M-TECH – WIRELESS NETWORKS AND APPLICATIONS

Amrita Centre for Wireless Networks and Applications

This M-Tech programme is intended to generate trained academic and research personnel in the highly demanding, useful and emerging area of wireless networks. The programme includes core subjects from Wireless Communications, Computer Science, Computer networks, advanced topics in wireless communications, mobile computing, sensor networks, embedded systems, signal processing, multimedia systems and applications such as landslide detection, environmental monitoring, etc. Building on a very successful joint project called WINSOC with about a dozen international partners, this new M-Tech program was introduced with a view to strengthen the academic and research activities in this highly advanced topics: Wireless Networks and Applications.

Students, when they graduate, will be well trained to enter into a broad spectrum of industries such as computers, communication networks, earth sciences, environmental sciences, disaster management, health care, e-governance activities, bio and nano-technologies, VLSI and embedded systems, agriculture and chemical industries and strategic planning.

CURRICULUM

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Sampling and Reconstruction: Sampling Theorem, Anti-aliasing Prefilters, Sampling of Sinusoids, Analog Reconstruction and Aliasing, Spectra of Sampled Signals, Discrete-Time Fourier Transform, Spectrum Replication, Practical Antialiasing Prefilters — Basic Components

Lab:Implementation using MATLAB.

TEXT BOOKS/REFERENCES:

16MA622 PROBABILITY AND STATISTICAL INFERENCE 2-0-1-3

Introduction to Probability, conditional Probability, Bayes’ theorem; Random variables, Analysis of discrete and continuous random variables, Probability distributions, distribution functions, mean and variance of random variables, standard discrete and continuous distributions and their properties; Analysis of Joint Probability Distributions of discrete and continuous random variables, Two or more random variables, joint, marginal and conditional probability distributions, independence of random variables, Covariance and correlation, Linear functions of random variables, several functions of random variables; Point estimation of Parameters and Sampling distributions: Central limit theorem, General concepts of point estimation, Methods of point estimation, method of moments, method of maximum likelihood, Bayesian estimation of parameters, Interval estimation, Confidence interval for the mean and variance of a normal population, large sample confidence interval for population proportions; Hypothesis Testing, general concepts, tests on mean and variance of one and two normal populations, tests on population proportion, testing for goodness of fit and independence; Introduction to nonparametric statistics, sign test, Wilcoxon signed rank test, Wilcoxon rank sum test.

TEXT BOOKS/REFERENCES:

16WN602 ADVANCED COMPUTER NETWORKS 3-0-1-4


TEXT BOOKS/REFERENCES:
4. NFV architecture document from ETSI NFV.

16WN603 ADVANCED COMPUTER PROGRAMMING 0-0-1-1

Programming in C, Basic Computer Organization and Architecture, Build and Compilation process, Debugging concepts, Data Types and Variables, Input/ Output implementation and usage, Control flow, Modular Programming with functions, Stack Frames and Activation Records, Arrays, Pointers, Strings, Structures, Implementation of Structures, Memory, Stacks, Recursion, Dynamic Memory Allocation, Heap, Program Runtime Analysis, Big-Oh Notation. Significant labs, e.g., Spell Checker with a real dictionary, complicated data structure such as a Vector/Set, Customer Relationship Management system, custom string Abstract Data Type, Maze, etc.

TEXT BOOKS/REFERENCES:

16WN604 DESIGN AND ANALYSIS OF ALGORITHMS 3-0-1-4

Significant labs: Implementation of algorithms using a structured or object-oriented programming language.

TEXT BOOKS/REFERENCES:

16WN605 OBJECT ORIENTED PROGRAMMING 0-0-1-1

Java Atomic Data Types and Operators, Reference types, Date and time types, Enumerations, Selection statements (If else, switch), Iterations (while, for), Working with Arrays, Objects and Classes, Access modifiers and methods, Constructors, Inheritance and Polymorphism, Interfaces, Anonymous interfaces, Java Generics, Generic Collections (Lists, Sets, Maps), Exceptions, Java IO library (java.nio), Functional programming with Java 8 lambdas, Java 8 Streams, Multithreading in Java, Design patterns in Java (Singleton, Factory, Builder), UML Diagrams (Object, Activity, DataFlow), Agile methodologies, Test driven development, Unit testing in Java with JUnit and Netbeans

TEXT BOOKS/REFERENCES:

16WN621 FUNDAMENTALS OF WIRELESS COMMUNICATIONS 3-0-1-4


Antennas: Introduction to Antennas, Integration of antennas into systems, characteristic antenna quantities, Types of antennas: Antennas for mobile station, Antennas for base station.


Cellular Networks: Basic Concepts, Multiple Access Techniques: FDMA, TDMA, CDMA, OFDMA and SDMA; Wireless Link Improvement: Introduction to types of codes, Equalization Techniques, Diversity methods.

Research Paper Discussion and Presentation.

Wireless Communication Laboratory: Conduct experiments using Labview, C and Matlab.

TEXT BOOKS/REFERENCES:

16WN622 EMBEDDED SYSTEM DESIGN 3-0-1-4

Microcontroller fundamentals: ARM ASM programming and basic of C; IO Interfacing: LED and Switch; Design and Development Process: Architecture, Microarchitecture, Design, Implementation, Verification and Validation; Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines; The Parallel Interface: GPIO; The Serial Interface: UART; PLL programming; Timer: SysTick; Fixed Point; Software: Structs, Stacks and Recursion; Device Driver: Interfacing with an Hitachi HD44780 display; IO Synchronization; Interrupts; DAC: Music Synthesis and Music Playback; ADC: Real world interfacing and Data Acquisition.

Significant labs include prototypes of actual embedded systems, e.g., Traffic Light Controller (FSM), LCD Device Driver (Hitachi HD44780), Digital Piano (DAC, Interrupts), Digital Vernier Caliper (ADC, Interrupts, LCD), Distributed Data Acquisition (Interrupts, ADC, LCD, UART).
Capstone Design Project, A popular video game, e.g., Space Invaders, Connect-4, Pipe Dream, etc.

TEXT BOOKS/REFERENCES:

16WN623 WIRELESS SENSOR NETWORKS 3-0-1-4


- TinyOS Libraries: http://www.tinyos.net/scoop/special/working_groups
- NS2, NS3
- Qualnet

Creating hierarchical network, Implementation of Data aggregation, clustering and Time synchronization Algorithms, Indoor and outdoor testing of algorithms to study the effects on range, delay and data loss at different power levels, Integration of Sensor networks with Wireless LAN.

TEXT BOOKS/REFERENCES:

16WN624 MOBILE COMMUNICATION NETWORKS 2-0-1-3

Overview of the legacy second generation (2G) and third generation 3G networks including key developments in spectrum aspects. Review of the stake holders including Service Providers (SPs), product manufactures and regulatory bodies and interplay and context for MCN. Architecture of 4G networks from 3GPP and introduction to the physical layer and resource management. Key elements underpinning the network architecture including access stratum and non-access stratum, end to end security principles, network and UE procedures. Network design framework for call set-up/release, mobility management in idle mode and active mode (handover) and the dependency on the user experience. Introduction to network operations, management and support (BSS/OSS) including relevant use cases in diagnostics, life cycle of trouble shooting. Role of network planning and performance management and deployment of the networks for Quality of Support (QoS) and Quality of Experience (QoE). Network evolution towards Evolved Packet Core (EPC), Mobile Edge Computing (MEC) focus on architecture changes plus impact assessment. Overview of air interface upgrades, scalable air interface, Self Organising Networks (SON) and Heterogeneous Networks (HetNets). Wifi technology evolution to upcoming concepts pertaining to LTE in WiFi and introduction to candidate proposals in 5G [5].

TEXT BOOKS/REFERENCES:
5. Information from IEEE papers and various standardization bodies including IETF, ETSI, 3GPP, WiFi alliance and 5GPPP.

16WN625 RESEARCH LEARNING AND PROBLEM FORMULATION 0-0-1-1

Critical analysis of top rated research papers including at least one survey paper and one or two good journal paper in the broad areas such as Wireless Communication, Wireless Networks, Wireless Sensor Networks, Context Aware Systems, Participatory Sensing, Embedded Systems etc. Formulation and presentation of research proposals on selected topics.

16WN701 ADVANCED SIGNAL PROCESSING 3-0-0-3

Discrete-Time Bases and Filter Banks, Continuous-Time Bases and Wavelets, Over complete Expansions and Continuous Transforms, Sparse representation, Linear and non-linear approximation in various bases, Non-linear signal estimation, Multidimensional filter banks and wavelets, Multifractal analysis using Wavelets, Multiscale geometric representation
and processing, Compressed sensing, Multidimensional Transforms, Synthetic-aperture radar (SAR) Technology.

TEXT BOOKS/REFERENCES:

16WN702 DISTRIBUTED SYSTEMS 3-0-0-3


TEXT BOOKS/REFERENCES:

16WN703 WIRELESS LOCAL AREA NETWORKS 2-0-1-3

chipsets, 802.11 a/b/g PHY - Physical-Layer, Architecture, The Radio Link, FHSS, DSSS, OFDM, QAM, ERP; 802.11n : MIMO, Beam Forming, Channel Bonding, Block ACK, 802.11e QoS / WMM, 802.11s Mesh network, 802.11ac, 802.11ad, Performance Analysis, Mathematical Modeling and Analysis. Cryptography – Concepts : PRF/PRP, Stream / Block Cyphers, RC4, 3DES, AES, Hashing, Asymmetric key pairs, Certificates, WLAN Security : WEP, TKIP, AES-CCMP, RADIUS, TLS, TLS over EAP, Kerberos, LEAP, PEAP, EAP-SIM, Network & Security Architecture, Network Planning & Analysis. Advanced Topics: Long Range Wi-Fi, Li-Fi, Passive Wi-Fi, 802.11ah (HaLow), 802.11af (White-Fi), 802.11ax, 802.11ay Lab: WLAN Lab based on the above topics will be conducted using Wireless routers, APs, Wi-Fi enabled smart phones, tablets and laptops and Long Range Wi-Fi base stations and CPEs as well as using QualNet simulation platform.

TEXT BOOKS/REFERENCES:

16WN704 ADVANCED EMBEDDED SYSTEMS 2-0-1-3


TEXTBOOKS/REFERENCES:

Mobile OS: Android, iOS; Software Systems; Smartphone architecture and Software development.

TEXT BOOKS/ REFERENCES:

16WN706 SMART SENSOR TECHNOLOGY 2-0-1-3

General concepts and terminology of measurement systems, transducer classification - Variable resistance transducers, Inductive transducers, capacitive transducers, general input-output configuration, static and dynamic characteristics of a measurement system, Statistical analysis of measurement data. Standards and Calibration.

Smart materials and systems: Piezoelectric materials, Shape-memory materials, Electro-Rheological (ER) fluids, Magneto-Rheological (MR) fluids.

MEMS: Introduction, emergence, devices and application, scaling issues, materials for MEMS, Thin film deposition, lithography and etching, Bulk micro machining, surface micro machining and LIGA process.


Introduction to Nanotechnology, Nano sensors, Molecular Nanotechnology, CNT Types, synthesis and applications.


TEXT BOOKS/ REFERENCES:

16WN707 MACHINE LEARNING 2-0-1-3

Role of learning in intelligent behavior, general structure of a learning system; learning from example; concept learning, Introduction to machine learning and machine learning applications, Supervised learning, Bayesian decision theory, Parametric methods, multivariate methods, dimensionality reduction, Support Vector Machine, clustering, nonparametric methods, decision trees, linear discrimination, Sparse Linear models, multilayer Perceptrons, local models, hidden Markov models, assessing and comparing classification algorithms, combining multiple learners, and reinforcement learning.

TEXT BOOKS/REFERENCES:

16WN708 CODING AND INFORMATION THEORY 3-0-0-3


Discussion on Selected Journal Papers.

TEXT BOOKS/REFERENCES:

16WN709 WIRELESS MULTIMEDIA NETWORKS 2-0-1-3

Research paper reading - IEEE Transactions and journal papers by Mihaela van der Schaar.

Mathematical Modeling and Analysis.

TEXT BOOKS/REFERENCES:

16WN710 ANTENNA ENGINEERING: THEORY AND DESIGN 2-0-1-3

Introduction, Antenna Basics, Antenna Arrays: Two element arrays, Multiplication of patterns, Linear Array with n -isotropic point sources of equal amplitude and spacing (Broadside, End fire Arrays), EFA with Increased Directivity, Scanning Arrays, N element linear array and directivity, Binomial Arrays- Uniform spacing and Non-uniform Amplitude.


TEXT BOOKS/REFERENCES:

16WN711 DISTRIBUTED NETWORK ALGORITHMS 2013


TEXT BOOKS/REFERENCES:

16WN712 SECURITY IN WIRELESS NETWORKS 2013

systems-2G/3G/4G, Telecom system and infrastructure attacks, Mobile app and OS security, PAN Security, IoT, NFC.
Lab: Wireless Security Lab based on the above topics will be conducted using Network Analyzers and QualNet simulation platform.

TEXT BOOKS/REFERENCES:

16WN713  4G MOBILE BROADBAND AND SMALL CELL NETWORKS  2-0-1-3

LTE: Architecture, Frame structure, Bandwidth Concepts, Cell search and reference signals, Scheduling- Proportional fair Scheduling, Link Adaptation; Uplink Controlling, Downlink Controlling, Inter-cell Interference control; LTE performance verification.
Heterogeneous Networks: Seamless Service Provisions, Power Management, Concurrent Aggregation in Wireless Networks; CoBA, Network Information Flow, XOR.
Small cell networks: Macro, Micro, Pico, Femto cell design and Applications, Fundamentals of access control in femto cells, Multiple Antenna Techniques in small cell networks, Mobility and Interference Management in small cell networks, Throughput improvement using small cells, Channel Modeling for 4G, Mobility Management; Security.

TEXT BOOKS/REFERENCES:

16WN714  ADVANCED WIRELESS COMMUNICATION TECHNOLOGIES  2-0-1-3

Pre-requisite: Introduction to vectors, Norm, Energy, Power of vectors. Properties of matrices, Transposes, Dot products, Solving Linear Equations, Rank of the matrixes, Orthogonality, Determinant, Eigen values, eigen vectors, SVD.
Space-time processing: Beamforming, spatial, temporal, frequency diversity, antenna gain, spatial canceling of interference. Definition of diversity order; Spatial Channel modeling.
MIMO: Introduction to Wireless MIMO Communications- Types of MIMO systems- SISO, SIMO, MISO, MIMO, MIMO interference systems. Point to point MIMO system Model - Capacity, SISO AWGN model- Performance; SISO Fading Channel Model- Performance; Outage
capacity, ergodic capacity; Capacity analysis of - Single user MIMO System with Full CSIT, Partial CSIT and Long term CSIT; Capacity Analysis of MIMO Fading Channel with long term and Short term channel Knowledge; Space-time Block Coded MIMO System, STTD, Alamouti Coding, Dominant mode Beamforming, ML, V-BLAST, D-BLAST- Performance analysis. Algorithms for MIMO. Spectral efficiency, link budget, coverage gain with MIMO. Limitations and implementation issues.


TEXT BOOKS/REFERENCES:

16WN715 BIG DATA AND APPLICATIONS 3-0-0-3


TEXT BOOKS/REFERENCES:

16WN716 ADAPTIVE SIGNAL PROCESSING 2-0-1-3

Wiener filter, Kalman Filter, Least Mean Square(LMS) and variants, LMS via DFT, DCT, Recursive Least Square(RLS), Fast transversal and Fast Lattice RLS, Convergence and tracking performance of adaptive filters; Applications of ASP, Spectral estimation, System identification, Channel equalization.

TEXT BOOKS/ REFERENCES:

16WN717 CLOUD COMPUTING AND INTERNET OF THINGS 2-0-1-3

Cloud Computing: Infrastructure as a Service (IaaS) providers - Google Compute Engine, Amazon AWS, Microsoft Azure; Cloud Database providers - Google Cloud SQL, Microsoft Cloud SQL Database; Cloud Storage providers: Google Drive API, Google Cloud Storage, Azure Blob Storage Platform as a Service (PaaS) providers for Web Rapid Application Development (RAD) - Google App Engine; Distributed Storage providers: Google Cloud Datastore, Azure tables; Distributed Computing providers and frameworks: Google Cloud Dataflow, Apache Spark.

Internet of things: Internet of Things definitions and frameworks, Internet of Things application examples, Fundamental IoT mechanisms and key technologies, Evolving IoT standards, Layer 1/2 connectivity: wireless technologies for the IoT; Applications of IoT in Environmental monitoring and Smart grid, Cloud solutions providers for IoT - Google Weave.

Laboratory: Deploying an application using an IaaS provider, Deploying an application using a PaaS provider, Writing applications using SQL vs NoSQL cloud storage solutions, Writing an application for Distributed Computing environments (Google Dataflow).

TEXT BOOKS/REFERENCES:

16MA704 RANDOM PROCESS AND QUEUEING MODELS 3-0-0-3

Queuing Models: Characteristics of Queuing Systems, Steady state solution of M/M/1 and M/M/C queuing models with Finite and Infinite Capacities, Stationary behavior of M/G/1.

TEXT BOOKS/REFERENCES:

16MA705 LINEAR ALGEBRA AND ITS APPLICATIONS 2-0-1-3


TEXT BOOKS/ REFERENCES:

16WN718 DETECTION AND ESTIMATION THEORY 2-0-1-3


TEXT BOOKS/ REFERENCES:

16MA706 COMPUTATIONAL OPTIMIZATION 2-0-1-3

Introduction- mathematical optimization, least-squares and linear programming, convex and nonlinear optimization, Convex sets, Steepest Descent, Newton's Method, Linear optimization,
Quadratic optimization, Generalized inequality constraints, Integer programming, Combinatorial optimization, Dynamic programming, Genetic Algorithms for optimization


TEXBOOKS/REFERENCES:

16MA707 GRAPH THEORY AND ITS APPLICATIONS IN WIRELESS NETWORKS 2-0-1-3

Graph Theory: An Introduction to Graph theory, Definition and examples, Subgraph, Complements and Graph Isomorphism, Vertex Degree: Euler Trials and Circuits, Planar Graphs, Hamilton Paths and Cycles, Probabilistic graph, Social Graphs, Applications in Social Networks, Graph Coloring and Chromatic Polynomials, Digraph, Dijkstra’s Shortest-Path Algorithm, maximal matching- perfect matching – k-factor graphs.


Algorithms and Applications: Shortest and longest path algorithm, Minimal and Maximal spanning tree algorithms, maximal matching algorithms, Coloring algorithms, Graph Partitioning algorithm.

Research Paper Discussion and Presentation on applied graph theory in wireless networks.

TEXT BOOKS/REFERENCES:

16WN797 LIVE-IN-LABS 0-0-1-1

AMRITA University has established live-in-labs at 100+ locations, mostly in rural areas spread across the length and breadth of India. Live-in-Labs© is an opportunity for students to live in a village environment so they can study problems first-hand in water, health, education, etc. and work together to devise solutions. Live-In-Labs will provide an experiential learning opportunity where each student can come and spend for 2 weeks to a semester in one of the live in labs based
on the area. They will become part of the interdisciplinary team of students and faculty drawn from across the disciplines from all participating universities. The live-in-labs have varied focus areas such as energy, water, healthcare, education, waste management, ICT for billion, skill building etc. During this process the students will share village life and observe and understand problems encompassing health and hygiene, energy, water, waste, environment, etc., touching the villagers’ lives, and define projects that seek to address these problems, devise solutions, implement, test and eventually demonstrate innovative solutions. One definitive achievement is that they will receive a deeper understanding of challenges faced by emerging developing countries. This gives the wonderful opportunity since emerging countries have the largest opportunity for new ideas, innovative solutions etc.