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UNIVERSITY OF MUMBAI

Syllabus For

M.Phil.Degree Course

in

Computer Science

(With effect from the academic year 2009-2010)

University of Mumbai

Syllabus for M.Phil. in Computer Science

Objective of the M.Phil. Course: To organize a path leading to successful research work in Computer Science. The intention is to introduce the candidate to (1) the deep foundations of core computing, (2) current trends in the rapidly evolving field and (3) the intellectual and philosophical framework necessary to explore wide spectrum of research in computing.

The three M.Phil. papers which broadly cover these aims are:

(1) Research and Teaching Methodology in Computing

(2) Recent Advances in Computing

(3) Electives

Paper 1: Research and Teaching Methodology in Computing

Note: Contemporary Theory and Practice of Core Computing is studied as part of research and training methodology, because there is a need to significantly upgrade the knowledge base for the purposes of research. Some basic ideas in research methodology, like the use of statistical and IT tools and searching the world wide web are routine activities of teachers in computing, so they are not emphasized here. Literature surveys are covered as an integral part of the Electives (see below).

Programming Paradigms: The imperative and declarative paradigms are studied, using the Python and Haskell programming languages, in order to develop rapid program prototyping skills and to become familiar with current technologies.

Analysis of Algorithms, Computability and Complexity: including recurrences and recursion; hash tables and functions; dynamic programming, greedy algorithms; amortized analysis (the accounting and potential methods); advanced data structures, the Fast Fourier Transforms (FFT), string matching; NP-completeness.

Formal Methods, Program Specification and Verification: Techniques for describing and reasoning about computer programs; introduction to tools like Z specification and Alloy modeling languages.

Recommended texts:

1. T.H.Cormen, Introduction to Algorithms
2. D. E. Knuth, The Art of Computer Programming (Vol. 1 to 4)
3. G. Dromey, Program derivation: The development of programs from specifications
4. E.W. Dijkstra and C.S. Schoelten, Predicate calculus and program semantics
5. D. Gries, The Science of Programming
6. J.M. Spivey, Understanding Z: A specification language and its formal semantics

Paper 2: Recent Advances in Computing

Background: The scope of computing has expanded so much in the last few decades that ACM (the professional organization for computing) has divided the broad expanse of computers and computing into five areas:

(1) Computer Engineering:	The discipline for building large computing systems with integrated hardware and software
(2) Software Engineering:	The discipline for building large computer programs
(3) Information Technology:	The tools and technologies for gathering, manipulating, storing, retrieving, and classifying recorded information
(4) Information Science:	The science underlying the organization of information (usually taught in management institutions)
(5) Computer Science:	The science underlying the architecture, languages, applications, as well as the mathematical foundations relating to computers and computation

It is virtually impossible to adequately cover in a single paper the trends and advances in this broad expanse. The following topics have been selected in order to provide a meaningful insight:

- Artificial intelligence
- Data mining and warehousing
- Software architectures
- Operating systems
- Networking
- High-performance computing
- Mobile technologies
- Information security

Each of these subjects has sufficient content to be developed over 50 lectures. In the present paper, the plan is to cover the basic concepts, some of the current trends and a related case study, in order to suggest possibilities about comparable research areas.

Standard text books are available on each of the subjects. The concerned teachers are to choose a case study (or research papers) and then work backwards to create a reading list.

Paper 3: Electives

Objective. One aim of this Paper is to create the background necessary to start the M.Phil. research project.

The concerned teachers will each select a contemporary niche topic (which will normally span several of the areas listed above in Paper 2, Recent Advances), e.g., topics like robotics, natural language processing, bioinformatics or game theory are dependent on artificial intelligence, high-performance computing and data mining. A list of niche topics cannot be prescribed in advance because the choice of topics will depend on the interests of both teachers and students. The list of topics and recommended reading material will be submitted to the concerned authorities, and their approvals obtained, within one month of the start of the M.Phil. coursework.

Activities commonly understood to be part of research methodology (like literature survey, writing a proposal, developing proof-of-concept, documentation and publication of the research work) are common to all students. These will be started at the outset of the coursework. After the teaching in the first two Papers gains momentum the core teaching of the electives, as discussed above, will commence.

The following three elective topics are submitted initially:

Elective 1: Computational Intelligence and Artificial Life

Unit 1: Mimicking nature for problem solving – What is life?, What is computation?, Computational beauty of nature (fractals, chaos, L-systems etc), artificial Life and complex systems – self-organization and emergent complex behavior, open-ended evolution.

Unit 2: Evolutionary computation – genetic algorithms, genetic programming.

Unit 3: Learning and evolution – Darwinian, Lamarkian, Baldwin.

Unit 4: Intelligence through collective behavior – particle swarm optimization, ant colony optimization, evolution and coevolution, competition and cooperation, artificial cultural evolution.

Unit 5: Artificial immune systems – overview of natural immune systems (NIS), basic concepts like antigen, antibody, distinction between self and non-self, B-cells and T-cells, epitope molecules and receptor molecules, affinity and binding, primary and secondary immune responses. Computational attributes of NIS – Recognition, feature extraction, diversity, learning, memory, distributed network,self regulation etc.

Unit 6: AIS Architecture – comparison with other biologically inspired computing techniques like artificial neural networks, evolutionary computation etc. AIS framework of abstract models of cells, molecules, affinity functions and general- purpose algorithms.

Unit 7: AIS models: Negative selection – self and non-self, detectors, affinity, r-contiguous algorithm etc., clonal selection – proliferation, mutation, crossover, affinity maturation, formation of memory cell, immune network – idiotopes and receptors, internal image, connected cell, network suppression and network activation. AIS and intrusion detection – IDS overview. Review of different AIS based approaches to ID.

Elective 2: Knowledge Engineering

Unit 1: Case study approach for data warehousing: transactions at Wal-Mart, complete client histories at an insurance firm, stockbroker financial information and portfolios.

Unit 2: Research issues in query processing and optimization, database design and view management.

Unit 3: Health services research data warehouse, data warehouse objectives – create person-level view of data, construction of data extraction tools to support accessing data by chronic conditions, complex customized research data requests related to chronically illness, new formats for Medicare enrollment, claims and assessment data that support research.

Unit 4: Data Mining – text mining, web mining, predictive data mining, discovery driven data mining, verification driven data mining, decision support technologies, bioinformatics & pattern discovery, integration of data mining and information extraction.

Unit 5: Knowledge Discovery Laboratory (KDL) – investigating how to find useful patterns in large and complex databases. study of underlying principles of data analysis algorithms, developing innovative techniques for knowledge discovery, and their applications to practical tasks in areas such as fraud detection, scientific data analysis, and web mining. focuse on relational knowledge discovery, constructing useful statistical models from data about complex relationships among people, places, things, and events. Social communication networks and their impact - the Web, telecommunications networks, relational databases, object-oriented databases, and other sources of structured and semi-structured data.

Elective 3: Modern Distributed Systems

Unit 1: Study of the implementations of distributed system principles in following modern distributed systems. Java RMI, Jini, CORBA, J2EE, .net, web services, BPEL, web services orchestration engines.

Unit 2: Mobile computing, mobile agents, P2P, distributed multimedia systems.

Unit 3: Application of distributed computing in communication models, process implementations, naming, distributed file systems, global states.

Unit 4: Clock synchronization, coordination and agreement, transaction and concurrency control, consistency and replication, distributed shared memory, fault tolerance and security.

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