School of Computer Science

Director

Minor, John T. (1985), Associate Professor; B.A., Rice University; Ph.D., University of Texas, Austin.

Graduate Coordinator

Datta, Ajoy K. (1988), Professor; B.S., M.S., Ph.D., Jadavpur University.

Graduate Faculty

Bein, Wolfgang (1998), Associate Professor; M.S., Ph.D., University of Osnabruck.

Berghel, Hal (1999), Professor; B.A., M.A., Ph.D., University of Nebraska, Lincoln.

Bryce, Renee (2006), Assistant Professor; B.S., M.S., Rensselaer Polytechnic Institute; Ph.D., Arizona State University.

Gewali, Laxmi P. (1989), Professor; B.S., Gauhati University, India; M.S., Tribhuwan University, Nepal; M.S., Ph.D., University of Texas-Dallas.

Kim, Yoohwan (2004), Assistant Professor; B.A., Seoul National University, Korea. M.S., Ph.D., Case Western Reserve University.

Larmore, Lawrence L. (1994), Professor; B.S., Tulane University; Ph.D., Northwestern University; Ph.D., University of California, Irvine.

Nartker, Thomas A. (1986), Professor; B.S., University of Dayton; M.S., University of Tennessee; Ph.D., Texas A&M University.

Ogawa, Roy H. (1983), Associate Professor; B.A., M.A., University of Hawaii; Ph.D., University of California, Berkeley.

Pedersen, Jan B. (2003), Assistant Professor; B.S., M.S., University of Aarhus, Denmark; Ph.D., University of British Columbia.

Pinelle, David (2007), Assistant Professor; B.S., Texas Tech University; Ph.D., University of Saskatchewan.

Taghva, Sidkazem (1987), Professor; B.S., Pahlavi University; M.S., University of Kansas; Ph.D., University of Iowa.

Yfantis, Evangelos A. (1979), Professor; B.S., University of Athens; M.S., Fairleigh Dickinson University; M.S., Rutgers University; M.S., New Jersey Institute of Technology; Ph.D., University of Wyoming.

The School of Computer Science offers programs leading to the Master of Science and the Doctor of Philosophy degrees in Computer Science. Areas of school strength include both theoretical and experimental computer science, especially within such areas as information and network security, Internet forensics, real-time algorithms, information retrieval, document analysis, graphics, computational geometry, networking and distributed systems, parallel programming, artificial intelligence, software engineering, and human-computer interfaces.

The distributed computing environment of the College of Engineering is housed in the Thomas T. Beam Engineering Complex. Several hundred modern computing systems are operated for purposes of instruction, experimentation, laboratory instrument control, data acquisition, and research. More than 50 of the systems are in public laboratories accessible to all engineering students. These laboratories contain both Windows and Unix/Linux clients and servers in a variety of modern configurations.

Students can also obtain permission to access the machines of the National Supercomputer Center for Energy and the Environment (NSCEE).

Master of Science in Computer Science

Admission Requirements - M.S.C.S. Degree Program

Applicants must submit the following to the Graduate College: an application and official transcripts of all college level work with a minimum GPA of 3.00. Two letters of recommendation concerning the student's potential for succeeding in the graduate program, another set of official transcripts, and the results of the Graduate Record Examination current to within five years should be sent directly to the school. In addition, applicants must have completed courses and their prerequisites equivalent to our undergraduate Programming Languages CS 326), Operating Systems (CS 370), Discrete Mathematics II (MATH 351), and Statistical Methods I (STAT 411) with an average grade of B or better. The Computer Science Admission Committee may elect to admit an outstanding applicant who has not satisfied all of the background requirements on a conditional basis. The student must complete these requirements before full admission to the program is granted.

For students who want to be considered for graduate assistantships, the deadline for all application materials is March 1 for the fall semester and October 1 for the spring semester. Otherwise, applications will be accepted up to May 1 for fall admission and November 1 for spring admission for domestic students and May 1 for fall and October 1 for spring for international students.

Degree Requirements - M.S.C.S. Degree Program

The student must pass at least 30 credits of 600- and 700-level courses with grades of C or better, subject to the following conditions and Graduate College policy:

1. At least 24 credits must be in computer science. Non-CS courses must be related to the student's research area and be approved by the school graduate committee.
2. At least 18 credits of computer science courses must be at the 700-level.
3. If equivalent courses have not been taken previously, CS 656, 677, and 660 must be included.
4. At most six credits of CS 791, (Thesis Option) or three credits of CS 790 (Project Option) can be included.

The student must also select either the Thesis Option or the Project Option. If the Thesis Option is selected, the student must submit a thesis conforming to the specifications of the Graduate College and pass a final oral examination covering the thesis and relevant course work. For the Project Option, the student must complete a computer science project and report approved by his advisor and pass a final oral examination over the project and relevant course work.

Courses in which the student earns a grade lower than C cannot be included in his or her program, and the student's total grade point average (GPA) must be 3.00 or higher while in the program. A student whose GPA falls below 3.00 will be placed on academic probation. That student must have an overall GPA of at least 3.00 by the end of two subsequent semesters, otherwise the student will be separated from the graduate program. A student on probation will not be allowed to register for CS 690, CS 790, CS 791, CS 792, CS 799, or equivalent courses in another department.

Doctor of Philosophy in Computer Science

Admission Requirements - Doctoral Degree Program

In addition to the requirements of the Graduate College, applicants for admission to the Ph.D. program in computer science must meet the following:

1. Students are expected to have a master's degree in computer science before applying to the Ph.D. program. On rare occasions, an unusually capable student may be admitted to work directly for the Ph.D. degree without having a master's degree.
2. A GPA of 3.30 (on a 4.00 scale) or higher in postbaccalaureate course work is required for admission.
3. At least three letters of recommendation (preferably from academic sources) attesting to the applicant's professional competence and academic potential are required.
4. A personal statement of purpose, which should be as specific as possible and should include the applicant's objectives and area(s) of interest, is required.
5. Satisfactory scores on both the general test of the Graduate Record Examination (GRE) and from the Computer Science subject test (C29) are required. Official score reports from the last five years are acceptable.

Degree Requirements - Doctoral Degree Program

The Ph.D. degree is awarded to a candidate who has demonstrated breadth of knowledge in computer science in general and has displayed depth of knowledge in the area of specialty as well as the ability to make original contributions to the body of knowledge in this field.

To successfully complete the Ph.D. program, a student must fulfill all the Graduate College degree requirements and the following requirements:

1. Complete 48 credits of course work.
2. Satisfactorily pass a written comprehensive examination.
3. Satisfactorily pass an oral qualifying examination.
4. Prepare a dissertation that must be acceptable to his or her Ph.D. committee.
5. Satisfactorily pass an oral defense of the dissertation.
6. Maintain a satisfactory rate of progress.

Course Requirements

A student entering the Ph.D. program with a master's degree in computer science is required to take at least 48 credits of course work subject to the following conditions:

1. At least 42 credits must be in computer science.
2. At least 18 credits of computer science courses must be at the 700 level (excluding CS 799 credits).
3. Must include exactly three credits of CS 792 (Research Seminar).
4. Must include a maximum of 18 credits of CS 799 (Dissertation Research).

A student entering the Ph.D. program with a bachelor's degree is required to take at least 24 extra credits of 600-and 700-level computer science courses in addition to the above 48 credits (at least half of them must be at the 700 level).

The Comprehensive Examination

The written comprehensive examination will be given twice a year. The comprehensives will assess the student's breadth of knowledge through three examinations covering the six Core Areas listed below and another examination in two other areas of his or her choice.

Core Areas

1. Automata and formal languages; Algorithms and data structures
2. Programming languages; Compiler construction
3. Computer architecture; Operating systems

Application areas

1. Artificial intelligence
2. Computer graphics and image processing
3. Computer simulation and networks
4. Data base systems
5. Software engineering and reliability
6. Document analysis
7. Networks and distributed computing
8. Geometric applications

The level of the examination is that of 600-level and 700-level courses in each area. A syllabus will be published well in advance of the exams listing the topics to be covered in each exam. Students are expected to take the comprehensive examination within two years of entering the Ph.D. program. All Ph.D. students are urged to take this examination as early as possible. Preference is given in the allocation of student financial support to those who have passed the comprehensive examination. The comprehensive examination may be attempted at most twice. Students who do not pass the comprehensive examination the first time must retake the examination at the next scheduled offering. Failure to pass the comprehensive examination after two attempts will normally lead to dismissal from the Ph.D. program. After passing the comprehensive examination, a research topic of mutual interest to the student and his/her proposed committee is selected. At this point, the student formally begins his/her research study.

The Qualifying Examination

The qualifying examination is an oral examination designed to test the depth of the student's knowledge in his or her area of research specialization. It must be taken before either (a) two years after passing the comprehensive examination or (b) four years after entering the Ph.D. program. It generally focuses on his/her dissertation proposal. The main purpose of this exam is to evaluate the technical merits and feasibility of the student's proposal for his/her Ph.D. dissertation. The student's Ph.D. committee must conduct the examination. This committee consists of five faculty members of whom one must be from outside the school of computer science. The student's advisor is the chairperson of this committee. The faculty member from outside the school is selected by the Graduate College from three faculty members who are suggested by the student in consultation with his or her advisor. The student must prepare a dissertation proposal before taking this examination. The student's advisor should have already

approved this proposal. This proposal must be given to the Ph.D. committee members at least two weeks before the date of the qualifying exam. The proposal must contain a discussion of the background literature on the problem area, description of the specific topic of research proposal approach, feasibility arguments, the objective of the research project, and a list of references. The student begins the exam with a presentation of the dissertation proposal. The remaining time is used for discussion and asking questions to determine if the student has sufficient depth of knowledge to carry out the proposed research. The examination cannot be taken more than twice. After successful completion of the qualifying examination, the student is advanced to candidacy for the doctoral degree.

Preparation of Dissertation

The candidate must prepare a dissertation on his or her research. The doctoral dissertation should represent a significant original research contribution to the field of computer science and be publishable in a recognized refereed journal.

Oral Defense

After completion of the dissertation, the candidate must pass a final oral defense of his/her dissertation. The candidate must make the final changes, if any, in the dissertation within three months from the date of the oral defense. A candidate can defend the dissertation no more than twice. Each member of the committee must approve the final dissertation.

Satisfactory Progress

To maintain satisfactory progress in the Ph.D. program a student must:

1. Pass the comprehensive examination within 2.50 years of entering the Ph.D. program.
2. Maintain a minimum grade point average required by the College of Engineering.
3. Pass the qualifying examination within four years of entering the Ph.D. program.
4. Maintain satisfactory progress towards research.
5. Students who enter the Ph.D. program with a master's degree must complete all requirements for the Ph.D. degree within six years. Those who enter the Ph.D. program with a bachelor's degree must complete all requirements for the Ph.D. degree within eight years. If these requirements are not met, the department may place the student on academic probation or drop him/her from the Ph.D. program.

Computer Science

CS 715 **3 credits**
Advanced Analysis of Algorithms
Analysis of the complexity and correctness of asymptotically efficient algorithms, including set partitioning, matrix multiplication, integer multiplication and pattern matchingalgorithms. The theory of NP-completeness; Cook's theoremand polynomial transformations. Basic NP-completeproblems, such as the three-satisfactory, three-dimensional matching and Hamiltonian circuit problems. PSPACE-completeness results, such as quantified Boolean formulas. Prerequisites: CS 656 and CS 677.

CS 717 **3 credits**
Advanced Computer Simulation
Advanced discrete simulation modeling using SIMSCRIPT 11.5 and SLAM. Advanced continuous simulation using ACSL. Modeling concepts, measuring random phenomena. Passive objects, application of simulation to operating systems and software design in general. Digital-analog solution of linear differential equations, industrial dynamics. Feedback systems. Prerequisite: CS 617.

CS 718 **3 credits**
Theory of Computation
Computability of functions and sets in terms of Turing machines and other computational models. Universal Turing machines and examples of unsolvable problems. Introduction to other computational models, such as the lambda-calculus, Post systems, Markov algorithms and recursive function theory. The Church-Turing thesis and proofs of equivalence between the models. Prerequisite: CS 656.

CS 719 **3 credits**
Advanced Automata and Formal Languages
Extensive study of context-sensitive, recursive and recursively enumerable languages, including ambiguity and closure properties: decidable and undecidable properties of the different language classes: the halting problem and Post's correspondence problem; properties of the deterministic context-free languages; LR(k) and LL(k) grammars. Prerequisite: CS 656.

CS 733
Geographic Data Base Systems **3 credits**
Spatial data types and operators: point queries, range queries, translation, rotation, and scaling. Data structures for object representation: arc tree, quadtrees. Commercial data bases vs. spatial data bases: relational, hierarchical, network. (May not be used to satisfy degree requirements in Computer Science.) Prerequisites: CS 135 or CS 117 or equivalent and STAT 611.

CS 740 **3 credits**
Statistical Pattern Recognition
Concepts and formal theoretical structures necessary for design and implementation of a pattern recognition system. Topics include: parametric and non-parametric methods, linear and non-linear classifiers and clustering algorithms. Prerequisites: STAT 667, MATH 253 or 265, and CS 302.

CS 741 **3 credits**
Structural Pattern Recognition
Survey of advanced pattern recognition techniques. Topics include: graph matching methods, syntactic approaches, neural nets, and context-dependent methods. Prerequisites: CS 656 and CS 677.

CS 742 **3 credits**
Document Image Understanding
Survey of document understanding methods and related topics that include: data compression, document exchange standards, layout analysis methods, logical analysis methods, OCR, error correction, and document routing. Prerequisites: CS 740 and CS 669.

CS 747 **3 credits**
Cryptography and Information Theory
Cryptography, cryptographic systems, encryption algorithms, cryptographic techniques, access control, lattice model of information flow, flow control mechanisms, inference control mechanisms, mechanisms restricting noise, mechanisms restricting statistics, statistical database models. Prerequisites: CS 370, STAT 411.

CS 750 **3 credits**
Computational Algorithms in VLSI
Application and inherent limitations of using VLSI to implement computational algorithms, design and analysis of algorithms for design of VLSI circuits, introduction to VLSI implementation of computational algorithms represented by logic circuits, lower bounds on area and time, systolic arrays and their applications, VLSI layout algorithms, VLSI test generation and simulation. Prerequisite: CS 677.

CS 754 **3 credits**
Discrete Optimization
Network optimization problems, use of advanced data structures. Topics may vary and include maximum-flow algorithms, multiterminal maximum flows, minimum cost flows and circulations, matching algorithms, approximation algorithms, and applications. Hamiltonian circuits in dense graphs, disjoint paths, the postman problem, introduction to combinatorial geometry, and linear programming. Prerequisite: CS 677.

CS 756 **3 credits**
Formal Semantics
Coverage of formal methods for defining the semantics of programming languages, including the operational, denotation and axiomatic approaches. Proof techniques for verifying properties of programs. Consistent and complementary definitions for a Pascal-like language discussed. Prerequisites: CS 326 and CS 656.

CS 758 **3 credits**
Computational Geometry
Geometric searching, point location, range searching, convex hull, Graham's scan, gift wrapping, dynamic convex hull, proximity closest pair, Voronoi diagram, triangulation. Intersection, visibility shortest paths, geometry of rectangles. Prerequisite: CS 677.

CS 763 **3 credits**
Advanced Computer Architecture
Advanced study of various current computer architectures. Examples taken from specialized architectures that support modern general-purpose programming, operating systems, artificial intelligence and data bases. SIMD and MIMD parallel architectures. Prerequisites: CS 326 and CS 663.

CS 767 **3 credits**
Advanced Computer Graphics
Hidden line elimination algorithms and implementation. Perfect interpolators, cubic and bicubic splines, Kriging, Hermite surfaces, nonperfect interpolators, Bezier curves and surfaces, B-splines, ray tracing algorithms, shading, lightness, motion, moving pictures, two- and three-dimensional fractals. Special topics. Prerequisite: CS 680.

CS 768 **3 credits**
Surface Estimation for Computer-Aided Geometric Design
Affine maps, function spaces, the DeCasteljan algorithm, Bernstein polynomials, Bezier surfaces, nonparametric curves, Lagrange polynomials, C continuity, B-spline basis, Frenet frame, G continuity, gamma splines, beta splines, geometric continuity, tensor product interpolants, volume deformations, curvatures. Prerequisite: CS 767.

CS 769 **3 credits**
Advanced Data Base Management
Continuation of CS 632, including normalization of relational data bases using functional and multivalued dependencies. Query processing, query interpretation, query optimization, and methods for implementing and optimizing logic queries. Knowledge data bases, distributed data bases and object-oriented data bases. Prerequisite: CS 657.

CS 770 **3 credits**
Advanced Operating Systems
Study of the design principles, organization, and performance analysis of large-scale computer operating systems. Particular subjects emphasized include coordination of tasks, solutions of deadlock problems, theories of segmentation and paging, and performance prediction. Prerequisite: CS 370.

CS 771 **3 credits**
Concurrent Computation
Study of concurrent programming methods and applications; event spaces; models of concurrency, such as Petri nets, CCS and CSP. Synchronization, data sharing and communication. Concurrency constructs in various programming languages. Scheduling and implementation techniques. Applications of concurrency in operating system design, fault-tolerance, and reliability. Prerequisites: CS 326 and CS 370.

CS 772 **3 credits**
Software Architecture
Survey of advanced techniques for specifying and designing large software systems. System verification. Reliability and project management. Prerequisites: CS 370, CS 672, and CS 660, or consent of instructor.

CS 777 **3 credits**
Parallel Algorithms
Methods for creating and analyzing parallel algorithms. Parallel programming languages and programming models of shared-memory and distributed architectures. Measuring complexity of parallel algorithms. NC-class versus P-class algorithms. Prerequisite: CS 677.

CS 778 **3 credits**
Advanced Translation
Formal semantics, automatic compiler generation, attribute grammars. Language issues as they relate to compiler generation. Prerequisite: CS 660.

CS 779 **3 credits**
Supercompliers for Parallel and Vector Computers
Dependence analysis, Diophantine equations, the GCD test, the Banerjee test, do-loop normalization, concurrency in loops, vector code generation, control dependence and vectorization, parallel code generation for doall-loops, parallel code generation for doacross-loops, shared memory parallelization, parallelization for distributed memory architectures. Prerequisite: CS 778.

CS 780 **3 credits**
Distributed Computing and Algorithms
Methods and algorithms of distributed computing. Topics may include architecture and design goals, formal approaches to distributed computing problems, networks and protocols, models of distributed computing, synchronization and communication, synchronous and asynchronous systems, fault-tolerance and reliability, self-stabilization, distributed algorithms and applications. Prerequisites: CS 370, CS 677.

CS 781 **3 credits**
Automated Deduction
Use of computers for forming deductions and proving theorems in symbolic logic covered. Topics include resolution, unification, proof strategies, and equality. Also examines areas of application: problem solving, question answering, program verification, automatic programming and logic programming (Prolog). Prerequisite: CS 682.

CS 782 **3 credits**
Expert System Construction
Design, organization, and construction of expert systems. Includes general concepts, characteristics, elements, advantages, and examples of expert systems. Also rule-based knowledge representations, inference techniques, implementation tools and shells, and advanced topics. Prerequisite: CS 682.

CS 785 **3 credits**
Computational Linguistics
Introduction to linguistics and computational linguistics, for natural language. Phonology, morphology, syntax, semantics, and lexicology. Text analysis and processing; construction of lexicons, and indexes and concordances. Introduction to text retrieval, translation, speech understanding and generation. Prerequisite: CS 656.

CS 786 **3 credits**
Advanced Computational Linguistics
Advanced study of computational linguistics. Emphasis on cognitive methods in natural language understanding and generation. Pragmatics and discourse. Prerequisite: CS 785.

CS 789 **3 credits**
Topics in Advanced Computer Science
Graduate-level course in some field of computer science, at advanced level, depending upon the current interest of the staff and the students. May be repeated with a different subject matter to a maximum of nine credits. Prerequisite: Consent of instructor.

CS 790 **1-3 credits**
Master's Project
May be repeated, but only three credits will be applied to the student's program. S/F grading only. Prerequisite: Consent of instructor.

CS 791 **3-6 credits**
Thesis
May be repeated, but only six credits will be applied to the student's program. S/F grading only. Prerequisite: Consent of instructor.

CS 792 **1 credit**
Research Seminar
Oral presentation of assigned articles. May be repeated to a maximum of four credits. Prerequisite: Consent of instructor.

CS 799 **1-6 credits**
Dissertation Research
Research analysis and writing towards completion of dissertation and subsequent defense. May be repeated but no more than 18 credits will be allowed in the degree. S/F grading only. Prerequisites: Graduate standing in Ph.D. program and consent of advisor.

The following courses may also be used for graduate credit. For descriptions of 600-level courses, please consult the current *Undergraduate Catalog*, where they are listed as 400-level classes.

CS 617	Introduction to Computer Simulation
CS 641	Advanced Internet Programming
CS 641L	Advanced Internet Programming Lab
CS 645	Internet Security
CS 648	Computer Security
CS 651	Multimedia Systems Design
CS 651L	Multimedia Systems Design Lab
CS 656	Automata and Formal Languages
CS 657	Database Management Systems
CS 660	Compiler Construction
CS 663	Computer Architecture
CS 665	Computer Networks I
CS 666	Computer Networks II
CS 669	Introduction to Digital Image Processing
CS 670	Networks and Distributed Systems
CS 671	Program Derivation
CS 672	Software Product Design and Development I
CS 673	Software Product Design II
CS 674	Decision Environments for Software Product Development
CS 677	Analysis of Algorithms
CS 680	Computer Graphics
CS 682	Artificial Intelligence
CS 689	Advanced Computer Science Topics
CS 690	Independent Study

Construction Management

Director

Shields, David (2003), Associate Professor; B.S., M.S., Texas A&M University; Ph.D., University of Texas at Austin, P.E. (Arizona).

Graduate Coordinator

Opfer, Neil (1989), Associate Professor; B.S., B.A. Washington State University; M.B.A. Purdue University; P.D., University of Wisconsin.

The Master of Science in Construction Management (M.S.C.M.) degree provides graduate-level study for those seeking mid- and upper-level management positions in the construction industry or continued study for the doctorate.

Students with degrees in construction management, engineering, science, architecture and business, as well as related disciplines are invited to apply. Applications for admission to the program are evaluated on an individual basis by the program's faculty.

Documents to be mailed to the Construction Management Program:

Address: University of Nevada Las Vegas; Construction Management Program; 4505 S. Maryland Parkway; Box 454005; Las Vegas, NV 89154-4005.

1. One official transcript from each post-secondary institution attended. Only transcripts sent directly from the institution are considered.
2. Two letters of recommendation.
3. One-page statement indicating the reasons why you wish to earn an M.S. degree.
4. GRE test scores taken in the last five years.

Documents submitted to the Graduate College:

Address: University of Nevada Las Vegas; Graduate College; 4505 S. Maryland Parkway; Box 451017; Las Vegas, NV 89154-1017.

1. A complete application form and a non-refundable fee. The most current application fees for U.S. citizens and international applicants are available online at http://www.graduatecollege.unlv.edu.
2. One official transcript of each post-secondary institution attended.

International students must also submit to the Graduate College:

1. Official translated copies of transcripts. Only transcripts sent directly from the institution to the UNLV Graduate College will be considered.
2. Official TOEFL or Michigan Test Scores (only if English is not native language) taken in the last two years.
3. High School Leaving Certificate (for international students only)

**The Confidential Financial Certificate must be submitted to the Office of International Students and Scholars