Draft Syllabus for Ph.D Entrance Examination

Amrita Center for Wireless Networks & Applications

Wireless Communication

Overview of Wireless Communications: Introduction to Wireless Communication Systems.
Transmission Fundamentals: Signals, Types and Properties of Signals, Frequency bands and its properties, Noise and Interference.
Modulation: AM Techniques, DM Techniques: An Overview, Linear and constant envelope Modulation Techniques and its combination, Spread Spectrum Modulation Techniques: DSSS and FHSS.
Introduction to Radio Wave Propagation, Types of propagation modes; Free Space Propagation Model, Propagation Mechanisms: Reflection, Diffraction, Scattering; Path Loss Models: Outdoor and Indoor Propagation Models, Signal Penetration into Buildings, Ray Tracing and Site Specific Modeling. Time and frequency coherence: Doppler spread and coherence time, Delay spread and coherence bandwidth.
Capacity of wireless channel, fading channels, Multiplexing: FDM, OFDM, TDM. Multiple Access Techniques: FDMA, TDMA, CDMA, OFDMA and SDMA. Cellular Networks: Basic Concepts. Wireless Link Improvement: Introduction to types of codes, Equalization Techniques, Diversity methods.

Foundations for Signal Processing

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 of DSP Systems: Quantization , Quantization Process, Oversampling and Noise Shaping, D/A Converters, A/D Converters, Analog and Digital Dither— Discrete-Time Systems: Input/Output Rules, Linearity and Time Invariance, Impulse Response, FIR and IIR Filters, Causality and Stability — FIR Filtering and Convolution: Block Processing Methods Sample Processing Methods, FIR Filtering in Direct Form— z-Transforms: Region of Convergence, Causality and Stability, Frequency Spectrum, Inverse z-Transforms—-Transfer Functions : Sinusoidal Response, Steady-State Response, Transient Response, Pole/Zero Designs, First-Order Filters, Parametric Resonators and Equalizers, Notch and Comb Filters, Deconvolution, Inverse Filters, and Stability — Signal Processing Applications---DFT/FFT Algorithms—Design of FIR filters — Using windows — Frequency sampling — Linear phase FIR filters. IIR Filters: Structure for IIR — State Space Analysis —Impulse invariance — Bilinear transformation Weiner filters.

Advanced Computer Programming

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.

Computer Networks

Communication model, Data Communication, Synchronous and asynchronous communication, Network protocols and standards, Network devices, Network servers, OSI model — TCP/IP protocol Suit — Comparison of OSI and TCP/IP. Data transmission: analog and digital transmission, Multiplexing, Physical and logical topologies — Transmission media. Data link layer- Frames and Error detection, LAN technologies and network topology hardware addressing and Frame type identification, LAN wiring and interface hardware, Extending LANs, Introduction to Wireless Networks — Wireless LAN technology, Standards-Infrared LANs, Spread Spectrum — DSSS, FHSS, Narrow band, Network layer — Intenet Addresses, ARP, RARP, IP, Routing algorithm — Interior and Exterior routing. ICMP, Classless and Subnet Address Extensions (CIDR), Internet Multicasting, NAT, VPN — Addressing and Routing, VPN with private address, Internet Security and Firewall design, ACLIN6 — the new version of IP. IP Telephony VolP — Basics- IP telephone system-protocols and layering-H.323 characteristics and layering, SIP. Transport layer services and principles — Principles of congestion control. Socket Introduction-address structures-Value-Result Arguments, Byte Ordering function, Byte manipulation functions. Elementary TCP sockets. TCP Client/ Server Model of Interaction and examples. Denial-of-service (DOS) attacks; Impact of wireless technology on transport protocols. Application layer protocols — World Wide Web: HTTP — File transfer: FTP — Electronic Mail — DNS — SNMP. Concept of cryptography, Symmetric key algorithms, Public key algorithms — RSA, Digital Signatures; E-mail and Web Security; WAN Technologies. Lab: Implementation of algorithms from the WN604 Advanced Computer Networks course, Socket Programming using C. Network packet tracing using packet level tracer. Network traffic analysis and hands on experimentation on switches and routers. Mathematical modeling and research analysis.

Design and Analysis of Algorithms

Algorithm Analysis-Methodologies for Analyzing Algorithms, Asymptotic Notation, Recurrence relations, Review of mathematical concepts and basic Data Structures-Stacks and Queues, Lists and Sequences, Trees, Priority Queues and Heaps ,Dictionaries and Hash Tables. Data Structures for Union-Find.

Search Trees-Ordered Dictionaries and binary Search Trees, AVL trees, Red black trees, B-trees, Sorting, Sets and Selection-Merge sort, Quick-Sort, A lower Bound on Comparison Based Sorting, Bucket Sort and Radix Sort, Comparison of sorting algorithms.

Fundamental Techniques-The Greedy Method, Divide and Conquer, Dynamic Programming, Simple String Matching Algorithms, Graphs-Graph traversals and applications- Biconnected components, strong components, Single Source Shortest Paths, All pairs Shortest Paths, Minimum Spanning Trees, Network Flow and Matching , Flows and Cuts.

NP-Completeness-:- P and NP, NP-completeness, Important NP-Complete Problems. Mesh Algorithms.

Antenna Theory and Design

Block diagram of pulse radar. Radar equation. Signal-to-noise ratio, probability density function and range, ambiguities, radar cross-section of target, target models, PRF, system losses.

CW and frequency-modulated radar Doppler effect, CW radar, FMCW radar. MTI and pulse Doppler radar-delay line cancellers and characteristics, blind speeds, douplet cancellation. MTI radars with power amplifier and power oscillators, transmitters. MTI from moving platform, pulse Doppler radars. Tracking radars. Tracking techniques-sequential lobing, conical scan monopulse. Tracking in range, acquisition. Tracking performance. Electronic scanning radar system, beam forming and steering methods, fire controlled radar. SAR. Radar transmitters, magnetron oscillators, hard tube and line-type pulser. Radar receivers, mixer amplifier, receiver noise, duplexers, displays, clutters, weather and interferences, system engineering and design. Pulse compression radar.

Fundamentals of radiation mechanism, vector potentials, radiation from current elements, radiation pattern, superposition and reciprocity theorems.

Small antennas, images, small antenna above ground, different types of linear arrays, multiplication of patterns, binomial arrays, antenna gain, effective area, antenna impedance, beam width, self and mutual impedance, folded dipole, Yaginda antennas. Mathematical theories of antennas, aperture antennas, slot antennas, cavity back slot antennas, horn antennas, waveguide radiator, parabolic reflectors, Cassegrain antennas. Broad band antennas, microstrip antennas, noise consideration, antenna measurements.

Wireless Sensor Networks

Overview of WSN: Introduction, Applications, Unique Constraints and challenges. General Architecture of a WSN: Von Neumann, Harvard Architecture, Super Harvard Architectures, Sensing Unit: ADC, Sampling, Quantization, Sensor Characteristics, Transducers, Impedance Matching. Processing Unit: Microcontrollers, DSP, ASIC, FPGA, General Constraints and Pros and Cons. Communication Unit: SPI, I2C. Power Management Unit.

Networking in WSN: Hierarchical, Non hierarchical, Clustering, Mutli hop, Single hop, Multiple Sinks and Sources. Coverage and Connectivity. Self Organization, Self configuration. MAC Protocols- Introduction, Low Duty cycle Protocols: SMAC, Contention Based Protocols: CSMA, PAMAS, Scheduling based Protocols: Leach, SMACS, TRAMA. Data Aggregation. Time synchronization: Types, RBS, LTS, HRTS. Routing: Proactive routing: DSDV, Optimized Link State Routing, DSR and Reactive routing: Flooding, Gossiping, Hierarchical Routing, Location based routing – Unicast, Multicast. Localization and Positioning: Overview, TOA, TDOA, AOA, RSSI, Range based Localization: Triangulation, Trilateration-Iterative and collaborative Multilateration, GPS based localization, Range free localization: APS, Event Driven Localization – Light House approach, Multi Sequence Positioning.

Embedded Systems

Overview of OS Fundamentals: Discussion & Implementation of minix operating systems. Embedded System: Introduction Embedded System- components-Embedded Processors-Bus snooping, MESI protocol, shared memory, Bank switching, Memory overlays-Basic peripherals, Interrupts and exceptions- Interrupt sources, Recognizing an interrupt, Interrupt Mechanisms, Interrupt Latency, Shared data problem, PIC Micro controller And Interrupting: CPU Architecture, registers, instruction sets addressing modes, timers, Interrupts Interrupt timing, I/O Expansion, I2C Bus Operation Serial EEPROM, Analog to digital converter,

UART-Baud Rate-Data Handling-Initialization, Special features — serial Programming-Parallel Slave Port Applications. Embedded microcomputer Systems: Motorola MC68H11 Family Architecture Registers, Addressing modes. Interfacing methods parallel I/O interface, Parallel port interface, Memory Interfacing, High speed I/O Interfacing Interrupts- interrupt service routine-features of interrupts-interrupt vector and Priority, timing generation and measurements, Serial I/O devices RS232, RS485, Analog Interfacing, Applications. Real Time Operating Systems: Introduction to OS-Multitasking OS-Scheduler Algorithms, Priority inversion, Tasks, Threads and processes, Exceptions-Memory model-Memory management address translation, Commercial operating systems-basic design Using RTOS.

Mobile Communication Networks

3G: Overview, UMTS: WCDMA, spreading scrabling and modulation, Overview of 3GPP; Mobile IP: IPv4, IPV6, Agent discovery, Registration, Tunneling and Encapsulation, Reverse Tunneling, packet Delivery. Mobile AdHoc Networks: Routing- LAR, GEDIR, Partition Detection – TORA, Link Reversal Algorithm. Opportunistic Routing: MORE, MIXIT MaNET: MAC and Transport Issues – Challenges: Hidden node problem. LTE – Architecture, Frame structure, Bandwidth Concepts, Uplink, Downlink, Intercell Interference control, Scheduling: Proportional fair Scheduling, Link Adaptation. Heterogeneous Networks:Seamless Service Provisions, Power Management, Concurrent Aggregation in Wireless Networks: CoBA, Network Information Flow, XOR. WiMAX: Introduction, Overview of Physical Layer, MAC- Layer, Mobility Management. Multi-Hop Wireless Mesh Networks. 4G:Protocol Boosters, Channel Modeling: Macro, Micro, Pico, Femto cell, Adaptive and reconfigurable Link Layer, Adaptive MAC, Adaptive Network layer, Adaptive TCP layer.

Machine Learning

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