M.Tech. Computer Science with Specialization in Embedded Systems (2017)

Semester - I

Sl. No.	Course code	Course Title	Core/Elective	Credits	Lec.	Lab	Marks
1	CSE 3101	Embedded Systems	C	4	4	0	100
2	CSE 3102	Programming Embedded Systems	C	4	4	2	100
		Total for Semester I		8	8	2	200

Semester - II

Sl. No.	Course code	Course Title	Core/Elective	Credits	Lec.	Lab	Marks
1	CSE 3201	Programming Massively Parallel Processors	C	4	4	2	100
2	-	Elective I	E	4	4	0	100
		Total for Semester II		8	8	2	200

Electives

CSE 3202 : Programming Smart Devices

CSE 3203 : Machine Learning for Multimedia Analysis

Semester - III

1	CSE 3301	Real-Time Digital Signal Processing	C	4	4	2	100
2	CSE 3302	Real Time Operating Systems	C	4	4	0	100
		Total for Semester III		8	8	2	200

Semester - IV

1	CSE 3401	Embedded Security	C	4	4	2	100
2	-	Elective II	E	4	4	0	100
		Total for Semester IV		8	8	2	200

Electives

CSE 3402 : Modelling cyber physical systems

CSE 3403 : Advanced Fuzzy Theory

Semester -V

Sl. No.	Course code	Course Title	Core/Elective	Credits	Lec.	Lab	Marks
1	CSE 3501	Advanced Optimization Techniques	C	4	4	0	100
2	CSE 3502	Project & Viva Voce	C	16	0	10	300
		Total for Semester V		20	4	10	400

Semester - VI

Sl. No.	Course code	Course Title	Core/Elective	Credits	Lec.	Lab	Marks
1	CSE 3601	Project & Viva Voce	C	20	0	15	400

Total credits for Degree: 72

CSE3101: EMBEDDED SYSTEMS

Core/Elective: **Core** Semester: **1** Credits: **4**

Course Description

This course concentrates on the fundamental concepts of embedded systems. This course provides a detailed examination of the internal structure and operation of embedded computer systems. Embedded system technologies including processors, DSP, memory and software are explained. Performance evaluation and optimization techniques are also discussed. This course includes basic concepts of embedded systems, 8051 and advanced processor architectures.

Course Objectives

To study the characteristics of embedded systems dependent on application domain.
To familiarize the mechanisms behind the state-of-the-art architectures for embedded systems.
To Study performance evaluation and optimization methods

Course Content

1. Definition of embedded system - Constraints on embedded vs. standalone systems - Concept of real-time design - Time scales for real-time systems - Embedded system design processes- Applications - Embedded Systems design process – Formalisms for System Design - Design example

2. 8051 and Advanced processor architectures- Memory organization- Real world interfacing- performance metrics-processor selection-memory selection
Program design and Analysis – Introduction to Program design – Models of programs – Assembly and Linking – Basic compilation techniques – Optimization: Time, Energy, Power, Size

3. Devices-Communication Buses-wireless devices-timer and counting devices-Real time clock-Networked embedded system-Processes and Operating systems – Multiple tasks and multiple processes – Context switching – Scheduling Policies – Inter process communication- Device drivers – Embedded Operating systems – POSIX standard

4. Evaluating system performance: Correctness - Speed - Profiling system performance - Performance optimization: Hand-optimization - Optimizing compilers -Pareto principle

5. Embedded software development process and tools-host and target machines-linking and locating software-Testing simulation-Debugging techniques-Issues in hardware software design and co-design.

REFERNCES

1. Wayne Wolf “Computers as Components: Principles of Embedded Computer Systems Design” Morgan Kaufmann; 4th edition, 2016
2. Alan Moore “Concepts and Design of Embedded Systems”, CLANRYE INTERNATIONAL, 1st edition, 2015
3. Tammy Noergaard “Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers” Newnes; 2 edition, 2012
4. Raj Kamal “Embedded Systems: Architecture, Programming and Design” McGraw-Hill Education (India); 2nd Edition edition (March 9, 2009) ISBN-13: 978-0070151253

CSE3102: PROGRAMMING EMBEDDED SYSTEMS

Core/Elective: **Core** Semester: **1** Credits: **4**

Course Description

This course will develop the skill required to program for embedded systems. ARM processors are used as the platform due to their relevance in the current systems.

Course Objectives

To familiarize the programming methods and tools for embedded systems.
To develop skills for writing optimized programs.

Profile

1. History of ARM processors - ARM technology -ARM naming conventions - ARM architecture –ARM subsystems - ARM instruction set - ARM assembly language - Why learn assembly? - Assembly optimization - bit manipulation - sorting - optimization objectives - runtime profiling with performance counters -memory bandwidth - memory mapping

2. Multicore and data-level optimization - Amdahl's law - polynomial evaluation - multiple cores using OpenMP- performance bounds - performance analysis - inline assembly using GCC - reducing instructions per Flop - reducing CPI - multiple Flops per instruction

3. Linux framebuffer - affine image transformations - bilinear interpolation -floating-point image transformation -floating-point performance - fixed-point arithmetic - fixed-point performance - real-time fractal generation

4. Stencil loops - mean filter - separable filters - memory access behavior of 2D filters - loop tiling - 2D filter implementation - capturing and converting video frames - Video4Linux driver and API

5. GPU microarchitecture - introduction to OpenCL - OpenCL programming model - OpenCL programming patterns - Kernel workload distribution - OpenCL implementation of Horner's method.

REFERNCES

1. Jason D. Bakos, Embedded Systems: ARM Programming and Optimization, Morgan Kaufmann, 2015.
2. James A. Langbridge, Professional Embedded ARM Development, Wrox, 2014.
3. William Hohl, Christopher Hinds, ARM Assembly Language: Fundamentals and Techniques 2nd Edition,CRC Press, 2014.
4. Andrew Sloss et al. ARM System Developer's Guide Morgan Kaufmann, 2004.

CSE3201: PROGRAMMING MASSIVELY PARALLEL PROCESSORS

Core/Elective: **Core** Semester: **2** Credits: **4**

Course Description

It used to be the case that parallel computing was confined to giant supercomputers. But nowadays it is literally everywhere - even in the small mobile handsets that most of us carry around. This course introduces parallel computing with a strong emphasis on programming.

Course Objectives

To understand the basics of parallel computing.

To develop programming skills required for parallel computing.

Course Content

1.Introduction - parallel computing - more speed or parallelism - languages and models - sequential vs parallel - concurrent, parallel, distributed - parallel hardware architecture - modifications to the von Neumann Model

2. Evolution of GPU - GPGPU - introduction to data parallelism - CUDA program structure - vector addition kernel - device global memory and data transfer

3. Cuda thread organization - mapping threads to multi-dimensional data - assigning resources to blocks - synchronization and transparent scalability - thread scheduling and latency tolerance

4. Memory access efficiency - CUDA device memory types - performance considerations - global memory bandwidth - instruction mix and thread granularity -floating point considerations

5. Parallel programming patterns - convolution - prefix sum - sparse matrix and vector multiplication - application case studies - strategies for solving problems using parallel programming.

REFERNCES

1. David B. Kirk, Wen-mei W Hwu Programming Massively Parallel Processors, 2nd Edition, Morgan Kaufmann, 2012.

2. Peter Pacheco, Introduction to Parallel Programming, Morgan Kaufmann, 2011.

3. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, MorganKaufmann, 2012.

4. Jason Sanders, Edward Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming, Addison-Westley Professional, 2010.

CSE3202: PROGRAMMING SMART DEVICES

Core/Elective: **Elective** Semester: **2** Credits: **4**

Course Description

This course introduces programming for smart mobile devices, using Android as the platform.

Course Objectives

To have an in-depth understanding of the Android platform.

To develop Java programming skills required for mobile applications.

Course Content

1. Overview of Java - Java Type System - Primitive Types - Objects and Classes - Inheritance – Polymorphism - Final and Static declarations - Abstract classes - Interfaces - Exception handling - Garbage collection -Scope - Java idioms

2. Sun Java vs Android Java - Android Studio - Basics of app design - anatomy of an android project – MVC paradigm -Debugging android applications - Layouts - View class - Android's Form widgets – ContainerViews - Using and Adapter

3. Activities and Intents - Activity lifecycle - Explicit and Implicit Intents - Passing data between Activities - Fragments - Fragment Lifecycle - ActionBar - Responsive design with Fragments -ListViews

4. Graphics in Android - ImageViews - Canvas Class - Recursive Drawing - Animate library - Audio - Multithreading and Multicore Processing - Thread approaches - Loopers - Canvas Movement and Views - SurfaceViews -AsyncTasks

5. Persistant Data - overview of Relational Databases - SQLite - SQL language - Database-Centric Data model for Android applications - Android Database classes - Database design for Android applications

REFERNCES

1. Trish Cornez, Richard Cornez, Android Programming Concepts, Jones & Bartlett Learning, 2015.

2. Zigurd Mednieks et al. Programming Android: Java Programming for the New Generation of MobileDevices, O'Reilly Media, 2nd Edition 2012

3. Paul Deitel et al. Android 6 for Programmers: An App-Driven Approach Prentice Hall, 3rd Edition,2015.

4. Ian G. Clifton Android User Interface Design: Implementing Material Design for Developers AddisonWesley Professional, 2nd Edition, 2015.

CSE3203: MACHINE LEARNING FOR MULTIMEDIA ANALYSIS

Core/Elective: **Elective** Semester: **2** Credits: **4**

Course Description

This course is about the machine learning techniques and algorithms used for acquiring, processing and extracting useful information from Audio, images and Video.

Course Objectives

To study machine learning concepts of Audio, Image and Video Processing.
To understand the mathematical foundations for machine learning approaches for manipulation of Audio, Image and Video Processing.

Course Content

1.Audio Acquisition, Representation and Storage- Introduction- Sound Physics, Production and Perception- Audio Acquisition- Sampling and Aliasing-The Sampling Theorem- Linear Quantization-Nonuniform Scalar Quantization- Audio Encoding and Storage Formats- Time-Domain Audio Processing

2.Image and Video Acquisition, Representation and Storage- Introduction- Human Eye Physiology-Structure of the Human Eye- Image Acquisition Devices-Digital Camera - Color Representation-Human Color Perception- Color Models-Image Formats-Image File Format Standards-JPEG Standard-Video Principles-MPEG Standard

3. Machine Learning- Taxonomy of Machine Learning- Learning from Examples-Supervised Learning-Reinforcement Learning-Unsupervised Learning-Bayesian Theory of Decision- Bayes Decision Rule- Bayes Classifier- Loss Function- Zero-One Loss Function- Discriminant Functions- Gaussian Density- Discriminant Functions for Gaussian Likelihood- Receiver Operating Curves

4. Clustering Methods- Expectation and Maximization Algorithm- Basic Notions and Terminology- K-Means- Self-Organizing Maps- Optimization by EM Algorithm- Fuzzy Clustering Algorithms- Hierarchical Clustering- Artificial Neural Networks and Neural Computation- Markovian Models for Sequential Data.

5. Applications- Speech and Handwriting Recognition- The General Approach- HMM Training- Recognition and Performance Measures- Automatic Face Recognition- Face Detection and Localization- Lighting Normalization- Feature Extraction- Classification-Video Segmentation and Keyframe Extraction- Shot Boundary Detection- Keyframe Extraction.

REFERNCES

1. Francesco Camastra, Alessandro Vinciarelli, Machine Learning for Audio, Image and Video Analysis: Theory and Applications, Springer; 2 edition (July 21, 2015)
2. Machine Learning: A Probabilistic Perspective, Kevin P Murphy, MIT Press (2012)
3. Pattern Recognition and Machine Learning, Christopher M Bishop, Springer, (2006)

4. The Elements of Statistical Learning: Data mining, Inference, and Prediction, Trevor Hastie et. al., 2nd Edn, Springer, (2009)

CSE3301: REAL-TIME DIGITAL SIGNAL PROCESSING

Core/Elective: **Core** Semester: **3** Credits: **4**

Course Description

This course introduces the theory of digital signal processing and the important skill of real-time DSP design and implementation techniques.

Course Objectives

To study principles, concepts and practice of Digital Signal Processing.
To familiarize Explain the methods and processes of constructing the different types of Filters

Course Content

1.Signals and signal processing-Classification of signals-operations-Digital signal processing-Discrete time signals and systems in the time domain- sequence representation- sampling-Discrete time systems

2. Discrete time signals in the transform domain-Discrete time Fourier transform-Discrete Fourier transform- Convolution- Z transform- Finite dimensional discrete time systems- Frequency response-Transfer functions-simple digital filters-All pass transfer function-Min-Max phase transfer function-Complementary transfer function-Inverse system.

3. Digital processing of continues time signals-sampling-sampling of band pass signals-Analog low pass filter-Band stop filter-Digital filter structures-Block diagram representation- FIR-IIR

4. Adaptive filters-system modeling-Equalization-adaptive line enhancer-adaptive noise cancelling-LMS Algorithm-RLS algorithm-Lattice ladder filters

5. Multi rate digital signal processing-rate alteration devices-sampling rate conversion-poly phase decomposition-Nyquist filters-digital filter banks-multilevel filter bank-linear prediction and optimum linear filters Random signals-correlation function-power spectra-forward and backward linear prediction-Wiener filter for filtering and prediction

REFERNCES

1. John G. Proakis, Dimitris K Manolakis, Digital Signal Processing: principles, Algorithms and Applications, Pearson; 4 edition, 2007
2. Li Tan, Jean Jiang: Digital Signal Processing: Fundamentals and Applications, Academic Press; 2 edition, 2013
3. Robert J. Schilling , Sandra L Harris;, Digital Signal Processing using MATLAB, CL Engineering; 3 edition, 2016
4. Juan Zhang, Digital Signal Processing: Fundamentals, Techniques and Applications, 1st ed, Nova Science Pub Inc, 2016

CSE3302: REAL TIME OPERATING SYSTEMS

Core/Elective: **Core** Semester: **2** Credits: **4**

Course Description

This course provides an introduction to the theory, structure and practice of real-time operating systems. Particular emphasis is placed on issues related to embedded applications. The course covers basic concepts, practical issues and commercial implementations of modern operating systems.

Course Objectives

To Understand the fundamental concepts of real-time operating systems
To Appreciate the use of multitasking techniques in real-time systems
To Understand the features and structures of practical implementations
To Appreciate how application areas impact on RTOS facilities

Course Content

1.Real-Time System concepts: Shared Resources – Multitasking – kernels – Schedulers – task priorities – mutual exclusion – deadlock – inter task communication – kernel objects

2.Timer and timer services: real time clocks – Timer ISRs – Soft timers – I/O subsystem – Memory management techniques – Concurrency – synchronization and communication

3. File system, device and memory management aspects – Performance and safety features – Real-Time POSIX issues

4. Structured Design for Real-time Systems - Designing for Multitasking; UML for Real-time Systems - System Integrity - Selecting Languages for RTS Development - C, Ada & Java - Cross Development Techniques

5.Case studies of Real Time Embedded operating systems – Monta vista Linux, QNX, VxWorks, Windows CE – eCos

REFERNCES

1. Qing Li and Caroline Yao “Real-Time Concepts for Embedded Systems” Elsevier; 1 edition, 2010
2. Rob Williams “Real-Time Systems Development”, Elsevier India (July 6, 2013)

CSE3401: EMBEDDED SECURITY

Core/Elective: **Core** Semester: **4** Credits: **4**

Course Description

Nowadays most of the common devices are `smart', i.e., they host embedded systems. Also increasingly they are having some way to connect to the outside world. While this makes it extremely convenient for the user, it also exponentially increases the possibility of an attack which can bring the entire system down. Hence it is extremely important to learn how to design secure embedded systems. This course looks at various security aws that embedded systems might have and design practices for avoiding them.

Course Objectives

To have a concrete understanding of various security aws that can crop up in embedded systems.

To have the ability to identify and address security issues in existing systems.

To develop the skills required to design embedded systems which are secure.

Course Content

1.Introduction to embedded security -security threats -security policies -the role of the operating system-levels of security -microkernel vs monolith - embedded operating system security requirements – access control - hypervisors and system virtualization.

2. Secure embedded software development - introduction -component architecture - principle of least privilege- secure development process- model driven design -case study.

3. Embedded cryptography - one-time pads -cryptographic modes - block ciphers- authenticated encryption - public key cryptography - key agreement - elliptic curve cryptography -message authentication codes - random number generation.

4. Data protection protocols - data-in-motion protocols - Ethernet security protocols - IPsec versus SSL - SSL/TLS - embedded VPN Clients - SSH - broadcast security.

5. Applications - embedded network transactions - transaction threats - automative security -android security software defend radio.

REFERNCES

1. Fei Hu, Security and Privacy in Internet of Things, CRC Press, 2016.
2. David Kleidermacher, Mike Kleidermacher Embedded Systems Security, Elsevier 2012.
3. Robert C. Seacord Secure Coding in C and C++, 2nd Edition, Pearson Education, 2014.
4. Timothy Stapko Practical Embedded Security, Elsevier, 2007.
5. Nikolay Elenkov Android Security Internals, No Starch Press, 2014.

CSE3402: MODELLING CYBER PHYSICAL SYSTEMS

Core/Elective: **Elective** Semester: **4** Credits: **4**

Course Description

The course examines wireless cellular, ad hoc and sensor networks, covering topics such as wireless communication fundamentals, medium access control, network and transport protocols, unicast and multicast routing algorithms, mobility and its impact on routing protocols, application performance, quality of service guarantees, and security. Energy efficiency and the role of hardware and software architectures may also be presented for sensor networks.

Course Objectives

To know problem solving techniques
To understand techniques for the design and analysis of efficient algorithms
To be able to design algorithms for new problems with volume of data

Course Content

1.Introduction to Cyber Physical System: Cyber physical system: Definition Applications, Design Process for Cyber Physical System: Modeling, Design, And Analysis: Modelling continuous dynamics, Newtonian Mechanics, Actor models, Properties that actors and the systems: Causal Systems, Memoryless Systems, Linearity and Time Invariance, Stability. Feedback-control

2. Modeling Discrete Systems: Discrete Systems ,State, Finite-State Machines: Transitions, The occurrence of reaction, Update functions, Determinacy and Receptiveness, Extended State Machines, Nondeterministic Finite State Machines , Behav iors and Traces

3. Hybrid Systems: Actor Model for State Machines, Continuous Inputs, State Refinements, Classes of Hybrid Systems: Timed Automata, Higher-Order Dynamics, Supervisory control.

4. Composition of State Machines: Concurrent Composition: Side-by-Side Synchronous Composition, Side-by-Side Asynchronous Composition, Shared Variables, Cascade Composition, General Composition, Hierarchical state machines

5. Concurrent Models of Computation : Structure of Models, Synchronous-Reactive Models: Feedback Models, Well-Formed and ill-Formed Models, Constructing a Fixed Point, Dataflow Models of Computation: Dataflow Principles, Synchronous Dataflow ,Dynamic Dataflow, Structured Dataflow, Process Networks, Timed Models of Computation: Time-Triggered Models, Discrete Event Systems, Continuous-Time Systems

REFERNCES

1. Principles of Cyber-Physical Systems: Rajeev Alur, MIT Press (2015)
2. Introduction to Embedded Systems - A Cyber-Physical Systems Approach: Edward A. Lee, Sanjit A. Seshia, Lulu.com (2011)
3. Applied Cyber-Physical Systems, Suh, S.C et.al (Edited), Springer (2014)
4. Cyber-Physical Systems: Integrated Computing and Engineering Design: Fei Hu, CRC Press

(2013)
5. Embedded System Design-Embedded Systems Foundations of Cyber-Physical Systems: Marwedel & Peter, SIE (2013).

CSE3403: ADVANCED FUZZY THEORY

Core/Elective: **Elective** Semester: **4**Credits: **4**

Course Description

This course concentrates on fuzzy set theory and its application. This includes the concepts, and techniques from fuzzy sets and fuzzy logic to enhance machine learning techniques.

Course Objectives

To study concepts of fuzzy set theory

To understand the fuzzy set theory techniques used to enhance machine learning techniques

Course Content

1. Crisp sets and Fuzzy sets - Introduction - crisp sets an overview-the notion of fuzzy sets-basic concepts of fuzzy sets- membership functions - methods of generating membership functions-Defuzzification methods-operations on fuzzy sets- fuzzy complement- fuzzy union- fuzzy intersection- combinations of operations-General aggregation operation

2. Fuzzy arithmetic and Fuzzy relations-Fuzzy numbers-arithmetic operations on intervals-arithmetic operations on fuzzy numbers-fuzzy equations- crisp and fuzzy relations-binary relations- binary relations on a single set - equivalence and similarity relations- compatibility or tolerance relation

3. Fuzzy measures - Fuzzy measures - belief and plausibility measure - probability measures -possibility and necessity measures- possibility distribution- relationship among classes of fuzzy measures.

4. Fuzzy Applications-Fuzzy approximate reasoning- Fuzzy Expert System-Fuzzy systems-Fuzzy controllers-Fuzzy Neural Networks- Fuzzy automata-Fuzzy Dynamic systems

5. Fuzzy Clustering-Fuzzy Pattern Recognition-Fuzzy image processing - Fuzzy data bases and information retrieval-Fuzzy Decision making - Fuzzy systems and Genetic algorithms - Fuzzy regression.

REFERNCES

1. George J Klir and Tina AFolger: Fuzzy Sets, Uncertainty and Information, Fuzzy Sets, Uncertainty and Information Pearson Education; 1st edition , 2015

2. George J Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications Pearson Education; 1stedition, 2015.

3. Timothy J Ross: Fuzzy logic with Engineering Applications; 3rd Edition,Wiley, 2011.

4. H. J. Zimmerman: Fuzzy Set theory and its Applications;4thEdition, Springer,2001.

CSE3501: ADVANCED OPTIMIZATION TECHNIQUES

Core/Elective: **Core** Semester: **5** Credits: **4**

Course Description

This course is about the well-known population-based optimization techniques developed during last three decades. This course emphasizing on the advanced optimization techniques to solve large-scale problems especially with nonlinear objective functions.

Course Objectives

To study concepts of Population based Optimization techniques.
To understand the mathematical foundations for various advanced optimization techniques

Course Content

1.Introduction to optimization- formulation of optimization problems-Review of classical methods-Linear programming-Nonlinear programming-Constraint optimality criteria-constrained optimization-Population based optimization techniques

2. Genetic Algorithm-Introduction-Working principle-Representation-selection-fitness assignment-reproduction-cross over-mutation-constraint handling-advanced genetic algorithms-Applications-
Artificial Immune Algorithm-Introduction-Clonal selection algorithm- Negative selection algorithm-Immune network algorithms-Dendritic cell algorithms

3. Differential Evolution-Introduction-Working principles-parameter selection-advanced algorithms in Differential evolution-Biogeography-Based Optimization-Introduction-Working Principles- Algorithmic variations

4. Particle Swarm Optimization-Introduction- Working principles- Parameter selection-Neighborhoods and Topologies-Convergence-Artificial Bee Colony Algorithm-Introduction- Working principles- Applications-Cuckoo search based algorithm-Introduction- Working principles- Random walks and the step size-Modified cuckoo search

5. Hybrid Algorithms-Concepts- divide and conquer- decrease and conquer-HPABC-HBABC-HDABC-HGABC-Shuffled Frog Leaping Algorithm-- Working principles -Parameters- Grenade Explosion Algorithm-Working principle-Applications

REFERNCES

1. DAN SIMON, Evolutionary Optimization Algorithms, Wiley; 1 edition, 2013
2. XIN-SHE YANG, Engineering Optimization: An Introduction with Metaheuristic Applications, Wiley; 1 edition, 2010
3. S.S. Rao, Engineering Optimization : Theory and Practice, New Age International Pvt. Ltd.; 4th edition , 2013

4. R. Venkata Rao, Teaching Learning Based Optimization Algorithm: And Its Engineering Applications, Springer; 1st ed, 2016