PAKISTAN INSTITUTE OF ENGINEERING AND APPLIED SCIENCES (PIEAS)
Department of Computer and Information Sciences (DCIS)

M. Phil. Program in Computer Science (CS)

Eligibility

a) 16 years of schooling
b) A course on Physics at Intermediate or Bachelor's level and Mathematics at both levels
c) Degree in Computer Science or a relevant area, from HEC/PEC recognized university, including
    i. M.Sc. Computer Science (M.Sc. CS)
    ii. Master of Computer Science (MCS)
    iii. 4-year Bachelor of Science in Computer Science or related areas
d) Minimum B-grade or at least 60% in the highest degree earned
e) For fellowship, first class academic carrier with only one 2nd division is allowed. Highest degree should be earned with 1st division.
f) For self finance, one 2nd division at any level

Salient Features

1. Fellows are required to qualify an eight-week semester called the "Zeroeth Semester" for the registration in M.Phil. Program.
2. Five regular semesters
3. Twelve courses and a Thesis Research Proposal in first three semesters with the following distribution:
    a. Five courses in 1st semester (13 cr. hrs.)
    b. Four courses in 2nd semester (12 cr. hrs.)
    c. Two taught courses, a lab course and a Thesis Research in 3rd semester (11 cr. hrs.)
4. Thesis Research in 4th and 5th semester (12 cr. hrs. each)
5. Total credit hours = 13 + 12 + 11 + 24 = 60
6. Fields of Specialization to be offered are indicated in the following table:

FIELDS OF SPECIALIZATIONS AND RELATED COURSE CODES

S.No.	SPECIALZATION	RELATED COURSES	
		SECOND SEMESTER	THIRD SEMESTER
1	Computational Intelligence and Machine Vision	CIS-521 to CIS-528	CIS-621 to CIS-629
2	Scientific Computing	CIS-541 to CIS-552	CIS-641 to CIS-648

Semester-Wise Course Plan

C: Core, **O**: Optional

S. No.	Course Code	Course Title	Cr. Hrs.	Course Status	Pre-requisites *
FIRST SEMESTER					
FIRST SEMESTER COMMON FOR BOTH SPECIALIZATIONS					
1	CIS-501	Numerical Methods and Optimization Techniques	3	C	NIL
2	CIS-502	Stochastic Processes	2	C	NIL
3	CIS-503	Principles of Digital Signal Processing	3	C	NIL
4	CIS-504	Algorithmic and Programming Methodologies	3	C	NIL
5	CIS-505	Theory of Computation	2	C	NIL
SECOND SEMESTER					
COMPUTATIONAL INTELLIGENCE AND MACHINE VISION					
6	CIS-521	Intelligent Agents	3	O	NIL
7	CIS-522	Artificial Neural Networks	3	O	NIL
8	CIS-523	Evolutionary Computing	3	O	NIL
9	CIS-524	Fuzzy Intelligence	3	O	NIL
10	CIS-525	Pattern Classification and Recognition	3	O	NIL
11	CIS-526	Digital Image Analysis and Processing	3	O	NIL
12	CIS-527	Natural Language Processing	3	O	NIL
13	CIS-528	Knowledge Engineering	3	O	NIL
14	CIS-595	Special Topics in CS-I	3	O	NIL
SCIENTIFIC COMPUTING					
15	CIS-541	Linear Systems Theory	3	O	NIL
16	CIS-542	Graphical Modeling and Algorithms	3	O	NIL
17	CIS-543	Queuing Theory	3	O	NIL
18	CIS-544	Monte Carlo Simulations	3	O	NIL
19	CIS-545	Information Coding and Cryptography	3	O	NIL
20	CIS-546	Parallel Computing	3	O	NIL
21	CIS-547	Real Time System Design and Architecture	3	O	NIL
22	CIS-548	Computer Animation	3	O	NIL
23	CIS-549	Finite Element Computations	3	O	NIL
24	CIS-550	Advanced Computer Architecture	3	O	NIL
25	CIS-551	Advanced Operating Systems	3	O	NIL
26	CIS-552	Advanced Database Systems	3	O	NIL
27	CIS-596	Special Topics in CS-II	3	O	NIL
THIRD SEMESTER					
COMPUTATIONAL INTELLIGENCE AND MACHINE VISION					
28	CIS-621	Machine Learning	3	O	CIS-525 or CIS-526
29	CIS-622	Cognitive Systems Modeling	3	O	CIS-521 or CIS-527
30	CIS-623	Biometrics Computing	3	O	CIS-525
31	CIS-624	Machine Vision	3	O	CIS-526 or CIS-528
32	CIS-625	Human Computer Interaction	3	O	CIS-527
33	CIS-626	Quantum Theory and Computing	3	O	NIL
34	CIS-627	Image and Video Compression	3	O	CIS-526
35	CIS-628	Game Theory	3	O	NIL
36	CIS-629	Computational Intelligence and Machine Vision Lab	3	C**	Relevant courses of 2nd semester
37	CIS-695	Special Topics in CS-III	3	O	
SCIENTIFIC COMPUTING					
38	CIS-641	Grid Computing	3	O	CIS-546
39	CIS-642	Virtual Reality	3	O	CIS-548
40	CIS-643	Non-Linear Systems	3	O	CIS-541
41	CIS-644	Modeling Chaos and Fractals	3	O	CIS-541
42	CIS-645	Parallel Algorithms	3	O	CIS-546

43	CIS-646	Advanced Optimization Techniques	3	O	NIL
44	CIS-647	Computational Mechanics	3	O	NIL
45	CIS-648	Scientific Computing Lab	3	C**	Relevant courses of 2nd semester
46	CIS-696	Special Topics in CS-IV	3	O	
47	CIS-698	M.Phil. Thesis Research***	2	C	Relevant courses in 1st and 2nd semesters

FOURTH AND FIFTH SEMESTER					
48	CIS-698	M.Phil. Thesis Research***	24	C	Relevant courses in 3rd semester

* Condition of pre-requisites may be relaxed in special cases by the Head, DCIS, on the recommendation of instructor concerned.

** Students of one specialization track have to register in the appropriate lab either CIS-629 or CIS-648.

*** Letter Grades A, B, C, and F will be awarded in these courses.

Note: Registered students of this program may register in courses offered by M.Sc. Systems Engineering program of DEE, if allowed by the Head, DCIS.

List of Courses

Course Contents
1st SEMESTER

CIS-501: Numerical Methods and Optimization Techniques

Status	Core
Credits	3
Prerequisites	NIL

Numerical evaluation of Eigen-values/Eigen-vectors, Solution of system of ODEs, Boundary value problems, Classification and solution of 2nd order Parabolic, Elliptic and Hyperbolic PDEs, Classical optimization of constrained/unconstrained functions, Gradient methods of optimization, Linear programming, Simplex method, Integer linear programming, Quadratic programming.

References

1. Faires J. D., and Burden R. L., *Numerical Methods*, 3rd ed., PWS Publishing Company, 2003.
2. Chapra S. C., and Canale R. P., *Numerical Methods for Engineers*, 5th ed., Mc-Graw Hill, 2006.
3. Reklaitis G. B., *Engineering Optimization Methods and Applications*, John Wiley & Sons, 1983.
4. Taha H. A., *Operations Research: An introduction*, 7th ed., Pearson Education, 2002.

CIS-502: Stochastic Processes

Status	Core
Credits	2
Prerequisites	NIL

Random variables and their types, Discrete and continuous random variables, Density function, Cumulative distribution function, Functions of random variables, Multiple random variables, Continuous time stochastic processes, Discrete time stochastic process, Markov chains, Hidden Markov model.

References

1. Yates R. D., and Goodman D. J., *Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers*, John Wiley & Sons, 2004
2. Carl W. H., *Probability and Stochastic Process for Engineers*, 2nd ed., Macmillan, 1984.
3. Garcia L. A., *Probability and Random Processes for Electrical Engineers*, 2nd ed., Addison-Wesley, 1994.

CIS-503: Principles of Digital Signal Processing

Status	Core
Credits	3
Prerequisites	NIL

Review of continuous-time signals and LTI systems, Review of frequency-domain analysis, Sampling and reconstruction, Discrete Fourier transform, Fast Fourier transform, Practical spectral analysis, Review of z-transforms and difference equations, Introduction to digital filters, Finite Impulse Response (FIR) Filters, Infinite Impulse Response (IIR) Filters, Digital Filter Realization and Implementation, Adaptive signal processing interference-cancellation, Spectral estimation Multirate Signal Processing, Digital Signal Processing Applications, DSP hardware.

References

1. Oppenheim A. V., Schafer R. W., and Buck J.R., *Discrete Time Signal Processing*, 2nd ed., Prentice Hall, 1999.
2. Proakis J. G., and Manolakis D. K., *Digital Signal Processing*, 4th ed., Prentice Hall, 2006.
3. McClellan J. H., Schafer R. W., and Yoder M.A., *Signal Processing First*, Pearson Education, 2005.
4. Oppenheim A. V., Schafer R. W., and Nawab S. H., *Signals and Systems*, 2nd ed., Prentice Hall, 1996.

CIS-504: Algorithmic and Programming Methodologies

Status	Core
Credits	3
Prerequisites	NIL

Complexity analysis, Asymptotic approximations, Distributions, Types of recurrences, Methods for solving recurrences, Generating functions, Transformations with generating functions, Functional equations on generating functions, The symbolic method, Lagrange inversion, Asymptotic expansions, Asymptotic approximations of finite sums, Euler-Maclaurin summation, Bivariate asymptotic, Permutations, Enumeration problems, Occupancy distributions, Maps.

References

1. Sedgewick R., and Flajolet P., *An Introduction to the Analysis of Algorithms*, 2nd ed., Addison Wesley, 1996.
2. Sterling L. S., and Shapiro E.Y., *Art of Prolog: Advanced Programming Techniques*, 2nd ed., MIT Press, 1994.
3. Stroustrup B., *The C++ Programming Language*, 3rd ed., Addison-Wesley, 1997.

CIS-505: Theory of Computation

Status	Core
Credits	2
Prerequisites	NIL

Automata theory, Formal languages, Turing machines, Computability theory and reducibility, Computational complexity, Determinism, Non-determinism, Time hierarchy, Space hierarchy, NP completeness, Selected advanced topics.

References

1. Michael S., *Introduction to the Theory of Computation*, PWS Publishing Company, 1997.
2. Lewis H. R., and Papadimitriou C.H., *Elements of Theory of Computation*, 2nd ed., Prentice Hall, 1998.
3. Savage J. E., *Models of Computation*, Addison Wesley, 1998.
4. Taylor R. G., *Models of Computation and Formal Languages*, Oxford University Press, 1997.
5. Jiang T., Li M., and Ravikumar B., *Formal Models and Computability- A Handbook of Computer Science*, CRC Press, 1996.

2nd SEMESTER

CIS-521: Intelligent Agents

Status	Optional
Credits	3
Prerequisites	NIL

Concepts of agents and intelligent agents, Types of agents, Action of agents, Percepts to actions. Structure of intelligent agents, Agent environments, Problem solving agents, Knowledge based agents, Communicating, Perceiving and acting, Planning agents, Decision-theoretic agents, Concepts of distributed Artificial Intelligence, Multiple agents, Agent communication languages, Interaction protocols, Agent development framework, Agent programming, Web based agents.

References

1. Resconi G., *Intelligent Agents*, Springer Verlag, 2004.
2. Russell S., and Norvig P., *Artificial Intelligence: A Modern Approach*, Prentice Hall, 2003.
3. Weiss G. (ed.), *Multi-Agent Systems: A Modern Approach to Distributed Artificial Intelligence*, MIT Press, 1999.
4. Wooldridge M., *Reasoning about Rational Agents*, MIT Press, 2000.
5. Ferber J., *Multi-Agent Systems: An Introduction to Distributed Artificial Intelligence*, Addison Wesley, 1999.

CIS-522: Artificial Neural Networks

Status	Optional
Credits	3
Prerequisites	NIL

Basic concepts of Neural-Computing, Learning processes, Single-layer perceptrons, Multilayer perceptrons, Radial-basis function networks, Strategies for avoiding overfitting, Support vector machines, Committee machines, Principal components analysis using neural networks, Self-organizing maps, Information-theoretic models, Stochastic machines, Neuro-dynamic programming, Temporal processing using feedforward networks, Neurodynamics, Recurrent neural networks.

References

1. Haykin S., *Neural Networks: A Comprehensive Foundation*, 2nd ed, Prentice Hall, 1999.
2. Hagan M.T., and Demuth, H., and Beale, M., *Neural Network Design*, PWS Publishing, 1996.
3. Fausett L., *Fundamentals of Neural Networks*, Prentice Hall, 1994.
4. Gupta M.M., Jin L., and Homma N., *Static and Dynamic Neural Networks: From Fundamentals to Advanced Theory*, Wiley Press, 2003.

CIS-523: Evolutionary Computing

Status	Optional
Credits	3
Prerequisites	NIL

Issues in classical optimization techniques, Introduction to evolutionary computation, Principles of evolutionary processes, Evolutionary programming, Genetic algorithms, Representation of data, Selection

methods, Search operators, Fitness evaluation, Constraint handling techniques, Population structure, Meta evolutionary approaches, Self-adaptation, Implementation issues, Evolutionary programming, Evolutionary strategies, Ant-colony optimization, Artificial immune systems.

References

1. Baeck T., *Evolutionary Computation*, Vol. 1 and 2, Taylor & Francis, 2000.
2. Mitchell M., *An Introduction to Genetic Algorithms*, MIT Press, 1996.
3. Eiben A.E., and Smith J.E., *Introduction to Evolutionary Computing*, Springer, 2003.
4. Jin Y.C. (Ed.), *Knowledge Incorporation in Evolutionary Computation*, Springer, 2005.
5. Koza J.R., Keane M.A., Streeter M. J., Mydlowec W., Yu J., and Lanza G., *Genetic Programming* IV: *Routine Human-Competitive Machine Intelligence*, Kluwer, 2003.

CIS-524: Fuzzy Intelligence

Status	Optional
Credits	3
Prerequisites	NIL

Basic concepts of fuzzy logic, Fuzzy Set Theory, Fuzzy relations, Fuzzy graphs and fuzzy arithmetic, Fuzzy if-then rules, Fuzzy implications and approximate reasoning, Fuzzy inference systems, Fuzzy models, Fuzzy logic in control engineering, Fuzzy logic in database management and Information systems, Application of Fuzzy in pattern recognition and system identification, Fuzzy experts systems, Adaptive neuro-fuzzy systems, Genetic algorithm and fuzzy logic.

References

1. Yen J., and Langari R., *Fuzzy Logic: Intelligence, Control and Information*, Prentice Hall, 1998.
2. Ross T. J., *Fuzzy Logic with Engineering Applications*, 2nd ed, John Wiley & Sons, 2004.
3. Pal S.K., and Mitra, S., *Neuro-fuzzy Pattern Recognition: Methods in Soft Computing*, Wiley, 1999.
4. Yan J., Ryan M., and Power J., *Using Fuzzy Logic: Towards Intelligent Systems*, Prentice Hall, 1994,
5. Jang J.R., Sun C., and Mizutani E., *Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence*, Pearson Education, 1996.

CIS-525: Pattern Classification and Recognition

Status	Optional
Credits	3
Prerequisites	NIL

Basic concepts, Linear and piece-wise linear techniques, Potential and stochastic approximation, Boolean and sequential decision making, Contextual, linguistic and array techniques, Coefficient analysis, Pattern preprocessing and feature selection, Learning decision functions, Pattern classification by distance functions, Pattern classification by likelihood functions, Trainable pattern classifiers, Deterministic and stochastic approach, Syntactic pattern recognition.

References

1. Gibson W., *Pattern Recognition*, Penguin Putnam, 2003.
2. Theodoridis S., and Koutroumbas, K., *Pattern Recognition*, 3rd ed., 2006.
3. Devroye L., Györfi L., and Lugosi G., *A Probabilistic Theory of Pattern Recognition (Stochastic Modelling and Applied Probability)*, Springer Verlag, 1997.
4. Bishop C. M., *Neural Networks for Pattern Recognition*, Clarendon Press-Oxford Press, 1996.

CIS-526: Digital Image Analysis and Processing

Status	Optional
Credits	3
Prerequisites	NIL

Image processing fundamentals, Image file formats, Digital image enhancement in spatial and frequency domain, Image segmentation, Image representation, Digital image restoration, Wavelets and multi-resolution processing, Image compression techniques, Morphological image processing, Color image processing.

References

1. Gonzolez R. C., and Woods R. E., *Digital Image Processing*, 2nd ed., Addison Wesely, 2002.
2. Gonzolez R. C., Woods R. E., and Eddins S. L., *Digital Image Processing using Matlab*, Pearson Education, 2004.
3. Castleman K. R., *Digital Image Processing*, Prentice-Hall Inc., 1996.

CIS-527: Natural Language Processing

Status	Optional
Credits	3
Prerequisites	NIL

Introduction to various fields of NLP, Challenges in NLP, Language characteristics and ambiguities, Linguistic NLP, Language modeling, morphology, syntax, phonology, phonetics, semantics, Statistical NLP, Zipf's Law, N-gram models, Parameter estimation, Lexicon - word classes and tagging, Parsing: deterministic and statistical methods, Combined linguistic and statistical approaches for NLP, Evaluation of NLP applications.

References

1. Manning C. D., and Schütze H., *Foundations of Statistical Natural Language Processing*, MIT Press, 1999.
2. Jurafsky D., and Martin J. H., *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*, Prentice Hall, 2000.
3. Jackson P., and Moulinier I., *Natural Language Processing for Online Applications: Text Retrieval, Extraction, and Categorization,* 5th ed., John Benjamins Publishing Company, 2002.

CIS-528: Knowledge Engineering

Status	Optional
Credits	3
Prerequisites	NIL

Knowledge engineering and knowledge systems, Historical perspective, Methodological pyramid principles, Model suite, Process roles, Impact and improvement analysis, Task and agent modeling, Guidelines for the context modeling process, Knowledge management, Knowledge model components, Knowledge model construction, Knowledge elicitation techniques and characteristics, Modeling communication aspects, Role and overview of the communication model, Designing knowledge systems.

References

1. Sowa J. F., *Knowledge Representation: Logical, Philosophical, and Computational Foundations,* Brooks Cole Publishing Co., 1999.
2. Gonzalez A. J., and Dankel D. D., *The Engineering of Knowledge-Based Systems,* Prentice Hall, 1993.
3. Poole D., Mackworth A., and Goebel R., *Computational Intelligence: A Logical Approach,* Oxford University Press, 1998.

CIS-595: Special Topics in CS-I

Status	Optional
Credits	3
Prerequisites	NIL

This course may be used for advanced topics not already covered in the syllabus. The special paper may be conducted as a lecture course or as an independent study course. The faculty must approve the topic and contents of the course.

CIS-541: Linear Systems Theory

Status	Optional
Credits	3
Prerequisites	NIL

Introduction to Linear Systems, Mathematical modeling of physical systems, Transfer function, Block diagram, Signal flow graph, Linearization of nonlinear systems, Introduction to control systems, State space analysis of linear dynamic systems, Stability of linear control systems, Time domain analysis of control systems, Root-locus technique, Time domain design of control systems, Frequency domain analysis of control systems, Compensation techniques and control system design, Control system simulations on MATLAB.

References

1. Ogata K., *Modern Control Engineering*, 4th ed., Prentice-Hall, 2002.
2. Kuo B.C., *Automatic Control Systems*, 7th ed., Prentice-Hall, 1995.
3. Dorf R.C., *Modern Control Systems*, 5th ed., Addison-Wesley, 1989.

CIS-542: Graphical Modeling and Algorithms

Status	Optional
Credits	3
Prerequisites	NIL

Introduction to graphs, trees, and spanning trees, Optimization algorithms in graph and trees, Probabilistic graphical models, Matching in general graphs, Coloring, Planarity, Connectivity, Communication reliability, Hamiltonicity, Arborescence and algorithm for computing minimum arborescence, Independent sets and perfect graphs, External graph theory, Ramsey Theory random graphs, Random walks on graphs, Bond graphs.

References

1. Diestel R., *Graph Theory*, 2nd ed., Springer-Verlag, 2000.
2. Bollobas B., *Modern Graph Theory,* Springer-Verlag, 1998.

3. Papadimitriou C.H., and Steiglitz K., *Combinatorial Optimization: Algorithms and Complexity*, Dover Publications, 1998.
4. West D.B., *Introduction to Graph Theory*, 2nd ed., Prentice Hall, 2000.

CIS-543: Queuing Theory

Status	Optional
Credits	3
Prerequisites	NIL

Description of queuing problem, Notations, Poisson process, Markovian property of the exponential distribution, Stochastic process and Markove chains, Steady state Birth-Death process, Markovian Birth-Death Queuing Model, Networks, Series and cyclic queues, Model with service patterns, Bounds, Approximation, Numerical techniques and simulation.

References

1. Kleinrock L., and Gail R., *Queuing Systems: Problems and Solutions*, John Wiley & Son, 1996.
2. Robertazzi T. G., *Computer Networks and Systems: Queuing Theory and Performance Evaluation*, Springer Verlag, 2000.
3. Gross D., and Harris C. M., *Fundamentals of Queuing Theory*, 3rd ed., John Wiley & Sons Inc. 1997.

CIS-544: Monte Carlo Simulations

Status	Optional
Credits	3
Prerequisites	NIL

Introduction to Monte Carlo simulations, Pseudo-Random number generation, Simple applications of Monte Carlo method, Use of Monte Carlo method in solving field problems, Monte Carlo simulation of real time systems, Case studies, Simulation of micro, macro and super macro systems.

References

1. Malvin H. K., and Pola A. W., *Monte Carlo Methods*, Vol. 1, John Wiley & Sons, 1986.
2. Bennett B. S., *Simulation Fundamentals*, Prentice Hall Inc., 1995.
3. Rieder W. G., and Busby A. R., *Introductory Engineering Modeling*, John Wiley & Sons, 1986.
4. Nakamura S., *Computational Methods in Engineering and Science*, John Wiley & Sons, 1997.

CIS-545: Information Coding and Cryptography

Status	Optional
Credits	3
Prerequisites	NIL

Introduction to Information Theory, Uncertainty and Information Entropy, Information Capacity Theorem, Source Coding Theorem, Huffman Coding, The Lempel-Ziv Algorithm, Run Length Encoding and the PCX Format, Channel Capacity and Coding, Channel Models, Random Selection of Codes, Error Correcting Codes, Syndrome Decoding, Perfect Codes, Optimal Linear Codes, Maximum Distance Separable (MDS) Codes, Cyclic Codes, BCH Codes, Reed-Solomon Codes, Nested Codes, Convolution Codes Tree Codes and Trellis Codes, Performance Bounds, Turbo Codes.

References

1. Trappe W., and Washington L. C., *Introduction to Cryptography with Coding Theory*, Prentice Hall, 2nd ed., 2005.
2. McEliece E.R., and Rota G. C., *Theory of Information & Coding*, Cambridge University Press, 2nd ed., 2002.
3. Hankerson D., *Coding Theory and Cryptography: The Essentials*, CRC Press, 2nd ed. 2000.
4. Mao W., *Modern Cryptography: Theory and Practice*, Prentice Hall PTR, 2003.
5. Schneier B., *Applied Cryptography: Protocols, Algorithms, and Source Code in C*, Wiley, 2nd ed., 1995.

CIS-546: Parallel Computing

Status	Optional
Credits	3
Prerequisites	NIL

Introduction, Parallel programming platforms, Memory architectures, Basic communication operations, Computational overheads, Level of abstraction, Principles of parallel computation, Model of computations and parallel overheads, Parallel programming using message passing paradigm, Programming shared memory address space platforms.

References

1. Culler D. E., Singh J. P., and Gupta A., *Parallel Computer Architecture: A Hardware/Software Approach*, Morgan Kaufmann Publisher, 1999.
2. Foster I., *Designing and Building Parallel Programs*, Addision-Wesley, 1995.
3. Grama A., Gupta A., Karypis G., and Kumar V., *Introduction to Parallel Computing*, 2nd ed., Addison-Wesley, 2003.

CIS-547: Real Time System Design and Architecture

Status	Optional
Credits	3
Prerequisites	NIL

High-level software architecture, Decomposition into tasks, Object orientation for embedded/real-time software, Deadlock, Lockout, Starvation, Intertask data communication, Intertask synchronization, Modeling of message queues, Mutexes, Priority inheritance and priority ceiling, Architectural design of device I/O drivers, Design patterns for embedded software, Evaluating real-time and multitasking software designs, Performance analysis, Task scheduling theory and calculations, Embedded systems design, Clusters, Safety-critical embedded systems design.

References

1. Douglass B.P., *Real-Time Design Patterns: Robust Scalable Architecture for Real-Time Systems*, Addison Wesley, 2002.
2. Qing L., and Yao C. *Real-time Concepts for Embedded Systems*, San Francisco: CMP Books, 2003.
3. Burns A., and Wellings A. *Real-Time Systems and Programming Languages*, Addison Wesley Longmain, 2001.

CIS-548: Computer Animation

Status	Optional
Credits	3
Prerequisites	NIL

Introduction to computer animation, Principles of animation, Modeling and Rendering, Key framing, Kino-dynamic planning, Kinematics and inverse kinematics, Space-time constraints, Least constraint, Multidimensional motion interpolation, Collision detection, Motion signal processing, Reusable motion synthesis using state-space controllers, Limit cycle control and its application to animation, Dynamical particle animation.

References

1. Rick P., *Computer Animation: Algorithms and Techniques*, Morgan Kaufmann, 2001.
2. Giambruno M., *3D Graphics & Animation*, 2nd ed., New Riders Press, 2002.
3. Kerlow I.V., *The Art of 3-D Computer Animation and Effects*, 3rd ed., John Wiley & Sons, 2003.

CIS-549: Finite Element Computations

Status	Optional
Credits	3
Prerequisites	NIL

Overview of structure and continuum mechanics, Variation methods (Rayleigh-Ritz and Galerkin). Finite element analysis for elliptic equations, Base functions and techniques of interpolation, Local stiffness matrix and global stiffness matrix, Time dependant problems, Computational implementations, Applications to solid mechanics, Stokes and Navier-Stokes flows. Overview of Non-Linear finite element analyses, Formulation of geometrically non-linear finite elements, Solution of non-linear equations, Computer implementation of non-linear analyses.

References

1. Kythe, P. K. K., and Wei, D., *An Introduction to Linear and Nonlinear Finite Element Analysis*, Birkhauser Verlag, Basel, 2003.
2. Rao S.S., *The Finite Element Method in Engineering*, 3rd ed., Butterworth Heinemann, 1999.
3. Smith I.M., and Griffiths D.V., *Programming the Finite Element Method*, 3rd ed., John Wiley & Sons, 2001.
4. Hughes T. J. R., *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Prentice-Hall, 2000.
5. Brebbia C.A., and Ferrante A.J., *Computational Methods for the Solution of Engineering Problems*, 3rd ed., John Wiley & Sons, 1986.

CIS-550: Advanced Computer Architecture

Status	Optional
Credits	3
Prerequisites	NIL

Overview of modern processor architectures, Processor Design, Memory Hierarchy, Cache and Cache Coherence, Bus Architecture, Types of parallel machine, Vector Pipeline Architectures, Replicated Architectures: SIMD/MIMD, Shared Memory and Distributed Memory, Connectivity, Clusters, Networks, Routing, Performance Comparison, Dataflow, Virtual Concurrency, Branch prediction, Caches, including the TLB, Emulated instruction sets, VLIW, Out of order execution, Latency hiding, Case Studies, e.g. iA64, Linux clusters, IBM SP , Microcontrollers, including the PIC, Real-time processors, including TMS320.

References

1. Patterson D. A., and Hennesy J. L., *Computer Organization and Design*, Morgan Kaufmann 1993.
2. Sima D., Fountain T., and Kacsuk P., *Advanced Computer Architectures*, Addison-Wesley 1997.

CIS-551: Advanced Operating Systems

Status	Optional
Credits	3
Prerequisites	NIL

Process Synchronization, Synchronization Mechanisms, Process Deadlocks, Distributed Operating Systems, Architectures of Distributed Systems, Theoretical Foundations, Distributed Mutual Exclusion, Distributed Deadlock Detection, Agreement Protocols, Distributed Resource Management, Distributed File Systems, Distributed Share Memory, Distributed Scheduling, Failure Recovery and Fault Tolerance, Recovery, Fault Tolerance, Protection and Security, Resource Security and Protection Access and Flow Control, Data Security Cryptography, Multiprocessor Operating Systems, Multiprocessor System Architectures, Multiprocessor Operating Systems, Database Operating Systems, Introduction to Database Operating Systems, Concurrency Control Theoretical Aspects, Concurrency Control, real-time systems, proportional share resource management, A substantial project is required.

References

1. Singhal M., and Shivaratri N. G., *Advanced Concepts in Operating Systems*, McGraw-Hill Series in Computer Science, 1994.

CIS-552: Advanced Database Systems

Status	Optional
Credits	3
Prerequisites	NIL

Database life cycle, Data modeling, Logical design and physical design, Database transactions, Concurrency control, Concurrency problems, Deadlocks, Serializability, Query optimization, Object oriented database processing, ODBMS standards, Object-relational features of the SQL standard, Database modeling using EER and industry modeling using UML, Foundation for Object/Relational Databases, Architecture of a distributed database system, Components of distributed database system, Data placement, Placement of DDBMS, Synchronization problem, Models and applications, Problems of distributed systems. Components of data warehousing, Operational data, Online analytical processing,

References

1. Toby J. T., *Database Modeling and Design*, Morgan Kaufman, 1999.
2. Philip A. B., and Eric N., *Principles of Transaction Processing*, Morgan Kaufmann, 1997.
3. Ozsu M. T., and Valduriez P., *Principles of Distributed Database Systems*, Prentice Hall, 2nd Ed., 1999.
4. Date C.J., and Darwen H., *Foundation for Object/Relational Databases: The Third Manifesto*, Addison Wesley, 1998.

CIS-596: Special Topics in CS-II

Status	Optional
Credits	3
Prerequisites	NIL

These are the courses that may be used for advanced topics not already covered in the syllabus. The special paper may be conducted as a lecture course or as an independent study course. The faculty must approve the topic and contents of the course.

3rd SEMESTER

CIS-621: Machine Learning

Status	Optional
Credits	3
Prerequisites	CIS-525 or CIS-526

Introduction, Concept learning and general-to-specific ordering, Decision tree learning, Supervised learning, Artificial neural networks, Evaluating hypotheses, Bayesian learning, Instance-based learning, Statistical learning methods, Memory based learning, Transformation based learning, Inductive logic programming, Support vector machine, Unsupervised learning, Temporal difference learning, Reinforcement learning, Explanation based learning.

References

1. Mitchell T. M., *Machine Learning*, McGraw-Hill, 1997.
2. Alpaydin E., *Introduction to Machine Learning*, MIT Press and Prentice Hall of India, 2004.
3. Nelson N. J., *Introduction to Machine Learning*, (Online book draft) http://robotics.stanford.edu/people/nilsson/mlbook.html, 2005.
4. Langley P., *Elements of Machine Learning*, Morgan Kaufmann, 1996.
5. Kodratoff Y., *Introduction to Machine Learning*, Morgan Kaufmann, 1993.

CIS-622: Cognitive Systems Modeling

Status	Optional
Credits	3
Prerequisites	CIS-521 or CIS-527

Introduction to cognitve modeling, Approaches to cognitive modeling, Cognitive architectures, Models of problem solving, language processing, Reasoning, Evaluation of models, Probabilistic models: Rational analysis, Decision making, Bayes classifier, and Belief networks, Models of syntactic processing, Models of priming and parallism, Models of semantic processing, Models of casual inferences, Case studies

References

1. Polk T.A., and Seifert C.M. (Editors), *Cognitive Modeling*, MIT Press, 2002.
2. Bechtel W., and Graham G., *A Companion to Cognitive Science*, Blackwell Publishers, 1999.
3. Myung J., Busemeyer J.R., and Pitt M.A., *Cognitive Modeling*, Sage Publisher, 2003.
4. Levine D.S., *Introduction to Neural and Cognitive Modeling*, 2nd ed., LEA, 2000.

CIS-623: Biometrics Computing

Status	Optional
Credits	3
Prerequisites	CIS-525

Introduction to Biometric process, Biometric parameters, Different biometric system architecture, Fingerprint based biometrics, Face recognition systems, Iris based biometrics, Speaker recognition systems using voice, Retina scan based biometrics, Hand scan based biometrics, Comparison of different biometrics verification techniques, Multimodal Biometrics, Biometric watermarking.

References

1. Wayman J., Jain A.K., Maltoni D., and Maio D., *Biometric Systems: Technology, Design and Performance Evaluation*, Springer, 2004.
2. Ashbourn J., *Practical Biometrics: From Aspiration to Implementation*, Springer, 2003.
3. Maltoni D., Maio D., Jain A.K., and Prabhakar S., *Handbook of Fingerprint Recognition*, Springer, 2005.
4. Bolle R., Connell J., Pankanti S., Ratha N., and Andrew S., *Guide to Biometrics*, Springer, 2003.

5. Jain A.K., Bolle R., and Pankanti S., *Biometrics: Personal Identification in Networked Society, International Series in Engineering and Computer Science*, Springer, 1999.

CIS-624: Machine Vision

Status	Optional
Credits	3
Prerequisites	CIS-526 or CIS-528

Concept of a machine vision system, Image file formats, Essentials of projective geometry, Image and camera models, Feature extraction, Camera calibration, Stereopsis, Structure from motion, Shape from single image cues, Object recognition, Pose Estimation, 3 D vision, Video images, Case studies.

References

1. Forsyth D. A. and Ponce J., *Computer Vision: A Modern Approach*, Prentice Hall, 2002.
2. Trucco and Verri A., *Introductory Techniques for 3-D Computer Vision*, Prentice Hall, 1998.
3. Gonzolez R. C., and Woods R. E., *Digital Image Processing*, 2nd ed., Addison Wesley, 2002.

CIS-625: Human Computer Interaction

Status	Optional
Credits	3
Prerequisites	CIS-527

Introduction and overview of HCI, Human information processing limitations, human decision making Human cognitive and sensory limits, Human memory, Human problem solving, Skill acquisition, Users' conceptual models, Decision making, Computer systems and user interfaces, human-system interaction, Interaction models and metaphors, Design process: overview, and need analysis, Design, verification, testing, and evaluation of HCI systems, Speech user interfaces, Computer supported cooperative work, organizational and social issues, HCI in mission-critical and high risk environments.

References

1. Shneiderman B., and Plaisant C., *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 4th ed., Addison Wesley, 2004.
2. Dix A. J., Finlay J. E., et. al., *Human-Computer Interaction*, 2nd ed., Prentice Hall, 1998.
3. Jacko J. A., and Sears A., *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*, Lea Press, 2002.
4. Preece J., Rogers Y. et. al., *Human-Computer Interaction: Concepts and Design*, Addison Wesley, 1994.

CIS-626: Quantum Theory and Computing

Status	Optional
Credits	3
Prerequisites	NIL

Introduction to quantum mechanics, Classical gates, Quantum bits, Universial quantum gates, Quantum computers, Quantum algorithms, Deutsch's problem, Fourier transform, Factoring, Shor's algorithm, Grover's algorithm, Classical and quantum cryptography, Quantum teleportation, Error correction, Physical implementation of quantum computing.

References

1. Nielsen M. A., and Chuang I. L., *Quantum Computation and Quantum Informatrion*, Cambridge University Press, 2002.
2. Brylinski R. K., and Chen G., *Mathematics of Quantum Computation*, Chapman and Hall, 2002.
3. Pittenger A. O., *An Introduction to Quantum Computing Algorithms*, Birkhauser, 2001.

CIS-627: Image and Video Compression

Status	Optional
Credits	3
Prerequisites	CIS-526

Motivation for image and video compression, Review of important concepts from information theory, Scalar and vector quantization, Human visual systems and vision modeling, Transform coding, Tree based encoding, Resolution pyramids and subband coding, Still image compression standards, Fractal image compression, Interframe coding, Differential PCM, Motion estimation, Motion compensation, Video compression standards, Filtering in video systems.

References

1. Clarke R., *Digital Compression of Still Images and Video*, Academic Press, 1995.
2. Jayant N., *Signal Compression, Coding of Speech, Audio, Image and Video*, World Scientific Co., 1997.
3. Kou K. W., *Digital Image Compression: Algorithms and Standards*, Springer, 1999.

CIS-628: Game Theory

Status	Optional
Credits	3
Prerequisites	NIL

Introduction, Matrix games, Games in normal form, Min-max theorems in zero-sum games, Existence of Nash equilibrium, Multi player games, Dynamic games, In-extensive form, Sub game perfect equilibria, Static games of incomplete information, Bayesian equilibria, Repeated games, Machine games, Optimal bargaining, Stackelberg solutions, the core, stable sets, the Shapley value, Nash solution, Differential games, Robust control, Evolutionary game theory.

References

1. Basar and Olsder, *Dynamic Non-cooperative Game Theory*, 2nd ed., Academic Press 1999.
2. Lewin J., *Differential Games*, Springer Verlag, 1994.
3. Myerson R.B., *Game theory: Analysis of conflict*, Harvard University Press, 1991.
4. Aumann R. J., and Maschler M.B., *Repeated Games with Incomplete Information*, MIT Press, 1995.
5. Tijs S., *Introduction to Game Theory*, Hindustan Book Agency, 2003.

CIS-629: Computational Intelligence and Machine Vision Lab

Status	Core
Credits	3
Prerequisites	Relevant course from 2nd semester

Under this compulsory course of the specialization track 'Computational Intelligence and Machine Vision' students will perform 8 to 12 experiments that will be related to the following broad topics:

1. DSP hardware
2. Stochastic Process Modeling and Simulation
3. Intelligent Mobile Agents
4. Stereo Vision
5. Hardware Implementation of Neural Networks
6. Neuro-fuzzy Pattern Classification System
7. Natural Language Interpreter
8. MPEG Standards
9. Biometric System Design
10. Animating Games

CIS-695: Special Topics in CS-III

Status	Optional
Credits	3
Prerequisites	NIL

This course is for advanced topics not already covered in the syllabus. The special paper may be conducted as a lecture course or as an independent study course. The faculty must approve the topic and contents of the course.

CIS-641: Grid Computing

Status	Optional
Credits	3
Prerequisites	CIS-546

Introduction, Grid architecture, Networking infrastructure, Protocols and quality of service, Computing platforms, Operating systems and network interfaces, Compilers, Languages and libraries for the grid, Grid scheduling, Resource management, Resource brokers, Resource reservations, Instrumentation and measurement, Performance analysis and visualization, Security, Accounting and assurance, The Globus Toolkit: Core systems and related tools such as the Message Passing Interface communication library, the Remote I/O (RIO) library, and the Nimrod parameter study library, Legion and related software, Open grid service architecture and Data grids.

References

1. Silva V., *Grid Computing For Developers*, Charles River Media, 2005.
2. Abbas A., *Grid Computing: Practical Guide to Technology & Applications*, Charles River Media, 2003.
3. Juhasz Z., Kacsuk P., and Kranzlmuller D., *Distributed and Parallel Systems: Cluster and Grid Computing*, Springer, 2004.

CIS-642: Virtual Reality

Status	Optional
Credits	3
Prerequisites	CIS-548

Introduction to Virtual Reality (VR), VR tools, VR computing architectures, Modeling of virtual environment: geometric modeling, Kinematics and physical modeling, Object behavior and model segmentation, and visualization parameters, Commercially available systems and their approach of developing virtual environment using object-oriented techniques: Actors and runtime system, Standard elements, VC Tool kit, Object-Oriented hierarchical database, The MAZ virtual environment format, Meta-script Language.

References

1. Sherman W.R., and Craig A.B., *Understanding Virtual Reality: Interface, Application, and Design*, Morgan Kaufmann, 2002.
2. Burdea G.C., and Coiffet P., *Virtual Reality Technology*, 2nd ed., Wiley-IEEE Press, 2003.
3. Bowman D.A., Kruijff E., LaViola J.J., and Poupyrev I., *3D User Interfaces: Theory and Practice*, Addison-Wesley, 2004.
4. Bartle R., *Designing Virtual Worlds*, New Riders Games, 2003.

CIS-643: Nonlinear Systems

Status	Optional
Credits	3
Prerequisites	CIS-541

Mathematical modeling of nonlinear Systems, Limit cycles, Bifurcation, Fundamental properties of solutions, Lie algebra, Lyapunov stability, Input-output stability, Passivity, Frequency domain analysis, Advanced stability analysis, Perturbation theory, Feedback control of nonlinear systems, Nonlinear control design tools**.**

References

1. Khalil H.K., *Nonlinear Systems*, 3rd ed., Prentice Hall, 2001.
2. Slotine J.J., and Li W., *Applied Nonlinear Control*, Prentice Hall, 1991.
3. Freeman R.A., and Kokotovic P.V., *Robust Nonlinear Control Design: State Space and Lyapunov Techniques*, Birkhauser Verlag, 1996.

CIS-644: Modeling Chaos and Fractals

Status	Optional
Credits	3
Prerequisites	CIS-541

Metric spaces, Chaos in real life, Fixed points, Periodic points, Attractors and repellers, Parameterized families of functions and bifurcations, Period doubling, Dynamics of the logistic map, Symbolic dynamics, chaos, Dynamic properties of chaotic systems, Topological equivalence of the logistic map and the shift map, Newton's method, Dynamics on the complex line, Iterations of rational functions, Julia sets, Mandelbrot set.

References

1. Mandelbrot B.B., *Fractals and Chaos*, Springer-Verlag, 2004.
2. Peitgen H.O., Jurgens H., Saupe D., and Jnrgens H., *Chaos and Fractals*, 2nd ed., Springer-Verlag, 2004.
3. Thompson J.M.T., and Stewart H.B., *Nonlinear Dynamics and Chaos*, 2nd ed., John Wiley & Sons, 2002.

CIS-645: Parallel Algorithms

Status	Optional
Credits	3
Prerequisites	CIS-546

Principals of parallel algorithms, Dense/sparse matrix algorithms, Sorting algorithms, Graph algorithms, Search algorithms, Fast Fourier Transform (FFT), Iterative solution of linear systems, Analysis of computation, communication and synchronization, Parallel numerical libraries.

References

1. Foster I., *Designing and Building Parallel Programs*, Addison-Wesley, 1995.
2. Grama A., Gupta A., Karypis G., and Kumar V., *Introduction to Parallel Computing*, 2nd ed., Addison-Wesley, 2003.
3. Roosta S. H., *Parallel Processing and Parallel Algorithms: Theory and Computation*, Springer-verlag, 2000.

CIS-646: Advanced Optimization Techniques

Status	Optional
Credits	3
Prerequisites	NIL

Non-Simplex methods, Non-linear optimization with equality and inequality constraints, Network models, Goal programming, Deterministic and probabilistic dynamic programming, Deterministic and probabilistic Inventory models, Forecasting models, Decision analysis and games, Markovian decision process, Geometric programming, Non-Smooth optimization.

References

1. Reklaitis G. V., Ravindran A., and Ragsdell K. M., *Engineering Optimization: Methods and Applications*, John Wiley & Sons, 1983.
2. Fletcher R., *Practical Methods of Optimization*, 2nd ed., John Wiley & Sons, 2004.
3. Taha H. A., *Operations Research: An introduction*, 7th ed., Pearson Education, 2002.
4. Chong E. K. P., and Zak S. H., *An Introduction to Optimization*, 2nd ed., John Wiley & Sons, 2004.

CIS-647: Computational Mechanics

Status	Optional
Credits	3
Prerequisites	NIL

Conservation Laws, Euler Equation, Incompressible and Compressible Navier Stokes Equations, Finite Difference Formulae for Parabolic elliptic and hyperbolic equations in fluid mechanics and their methods of solution, Linear stability analysis, Godunov's theorem, Non-linear Advection, Berger's equation, Shocks and shock relations, Riemann Invariants, Riemann Problem, TVD scheme, Lattice Boltzmann Method for fluid dynamics.

References

1. Anderson J. D., *Computational Fluid Dynamics: The Basics with Applications*, Mc Graw Hill, 1995.
2. Hoffmann K. A., and Chiang S. T., Computational Fluid Dynamics, (Vol 1-3) 4th Ed., Engineering Education Systems, 2000.
3. Sacci S., and Succi S., *The Lattice Boltzmann Equation for Fluid Dynamics and Beyond*, Oxford University Press, 2001.
4. Chung, T.J., Computational Fluid Dynamics, Cambridge University Press, 2002.
5. Date A.W., Introduction to Computational Fluid Dynamics, Cambridge University Press, 2005.

CIS-648: Scientific Computing Lab

Status	Core
Credits	3
Prerequisites	Relevant courses from 2nd semester

Under this compulsory course of the specialization track 'Scientific Computing' students will perform 8 to 12 experiments that will be related to the following broad areas:

1. DSP hardware
2. Stochastic Process Modeling and Simulation
3. Simulating Real Time Queues
4. Network Modeling and Simulation
5. Modeling and Control of Linear Systems
6. Monte Carlo Simulations
7. Simulation and Implementation of Coding Algorithms
8. Distributed Operating System
9. Fractals Geometry
10. Finite Element Computations in Mechanics

CIS-696: Special Topics in CS-IV

Status	Optional
Credits	3
Prerequisites	NIL

These courses for advanced topics not already covered in the syllabus. The special paper may be conducted as a lecture course or as an independent study course. The faculty must approve the topic and contents of the course.

M.Phil. THESIS RESEARCH IN 3rd, 4th and 5th SEMESTER

CIS-698: M.Phil. Thesis Research

Status	Core
Credits	2+12+12
Prerequisites	Relevant courses in 3rd semester

Under this title, student will conduct research based project on some Computer Science related problem. He/She may take part in the on-going research or may introduce a novel approach in a specific field in consultation with his/her supervisor.

Under CIS-698 a proposal for Thesis Research should be developed for the project to be taken, being offered by the faculty member within the institute or outside. Under CIS-698, in fourth and fifth semesters, full time Thesis Research should be carried out based on the Thesis Research Proposal developed in third semester. This work of 4th and 5th semesters will be equivalent to four courses (12 cr. hrs.), each.

In CIS-698, concerned supervisor will instruct and supervise the student. He/She along with other examiners will assess and evaluate the student. A report and seminar should be given by the student before the end of each semester. The nature of the project may be research, development or design and may involve experimental or computational work or combination of both. Student performance in these activities will also be counted towards the overall evaluation. Normally this project is to be completed in full time work as specified, however, if supervisor(s) would feel at any stage that more time is required for the satisfactory completion of the project, the duration may be extended.