School of Computer Science and Engineering Department of Computer Science & Engineering M.Tech Syllabus– 2025 Onwards

Syllabus (M.Tech. CSE)

CSE6101: Computational Mathematics [4 0 0 4]

Linear Algebra Refresher: Vector spaces, basis, and dimension, Eigenvalues, eigenvectors, SVD, Matrix norms and conditioning, Application: PCA and dimensionality reduction; Numerical Computation: Root finding: Bisection, Newton-Raphson, Interpolation and curve fitting: Lagrange, Spline, Numerical differentiation and integration, Error analysis and convergence; Probability and Statistics: Random variables, probability distributions (Discrete and Continuous), Expectation, variance, covariance, Central limit theorem, Law of large numbers, Estimation, confidence intervals, hypothesis testing; Stochastic Processes & MCMC: Markov Chains, Bayesian inference, Monte Carlo and Markov Chain Monte Carlo methods, Applications: Sampling, Bayesian Networks, Probabilistic Inference; Optimization Techniques and Models, Numerical liner algebra, Ordinary Differential Equations and Applications. Model verification: timed automata and hybrid machines.

References:

1. G. Strang, Linear Algebra and Learning from Data, (1e), Wellesley, MA: Wellesley-Cambridge Press, 2019.

2. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, (3e), Providence, RI: American Mathematical Society, 2009.

3. S. C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, (4e), New York, NY: McGraw Hill Education, 2017.

CSE6102: Advanced Data Structures and Algorithms [3 0 2 4]

Algorithm Foundations: asymptotic notations, recurrence solutions, and amortized complexity; Parallel Algorithms: parallel addition, quicksort, selection, search (K-ary), and energy complexity analysis; Graph Algorithms: parallel approaches for connected components and maximum independent set; Advanced Data Structures: van Emde Boas Trees, Bloom filters, and Count-Min sketch; Network Flow: flow networks, augmenting paths, Ford-Fulkerson, Edmonds-Karp, push-relabel, max-flow min-cut, bipartite matching; Randomized Algorithms: Las Vegas, Monte Carlo methods, linearity of expectation, Chernoff bounds, min-cut and skip lists; Online Algorithms: scheduling, online matching, Steiner tree, and multiplicative weights; NP-Completeness: P, NP, NP-Complete, reductions, SAT, Cook's

Theorem; Approximation Algorithms: TSP (Christofides), Set Cover, PTAS, FPTAS, and LP-based approaches.

References:

1. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, (2e), Athena Scientific, July 2008.

2. M. Mitzenmacher and E. Upfal, Probability and Compuitng: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press, 2017.

3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Introduction to Algorithms, (3e), MIT Press, 2009.

4. Michael T. Goodrich and Roberto Tamassia, Algorithm Design and Applications, (1e), Wiley, 2015.

CSE6103: Artificial Intelligence [3 0 2 4]

Evolution of AI: symbolic, sub-symbolic, neuro-symbolic; Intelligent agents: PEAS, rationality, architectures; Advanced problem solving and planning: STRIPS, GraphPlan, HTN, theorem proving; knowledge representation and reasoning: propositional and first-order logic, ontologies OWL, RDF, and expert systems; Probabilistic AI: feature Bayesian and Markov networks, inference techniques, EM algorithm, and statistical relational learning; Decision-making and learning: MDPs, POMDPs; RL methods: Q-learning, DQN, Actor-Critic, with applications in robotics; Language and vision: NLP fundamentals, transformers, LLMs (e.g., GPT-4), and computer vision tasks; cognitive and multi-agent systems: BDI models, collaboration strategies; Ethics and responsible AI: fairness, explainability (LIME, SHAP), governance, and AI alignment.

References:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, (4e), Pearson, 2021

2. Kevin Knight, Elaine Rich, and Shivashankar B. Nair, Artificial Intelligence, (3e), McGraw Hill Publication, 2012.

3. John R. Searle and Matthias Scheutz, The Philosophy of Artificial Intelligence, (1e), Oxford University Press, 2020.

CSE6104 : Research Methodologies [4 0 0 4]

Introduction to Research: Meaning and Concepts, Types of Research, Process of Research, Classification of Variables, Review of Literature, Formulating Research Problem & determining research objectives, Ethics in Research, Limitations in Research. Research Repositories; Research Design: Meaning & concept of research design, Types of Research Design, Need for

research design, Features of a Good research Design, Developing a Research Plan; Data Collection: Types of Data, Primary and Secondary Data, Benefits and Drawbacks, Various methods of Data Collection, Measurement Scales – Classification of Scales, Measurement error, Criteria for Good Measurement; Data Analysis: Statistical Analysis, Multivariate Analysis, Correlation Analysis; Regression Analysis, Principle Component Analysis, Samplings; Hypothesis Formulation and Testing: Hypothesis, Important Terms, Types of Research Hypothesis, Hypothesis Testing, Z-Test, t-Test, f-Test, Making a Decision; Types of Errors, ROC Graphics; Test Procedures: Parametric and Non-Parametric Tests, ANOVA; Mann-Whitney Test, Kruskal-Wallis Test, Chi-Square Test, Multi-Variate Analysis; Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Types of Reports, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Oral Presentation, Thesis writing, research paper writing, preparing synopsis & summary of research thesis work; Publishing research papers, reference writing: foot note, Various electronic tools for citation and referencing, in-text citation, bibliography, citation styles, Bibliometrics.

References:

1. Kothari, C. R., Research methodology: Methods and techniques (4e). New Age International Publishers, 2019.

2. Bordens, K. S., & Abbitt, B. B., Research design & methods: A process approach (8e). McGraw Hill, 2011.

3. Chawla, D., & Sondhi, N., Research methodology: Concepts and cases. Vikas Publishing House, 2011.

4. Cooper, D., & Schindler, P., Business research methods. McGraw Hill, 2014.

5. Bryman, A., & Bell, E., Business research methods (3e). Oxford University Press, 2011.

6. William, G., Business research methods (8e). Cengage Learning, 2016.

CSE6140: Applied Cryptography [4 0 0 4]

Mathematical Foundations: Modular arithmetic, Number theory, Euler's theorem, Fermat's theorem, Chinese Remainder Theorem, Finite fields; Symmetric Key Cryptography: Block ciphers (DES, AES), Modes of operation, Key distribution and management; Asymmetric Key Cryptography: RSA, ElGamal encryption, Diffie-Hellman key exchange, Elliptic curve cryptography; Hash Functions and Message Authentication: Cryptographic hash functions (MD5, SHA-1, SHA-2, SHA-3), properties of hash functions, message authentication codes (HMAC, CMAC), digital signature algorithms (DSA, ECDSA); Real-World Cryptographic Deployments: TLS 1.3 protocol, Signal secure messaging protocol, Bluetooth security features, AWS key management practices; Lattice-Based Cryptography: Lattice theory basics, Shortest Vector Problem (SVP), Learning with Errors (LWE), Short Integer Solution (SIS), Module-LWE,

Module-SIS problems; Post-Quantum Cryptography: Kyber (ML-KEM), Dilithium (ML-DSA), FIPS 203, FIPS 204, performance and implementation considerations.

Reference Books:

1. J. Katz and Y. Lindell, Introduction to Modern Cryptography, (3e), Boca Raton, FL: CRC Press, 2020.

2. C. Peikert, A Decade of Lattice Cryptography, Foundations and Trends in Theoretical Computer Science, 2016.

3. N. Ferguson, B. Schneier, and T. Kohno, Cryptography Engineering: Design Principles and Practical Applications, Hoboken, NJ: Wiley, 2010.

4. C. Paar and J. Pelzl, Understanding Cryptography: A Textbook for Students and Practitioners, (1e), Berlin, Germany: Springer, 2010.

5. D. J. Bernstein, J. Buchmann, and E. Dahmen (Eds.), Post-Quantum Cryptography, Berlin, Germany: Springer, 2009.

6. Bruce Schneier, Applied Cryptography: Protocols, Algorithms, and Source Code in C, (2e), Hoboken, NJ: Wiley, 2015.

7. Alfred J. Menezes, Paul C. van Oorschot, and Scott A. Vanstone, Handbook of Applied Cryptography, (5e), Boca Raton, FL: CRC Press, 2018.

CSE6141: Machine Learning [4 0 0 4]

Mathematical Foundations: optimization, information theory, generalization bounds; Learning Theory & Regularization: PAC learning, VC-dimension, Elastic Net, SCAD, model pruning), Supervised Learning: kernel methods, Gaussian processes, transfer/meta/few-shot learning, model calibration; Deep Learning: CNNs, RNNs, Transformers, AdamW, DropConnect, distributed/mixed-precision training; Generative Models: VAEs, GANs, Diffusion Models, FID, IS; Reinforcement Learning: PPO, DDPG, Actor-Critic, multi-agent RL, robotics/gaming applications; Modern Topics: LLMs, RAG, CLIP, Flamingo, federated learning, XAI, AI fairness; Research & Deployment: reproducibility, ablation studies, ONNX, TensorRT, real-world use cases in healthcare, FinTech, NLP.

References:

1. Tom Mitchell, Machine Learning, (1e), McGraw Hill Publication, 2017.

2. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, (2e), MIT Press, 2012.

3. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, (1e), MIT Press, 2016.

CSE6150: Cybersecurity Tools & Cyberattacks [4 0 0 4]

Introduction to Cybersecurity and Threat Landscape: Cybersecurity basics and CIA triad; Threat actors and motivations; Types of attacks: DDoS, phishing, ransomware, SQL injection, XSS, malware, APT; Cyber kill chain and attack lifecycle; High-profile cyberattacks and case studies; Operating System and Network Vulnerabilities: OS-level vulnerabilities: privilege escalation, file inclusion; Network threats: sniffing, spoofing, MITM attacks; Firewalls, IDS/IPS, honeypots; Vulnerability assessment & exploitation basics; Cybersecurity Tools and Techniques: Vulnerability scanning and management; Network monitoring and packet inspection; Log analysis and SIEM basics; Antivirus & malware sandboxing; Security auditing and hardening; Penetration Testing & Ethical Hacking: Penetration testing methodology (Recon, Scanning, Gaining Access, Maintaining Access, Reporting); Web application security; Social engineering attacks; Wireless and mobile security; Mitigation Strategies and Security Best Practices: Secure system configuration and hardening; Patch management and zero-day response; Security policies and governance; Incident response and digital forensics; Legal and ethical aspects of cybersecurity.

References:

1. W. Stallings, Network Security Essentials: Applications and Standards, (6e), Pearson, 2016.

2. C. Easttom, Computer Security Fundamentals, (4e), Pearson, 2018.

3. J. Erickson, Hacking: The Art of Exploitation, (2e), No Starch Press, 2008.

4. G. Weidman, Penetration Testing: A Hands-On Introduction to Hacking, (2e), No Starch Press, 2014.

5. NIST, Cybersecurity Framework, National Institute of Standards and Technology, 2018. [Online]. Available: https://www.nist.gov/cyberframework

6. CIS, CIS Controls, Center for Internet Security, 2023. [Online]. Available: https://www.cisecurity.org/controls/

CSE6151: Computer Vision [4 0 0 4]

Introduction: Overview of computer vision and its applications; Image Formation: Geometric primitives and transformations; photometric image formation and the digital camera; Image Processing: Point operators, linear filtering, non-linear filtering, Fourier transforms, pyramids and wavelets, and geometric transformations; Model Fitting and Optimization: Scattered data interpolation, variational methods and regularization, and Markov random fields; Deep Learning: Supervised learning, unsupervised learning, deep neural networks, convolutional

networks and more complex models; Recognition: Instance recognition, image classification, object detection, semantic segmentation, video understanding and vision and language; Feature Detection and Matching: Points and patches, edges and contours, contour tracking, lines and vanishing points, segmentation; Image Alignment and Stitching: Pairwise alignment, image stitching, global alignment and compositing; Motion Estimation: Translational alignment, parametric motion, optical flow and layered motion; Depth Estimation: Epipolar geometry, sparse correspondence, dense correspondence, local methods, global optimization, deep neural networks for depth estimation and multi-view stereo and monocular depth estimation; Applications and Case Studies: Autonomous vehicles, medical image analysis, surveillance systems, augmented and virtual reality, and industrial automation.

References:

1. Richard Szeliski, Computer Vision: Algorithms and Applications, (2e), Springer, 2022.

2. David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, (2e), Pearson, 2011.

3. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, (2e), Cambridge University Press, 2004.

CSE6201: Advanced Database Management Systems [3 0 2 4]

Advanced Relational Database Design: Functional Dependencies & Normal Forms (BCNF, 4NF, 5NF), Multivalued & Join Dependencies, Relational Decomposition and Lossless Joins, Dependency Preservation; Query Optimization: Query Processing and Optimization Techniques, Cost-Based Optimization, Heuristics in Query Optimization, Use of Indexes and Joins Optimization, Query Execution Plans; Distributed and Parallel Databases: Distributed DBMS Architecture, Fragmentation, Replication, and Allocation, Distributed Query Processing, Distributed Transactions and Commit Protocols (2PC, 3PC), Parallel Database Architectures and Query Execution, NoSQL and New Data Models: Limitations of Relational Model; Key-Value Stores, Document Stores, Column-Family Stores, Graph Databases, CAP Theorem, NoSQL Query Languages; Case Studies: MongoDB / Cassandra / Neo4j; Big Data and Cloud Databases: Big Data Characteristics, Hadoop Ecosystem Overview, HDFS, MapReduce, Cloud Data Management, Database-as-a-Service (DBaaS): Amazon RDS / Google Cloud Spanner; Advanced Topics and Research Trends: Data Warehousing and OLAP, Temporal and Spatial Databases, Data Streams and Real-Time Analytics, Semantic Web and RDF Stores, Introduction to GraphQL and NewSQL, Privacy, Security, and Ethics in Data Management.

References:

1. Silberschatz, H. F. Korth, and S. Sudarshan, Database System Concepts, (7e), McGraw Hill Publication, 2019.

2. M. T. Özsu and P. Valduriez, Principles of Distributed Database Systems, (3e), Boston, MA: Springer, 2015.

3. P. J. Sadalage and M. Fowler, NoSQL Distilled, (1e), Boston, MA: Addison-Wesley, 2012.

CSE6202: Advanced Programming Paradigm [3 0 2 4]

Hash tables: Consistent hashing, Locality-sensitive hashing, Bloom filters, Cuckoo hashing; Data structures for combinatorial optimization: Fibonacci heaps, dynamic graph structures; Search trees; Skip lists; Self-adjusting data structures: Splay Trees, Tries and suffix trees, Geometric data structures; Implementation of HITS and Page Rank algorithms; Implement the online advertisement problem as a bipartite matching problem; Message Passing Interface (MPI): Basics of MPI, Communication between MPI processes, Basics of OpenMP API, Sharing of work among threads using loop constructs in OpenMP.

Reference Books:

1. T. Roughgarden, CS261: A Second Course in Algorithms, Stanford University, 2016; and Randomized Algorithms: COMS 4995, Columbia University, 2019.

2. T. Roughgarden, CS168: The Modern Algorithmic Toolbox, Stanford University, Spring 2017.

3. R. Motwani, CS361A: Advanced Data Structures and Algorithms, Stanford University, Autumn Quarter 2005–06.

4. Stanford University, CS166: Data Structures, 2016–2021. Available: https://web.stanford.edu/class/cs166/.

CSE6203: Advanced Computer Networks [3 0 2 4]

Introduction: Error control, flow control and traffic management system in computer networks; Flow Control: classification, open-loop flow control, closed loop flow control, and hybrid flow control; Traffic Management: Traffic Models, Traffic Classes, Time Scales of Traffic Management, Scheduling, Renegotiation, Signalling, Admission Control, Peak-Load Pricing and Capacity Planning, Differentiated Service, Quality of Service, Traffic Polishing, Traffic Shaping; Mathematics for Computer network: Stochastic Processes and Queueing Theory, Stochastic Processes, Continuous-time Markov Chains, Birth-death processes; The M/M/1 queue and its variations; M/D/1 : deterministic service times, G/G/1 and network of queues; Network Softwarization: Software Defined Networking (SDN) - Deep Dive (Northbound and Southbound interface), Deep Dive (Network topologies; Container Network Interfaces), Working with Mininet; Data Center Networking: Network Function Virtualization (NFV) -

Architecture and Concepts, Programmable Networks - Introduction to P4, SmartNICS and P4 switches, Content Distribution on the Internet, Architectures for Information Centric Networking.

References:

1. S. Keshav, An Engineering Approach to Computer Networking: ATM Networks, the Internet, and the Telephone Network, (1e), Boston, MA: Addison-Wesley, 1997.

2. S. Keshav, Mathematical Foundations of Computer Networking, (1e), Boston, MA: Addison-Wesley, 2012.

3. H. J. Chao and B. Liu, High Performance Switches and Routers, (1e), Hoboken, NJ: Wiley-IEEE Press, 2007.

4. G. M. de Brito, P. B. Velloso, and I. M. Moraes, Information-Centric Networks: A New Paradigm for the Internet, (1e), Hoboken, NJ: Wiley-ISTE, 2013.

5. B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran, and C. Tschudin, Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology, RFC 8793, June 2020.

6. L. Peterson, B. Davie, T. Vachuska, M. Cascone, and A. O'Connor, Software-Defined Networks: A Systems Approach, (Online Edition), 2020.

7. G. Lee, Cloud Networking: Understanding Cloud-Based Data Center Networks, (1e), Waltham, MA: Morgan Kaufmann, 2014.

CSE6240: Digital Forensics [4 0 0 4]

Introduction to Digital Forensics: Cybercrimes, Overview of hardware and operating systems, types of digital evidence, Logical structure of storage media/devices, Branches of Digital Forensics, Phases of Digital forensics, Seizure, Chain of custody, Various File Systems, Type of Acquisition live vs standalone machine, memory volatility and precautions, Hidden/deleted Data recovery HPA, DCO, Computer forensics tools; Network Forensics: Cyber-attacks on network, network-based digital evidence, Acquisition, live acquisitions, Traffic Analysis, wireless network forensics, Event log analysis, Intrusion detection, Reconstructing web browsing, email investigation, Network forensics tools; Mobile Forensics: Different OS and Memory in Mobile phones, collecting evidence, preservation methods, interpretation of digital evidence on mobile networks, Mobile Forensics Tools; IoT Forensics: Analyzing evidence from IoT devices and smart systems, Forensic Toolkit for IoT, Cellebrite IoT Module; IoT-Analyzer; Cyber Laws and Ethics: Indian IT Act, Intellectual property right, Criminal Justice system for forensics, Audit/investigative, Investigative procedures/standards for extraction, preservation, and deposition of legal evidence in a court of law; challenges in court of law.

References:

1. B. Nelson, A. Phillips, and C. Steuart, Guide to Computer Forensics and Investigations, (6e), Boston, MA: Cengage Learning, 2018.

2. S. H. Davidoff and J. Ham, Network Forensics: Tracking Hackers Through Cyberspace, (1e), Indianapolis, IN: Prentice Hall, 2012.

3. R. Montasari, H. Jahankhani, R. Hill, and S. Parkinson, Digital Forensic Investigation of Internet of Things (IoT) Devices, (1e), Cham, Switzerland: Springer, 2020.

4. K. Barmpatsalou, T. Cruz, E. Monteiro, and P. Simoes, Mobile Device Forensics: A Practitioner's Guide to iOS and Android Investigations, (1e), Hoboken, NJ: Wiley, 2022.

5. P. Duggal, Cyber Law: An Exhaustive Section-Wise Commentary on the Information Technology Act Along With Rules, Regulations, Policies, Notifications, etc., (1e), Nagpur, India: Wadhwa Book Company, 2023.

CSE6241: Reinforcement Learning [4 0 0 4]

Introduction: Introduction to Machine Learning and its various types, Motivation and Introduction to Reinforcement Learning, Multi arm Bandits, Markov Decision Process, Value functions; Dynamic programming: Policy evaluation and improvement, Value iteration and Policy iteration algorithms; Tabular RL & Model-Free Prediction & Control: Dynamic Programming (DP) Methods: Policy Evaluation and Improvement, Value Iteration and Policy Iteration Algorithms, Monte Carlo (MC) Methods: Prediction and Estimation of Action Values; Temporal Difference (TD) Learning: TD(0), SARSA, Q-Learning; Off-Policy Learning: Importance Sampling; Convergence Guarantees; Function Approximation and Deep Reinforcement Learning: Value Function Approximation, Linear and Non-linear Methods, Deep Q-Networks (DQN) and Variants, Policy Gradient Methods: REINFORCE, Actor-Critic, PPO, DDPG; Model-Based vs. Model-Free RL; Advanced Reinforcement Learning: Imitation Learning, Behavioral Cloning, Inverse RL, Generative Adversarial Imitation Learning (GAIL), Meta-Learning in RL, Fast Adaptation, Model-Agnostic Meta-Learning (MAML); Multi-Agent RL (MARL): Cooperative/Competitive Settings; Partially Observable Environments (Dec-POMDPs); Batch and Offline RL: Challenges and Solutions; Applications and Emerging Trends Real-World Applications: Game Playing; Robotics; Autonomous Systems; Neural Architecture Search (NAS) using RL; Ethical and Safety Considerations.

References:

1. R. S. Sutton and A. G. Barto, Reinforcement Learning: An Introduction, (2e), Cambridge, MA: MIT Press, 2018.

2. C. Szepesvári, Algorithms for Reinforcement Learning, (1e), San Rafael, CA: Morgan & Claypool, 2010.

3. Z. Xiao, Reinforcement Learning: Theory and Python Implementation, (1e), Singapore: Springer, 2024.

4. S. E. Li, Reinforcement Learning for Sequential Decision and Optimal Control, (1e), Singapore: Springer, 2024.

CSE6250: Blockchain Technology [4 0 0 4]

Introduction to Blockchain Technology: Overview of Blockchain, History and Evolution, Features of Blockchain, Types of Blockchain (Public, Private, Consortium); Blockchain Architecture and Components: Blocks, Transactions, Hash Functions, Merkle Trees, Distributed Ledger Technology (DLT), P2P Networks; Consensus Mechanisms: Proof of Work (PoW), Proof of Stake (PoS), Delegated PoS; Practical Byzantine Fault Tolerance (PBFT), Comparison of Mechanisms; Cryptography in Blockchain: Hashing; Digital Signatures, Public Key Infrastructure (PKI), Wallets and Addresses, Security and Privacy; Smart Contracts and Ethereum: Introduction to Ethereum, Solidity Programming Basics, Writing and Deploying Smart Contracts, Gas and Transactions, Tools like Remix, Ganache, MetaMask; Blockchain Applications: Use Cases in Banking, Healthcare, Supply Chain; Government, Voting Systems, NFTs and Metaverse Basics; Challenges and Future Trends: Scalability, Interoperability, Energy Consumption; Legal and Regulatory Issues, Blockchain beyond Cryptocurrency.

References:

1. Melanie M. Swan, Blockchain: Blueprint for a New Economy, (1e), Sebastopol, CA: O'Reilly Media, 2015.

2. M. Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, (2e), Sebastopol, CA: O'Reilly Media, 2017.

3. Bashir, Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained, (3e), Birmingham, UK: Packt Publishing, 2020.

4. R. Wattenhofer, The Science of the Blockchain, (1e), Zurich, Switzerland: Distributed Computing Group, ETH Zurich, 2016.

5. Narayanan, J. Bonneau, E. Felten, A. Miller, and S. Goldfeder, Bitcoin and Cryptocurrency Technologies: Comprehensive Introduction, (1e), Princeton, NJ: Princeton University Press, 2016.

CSE6251: Generative AI [4 0 0 4]

Introduction to Generative AI: Overview, history, and foundational concepts; Generative Adversarial Networks (GANs): architectures, training strategies, conditional GANs; Variational Autoencoders (VAEs): theory, implementation, and variations; Diffusion Models and Flow-based Generative Models; Applications in Natural Language Processing: transformer-based models, GPT series; Image Generation: StyleGAN, DALL-E; Audio and Video Generation; Evaluation Metrics for generative models: inception score, FID, precision-recall curves; Ethical considerations and societal impact of generative AI, responsible AI practices.

References:

1. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, (1e), Cambridge, MA: MIT Press, 2016.

2. D. Foster, Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play, (2e), Sebastopol, CA: O'Reilly Media, 2022.

3. F. Chollet, Deep Learning with Python, (2e), Shelter Island, NY: Manning Publications, 2021.

4. L. Weng, Generative Models, OpenAI Technical Report and Blogs, 2018. Available: https://lilianweng.github.io/lil-log/

5. R. Valle, Hands-On Generative Adversarial Networks with Keras: Your Guide to Implementing Next-Generation Generative Adversarial Networks, (1e), Birmingham, UK: Packt Publishing, 2019.

CSE6261: Quantum Computing [4 0 0 4]

Quantum Theory Foundations: qubits, gates, measurements, Hilbert spaces, unitary operators, entanglement, decoherence; Measurement frameworks: projective measurement, POVMs, non-classical phenomena like Bell inequalities and the CHSH game; Quantum Algorithms: circuit models, teleportation, superdense coding, Deutsch-Jozsa, Grover's, Simon's, Shor's algorithms, VQE, QAOA, hybrid quantum-classical methods using Qiskit, PennyLane; Quantum Error Correction: noise models, Shor and Steane codes, surface codes, fault tolerance, logical qubit construction; Quantum Cryptography: BB84, E91, QKD networks, device-independent protocols, post-quantum cryptography; Hardware section: superconducting, ion-trap, photonic, spin-based, and topological qubits, coherence, control, scaling challenges; Quantum Metrology: precision limits, enhanced sensors, applications in imaging and navigation; Quantum Networks: entanglement distribution, repeaters, quantum internet architecture, national initiatives; Quantum Software and Simulation: Language: Qiskit, Cirq, Q#, simulators: QuTiP, QuEST, and quantum system simulations in science.

References:

1. M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, (10e), Cambridge, UK: Cambridge University Press, 2010.

2. G. Benenti, G. Casati, D. Rossini, and G. Strini, Principles of Quantum Computation and Information: A Comprehensive Textbook, (1e), Singapore: World Scientific, 2019.

3. C. C. Gerry and P. L. Knight, Introductory Quantum Optics, (2e), Cambridge, UK: Cambridge University Press, 2023.

4. D. Bouwmeester, A. Ekert, and A. Zeilinger, The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation, (1e), Berlin, Germany: Springer, 2000.

5. H. M. Wiseman and G. J. Milburn, Quantum Measurement and Control, (1e), Cambridge, UK: Cambridge University Press, 2010.

CSE6262: Natural Language Processing [4 0 0 4]

Introduction: Ambiguity and uncertainty in language, phases in natural language processing; Linguistic resources: Introduction to corpus, WordNet, IndoWordNet, VerbNet; Text preprocessing: Tokenization, Normalization, Edit distance, Advanced Edit distance; Part of Speech tagging: Stochastic POS tagging, handling of unknown words, named entity recognition, multi word expression, Word sense Disambiguation, Hidden Markov Model, Viterbi algorithm; Parsing: Top down, Bottom up, CYK, CFG, PCFG; Text representation and Language model: Bag of Word, Tf-Idf; Ngram, evaluation of language model, smoothening; DeepNLP: Embedding, One hot representation, Distributed representation and its evaluation, Recurrent neural network, Long Short-Term Memory (LSTM), Convolutional neural network, Self Attention mechanism, Introduction to Transformer architecture; Discourse: Reference resolution, constraints on co-reference, algorithm for pronoun resolution, text coherence, discourse structure; Topic Modeling: Latent Dirichlet Allocation (LDA), Non-negative Matrix Factorization (NMF), Visualizing topics and clusters; Application of NLP: Text summarization, Sentiment Analysis, Aspect based sentiment analysis, Question Answering system.

References:

1. D. Jurafsky, J. H. Martin, Speech and Language Processing, (3e), Pearson, 2025.

2. L. Tunstall, L. v. Werra, Thomas Wolf, Natural Language Processing with Transformers, (1e), O'Reilly Media, 2022.

3. D. Rothman, Transformers for Natural Language Processing, (2e), Packt Publishing, 2022.

CSE6263: Social Networks Analysis [4 0 0 4]

Introduction: Key concepts, applications, and measures in network analysis, Nodes, Edges, and Network measures, Describing Nodes and Edges, Describing Networks, Layouts; Properties of Real-World Networks: Random graphs, small worlds problem; Network Measures & Structural Roles - Centrality: Degree Centrality, Eigenvector Centrality, Katz Centrality, PageRank Centrality, Closeness Centrality, Group Centrality, Transitivity and Reciprocity, Balance and Status; Similarity: Structural Equivalence, Regular Equivalence; Community Discovery & Dynamics - Member-based: Girvan–Newman (edge betweenness), Louvain (greedy modularity), Label Propagation; Group-based: Stochastic Block Models, overview of

inference via EM; Temporal evolution: snapshot vs incremental clustering, concept drift, illustrative; Evaluation: modularity; conductance, coverage (without ground truth), NMI, ARI (with ground truth); Link prediction: similarity indices (CN, AA, Jaccard), path-based (Katz), supervised binary classifiers, discussion on cold-start and sparsity; Graph Representation Learning & Network Applications - Shallow embeddings: DeepWalk; Node2Vec, LINE—skip-gram objective and hyper-parameter effects; Knowledge graphs & meta-paths: metapath2vec, path-based attention; Graph neural networks: Spectral vs

spatial GCNs, GraphSAGE; attention-based variants; Influence & outbreaks: independent-cascade and linear-threshold models.

References:

1. D. Easley and J. Kleinberg, Networks, Crowds and Markets, Cambridge, 2010.
2. M. Newman, Networks: An Introduction, Oxford, 2010.
3. C. C. Aggarwal, Social Network Data Analytics, Springer, 2011.
4. T. Chakraborty, Social Network Analysis, Wiley, 2021.
5. S. P. Borgatti, M. G. Everett, and J. C. Johnson, Analyzing Social Networks, (2e), SAGE Publications Ltd, 2018.
6. J. Scott, Social Network Analysis, (3e), SAGE Publications Limited, 2013.
7. D. Jurafsky and J. H. Martin, Speech and Language Processing, (3e), Pearson, 2025.

CSE6264: Recommender Systems [4 0 0 4]

Introduction to Recommender Systems: What is a recommendation engine?; Need for recommender systems, Framework of recommendation systems, Personalization strategies, Privacy concerns, Functions and techniques in recommender systems, Role of Human-Computer Interaction, Dataset challenges: the cold-start problem; Collaborative Filtering-based Techniques: understanding ratings and rating data, User-based nearest neighbour recommendation, Item-based nearest-neighbour recommendation, Model-based and preprocessing-based collaborative filtering approaches, Comparison of user-based and item-based recommendation techniques, Concept drift and data drift in collaborative filtering; Content-based Recommender Systems: Architecture of content-based recommenders, Content representation and content similarity: item profiles, feature extraction, use of tags, Learning user profiles: profile representation and filtering, Similarity-based retrieval methods, Classification algorithms for content recommendation, Knowledge-based recommenders: knowledge representation and reasoning; Constraint-based and case-based recommenders; Constraint-based Approaches: Constraint-based recommenders: recommendation knowledge base development, user guidance, recommendation calculation; Evaluation of Recommender

Systems: Evaluation paradigms: offline evaluation design and goals; Case study: Netflix Prize dataset; Data partitioning techniques: hold-out and cross-validation; Accuracy metrics: RMSE vs. MAE; Impact of the long tail; Ranking evaluation: correlation-based metrics, utility-based metrics, ROC-based evaluation.

References:

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2. J. Leskovec, A. Rajaraman, and J. Ullman, Mining of Massive Datasets, (2e), Cambridge University Press, 2012.

3. P. Pavan Kumar, S. Vairachilai, and Sirisha Potluri, Recommender Systems: Algorithms and Applications, (1e), CRC Press, 2021.

CSE6265: Cloud Infrastructure and Virtualization [4 0 0 4]

Cloud Architecture: layered design, NIST reference model, cloud deployment models (public, private, hybrid); Service models: IaaS, PaaS, SaaS, cloud storage concepts, advantages, cloud computing reference model; Historical developments: distributed systems, virtualization, Web 2.0, utility computing. Building cloud environments: Infrastructure development, AWS, Google App Engine, Microsoft Azure, Hadoop, Salesforce; AWS tools: EC2, ECS, Code Commit, Build, Deploy, Pipeline, CloudWatch, Auto Scaling, Control Tower; Virtualization virtualization characteristics, taxonomy, hardware virtualization, desktop virtualization; Virtual machines: process and system VMs, memory and instruction emulation, dynamic binary optimization, resource virtualization; Case study: Intel VT-x, Pros and cons of virtualization technologies like Xen, VMware, and Hyper-V.

References:

1. R. Buyya, J. Broberg, and A. Goscinski, Cloud Computing Principles and Paradigms, (1e), Wiley Publishers, 2013.

2. B. Sosinsky, Cloud Computing Bible, (1e), Wiley, 2011.

3. M. Miller, Cloud Computing: Web-based Applications that change the way you work and collaborate online, (1e), Pearson, 2008.

4. D. S. Linthicum, Cloud Computing and SOA Convergence in Your Enterprise: A Step-by-Step Guide, (1e), Addison Wesley Information Technology Series, 2010.

5. T. Velte, A. T. Velte, and R. Elsenpeter, Cloud Computing: A Practical Approach, (1e), McGraw Hill, 2017.

CSE6266 : Malware Analysis and Intrusion Detection [4 0 0 4]

Introduction to Malware and Intrusions: Malware overview: viruses, worms, Trojans, ransomware, spyware, rootkits, bots; Malware lifecycle and propagation techniques; Famous malware case studies (Stuxnet, WannaCry, Pegasus); Intrusion basics: taxonomy, attacker models, intrusion kill chain; Relationship between malware and intrusions; Malware Analysis Techniques: Static analysis, signatures, hashing, disassembly, string analysis; Dynamic analysis: sandboxing, monitoring, debugging tools; Reverse engineering basics for malware; Memory forensics and persistence mechanisms; Malware evasion and anti-analysis techniques; Intrusion Detection Systems: IDS architecture and design goals; Signature-based vs. anomaly-based vs. specification-based IDS; HIDS vs. NIDS vs. Hybrid IDS; Intrusion Prevention Systems (IPS); Evasion techniques against IDS and countermeasures; Case studies of enterprise IDS deployments; IDS Tools and Platforms: Snort: architecture, rule writing, and deployment; Suricata: configuration and advanced detection features; Zeek (Bro): traffic analysis and protocol detection; Honeypots and deception systems; Integration of IDS/IPS in Security Information and Event Management (SIEM); Machine Learning and Advanced IDS: Feature extraction from traffic and system logs; Supervised ML methods: SVM, Random Forest, Decision Trees; Unsupervised detection: clustering, outlier detection; Deep learning in IDS: CNN, RNN, Autoencoders; Adversarial machine learning and IDS robustness; Emerging trends: IDS in IoT, cloud, and encrypted traffic; blockchain-based IDS.

References:

1. Michael Collins, Network Security Through Data Analysis: From Data to Action, O'Reilly, 2017.

2. Chris Sanders, Applied Network Security Monitoring: Collection, Detection, and Analysis, Syngress Media Inc., 2013.

3. Richard Bejtlich, The Practice of Network Security Monitoring, No Starch, 2013.

4. Michael Sikorski & Andrew Honig, Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software, No Starch Press, 2012.

5. Rafeeq Ur Rehman, Intrusion Detection with SNORT: Advanced IDS Techniques Using SNORT, Apache, MySQL, PHP, and ACID, Prentice Hall, 2003.

6. Rebecca Bace, Intrusion Detection, Macmillan, 2000.