M. Phil. Program in Computer Science (CS)

Fields of Specialization

1	Computational Intelligence and Machine Vision
2	Scientific Computing
3	Information System Security

Semester-Wise Course Plan

IR: Institutional Requirement, **C**: Compulsary, **O**: Optional

S. No.	Course Code	Course Title	Cr. Hrs.	Course Status	Pre-requisites *
SPRING SEMESTER – YEAR 1					
COMMON FOR THREE SPECIALIZATIONS					
1	CMS-501	Communication Skills	1	IR	NIL
2	CIS-502	Stochastic Processes	2	C	NIL
3	CIS-504	Algorithms Design	3	C	NIL
4	PAM-524	Linear Algebra	3	C	NIL
5	CIS-551	Advanced Operating Systems	3	C	NIL
SUMMER SESSION – YEAR 1					
COMPUTATIONAL INTELLIGENCE AND MACHINE VISION					
6	EE-508	Computational Intelligence	3	C	NIL
7	CIS-526	Digital Image Processing and Analysis	3	C	NIL
SCIENTIFIC COMPUTING					
8	PAM-568	Numerical Solution of Differential Equations	3	C	NIL
9	CIS-546	Parallel Computing	3	C	NIL
INFORMATION SYSTEM SECURITY					
10	CIS-561	Computer Forensics	3	C	NIL
11	CIS-562	Information Theory and Coding	2+1	C	NIL
FALL SEMESTER – YEAR 1					
COMPUTATIONAL INTELLIGENCE AND MACHINE VISION					
12	CIS-505	Theory of Computation	3	C	NIL
13	CIS-550	Advanced Computer Architecture	3	C	NIL
14	CIS-522	Human Computer Interaction	3	O	NIL
15	CIS-523	Evolutionary Computing	3	O	NIL
16	CIS-525	Pattern Classification and Recognition	3	O	NIL
17	CIS-527	Natural Language Processing	3	O	NIL
18	CIS-528	Knowledge Engineering	3	O	NIL
19	CIS-529	Bio Informatics	3	O	NIL
20	CIS-531	Medical Image Processing	3	O	CIS-526
21	CIS-532	Graphics and Visualization	3	O	NIL
22	CIS-595	Special Topics in CIMV-I	3	O	
SCIENTIFIC COMPUTING					
23	CIS-505	Theory of Computation	3	C	NIL
24	CIS-532	Graphics and Visualization	3	O	NIL
25	CIS-541	Cloud Computing	3	O	NIL
26	CIS-542	Optimization Techniques	3	O	NIL
27	CIS-544	Monte Carlo Simulations	3	O	NIL
28	CIS-549	Finite Element Computations	3	O	PAM-585
29	CIS-550	Advanced Computer Architecture	3	C	NIL

30	CIS-555	Cluster System Management	2+1	O	CIS-546
31	PAM-585	Numerical Methods and Optimization Techniques	3	O	NIL
32	CIS-596	Special Topics in SC-I	3	O	
33	CIS-505	Theory of Computation	3	C	NIL
34	CIS-550	Advanced Computer Architecture	3	C	NIL
35	CIS-552	Advanced Database Systems	3	O	NIL
36	CIS-563	Cryptographic Algorithms	3	O	CIS-562
37	CIS-564	Software Security	3	O	CIS-561
38	CIS-565	Information System Security Management	3	O	NIL
39	CIS-566	Computer Security Management	3	O	NIL
40	CIS-597	Special Topics in ISS-I	3	O	

SPRING SEMESTER - YEAR 2					
COMPUTATIONAL INTELLIGENCE AND MACHINE VISION					
41	NE-501	Fundamentals of Nuclear Engineering	3	IR	NIL
42	CIS-621	Machine Learning	3	O	CIS-525
43	CIS-623	Biometrics Computing	3	O	CIS-525
44	CIS-624	Machine Vision	3+1	C	CIS-526
45	CIS-630	Advanced Evolutionary Computing	3	O	CIS-523
46	CIS-631	Intelligent Watermarking Techniques	3	O	EE-508
47	CIS-642	Virtual Reality	3	O	CIS-532
48	CIS-695	Special Topics in CIMV-II	3	O	
49	CIS-698	M.Phil. Thesis Research**	3	C	Relevant courses in previous semester
SCIENTIFIC COMPUTING					
50	NE-501	Fundamentals of Nuclear Engineering	3	IR	NIL
51	CIS-548	Computer Animation	3	O	CIS-532
52	CIS-641	Grid Computing	3	O	CIS-546
53	CIS-645	Parallel Algorithms	3+1	C	CIS-546
54	CIS-646	Advanced Optimization Techniques	3	O	PAM-585
55	CIS-696	Special Topics in SC-II	3	O	
56	CIS-698	M.Phil. Thesis Research**	3	C	Relevant courses in previous semester
INFORMATION SYSTEM SECURITY					
57	NE-501	Fundamentals of Nuclear Engineering	3	IR	NIL
58	CIS-661	Data Warehousing	3	O	CIS-552
59	CIS-664	Secure Communication Design	3+1	C	CIS-562
60	CIS-665	Embedded System Security	3	O	CIS-563
61	CIS-697	Special Topics in ISS-II	3	O	
62	CIS-698	M.Phil. Thesis Research**	3	C	Relevant courses in previous semester

SUMMER SEMESTER - YEAR 2					
COMMON FOR THREE SPECIALIZATIONS					
63	CIS-698	M.Phil. Thesis Research**	12	C	Relevant courses in previous semester

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

** M.Phil. thesis will be graded as Excellent, Very Good, Good, Fair or Unsatisfactory.

Note:

- Registered students of this program may register in courses offered by MS programs in other disciplines at PIEAS, if allowed by the Head, DCIS.

Course Contents

CMS-501: Communication Skills

Status	Institutional Requirement
Credits	1
Prerequisites	Nil

Writing module: Preparation of a project proposal or technical report, writing letters, mission statements, office memos etc; Speaking module: Presentation of the project proposal or technical report; Listening module: Simulations of interviews, lectures and question-answer sessions; Reading module: Reading of a suitable fiction novel (approximately 30-50 pages a week) with the use of vocabulary support, completion of assigned tasks and discussions.

References

1. Eric H. G., and Glendinning N., *English for Electrical and Mechanical Engineering*, Oxford University Press, 1995.
2. Huckin T. N., and Oslen L.A., *Technical Writing and Professional Communication for Nonnative Speakers of English*, 2nd Edition, McGraw Hill, 1991.
3. Swales J. M., and Feak C. B., *Academic Writing for Graduate Students, A Course for Nonnative Speakers of English*, 3rd Edition, Uni. of Michigan Press, 1994.

NE-501: Fundamentals of Nuclear Engineering

Status	Institutional Requirement
Credits	3
Prerequisites	Nil

Role and importance of nuclear energy; Nuclear cross-sections; Reaction rates; Nuclear fission and chain reaction; Criticality conditions; Conversion and breeding, Reactor components and their characteristics; Classification and design features of research, production, and power reactors, Introduction to fast and fusion reactor systems; Different types of fuel cycles; Core and feed-material preparations; Uranium enrichment; Fabrication of fuel; Reprocessing of irradiated fuel; Process waste disposal; Reactor fuel requirements; Burnup studies of nuclear fuels; Fuel cycle performance of commercially available reactors; In-core fuel management and fuel management strategies.

References:

1. Lamarsh, J. R, *Introduction to Nuclear Engineering*, Addison-Wesley, 1983.
2. Glasstone, S. and A. Sesonske, *Nuclear Reactor Engineering*, D Van Nostrand, 1981.
3. Rahman, I. U. and Sheikh P. S., *Introduction to Nuclear Engineering*, Krieger, 1981.
4. Graves H. W. Jr., *Nuclear Fuel Management*, John Wiley, 1979.

CIS-502: Stochastic Processes

Status	C
Credits	2
Prerequisites	Nil

Random variables and their types; Discrete and continuous random variables; Distribution and Density function; Cumulative distribution function; Independence; Conditional distributions; Expectations; Limit theorem; Functions of random variables; Multiple random variables; Gaussian processes; 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. Papoulis A. and Pillai S. U., *Probability, Random Variables and Stochastic Processes* 4th ed., McGraw-Hill, 2002.
3. Stark 1. H. and Woods J., *Probability, Random Processes and Estimation Theory for Engineers*, 2nd ed., Prentice-Hall, 1994.
4. Garcia L. A., *Probability and Random Processes for Electrical Engineers*, 2nd ed., Addison-Wesley, 1994.

CIS-504: Algorithms Design

Status	C
Credits	3
Prerequisites	Nil

Review of algorithmic basics; Brute force and divide & Conquer approaches; Dynamic programming: Optimization, Matrix chain multiplication, Assembly-line scheduling, Knapsack problem, Longest common subsequence, Optimal binary search trees; Greedy algorithms: Activity selection, Fractional Knapsack, Huffman coding problem; Graph algorithms: Review of basic graph algorithms, All-pairs shortest paths, Floyd-Warshall algorithm, Johnson's algorithm; Network flow: Bipartite matching, Hopcroft-Karp paths, Ford-Fulkerson algorithm, Edmonds-Karp algorithm, String algorithms: Rabin-Karp algorithm, Finite automaton algorithm, Knuth-Moris-Pratt algorithm; Polynomials and Fast Fourier Transform: Matrix multiplication on polynomials, The Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT); NP completeness: Circuit satisfiability, 3-CNF, Cliques; Approximation algorithms: Vertex-cover and TSP, 1.5-approximation set-cover; Randomized algorithms: Randomized max 3-SAT, Probabilistic Maxcut, Derandomization of MST, Randomized median; Geometric algorithms: convex hull, segment intersection, closest-pair, voronoi, flip algorithm.

References

1. Kleinberg J., and Tardos É., *Algorithm Design*, Pearson, 2006.
2. Sedgewick R., and Wayne K., *Algorithms*, 4th ed., Addison-Wesley, 2012.
3. Cormen T. H., Leiserson C. E., Rivest R. L., and Stein C., *Introduction to Algorithms*, 3rd ed., MIT Press, 2009.
4. Skiena S., *The Algorithms Design Manual*, 2nd ed., Springer, 2008.

CIS-505: Theory of Computation

Status	C
Credits	3
Prerequisites	Nil

Automata theory; Formal languages; The pigeonhole principle; Turing machines; Context-free grammars; Parsing and ambiguity; Recursively enumerable languages; Unrestricted grammars; The Chomsky hierarchy; Computability theory and reducibility; Randomness; Determinism; Non-determinism; Time hierarchy; Space hierarchy; Recursive functions; The Ackermann's Function and its inverse; P and NP completeness.

References

1. Sipser M., *Introduction to the Theory of Computation*, 3rd ed., Cengage Learning, 2012.
2. Rosenberg A. L., *The Pillars of Computation Theory: State, Encoding, Nondeterminism*, Springer, 2009.
3. Puntambekar A. A., *Theory of Computation*, Technical Publications, 2009.
4. Kozen D. C., *Theory of Computation*, Springer, 2006.

EE-508: Computational Intelligence

Status	C
Credits	3
Prerequisites	Nil

Basic concepts of computational intelligence; Single-layer and multi-layer feedforward neural networks; Feedback and recurrent neural networks; Learning vector quantizer (lvq); Self-organizing feature maps; Radial basis function neural networks; Support Vector Machines; Genetic algorithms, Genetic programming; Fuzzy sets and fuzzy logic, Fuzzy neural networks; Swarm intelligence and Ant colony optimization, Hidden Markov Models.

References

1. Engelbrecht, A. P., *Computational Intelligence: An Introduction*, 2nd Ed., Wiley, NY, 2007.
2. Hastie, T., Tibshirani, R., and Friedman, J., *The Elements of Statistical Learning*, 3rd Ed., Springer, 2009.
3. Zurada, J., *Introduction to Artificial Neural Systems*, West Publishing Company, St. Paul, 1992.

CIS-522: Human Computer Interaction

Status	Optional
Credits	3
Prerequisites	Nil

Overview of Human Computer Interaction (HCI); Human capabilities: Perception, Memory, Cognition; Human diversity; Input devices and interaction techniques; Decision making; HCI tasks and metrics; Models of design: Goals Operators Methods Selection rules (GOMS), Keystroke Level, and Norman's 7 Stages; Principles and rules for interface verification, testing, and evaluation; Designing and building visual interfaces, multimodal interfaces, and perceptual interfaces.

References

1. Preece J., Rogers Y., Sharp H., Benyon D., Holland S., and Carey T., *Human-Computer Interaction: Concepts and Design*, Addison Wesley, 1994.
2. Rogers Y., Sharp H., and Preece J., *Interaction Design: Beyond Human - Computer Interaction*, 3rd ed., Wiley, 2011.
3. Shneiderman B., and Plaisant C., *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 5th ed., Addison Wesley, 2009.
4. Dix A. J., Finlay J. E., Abowd G. D., and Beale R., *Human-Computer Interaction*, 3rd ed., Prentice Hall, 2004.

CIS-523: Evolutionary Computing

Status	Optional
Credits	3
Prerequisites	Nil

Issues in classical optimization techniques; Introduction to evolutionary computation: Principles of evolutionary processes, Genetic algorithms, Genetic Programming, Evolutionary programming, Evolutionary strategies; Representation of data; Selection methods; Search operators; Fitness evaluation; Constraint handling techniques; Population structure; Meta evolutionary approaches; Self-adaptation; Implementation issues.

References

1. Eiben E. A. and Smith, E. J., *Introduction to Evolutionary Computing*, Natural Computing Series, Springer, 2010.
2. Adrieas P. E., *Computational Intelligence: An Introduction*, 2nd ed., John Wiley & Sons, 2007.
3. Baeck T., *Evolutionary Computation*, Vol. 1 and 2, Taylor & Francis, 2000.
4. Jin Y. C. (Ed.), *Knowledge Incorporation in Evolutionary Computation*, Springer, 2005.
5. Poli R., Langdon B. W. and McPhee F. N, *A Field Guide to Genetic Programming*, Lulu Enterprises, UK Ltd, 2008.

PAM-524: Linear Algebra

Status	C
Credits	3
Prerequisites	Nil

Basics of linear algebra: Gaussian elimination and matrices, two-point boundary value problems, ill-conditioned systems, homogeneous & non homogeneous systems, electrical circuits, matrix algebra, matrix inversion, factorization, elementary matrices & equivalence, determinants and its properties; Vector spaces: spaces and subspaces, four fundamental subspaces, linear independence, basis and dimension, classical least squares, change of basis and similarity, invariant subspaces, linear transformations, normed spaces, metric vector spaces, metric spaces, Hilbert spaces, complex vector spaces and its properties; Norms, inner products, and orthogonality: vector & matrix norms, inner-product spaces, complex inner product spaces, orthogonal vectors, Gram–Schmidt procedure, unitary and orthogonal matrices, orthogonal reduction, discrete Fourier transform, complementary subspaces, range-nullspace decomposition, orthogonal decomposition, singular value decomposition, orthogonal projection, angles between subspaces; Eigenvalues and eigenvectors: elementary properties of eigen system, diagonalization by similarity transformations, functions of diagonalizable matrices, systems of differential equation, normal matrices, positive definite matrices, nilpotent matrices and Jordan structure, functions of nondiagonalizable matrices, difference equations, limits, and summability, minimum polynomials and Krylov methods; Perron–Frobenius theory: Introduction, positive matrices, nonnegative matrices, stochastic matrices and Markov chain.

References

1. Meyer, C.D., *Matrix Analysis and Applied Linear Algebra*, 3rd Ed., siam, 2000.
2. Lay D.C., *Linear Algebra and Its Applications*, 3rd Ed., Pearson Addison-Wesley, 2006.
3. Anton H. and Rorres C., *Elementary Linear Algebra with Applications*, 9th Ed., John Wiley & Sons, 2005.
4. Strang G., *Linear Algebra and Its Applications*, 3rd Ed., Wellesley-Cambridge Press, 1988.

CIS-525: Pattern Classification and Recognition

Status	Optional
Credits	3
Prerequisites	Nil

Basic concepts; Linear and piece-wise linear classification 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; Bayesian classification; Estimation of Densities; Pattern classification by likelihood functions; Trainable pattern classifiers; Deterministic and stochastic approach; Syntactic pattern recognition.

References

1. Theodoridis S., and Koutroumbas K., *Pattern Recognition*, 4th ed., Elsevier Inc., 2009.
2. Devroye L., Györfi L. and Lugosi G., *A Probabilistic Theory of Pattern Recognition*, Springer Verlag, 1997.
3. Duda R.O., Hart P. E. and Stork D. G., *Pattern Classification*, 2nd ed., John Wiley & Sons, 2001.
4. Tou J.T. and Gonzales R.C., *Pattern Recognition Principles*, Addison-Wesley, MA, 1981.
5. Bishop C. M., *Neural Networks for Pattern Recognition*, Clarendon Press-Oxford Press, 1996.

CIS-526: Digital Image Processing and Analysis

Status	C
Credits	3
Prerequisites	Nil

Image processing fundamentals: Visual perception, Image sensing and quantization; Digital image enhancement: spatial and frequency domain enhancement, histogram processing, smoothing and sharpening filters; Color Image Processing: Colors models and transformations; Wavelets and multi-resolution processing; Image compression: compression models, Lossy and lossless compressions; Morphological image processing; Image segmentation: Thresholding and region based segmentation.

References

1. Gonzolez R. C., and Woods R. E., *Digital Image Processing*, 3rd ed., Addison Wesely, 2008.
2. Umbaugh S. E., *Digital Image Processing and Analysis: Human and Computer Vision Application with CVIPtools*, 2nd ed, CRC Press, 2011.

3. Marques O., *Practical Image and Video Processing Using MATLAB*, Wiley/IEEE Press, 2011 .
4. Seul M., O'Gorman L., and Sammon M. J., *Practical Algorithms for Image Analysis*. 2nd ed, Cambridge University Press, 2008.
5. Gonzolez R. C., Woods R. E., and Eddins S. L., *Digital Image Processing using Matlab*, Pearson Education, 2004.

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 parsing, Statistical methods of parsing; 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**,** 2009.
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. Brachman R. and Levesque H., *Knowledge Representation and Reasoning*, Morgan Kaufmann, 2004.
3. Schreiber G. and Akkermans H., *Knowledge Engineering and Management: The CommonKADS Methodology*, The MIT Press, 1999.
4. Gonzalez A. J. and Dankel D. D., *The Engineering of Knowledge-Based Systems*, Prentice Hall, 1993.
5. Poole D., Mackworth A. and Goebel R., *Computational Intelligence: A Logical Approach,* Oxford University Press, 1998.

CIS-529: Bio Informatics

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to bioinformatics: biological sequence, DNA, RNA, submitting DNA sequences to the database; Phylogenetic and mutation studies; Proteins-only submission; Sequence types and genome centers; Protein Structure: Introduction to structures, Protein data banks, Structure file formats, visualizing structural information, structure similarity searching; Sequence Alignment: evolutionary basics of sequence alignments, FASTA, BLAST,

Multiple alignment; Proteins identity based on composition, Motifs and Patterns; EST; TIGR Gene indices; STACK; GENE prediction; Protein subcellular Localization; Systems Biology.

References

1. Lesk A., *Introduction to Bioinformatics*, Oxford University Press, 3rd ed., 2008.
2. Jones N. C., and Pevzner A. P., *An Introduction to Bioinformatics Algorithms*, MIT Press, 2004.
3. Pevsner j., *Bioinformatics and Functional Genomics*, 2nd ed., Wiley-Blackwell, 2009.
4. Agostino M., *Practical Bioinformatics*, Garland Science, 2012.

CIS-531: Medical Image Processing

Status	Optional
Credits	3
Prerequisites	CIS-526 or equivalent

Sources of medical images (X-ray, CT, MRI, PET and Ultrasound); Medical image formats (DICOM, PACS, etc.); Medical image Analysis: Enhancement, Registration, Segmentation and Transformation of medical images, reconstruction methods; Medical image classification and computer aided diagnoses; Protection and Authentication of medical images; Medical image compression and communication; Functional imaging; Neuro imaging; Tele radiology; Tele diagnosis.

References

1. Birkfelln W., *Applied Medical Image Processing: A Basic Course*, Taylor & Francis , 2010.
2. Epstein C. L., *Introduction to the Mathematics of Medical Imaging*, Prentice Hall, 2003.
3. Fitzpatrick J.M., and Sonka M., *Handbook of Medical Imaging*, Society of Photo Optical, 2000.
4. Gonzalez R. C., and Woods R. E., *Digital Image Processing*, 3rd ed., Prentice Hall, 2007.

CIS-532: Graphics and Visualization

Status	Optional
Credits	3
Prerequisites	Nil

Applications of visualization; Object representation and modeling; Graphics libraries: Graphics functions, Basics of OpenGL; Basic raster graphics output primitives: Coordinate specifications, Rasterization algorithms, Drawing points, lines, curves, and filled areas; Projection and viewing geometric transformations; Polygonal geometries: Classification of polygons, Inside-outside tests, Front and back polygon faces; Culling and hidden surface removal; Geometry subdivision; Color and illumination models.

References

1. Theoharis T., Papaioannou G., Platis N., Patrikalakis N.M., *Graphics and Visualization: Principles & Algorithms*, A.K.Peters/CRC Press, 2008.
2. Hearn D. D., Baker M. P., and Carithers W., *Computer Graphics with OpenGL*, 4th ed., Pearson, 2010.
3. Angel A., *OpenGL: A Primer*, 3rd ed., Addison-Wesley, 2007

CIS-541: Cloud Computing

Status	Optional
Credits	3
Prerequisites	Nil

Cloud computing: Overview, Cloud types, Cloud deployment models; Cloud computing architecture: Software as a Service (SaaS), Service-Oriented Architecture (SOA), Cloud Architectures SOA, Platform as a Service (PaaS), Infrastructure as a Service (laaS), Identity as a Service (lDaaS); Data Storage in the Cloud; Virtualization: Characteristics, Taxonomy, Technology examples; Cloud security; Disaster recovery in cloud; Managing the

cloud; Migrating to the cloud; Designing and coding cloud-based applications; Cloud and mobile devices; Application scalability; Future trends.

References

1. Velte A. T., Velte T. J., and Elsenpeter R., Cloud Computing: *A Practical Approach*, McGraw-Hill, 2010.
2. Jamsa K., *Cloud Computing: SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile, Security and More*, Jones & Bartlett Learning, 2013.
3. Rittinghouse J. W., and Ransome J. F., *Cloud Computing: Implementation, Management, and Security*, CRC Press, 2010.

CIS-542: Optimization Techniques

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to optimization techniques; Linear programming: the simplex method, duality in linear programming, sensitivity analysis; One variable optimization: search methods, polynomial approximations, Golden Section method; Unconstrained optimization techniques: zero-order methods, first-order methods, second-order methods, convergence criteria; Constrained optimization techniques: Direct methods: random search, sequential linear programming, the method of feasible directions, generalized reduced gradient method, sequential quadratic programming; Indirect methods: penalty function methods, augmented lagrange multiplier method; Integer linear programming.

References

1. Reklaitis G. B., Ravindran A., and Ragsdell K. M., *Engineering Optimization Methods and Applications*, 2nd ed., John Wiley & Sons, 2006.
2. Singiresu S. Rao, *Engineering Optimization: Theory and Practice*, 4th ed., John Wiley & Sons, 2009.
3. Taha H. A., *Operations Research: An introduction*, 9th ed., Pearson Education, 2010.

CIS-544: Monte Carlo Simulations

Status	Optional
Credits	3
Prerequisites	Nil

Overview of Monte Carlo Methods; Types of Randomness; Uniform Random Number Generators; Randomness Tests; Review of Discrete and Continuous Probability Distributions; Discrete Random Variate Generation; Continuous Random Variate Generation; Monte Carlo Evaluation of Finite-Dimensional Integrals; Variance Reduction Techniques; Markov Chain Monte Carlo: Discrete Markov Chains, Metropolis Algorithm, Ising Model, Random Walks, Brownian Motion; Optimization by Monte Carlo Methods: Simulated Annealing, Genetic Algorithms; Optimization Applications.

References

1. Kalos, M. H. and Whitlock P. A., *Monte Carlo Methods*, 2nd ed., Wiley-VCH, 2008.
2. Ronald W. Shonkwiler,Franklin Mendivil,., *Explorations in Monte Carlo Methods*, Springer, 2009.
3. William L. Dunn, J. Kenneth Shultis, *Exploring Monte Carlo Methods*, Elsevier, 2012.
4. Ivan T Dimov., *Monte Carlo Methods for Applied Scientists*, World Scientific, 2008.

CIS-546: Parallel Computing

Status	C
Credits	3
Prerequisites	Nil

Parallel Programming Platforms; Memory Architectures; Basic Communication Operations: Broadcast, Scatter and Gather; Computational Overheads; Level of Abstraction, Principles of Parallel Computation: Decomposition Techniques, Mapping Techniques, Model of Computations and Parallel Overheads: Sources of Overheads,

Performance Metrics, Scalability; Parallel programming using message passing paradigm; Programming shared memory address space platforms.

References

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

CIS-548: Computer Animation

Status	Optional
Credits	3
Prerequisites	CIS-532

Applications of 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, 2002.
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	PAM-585

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; 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*, 5th ed., Butterworth Heinemann, 2011.
3. Smith I.M., and Griffiths D.V., *Programming the Finite Element Method*, 4th ed., John Wiley & Sons, 2004.
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	C
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; TLB; Emulated instruction sets; VLIW; Out of order execution; Latency hiding; Case Studies: iA64, Linux clusters and IBM SP; Microcontrollers: Intel, PIC; Real-time processors: TMS320.

References

1. Hennessy J. L. and Patterson D. A., *Computer Architecture -- A Quantitative Approach*, 5th Ed., Morgan Kaufmann Publications, Elsevier, Inc., 2012.
2. Stallings W., *Computer Organization and Architecture*, 9th Ed., Pearson Education Ltd, 2012.
3. Murdocca M. J., Heuring V. P., *Computer Architecture and Organization: An Integrated Approach*, John Wiley & sons Inc, 2007.
4. Englander I., *The Architecture of Computer Hardware and System Software: An Information Technology Approach*, International Student Version, 4th Ed., John Wiley & sons Inc, 2010.

CIS-551: Advanced Operating Systems

Status	C
Credits	3
Prerequisites	Nil

Process Synchronization: Synchronization Mechanisms, Process Deadlocks; Distributed Operating Systems: Architectures, Mutual Exclusion, Deadlock Detection, Agreement Protocols; Distributed Resource Management: File Systems, Share Memory, Scheduling; Failure Recovery and Fault Tolerance; Protection and Security: Resource Security and Protection, Data Security; Multiprocessor Operating Systems; Database Operating Systems.

References

1. Singhal M., and Shivaratri N. G., *Advanced Concepts in Operating Systems*, McGraw-Hill Series in Computer Science, 2008.
2. Silberschatz A., Galvin, P. B., Gagne G., *Operating System Concepts*, 9th ed., John Wiley & Sons, 2013.
3. Stalling W., *Operating Systems*, 5th ed., Pearson Education, 2006.
4. Tanenbaum A. S., Modern Operating Systems, 3rd ed., Prentice Hall, 2007.

CIS-552: Advanced Database Systems

Status	Optional
Credits	3
Prerequisites	Nil

Database life cycle; Data modeling; Extended ER Constructs; Database transactions; Concurrency control: Concurrency problems, Deadlocks, Serializability; Query execution; Query optimization; Distributed database architecture; Rationale for distribution; Components of distributed database system: Data placement, Placement of DDBMS; Synchronization problem; Models and applications; Problems of distributed systems; Temporal databases; Logic-based databases; Object databases; Object/Relational Databases.

References

1. Toby J. T., *Database Modeling and Design*, Morgan Kaufman Pub, 2011.
2. Philip A. B., and Eric N., *Principles of Transaction Processing*, Morgan Kaufmann Pub, 2009.
3. Ozsu M. T., and Valduriez P., *Principles of Distributed Database Systems*, Springer, 2011.
4. Date C.J., and Darwen H., *Foundation for Object/Relational Databases: The Third Manifesto*, Addison Wesley, 1998.

CIS-555: Cluster System Management

Status	Optional
Credits	2+1
Prerequisites	CIS-546

Overview of Cluster Computing; Cluster Computer and its Architecture; Constructing Scalable Services; Cluster Interconnects; Deploying a High Throughput Computing; Cluster Setup and its Administration; Load Balancing in Clusters; Cluster Middleware; Resource Management and Scheduling; Programming Environments and Tools; Cluster Administration Tools; Cluster Workload Management; Parallel Debuggers and Profilers; Performance Analysis Tools; Numerical and Scientific Software for Clusters.

References

1. Buyya R. (ed.), "*High Performance Cluster Computing: Systems and Architectures*", Prentice Hall, 1999.
2. Kopper K.,"*The Linux Enterprise Cluster*", No Starch Press, 2005.
3. Gropp W., Lusk e., and Sterling T. (eds), "*Beowulf Cluster Computing with Linux*", Second Edition, The MIT Press, 2003.
4. Bookman C., "*Linux Clustering: Building and Maintaining Linux Clusters*", New Riders Publishing, 2002.
5. Hwang K., Dongarra J., and Fox G., "*Distributed and Cloud Computing: From Parallel Processing to the Internet of Things* ", Morgan Kaufmann, 2012.

CIS-561: Computer Forensics

Status	C
Credits	3
Prerequisites	Nil

Overview of Digital Forensics; Forensic Modeling and Principles; Digital Evidence; Data Acquisition; Forensic Duplication; Forensics Analytics; Forensic Examination of Computers, Digital and Electronic Media; Network Surveillance and Accountability; Network Attack, Traceback, and Attribution; Multicast Fingerprinting; Multimedia Forensics; Forensic Tools; Steganography and Steganalysis; Anti-Forensics; Intrusion and Online Frauds Detection; Cyber Law; Security and Privacy Policies and Guidelines.

References

1. Nelson B., Phillips A., and Steuart C., *Guide to Computer Forensics and Investigations*, 4th Ed., Cengage Learning, 2009.
2. Sammons J., *The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics*, Elsevier, 2012.
3. Kruse W. G., and Heiser J. G., *Computer Forensics: Incident Response Essentials*, Addition-Wesley, 2001.
4. Mena J., *Machine Learning Forensics for Law Enforcement Security and Intelligence*, Auerbach Publications, 2011.

CIS-562: Information Theory and Coding

Status	C
Credits	2+1
Prerequisites	Nil

Theory of information: Entropy, Mutual information, Source coding theorem; Lossless compression of data, Optimal lossless coding; Communication channels: Channel capacity, Noisy communication channels, Channel coding theorem, Source channel separation theorem, Multiple access channels, Broadcast channels, Gaussian noise, and time-varying channels; Huffman coding; Universal source coding; Differential entropy; Block codes and Convolutional codes; Error correction code; Reliable and efficient communication systems.

References

1. Cover T. M, and Thomas J. A, *Elements of Information Theory*, 2nd Ed., John Wiley & Sons, 2006.
2. Wicker B. S., *Error Control systems for Digital Communication and Storage*, Prentice-Hall, 1994.
3. Gallagher R. G., *Information Theory and Reliable Communication*, Springer-Verlag, 1970.

CIS-563: Cryptographic Algorithms

Status	Optional
Credits	3
Prerequisites	CIS-562

Definitions: Cryptography, cryptanalysis, steganography, encryption, decryption, plaintext, cipher text, etc; Mathematics of Cryptology: Number theory, Abstract algebra: groups, rings, fields; Modular Arithmetic; Classical Cryptology: Simple Substitution ciphers, Transposition ciphers, ploy-alphabetic ciphers; Secret Key Cryptography: Modern Block Ciphers: Data Encryption Standard (DES), Advanced Encryption Standard (AES), Stream ciphers: LFSR-based stream ciphers, RC4; Modes of Cipher operations: ECB, CBC, CFB, OFB; Public Key Cryptography: Key agreement: Diffie-Hellman, Elliptic Curve Cryptography; RSA, Digital Signatures Integrity and authentication; Hash Functions: MD5, SHA1; Message Authentication Codes

References

1. Stallings W., *Cryptography and Network Security: Principles and Practice*, 4th ed, Publisher: Prentice Hall, 2006.
2. Mollin R. A., *An Introduction to Cryptography*, 2nd ed, Taylor & Francis, 2007.
3. Delfs H., Knebl H., *Introduction to Cryptography: Principles and Applications*, 2nd ed, Springer, 2007.
4. Konheim A. G., *Computer Security and Cryptography*, John Wiley & Sons, 2007.

CIS-564: Software Security

Status	Optional
Credits	3
Prerequisites	CIS-561

Software Flaws and Malwares: Viruses and their countermeasures, Worms, Trojan Horses, Bots, Rootkits; Buffer Overflow: Basics, Stack Buffer Overflow, Heap Overflow, Global Data Area Overflow; Compile Time and Runtime Defenses; Hostile Scripts: CGI Scripts, Web Scripts, Handling Script Security Miscellaneous, Spyware; Mobile Agent Security; Software-Based Attacks: Software Reverse Engineering, Software Tamper Resistance, Content Filtering; Digital Rights Management; Secure Software Development; Operating Systems and Security; Linux Security; Windows and Windows Vista Security; Database Security; Securing Digital Contents.

References

1. Stallings W., Brown L., *Computer Security: Principles and Practice* Prentice Hall, 2012.
2. Kizza J. M., *A Guide to Computer Network Security*, Springer, 2009.
3. Salomon D., *Foundations of Computer Security*, Springer, 2006.
4. Charles P. Pfleeger, *Security in Computing*, 4th ed, Prentice Hall, 2006

CIS-565: Information System Security Management

Status	Optional
Credits	3
Prerequisites	Nil

Elements of Information Protection, Difference between Information and Computer Security, Roles and Responsibilities, Common Threats, Policies and Procedures, Risk Management, Fraud and Theft, Malicious Hackers, Denial-of-Service Attacks, Social Engineering, Information Security Architecture, Enterprise wide Security Program, Business Unit Responsibilities, Information Security Awareness Program, Information Security Program Infrastructure, Employment, Standards of Conduct, Conflict of Interest, Performance Management, Employee Discipline, Corporate Communications, Workplace Security, Business Continuity Plans (BCPs), Procurement and Contracts, Records Management, Asset Classification, Organization wide Policy Document, Legal Requirements

References

1. Stamp M., *Information Security: Principles and practice*, John Wiley & Sons, 2006.
2. Thomas R. Peltier et al., *Information Security Fundamentals*, Auerbach Publications, 2005.
3. Michael G. Solomon, Mike Chapple, *Information Security Illuminated*, , Jones and Bartlett, 2005
4. Tudor J. K., *Information Security Architecture-An Integrated Approach to Security in the Organization*, Auerbach Publications, 2001.

CIS-566: Computer Security Management

Status	Optional
Credits	3
Prerequisites	Nil

User Authentication: Password-bases, token-based, biometric, remote authentication; PKI Systems: Overview, Components, Procedures, Current and Future Aspects; Access Control: Principles, Discretionary and Role based; Trusted Computing and Multilevel Security: Bell-LaPadula Model, Concept of Trusted Systems, Trusted Computing and the Trusted Platform Module; Security Management: Organizational Context; Risk Analysis and Assessment, Disaster Management; IT Security Controls: Safeguards, Plans, and Procedures, Implementation and follow up; Physical and Infrastructure Security: Threats, Prevention and mitigation; Human Resources Security: Awareness, training and education, employment practices and policies, legal and ethical aspects; Security Auditing: Architecture, Audit Trail, Logging Function, Audit Trail Analysis.

References

1. Stallings W., and Brown L., *Computer Security: Principles and Practice* 2nd ed, Prentice Hall, 2012.
2. David Challener et al., *A Practical Guide to Trusted Computing*, IBM Press, 2007.
3. Liska A., *The Practice of Network Security: Deployment Strategies for Production Environments*, Prentice Hall, 2002.
4. Ferraiolo D. F., D. Kuhn R., and Chandramouli R., *Role-Based Access Control*, Artech House, 2003.
5. Albanese J., and Sonnenreich W., *Network Security Illustrated*, McGraw-Hill, 2004.

PAM-568: Numerical Solution of Differential Equations

Status	C
Credits	3
Prerequisites	Nil

Review of Differential equations; Numerical solution of ODEs; One-step and Multi-step methods, Explicit and Implicit Methods, Euler's method, Runge-Kutta methods, Adams methods, Predictor-Corrector methods, Stiff Differential Equations, Backward Difference Methods for Stiff problems, Extrapolation Methods; Accuracy and Stability; Boundary Value Problems; Linear and Non-linear finite difference methods, Linear and Non-linear Shooting methods, Variational Techniques; Partial Differential equations; Classification, Time-dependent problems; Finite Difference and Finite Element Methods, Solution of Sparse Linear Systems: Direct and Iterative methods; Multi-grid methods.

References

1. Granville S., *The Numerical Solution of Ordinary and Partial Differential Equations*, 2nd ed., John-Wiley and Sons, 2005.
2. Randall J. L., *Finite Difference Methods for Ordinary and Partial Differential Equations – Steady State and Time Dependent Problems*, Society of Industrial and Applied Mathematics (SIAM) Pub. Philadelphia, PA 2007.
3. Lambert J. D., *Numerical Methods for Ordinary Differential Equations*, John-Wiley and Sons, 1997.
4. Ŝolín P., *Partial Differential Equations and The Finite Element Method*, John-Wiley and Sons, 2006.

PAM-585: Numerical Methods and Optimization Techniques

Status	Optional
Credits	3
Prerequisites	Nil

Review of eigen-value problems, Numerical solution; Solution of system of ODEs; Boundary value problems; Classical optimization techniques: constrained and unconstrained sets, line search, trust region approaches, Simplex, Newton's Quasi-Newton, conjugate direction, and Levenberg-Marquardt methods; elimination, Lagrangian, and active set methods, quadratic and mixed integer programming; Stochastic optimization, simulated annealing, particle swarm and game theory optimization; Evolutionary algorithms; Applications.

References

1. Cavazzuti M., *Optimization Methods: From Theory to Scientific Design*, Springer-Verlag, 2013.
2. Burden R.L., and Faires J.D., *Numerical Analysis*, 9th ed., Brooks-Cole, Cengage Learning, 2010.
3. Gupta C. B., *Optimization Techniques in Operation Research*, I.K. Intl. Pub. House, New Delhi, 2007.
4. Marti K., *Stochastic Optimization Methods*, 2nd ed., Springer-Verlag, 2008.

CIS-595: Special Topics in CIMV-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-596: Special Topics in SC-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-597: Special Topics in ISS-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-621: Machine Learning

Status	Optional
Credits	3
Prerequisites	CIS-525

Introductory concept of machine learning; General-to-specific ordering; Decision tree learning; Supervised learning; Evaluating hypotheses; Bayesian learning; Instance-based learning; Statistical learning methods; Memory based learning; Transformation based learning; Inductive logic programming; Unsupervised learning; Temporal difference learning; Reinforcement learning; Explanation based learning.

References

1. Mitchell T. M., *Machine Learning*, McGraw-Hill, 1997.
2. Bishop C. M., *Pattern Recognition and Machine Learning*, Springer 2006.
3. Cherkassky V., *Learning from Data: Concepts, Theory, and Methods*, 2nd Ed., John Wiley & Sons, 2007.
4. Nelson N. J., *Introduction to Machine Learning*, (Online book draft), 2005.
5. Langley P., *Elements of Machine Learning*, Morgan Kaufmann, 1996.
6. Witten I. H., Frank E., and Hall M. A., *Data Mining: Practical Machine Learning Tools and Techniques*, 3rd Ed., Morgan Kaufmann, 2011.

CIS-623: Biometrics Computing

Status	Optional
Credits	3
Prerequisites	CIS-525

Overview of biometrics; Existing biometric technologies: Fingerprints, Face, Iris, Hand geometry, Palmprint, Ear, Voice, Retina, etc.; Performance evaluation and comparison of biometrics: Performance measures, Reliability, Uniqueness, and Comparison; Multimodal biometric authentication: Types of fusion, Score normalization, Intramodal and multimodal fusion, Strategies; Biometric security: Anti-spoofing measures, Liveness detection; Issues of privacy: Public concerns, Research issues in personal identification; Biometric watermarking.

References

1. Ashbourn J., *Practical Biometrics: From Aspiration to Implementation*, Springer, 2004.
2. Ashbourn J., *Biometrics: Advanced Identity Verification*, Springer-Verlag, 2000.
3. Jain A.K., Bolle R., and Pankanti S., *Biometrics: Personal Identification in Networked Society*, *International Series in Engineering and Computer Science*, Springer, 1999.
4. Wayman J., Jain A.K., Maltoni D., and Maio D., *Biometric Systems: Technology, Design and Performance Evaluation*, Springer, 2010.

CIS-624: Machine Vision

Status	C
Credits	3+1
Prerequisites	CIS-526

Overview of a machine vision system; Image formation; Feature extraction and matching; 2D and 3D Transformations; 2D and 3D Projective geometry; Camera models; Camera calibration; Single view geometry; Epipolar geometry; Stereo vision; Structure from motion; Shape from single image cues; Shape from more than one images: Contours, Stereo; Pose estimation; Image mosaicing; Image-based rendering.

References

1. Forsyth D. A. and Ponce J., *Computer Vision: A Modern Approach*, Prentice Hall, 2011.
2. Szeliski R., *Computer Vision: Algorithms and Applications*, Springer, 2010.
3. Hartley R, and Zisserman A., *Multiple View Geometry in Computer Vision*, 2nd Ed., Cambridge University Press, 2004.
4. Trucco and Verri A., *Introductory Techniques for 3-D Computer Vision*, Prentice Hall, 1998.

CIS-630: Advanced Evolutionary Computing

Status	Optional
Credits	3
Prerequisites	CIS-523

Theoretical foundations of Genetic Algorithms (GA); Applications of GA in constrained nonlinear optimization problems; Diploid genetic algorithms; Differential Evolution; Genetic Programming: Recent advances in Genetic Programming (GP), GPlab toolbox; Multi-objective optimization: Applications of evolutionary algorithms in multi-objective optimization problems, Non-dominated Sorting Genetic Algorithm (NSGA-II); Immune inspired systems and their performance comparison with GA and GP; Hybrid evolutionary computing techniques.

References

1. Goldberg, D. E., *The Design of Innovation: Lessons from and for Competent Genetic Algorithms*, Boston, MA: Kluwer Academic Publishers, 2002.
2. Fogel, D. B., *Evolutionary computation: Toward a new philosophy of machine intelligence*, IEEE Press, New York, 3rd edition, 2005.
3. Haupt, L. R., and Haupt, E. S., *Practical Genetic Algorithms*, 2nd ed., Wiley-Interscience, 2004.

CIS-631: Intelligent Watermarking Techniques

Status	Optional
Credits	3
Prerequisites	EE-508

Watermarking and intelligent techniques: Evolutionary algorithms based watermarking, Intelligent watermarking in spatial and transform domain; Watermarking based on vector quantization and spread spectrum; Intelligent audio and video watermarking; Benchmarks of watermarking; Robust watermarking schemes using machine learning approaches; Practical issues and limitations in watermarking; Optimal tradeoff of watermarking properties using intelligent approaches.

References

1. Huang H. C., Jain L. C., and Pan J. S., *Intelligent Watermarking Techniques*, World Scientific Pub Co Inc, 2004.
2. Barni M., and Bartolini F., *Watermarking Systems Engineering: Enabling digital assets security and other application*, Marcel Dekker, 2004.
3. Cox I. J., Miller M. L., et. al., *Digital Watermarking and Steganography*, Morgan Kaufmann, 2007.

CIS-641: Grid Computing

Status	Optional
Credits	3
Prerequisites	CIS-546

Grid Architectures; 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-532

Overview of Virtual Reality (VR) and Augmented Reality (AR); Projective geometry; Camera calibration; Visual coherence; Visualization techniques; Real-time tracking and pose estimation; Rendering; Characterization of virtual environments; Hardware to create virtual environments; 3D interaction and collaboration in virtual environments; Human factors and human perception; Virtual characters; Modelling and creating virtual environments; AR Tool kit.

References

1. Behringer R., Klinker G., and Mizell D., *Augmented Reality: Placing Artificial Objects in Real Scenes*, CRC Press, 1999.
2. Ong S. K., and Nee A. Y. C., *Virtual and Augmented Reality Applications in Manufacturin* , Springer, 2013.
3. Fuchs P., Moreau G., and Guitton P., *Virtual Reality: Concepts and Technologies*, CRC Press, 2011.
4. Bowman D. A., Kruijff E., LaViola J. J., and Poupyrev I., *3D User Interfaces: Theory and Practice*, Addison-Wesley, 2004.
5. Sherman W. R., and Craig A. B., *Understanding Virtual Reality: Interface, Application, and Design*, Morgan Kaufmann, 2002.
6. Burdea G. C., and Coiffet P., *Virtual Reality Technology*, 2nd ed., Wiley-IEEE Press, 2003.

CIS-645: Parallel Algorithms

Status	C
Credits	3+1
Prerequisites	CIS-546

Principals of parallel algorithms; Dense/sparse matrix algorithms: matrix-vector and matrix-matrix multiplication using 1D and 2D decomposition techniques; Sorting algorithms: issues in sorting, sorting networks, bubble sort, quick sort, other sorting algorithms; Graph algorithms: definition and representation, Prim's algorithm, Dijkstra's algorithm, sparse graphs algorithms; Search algorithms for discrete optimization problems; Fast Fourier Transform (FFT): binary-exchange and transpose algorithms; Iterative solution of linear systems; Analysis of computation, communication and synchronization; Parallel numerical libraries.

References

1. Roosta S. H., *Parallel Processing and Parallel Algorithms: Theory and Computation*, Springer-verlag, 2000.
2. Rauber T., and Rünger G., *Parallel Programming: for Multicore and Cluster Systems*, Springer, 2010.
3. Grama A., Gupta A., Karypis G., and Kumar V., *Introduction to Parallel Computing*, 2nd ed., Addison-Wesley, 2003.
4. Quinn M., Parallel *Programming in C with MPI and OpenMP*, McGraw-Hill 2003.
5. Foster I., *Designing and Building Parallel Programs*, Addison-Wesley, 1995.

CIS-646: Advanced Optimization Techniques

Status	Optional
Credits	3
Prerequisites	PAM-585

Non-Simplex methods: Khachiyan's, Affine Scaling, Karmarkar's Method; Non-linear optimization with equality and inequality constraints; Network models: Minimal Spanning Tree Algorithm, Shortest-Route Problem, Maximal flow models; Goal programming; Deterministic and probabilistic dynamic programming; Inventory models: Static Ecol1omic-Order-Quantity (EOQ) Models, Dynamic EOQ Models; Forecasting models: Moving Average Technique, Exponential Smoothing, Regression; Decision analysis and games; Markovian decision process: Finite-Stage Dynamic Programming, Infinite-Stage Model; Geometric programming; Non-Smooth optimization.

References

1. Reklaitis G. V., Ravindran A., and Ragsdell K. M., *Engineering Optimization: Methods and Applications*, John Wiley & Sons, 2nd edition, 2006.
2. Fletcher R., *Practical Methods of Optimization*, 2nd ed., John Wiley & Sons, 2000.
3. Taha H. A., *Operations Research: An introduction*, 9th ed., Pearson Education, 2010.
4. Deb K., Optimization for Engineering Design: Algorithms and Examples, Prentice Hall, 2005.

CIS-661: Data Warehousing

Status	Optional
Credits	3
Prerequisites	CIS-552

Data warehouse essentials; Need for a DW; Decision support vs. transaction processing; Evolution of a DW; Business requirements; Matching information to classes of users; Dimensional modeling; Architecture and Infrastructure; Data extraction; Transformation and loading; Selected De-normalizations; Horizontal and vertical partitioning; Materialized views; Physical design of DW; Data mart design; Web data warehousing; Data quality management; Knowledge discovery: Prediction, Market-basket analysis, Clustering.

References

1. Anahory S., *Data Warehousing in the Real World*, Pearson Education, 2003
2. Ponniah P., *Data Warehousing Fundamentals*, John Wiley & Sons, 2001.
3. Kimball R., *The Data Warehouse Lifecycle Toolkit: Expert Methods for Designing, Developing and Deploying Data Warehouses*, John Wiley & Sons, 1998.
4. Corr L., *Agile Data Warehouse Design*, DecisionOne Press, 2011.

CIS-664: Secure Communication Design

Status	C
Credits	3+1
Prerequisites	CIS-562

Security in Web Services: Introduction, Technologies, Standards; Security in E-Services: Introduction, Requirements, Application; Grid Security: Introduction, Challenges, Infrastructure, Environments; Voice Over IP (VoIP) Security: Introduction, Issues in VoIP, Intrusion Detection Systems; Security in Wireless Networks and Devices: Cellular Wireless Communication, Wireless LANs, Wireless Application Protocol; Bluetooth Security: Introduction, Technology, Architecture, Weaknesses and Countermeasures; Mobile Telecom Networks: GPRS, UMTS, Architectures; Security in Mobile Ad Hoc Networks (MANETs): Introduction, Routing Protocols, Vulnerabilities, Preventing Attacks, Cryptographic Tools; Wireless Sensor Networks: Introduction, Sensor Devices, Sensor Network Security

References

1. Douligeris C., and Serpanos D. N., *Network Security Current Status and Future Directions*, John Wiley & Sons, 2007.
2. Ling Q.., *Secure Communication System Design for Wireless Networks*, ProQuest, 2007.
3. Sutton R. J., *Secure Communications Applications and Management*, John Wiley & Sons, 2002.
4. Tara M. , and Elden C. R., *Wireless Security and Privacy: Best Practices and Design Techniques*, Addison Wesley, 2002

CIS-665: Embedded System Security

Status	Optional
Credits	3
Prerequisites	CIS-563

Embedded Device Security; Smart Cards and RFID Tags; Network on Chip Security; Side Channel Attacks on Embedded Systems; Networked Embedded Systems and Resource Constraints; Choosing and Optimizing Cryptographic Algorithms for Resource-Constrained Systems; Optimization Guidelines; Hardware-Based Security; Security Issues and the Future of Embedded Applications Security; Programming Languages and Security; Microchip PIC with Ethernet Controller; Application Implementation on PIC; Rabbit 4000 CPU with Dynamic C; Rabbit: Case Study-Internet Enabled Vending Machine; Secure Rabbit Processor; FPGA Security

References

1. Stapko T., *Practical Embedded Security: Building Secure Resource-Constrained Systems*, Elsevier, 2008.
2. Gebotyes C.H., *Security in Embedded Devices*, Springer, 2006.

CIS-695: Special Topics in CIMV-II

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-696: Special Topics in SC-II

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.

CIS-697: Special Topics in ISS-II

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.

M.Phil. THESIS RESEARCH IN SPRING and SUMMER SEMESTER

CIS-698: M.Phil. Thesis Research

Status	C
Credits	3+12
Prerequisites	Relevant courses in previous 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 and full time Thesis Research should be carried out based on the Thesis Research Proposal developed. 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.