal, and V. Chaitanya, PHI.

Course Name: **AI based Programming Lab** Course Code: **CS-654**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide skills for designing and analyzing AI based algorithms.
- To enable students to work on various AI tools.
- To provide skills to work towards solution of real life problems.

List of Experiments

1. Installation and working on various AI tools viz. Python, R tool, GATE, NLTK, MATLAB, etc.
2. Data preprocessing and annotation and creation of datasets.
3. Learn existing datasets and Treebanks
4. Implementation of searching techniques in AI.
5. Implementation of Knowledge representation schemes.
6. Natural language processing tool development.
7. Application of Machine learning algorithms.
8. Application of Classification and clustering problem.
9. Working on parallel algorithms.
10. Scientific distributions used in python for Data Science - Numpy, scify, pandas, scikitlearn, statmodels, nltk.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Elicit, analyze and specify software requirements.
CO2: Simulate given problem scenario and analyze its performance.
CO3: Develop programming solutions for given problem scenario.

Course Name: **Deep Learning** Course Code: **CS-661** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To build the foundation of deep learning.
- To understand how to build the neural network.
- To enable the students develop successful machine learning projects.

Course Content

Introduction: Feed forward Neural networks, Gradient descent and the back propagation algorithm, Unit saturation, the vanishing gradient problem, and ways to mitigate it. RelU Heuristics for avoiding bad local minima, Heuristics for faster training, Nestors accelerated gradient descent, Regularization, Dropout. Convolutional Neural Networks: Architectures, convolution / pooling layers, Recurrent Neural Networks: LSTM, GRU, Encoder Decoder architectures. Deep Unsupervised Learning: Autoencoders, Variational Auto-encoders, Adversarial Generative Networks, Auto-encoder and DBM Attention and memory models. Dynamic memory networks, Applications of Deep Learning to Computer Vision: Image segmentation, object detection, automatic image captioning, Image generation with Generative adversarial networks, video to text with LSTM models, Attention models for computer vision tasks. Applications of Deep Learning to NLP: Introduction to NLP and Vector Space Model of Semantics, Word Vector Representations: Continuous Skip-Gram Model, Continuous Bag-of-Words model (CBOW), Glove, Evaluations and Applications in word similarity, Analogy reasoning: Named Entity Recognition, Opinion Mining using Recurrent Neural Networks: Parsing and Sentiment Analysis using Recursive Neural Networks: Sentence Classification using Convolutional Neural Networks, Dialogue Generation with LSTMs, Applications of Dynamic Memory Networks in NLP, Factoid Question Answering, similar question detection, Dialogue topic tracking, Neural Summarization.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Learn the fundamental principles of deep learning.

CO2: Identify the deep learning algorithms for various types of learning tasks in various domains.

CO3: Implement deep learning algorithms and solve real-world problems.

Books and References

1. Deep Learning by Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press.
2. The Elements of Statistical Learning by T. Hastie, R. Tibshirani, and J. Friedman, Springer.
3. Probabilistic Graphical Models by D. Koller, and N. Friedman, MIT Press.

Course Name: **Big Data Analytics**
Course Code: **CS-662**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand the Big Data Platform and its Use cases.
- Apply analytics on Structured and Unstructured Data.
- Acquire the knowledge and working on Big Data platforms

Course Content

Introduction to Big Data: Types of Digital Data, Introduction to Big Data, Big Data Analytics, Relational Databases & SQL, Data Cleansing and Preparation, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analyzing Data with Hadoop, Hadoop Streaming, IBM Big Data Strategy, Infosphere BigInsights and Big Sheets. HDFS (Hadoop Distributed File System): The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures. Map Reduce, Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features. Hadoop Eco System Pig: Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive: Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase: HBasics, Concepts, Clients, Example, Hbase Versus RDBMS. Big SQL, Data Analytics with R, Machine Learning: Introduction, Supervised Learning, Unsupervised Learning, collaborative filtering. Big Data Analytics with BigR.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe and analyze various Big Data platforms.

CO2: Develop Big Data Solutions using Hadoop Eco System.

CO3: Apply Machine Learning Techniques using R

Books and References

1. Data Science for Business by F. Provost and T. Fawcett, O'Reilly Media.
2. Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics by Bill Franks, John Wiley & Sons.
3. Hadoop: The Definitive Guide by Tom White, O’reily Media.
4. Big Data and Business Analytics by Jay Liebowitz, Auerbach Publications, CRC Press.

Course Name: **Speech Information Processing**
Course Code: **CS-663**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand the concept of speech processing.
- To build speech based systems.
- To analyze the performance of speech processing systems.

Course Content

Introduction: Speech and Language, Speech analysis, Speech coding, speech production models, speech analysis and analysis-synthesis systems, Mechanisms and Models of the Human Auditory System, linear predictive coding (LPC) analysis, speech recognition, Graphical models, Hidden Markov models, Recognition and training algorithms, Language models, Search algorithms, Optimization, adaptation, Noise robustness, Digital Coding of Speech. Message Synthesis from Stored Human Speech Components. Phonetic Synthesis by Rule. Speech Synthesis from Textural or Conceptual Input. Introduction to Automatic Speech Recognition: Template Matching. Stochastic Modeling. Practical Techniques for Improving Speech Recognition and Performance. Automatic Speech Recognition for Large Vocabularies. Speaker Recognition and other Para-linguistic Technologies. Human Auditory System, Digital Coding of Speech, Phonetics Synthesis by Rule: Introduction Automatic Speech Recognition, Discriminative training for speech recognition, Speech recognition applications, Speech synthesis, voice conversion, Speaker recognition.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the mechanism of human speech production and perception.
CO2: Explain each component of speech recognition systems.
CO3: Have an understanding of the importance of probabilistic modeling in speech recognition.
CO4: Build a speech recognition system.

Books and References

1. Digital Speech Processing: Synthesis, and Recognition by Sadaoki Furui, CRC Press.
2. Speech Synthesis and Recognition by Wendy Holmes, CRC Press.
3. Audio Signal Processing and Coding by Andreas Spanias, Ted Painter and Venkatraman Atti, Willey.

Course Name: **Deep Learning and Data Analytics Lab** Course Code: **CS-664**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide exposure of working on Deep learning and Data Analytics platforms.
- To design and implement solutions for real life problems.

List of Experiments

1. Installation and working on various tools viz. Hadoop, Python, Spark, NoSQL, ANACONDA, Tensorflow, Keras, AWS, etc.
2. Understanding key technology foundations required for Big Data.
3. Learning Hadoop system for implementing Big Data problems.
4. Development of real-time data based application using Hadoop.
5. Development of applications using pytorch library.
6. Knowledge extraction from given data.
7. Use of machine learning and deep learning techniques for solving image related problems.
8. Comparative evaluation of deep learning models.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Simulate/implement given problem scenario and analyze its performance.

CO2: Design solutions for real life problems.

Course Name: **Cognitive Systems**
Course Code: **CS-716**
Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To provide an understanding of the central challenges in realizing aspects of human cognition.
- To provide a basic exposition to the goals and methods of human cognition.
- To develop algorithms that use AI and machine learning along with human interaction and feedback to help humans make choices/decisions.
- To support human reasoning by evaluating data in context and presenting relevant findings along with the evidence that justifies the answers.

Course Content

Understanding Cognition, IBM's Watson, Design for Human Cognition, Augmented Intelligence, Cognition Modeling Paradigms: Declarative/ logic-based computational cognitive modeling, connectionist models of cognition, Bayesian models of cognition, a dynamical systems approach to cognition. Cognitive Models of memory and language, computational models of episodic and semantic memory, modeling psycholinguistics, Cognitive Modeling: modeling the interaction of language, memory and learning, Modeling select aspects of cognition classical models of rationality, symbolic reasoning and decision making, Formal models of inductive generalization, causality, categorization and similarity, the role of analogy in problem solving, Cognitive Development Child concept acquisition. Cognition and Artificial cognitive architectures such as ACT-R, SOAR, OpenCog, CopyCat, Memory Networks. DeepQA Architecture, Unstructured Information Management Architecture (UIMA), Structured Knowledge, Business Implications, Building Cognitive Applications, Application of Cognitive Computing and Systems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand what cognitive computing is, and how it differs from traditional approaches.
CO2: Plan and use the primary tools associated with cognitive computing.
CO3: Plan and execute a project that leverages cognitive computing.
CO4: Understand and develop the business implications of cognitive computing.

Books and References

1. The Cambridge Handbook of Computational Psychology by Ron Sun (ed.), Cambridge University Press.
2. Formal Approaches in Categorization by Emmanuel M. Pothos, Andy J. Wills, Cambridge University Press.
3. Cognition, Brain and Consciousness: Introduction to Cognitive Neuroscience by Bernard J. Bears, Nicole M. Gage, Academic Press.
4. Cognitive Computing and Big Data Analytics by Hurwitz, Kaufman, and Bowles, Wiley.

Course Name: **Neural Network and Fuzzy Logic**
Course Code: **CS-717**
Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the basic principles, techniques, and applications of neural network and fuzzy logic
- Provide the mathematical background for carrying out the optimization associated with neural network learning.
- Develop the skills to gain basic understanding of the areas of Artificial Neural Networks and Fuzzy Logic.

Course Content

Neural Networks: Introduction, biological neuro-system, neurons and its mathematical models, ANN architecture, learning rules, supervised and unsupervised learning model, reinforcement learning, ANN training Algorithms-perceptions, Training rules, Delta, Back propagation algorithm, Multilayer perceptron model, Hopfield networks, Associative memories. Fuzzy Logic: Classical and Fuzzy Sets, Membership Function, Fuzzy rule generation, Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of operations, aggregation operations. Fuzzy Arithmetic: Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals and numbers, Lattice of fuzzy numbers, Fuzzy equations. Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges. Uncertainty based Information: Significance of uncertainty, Uncertainty and information, Principles of uncertainty, Reasoning under uncertainty: heuristics, empirical associations, objective and subjective probabilities, Non-specificity of Fuzzy and Crisp Sets, Fuzziness of Fuzzy Sets.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Comprehend the fuzzy logic and the concept of fuzziness.
CO2: Understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic.
CO3: Understand the fundamental theory and concepts of neural networks, Identify different neural network architectures, algorithms, applications and their limitations.
CO4: Understand appropriate learning rules for each of the architectures and learns several neural network paradigms and its applications.

Books and References

1. Learning and Soft Computing by V. Kecman, Pearson.
2. Genetic Algorithms in Search Optimization and Machine Learning by D. E. Goldberg, Addison Wesley.
3. Neural Network and fuzzy systems by B. Kosko, Prentice Hall of India.
4. Intelligent Hybrid Systems by S. Goonatilake and S. Khebbal, Wiley.

Course Name: **Game Theory and Applications** Course Code: **CS-718** Course Type: **Programme Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To teach students some strategic considerations to take into account making their choices.
- To learn basic concepts of game theory.
- To apply game theoretic models to real world problems.

Course Content

Introduction: games and decisions, Games Strategies, Costs and Payoff, Basic Solution Concepts, Finding equilibria and Learning in Games. Zero-sum games: secure strategy, Maximin, Maximax, and Minimax Regret Solvability, value of a game. Normal form games: dominance, iterated dominance, Nash equilibrium. N-player games, mixed strategy nash equilibria. Graphical Games: Computing Nash equilibria in Tree Graphical Games, Graphical Games and correlated Equilibria. Extensive form games: subgame perfection, sequential equilibrium, Stackelberg Model of Duopoly, Buying Votes, Committee Decision-Making. Bargaining: Rubinstein bargaining, Nash bargaining. Repeated games: Folk theorem and repeated prisoner’s dilemma. Tacit collusion. Incomplete information games: Bayesian equilibrium, higher order beliefs. Auctions and mechanism design: Basic auctions, voting, Vickrey-Clarke-Groves Auction. Cryptography and Game theory: cryptographic influence on game theory and Game theoretic influence on cryptography.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Solve strategic games between two and more agents in non-cooperative scenario.

CO2: Analyze and solve both simultaneous-moves and sequential-moves games.

CO3: Learn different methods to solve games.

Books and References

1. A Course in Game Theory by M. J. Osborne & A. Rubinstein, MIT Press.
2. Algorithmic Game Theory by N. Nisan, T. Rougharden, E. Tardos and V. V. Vazirani, Cambridge University Press.
3. Game Theory and Applications by Tatsuro Ichiishi, Abraham Neyman and Yair Tauman, Elsevier.
4. Essentials of Game Theory: A Concise, Multidisciplinary Introduction by K. Leyton-Brown and Y.Shoham, Morgan & Claypool Publishers.

Course Name:	**Data Mining**
Course Code:	**CS-719**
Course Type:	**Programme Elective-I**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To introduce students to the basic applications, concepts, and techniques of data mining and web mining.
- To develop skills for using recent data mining softwares to solve practical problems in a variety of disciplines.
- To develop the skills to conduct mining of World Wide Web.

Course Content

Types of data mining problems. The process of data mining. Statistical evaluation of big data: statistical prediction, performance measures, pitfalls in data-mining evaluation. Data preparation: data models, data transformations, handling of missing data, time-dependent data, and textual data. Data reduction: feature selection, principal components, smoothing data, case subsampling. Predictive modeling: mathematical models, linear models, neural nets, advanced statistical models, distance solutions, logic solutions, decision trees, decision rules, Association rules, model combination. Solution analyses: graphical trend analyses, comparison of methods. Future trends: text mining, visualization, distributed data. Text mining: extracting attributes, structural approaches: parsing, soft parsing. Bayesian approach to classifying text, Web mining: classifying web pages, extracting knowledge from the web, Sequential Pattern Mining, Pattern Mining Applications: Mining Spatiotemporal and Trajectory Patterns, Constraint-Based Mining, Graph Pattern Mining. Data Warehouse and OLAP, Data Warehouse and DBMS, Multidimensional data model, OLAP operations, loan data set.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Design and implement systems for data mining and web mining.

CO2: Evaluate the performance of different data-mining algorithms.

CO3: Propose data-mining solutions for different applications.

Books and References

1. Data Mining Concepts and Techniques by Jiawei Han and Michelien Kamber, Morgan Kaufmann.
2. Data Warehousing, Data mining and OLAP by Alex Berson and Stephen Smith, McGraw Hill.
3. Web Data Mining by Liu Bing, Springer-Verlag.
4. Mining the World Wide Web by Chang George, Springer-Verlag.

Course Name: **Probabilistic Graphical Models**
Course Code: **CS-726**
Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce the concepts of probabilistic graphical models.
- To Link the probabilistic graphical model techniques with the real applications.
- To provide students an opportunity to explore how to link probabilistic graphical models in their research area.

Course Content

Introduction to Graphical Models: Probability theory, Bayesian network: representation and independence, Bayes ball algorithm and variable elimination algorithm, Hidden Markov models, Markov random field: representation and Gibbs distribution, induced MRF and factorization, independence, Conditional random field: representation and cluster graphs, Message passing: belief propagation, Cluster graph properties and construction, Variable Elimination, Sum-Product Message Passing, Expectation-Maximization Algorithm Modeling Networks, Ising Models, Gaussian Graphical Models, Factor Analysis, State Space Models, Variational Inference: Loopy Belief Propagation, Mean Field Approximation , Case Study: Learning Topic Models, Approximate Inference: Markov Chain Monte Carlo, Dirichlet Processes, Hierarchical Dirichlet Processes, Hilbert Space Embedding's of Distributions, Kernel Graphical Models, Spectral Algorithms for Graphical Models Case Study: Parsing in Natural Languages, Graph-Induced Structured Input-Output Methods, Structured Sparse Additive Models, Distributed MCMC, Maximum-Margin Learning of Graphical Models, Posterior Regularization.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Relate practical problems to probabilistic graphical models.

CO2: Students will be able to explain various probabilistic models through case studies.

CO3: Able to apply the probabilistic graphical models in their research areas.

Books and References

1. Probabilistic graphical models – Principles and techniques by Daphne Koller and Nir Friedman, MIT Press.
2. An Introduction to Graphical Models by Michael I. Jordan, Springer.
3. Probabilistic Graphical Models by Koller Daphne, MIT Press.
4. Probabilistic Graphical Models: Principles and Applications by Luis Enrique Sucar, Springer.

Course Name: **Digital Image Processing**
Course Code: **CS-727**
Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To study the concepts of Digital Image Processing focuses on various image processing methods.
- To study the image enhancement and compression techniques.
- To study image restoration and segmentation procedures.
- To study an advanced Digital Image Processing investigates algorithms and techniques for a variety of imaging applications.

Course Content

Introduction: Examples of fields that use digital image processing, fundamental steps in digital image processing, components of image processing system. Digital Image Fundamentals: A simple image formation model, image sampling and quantization, basic relationships between pixels. Image enhancement in the spatial domain: Basic gray-level transformation, histogram processing, enhancement using arithmetic and logic operators, basic spatial filtering, smoothing and sharpening spatial filters, combining the spatial enhancement methods. Image Restoration: A model of the image degradation/restoration process, noise models, restoration in the presence of noise–only spatial filtering, Weiner filtering, constrained least squares filtering, geometric transforms, Introduction to the Fourier transform and the frequency domain, estimating the degradation function. Color Image Processing. Image Compression: Fundamentals, image compression models, error-free compression, lossy predictive coding, image compression standards. Morphological Image Processing: Preliminaries, dilation, erosion, open and closing, hit or miss transformation, basic morphologic algorithms. Image Segmentation: Detection of discontinuous, edge linking and boundary detection, thresholding, region–based segmentation. Object Recognition : Patterns and patterns classes, recognition based on decision–theoretic methods, matching, optimum statistical classifiers, neural networks, structural methods – matching shape numbers, string matching.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Review the basic concepts of a digital image processing.
CO2: Analyze images in the spatial domain using various transformation techniques.
CO3: Apply the image processing techniques in various domain of image processing.
CO4: Analyses the techniques real world applications.

Books and References

1. Digital Image Processing using MATLAB by Gonzales Woods, Gatesmark Publishing.
2. Fundamentals of Digital Image Processing by A K Jain, Prentice Hall Publishing.
3. Digital Image Processing by Rafael C. González, Richard Richard Eugene Woods and L.Steven, Prentice Hall.

Course Name: **Information Retrieval** Course Code: **CS-728** Course Type: **Programme Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To learn concepts of Information Retrieval from documents and web portals.
- To evaluate the efficiency of existing Information Retrieval approaches.
- To implement Information Retrieval approaches in real applications.

Course Content

Introduction: Information retrieval process, Indexing, Information retrieval model, Boolean retrieval model, Dictionary and Postings: Tokenization, Stop words, Stemming, Inverted index, Skip pointers, Phrase queries, Tolerant Retrieval: Wild card queries, Permuterm index, Bigram index, Spelling correction, Edit distance, Jaccard coefficient, Soundex, Evaluation Precision, Recall, F-measure, E-measure, Normalized recall, Latent Semantic Indexing, Eigen vectors, Singular value decomposition, Lowrank, approximation, Problems with Lexical Semantics, Query Expansion Relevance feedback, Rocchio algorithm, Probabilistic relevance feedback, Query Expansion and its types, Query drift, Probabilistic Information Retrieval: Probabilistic relevance feedback, Probability ranking principle, Binary Independence Model, Bayesian network for text retrieval, Structural terms, Content Based, Image Retrieval

Content Based Image retrieval, Challenges in Image retrieval, Image representation, Indexing and retrieving images, Relevance feedback, Open source Search engine Frameworks: Components of a Search engine, Web search: The structure of the web, Queries and users, Static ranking, Dynamic ranking, Evaluating web search, The user, paid placement, Search engine optimization/spam, Web Search Architectures: Crawling, Meta-crawlers and Focused Crawling, Web Crawlers: Crawling the web, Document feeds, Storing documents and detecting duplicates, Index Compression: Statistical properties of terms in IR, Dictionary compression, Postings File compression, XML retrieval: XML Indexing and Search, Data vs. Text-centric XML, Text-Centric XML retrieval, A vector space model for XML retrieval, Link Analysis: hubs and authorities, Page Rank and HITS algorithms.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand different Information Retrieval models.

CO2: Evaluate various Information Retrieval models.

CO3: Evaluate and optimize search engines and develop optimized web sites.

Books and References

1. Introduction to Information Retrieval by C. Manning, P. Raghavan, and H. Schutze, Cambridge University Press.
2. Modern Information Retrieval: The Concepts and Technology behind Search by Ricardo Baeza Yates and Berthier Ribeiro Neto, ACM Press.
3. Search Engines: Information Retrieval in Practice by Bruce Croft, Donald Metzler and Trevor Strohman, Addison Wesley.
4. An Introduction to Search Engines and Web Navigation by Mark Levene, Wiley.

Course Name: **Machine Translation** Course Code: **CS-729** Course Type: **Programme Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To teach students machine translation approaches.
- To evaluate the performance of machine translation Systems.
- To develop translation models for Indian Languages.

Course Content

Introduction: Automating knowledge acquisition for machine translation, Basic probability theory, n-gram language models, smoothing techniques for language modeling Absolute discounting and Kneser-Ney smoothing. Language Modeling Probability, language models, and conditional language models, Very large language models. Word alignment and the expectation maximization algorithm. MT evaluation: BLEU, Google Translate and Bing Translator. Introduction to Moses, Corpus Acquisition from Internet, Latent-variable translation models, Phrase-based translation and decoding, Statistical phrase-based translation, The complexity of phrase alignment problems. Relationship to EBMT. Phrase extraction. Estimating phrase translation probabilities and the problem of overfitting. Phrase reordering models. Phrase-based decoding. k-best lists. Maximum entropy. Minimum error-rate training. Perceptron, max-margin methods. System combination. Syntax-based translation, Hierarchical and syntax-based MT. Synchronous context-free grammars and tree-substitution grammars. Extracting synchronous CFGs and TSGs from parallel data. Estimating rule probabilities and the problem of overfitting. Extracting synchronous TSGs from tree, tree data and the problem of nonisomorphism. CKY decoding. CKY with an n-gram language model. Binarization. K-best lists. Decoding with lattices. Source-side tree decoding. Syntax-based language models. Semantics-based translation. Neural probabilistic language models Conditional neural language models, large vocabulary language modeling, large vocabulary translation modeling, Effective Approaches to Attention-based Neural Machine Translation, Incorporating Structural Alignment Biases into an Attentional Neural Translation Model, Neural Machine Translation and Sequence-to-sequence Models.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand machine translation system.

CO2: Explain, apply, and assess manual and automatic evaluation methods for machine translation.

CO3: Build their own translation model using existing tools for machine translation.

Books and References

1. Statistical Machine Translation by Philipp Koehn, Cambridge University Press.
2. Deep Learning by Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press.
3. Linguistic Fundamentals for Natural Language Processing by Emily Bender, Morgan & Claypool.

Course Name: **Computer Vision** Course Code: **CS-736** Course Type: **Programme Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To study the development of algorithms and techniques to analyze and interpret the visible world around us.
- Be familiar with both the theoretical and practical aspects of computing with images.
- To understand the basic concepts of Computer Vision.
- Understand the geometric relationships between 2D images and the 3D world.
- Ability to apply the various concepts of Computer Vision in other application areas.

Course Content

Digital Image Formation and low-level processing: State-of-the-art, fundamentals of image formation. Transformation: orthogonal, Euclidean, affine, projective. Fourier transform, convolution and filtering, image enhancement, restoration, histogram processing. Depth estimation and multi-camera views: perspective, binocular stereopsis: camera and epipolar geometry, homography, rectification, DLT, RANSAC, 3-D reconstruction framework, auto-calibration, apparel. Feature extraction: Edges canny, LOG, DOG. Line detectors (Hough Transform), Corners: Harris and Hessian Affine, orientation histogram, SIFT, SURF, HOG, GLOH. Scale-Space Analysis: Image pyramids and Gaussian derivative filters, Gabor filters and DWT. Image Segmentation: Region growing, edge based approaches to segmentation, graph-cut, mean-shift, MRFs, texture segmentation, object detection. Clustering: K-Means, K-Medoids, mixture of Gaussians. Classification: Discriminant function, supervised, un-supervised, semi-supervised. Classifiers: Bayes, KNN, ANN models. Dimensionality Reduction, Motion Analysis: background subtraction and modeling, optical flow, KLT, spatio-temporal analysis, dynamic stereo, motion parameter estimation. Shape from X: light at surfaces, phong model, reflectance map, Albedo estimation, photometric stereo, use of surface smoothness, constraint, shape from texture, color, motion and edges. Applications: CBIR, CBVR, activity recognition, computational photography, biometrics, stitching and document processing. Recent Trends: 3-D Printing, 3-D sensing, simultaneous location and mapping, GPU, edge-computing, augmented reality, virtual reality cognitive models, fusion and super resolution.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the fundamental problems of computer vision.

CO2: Implement various techniques and algorithms used in computer vision.

CO3: Analyze and evaluate critically the building and integration of computer vision algorithms.

CO4: Demonstrate awareness of the current key research issues in computer vision.

Books and References

1. Computer Vision: Algorithms and Applications by Richard Szeliski, Springer-Verlag.
2. Computer Vision: A Modern Approach by D. A. Forsyth and J. Ponce, Pearson Education.
3. Multiple View Geometry in Computer Vision by Richard Hartley and Andrew Zisserman, Cambridge University Press.
4. Introduction to Statistical Pattern Recognition by K. Fukunaga, Academic Press, Morgan Kaufmann.
5. Digital Image Processing by R.C. Gonzalez and R.E. Woods, PHI.

Course Name: **Network Science and Modelling**
Course Code: **CS-737**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To examine modern techniques for analyzing and modeling the structure and dynamics of complex networks.
- To focus on statistical algorithms and methods in network science.
- To emphasize model interpretability and understanding the processes that generates real data.

Course Content

Introduction and overview, Measures of structural importance, Random graphs: homogeneous degrees, heterogeneous degrees, Large-scale structure: Associativity and modularity, stochastic block models, Spreading processes on networks, generalizations and theorems, Wrangling network data: sampling, data, statistics, and tests, Spatial networks, Growing networks, Fall break, Dynamics networks. Introduction to Probability: Bayes' theorem, Conditional probability, Total probability, Discrete and Continuous Random variables, Common distributions, Probability Generating Functions, and Laplace Transforms, examples from computer networking, Stochastic processes, Discrete time Markov chains. Continuous time Markov chains, Queuing systems (M/M/1, M/M/c/k, M/G/1), Queuing networks, Statistical analysis of simulations, Specific topics: Introduction to performance measures, basic probability review, Markov chains, basic queuing models, introduction to simulation modeling, some advanced queuing models, basic queuing networks.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Get acquainted with network based modelling techniques.

CO2: Grasp working knowledge of network based modeling techniques.

CO3: Select appropriate evaluation techniques, and apply to real world problems.

Books and References

1. Simulation Modeling and Analysis by Law and Kelton, McGraw Hill.
2. Networks: An Introduction by M.E.J. Newman, Oxford University Press.
3. Networks, Crowds and Markets by D. Easley and J. Kleinberg, Cambridge University Press
4. Introduction to the Modeling and Analysis of Complex Systems by Hiroki Sayama. Open SUNY Textbooks.
5. Quantitative System Performance - Computer System Analysis Using Queueing Network Models by Edward D. Lazowska, John Zahorjan, G. Scott Graham and Kenneth C. Sevcik, Prentice-Hall.

Course Name: **Spatial and Temporal Computing**
Course Code: **CS-738**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To distinguish traditional relational data and spatial data.
- To apply relevant spatial data mining techniques to solve a variety of spatial problems.
- To apply spatial and temporal analysis to real world problems.

Course Content

Introduction: Geo-spatial science, systems and services, spatial concepts and data models: field vs object based, spatial query languages. Fundamental spatial algorithms: space filling curves, vornoi diagrams. Spatial storage and indexing: Grid files, Quadtrees and R-trees, query processing, join strategies, and optimization. Spatial networks: conceptual, logical and physical level design issues, temporal databases, time domain, granularity, temporal data models and extensions of SQL, Sequenced semantics, Spatial databases, Query processing in spatial network databases, spatial data mining: classification, association and clustering. Spatial statistics: hot-spot and distributions using Arc. Conceptualization of spatial relationships: spatial autocorrelation by distance, autocorrelation, nearest neighbor, hot-spot analysis. Exploratory regression, OLS, Geographically weighted regression, Spatial computing systems: Geographic Information Systems: Open Source GRASS GIS, ESRI ArcGIS family. Database Management Systems: PostgreSQL, PostGIS, IBM DB2 Spatial Extender, MS SQL Server Spatial. Spatial data mining platforms: R, standards opengeospatial.org, ISO TC 211. Spatial analysis in networks. Spatio-temporal computing: techniques of spatial and temporal analysis, point patterns, geostatistics, spectral analysis, wavelet analysis, interpolation, and mapping. Spatial information services: virtual globes, location based services, enterprise consulting. Application programming interfaces: HTML5 Geolocation API, Google Maps API, Bing Maps API, Flickr location API, Twitter location API.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Become familiar with technologies used in spatial and temporal data.

CO2: Use advanced technologies to build applications combined with geographical data.

CO3: Be familiar with tools and technologies to evaluate and compare systems.

Books and References

1. Spatial Analysis: Modeling in a GIS Environment by Paul Longley and Michael Batty, Wiley.
2. CyberGIS for Geospatial Discovery and Innovation by Shaowen Wang, Michael F. Goodchild, Springer.
3. Spatial Databases: A Tour by Shashi Shekhar and Sanjay Chawla, Pearson.

Course Name: **Evolutionary Computing** Course Code: **CS-739** Course Type: **Programme Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To discuss the major approaches of evolutionary computing.
- To develop solutions for problems using evolutionary approaches
- To understand biological process that can be mimicked computationally.

Course Content

Introduction to Models and Concept of Computational Intelligence, Social Behavior as Optimization: Discrete and Continuous Optimization Problems, Classification of Optimization Algorithms, Optimization background and terminology: Gradient optimization methods, sampling methods, linear programming, combinatorial optimization. Evolutionary Biology background: Genotype and phenotype, unit of selection, genes and traits, chromosomes, alleles, diploid and haploid, fitness, mutation and recombination. Selection, variation and landscapes. The strengths and weaknesses of the evolutionary model. Inductive bias. The No free lunch theorem. Genetic Algorithms: Representation, operators, and standard algorithm. Evolutionary strategies: Evolution in continuous variables. Transformations. Genetic Programming. Building blocks and architecture-altering operators. Libraries and Trees. Selection mechanisms: Fitness proportionate, rank, tournament, Stochastic Universal Sampling and Boltzman selection methods. Niching methods. Spatial methods. Artificial landscapes and test functions: The Two-armed bandit problem. Gene Expression Programming, Multi-modal and deceptive functions. Royal roads. N-k landscapes. Hierarchical and fractal functions. Pareto evolution. Co-evolution: Multiple populations and single-population co-evolution, Multiobjective evolutionary algorithms: Plasticity and life-time learning. Lamarckian learning, The Baldwin effect. Symbiosis as a source of evolutionary innovation. Macro-mutations, Tabu Search: Tabu Tenure, Cycle Detection & Aspiration Criterion, Reactive Tabu Search. Swarm Intelligence Techniques: Particle Swarm Optimization, Ant Colony Optimization, Artificial Bees and Firefly Algorithm, Hybridization and Comparisons of Swarm Techniques, Application of Swarm Techniques in Different Domains and Real World Problems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the relations between the most important evolutionary algorithms.

CO2: Understand the implementation issues of evolutionary algorithms.

CO3: Determine the appropriate parameter settings to make different evolutionary algorithms work well.

CO4: Design new evolutionary operators, representations and fitness functions.

Books and References

1. An introduction to genetic algorithms by Melanie Mitchell, MIT Press.
2. Computational Intelligence: An Introduction by A.P. Engelbrecht, Wiley.
3. Genetic Algorithm in Search Optimization and Machine Learning by D. E. Goldberg, Pearson Education.

Course Name: **Cryptography and Security Analytics** Course Code: **CS-746** Course Type: **Programme Elective-IV**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To understand basics of cryptography and network security
- To learn about Security analytics by analyzing network traffic.
- Apply data mining and NLP techniques to investigate security breaches.
- To develop tools to mitigate various security attacks.

Course Content

Introduction : Need and basic goals for computer security, security threats, Cryptography : secret key and public key cryptography, Pseudo random bit generators, Block and stream ciphers, Hash functions and message digests, Public key encryption, authentication, digital signatures, zero knowledge interactive protocols. Network Security: problems in network security, kinds of attacks, PKI, key exchange protocols. Protocol vulnerabilities: examples of protocol vulnerabilities such as in TCP/IP, denial of service attacks. Tools for network security such as firewalls and intrusion detection systems, malware, intrusion detection, denial of service, email and web security, Unique characteristics of security domain: availability of datasets, unbalanced data and diversity of data in each class, active adversary, asymmetrical costs of misclassification, poisoning of datasets, the base-rate fallacy, time scale of attacks, nonstationarity inference, Data: Types of data and preprocessing/visualization, Unsupervised learning: clustering, Supervised learning: decision trees, soft-margin support-vector machines, neural networks, one-class, semi-supervised and multi-criteria learning, incremental classification, NLP: Markov chain models including HMMs and incremental HMMs, basic definitions and applications of NLP tasks such as part-of-speech tagging and word-sense disambiguation, WordNet, semantic feature selection, Applications of the above analytical methods to network and web security problems including intrusion detection, denial-of-service attacks, phishing email and web site detection, and anomaly detection.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the most common type of cryptography algorithms and network security concepts.

CO2: Understand data mining and NLP techniques and apply them to security problems.

CO3: Identify the weaknesses in the existing networking protocols and cryptographic algorithms.

CO4: Conduct vulnerability assessments of existing networks.

Books and References

1. Cryptography, Theory and Practice by Douglas R. Stinson, CRC Press.
2. Cryptography and Network Security: Principles and Practices by W. Stallings, Prentice Hall.
3. Applications of Data Mining in Computer Security by D. Barbara and S. Jajodia, Kluwer Academic.
4. Statistical Methods in Computer Security by William W.S. Chen, Marcel Dekker, Marcel Dekker.
5. Investigative data mining for security and criminal detection by Jesus Mena, Butterworth-Heinemann.

Course Name: **IPR in Artificial Intelligence** Course Code: **CS-747** Course Type: **Programme Elective-IV**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To explain the art of interpretation and documentation of research work.
- To explain various forms of intellectual property rights.
- To discuss leading International regulations regarding Intellectual Property Rights.

Course Content

Defining the Research Problem in AI, Reviewing the literature in AI, Research Design, Data Collection, Validation, Interpretation and Report Writing, LaTeX tool, presentation preparation, History and theory of AI Regulation, AI and Copyright: Authorship, Ownership and Infringement, Automated Copyright Enforcement. AI, Data and Big Data: Ownership and Protection, Patenting AI. AI-generated Inventions: Inventiveness and Ownership, AI and Patent Enforcement, Trade Secrets, and Product Innovation, Autonomous Driving, AI and Blockchain. The Concept, Intellectual Property System in India, World Intellectual Property Organisation, WIPO and WTO, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Document the research outcome of the work carried out in the area of Artificial Intelligence.

CO2: Generate Copyright or patent in the area of Artificial Intelligence.

Books and References

1. Professional Programme Intellectual Property Rights, Law and Practice, the Institute of Company Secretaries of India, Statutory Body under an Act of Parliament.
2. World Intellectual Property Organisation (WIPO). https://www.wipo.int/about-ip/en/artificial_intelligence/

Course Name: **Affective Computing and Interaction**
Course Code: **CS-748**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To learn emotional recognition techniques.
- To gain a broader knowledge and understanding of the various affective computing models.
- To learn about various machines developed using human emotion.

Course Content

Introduction: Affective Computing and the Challenge of mood measurement and forecasting. Affective phenomena: emotion, mood, attitude/sentiment, personality. Computers, robots, smartphones with emotional intelligence. Emotion Theory: Dual-process theories of emotion, Constructivist theories, Appraisal theories. Affective Technology Interaction and Empathy: Computational Appraisal Theory, reinforcement learning based approaches, recognizing emotional context, facial affect recognition, Ethical issues related to emotion and AI, Emotionally Intelligent Human Computer Interaction, Emotion and Perception, Decision-making, and Creativity, Emotion and Learning, Physiology of Emotion, Behavioral game theory, Neurological Mechanisms involved in Emotion, Affect Recognition by Wearable's and other Machines, Communicating Frustration/Stress in Autism and in Customer Experience, Responding to User Emotion to Reduce User Frustration, Inducing Emotion, Robots/Agents that "have" Emotion, Expression of Emotion by Machines/Agents/Synthetic characters, Philosophical, Social, Ethical Implications of Affective Computing, Machine/Mobile Empathy and Emotional Support, Lie Detection and Stress Detection.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Have a good understanding of the role of emotion and machine interaction.

CO2: Have an understanding of the aesthetic aspect of machine design.

CO3: Develop systems to reduce the emotional gap between humans and machines, all within the context of interactions.

Books and References

1. Affective Computing and Interaction: Psychological, Cognitive and Neuroscientific Perspectives by Didem Gökçay and Gülsen Yildirim, IGI Global.
2. The Encyclopedia of Human-Computer Interaction by Jonas Lowgren, John M. Carroll, Marc Hassenzahl, and Thomas Erickson, Interaction Design Foundation.
3. Affective Computing by R.W. Picard, MIT Press.
4. The Oxford Handbook of Affective Computing by R.A. Calvo, S.K. D'Mello, J. Gratch, and A. Kappas, Oxford University Press.

Course Name: **Internet of Things**
Course Code: **CS-749**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about Internet of Things.
- To introduce the fundamental concepts relevant to design issues related to Internet of Things.
- To enable the students to understand the basic principles of mobility in Internet of Things

Course Content

Introduction to IoT: Sensing, Actuation, Communication Protocols, Sensor Networks, IoT architecture, standards considerations. Machine-to-Machine Communications, Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management. IoT reference Model, Sensors for IoT Applications, IoT Map Device, Wireless Sensor Structure, Energy Storage Module, Power Management Module, RF Module, Sensing Module, ACOEM Eagle, EnOcean Push Button, NEST Sensor, Ninja Blocks, Wearable Electronics, Implementation of IoT with Raspberry Pi, Clayster libraries, SDN for IoT, Interfacing the hardware: Internal representation of sensor values, Persisting data, External representation of sensor values, Exporting sensor data, development of the actuator project. Security Architecture in the Internet of Thing, RFID False Authentications, Application of Geographical Concepts and Spatial Technology to the Internet of Things: Applying spatial relationships, functions, and models, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Case Studies: Agriculture, Healthcare, and Activity Monitoring. Sensor-Cloud, Smart Cities and Smart Homes.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Solve basic network design problems of Internet of Things.

CO2: Define the concept of data communications protocols and convergence of technologies.

CO3: Understand the principles and various research issues related to Internet of Things.

Books and References

1. Internet of Things Principles and Paradigms by Rajkumar Buyya and Amir Vahid Dastjerdi, Elsevier.
2. From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence by Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand and David Boyle, Academic Press.
3. Sensors, Actuators and Their Interfaces by N. Ida, Scitech Publishers.