MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI – 12.

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Ph.D., (Computer Science / Computer Application /

Information Technology & Engineering / Computer Science & Engineering

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From the Academic Year – (2017-2018)

Admission Norms, Scheme of Examination and Syllabus

S.No	Subject	Credits
1	Research and Teaching Methodology	4
2	Recent Research Topics in Computing	4
3	Elective – I & Elective – II (Or) Elective – I & Elective –II/Dissertation	4 4 4 4

Total No. of. Credits

List of Electives Offered:

1. Network and Information Security
2. Advanced Wireless Network Architecture
3. Software Defined Networks
4. Internet of Things(IoT)
5. Digital Video Acquisition and Analysis
6. Pattern Recognition
7. Video Data Management and Information Retrieval
8. Advanced Digital Image Processing
9. Data Mining and Data Warehousing
10. Big Data Analytics

11. Deep Learning
12. Machine Learning Techniques
13. Cloud Computing
14. Bio-Inspired Computing
15. Multi-core Architectures

MANDATORY COURSE WORKS

Computer Science / Computer Application /

Information Technology & Engineering / Computer Science & Engineering

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2017-2018

CORE I - RESEARCH AND TEACHING METHODOLOGY

OBJECTIVES **:**

- To understand the importance of Research Methodology
- To ensure the reliability and validity of experiments
- To perform exploratory data analysis
- To apply the statistical testing to prove the hypothesis
- To provide the inference using quantitative data analysis
- To make use of computer aids to analyse the data, prepare reports and presentations
- Able to evaluate methodology of teaching

UNIT - I

INTRODUCTION OF RESEARCH AND FORMULATION

Motivation and Objectives – Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Defining and formulating the research problem - Selecting the problem - Necessity of Primary and secondary sources – Reviews, treatise, monographs, patents –Critical literature review defining the problem - Importance of literature review in defining a problem – Literature review –Primary and secondary sources-Reviews,treatise,monographs,patents-Critical Literature review

RESEARCH DESIGN AND METHODS

Research design – Basic Principles- Need of research design –– Features of good design – Important concepts relating to research design.

UNIT- II

Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models - Developing a research plan - Exploration, Description, Diagnosis, Experimentation - Determining experimental and sample designs.

DATA COLLECTION

Execution of the research - Observation and Collection of data - Methods of data collection.

UNIT- III

DATA ANALYSIS

Quantitative Methods: Online Quantitative Design and Survey – Descriptive Measures – Probability – Random Variables and Distribution Functions – Discrete Probability Distributions – Continuous Probability Distribution – Sampling Distributions – Theory of Estimation – Hypothesis Testing – Correlation – Regression – Principles of Sample Survey – Types of Sampling – Design of Experiments – CRD-RBD-LSD-Factor Analysis – Cluster Analysis –Discriminant Analysis – Multiple Regression and Correlation – Canonical Correlation – Application of Statistical Software Packages.

REPORTING AND THESIS WRITING

Reporting and thesis writing – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes – Use of Oral presentation – Software Packages for thesis Preparation– Planning – Preparation – Practice – Making presentation – Use of visual aids - Importance of effective communication.

UNIT-IV APPLICATION OF RESULTS AND ETHICS

Application of results and ethics - Environmental impacts - Ethical issues - ethical committees - Commercialization – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism – Application of Plagiarism detection tools - Citation and acknowledgement - Reproducibility and accountability.

UNIT V

METHODOLOGY OF TEACHING

Teaching – Objectives of Teaching, Phases of Teaching – Teaching Methods: Lecture Method, Discussion Method, Discovery Learning, Inquiry, Problem Solving Method, Project method, Seminar – Integrating ICT in Teaching: Individualized Instruction, Ways for Effective Presentation with PowerPoint – Documentation – Evaluation: Formative, Summative & Continuous and Comprehensive Evaluation – Later Adolescent Psychology: Meaning, Physical, Cognitive, Emotional, Social and Moral Development – Teaching Later Adolescents.

OUTCOMES:

- Explain the importance of the research methodology
- To validate the reliability
- Select and apply different research approaches and methodologies

- Develop data collection instrument according to the underlying theoretical framework.
- Analyse quantitative data and qualitative data using software packages
- Provide valid inference
- Construct and document an appropriate research design
- Discuss limitations and potential contribution to theory and practice of research
- Effectively apply the appropriate computer tools in each stage of research
- Ability to implement effective ICT based Teaching Methods

REFERENCES

1. C R Kothari, Paperback "Research Methodology: Methods and Techniques", 2014
2. Modern Language Association Handbook, Eight Edition, 2016
3. R. Paneerselvam, "Research Methodology" 2nd Edition, PHI, 2014
4. John W Creswel, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 3rd Edition, 2014
5. S.C. Gupta & V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi, 2014 Edition.
6. S.C. Gupta & V.K. Kapoor, Fundamentals of Applied Statistics, Sultan Chand & Sons. 2014 Edition.
7. Sampath.K, Panneerselvam.A & Santhanam.S (1984), Introduction to Educational Technology (2nd Revised Ed.) New Delhi: Sterling Publishers.
8. Sharma.S.R(2003).Effective Classroom teaching modern methods, tools & techniques, Jaipur: Mangal Deep.
9. Vedanayagam.E.G (1989). Teaching Technology for College Teachers, Newyark: SterlingPublishers.

CORE II- RECENT RESEARCH TOPICS IN COMPUTING

***OBJECTIVES*:**

- To apply AI techniques primarily for machine learning, vision, and robotics.
- To understand the fundamentals of Internet of Things
- To study about virtualization and cloud resource management
- To model and visualize the social network
- To introduce visual perception and core skills for visual analysis
- Learn developmental and artificial immune systems
- To get exposed to the domain of bioinformatics
- To know about various applications of natural language processing
- Understand behavioural systems especially in the context of Robotics

UNIT I SOFT COMPUTING

Introduction of soft computing - soft computing vs. hard computing- various types of soft computing techniques- applications of soft computing-Neuron- Nerve structure and synapse Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- McCullochPitts neuron model- Perceptron model- Adeline and Madeline- multilayer perception model- back propagation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training applications.Introduction to Deep Learning.

UNIT II CLOUD ARCHITECTURE AND INTERNET OF THINGS

Introduction: Cloud delivery model, Cloud Storage Architectures, Software as a Service (SaaS): SaaS service providers – Google App Engine, Salesforce.com and googleplatfrom – Benefits – Operational benefits - Economic benefits – Evaluating SaaS – Platform as a Service (PaaS): PaaS service providers – Right Scale – Salesforce.com – Rackspace – Force.com – Services and Benefits – Infrastructure-as-a -Service (IaaS): IaaS Service Providers – Amazon EC2 – GoGrid.

Introduction to Distributed Computing: architectural models - fundamental models - P2P systems - Introduction to inter process communications - external data representation and marshalling- client server communication - group communication- multicast/pubsub - Energy Efficient Computing - Cloud computing.

Definitions and Functional Requirements –Motivation – Architecture - Web 3.0 View of IoT– Ubiquitous IoT Applications – Four Pillars of IoT – DNA of IoT - The Toolkit Approach for End-user Participation in the Internet of Things. Middleware for IoT: Overview – Communication middleware for IoT –IoT Information Security.

UNIT III BIG DATA AND VIRTUALIZATION

Big Data - Map Reduce – Hadoop, Hive, MapR – Sharding – NoSQL Databases – Cloud databases - S3 - Hadoop Distributed File Systems – Visualizations - Visual Data Analysis Techniques - Interaction Techniques – Social Network Analysis – Collective Inferencing – Egonets - Systems and Applications

Linux System- Basic Concepts ;System Administration-Requirements for Linux System Administrator, Setting up a LINUX Multifunction Server, Domain Name System, Setting Up Local Network Services; Virtualization- Basic Concepts, Setting Up Xen,VMware on Linux Host and Adding Guest OS.

UNIT IV BIO INSPIRED COMPUTING AND BIO INFORMATICS

Introduction of Foundations of evolutionary theory – Genotype – artificial evolution – genetic representations – initial population – fitness functions – selection and reproduction – genetic operators – evolutionary measures – evolutionary algorithms – evolutionary electronics – evolutionary algorithm case study Cellular systems – cellular automata – modeling with cellular systems – other cellular systems – computation with cellular systems – artificial life – analysis and synthesis of cellular systems

Need for Bioinformatics technologies – Overview of Bioinformatics technologies – Structural bioinformatics – Data format and processing – secondary resources-Applications – Role of Structural bioinformatics - Biological Data Integration System.

UNIT V NATURAL LANGUAGE PROCESSING AND ROBOTICS

Natural Language Processing – Mathematical Foundations – Elementary Probability Theory – Essential information Theory - Linguistics Essentials - Parts of Speech and Morphology – Phrase Structure – Semantics – Corpus Based Work

Specifications of Robots- Classifications of robots – Work envelope - Flexible automation versus Robotic technology – Applications of Robots

Tool Maker's microscope - Co-ordinate measuring machines - Universal measuring machine - Laser viewers for production profile checks - Image shearing microscope - Use of computers - Machine vision technology - Microprocessors in metrology.

OUTCOMES:

- Provides a basic exposition to the goals and methods of Artificial Intelligence.
- Design a portable IoT using Arduino/ equivalent boards and relevant protocols
- To implement virtualization and cloud resource management
- Predict the possible next outcome of the social network
- Explain principles of visual perception

REFERENCES

1. 1.Arshdeep Bahga,vijay Madisetti,"Internet Of Things –A hands-on approach",Universities Press-2015.
2. 2.kevin P.Murphy,"Machine learning:A probabilistic perspective ".MIT press,2012.
3. 3.Charu C.Aggarwal,"Social Network Data Analytics"Springer,2011
4. 4.Evan Stubbs,"The value of business analtics:Identifying the path to profitability",Wiley,2011.
5. 5.A.E Elben and J.E Smith,"Introduction to Evolutionary computing ",Springer,2010

ELECTIVE PAPERS

PAPER 1 - NETWORK AND INFORMATION SECURITY

OBJECTIVES:

- To understand the fundamentals of Cryptography
- To acquire knowledge on standard algorithms used to provide confidentiality, integrity and authenticity.
- To understand the various key distribution and management schemes
- To understand how to deploy encryption techniques to secure data in transit across data networks
- To design security applications in the field of Information technology

UNIT I INTRODUCTION

An Overview of Computer Security-Security Services-Security Mechanisms-Security Attacks Access Control Matrix, Policy-Security policies, Confidentiality policies, Integrity policies and Hybrid policies.

UNIT II CRYPTOSYSTEMS & AUTHENTICATION

Classical Cryptography-Substitution Ciphers-permutation Ciphers-Block Ciphers-DES- Modes of Operation- AES-Linear Cryptanalysis, Differential Cryptanalysis- Hash Function - SHA 512- Message Authentication Codes-HMAC - Authentication Protocols –

UNIT III PUBLIC KEY CRYPTOSYSTEMS

Introduction to Public key Cryptography- Number theory- The RSA Cryptosystem and Factoring Integer- Attacks on RSA-The ELGamal Cryptosystem-Digital Signature Algorithm-Finite Fields Elliptic Curves Cryptography- Key management – Session and Interchange keys, Key exchange and generation-PKI

UNIT IV SYSTEM IMPLEMENTATION

Design Principles, Representing Identity, Access Control Mechanisms, Information Flow and Confinement Problem Secure Software Development: Secured Coding - OWASP/SANS Top Vulnerabilities - Buffer Overflows - Incomplete mediation - XSS - Anti Cross Site Scripting Libraries - Canonical Data Format - Command Injection - Redirection - Inference – Application Controls

UNIT V NETWORK SECURITY

Secret Sharing Schemes-Kerberos- Pretty Good Privacy (PGP)-Secure Socket Layer (SSL)- Intruders – HIDS- NIDS - Firewalls - Viruses

OUTCOMES:

- Upon Completion of the course, the students will be able to
- Implement basic security algorithms required by any computing system.
- Analyze the vulnerabilities in any computing system and hence be able to design a security solution.
- Analyze the possible security attacks in complex real time systems and their effective countermeasures Identify the security issues in the network and resolve it.
- Evaluate security mechanisms using rigorous approaches, including theoretical derivation, modeling, and simulations
- Formulate research problems in the computer security field

REFERENCES:

1. William Stallings, "Cryptography and Network Security: Principles and Practices", Third Edition, Pearson Education, 2006.
2. Matt Bishop ,"Computer Security art and science ", Second Edition, Pearson Education, 2002
3. Wade Trappe and Lawrence C. Washington, "Introduction to Cryptography with Coding Theory" Second Edition, Pearson Education, 2007
4. Jonathan Katz, and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press, 2007
5. Douglas R. Stinson, "Cryptography Theory and Practice", Third Edition, Chapman & Hall/CRC, 2006 6.
6. Wenbo Mao, "Modern Cryptography – Theory and Practice", Pearson Education, First Edition, 2006.
7. Network Security and Cryptography, Menezes Bernard, Cengage Learning, New Delhi, 2011
8. Man Young Rhee, Internet Security, Wiley, 2003 9. OWASP top ten security vulnerabilities: http://xml.coverpages.org/OWASP-TopTen.pdf

PAPER 2 - ADVANCED WIRELESS NETWORK ARCHITECTURE

OBJECTIVES:

- To understand the fundamentals of Wireless and Sensor Networks.
- To acquire knowledge on standard algorithms used to provide confidentiality, integrity and authenticity.
- To understand VLC and LI-FI Networks.
- To understand the Modulation Schemes.

UNIT I INTRODUCION –WIRELESS NETWORKS

Migration to 3G Networks – IMT 2000 and UMTS – UMTS Architecture – User Equipment – Radio Network Subsystem – UTRAN – Node B – RNC functions – USIM – Protocol Stack – CS and PS Domains – IMS Architecture – Handover – 3.5G and 3.9G a brief discussion – 4G LAN and Cellular Networks – LTE – Control Plane – NAS and RRC – User Plane – PDCP, RLC and MAC – WiMax IEEE 802.16d/e – WiMax Internetworking with 3GPP

UNIT II WIRELESS SENSOR NETWORKS (WSN)

Unique constraints and challenges – advantages of WSNs – Sensor network applications – Collaborative processing – Key definitions of sensor networks Canonical Problem: Localization and tracing – tracking scenario – Problem formulation – distributed representation and inference of states – tracking multiple objects – sensor models – performance comparison and metrics. Networking sensors: Key assumptions – Medium access control – General issues – Geographic energy aware routing – attribute based routing. Infrastructure Establishment: Topology control – clustering

UNIT III ADHOC AND HETEROGENOUS NETWORKS

Introduction to Adhoc networks, characteristics features and applications. of Wireless channel Characteristics, Adhoc Mobility Models:- Indoor and outdoor mobility models, Entity Vs Group mobility models. Handover – basic definition, Handover Characteristics –Hard and Soft handover-Handover mechanisms. Routing Protocols: Design issues, goals and classification. Proactive Vs reactive routing, Unicast routing algorithms, Multicast routing algorithms, hybrid routing algorithms, Energy aware routing algorithms, Hierarchical Routing, QOS aware routing.

UNIT-IV VLC and LI-FI networks

Introduction History of OWC-Advantages-Application areas. Introduction of Li-Fi-Terminologies .Challenges of OWC. OWC Communication scenarios, optical Front-ends, optical wireless channel. Cellular network :Case study in an aircraft cabin. Front-end non-Linearity

UNIT-V VLC MODULATION SCHEMES

Digital Modulation Schemes-optical signals, Single carrier, Multicarrier. Spectral efficiency and information rate- Constraints –Modulation schemes with AWGN. Information rate of OFDM-based with non-linear distortion. Modulation Schemes in the dispersive channel with AWGN.MIMO Transmission-System model-Techniques-BER performance. Throughput of Cellular OWC networks-Introduction-System throughput-Interference coordination in optical cells-System throughput with busy burst and fair reservation mechanism.

OUTCOMES:

- Student will be able to know working of modern wireless and cellular Networks.
- Student will utilize the different models of wireless network to overcome path loss in large and small propagations.
- Student will be able to differentiate between the development of fixed and wireless networks.

REFERENCES:

1. C.Siva Ram Murthy and B.S.Manoj, Adhoc Wireless Networks Architectures and protocols, 2nd edition, Pearson Education.
2. Pei Zheng and Lionel M Li, „Smart Phone & Next Generation Mobile Computing", Morgan Kaufmann Publishers, 2006.
3. Charles E. Perkins, Ad hoc Networking, Addison – Wesley
4. Wireless Sensor networks : Feng Zhao,Leonidas Guibas –Morgan Kaufmann Publications – 2012.
5. Fundamentals of Wireless sensor networks Theory and Practice – Waltenegus Dargie, Christian Poellabauer – Wiley – 2010
6. Principles of LED Light Communications: Towards Networked Li-Fi, *Svilen Dimitrov, Harald Haas*

PAPER 3 – SOFTWARE DEFINED NETWORKS

OBJECTIVES:

- To learn about what software defined networks are
- To understand the separation of the data plane and the control plane
- To learn about the use of SDN in data centers
- To learn about different applications of SDN

UNIT I INTRODUCTION

History of Software Defined Networking (SDN) – Modern Data Center – Traditional Switch Architecture – Why SDN – Evolution of SDN – How SDN Works – Centralized and Distributed Control and Date Planes

UNIT II OPEN FLOW & SDN CONTROLLER

Open Flow Specification – Drawbacks of Open SDN, SDN via APIs, SDN via Hypervisor-Based Overlays – SDN via Opening up the Device – SDN Controllers – General Concepts

UNIT III DATA CENTERS

Multitenant and Virtualized Multitenant Data Center – SDN Solutions for the Data Center Network – VLANs – EVPN – VxLAN – NVGRE

UNIT IV SDN PROGRAMMING

Programming SDNs: Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs – Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications.

UNIT V SDN

Juniper SDN Framework – IETF SDN Framework – Open Daylight Controller – Floodlight Controller – Bandwidth Calendaring – Data Center Orchestration

OUTCOMES:

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

- Critically analyze and appreciate the evolution of software defined networks
- Point out the various components of SDN and their uses
- Explain the use of SDN in the current networking scenario

- Design and develop various applications of SDN

TEXT BOOKS:

1. Thomas D. Nadeau, Ken Gray, ―SDN: Software Defined Networks‖, O'Reilly Media,2013.
2. Paul Goransson and Chuck Black, ―Software Defined Networks: A Comprehensive Approach‖, First Edition, Morgan Kaufmann, 2014.

REFERENCES:

1. Siamak Azodolmolky, ―Software Defined Networking with Open Flow‖, PacketPublishing, 2013.
2. Vivek Tiwari, ―SDN and Open Flow for Beginners‖, Amazon Digital Services, Inc., 2013.
3. Fei Hu, Editor, ―Network Innovation through Open Flow and SDN: Principles and Design‖, CRC Press, 2014.

PAPER 4 - INTERNET OF THINGS (IoT)

OBJECTIVES:

- To understand the fundamentals of Internet of Things
- To learn about the basics of IOT protocols
- To build a small low cost embedded system using Raspberry Pi.
- To apply the concept of Internet of Things in the real world scenario

UNIT I INTRODUCTION TO IoT

Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies - IoT Levels & Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management with NETCONF-YANG- IoT Platforms Design Methodology

UNIT II IoT ARCHITECTURE

M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture

UNIT III IoT PROTOCOL

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus– Zigbee Architecture – Network layer – 6LowPAN - CoAP – Security

UNIT IV BUILDING IoT WITH RASPBERRY PI & ARDUINO

Building IOT with RASPERRY PI- IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints - IoT Device -Building blocks -Raspberry Pi -Board - Linux on Raspberry Pi - Raspberry Pi Interfaces -Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.

UNIT V CASE STUDIES AND REAL-WORLD APPLICATIONS

Real world design constraints - Applications - Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT– Software & Management Tools for IoT Cloud Storage Models & Communication APIs - Cloud for IoT - Amazon Web Services for IoT.

OUTCOMES:

- Upon completion of this course, the students should be able to:
- Analyze various protocols for IoT
- Develop web services to access/control IoT devices.
- Design a portable IoT using Rasperry Pi
- Deploy an IoT application and connect to the cloud.
- Analyze applications of IoT in real time scenario

REFERENCES:

1. Arshdeep Bahga, Vijay Madisetti, —Internet of Things – A hands-on approach , Universities Press, 2015

2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), —Architecting the Internet of Things , Springer, 2011.

3. Honbo Zhou, —The Internet of Things in the Cloud: A Middleware Perspective , CRCPress, 2012.

4. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Elsevier, 2014.

5. Olivier Hersent, David Boswarthick, Omar Elloumi , —The Internet of Things – Key applications and Protocols , Wiley, 2012

PAPER 5 - DIGITAL VIDEO ACQUISITION AND ANALYSIS

OBJECTIVES:

- This course serves as a baseline course to provide students with a basic understanding of digital video processing
- It emphasize on video segmentation, video standards, compression and content based retrieval

UNIT I VIDEO ACQUISITION AND REPRESENTATION & MOTION ANALYSIS

Spatio Temporal Sampling – Sampling Structure Conversion – Interpolation – Color spaces – Video formats. 2D and 3D Motion Estimation and Compensation – Optical Flow methods – Block based – point correspondences – Gradient based – Intensity matching – Feature matching – Frequency domain motion estimation – Depth from motion - Structure from stereo – 3D Reconstruction –Motion analysis Applications: Video Summarization, Video Surveillance, Video Watermarking, Video Mosaicing

UNIT II VIDEO OBJECT TRACKING AND SEGMENTATION

2D and 3D motion tracking – blob tracking – kernel based – Contour tracking – Feature matching – Filtering – mosaicing – Video Segmentation – Mean Shift based – Active shape model – Video shot boundary detection.

UNIT III VIDEO FILTERING

Motion Compensation – Noise Filtering – Enhancement and Restoration – Video Stabilization and Super Resolution.

UNIT IV VIDEO CODING, REPRESENTATION

Video Standards: MPEG 1,2, MPEG-4, MPEG-7, H.261, H.263, H.264. Video compression – Inter frame Compression – 3D Waveform based – Motion Compensation.

UNITV CONTENTBASEDVIDEO RETRIEVAL AND VIDEOBASED RENDERING

Object based coding – Content based representation – Feature extraction – MPEG 7 Visual descriptors – Low to high level representation (CSS, Poly, B-Splines etc.) – Video Indexing and retrieval – search engines. Generation of mosaics from video; Detection of Video object alpha-matte and Video cut & paste for Virtual Reality applications.

OUTCOME:

- After the course, students could have sufficient understanding of digital video processing and its relevant processing tasks

TEXT BOOKS:

1. Digital Image Sequence Processing, Compression and Analysis – Todd R. Reed, CRC Press, 2004.

2. H.264 and MPEG-4 Video Compression: Video Coding for Next Generation Multimedia – Iain E.G. Richardson, Wiley, 2003

3. Digital Video Processing – A. Murat Tekalp, Prentice Hall, 1995.

REFERENCES:

1. Video Processing and Communications by Yao wang, Joern Ostermann and YaQin Zhang, Prentice Hall, 2002, ISBN 0-13-017547-1.

2. Handbook of Image and Video processing – AI Bovik (Alan C Bovik), Academic

PAPER 6 PATTERN RECOGNITION

UNIT I PATTERN CLASSIFIER

Overview of pattern recognition – Discriminant functions – Supervised learning – Parametric estimation – Maximum likelihood estimation – Bayesian parameter estimation – Perceptron algorithm – LMSE algorithm – Problems with Bayes approach – Pattern classification by distance functions – Minimum distance pattern classifier.

UNIT II UNSUPERVISED CLASSIFICATION

Clustering for unsupervised learning and classification – Clustering concept – C-means algorithm – Hierarchical clustering procedures – Graph theoretic approach to pattern clustering – Validity of clustering solutions.

UNIT III STRUCTURAL PATTERN RECOGNITION

Elements of formal grammars – String generation as pattern description – Recognition of syntactic description – Parsing – Stochastic grammars and applications – Graph based structural representation.

UNIT IV FEATURE EXTRACTION AND SELECTION

Entropy minimization – Karhunen – Loeve transformation – Feature selection through functions approximation – Binary feature selection.

UNIT V RECENT ADVANCES

Structural PR, SVMs, FCM, Soft-computing and Neuro-fuzzy – Pattern classification using Genetic Algorithms.

OUTCOMES:

- After the course, students could earn sufficient knowledge on pattern classification and feature extraction.
- With these backgrounds, students would be able to learn more advanced classification techniques

REFERENCES:

1. Robert J.Schalkoff, Pattern Recognition Statistical, Structural and Neural Approaches, John Wiley & Sons Inc., New York, 1992.
2. Tou and Gonzales, Pattern Recognition Principles, Wesley Publication Company, London, 1974.
3. Duda R.O., and Har P.E., Pattern Classification and Scene Analysis, Wiley, New York, 1973.
4. Morton Nadier and Eric Smith P., Pattern Recognition Engineering, John Wiley & Sons, New York, 1993.
5. Statistical pattern Recognition; K. Fukunaga; Academic Press, 2000.
6. S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009

PAPER 7 - VIDEO DATA MANAGEMENT AND INFORMATION RETRIEVAL

OBJECTIVES:

- To understand the fundamentals of video processing
- To learn and understand the video abstraction
- To understand video data management and retrieval

UNIT I FUNDAMENTALS OF VIDEO PROCESSING

Video Capture and Display - Principles of Color Video, Video Cameras, Video Display.Composite versus Component Models. Gamma Connection, Video Formation, Perception and Representation, Video Modeling- Camera Model, Object Model, Scene Model, Digital Video Notation. ITU-R.BT.601 Digital Video Format. Other Digital Video Formats and Applications. Digital Video Quality Measure.

UNIT II FEATAURES OF VIDEO SIGNALS

Color -Color Space Transformations, Representation of Color Features; Texture - statistical Texture Analysis, Spectral Features of Texture; Edge Analysis - Edge Detection by Gradient Operators, Edge Characterization by second Derivative, Edge Finding and Consistency Analysis, Edge Model Fitting, Description and Analysis of Edge Properties, Contour and Shape Analysis, Moment Analysis, Motion Analysis - Mapping of motion into the image plane, Motion Estimation by the Optical Flow Principle, Motion Estimation by Matching, Multi resolution Motion Estimation.

UNIT III HIGH LEVEL FEATURES OF VIDEO

Mosaics Face Detection and Description, Audio Signal Features- Basic Features, Speech Signal Analysis, Musical Signals, Instruments and Sounds.

UNIT IV VIDEO ABSTRACTION

Video Abstraction, Types of video abstraction, Applications, Video Summarization and techniques, Dynamic Summary – Highlight Detection and Summary sequence Generation, Types of visualization.

UNIT V VIDEO DATA MANAGEMENT AND RETRIEVAL

An Overview of Video Information Retrieval Techniques, Shot Boundary Detection, Innovative Shot Boundary Detection for Video Indexing, Scene Changed Detection, Content based video retrieval

OUTCOME

- Demonstrate a broad range of fundamental of video processing
- Demonstrate and apply the knowledge by analysing the video signals
- Understand various features of video and video data management

REFERENCES:

1. Yao Wang, JörnOstermann, and Ya-Qin Zhang, „Video Processing and Communications", Prentice Hall, 2002 (Published September 2001) ISBN 0-13-017547-1

2. J.R.Ohm , „Multimedia Communication Technology", Springer Publication, 2004.

3. Sagarmay Deb, 'Video Data Management and Information Retrieval", Idea Group Inc (IGI), 2005.

4. "Handbook on Image and Video Processing", A.I.Bovik, Academic Press. 5. "Digital Video", Tekalp, Prentice Hall.

PAPER 8 - ADVANCED DIGITAL IMAGE PROCESSING

OBJECTIVES:

- To understand the image fundamentals and mathematical transforms necessary for image. processing and to study the image enhancement techniques.
- To understand the image segmentation and representation techniques.
- To understand how image are analyzed to extract features of interest.
- To introduce the concepts of image registration and image fusion.
- To analyze the constraints in image processing when dealing with 3D datasets.

UNIT I FUNDAMENTALS OF DIGITAL IMAGE PROCESSING

Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT, and SVD. Image enhancement in spatial and frequency domain, Review of morphological image processing

UNIT II SEGMENTATION

Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour methods-Level set method, Texture feature based segmentation, Model based segmentation, Atlas based segmentation, Wavelet based Segmentation methods

UNIT III FEATURE EXTRACTION

First and second order edge detection operators, Phase congruency, Localized feature extraction-detecting image curvature, shape features Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Runlength features, Fractal model based features, Gabor filter, wavelet features

UNIT IV REGISTRATION AND IMAGE FUSION

Registration- Preprocessing, Feature selection-points, lines, regions and templates Feature correspondence-Point pattern matching, Line matching, region matching Template matching .Transformation functions-Similarity transformationand Affine Transformation. Resampling- Nearest Neighbour and Cubic Splines Image Fusion-Overview of image fusion, pixel fusion, Multiresolution based fusiondiscrete wavelet transform, Curvelet transform. Region based fusion.

UNIT V 3D IMAGE VISUALIZATION

Sources of 3D Data sets, Slicing the Data set, Arbitrary section planes, The use of color, Volumetric display, Stereo Viewing, Ray tracing, Reflection, Surfaces, Multiply connected surfaces, Image processing in 3D, Measurements on 3D images.

OUTCOMES:

- To apply image processing techniques in both the spatial and frequency domains.
- To design image analysis techniques in the form of image segmentation and to evaluate the methodologies for segmentation.
- To conduct independent study and analysis of feature extraction techniques.

TEXT BOOK:

1. John C.Russ, "The Image Processing Handbook", CRC Press,2007.

2. Mark Nixon, Alberto Aguado, "Feature Extraction and Image Processing", Academic Press, 2008.

3. Ardeshir Goshtasby, " 2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications",John Wiley and Sons,2005.

4. H.B.Mitchell, "Image Fusion Theories, Techniques and Applications", Springer,2010.

REFERENCES:

1. Rafael C. Gonzalez, Richard E. Woods, , Digital Image Processing', Pearson, Education, Inc., Second Edition, 2004.

2.Anil K. Jain, Fundamentals of Digital Image Processing', Pearson Education, Inc., 2002.

3. Rick S.Blum, Zheng Liu," Multisensor image fusion and its Applications",Taylor& Francis,2006. Faulty of I and C Engg (Approved in 16th AC(Ad hoc) 02.12.2010) ITEM NO. FI 16.01(10)

PAPER 9 - DATA MINING AND DATA WAREHOUSING

Objectives:

- This course will introduce the concepts, techniques, design and applications of data warehousing and data mining.
- Learning Outcome and End use:
- Appreciate the strengths and limitations of various data mining and data warehousing models.
- Describe and utilize a range of techniques for designing data warehousing and data mining systems for real-world applications.

Unit I :

DATA MINING: Motivation -Steps in Data Mining – Architecture - Data Mining and Databases – Data Warehouses – Data Mining functionalities – Classification – Data Mining Primitives – Major issues. DATA PREPROCESSING: Descriptive data summarization -Data Cleaning – Data integration and transformation – Data Reduction– Data discretization and concept hierarchy generation.

Unit II:

DATA WAREHOUSE and OLAP TECHNOLOGY: Need for Data Warehouse- multidimensional data model- Data Warehouse architecture - Data Warehousing to Data mining. MINING FREQUENT PATTERNS, ASSOCIATIONS AND CORRELATIONS: Frequent itemsets, Association rules – Efficient and Scalable frequent itemset mining methods – mining various kinds of Association rules.

Unit III:

CLASSIFICATION AND PREDICTION: Issues regarding classification and prediction – Classification by Decision Tree induction –Bayesian Classification – Rule based classification – Classification using Neural Networks Prediction – Accuracy and error measures – Evaluating the accuracy of classifiers and predictors.

Unit IV:

CLUSTER ANALYSIS: Types of data – Partitioning Methods: k means and k Medoids – Hierarchical Methods: Agglomerative and Divisive hierarchical clustering- Outlier analysis.

Unit V:

MINING TIME SERIES, SEQUENCE DATA: Trend analysis – similarity search – sequence patterns in transactional databases sequential pattern mining: concepts and primitives. MINING TEXT, MULTIMEDIA AND THE WORLD WIDE WEB: Text data analysis and information retrieval- Dimensionality reduction for text – text mining

approaches – similarity search in multimedia data – classification and prediction analysis -mining the web page layout structure – mining multimedia data on the web-web usage minin

OUTCOMES:

- Interpret the contribution of data warehousing and data mining to the decision-support level of organizations
- Evaluate different models used for OLAP and data pre-processing
- Categorize and carefully differentiate between situations for applying different data-mining techniques: frequent pattern mining, association, correlation, classification, prediction, and cluster and outlier analysis

REFERENCES:

1. HanJiawei, Micheline Kamber and Jian Pei "Data Mining: Concepts and Techniques", Morgan Kaufmann, 2011.
2. Soman K P, ShyamDiwakar and Ajay V, "Insight into Data Mining Theory and Practice", PHI Learning, 2009.
3. Arun K Pujari, "Data Mining Techniques", University Press, 2013.

PAPER 10 - BIG DATA ANALYTICS

OBJECTIVS

- Be exposed to big data
- Learn the different ways of Data Analysis
- Be familiar with data streams
- Learn the mining and clustering
- Be familiar with the visualization

UNIT I

INTRODUCTION TO DATA SCIENCE Introduction: Introduction of Data Science-Getting started with R- Exploratory Data Analysis- Review of probability and probability distributions- Bayes Rule Supervised Learning- Regression- polynomial regression- local regression- knearest neighbors.

UNIT II

UNSUPERVISED LEARNING Unsupervised Learning- Kernel density estimation- k-means- Naive Bayes- Data and Data Scraping Classification-ranking-logistic regression. Ethics- time seriesadvanced regression- Decision trees- Best practices- feature selection.

UNIT III

BIG DATA FROM DIFFERENT PERSPECTIVES Big data from business Perspective: Introduction of big data-Characteristics of big data-Data in the warehouse and data in Hadoop- Importance of Big data- Big data Use cases: Patterns for Big data deployment. Big data from Technology Perspective: History of Hadoop-Components of Hadoop-Application Development in Hadoop-Getting your data in Hadoop-other Hadoop Component.

UNIT IV

INFOSPHERE BIGINSIGHTS Infosphere Big Insights: Analytics for Big data at rest-A Hadoop -Ready Enterprise-Quality file system-Compression –Administrative

tooling-SecurityEnterprise Integration –Improved workload scheduling-Adaptive map reduce-Data discovery and visualization-Machine Analytics

UNIT V

INFOSPHERE STREAMS Infosphere Streams: Analytics for Big data in motion-Infosphere Streams Basicsworking of Infosphere Streams-Stream processing language-Operators-Stream toolkits-Enterprise class

OUTCOMES:

- Apply the statistical analysis methods.
- Design distributed file systems.
- Apply Stream data model.
- Use Visualization techniques

REFERENCES

1. Noreen Burlingame and Lars Nielsen, “A Simple Introduction To Data Science”, 2012.
2. “Understanding Big Data: Analytics for Enterprise Class Hadoop and streaming Data”, The McGraw-Hill Companies, 2012.

PAPER 11 - DEEP LEARNING

Objectives

- The objective of this course is to cover the fundamentals of neural networks as well as some advanced topics such as recurrent neural networks, long short term memory cells and convolution neural networks. The course also requires students to implement programming assignments related to these topics.

UNIT I

Basics: Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm. **Feedforward Networks:** Multilayer Perceptron, Gradient Descent, Backpropagation, Empirical Risk Minimization, regularization, autoencoders.

UNIT II

Deep Neural Networks: Difficulty of training deep neural networks, Greedy layerwise training.

UNIT III

Better Training of Neural Networks: Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).

UNIT IV

Recurrent Neural Networks: Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs**Convolutional Neural Networks:** LeNet, AlexNet. **Generative models:** Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines.

Unit V

Recent trends: VariationalAutoencoders, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning **Applications:** Vision, NLP, Speech (just an overview of different applications in 2-3 lectures)

OUTCOMES:

- **Deep learning** is a set of student educational **outcomes.**
- Including acquisition of robust core academic content, higher-order thinking skills, and **learning** dispositions.

Textbooks

1. Deep Learning, Ian Goodfellow and YoshuaBengio and Aaron Courville, MIT Press, 2016.

References:

1. Neural Networks: A Systematic Introduction, Raúl Rojas, 1996
2. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

PAPER 12 - MACHINE LEARNING TECHNIQUES

Objectives:

- To prepare the students to understand and learn the machine learning techniques and to apply them for the practical problems.

UNIT I

FOUNDATIONS OF LEARNING Components of learning – learning models – geometric models – probabilistic models – logic models – grouping and grading – learning versus design – types of learning – supervised – unsupervised – reinforcement – theory of learning – feasibility of learning – error and noise – training versus testing – theory of generalization – generalization bound – approximation generalization tradeoff – bias and variance – learning curve 3

UNIT II

LINEAR MODELS Linear classification – univariate linear regression – multivariate linear regression – regularized regression – Logistic regression – perceptrons – multilayer neural networks – learning neural networks structures – support vector machines – soft margin SVM – going beyond linearity – generalization and overfitting – regularization – validation

UNIT III

DISTANCE-BASED MODELS Nearest neighbor models – K-means – clustering around medoids – silhouettes – hierarchical clustering – k-d trees – locality sensitive hashing – non-parametric regression – ensemble learning – bagging and random forests – boosting – meta learning

UNIT IV

TREE AND RULE MODELS Decision trees – learning decision trees – ranking and probability estimation trees – regression trees – clustering trees – learning ordered rule lists – learning unordered rule lists – descriptive rule learning – association rule mining – first-order rule learning

UNIT V

REINFORCEMENT LEARNING Passive reinforcement learning – direct utility estimation – adaptive dynamic programming – temporal-difference learning – active reinforcement learning – exploration – learning an actionutility function –

Generalization in reinforcement learning – policy search – applications in game playing – applications in robot control

OUTCOMES:

At the end of the course the students will be able to:

- Describe the various machine learning concepts and models.
- Apply the concepts for the practical problems.
- Compare and analyse the performance of various machine learning algorithms

REFERENCES :

1. Y. S. Abu-Mostafa, M. Magdon-Ismail, and H.-T. Lin, “Learning from Data”, AMLBook Publishers, 2012.
2. P. Flach, “Machine Learning: The art and science of algorithms that make sense of data”, Cambridge University Press, 2012.
3. K. P. Murphy, “Machine Learning: A probabilistic perspective”, MIT Press, 2012.
4. C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2007.
5. D. Barber, “Bayesian Reasoning and Machine Learning”, Cambridge University Press, 2012.
6. M. Mohri, A. Rostamizadeh, and A. Talwalkar, “Foundations of Machine Learning”, MIT Press, 2012.
7. T. M. Mitchell, “Machine Learning”, McGraw Hill, 1997.
8. S. Russel and P. Norvig, “Artificial Intelligence: A Modern Approach”, Third Edition, Prentice Hall, 2009
9. Peter Flach,”Machine Learning”,Cambridge University Press,2015.
10. Shai Shalar-Schwartz & Shai Ben-David,”Understand Machine Learning,Cambridge University,2015.

PAPER 13 - CLOUD COMPUTING

Objectives:

- To prepare the students to understand and learn the machine learning techniques and to apply them for the practical problems.

Unit I

Distributed System Models and Enabling Technologies: Scalable Computing over the Internet, Technologies for Network-Based Systems, System Models for Distributed and Cloud Computing, Software Environments for Distributed Systems and Clouds, Performance, Security and Energy Efficiency

Computer Clusters for Scalable Parallel Computing: Clustering for Massive Parallelism, Computer Clusters and MPP Architectures, Design Principles of Computer Clusters, Cluster Job ad Resource Management

UnitII

Cloud Platform Architecture over Virtualized Data Centers: Cloud Computing and Service Models, Data-Center Design and Interconnection Networks, Architectural Design of Compute and Storage Clouds, Public Cloud Platforms GAE, AWS, and Azure, Inter-cloud Resource Management, Cloud Security and Trust Management

Unit III

Service-Oriented Architectures for Distributed Computing: Services and Service-Oriented Architecture, Message-Oriented Middle-ware, Portals and Science Gateways, Discovery, Registries, Metadata and Databases, Work-flow in Service-Oriented Architectures.

Unit IV

Cloud Programming and Software Environments: Features of Cloud and Grid Platforms, Parallel and Distributed Programming Paradigms, Programming Support of Google App Engine, Programming on Amazon AWS and Microsoft Azure, Emerging Cloud Software Environments.

Unit V

Ubiquitous Clouds and the Internet of Things: Cloud Trends in Supporting Ubiquitous Computing, Performance of Distributed Systems and the Cloud, Enabling

Technologies for the Internet of Things, Innovative Applications of the Internet of Things, On-line Social and Professional Networking

OUTCOMES:

- Completing this course should provide you with a good understanding of **cloud computing.**
- A systematic knowledge of the fundamental technologies, architecture, and security ..... Identify problems.
- Explain, analyze, and evaluate various **cloud computing** solutions.

REFERENCES:

1. Distributed and Cloud Computing- Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra –Elsevier-2012
2. Cloud Computing – A Hands-on Approach – Arshdeep Bahga, Vijay Madisetti – University Press2014
3. Enterprise Cloud Computing – Gautam Shroff – Cambridge University Press – 2014.

PAPER 14 - BIO-INSPIRED COMPUTING

OBJECTIVES:

- To Understand Cellular Automata and artificial evolution
- To Learn artificial neural systems and related learning algorithms
- To learn developmental and artificial immune systems
- To understand behavioral systems especially in the context of Robotics
- To understand collective systems such as ACO, PSO, and swarm robotics

UNIT I EVOLUTIONARY AND CELLULAR SYSTEMS

Foundations of evolutionary theory – Genotype – artificial evolution – genetic representations – initial population – fitness functions – selection and reproduction – genetic operators – evolutionary measures – evolutionary algorithms – evolutionary electronics – evolutionary algorithm case study Cellular systems – cellular automata – modeling with cellular systems – other cellular systems – computation with cellular systems – artificial life – analysis and synthesis of cellular systems

UNIT II NEURAL SYSTEMS

Biological nervous systems – artificial neural networks – neuron models – architecture – signal encoding – synaptic plasticity – unsupervised learning – supervised learning – reinforcement learning – evolution of neural networks – hybrid neural systems – case study

UNIT III DEVELOPMENTAL AND IMMUNE SYSTEMS

Rewriting systems – synthesis of developmental systems – evolutionary rewriting systems – evolutionary developmental programs Biological immune systems – lessons for artificial immune systems – algorithms and applications – shape space – negative selection algorithm – clonal selection algorithm - examples

UNIT IV BEHAVIORAL SYSTEMS

Behavior is cognitive science – behavior in AI – behavior based robotics – biological inspiration for robots – robots as biological models – robot learning – evolution of behavioral systems – learning in behavioral systems – co-evolution of body and control – towards self reproduction – simulation and reality .

UNIT V COLLECTIVE SYSTEMS

Biological self-organization – Particle Swarm Optimization (PSO) – ant colony optimization (ACO) – swarm robotics – co-evolutionary dynamics – artificial evolution of competing systems – artificial evolution of cooperation – case study

OUTCOMES:

- Implement and apply evolutionary algorithms

- Explain cellular automata and artificial life
- Implement and apply neural systems
- Explain developmental and artificial immune systems
- Explain behavioral systems
- Implemennt and apply collective intelligence systems

REFERENCES:

1. A.E. Elben and J. E. Smith, “Introduction to Evolutionary Computing”, Springer, 2010.
2. F. Neumann and C. Witt, “Bioinspired Computation in combinatorial optimization: Algorithms and their computational complexity”, Springer, 2010.
3. D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence", MIT Press, 2008.
4. Simon O. Haykin, “Neural Networks and Learning Machines”, Third Edition, Prentice Hall, 2008.
5. M. Dorigo and T. Stutzle, “Ant Colony Optimization”, A Bradford Book, 2004.
6. R. C. Ebelhart et al., “Swarm Intelligence”, Morgan Kaufmann, 2001.

PAPER 15 - MULTI CORE ARCHITECTURES

OBJECTIVES:

- To introduce the students to the recent trends in the field of Computer Architecture and identify performance related parameters
- To understand the different multiprocessor and their issues
- To expose the different types of multi-core architectures to the scholars
- To understand the design of the memory hierarchy in various architectures

UNIT I FUNDAMENTALS OF COMPUTER DESIGN AND ILP

Fundamentals of Computer Design – Measuring and Reporting Performance – Instruction Level Parallelism and its Exploitation – Concepts and Challenges – Limitations of ILP – Multithreading – SMT and CMP Architectures – The Multicore era.

UNIT II MEMORY HIERARCHY DESIGN

Introduction–Optimizations of Cache Performance–Memory Technology and Optimizations– Protection: Virtual Memory and Virtual Machines–Design of Memory Hierarchies–Case Studies.

UNIT III MULTIPROCESSOR ISSUES

Symmetric and Distributed Shared Memory Architectures – Cache Coherence Issues – Performance Issues – Synchronization Issues – Models of Memory Consistency – Interconnection Networks – Buses, Crossbar and Multi-stage Interconnection Networks.

UNIT IV MULTICORE ARCHITECTURES

Homogeneous and Heterogeneous Multi-core Architectures – Intel Multicore Architectures – SUNCMP architecture – IBM Cell Architecture. Introduction to Warehouse-scale computers, CloudComputing – Architectures and Issues – Case Studies.

UNIT V VECTOR, SIMD AND GPU ARCHITECTURES

Vector Architecture – SIMD Extensions for Multimedia – Graphics Processing Units – Case Studies – GPGPU Computing – Detecting and Enhancing Loop Level Parallelism.

OUTCOMES:

- Identify the limitations of ILP and the need for multicore architectures
- Discuss the issues related to multiprocessing and suggest solutions
- Point out the salient features of different multicore architectures and how they exploit parallelism
- Critically analyze the different types of inter connection networks
- Design a memory hierarchy and optimize it

REFERENCES:

1. John L. Hennessey and David A. Patterson, "Computer Architecture – A Quantitative Approach", Morgan Kaufmann / Elsevier, 5th edition, 2012.

2. Darryl Gove, "Multicore Application Programming: For Windows, Linux, and Oracle Solaris", Pearson, 2011.

3. David B. Kirk, Wen-mei W. Hwu, "Programming Massively Parallel Processors", Morgan Kauffman, 2010.

4. Wen– mei W. Hwu, "GPU Computing Gems", Morgan Kaufmann / Elsevier, 2011