M. TECH. (CS) CYBER PHYSICAL SYSTEM

Academic Year 2022-2023

Department of Computer Science

School of Mathematics, Statistics and Computational Sciences

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CENTRAL UNIVERSITY OF RAJASTHAN
Department of Computer Science
Semester Wise Scheme and Syllabus of
M. Tech. (CS) Cyber Physical System (2 Years)
(For Semesters- I to IV Semesters: 2022-2023 to Onward)

Scheme of M. Tech. (CS) Cyber Physical System (2 Years)

The details of the courses with code, title and the credits assign are as given below.

Course Category

CC: Compulsory Course, EC: Elective Course.

Course Code: First 3 Characters (Departmental Code), First digit (Course level), Next 2 digits (Serial of the course).

Semester-I

S. No.	Course Code	Course Title	Type of Course (CC/EC)	L	T	P	Credits
1	CPS 601	Introduction to Cyber Physical Systems	CC	3	1	0	4
2	CPS 602	Simulation of Dynamical Systems	CC	3	1	0	4
3	CPS 603	Image Processing & Computer Vision	CC	3	0	2	4
4	CPS 604	Vehicular Ad-Hoc Networks (VANETs)	CC	3	1	0	4
5	CPS 605	Edge & Fog Computing	CC	3	1	0	4
6	CPS 606	Cyber Physical System Modelling and Simulation Lab	CC	0	0	4	2
7	CPS 607	Vehicular Ad-Hoc Networks (VANETs) Lab	CC	0	0	4	2
Total							24

Semester – II

S. No.	**Course Code**	**Course Title**	**Type of Course (CC/EC)**	**L**	**T**	**P**	**Credits**
1	CPS 608	Security in CPS	CC	3	1	0	4
2	CPS 609	Data Communication and Networking	CC	3	1	0	4
3	CPS 610	Embedded System Design	CC	3	0	2	4
4	CPS 611	Machine Learning	CC	3	0	0	3
5	CPS 612	Mobile Computing	CC	3	1	0	4
6		Elective I-	EC	3	1	0	4
7	CPS 613	Machine Learning Lab	CC	0	0	2	1
Total							24

Semester – III

S. No.	Course Code	Course Title	Type of Course (CC/EC)	L	T	P	Credits
1	CPS 614	Blockchain & Cyber Security	CC	3	1	0	4
2		Elective II	CC	3	1	0	4
3		Elective III	EC	3	1	0	4
5	CPS 615	Dissertation – I		0	12	0	12
Total							24

Semester – IV

S. No.	Course Code	Course Title	Type of Course (CC/EC)	L	T	P	Credits
1	CPS 616	Dissertation – II	CC	0	24	24	24
Total							24

List of Electives:

CPS 617 Internet of Things
CPS 618 Smart Transportation Systems
CPS 619 Cloud Computing
CPS 620 Smart Health Technology
CPS 621 Industrial Internet of Things (IIoT)
CPS 622 Database Systems: Design and Implementation

Semester-I

CPS 601 Introduction to Cyber Physical Systems

Preparatory Course Material

Basics of Differential equations and basics of Microprocessors from any standard textbook.

Objectives

The Instructor will:

1. introduce modeling of CPS
2. introduce ability to analyze and simulate CPS systems

Learning Outcomes

The students are expected to have the ability to:

1. apply modeling and associated tools for Hybrid system
2. to analyze CPS by with holistic models of cyber and physical components.

Contents

Unit I Motivation and examples of CPS e.g. Energy, Medical and Transportation cyber physical systems; Key design drivers and quality attributes of CPS. (7 lectures)

Unit II Attributes of high confidence CPS; Continuous systems modeling; Discrete time system modeling; Finite state machine; (7 lectures)

Unit III Extended state machines; Hybrid system modeling; Classes of Hybrid Systems. (7 lectures)

Unit IV Analysis and Verification: Basic concepts of embedded systems; Embedded Processors; (7 lectures)

Unit V Input-outputs; Invariants and Temporal Logic; Linear Temporal Logic; Equivalence and Refinement; (8 lectures)

Unit VI Development of models from specifications; Rechability analysis and Model Checking (6 lectures)

Text Books:

1. R. Rajkumar, D. de. Niz and M. Klein, (2017), Cyber Physical Systems, Addision-Wesely.
2. E.A.Lee and S A Shesia, (2018), Embedded system Design: A Cyber-Physical Approach, Second Edition, MIT Press.
3. A.Platzer, (2017), Logical Foundations of Cyber Physical Systems, Springer.

Semester-I
CPS 602 Simulation of Dynamical Systems

Objectives
The Instructor will:

1. introduce different techniques to simulate different class of systems.

Learning Outcomes
The students are expected to have the ability to:

1. use different tools for simulating systems using right set of simulation parameters

Contents
Unit I Simulation as problem solving tool; Basic principles of numeric integration; (7 lectures)
Unit II Euler integration; difference equation simulation (7 lectures)
Unit III Runge–Kutta Algorithms; stability domains of Runge–Kutta Algorithms; (7 lectures)
Unit IV extrapolation technique; solver for Differential Algebraic Equations; (7 lectures)
Unit V Random variables; probability distribution; poison process; Markov process; (7 lectures)
Unit VI Markov chain, Bayesian statistics; simulated annealing; Monte-Carlo simulation (7 lectures)

Text Books:
1. François E. Cellier and Ernesto Kofman (2006), Continuous Systems Simulation, Springer 2006
2. Sheldon M. Ross (2013), Simulation, Academic Press, 5th Edition.

Semester-I

CPS 603 Image Processing & Computer Vision

Course Pre-requisites: The students should have knowledge of

1. Some exposure to MATLAB/Python and Open
2. Knowledge of basic matrix theory (linear algebra) would be helpful, but not necessary

Course Objectives:

1. know the fundamental techniques for image processing, video processing, and computer vision
2. understand the basics of analog and digital video: and apply machine learning in the field of computer vision.

Course Outcomes:

The student will be able to

1. know the fundamental techniques for image processing, video processing, and computer vision
2. understand the basics of analog and digital video: video representation and transmission
3. acquire the basic skill of designing image/video compression
4. Familiarize himself/herself with image/video compression standards

Content:

Unit I: Overview of image processing systems, Image formation and perception, Continuous and digital image representation, Image quantization: uniform and non-uniform, visual quantization (dithering). (8 lectures)

Unit II: Image contrast enhancement: linear and non-linear stretching, histogram equalization, Continuous and discrete-time Fourier Transforms in 2D; and linear convolution in 2D. (8 lectures)

Unit III: Image smoothing and image sharpening by spatial domain linear filtering; Edge detection, Discrete Fourier transform in 1D and 2D, and image filtering in the DFT domain. (8 lectures)

Unit IV: Median filtering and Morphological filtering, Color representation and display; true and pseudo color image processing, Image sampling and sampling rate conversion (resize). (8 lectures)

Unit V: Image segmentation and Feature Extraction Various methods of image segmentation, edge detection, object proposals, SIFT features. Multi-view Geometry Shape from stereo and motion, feature matching, surface fitting, Active ranging Object Recognition: Traditional Methods HoG/SIFT features, Bayes classifiers, SVM classifiers (8 lectures)

Unit VI: Object Recognition: Deep Learning Methods : Image classification, object detection and semantic segmentation, adversarial attacks. Various neural network architectures, visualization techniques. Motion analysis and Activity Recognition: Motion detection and tracking, Inference of human activity from image sequences (8 lectures)

Text Books:

1. Forsyth and Ponce, “Computer Vision – A Modern Approach”, Second Edition, Prentice Hall, 2011.
2. Emanuele Trucco and Alessandro Verri, “Introductory Techniques for 3-D Computer Vision”, Prentice Hall, 1998.
3. Olivier Faugeras, “Three Dimensional Computer Vision”, MIT Press, 1993.

Reference Books:

1. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer, 2011
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, “Image Processing, Analysis and Machine Vision”, Third Edition, CL Engineering, 2013.

Semester-I

CPS 604 Vehicular Ad-Hoc Networks (VANETs)

Objectives

The Instructor will:

1. Introduce the emerging technologies, standards and applications in vehicular communication systems.
2. Provide the design considerations and challenges of vehicle-to-infrastructure and vehicle-to-vehicle communications. Theories such as vehicular mobility modeling, and vehicular technologies and standards from the physical to network layers will be introduced in the course. Examples of emerging applications of vehicular communications in Intelligent Transportation Systems will also be studied and discussed.

Learning Outcomes

The students are expected to have the ability to:

1. Understand and describe the basic theories and principles, technologies, standards, and system architecture of vehicular ad-hoc networks (VANET) or inter-vehicle communication networks.
2. Analyze, design, and evaluate vehicular communication platforms for various kinds of safety and infotainment applications.

Contents

Unit I Introduction: Basic principles and challenges, past and ongoing VANET activities Cooperative Vehicular Safety Applications: Enabling technologies, cooperative system architecture, safety applications (7 lectures)

Unit II Vehicular Mobility Modeling: Random models, flow and traffic models, behavioral models, trace and survey based models, joint transport and communication simulations (7 lectures)

Unit III Physical Layer Considerations for Vehicular Communications: Signal propagation, Doppler spread and its impact on OFDM systems (7 lectures)

Unit IV MAC Layer of Vehicular Communication Networks: Proposed MAC approaches and standards, IEEE 802.11p (8 lectures)

Unit V VANET Routing protocols: Opportunistic packet forwarding, topology-based routing, geographic routing (8 lectures)

Unit VI Emerging VANET Applications: Limitations, example applications, communication paradigms, message coding and composition, data aggregation. Standards and Regulations: Regulations and Standards, DSRC Protocol Stack, Cellular V2X (8 lectures)

Text Books:

1. Olariu, S., & Weigle, M. C. (2017). Vehicular networks: from theory to practice. Chapman and Hall/CRC
2. Murthy, C. S. R. (2006). Ad hoc wireless networks: Architectures and protocols. Pearson Education India

Reference Books

1. Emmelmann, M., Bochow, B., & Kellum, C. (Eds.). (2010). Vehicular networking: Automotive applications and beyond (Vol. 2). John Wiley & Sons
2. Claudia Campolo , Antonella Molinaro, Riccardo Scopigno(2015). Vehicular ad hoc Networks, Springer
3. Hartenstein, H., & Laberteaux, K. (2010). VANET: vehicular applications and inter-networking technologies (Vol. 1). Chichester: Wiley
4. Sommer, C., & Dressler, F. (2015). Vehicular networking. Cambridge University Press
5. Moustafa, H., & Zhang, Y. (2009). Vehicular networks: techniques, standards, and applications. Auerbach publications

Semester-I

CPS 605 Edge & Fog Computing

Objectives

1. This course will introduce design concepts, frameworks, and applications in Edge Computing to the audience

Learning Outcomes:

1. To understand various edge devices and their ecosystems, issues and challenges
2. To develop edge-based distributed computing platforms and applications

Contents

Unit I Introduction of Edge and Fog Computing: Internet of Things (IoT) and New computing paradigms, Fog computing: A platform for Internet of Things and analytics, Emergence of edge computing, Legal aspects of operating IoT applications in the fog. (7 Lectures)

Unit II Edge Architecture: Multi-Tier cloud computing framework; Data services with clouds at home; Leveraging mobile devices to provide cloud service at the edge; Fast, scalable and secure onloading of edge functions. (8 Lectures)

Unit III Networking for Edge & Fog: Integrating IoT + Fog + Cloud Infrastructures: System modeling and research Challenges, Management and Orchestration of network slices in 5G, Fog, Edge, and Clouds. (7 Lectures)

Unit IV System Design: Optimization problems in fog and edge computing, Middleware for fog and edge Computing: Design issues, A Lightweight container middleware for edge cloud architectures. (8 Lectures)

Unit V Data Processing: Data management in fog computing, Predictive analysis to support fog application deployment, Using machine learning for protecting the security and privacy of Internet of Things (IoT) systems, fog Computing realization for Big data analytics. (8 Lectures)

Unit VI Applications and Case Studies: Fog computing realization for Big data analytics, Exploiting fog computing in health monitoring, Smart surveillance video stream processing at the edge for real-time human objects tracking, Fog computing model for evolving smart transportation applications. (7 Lectures)

Text Books:

1. R. BUYYA, S.N. SRIRAMA (2019), Fog and Edge Computing: Principles and Paradigms, Wiley-Blackwell, 2019.

Semester-I

CPS 606 Cyber Physical System Modelling and Simulation Lab

Objectives

The Instructor will:

1. introduce techniques to model/simulate different Cyber Physical Systems
2. introduce techniques to verify different CPS models Learning

Outcomes

The students are expected to have the ability to:

1.use different tools for Modelling/Simulation and verifications.

Contents

Modelling experiments in continuous, discrete and hybrid system; Verification of model using different techniques; Sensitivity analysis of Models; Sensitivity analysis of Hybrid Models; Scheduling in embedded system

Semester-I

CPS 607 Vehicular Ad-Hoc Networks (VANETs) Lab

Laboratory Experiments

Programming exercises using NS3, QualNet and Java

Lab Programmers are based on the theory subject (CPS 604 Vehicular Ad-Hoc Networks (VANETs)) content delivery

Semester – II

CPS 608 Security in CPS

Preparatory Course Material

Basics of Control System from Norman Nice, 2007.

Objectives

The Instructor will:

1. introduce mathematical framework for Cyber Physical System attacks
2. introduce centralized and decentralized techniques of attack detection

Learning Outcomes

The students are expected to have the ability to:

1. analyze the system for possible security vulnerability.
2. design attack resilient system.

Contents

Unit I Review of graph theory based models; some examples from infrastructure system modelling; Descriptor system; Unified modelling of CPS attack; case of undetectable attacks; (7 lectures)

Unit II Graph theoretic characterization of attacks and its limitations; Centralized and distributed monitors; examples from power system, water distribution networks etc. (7 lectures)

Unit III Security issues of Industrial Control Systems; Integrity attacks on SCADA systems; Model based technique to detect integrity attacks on sensors. (7 lectures)

Unit IV threat model and its effect on control scheme; countermeasure for detecting such attacks; watermarking scheme; (7 lectures)

Unit V Design of observers under sensor and actuator attacks; design of observer for distributed environment under different attacks; (7 lectures)

Unit VI applications of swarms of UAVs; Control design with denial service attack; case studies (7 lectures)

Text Books:

1. F. Pasqualetti, F. Dörfler and F. Bullo, "Attack Detection and Identification in Cyber-Physical Systems," in IEEE Transactions on Automatic Control, vol. 58, no. 11, pp. 2715-2729, Nov. 2013.

2. H. Fawzi, P. Tabuada and S. Diggavi, "Secure Estimation and Control for Cyber-Physical Systems Under Adversarial Attacks," in IEEE Transactions on Automatic Control, vol. 59, no. 6, pp. 1454-1467, June 2014.

3. Yilin Mo, Rohan Chabukswar and Bruno Sinopoli “Detecting Integrity Attacks on SCADA Systems” in IEEE Transactions on Control System Technology, Vol. 22, No. 4, 2014

4. F. Pasqualetti, F. Dörfler and F. Bullo “Control Theoretic methods for Cyber Physical Security”, in IEEE Control System Magazine, pp. 110-127, Feb. 2015

Semester – II

CPS 609 Data Communication and Networking

Preparatory Course Material

1. Zheng, L., Principles of Wireless Communications, MIT OpenCourseWare, Electrical Engineering & Computer Science, Massachusetts Institute of Technology, https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-452-principlesof-wireless-communications-spring-2006/index.htm

Objectives

The Instructor will:

1. Expose the students to distinguishing features of wireless networks

Learning Outcomes

The students are expected to have the ability to:

1. Design and optimize wireless network architectures.
2. Implement security techniques for wireless networks.

Contents

Unit I Fundamentals: Layered architecture overview, data communication techniques, motivations for cross-layer protocol design, motivations for performance analysis, forward error correction and re-transmission performances (7 Lectures)

Unit II Network layer and topology design: Markov and semi-Markov processes, Little's theorem, M/M/m/k, M/G/1 systems, priority queueing, network of queues, network traffic behavior, routing algorithms and analysis, distributed networks, design constraints, bounded latency networks, optimization, cognitive networks (8 Lectures)

Unit III Network Management: Power management, time synchronization, localization, energy-efficient protocols for sensor networks (7 Lectures)

Unit IV Mechanisms to improve performance: Self-Organizing Network, Software-Defined Networking (7 Lectures)

Unit V Transport and Application Layers: congestion control and quality of service, scheduling, multimedia, key aspects and design issues (7 Lectures)

Unit VI Reliability and security: Security requirement and attacks, Encryption techniques, reliable and secure communication protocols (7 Lectures)

Text Books:

1. Dargie, W., and Poellabauer, C., (2010), Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley
2. Stallings, W., (2007), Data and Computer Communications, 8th Edition, Pearson
3. Bertsekas, D. P. and Gallager, R. G., (1992), Data Networks, 2nd Edition,

Prentice Hall Self-Learning Material

1. Mishra, S., Wireless Adhoc and Sensors Networks, NPTEL Course Material, Department of Electrical and Electronics Communication Engineering, Indian Institute of Technology Kharagpur, https://nptel.ac.in/courses/106105160/
2. Zou, Y., Zhu, J., Wang, X., and Hanzo, L., "A Survey on Wireless Security: Technical Challenges, Recent Advances, and Future Trends," in Proceedings of the IEEE, vol. 104, no. 9, pp. 1727-1765, Sept. 2016.
3. W. Xia, Y. Wen, C. H. Foh, D. Niyato and H. Xie, "A Survey on Software-Defined Networking," in IEEE Communications Surveys & Tutorials, vol. 17, no. 1, pp. 27-51, First quarter 2015.

Semester – II

CPS 610 Embedded System Design

Preparatory Course Material

1. Marilyn Wolf, Computers as Components: Principles of Embedded Computing System Design, Third Edition, Elsevier 2012.

Objectives

The instructor will:

1. introduce concepts of different architectures and programming languages of embedded processors.
2. introduce design of embedded systems.

Learning Outcomes

The students are expected to have the ability to:

1. program and to design embedded system using 32-bit embedded processors based on system specifications.
2. use different IDE and debugging tools.

Contents

Unit I Review of Embedded Computing; embedded system design process; CPS and embedded Computing (5 lectures)

Unit II Architecture of ARM Cortex M3 and Cortex A series processors; Memory system mechanism; Cache; Memory management units and address translation; (8 lectures)

Unit III Performance assessment of embedded processor; Introduction to Embedded Multicore Architecture (8lectures)

Unit IV Programming of Embedded processors using assembly and C; models for program -- data flow graphs; Assembly language programming of ARM Cortex M3; Hardware software co-design; (8 lectures)

Unit V Processes and real time operating systems; Multi-rate system; real time scheduling algorithms e.g. RMA,EDF and their variants; (8 lectures)

Unit VI Energy efficient scheduling algorithms; Examples of design of embedded systems. (6 lectures)

Text Books:

1. JosephYiu, (2013), The definitive Guide to ARM Cortex M3 and M4 Processors, 3 rd Edition, Elsevier.
2. Marilyn Wolf, (2014), High Performance embedded Computing: Applications in Cyber Physical Systems and Mobile Computing, 2nd Edition, Elsevier.

Self Learning Material

1. Prof. Santanu Chaudhary, Introduction to Embedded Computing, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Delhi, https://nptel.ac.in/courses/108102045/#

Semester – II
CPS 611 Machine Learning

Objective:

1. The objective is to familiarize the audience with some basic learning algorithms and techniques and their applications, as well as general questions related to analyzing and handling large data sets.
2. Several libraries and data sets are publicly available, that will be used to illustrate the application of machine learning algorithms.
3. The emphasis will be on machine learning algorithms and applications, with some broad explanation of the underlying principles.
4. To develop the basic skills necessary to pursue research in machine learning.
5. To develop the design and programming skills that will help you to build intelligent, adaptive artifacts.

Learning outcomes:

After completing the study of the discipline "Machine Learning ", the student are expected to:

1. Able to understand complexity of Machine Learning algorithms and their limitations;
2. Able to understand modern notions in data analysis oriented computing;
3. Capable of confidently applying common Machine Learning algorithms in practice and implementing their own;
4. Capable of performing experiments in Machine Learning using real-world data.

Contents

UNIT I: Basics: Introduction to Machine Learning - Different Forms of Learning, Basics of Probability Theory, Linear Algebra and Optimization. Regression Analysis: Linear Regression, Ridge Regression, Lasso, Bayesian Regression, Regression with Basis Functions. (6 lectures)

UNIT II Classification Methods: Instance-Based Classification, Linear Discriminant Analysis, Logistic Regression, Large Margin Classification, Kernel Methods, Support Vector Machines, Multi-class Classification, Classification and Regression Trees. (6 lectures)

Unit III Neural Networks: Non-linear Hypotheses, Neurons and the Brain, Model Representation, Multi-layer Networks, Back-propagation, Multi-class Discrimination, Training Procedures, Localized Network Structure, Deep Learning. (6 lectures)

UNIT IV: Graphical Models: Hidden Markov Models, Bayesian Networks, Markov Random Fields, Conditional Random Fields. Ensemble Methods: Boosting - Adaboost, Gradient Boosting, Bagging - Simple Methods, Random Forest. (6 lectures)

Unit V Clustering: Partitional Clustering - K-Means, K-Medoids, Hierarchical Clustering - Agglomerative, Divisive, Distance Measures, Density Based Clustering – DBscan, Spectral Clustering. (6 lectures)

UNIT VI Dimensionality Reduction: Principal Component Analysis, Independent Component Analysis, Multidimensional Scaling, and Manifold Learning. Reinforcement Learning: Q-Learning, Temporal Difference Learning. (6 lectures)

Text Books:

1. Pattern Recognition and Machine Learning. Christopher Bishop. Machine Learning. Tom Mitchell.

Additional Textbooks: Pattern Classification. R.O. Duda, P.E. Hart and D.G. Stork. Data Mining: Tools and Techniques. Jiawei Han and Michelline Kamber. Elements of Statistical Learning. Hastie, Tibshirani and Friedman. Springer.

Semester – II

CPS 612 Mobile Computing

Pre-requests to the Course:

Computer Networks.

Data Communication.

Objectives:

1. The objective is to understand various generations of Mobile Communication such as 2G, 3G and 4G.
2. To study various issues and challenges in Physical layer such as analog to digital conversion and various modulation and demodulation techniques.
3. Illustration of various physical layer issues like inter symbol interference, ISI Mitigation. Physical layer parameter such as refraction, reflection and signal to noise ratio to improve the quality.
4. Demonstrate the Various MAC Layer challenges in Wireless Networks when compared to structured Networks.
5. Study of various Routing Layer Protocols suitable for Wireless Ad-Hoc Networks and Protocol operations.
6. Study of various TCP Layer issues and challenges for Wireless Networks.

Learning Outcomes:

1. Able to understand the difference between sequential architecture and parallel architecture to execute the scientific applications.
2. Understand the way to develop parallel algorithm and way of execution on parallel computing environment.
3. Analysis of time and space complexity for a particular mathematical problem in sequential as well as parallel.
4. Writing programs for to solve Partial differential equations (PDE) and Matrix decomposition.
5. Solve some Computational biology applications using Dynamic programming approaches.

Contents

Unit I Introduction, Applications, A short history of wireless Communication, A market for Mobile Communications, Some open research topics, A Simple Reference Model. (7 lectures)

Unit II Overview, Wireless Transmission , Frequency for radio transmission, Regulations, Signals , Antennas , Signal Propagation , Path Loss of radio Signals , Additional signal Propagation effects, Multi-path Propagation. Multiplexing, Modulation, Spread Spectrum. (8 lectures)

Unit III Medium Accesses Control, Motivation for Specialization MAC, Hidden and exposed terminals, near and Far Terminals, SDMA, FDMA, TDMA, CDMA. (7 lectures)

Unit IV Wireless LAN, IEEE 802.11: System Architecture, Protocol architecture, Physical Layer, MAC Control Layer, MAC Management, 802.11b, 80.11a, (7 lectures)

Unit V HIPERLAN, Bluetooth : User Scenario, Architecture, Radio Layer, Link Manager Protocol, L2CAP, SDP, IEEE 802.15. (7 lectures)

Unit VI Mobile Network Layer, Mobile IP, Dynamic Host Configuration Protocol, Mobile AdHoc Networks, Mobile Transport Layer, Classical TCP Improvements. (7 lectures)

Text Books:

1) Mobile Communications by JochenH.Schiller.

2) Mobile Computing, Technology Applications and Service Creation by Asoke K Talukder and Roopa R Yavagal.

Reference Books:

1) Stojmenovic and Cacute, “Handbook of Wireless Networks and Mobile Computing”, Wiley, 2002, ISBN0471419028.
2) Reza Behravanfar, “Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML”, ISBN: 0521817331, Cambridge University Press, October 2004,
3) Adelstein, Frank, Gupta, Sandeep KS, Richard III, Golden , Schwiebert, Loren, “Fundamentals of Mobile and Pervasive Computing”, ISBN: 0071412379, McGraw-Hill Professional, 2005.

Semester – II

CPS 613 Machine Learning Lab

Lab is conducted on the basis of content delivered in the theory subject (CPS 611 Machine Learning)

Semester – III

CPS 614 Blockchain & Cyber Security

Objectives

The Instructor will:

1. Explain how blockchain technology works
2. Integrate blockchain technology into the current business processes to make them Secure

Learning Outcomes

The students are expected to have the ability to:

1. Understand what and why of Blockchain
2. Explore the major components of Blockchain and Identify a use case for a Blockchain application
3. Create your own Blockchain network application

Contents

Unit I: Introduction to Blockchain: Digital Trust, Asset, Transactions, Distributed Ledger Technology, Types of network, Components of blockchain (cryptography, ledgers, consensus, smart contracts) Introduction to security, attacks, computer criminals, security services. Cryptography: Substitution ciphers, transposition cipher, confusion, diffusion, symmetric and asymmetric encryption. (7 lectures)

Unit II: DES, odes of DES. Hash function, key exchange, digital signatures and certificates. PKI and Cryptography: Private keys, Public keys, Hashing, Digital Signature (5 lectures)

Unit III: Consensus: Byzantine Fault, Proof of Work, Proof of Stake Public Key Cryptosystems: Principles of Public Key Cryptosystems, Factorization, RSA Algorithm, security analysis of RSA, Exponentiation in Modular Arithmetic. (8 lectures)

Unit IV: Key Management in Public Key Cryptosystems: Distribution of Public Keys, Distribution of Secret keys using Public Key Cryptosystems. Discrete Logarithms, Diffie-Hellman Key Exchange. (8 lectures)

Unit V: Cryptocurrency: Bitcoin creation and economy, Limited Supply and Deflation, Hacks, Ethereum concept and Ethereum classic, Hacks Why it is so revolutionary – both (8 lectures) Blockchain Applications: Building on the Blockchain, Ethereum Interaction - Smart Contract and Token (Fungible, non-fungible), Languages, How you would go about creating your own blockchain, Blockchain-as-a-service (10 lectures)

Unit VI: Blockchain Use Cases: Finance, Industry and Blockchain in Government (4 lectures) Security and Research Aspects: Blockchain Security (DDos), Research Aspects in Blockchain, AI, Blockchain and Big Data (6 lectures)

Textbook

1. Bahga, A., & Madisetti, V. (2017). Blockchain Applications: A Hands-On Approach. VPT.
2. Stalling Williams: Cryptography and Network Security: Principles and Practices, 4th Edition, Pearson Education, 2006.
3. 2. Kaufman Charlie et.al; Network Security: Private Communication in a Public World, 2nd Ed., PHI/Pearson.

List of Electives:

CPS 617 Internet of Things

Course Objectives

To teach state of art of wireless sensor networks
To discuss importance of communication protocols.
To teach challenges in routing protocol and overview of transport layer protocols.
To teach basics of Internet of Things.

Learning Outcomes:

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

1. Understand technological background of sensor networks.
2. Able to design applications using Raspberry Pi.
3. Design and apply various existing routing protocols of sensor networks.
4. Design the architecture and reference model of IoT.

Contents

Unit I: Introduction: Overview of Wireless Sensor Networks – Characteristics, Applications, Design objectives, challenges. Technological Background – MEMS Technology, Hardware and Software Platforms, (7 lectures)
Unit II: Wireless Sensor Network Standards. Sensor network architectures and protocol stack. Medium Access Control: Fundamental MAC protocols, (7 lectures)
Unit III: Objectives of MAC design, Energy efficiency in MAC design, MAC protocols for wireless sensor networks – Contention based protocols, Contention free protocols, Hybrid protocols. (8 lectures)
Unit III: Network and Transport Layer: Fundamentals and Challenges of Routing protocol, Overview of Routing protocols: Location-aided protocols, Layered and Innetwork processing based protocols, Data centric and multipath Protocols. (7 lectures)
Unit IV: Data aggregation mechanisms. Traditional transport protocols, Transport protocols for sensor networks. (7 lectures)
Unit V: Basics on Internet of Things: Introduction, Reference Model and architecture, IoT reference Model. (7 lectures)
Unit VI: IoT Reference Architecture Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

Text Books:

1. Jun Zheng, Abbas, " Wireless sensor networks A networking perspective", WILEY, 2009.
2. Kazem Sohraby, Daniel Minoli, & Taieb Znati, ―Wireless Sensor NetworksTechnology, Protocols, And Applications‖, John Wiley, 2007
3. Thomas Haenselmann, ―Wireless Sensor Networks: Design Principles for Scattered Systems‖, Oldenbourg Verlag, 2011
4. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st 9 Edition, VPT, 2014.
5. E. H. Callaway, Jr. E. H. Callaway, Wireless Sensor Networks Architecture and Protocols: CRC Press.
6. F. Zhao and L. Guibas, Wireless Sensor Network: Information Processing Approach, Elsevier.
7. A. Hac, Wireless Sensor Network Designs, John Wiley & Sons 8. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013

CPS 618 Smart Transportation Systems

Course Objectives:

1. To measure and monitor the impact of external events on mobility in cities
2. To optimize designs or operational strategies in a network setting
3. To make short-term predictions of transport system characteristics using real-time data

Expected Course Outcome:

1. Design an informatics system to collect data for a smart transport System.
2. Evaluate time use substitution effects of other technologies related to Mobility.
3. Evaluate the effect of a traffic, transit, taxi, or parking system design on users.
4. Evaluate the effect of spatiotemporal changes on activity participation, time of day scheduling, and trip chaining.
5. Design privacy-aware information systems. 6. Develop a portfolio management system for a transport network

Content

Unit I: Introduction to transportation systems and urbanization**:** Generic architecture of Intelligent Transportation system- Elements of a transport system Manhem-Florian-Gaudry (MFG) framework- smart cities, Big data and Internet of Things Monitoring mobility in smart cities. (7 lectures)

Unit II: Informed Transportation systems**:** Need to evaluate congestion effects- User Equilibrium on road networks- Road network assignment- Frake-Wolfe algorithm for transport network assignment- Symmetric linearization algorithm for transit equilibrium assignment problem-Transit Assignment variants-Different types of Mobility As a Service (MaaS). (7 lectures)

Unit III: Market Schedule Equilibrium for Multimodal Systems: The need to evaluate activity scheduling behavior- Kang-Chow-Recker (KCR) Trip Paradox Complexity of activity scheduling- Model Formulation and Analytical Properties-Solution Algorithms- Market schedule equilibrium for a transport System- The aggregation problem Urban freight activity analysis. (7 lectures)

Unit IV: Inverse Transportation Problems: Machine learning applications in urban transport-Inverse Transportation Problems-Wang's cutting plan algorithm- Model and Solution Method. (7 lectures)

Unit V: Privacy in Learning: User privacy - Operator competitive privacy control- Network learning with privacy awareness – Research and design challenges. (7 lectures)

Unit VI: Network Design: Network design problems- Vehicle Routing Problems- Line Planning Problems- Bi-level network design- Continuous Network Design Problems- Activity-Based Network Design Network design under coexisting systems. (7 lectures)

Text Books:

1. Chow, Joseph. Informed Urban transport systems: Classic and emerging mobility methods toward smart cities. Elsevier, 2018.
2. Sładkowski, Aleksander, and Wiesław Pamuła, eds. Intelligent transportation systemsproblems and perspectives. Vol. 303. Cham: Springer international publishing, 2016.

Reference Books:

1. Statistical and econometric methods for transportation data analysis, Washington, S., & Karlaftis, F. M. Mannering (2011)
2. Secure and Trustworthy Transportation Cyber Physical Systems – Yunchuan Sun and others, springer, 2017
3. Data analytics for intelligent transportation systems. Chowdhury, Mashrur, Amy Apon, and Kakan Dey, eds Elsevier, 2017.

CPS 619 Cloud Computing

Pre-requests to the course: -

• Computer Networks.

• Operating System.

Objectives:-

1. Demonstrate the various Distributed technologies to perform the complex task in highly distributed environment.
2. Demonstrate the service oriented architecture to provide on-demand services to Internet users.
3. Design service level agreements (SLA) to meet the guaranty services in Cloud Environment.
4. Design Energy efficient Scheduling techniques to balance the Workload in a distributed environment.
5. Design Energy Efficient model for sustainable cloud platform for next decade various novel service integration paradigm.

Learning Outcomes:

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

1. Student will able to understand basic concepts required to develop cloud computing applications.
2. Student will able to develop applications for cloud computing to provide on-demand services required for users.
3. Student will able to understand the service oriented architecture such as IaaS, PaaS and SaaS.
4. Student will able to design and implement a novel cloud computing application in simulation environment.
5. Student will able to do comparative study and analysis of different economic cloud computing models with existing conventional software developing methodologies.

Contents

Unit I: Introduction: Introduction to Cloud Computing, Roots of Cloud Computing: Fundamental concepts of Distributed Systems, Cluster Computing, Grid Computing, and Mobile Computing. (7 lectures)

Unit II: Cloud Models Basics of Cloud Computing Concepts, Characteristics of Cloud Computing, Need for Cloud, Cloud Deployment models: private, public, hybrid and community cloud, Cloud Services: Resource-as-a-Service (RaaS), Infrastructure-as-aService (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS), Examples of each service. (7 lectures)

Unit III: Cloud Services RaaS: Usage of Physical resources like servers, networks, data center etc, IaaS: Virtualization,. PaaS: Integrated lifecycle platform: Google App Engine, Microsoft Azure, Anchored life cycle platform: Salesforce platform, SaaS: Characterizing SaaS, Salesforce's software environment. (8 lectures)

Unit IV: Resource Scheduling for Cloud Computing: - Introduction, Virtual Machine provisioning and Migration Services, Scheduling techniques of Virtual machines for resource reservation, (7 lectures)

Unit V: Cloud Service Scheduling hierarchy, Economic models for Resource-allocation scheduling , Heuristic Models for task –execution scheduling : Static Strategies , Dynamic Strategies , Heuristic Schedulers. Cloud Applications Cloud Applications, (7 lectures)
Unit VI: Cloud challenges, Cloud Security and privacy issues, Mobile Cloud Computing, Integration of Cloud with Wireless Sensor Network and its application. (7 lectures)

Text Books:

1. Cloud Computing Bible by Barrie Sosinsky, Wiley Publication, 2011.
2. Cloud Computing: A Practical Approach by Anthony T. Velte Toby J. Velte, Robert Elsenpeter, The McGraw-Hill Publication, 2010.
3. Cloud Computing: Concepts, Technology and Architecture by Thomas Erl, Zaigham Mahmood, and Ricardo Puttini, 1st Edition, Prentice Hall.
4. Cloud Computing: Data-Intensive Computing and Scheduling by Frederic Magoules , Jie Pan, and Fei Teng. CRC Press. Taylors & Francis Group.

Reference Books:

1. Cloud Computing for Dummies, Judith Hurwitz, Robin Bloor, Marcia Kaufman and Fern Halper, Wiley Publication.
2. New frontiers in information and software as a service, Divyakant Agrawal, K. SelcukCandan, WenSyan Li (Eds.), Springer Proceedings.
3. Cloud Computing Theory and Practice Danc. Marinercus, Elsevier, 2013.

CPS 620 Smart Health Technology

Course Objectives:

The objective of this course are:

1. The course demonstrates the potential benefits of smart technology when it comes to improving patient contact with physicians, and monitoring of patients' conditions, in a way that causes minimal interference with their daily lives.
2. It helps to simplify care for both patients and their care providers by enabling emerging technologies and efficiently reduce the burden of treatment.
3. It involved with connected healthcare, which along with the rigour of drug development procedure with the development of new digital medicines.

Expected Course Outcome:

After successfully completing the course, the students should be able to

1. Identifies the basic fundamentals of smart healthcare models and informatics.
2. Understanding various network technologies involved with smart healthcare.
3. Studying the technology related to security in healthcare.
4. Studying the connectivity and advanced technologies of health care**.**

Content:

Unit I: Fundamentals of Healthcare Informatics & smart Home Technologies in Healthcare: Wireless Sensor Networks for wellness monitoring-Types of sensors actuators-Wireless protocols, Wireless network implementation, Classification of smart home technologies to support elderly people-safety systems-environmental control systems-Energy control systems-Reminder Systems Medication Dispensing systems-communication and Entertainments systems. (8 lectures)

Unit II: Healthcare Delivery Models and Processes: Pervasive systems in Healthcare,-SMART-system description, core software & User acceptance. Development of pervasive Mobile technology solution- Methodologies and Tools for the development of pervasive healthcare applications. (7 lectures)

Unit III: Connectivity Technologies: Networking and communication Issues for pervasive healthcare, E-health through satellite Networks, E-health via Mobile Networks, Personal area Networks-On body networks, off body networks, (7 lectures)

Unit IV: Methodologies & tools for development of healthcare applications: A health care scenario, healthcare information system architecture, access control framework, context information management, prototype implementation (7 lectures)

Unit V: Security for smart healthcare: Security threats for pervasive healthcare-Intrusion detection, privacy & context Aware Security, Security requirements, challenges, security solutions-TinySec-Encryption and Authentication, Tinysec Packet Format, Tinysec Implementation, Limitation-Ecliptic curve cryptography, Hardware Encryption, Runtime Security Service composition, Biometric methods (8 lectures)

Unit VI: Tele-Health Principles & Applications: Applications and Benefits from telemedicine and Home care, factors affecting the telemedicine and home care, challenges for implementation, case study of telemedicine. Applications : AGETECH framework, OFSETH,FitMobility,Fit4Life,MART. (7 lectures)

Text Books:

1. Antonio Coronato, Giuseppe De Pietro, "Pervasive and Smart Technologies for Healthcare: Ubiquitous Methodologies and Tools" Published in the United States of America by Medical Information Science Reference,2010

2. Christoph Thuemmler • Chunxue Bai, “Health 4.0: How Virtualization and Big Data are Revolutionizing Healthcare”, Springer International Publishing Switzerland 2017, ISBN 978-3-319-47616-2.

Reference Books

1. Catrene wg, “ Smart Systems for Healthcare and Wellness”, January 2014
2. Bruno Bouchard, “Smart Technologies in Healthcare”, by CRC Press is an imprint of Taylor & Francis Group, an Informa business, 2017, International Standard Book Number-13: 978- 1-4987-2200-1
3. Seyed Shahrestani,” Internet of Things and Smart Environments Assistive Technologies for Disability, Dementia, and Aging”, Springer publications, 2017, ISBN 978-3-319-60163-2.

CPS 621 Industrial Internet of Things (IIoT)

Prerequisite: Nil

Course Outcomes:

1. Describe Industrial Internet of Things and Cyber Physical manufacturing
2. Demonstrate Cyber Physical and Cyber Manufacturing systems
3. Describe Architectural design patterns for industrial Internet of Things
4. Analyse AI and data Analytics for Industrial Internet of Things
5. Evaluation of Workforce and Human Machine Interaction and Application of Industrial Internet of Things

Content

Unit I: Understanding Industrial Internet of Things (IIoT): Industrial Internet of Things and Cyber Manufacturing Systems, Application map for Industrial Cyber Physical Systems, Cyber Physical Electronics production. (8 lectures)

Unit II: Modeling of CPS and CMS: Modeling of Cyber Physical Engineering and manufacturing, Model based engineering of supervisory controllers for cyber physical systems, formal verification of system, components, Evaluation model for assessments of cyber physical production systems. (10 lectures)

Unit III: Architectural Design Patterns for CMS and IIoT: CPS-based manufacturing and Industries 4.0., Integration of Knowledge base data base and machine vision, Interoperability in Smart Automation, Enhancing Resiliency in Production Facilities through CPS. Communication and Networking of IIoT. (8 lectures)

Unit IV: Artificial Intelligence and Data Analytics for manufacturing: Application of CPS in Machine tools, Digital production, Cyber Physical system Intelligence, Introduction to big data and machine learning and condition Monitoring. (6 lectures)

Unit V: Evaluation of Workforce and Human Machine Interaction: Worker and CPS, Strategies to support user intervention. Introduction to Advance manufacturing and Innovation Ecosystems. (6 lectures)

Unit VI: Application of IIoT: Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector (6 lectures)

Text Books:

1. Sabina Jeschke, Christian Brecher Houbing Song , Danda B. Rawat Editors Industrial Internet of Things Cyber Manufacturing Systems

2. Hakima Chaouchi, " The Internet of Things Connecting Objects to the Web" ISBN : 978-1-84821- 140-7, Willy Publications Olivier Hersent, David Boswarthick, Omar Elloumi,

3. The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2nd Edition, Willy Publications

4. Inside the Internet of Things (IoT), Deloitte University Press

5. Internet of Things- From Research and Innovation to Market Deployment; By Ovidiu & Peter; River Publishers Series

6. Five thoughts from the Father of the Internet of Things; by Phil Wainewright - Kevin Ashton

7. How Protocol Conversion Addresses IIoT Challenges: White Paper By RedLion.

8. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights ,2014

CPS 622 Database Systems: Design and Implementation

Prerequisites

The course is intended for graduate students and advanced undergraduates. A good background in DBMS fundamentals is required, therefore, 15-415 (or equivalent) is a desired prerequisite. Students should be comfortable with the relational model, SQL, and the basic functions of database systems. Students should also be capable of implementing a large, complex system on UNIX in C or C++.

Learning Objectives:

By the time the students finish the course, they should be able to

1. Understand key concepts of relational database management systems;
2. Understand key management issues surrounding database technology and emerging business applications enabled by database technology;
3. Understand the importance of database design through Entity Relationship Diagrams and models(ERD);
4. Design and understand queries using Structured Query Language (SQL);
5. Perform a real-world database design and implementation in Microsoft Access and MySQL.

Content

Unit I Introduction to Database systems - Goals and functions of DBMS, Transactions, Reference architecture for a relational DBMS, etc. (7 lectures)

Unit II "The Roots" - Overviews of the classic relational systems: System R, and INGRES. Architectural Foundations - Performance, availability, and reliability characteristics of hardware and operating systems that impact the design of a DBMS. (7 lectures)

Unit III Buffer Management - Memory management for multi-user systems, DBMin algorithm, implications of transaction semantics. Access Paths and Indexes - Structures that are optimized for disk-resident data: e.g., B+trees and Linear hashing (8 lectures)

Unit IV Query Processing - access path selection, join methods, optimization techniques, sub-query and view processing. Benchmarking and Performance - TPC and Wisconsin benchmarks, performance measurement, and performance tuning. (8 lectures)

Unit V Concurrency Control - Locking techniques, lock manager implementation, comparison of pessimistic and optimistic techniques, concurrent access to search structures, deadlock handling. (7 lectures)

Unit VI Logging and Crash Recovery - Write-Ahead-Logging, the ARIES recovery system, shadow-based techniques, media failure. Data mining for warehouses, emerging internet applications, and new data representation standards. (7 lectures)

Text Books:

1. Database Systems: Design, Implementation and Management, 11th edition. Coronel, Morris & Rob, Cengage Learning. 10th edition can also be used
2. Readings in Database Systems, Third Edition - edited by Michael Stonebraker and Joe Hellerstein, Morgan Kaufmann Publisher March 1998. Several of the papers in this book are available through the ACM digital library.