Syllabus
for
M. Tech. (Computer Engineering)
M. Tech(Computer Science)
M. Tech. (Computer Science & IT)
M. Tech. (Computer Science & Engg.)
w.e.f. July 2017
### Department of Computer Engineering
#### Master of Technology (Computer Engineering)

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<th>Course Name</th>
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List of Electives

Elective 1
1. Cloud Computing
2. Game Theory
3. Natural Language Processing
4. Social Network Analysis

Elective 2
1. Intrusion Detection System
2. Model Checking
3. Artificial Intelligence and Knowledge Reasoning
4. High Performance Computing

Elective 3
1. Software Testing
2. Algorithms for Big Data-structures
3. Software Language Engineering
4. Cryptography and Network Security

Elective 4
1. Introduction to Cognitive System
2. Virtual Reality
3. Mobile Computing
4. Storage Systems

Elective 5:
1. Functional Programming
2. Object Oriented Systems
3. Reinforcement Learning
4. Pattern Recognition
MTCE1101: Computer Algorithms

L:3 T:1 P:0 MSE:20 CA:20 ESE:60

Prerequisites: Data-structures.

Course Contents


Graph algorithm: Search algorithms, computation of strongly connected components, shortest distance algorithms, minimum spanning tree algorithms.

Network-flow algorithm: Ford-Fulkerson method; preflow-push algorithm

Geometric algorithm: convex-hull computation, line-segment intersection computation, closest-pair computation.

String matching: Rabin Karp algorithm, Knuth-Morris-Pratt algorithm, Boyer-Moore algorithm

Matrix algorithms: Strassen’s multiplication algorithm, LU decomposition, inverse computation

Polynomial computation algorithms: multiplication using DFT, division

Number theoretic algorithms: division, solution of modular linear equation, primality testing.

REFERENCES:


NPTEL Course


MTCE1102: Introduction to Machine Learning

L:3 T:1 P:0 MSE:20 IA:20 ESE:60

Prerequisites: Basic programming skills (in Python), algorithm design, basics of probability & statistics

Course Contents

Introduction: Basic definitions, types of learning, hypothesis space and inductive bias, evaluation, cross-validation.
Linear regression, Decision trees, overfitting.
Instance based learning, Feature reduction, Feature Selection, Collaborative filtering based
recommendation.
Probability and Bayes learning, Evaluation Measures, Hypothesis Testing.
Logistic Regression, Linear Classification, Support Vector Machine, Kernel function and Kernel SVM.
**Neural network:** Perceptron, multilayer network, backpropagation, introduction to deep neural network.
Computational learning theory, PAC learning model, Sample complexity, VC Dimension, Ensemble learning ad methods.
**Clustering:** k-means, adaptive hierarchical clustering, Gaussian mixture model.
Expectation Maximization, Introduction to Reinforcement Learning.

**REFERENCES:**
5. Darren Cook Practical Machine Learning with H2O Oreilly 2017

**NPTEL Courses:**
1. Introduction to Machine Learning by Dr. Balaraman Ravindran, IIT Madras.
2. Introduction to Machine Learning by Prof. S. Sarkar, IIT Kharagpur.

**MTCE1103: Advanced Computer Network**

| L:3 T:1 P:0 | MSE:20 IA:20 ESE:60 |

**Prerequisites:** Computer Network.

**Course Contents**
Review to Fundamentals of Computer N/Ws, TCP/IP reference model, Interior and Exterior Gateways routing application layered protocols such as DHCP, BOOTP OSI, TCP/IP, ATMX.25, frame relay, switching techniques in communication system.
Fundamentals of Optical Networks, SONET/SDH Introduction, TDM Networks elements, Generation of optical N/W’s.
Introduction to key optical node Organization and key other terms, Cross connect Terminology, brief introduction to TDM and WDM, Evolution of optical system, Key Attributes of optical fiber, Digital Multiplexing Hierarchy, Characterization of optical fiber, timing and Synchronization.
Fiber Optic Technologies History, Basic fundamentals Operation, Physical properties, networking elements. Wavelength Division Multiplexing Principle of Operation, CDM/DWDM, and WDM networks elements, Impairments and Compensation in WDM.
SONET/ SDH Multiservice platform. Protection / Restoration and diversity in optical N/W’s, MPLS/GMPLS introduction.

REFERENCES:
1. Optical Networks Control, Bala Rajagopalan, Gerg Bernstein, Debanjan saha.

<table>
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<tr>
<th>MTCE1104: Cloud Computing (Elective I)</th>
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Prerequisites: Distributed Systems, Computer Networks

Course Contents

Unit 1: Introduction to distributed and cluster computing, Basics of the emerging cloud computing paradigm, Cloud Benefits (10)
Unit 2: Virtualization concepts and types, KVM, VM Scheduling (8)
Unit 3: Disaster Recovery, Scaling (6)
Unit 4: Cloud security, Regulatory and compliance issues, VM Security Issues (6)
Unit 5: Latest Research Paper Topics (10)

Text Books:
4. Tim Mather Cloud Security and Privacy, Oreilly 2015

References:

NPTEL/Open Course Course

MTCE1104: Game Theory: (Elective-1)
L:3 T:1 P:0  MSE:20 IA:20 ESE:60

Prerequisites:

Course Contents
1. Introduction and Outline of the Course, Definitions, Utilities, Rationality, Intelligence, Common Knowledge, Classification of Games

I. NON-COOPERATIVE GAME THEORY
   Extensive Form Game  Strategic Form Games with Illustrative Examples  Dominant Strategy Equilibria  Pure Strategy Nash Equilibrium with Illustrative Examples and Key Results  Mixed Strategy Nash Equilibrium with Illustrative Examples and Key Results such as the Nash Theorem  Computation of Nash Equilibria and introduction to algorithmic theory  Matrix Games: Saddle Points, Minimax Theorem  Bayesian Games, Bayesian Nash Equilibrium  Evolutionary Game Theory (ESS Strategies)  Repeated Game

II. MECHANISM DESIGN

PART III: COOPERATIVE GAME THEORY
   Correlated Strategies and Correlated Equilibrium  The Nash Bargaining Problem  Coalitional Games (Transferable Utility Games)  The Core  The Shapley Value  Other Solution Concepts: Kernel, Nucleolus  To Probe Further and Conclusion

Reference Books
4. Game Theoretic Problems in Network Economics and Mechanism Design Solutions. Springer,
Natural Language Processing

L:3 T:1 P:0  MSE:20 IA:20 ESE:60

Prerequisites: A previous course on Artificial Intelligence will help. Courses of Data Structures and Algorithms should have been done. Exposure to Linguistics is useful, though not mandatory.

Course Contents

Top Down Parsing Algorithms, Noun Structure; Top Down Parsing Algorithms, Non-noun Structure and Parsing Algorithms, Probabilistic parsing; sequence labeling, PCFG, Training issues;
Arguments and Adjuncts, Probabilistic parsing; inside-outside probabilities, Speech : Phonetics, HMM, Morphology, Graphical Models for Sequence Labelling in NLP, Phonetics, Consonants (place and manner of articulation) and Vowels, Forward Backward probability;
Viterbi Algorithm, Phonology, Sentiment Analysis and Opinions on the Web, Machine Translation and MT Tools - GIZA++ and Moses, Text Entailment, POS Tagging, Phonology;
ASR, Speech Synthesis, HMM and Viterbi, Precision, Recall, F-score, Map, Semantic Relations; UNL; Towards Dependency Parsing, Universal Networking Language, Semantic Role Extraction, Baum Welch Algorithm; HMM training.

REFERENCES:

NPTEL Course:

1. Natural Language Processing by Prof. Pushpak Bhattacharyya, IIT Bombay.

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<tr>
<th>MTCE1104: Social Network Analysis (Elective I)</th>
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**Course Contents**

Introduction, Network Analysis.
Properties of Social Networks.
Community Analysis.
Case Study: Citation Networks.

REFERENCE:

5. Social Network Analysis for Startup Tsvetovat, 2015 Oreilly.

NPTEL Course:


<table>
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<tr>
<th>MTCE1105: Intrusion Detection System (Elective 2)</th>
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**Prerequisites:**

**Course Contents**

Intruder types, intrusion methods, processes and detection, message integrity and authentication, honey pots.
General IDS model, data mining based IDS, Denning model, data mining framework for constructing features and models for intrusion detection systems
Unsupervised anomaly detection, CV5 clustering, SVM, probabilistic and statistical modeling, general IDS model and taxonomy, evaluation of IDS, cost sensitive IDS.
NBAD, specification based and rate based DDOS, scans/probes, predicting attacks, network based...
anomaly detection, stealthy surveillance detection; Defending against DOS attacks in scout: signature-based solutions, snort rules.
Host-based anomaly detection, taxonomy of security flaws in software, self-modeling system calls for intrusion detection with dynamic window size.
Secure intrusion detection systems, network security, secure intrusion detection environment, secure policy manager, secure IDS sensor, alarm management, intrusion detection system signatures, sensor configuration, signature and intrusion detection configuration, IP blocking configuration, intrusion detection system architecture

Reference Books


MTCE1105: Model Checking (Elective 2)

L:3 T:0 P:0 MSE:20 IA:20 ESE:60

Prerequisites: Familiarity with basic algorithms and finite-state machines preferable

Course Contents

Modeling systems as Finite-state machines, Using the model-checker NuSMV, Linear-time properties for verification, Regular properties – automata over finite words, Omega-regular properties – automata over infinite words, Model checking omega-regular properties, Linear Temporal Logic (LTL), Algorithms for LTL, Computation Tree Logic (CTL), Algorithms for LTL, Models with timing constraints – timed automata, More on timed automata, Probabilistic models I, Probabilistic models II, Probabilistic models III.

REFERENCES:

NPTEL Course:

1. Model Checking by Prof. B. Srivathsan, CMI.

| MTCE1105 Artificial Intelligence: Knowledge Representation and Reasoning |
| L:3 T:0 P:0 | MSE:20 IA:20 ESE:60 |

Prerequisites: Some exposure to formal languages, logic and programming.

Course Contents

Introduction: Introduction to Knowledge Representation and Reasoning and Formal Logics.


Ontology and Description Logics: A Description Logic, Normalisation, Structure Matching, Classification, A-box Reasoning, Extensions, ALC, Further Extensions.

Inheritance: Taxonomies and Inheritance, Beliefs, Credulous and Skeptical Reasoning.


REFERENCES:


NPTEL Course
MTCE1105: High Performance Computing (Elective 2)

Prerequisites: Computer programming, Data structures.

Course Contents

Program Execution: Program, Compilation, Object files, Function call and return, Address space, Data and its representation.

Computer Organization: Memory, Registers, Instruction set architecture, Instruction processing.

Pipelined Processors: Pipelining, Structural, data and control hazards, Impact on programming.

Virtual Memory: Use of memory by programs, Address translation, Paging.

Cache Memory: Organization, impact on programming, virtual caches.


Program Profiling

File Systems: Disk management, Name management, Protection.

Parallel Architecture: Inter-process communication, Synchronization, Mutual exclusion, Basics of parallel architecture, Parallel programming with message passing using MPI.

REFERENCE:


NPTEL Course:

1. High Performance Computing by Prof. Mathew Jacob, IISc Bangalore.
Dr. B. A. Tech. University-Lonere

Semester II

MTCE1201: Data Science

L:3 T:1 P:0  MSE:20 IA:20 ESE:60

Prerequisites:

Course Contents

Data Mining Patterns: Cluster Analysis, Anomaly Detection, Association Rules,

Data Mining Sequences:

Text Mining: Text mining Text Clusters

Data Analysis: Simple regression, Multiple Regression, Multivariate Regression Analysis, Robust Regression, Correlation, Clustering.

Data Visualization: R graphics, Plotting, Scatter Plots Bar Charts and Plots 3D graphics

Machine Learning: Data Partitioning Predicting events with machine learning, Supervised and Unsupervised learning.

Reference Books

1. Dan Toomey, R for Data Science, Packit First Edition Publishing 2014 NPTEL/Open Course
2. Hadley Wickham et al R for Data Science Oreilly 2016
3. Richard Cotton Learning R Oreilly 2013

MTCE1202: Software Architecture

L:3 T:1 P:0  MSE:20 IA:20 ESE:60

Prerequisites:

Course Contents


Reference Books
1. Paul Clements, Documenting Software Architecture, Addison Wesley
2. Fran Buschman Pattern Oriented Software Architecture Vol I

MTCE1203 Software Testing (Elective 3)

Course Contents

Introduction: Principles of testing, Software development life cycle models.

Types of testing: White box testing - Static testing, Structural testing, Black box testing–Requirement based testing, positive and negative testing, boundary value analysis, decision tables, equivalence partitioning, state based or graph based testing, compatibility testing, user documentation testing, domain testing.

Integration testing: top down integration, bottom up integration, bi-directional integration, system integration System and Acceptance testing–functional testing–design/architecture verification, business vertical testing, deployment testing, beta testing, certification standards and testing for compliance;

Non-functional testing: setting up the configuration, coming up with entry/exit criteria, balancing key resources, scalability testing, reliability testing, stress testing, interoperability testing;

Acceptance testing: acceptance criteria, selecting test cases for acceptance testing, executing acceptance tests.

Performance testing: collecting requirement, writing test cases, automating performance test cases, analyzing the performance test results, performance benchmarking, capacity planning.

Regression testing: erforming an initial smoke or sanity test, understanding criteria for selecting the test cases, classifying test cases, methodology for selecting test cases, resetting the test cases for regression testing Test planning, management, execution and reporting.

Test metrics and measurements.

REFERENCE:

**Prerequisites:** Algorithms, probability theory.

**Course Contents**
Intro to Probability Theory, Tail bounds with Applications, Markov Chains and Random Walks.
Randomized Algorithms against an Oblivious Adversary, Pairwise Independence and Universal Hashing, The Streaming Model, Approximate Counting, Approximate Median.
Flajolet Martin-Distinct Sampling, Alon-Mattias-Szegedy Sketch, Bloom Filters, Count-min Sketch, Property Testing Model, Local search and testing connectivity.
Enforce and Test Technique: Biclique and Bipartiteness Testing.

**REFERENCE:**
2. Algorithmic and Analysis Techniques in Property Testing, by Dana Ron.

**NPTEL Course:**

**MTCE1203 Real-Time System (Elective 3)**

**Prerequisites:** Programming and Data Structures, Operating Systems, Computer Architecture and Organization, Computer Communication, and Database Systems.

**Course Contents**

**Real-Time Task Scheduling:** Concept, Types of real time task and their characteristics, Task scheduling, Clock-Driven Scheduling, Hybrid Schedulers, Event-driven scheduling, EDF scheduling, Rate monotonic System, Issue associate with RMA, Issue in using RMA in practical situations.

**Handling Resource Sharing and Dependencies Among Real-Time Tasks:** Resource Sharing Among

**Scheduling Real-Time Tasks in Multiprocessor and Distributed Systems:** Multiprocessor task Allocation, Dynamic Allocation of Tasks, Fault Tolerant Scheduling of Tasks, Clocks in Distributed Real Time Systems, Centralized Clock Synchronization, Distributed Clock Synchronization.


**REFERENCE:**

**NPTEL Course:**
1. Real Time Systems by Prof. Rajib Mall, IIT Kharagpur.

**Prerequisites:**

**Course Contents**

Introduction: Basic objectives of cryptography, secret-key and public-key cryptography, one-way and trapdoor one-way functions, cryptanalysis, attack models, classical cryptography. Block ciphers: Modes of operation, DES and its variants, RCS, IDEA, SAFER, FEAL, BlowFish, AES, linear and differential cryptanalysis. Stream ciphers: Stream ciphers based on linear feedback shift registers, SEAL, unconditional security. Message digest: Properties of hash functions, MD2, MD5 and SHA-1, keyed

Text Books:

NPTEL course


MTCE1204 Introduction to Cognitive Science (Elective 4)

L:3 T:0 P:0

Prerequisites: Introduction to Computing.

Course Contents

Philosophical Issues (fundamental assumptions underlying differing theories), Cognitive Psychology (experiments revealing computational processes underlying cognition), Neuroscience (understanding at the micro-level; wetware), Computational intelligence (simulation and testing of cognitive models), Linguistics (a prime window into cognition is through language).

Perception: Embodiment; From qualia to representation.

Space, Time and Language: Spatial and Temporal categories.

Categorization and Concepts: Prototype Theory, Objects and Events.

Language: Lexical structure, compositionality, and semantics.
Learning: Developmental models.


REFERENCE:


MTCE1204 Virtual Reality (Elective 4)

L:3 T:0 P:0 MSE:20 IA:20 ESE:60

Prerequisites: Basic maths and exposure to engineering.

Course Contents

Introduction: Course mechanics, Goals and VR definitions, Historical perspective, Birds-eye view(general), Birds-eye view(hardware), Birds-eye view/software, Birds-eye view/sensation and perception.

Geometry of Virtual Worlds: Geometric modeling, Transforming models, Matrix algebra and 2D rotations, 3D rotations and yaw, pitch, and roll, Axis-angle representations, Quaternions, Converting and multiplying rotations, Homogeneous transforms, The chain of viewing transforms, Eye transforms, Canonical view transform, Viewport transform.

Light and Optics: Three interpretations of light, Refraction, Simple lenses, Dioplers, Imaging, properties of lenses, Lens aberrations, Optical system of eyes.


Visual Perception: Depth perception, Motion perception, Frame rates and displays.

Tracking Systems: Overview, Orientation tracking, Tilt drift correction, Yaw drift correction, Tracking with a camera, Perspective n-point problem, Filtering, Lighthouse approach.


Audio: Physics and physiology, Auditory perception, Auditory localization, Rendering, Spatialization
and display, Combining other senses.

**Interfaces:** Interfaces overview, Locomotion, Manipulation, System control, Social interaction, Evaluation of VR Systems.

**REFERENCE:**


**NPTEL Course:**

1. Virtual Reality by Prof. Steven LaValle, IIT Madras.

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**MTCE104 Mobile Computing (Elective 4)**

L:3 T:0 P:0 MSE:20 IA:20 ESE:60

**Prerequisites:** Java Programming, Operating Systems, Basic knowledge on socket connection.

**Course Contents**

Introduction to mobile computing, installing of required software and preparing the working environment, creating your first Android Application.

Layouts, Views, Resources.

Activities, Intents.

Background tasks, Connecting to the Internet.

Fragments, Preferences.

User Interaction – input, menu items, custom views.

User Experience – themes and styles, material design, adaptive layouts, accessibility, localization, debugging the UI.

Storing Data, SQLite database.

Sharing Data, content resolvers and providers, loaders to load data.

Services, background work, alarms, broadcast receivers.

Notification, widgets, transferring data efficiently, publishing app.
Multiple form factors, sensors, Google cloud messaging, monetizing your app.

**REFERENCE:**

2. Android Programming – Pushing the limits by Hellman.

**NPTEL Course:**

1. Mobile Computing by Prof. Pushpendra Singh, IIITD.

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<th>MTCE104 Storage System (Elective 4)</th>
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**Prerequisites:** Operating System.

**Course Contents**

**Introduction:** History: computing, networking, storage, Need for storage networking, SAN, NAS, SAN/NAS Convergence, Distributed Storage Systems, Mainframe/proprietary vs. open storage, Storage Industry Organizations and Major Vendors Market, Storage networking strategy (SAN/NAS or Distr storage), Impact of Regulations: existing and new.

**Technology:** Storage components, Data organization: File vs. Block, Object; Data store; Searchable models, Storage Devices (including fixed content storage devices), File Systems, Volume Managers, RAID systems, Caches, Prefetching.

**Network Components:** Connectivity: switches, directors, highly available systems, Fibre Channel, 1GE/10GE, Metro-ethernet, Aggregation, Infiniband.

**Error Management:** Disk Error Mgmt, RAID Error Mgmt, Distr Systems Error Mgmt

**Highly available and Disaster-tolerant designs:** Ordered writes, Soft updates and Transactions, 2 phase, 3 phase, Paxos commit protocols, Impossibility Results from Distributed Systems, Choose 2 of 3: Availability, Consistency and Partition Tolerance.

**Layering and Interfaces in Storage Protocols:** SCSI 1/2/3SNIA model.

**SAN Components:** Fibre Channel, IP-based Storage (iSCSI, FCIP, etc.), Examples, NAS: NFS, CIFS, DAFS

**Large Storage Systems:** Google FS/BigTable, Cloud/Web-based systems (Amazon S3), FS+DB convergence, Programming models: Hadoop

**Archival Systems:** Content addressable storage, Backup: serverless, LAN free, LAN Replication issues, Storage Security, Storage Management, Device Management, NAS Management, Virtualization : Virtualization solutions, SAN Management: Storage Provisioning, Storage Migration,
NPTEL Course:
1. Storage Systems by Dr. K. Gopinath, IISc Bangalore.

**MTCE105 Functional Programming (Elective 5)**

| L:3 | T:0 | P:0 | MSE:20 | IA:20 | ESE:60 |

**Prerequisites:**

**Course Contents**

- Introduction to Haskell and the ghci interpreter
- Defining functions: guards, pattern matching and recursion
- Lists, strings and tuples 4. Types and polymorphism
- Higher order functions on lists: map, filter, list comprehension
- Computation as rewriting, lazy evaluation and infinite data structures
- Conditional polymorphism and type classes
- User defined datatypes: lists, queues, trees
- Input/output and the ghc compiler
- Arrays

**MTCE1205 Object-Oriented System (Elective 5)**

| L:3 | T:0 | P:0 | MSE:20 | IA:20 | ESE:60 |

**Prerequisites:**

**Course Contents**

- Review of programming practices and code-reuse; Object model and object-oriented concepts;
- Object-oriented programming languages and implementation; Object-oriented analyses and design using UML structural, behavioral and architectural modeling; Unified development process, Software reuse design patterns, components and framework; Distributed object computing, interoperability and middle ware standards COM/DCOM and CORBA; Object-oriented database system data model, object definition and query language, object-relational system.

**REFERENCE:**
1. Object Oriented System Analysis, Sally Shlaer, Prentice Hall PTR.

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**MTCE205 Reinforcement Learning (Elective 5)**

| L:3 T:0 P:0 | MSE:20 IA:20 ESE:60 |

**Course Contents**


**REFERENCE:**


**NPTEL Course:**

1. Reinforcement Learning by Dr. B. Ravindran, IIT Madras.

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**MTCE1205 Pattern Recognition (Elective 5)**

| L:3 T:0 P:0 | MSE:20 IA:20 ESE:60 |

**Prerequisites:** Vector spaces and Linear Algebra, Algorithms, Probability theory, Statistics.

**Course Contents**

**Introduction and mathematical preliminaries:** What is pattern recognition?, Clustering vs. Classification; Applications; Linear Algebra, vector spaces, probability theory, estimation techniques, Decision Boundaries, Decision region / Metric spaces/ distances.

**Classification:** Bayes decision rule, Normal Distribution, Error probability, Error rate, Minimum distance classifier, Mahalanobis distance; K-NN Classifier, Linear discriminant functions and Non-linear decision boundaries. Mahalanobis Distance, K-NN Classifier, Fisher’s LDA, Single and Multilayer perceptron, training set and test sets, standardization and normalization.

**Clustering:** Basics of Clustering; similarity/dissimilarity measures, clustering criteria, Different distance functions and similarity measures, Minimum within cluster distance criterion, K-means clustering, single linkage and complete linkage clustering, MST, K-medoids, DBSCAN, Visualization.
of datasets, existence of unique clusters or no clusters.

**Feature selection:** Problem statement and Uses, Probabilistic separability based criterion functions, interclass distance based criterion functions, Branch and bound algorithm, sequential forward/backward selection algorithms, (l,r) algorithm. Probabilistic separability based criterion functions, interclass distance based criterion functions.

**Feature Extraction:** PCA, Kernel PCA.

**Recent advances in PR:** Structural PR, SVMs, FCM, Soft-computing and Neuro-fuzzy techniques, and real-life examples.

**REFERENCE:**


**NPTEL Course:**

1. Pattern Recognition by Prof. Sukhendu Das and Prof. C.A. Murthy, IIT Madras.