

**DEPARTMENT OF INFORMATION TECHNOLOGY
SCHOOL OF ENGINEERING AND TECHNOLOGY,
NAGALAND UNIVERSITY, KOHIMA CAMPUS, MERIEMA**

COURSE STRUCTURE FOR PRE-PHD (COURSE WORK) PROGRAM
W.E.F THE ACADEMIC YEAR 2022-23

COURSE STRUCTURE

Sl. No	Course code	Course Title	Credit [L-T-P]
1	SETP01	Research methodology	[4-0-0] =4
2	SETP02	Research And Publication Ethics	[1-0-1] =2
3	ITPEL0*	Elective I	[3-0-0] =3
4	ITPEL0*	Elective II	[3-0-0] =3
		Total	12 credits

List of Electives

S. No.	Course Code	Course Title	Credit [L-T-P]
1	ITPEL01	Big Data Analytics	[3-0-0] =3
2	ITPEL02	Foundations of Data Science	[3-0-0] =3
3	ITPEL03	Deep Learning for Computer Vision	[3-0-0] =3
4	ITPEL04	Neuro-fuzzy systems	[3-0-0] =3
5	ITPEL05	Intelligent systems	[3-0-0] =3
6	ITPEL06	Image Processing and Computer Vision	[3-0-0] =3
7	ITPEL07	Fundamentals of Internet of Things	[3-0-0] =3
8	ITPEL08	Computational Geometry	[3-0-0] =3
9	ITPEL09	Statistical methods	[3-0-0] =3
10	ITPEL10	Advanced Cyber Security	[3-0-0] =3
11	ITPEL11	Quantum Computing	[3-0-0] =3
12	ITPEL12	AI for Bioinformatics	[3-0-0] =3
13	ITPEL13	Natural Language Processing	[3-0-0] =3

SETP01: Research Methodology

Unit I: Research Methodology

Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research Process, Criteria of Good Research, Common Problems for Researchers

Unit II: Research Problem

What is a Research Problem?, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem

Research Design

Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs. Principles of Experimental Designs.

Unit III:

Interpretation & Report Writing: Meaning of interpretation, technique of interpretation, Types and structures of research documentation; Approaches and guidelines for documenting and reporting research process and outcomes; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; ethical issues; scientific misconduct.

Unit IV:

Intellectual Property Right (IPR) issues IPR introduction and origin, Basics of patents: types of patents, Indian Patent Rules and validity, International Patent Rules and validity, Necessity and advantage-disadvantage of doing Patent to an invention. patent infringement- meaning, scope, litigation, case studies and examples; Commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists university/organizational rules in India and abroad, collaborative research.

References:

1. C. R. Kothari, Research Methodology: Methods and Techniques, New Age Publishers.
2. Krishnan Nallaperumal, Engineering Research Methodology
3. Online materials on WIPO and IPR
4. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
5. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.

CPE-RPE: Research And Publication Ethics

1. Philosophy and Ethics

1. Introduction to philosophy definition, nature and scope, branches.
2. Ethics: definition moral philosophy, nature of moral judgments and reactions.

2. Scientific Conduct

1. Ethics with respect to science and research.
2. Intellectual honesty and research integrity.
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP).
4. Redundant publications duplicate and overlapping publications, salami slicing.
5. Selective reporting and misrepresentation of data.

3. Publication Ethics

1. Publication ethics: definition, introduction and importance.
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest.
4. Publication misconducts: definition, concept, problems that lead to unethical behavior and vice versa, types.
5. Violation of publication ethics, authorship and contributorship.
6. Identification of publication misconduct, complaints and appeals.

4. Open Access Publishing

1. Open access publication and initiatives.
2. HERPA/RoMEO online resource to check publisher copyright & self –archiving policies.
3. Software tool to identify predatory publication developed by SPPU.
4. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

5. Publication Misconduct

A) Group Discussions

1. Subject specific ethical issues, FFP, authorship.
2. Conflicts of interest.
3. Complaints and appeals: examples and fraud from India and abroad.

B) Software tools

Use of plagiarism software like Turnitin, Urkund and other open source software tools.

6. Databases and Research Metrics

A) Databases

1. Indexing databases.
2. Citation databases: Web of Science, Scopus, etc.

B) Research Metrics

1. Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score.
2. Metrics: h-index, g index, i10 index, Altmetrics

References

Bird, A (2006). Philosophy of Science. Routledge

Macintyre, Alasdair (1967) A short History of ethics. London
 P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN: 978-9387480865
 National Academy of sciences, National Academy of Engineering and Institute of Medicine (2009). On Being a scientist: A Guide to responsible Conduct in research: third Edition. National Academics Press
 Resnik, D.B (2011). What is ethics in research & why is it important. National Institute of Environmental health Science, 1-10. Retrieved from <https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
 Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179-179. <https://doi.org/10.1038/489179a>
 Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN: 978-81-939482-1-7.
http://www.insaindia.res.in/pdf/Ethics_Book.pdf

ITPEL01: Big Data Analytics

1. INTRODUCTION TO BIG DATA Introduction– distributed file system–Big Data and its importance, Four Vs, Drivers for Big data, Big data analytics, Big data applications. Algorithms using map reduce
2. INTRODUCTION TO HADOOP AND HADOOP ARCHITECTURE Big Data – Apache Hadoop & Hadoop EcoSystem, Moving Data in and out of Hadoop – Understanding inputs and outputs of MapReduce -, Data Serialization.
3. HDFS, HIVE AND HIVEQL, HBASE HDFS-Overview, Installation and Shell, Java API; Hive Architecture and Installation, Comparison with Traditional Database, HiveQL Querying Data, Sorting And Aggregating, Map Reduce Scripts, Joins & Sub queries, HBase concepts, Advanced Usage, Schema Design, Advance Indexing, PIG, Zookeeper , how it helps in monitoring a cluster, HBase uses Zookeeper and how to Build Applications with Zookeeper
4. SPARK Introduction to Data Analysis with Spark, Downloading Spark and Getting Started, Programming with RDDs, Machine Learning with MLlib.
5. NoSQL What is it?, Where It is Used Types of NoSQL databases, Why NoSQL?, Advantages of NoSQL, Use of NoSQL in Industry, SQL vs NoSQL, NewSQL
6. Data Base for the Modern Web Introduction to MongoDB key features, Core Server tools, MongoDB through the JavaScript’s Shell, Creating and Querying through Indexes, Document-Oriented, principles of schema design, Constructing queries on Databases, collections and Documents , MongoDB Query Language.

Reference

1. Boris lublinsky, Kevin t. Smith, AlexeyYakubovich, “Professional Hadoop Solutions”, Wiley, ISBN: 9788126551071, 2015.
2. Chris Eaton,Dirk derooset al. , “Understanding Big data ”, McGraw Hill, 2012.
3. BIG Data and Analytics , Sima Acharya, Subhashini Chhellappan, Willey

4. MongoDB in Action, Kyle Banker, Piter Bakkum, Shaun Verch, Dream tech Press
5. Tom White, "HADOOP: The definitive Guide", O Reilly 2012.
6. VigneshPrajapati, "Big Data Analytics with R and Hadoop", Packet Publishing 2013.
7. <http://www.bigdatauniversity.com/>
8. Learning Spark: Lightning-Fast Big Data Analysis Paperback by Holden Karau

ITPEL02: Foundations of Data Science

1. Introduction: What is Data Science? Big Data and Data Science – Datafication – Current landscape of perspectives – Skill sets needed; Matrices – Matrices to represent relations between data, and necessary linear algebraic operations on matrices - Approximately representing matrices by decompositions (SVD and PCA); Statistics: Descriptive Statistics: distributions and probability – Statistical Inference: Populations and samples – Statistical modeling – probability distributions – fitting a model – Hypothesis Testing – Intro to R/ Python.
2. Data preprocessing: Data cleaning – data integration – Data Reduction Data Transformation and Data Discretization. Evaluation of classification methods – Confusion matrix, Students T-tests and ROC curves-Exploratory Data Analysis – Basic tools (plots, graphs and summary statistics) of EDA, Philosophy of EDA – The Data Science Process.
3. Basic Machine Learning Algorithms: Association Rule mining – Linear Regression- Logistic Regression – Classifiers – k-Nearest Neighbors (k-NN), k-means -Decision tree – Naive Bayes- Ensemble Methods – Random Forest. Feature Generation and Feature Selection – Feature Selection algorithms – Filters; Wrappers; Decision Trees; Random Forests.
4. Clustering: Choosing distance metrics – Different clustering approaches – hierarchical agglomerative clustering, k-means (Lloyd's algorithm), – DBSCAN – Relative merits of each method – clustering tendency and quality.
5. Data Visualization: Basic principles, ideas and tools for data visualization

References

1. Cathy O'Neil and Rachel Schutt, "Doing Data Science, Straight Talk From The Frontline", O'Reilly, 2014.

2. Jiawei Han, Micheline Kamber and Jian Pei, “ Data Mining: Concepts and Techniques”, Third Edition. ISBN 0123814790, 2011.
3. Mohammed J. Zaki and Wagner Miera Jr, “Data Mining and Analysis: Fundamental Concepts and Algorithms”, Cambridge University Press, 2014.
4. Matt Harrison, “Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization , O’Reilly, 2016.
5. Joel Grus, “Data Science from Scratch: First Principles with Python”, O’Reilly Media, 2015.
6. Wes McKinney, “Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython”, O’Reilly Media, 2012.

ITPEL03: Deep Learning for Computer Vision

1. Introduction and Overview: Course Overview and Motivation; Introduction to Image Formation, Capture and Representation; Linear Filtering, Correlation, Convolution
2. Visual Features and Representations: Edge, Blobs, Corner Detection; Scale Space and Scale Selection; SIFT, SURF; HoG, LBP, etc.
3. Visual Matching: Bag-of-words, VLAD; RANSAC, Hough transform; Pyramid Matching; Optical Flow
4. Deep Learning Review: Review of Deep Learning, Multi-layer Perceptrons, Backpropagation
5. Convolutional Neural Networks (CNNs): Introduction to CNNs; Evolution of CNN Architectures: AlexNet, ZFNet, VGG, InceptionNets, ResNets, DenseNets
6. Visualization and Understanding CNNs: Visualization of Kernels; Backprop-to-image/Deconvolution Methods; Deep Dream, Hallucination, Neural Style Transfer; CAM, Grad-CAM, Grad-CAM++; Recent Methods (IG, Segment-IG, SmoothGrad)
7. CNNs for Recognition, Verification, Detection, Segmentation: CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss); CNNs for Detection: Background of Object Detection, R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD, RetinaNet; CNNs for Segmentation: FCN, SegNet, U-Net, Mask-RCNN
8. Attention Models: Introduction to Attention Models in Vision; Vision and Language: Image Captioning, Visual QA, Visual Dialog; Spatial Transformers; Transformer Networks
9. Deep Generative Models: Review of (Popular) Deep Generative Models: GANs, VAEs; Other Generative Models: PixelRNNs, NADE, Normalizing Flows, etc
10. Variants and Applications of Generative Models in Vision: Applications: Image Editing, Inpainting, Superresolution, 3D Object Generation, Security; Variants: CycleGANs, Progressive GANs, StackGANs, Pix2Pix, etc

References

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 2016
2. Michael Nielsen, Neural Networks and Deep Learning, 2016
3. Yoshua Bengio, Learning Deep Architectures for AI, 2009
4. Richard Szeliski, Computer Vision: Algorithms and Applications, 2010.
5. Simon Prince, Computer Vision: Models, Learning, and Inference, 2012.
6. David Forsyth, Jean Ponce, Computer Vision: A Modern Approach, 2002.

ITPEL04: Neuro-fuzzy systems

1. Introduction: Introduction to CI, History of CI, Basic techniques and applications of CI, Introduction to Neural Network, Fuzzy Logic, Genetic Algorithm, Hybrid System.
2. Elementary and Advance Search Techniques: State Space Search, Blind Search, Heuristic Search(Hill Climbing, A/A* Algorithm, Min-Max Search, Constraint Satisfaction), Multi-Objective Genetic Algorithm.
3. Fuzzy Set Theory: Fuzzy Sets, Basic Definition and Terminology, Set-theoretic Operations, Member Function Formulation and Parameterization, Fuzzy Rules and Fuzzy Reasoning using IF-THEN rules, Extension Principle and Fuzzy Relations, Fuzzy Inference Systems, Different Fuzzy Models: Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models, Input Space Partitioning and Fuzzy Modeling.
4. Optimization: Derivative-based Optimization, Descent Methods, The Method of Steepest Descent, Classical Newton's Method, Step Size Determination, Derivative-free Optimization, Concepts of Genetic Algorithms, GA techniques, Simulated Annealing, Random Search, Downhill Simplex Search, Evolutionary Computing, Swarm optimization, Green Computing, Big data mining.
5. Neural Networks & Deep Learning: Artificial Neural Network, Supervised Learning Neural Networks, Perceptrons and its limitations, Adaline, Back propagation learning algorithm Mutilayer Perceptrons, Radial Basis Function Networks, Unsupervised Learning Neural Networks, Deep Neural Network, Convolutional Neural Network, Competitive Learning Networks, Kohonen Self- Organizing Networks, Learning Vector Quantization, Hebbian Learning, Hop-field networks.
6. Neuro Fuzzy Modelling: Adaptive Neuro-Fuzzy Inference Systems, Architecture, Hybrid Learning Algorithm, Learning Methods that Cross- fertilize ANFIS and RBFN, Coactive Neuro Fuzzy Modeling, Framework Neuron Functions for Adaptive Networks, Neuro Fuzzy Spectrum. Introduction to Neuro Fuzzy Control.

Reference

1. Fuzzy Logic with Engineering Applications, Timothy J. Ross, McGraw-Hill, 1997.
2. Genetic Algorithms: Search, Optimization and Machine Learning, Davis E. Goldberg, Addison Wesley, N.Y., 1989.
3. Neural Networks: A Comprehensive Foundation, Simon Haykin. Prentice Hall
4. Neural Network Design, M. T. Hagan, H. B. Demuth, Mark Beale, Thomson Learning, Vikash Publishing House.
5. Neural Networks, Fuzzy Logic and Genetic Algorithms, S. Rajasekaran and G.A.V.Pai, PHI, 2003

ITPEL05: Intelligent systems

1. INTRODUCTION AND BASIC CONCEPTS Introduction- Humans and Computers, the structure of the brain, learning in machines, the differences. The basic neuron- Introduction, modelling the single neuron, learning in simple neurons, the perception: a vectorial perspective, the perception learning rule, proof, limitations of perceptrons.
2. MULTILAYER NETWORKS The multi layer perceptron: Introduction, altering the perception model, the new model, the new learning rule, multi layer perception algorithm, XOR problem. Multi layer feed forward networks, error back propagation training algorithm: problems with back propagation, Boltzmann training, Cauchy training, combined back propagation, Cauchy training.
3. RESONANT NETWORKS AND APPLICATIONS Hop-field networks: recurrent and bi-directional associative memories, counter propagation network, Artificial Resonance Theory (ART) Application of neural network: Hand written digit and character recognition- Travelling sales man problem, a neuro-controller.
4. FUZZY SET THEORY Introduction to fuzzy set theory: Fuzzy set vs Crisp set, properties of fuzzy sets, operations on fuzzy set – fuzzy compliments, fuzzy intersection- T-norms, fuzzy union- t- co-norm, fuzzy relations.
5. FUZZY LOGIC AND SYSTEMS Fuzzy Logic: Classical logic, multi valued logic, fuzzy propositions, fuzzy quantifiers, linguistic hedges and their inferences.
6. Fuzzy systems: fuzzy controllers, fuzzy systems and neural networks, fuzzy neural networks, fuzzy automata, fuzzy dynamic system.

References

1. G.J. Klir & Bo Yuan, “Fuzzy Sets and Fuzzy Logic Theory and Applications”, Prentice Hall of India, 2009.
2. Timothy S. Ross, “Fuzzy Logic with engineering applications”, Wiley India Pvt. Ltd., 2011.
3. Kosko B, “Neural Networks and Fuzzy Systems: A dynamical system approach to machine intelligence”, Prentice Hall of India, 2009

4. R Beale & T Jackson, “Neural Computing, An Introduction”, Adam Hilger, 1990.
5. Rao V.B and Rao H.V., “C++, Neural Networks and Fuzzy Logic”, BPB Publications, 2003.
6. Simon Kendal, Malcolm Creen, “An Introduction to Knowledge Engineering”, Springer-Verlag Limited, 2007

ITPEL06: Image Processing and Computer Vision

1. Introduction to Computer Vision and Basic Concepts of Image Formation: Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts.
2. Fundamental Concepts of Image Formation: Radiometry, Geometric Transformations, Geometric Camera Models.
3. Fundamental Concepts of Image Formation: Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections. Image Transforms. Image Enhancement, Image Filtering, Colour Image Processing, Image Segmentation
4. Image Descriptors and Features: Texture Descriptors, Colour Features, Edges/Boundaries. Object Boundary and Shape Representations. Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency
5. Fundamentals of Machine Learning: Linear Regression, Basic Concepts of Decision Functions, Elementary Statistical Decision Theory, Parameter Estimation, Clustering for Knowledge Representation, Dimension Reduction, Linear Discriminant Analysis.

References

1. Forsyth & Ponce, “Computer Vision-A Modern Approach”, Pearson Education.
2. M.K. Bhuyan , “ Computer Vision and Image Processing: Fundamentals and Applications”, CRC Press, USA, ISBN 9780815370840 - CAT# K338147.
3. Richard Szeliski, “Computer Vision- Algorithms & Applications”, Springer.

ITPEL07: Fundamentals of Internet of Things

1. Introduction to IoT: Sensing, Actuation, Networking basics, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, IoT Definition, Characteristics. IoT Functional Blocks, Physical design of IoT, Logical design of IoT,

Communication models & APIs.

2. M2M to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics. Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT,
3. M2M vs IoT An Architectural Overview–Building architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. Reference Architecture and Reference Model of IoT.
4. IoT Reference Architecture- Getting Familiar with IoT Architecture, Various architectural views of IoT such as Functional, Information, Operational and Deployment. Constraints affecting design in IoT world- Introduction, Technical design Constraints.
5. Domain specific applications of IoT: Home automation, Industry applications, Surveillance applications, Other IoT application.
6. Developing IoT solutions: Introduction to Python, Introduction to different IoT tools, Introduction to Arduino and Raspberry Pi Implementation of IoT with Arduino and Raspberry, Cloud Computing, Fog Computing, Connected Vehicles, Data Aggregation for the IoT in Smart Cities, Privacy and Security Issues in IoT.

References

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2014
2. Vijay Madiseti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, 1st Edition, VPT, 2014
3. Francis daCosta, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1st Edition, Apress Publications, 2013
4. Cuno Pfister, Getting Started with the Internet of Things, O’Reilly Media, 2011, ISBN: 978-1-4493- 9357-1

ITPEL08: Computational Geometry

1. Geometric Preliminaries, DCEL (Doubly Connected Edge List) data structure, Polygon, Planar Straight Line Graph (PSLG) Area of a triangle, area of a polygon, Determinant used to test position of a point with respect to a directed line. Convex polygons, properties and point location in convex polygon (inside-outside test) Plane sweep algorithm, Algorithm for Line segment intersection problem using plane sweep technique.
2. Point location in PSLG – Slab method, Chain method and complexity analysis. Range Searching – 1D Range search, Kd Trees.
3. Polygon Triangulation: Regularization of polygons, properties of triangulations – Proofs, triangulation of monotone polygon – algorithm and complexity analysis. Linear

Programming – Half plane intersection, Incremental algorithm and Randomized algorithm

4. Art Gallery Theorem, Guarding Art Gallery, Fisk's proof using three colouring. Arrangements of Lines – Duality, Combinatorics of arrangements, Zone Theorem, Algorithm for Constructing arrangements of lines.
5. Convex Hulls- Convex Hull Algorithms in the Plane -Graham's Scan Algorithm, Jarvi's March, Divide and Conquer Algorithm.
6. Voronoi Diagrams- Properties and applications in the plane. Proofs of properties related to vertices and edges of voronoi diagrams Algorithm for constructing voronoi diagram. Delaunay Triangulation.

References

1. Computational Geometry: Algorithms and Applications by Mark de Berg et al., Third Edition.
2. Computational Geometry: An Introduction by Franco P. Preparata and Ian Shamos.

ITPEL09: Statistical methods

1. Sample Survey: Elementary concept; Advantages of sample survey over census; Simple random sampling (SRS); SRSWR and SRSWOR; Drawing of random sample & estimation of average, total etc.; Sampling and non-sampling errors; Concept of stratified random sampling.
2. Statistical Methods :Population and its parameters; Sample and its statistics; Frequency distribution; Graphical representation; Measures of central tendency; Measures of dispersion; Moments; Simple correlation and regression.
3. Tests of Significance: Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory, Introduction to theory of estimation and confidence intervals.
4. Probability: Theory of probability. Random variable and mathematical expectation, Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Suggested Readings:

References:

1. Anderson T. W. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley.
2. Dillon W. R & Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.
3. Goon A. M, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.
4. Goon A. M, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.

5. Hoel P. G. 1971. Introduction to Mathematical Statistics. John Wiley.
6. Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan

ITPEL10: Advanced Cyber Security

Course prerequisite: Cyber security concepts, Machine learning concepts

Unit I: Fundamentals of Cyber Security: Security principles: CIA triad, risk management, zero trust models; Security policies, standards, and compliance (ISO 27001, NIST); Cryptography basics: symmetric, asymmetric, hashing, digital signatures; Threats, vulnerabilities, exploits, and attack vectors

Unit II: System & Network Security Foundations: Operating system internals: processes, memory management, system calls; Malware persistence in OS and kernel space; Network security protocols & vulnerabilities; Intrusion detection/prevention (IDS/IPS), firewalls, honeypots

Unit III: Malware and Memory Artefacts: Malware classification: viruses, worms, rootkits, ransomware, APTs; Fileless and in-memory malware techniques; Memory artefact collection and volatile memory analysis; Tools & techniques: Volatility, Rekall, Redline, YARA rules; Case studies on memory-based malware attacks

Unit IV: Artificial Intelligence in Cyber Security: AI/ML for malware detection: signature-based vs behavior-based; Deep learning for memory artefact analysis (CNN, RNN, Transformers); AI in intrusion detection and anomaly detection; Adversarial AI: attacks on AI models and AI-powered malware; Research trends: Federated learning for cyber security, explainable AI (XAI) for threat analysis

Text Books

1. Stallings, W. (2023). Cryptography and Network Security: Principles and Practice (8th ed.). Pearson.
2. Anderson, R. (2020). Security Engineering: A Guide to Building Dependable Distributed Systems (3rd ed.). Wiley.
3. Ligh, M. H., Case, A., Levy, J., & Walters, A. (2014). The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory. Wiley.
4. Gupta, B. B., Sheng, Q. Z., & Qiu, M. (2021). Artificial Intelligence for Cybersecurity. CRC Press.

Reference Books

1. Pfleeger, C. P., Pfleeger, S. L., & Margulies, J. (2015). Security in Computing (5th ed.). Prentice Hall.
2. Sikorski, M., & Honig, A. (2012). Practical Malware Analysis: The Hands-on Guide to Dissecting Malicious Software. No Starch Press.
3. Monnappa, K. A. (2018). Learning Malware Analysis: Explore the Concepts, Tools, and Techniques of Malware Analysis. Packt.
4. Wang, C., & Wang, D. (2020). Machine Learning for Cyber Security. Springer.
5. Sikos, L. F. (2021). Artificial Intelligence for Cybersecurity: Techniques, Challenges and Applications. Springer.

ITPEL11: Quantum Computing

Course prerequisite: Machine learning concepts, probability theory and complex numbers.

Unit I: Foundations of Quantum Computing: Qubits, superposition, entanglement, measurement; Quantum gates and quantum circuits; Quantum error correction and decoherence; Quantum complexity classes and computational models

Unit II: Quantum Algorithms: Deutsch–Jozsa, Grover’s search, and Shor’s factoring algorithm; Quantum Fourier Transform (QFT); Variational Quantum Algorithms (VQE, QAOA); Hybrid quantum-classical computation

Unit III: Machine Learning and Quantum Machine Learning (QML): Basics of classical ML: supervised, unsupervised, reinforcement learning; Quantum data encoding and feature spaces; Quantum kernels, quantum SVM, quantum neural networks; Quantum-inspired ML algorithms

Unit IV: Applications & Research Frontiers: Quantum ML in optimization, cryptography, and drug discovery; Quantum generative models and quantum reinforcement learning; Current platforms: IBM Q, Google Sycamore, Rigetti, Xanadu; Research challenges: scalability, noise, quantum supremacy, post-quantum security

Text Books

1. Nielsen, M. A., & Chuang, I. L. (2010). Quantum Computation and Quantum Information (10th anniversary ed.). Cambridge University Press.
2. Rieffel, E., & Polak, W. (2014). Quantum Computing: A Gentle Introduction. MIT Press.
3. Hidary, J. D. (2019). Quantum Computing: An Applied Approach. Springer.
4. Schuld, M., & Petruccione, F. (2021). Machine Learning with Quantum Computers (2nd ed.). Springer.

Reference Books

1. Bernhardt, C. (2019). Quantum Computing for Everyone. MIT Press.
2. Wittek, P. (2014). Quantum Machine Learning: What Quantum Computing Means to Data Mining. Academic Press.
3. Schuld, M., & Petruccione, F. (2018). Supervised Learning with Quantum Computers. Springer.
4. Schaerf, L., & Venegas-Andraca, S. E. (2022). Quantum Machine Learning: Foundations, Algorithms, and Applications. Cambridge University Press.
5. Xanadu Quantum Technologies Inc. (n.d.). PennyLane Documentation and Tutorials. <https://pennylane.ai/>
6. IBM Quantum. (n.d.). Qiskit Textbook. <https://qiskit.org/textbook/>
7. Google Quantum AI. (n.d.). Cirq Documentation. <https://quantumai.google/cirq>

ITPEL12: AI for Bioinformatics

Course prerequisites: *Machine learning concepts. Probability and Statistics*

Unit I: Foundations of Bioinformatics and AI: Introduction to Bioinformatics: DNA, RNA, proteins, biological networks; Biological databases: GenBank, UniProt, PDB, GEO, ENSEMBL; Core AI/ML concepts: supervised/unsupervised learning, neural networks, feature engineering; Sequence analysis: alignments, motif discovery, hidden Markov models (HMMs); Basics of computational genomics and proteomics.

Unit II: Machine Learning and Deep Learning in Bioinformatics: Classical ML in bioinformatics: SVMs, Random Forests, Bayesian methods; Deep learning for biosequence data: CNNs for motifs, RNNs/Transformers for sequences; AI for structural bioinformatics: protein structure prediction (AlphaFold, RoseTTAFold); AI in transcriptomics and single-cell analysis; Biomarker discovery, disease classification, and drug-target prediction.

Unit III: AI in system biology and bioinformatics: Graph Neural Networks (GNNs) for biological networks and pathways; Generative AI for drug discovery: GANs, VAEs, Diffusion Models; Reinforcement learning in protein folding and drug design; AI in systems biology: modeling metabolic and signaling pathways; AI for microbiome and metagenomic data analysis.

Unit IV: Interpretability, Ethics, and Case Studies: Explainable AI (XAI) methods for biological data; Bias and fairness in AI-driven bioinformatics; Privacy-preserving machine learning for genomic and clinical data; Case studies: AlphaFold, BioBERT, DeepVariant, RosettaFold; Applications of AI in personalized medicine and clinical decision support.

Text Books

1. Zhang, Y., & Rajapakse, J. C. (2009). *Artificial Intelligence in Bioinformatics*. John Wiley & Sons.
2. Ramsundar, B., Eastman, P., Walters, P., & Pande, V. (2019). *Deep Learning for the Life Sciences: Applying Deep Learning to Genomics, Microscopy, Drug Discovery, and More*. O'Reilly Media.
3. Compeau, P., & Pevzner, P. (2014). *Bioinformatics Algorithms: An Active Learning Approach* (Vols. I–II, 2nd ed.). Active Learning Publishers.

Reference Books

1. Zhang, Y., & Rajapakse, J. C. (2009). *Machine Learning in Bioinformatics*. John Wiley & Sons.
2. Lytras, M., & Sarirete, A. (2021). *Artificial Intelligence and Big Data Analytics for Smart Healthcare*. Academic Press.
3. Recent case study papers on AlphaFold, BioBERT, DeepVariant, and RosettaFold (for Unit IV applications).

ITPEL13: Natural Language Processing

Course prerequisites: *Linear Algebra, Probability and Statistics, Python, Machine Learning fundamentals.*

Unit 1: Foundations of NLP and Language Modeling: Introduction, Words and Tokens, N-gram Language Models, Logistic Regression and Text Classification, Embeddings.

Unit 2: Linguistic structure, parsing, tagging: Sequence Labeling for Parts of Speech and Named Entities, Context-Free Grammars and Constituency Parsing, Dependency Parsing, Information Extraction: Relations, Events, and Time, Semantic Role Labeling and Argument Structure, Lexicons for Sentiment, Affect, and Connotation, Coreference Resolution and Entity Linking, Discourse Coherence.

Unit 3: Neural Models and Deep Learning for NLP: Neural Networks, RNNs and LSTMs, Attention and Transformers, Pretrained Language Models (BERT, GPT, etc.), Convolutional Neural Networks (CNNs), Generative Adversarial Networks (GANs).

Unit 4: Advanced Applications in NLP: Information Retrieval and Retrieval-Augmented Generation, Machine Translation, Prompt Engineering and Few-Shot Learning, Fine-tuning Large Language Models (LLMs), Chatbots and Dialogue Systems, Question answering.

Text books:

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing," Pearson education, latest edition.
2. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

References:

1. Christopher Manning and Hinrich Schutze, "Foundations of statistical natural language processing," MIT press, 1999.
2. Jacob Eisenstein, "Introduction to natural language processing," Illustrated edition, The MIT press, 2019.
3. James A.. *Natural language Understanding 2e*, Pearson Education, 1994.