

## COMPUTER SCIENCE

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### COLLEGE OF SCIENCE

**Akkaya, Kemal**, Assistant Professor, Ph.D., University of Maryland, Baltimore County, 2005; 2005. Wireless sensor and actuator networks, ad-hoc networking, spatio temporal and geosensor databases.

**Carver, Norman F., III**, Associate Professor, Ph.D., University of Massachusetts, 1990; 1995. Multi-agent systems, sensor interpretation, knowledge-intensive control of AI systems.

**Che, Dunren**, Assistant Professor, Ph.D., Beijing University of Aeronautics and Astronautics, Beijing China, 1994; 2001. Database, structured document management, bioinformatics.

**Cheng, Qiang**, Assistant Professor, Ph.D. University of Illinois, 2002. Multimedia computing and security, biomedical image and information processing.

**Danhof, K. J.**, Professor, *Emeritus*, Ph.D., Purdue University, 1969; 1969.

**Gupta, Bidyut**, Professor, Ph.D., University of Calcutta, 1986; 1988. Distributed systems, fault-tolerant computing, mobile communication.

**Hexmoor, Henry**, Assistant Professor, Ph.D., University of Buffalo, 1996; 2006. Artificial intelligence, Multi-agent systems, cognitive science, mobile robotics, knowledge representation and reasoning.

**Hou, Wen-Chi**, Associate Professor, Ph.D., Case Western Reserve University, 1989; 1989. Statistical databases, query optimization, data stream processing, spatial data structures.

**Mark, Abraham M.**, Professor, *Emeritus*, Ph.D., Cornell University, 1947; 1950.

**McGlenn, Robert J.**, Associate Professor, *Emeritus*. Ph.D., Southern Illinois University Carbondale, 1976; 1981.

**Mogharreban, Namdar**, Associate Professor, Ph.D., Southern Illinois University Carbondale, 1989; 1999. End user computing, computer training, computing in special populations, decision making, decision science.

**Phillips, Nicholas C.K.**, Associate Professor, *Emeritus*, Ph.D., University of Natal, 1967; 1988.

**Rahimi, Shahram**, Associate Professor, Ph.D., University of Southern Mississippi, 2002; 2002. Distributed computing, software agents, expert systems, fuzzy logic, soft computing.

**Wainer, Michael S.**, Associate Professor, Ph.D., University of Alabama at Birmingham, 1987; 1988. Computer graphics, agile software development and testing, HCI.

**Wright, W. E.**, Professor, *Emeritus*, D.Sc., Washington University, 1972; 1970.

**Zargham, M. R.**, Professor and *Chair*, Ph.D., Michigan State University, 1983; 1983. Computer architecture, fuzzy logic, neural networks, parallel processing, expert systems.

**Zhu, Mengxia**, Assistant Professor, Ph.D., Louisiana State University, 2005; 2006. Remote visualization system, distributed high-performance computing, bioinformatics, distributed sensor networks.

The Department of Computer Science offers graduate programs leading to the Master of Science degree and Doctor of Philosophy degree in computer science. For admission procedures to these degree programs refer to the Graduate School or department website ([www.cs.siu.edu](http://www.cs.siu.edu)).

This program requires a nonrefundable \$50.00 application fee that must be submitted with the application for Admissions to Graduate Study in Computer Science. Applicants may pay this fee by credit card if applying electronically. Applicants submitting a paper application must pay by personal check, cashier's check, or money order made out to SIU, and payable to a U.S. Bank.

Decisions concerning the admission of students in, and retention of students in, the graduate program will be made by the department faculty subject to the requirements of the Graduate School.

### Master of Science Degree in Computer Science

*Admission.* The evaluation of applicants for admission is based primarily on the student's academic record with particular attention being given to past performance in relevant undergraduate course work. Applicants are expected to have a substantial background in undergraduate computer science courses covering programming, data structures, computer organization, logic design as well as discrete mathematics, calculus, and linear algebra. The applicant is expected to have completed course work in the above subject areas prior to admission. Normally, a GPA of at least 3.0/4.0 is required by the Department of Computer Science. In addition, applicants must submit Graduate Record Examination (GRE) general test scores. It is recommended that results from the GRE subject area test (computer science or a related field) also be submitted.

*Requirements.* A student who has been admitted to the master's degree in computer science can meet the requirements for the Master of Science degree by completing 33 hours of graduate credit subject to the following constraints:

1. Each of the courses CS 401, CS 414, and CS 455 must be taken. (If a specific course, or its equivalent, is already part of the student's academic background, an alternate course will be substituted, with Graduate Program Director approval.)
2. The 33 hours of graduate work must include at least four 500-level CS lecture courses.

3. Elective courses should be chosen from CS courses, excluding any cross-listed courses. Alternate or substitution courses require Graduate Program Director approval.
  4. Students are required to write a thesis carrying 6 credit hours under CS 599. No more than 3 credit hours of CS 599 can be taken per semester.
  5. All course registrations must have the written approval of the Graduate Program Director.
- After completion of all work, the student will be given a final oral examination over the thesis and other course work.

### **Doctor of Philosophy Degree in Computer Science**

*Admission.* Subject to meeting the admission requirements of the Graduate School, admission requirements for the Ph.D. in computer science consist of:

1. A masters' degree in computer science or a related field with a minimum GPA of 3.25/4.0.
2. Graduate Record Examination (GRE) general test scores. It is recommended that results from the GRE subject area in computer science or a related area be included.
3. In exceptional cases, high achieving students with only bachelor degrees will be admitted to the program. Each student, in addition to the Ph.D. program course requirements, must complete at least 15 semester hours of approved computer science courses including CS 401, CS 414, CS 455, and two 500-level lecture courses, with a minimum accumulated GPA of 3.25/4.0 in those courses. If a specific course, or its equivalent, is already part of the student's academic background, an alternate course will be submitted.

Each applicant is reviewed and evaluated on an individual basis. The evaluation of applicants for admission is based primarily on the student's academic record and area of research interest. Application materials should include evidence of scholarly ability and/or achievement (e.g. awards, scholarships, work experience, recommendation letters, and published research papers). Only those who best meet the research goals and objectives of the doctoral program will be selected for admission.

*Requirements.* The student must fulfill the requirements for the departmental Qualifying Examination within three years of enrollment in the doctoral program. The Qualifying Examination is organized and administered by the student's academic advisor. The faculty prepares a written test based on at least two areas of concentration related to the student's intended dissertation area. Questions will be drawn from regularly scheduled 400 and 500-level graduate courses at SIUC. The grade for the exam will be on a Pass or Fail basis for each subject area. If a student fails to pass any subject area of the written examination, a second chance is given for the failed topic test. Students who fail the Qualifying Examination after two attempts will be dismissed from the Ph.D. program.

To fulfill the course requirements of the Ph.D. program, the student must complete at least 24 credit hours of 400/500-level courses and 24 credit hours of CS 600 Dissertation research, all of which are subject to the following constraints:

1. The course work must include two one-credit hour seminar courses, six credit hours from an approved list of computer science 400/500-level courses, and six elective credit hours of CS 500-level courses.
2. The student must file a request with the Department to appoint a Dissertation Committee to supervise the remaining doctoral work. This committee will consist of five graduate faculty members, one or two of whom will be from a graduate program outside the Department, one preferable from outside this university. The student's dissertation advisor will serve as the Chair of this committee.
3. Each student should complete a course of study as determined by the student's dissertation committee.
4. The course of study must include a minimum of six credit hours of 400/500-level courses from academic departments other than computer science. These courses must be selected from a list approved by the Department.
5. Having passed the qualifying exams and after completion of most of the course requirements, a student will begin working on a dissertation proposal. The next step will be a Preliminary Examination consisting of an oral test on the student's proposed research topic. The student will pass the Preliminary Examination only if the members of the committee, with at most one exception, judge the performance of the student's oral examination to be satisfactory. In the event the student's performance is unsatisfactory, the committee will reschedule the exam for a later time. A student who fails the reexamination will be dismissed from the Ph.D. program.
6. A student will be officially admitted to candidacy for the Ph.D. degree after passing the Preliminary Exam and upon completion of all course work. The student must then complete 24 credit hours of dissertation credit, restricted to nine hours per semester. When the research is complete and the dissertation is written, a final oral examination will take place to determine if the research conducted is worthy of the Ph.D. degree. This dissertation must conform to high literacy and scholastic standards and comply with all the relevant requirements of the Graduate School. The dissertation must represent original research of good quality. From the dissertation, the candidates should publish (or have accepted for publication) a minimum of two articles in peer-reviewed publications, at least one of which should be a journal.

7. Each candidate must pass a final oral exam over the candidate's dissertation, conducted by the candidate's Dissertation Committee. The dissertation will be accepted provided the dissertation advisor and at least three of the other four members of the committee so agree.
8. Degree requirements, graduation, and time limits are subject to the general guidelines of the Graduate School.

### Courses (CS)

**401-3 Computer Architecture.** Review of logical circuit design. Hardware description languages. Algorithms for high-speed addition, multiplication and division. Pipelined arithmetic. Implementation and control issues using PLA's and microprogramming control. Cache and main memory design. Input/Output. Introduction to interconnection networks and multiprocessor organization. Prerequisite: 315 with a grade of *C* or better.

**402-3 Theory and Applications of Computer Aided Design.** A study of algorithmic techniques, which solve high complexity design rules. Graph algorithms and formulations, randomized solutions, techniques from operations research and statistics, computational geometry algorithms and data structures are introduced. The techniques are mainly applied on the physical design/automation problem for integrated circuits and systems. Prerequisite: 315 and 355 each with grade of *C* or better.

**404-3 Autonomous Mobile Robots.** This course is a comprehensive introduction to modern robotics with an emphasis on autonomous mobile robotics. Fundamentals of sensors and actuators as well as algorithms for top level control are discussed. Multi-robotics and human-robot interaction issues are explored. A group project is an integral part of this course. Prerequisite: 330 with a grade of *C* or better.

**406-3 Basic Linux System Administration.** This course will be an introduction to the administration of Linux systems, with emphasis on security for networked systems. Topics to be covered include: installation and configuration of Linux distributions, typical maintenance activities, and security measures for networked systems. Students will have access to lab machines for hands on practice. Prerequisite: 306 with a grade of *C* or better.

**408-3 Applied Cryptography.** This course is a comprehensive introduction to modern cryptography, with an emphasis on the application and implementation of various techniques for achieving message confidentiality, integrity, authentication and non-repudiation. Applications to Internet security and electronic commerce will be discussed. All background mathematics will be covered in the course. Prerequisite: 220 and MATH 221 or their equivalents.

**410-3 Computer Security.** A broad overview of the principles, mechanisms, and implementations of computer security. Topics include cryptography, access control, software security and malicious code, trusted systems, network security and electronic commerce, audit and monitoring, risk management and disaster recovery, military security and information warfare, physical security, privacy and copyrights, and legal issues. Prerequisite: 306 with a grade of *C* or better.

**412-3 Programming Distributed Applications.** This course uses advanced features of the Java programming language to develop networked, distributed, and web-based applications. Topics covered include, but are not limited to, sockets, datagrams, the Java security model, threads, multi-tier architectures, Java RMI, Java database connectivity, and Java-based mobile agents. Prerequisites: 220 with a grade of *C* or better.

**414-3 Operating Systems.** An extended treatment of the components of operating systems, including I/O programming, memory management, virtual memory, process management, concurrency, device management and file management. Prerequisite: 306 and 330 each with a grade of *C* or better.

**416-3 Compiler Construction.** Introduction to compiler construction. Design of a simple complete compiler, including lexical analysis, syntactical analysis, type checking and code generation. Prerequisite: 306 and 311 each with a grade of *C* or better.

**420-3 Parallel and Distributed Computing.** This course serves as an introduction to the areas of parallel and distributed computing. The major approaches to parallel programming, including shared-memory multiprocessing and message-passing multicomputing, will be covered in some detail. Students will have programming experience in each of these paradigms. Architectural considerations, algorithm design and measures of performance will be covered. In addition, the course will provide an introduction to distributed computing on a network of computers. Parallel and distributed computing will be contrasted. Other approaches to parallelism including data parallelism (SIMD) and vector processing will be surveyed. Prerequisite: 306 and 355 each with a grade *C* or better.

**430-3 Database Systems.** This course concentrates on the relational model and includes several query languages. Topics covered include normalization, database design, catalogs, transaction support, concurrency control, integrity support, backup and recovery, and security. Projects involve the use of both personal and enterprise database systems. Prerequisite: 220 with a grade of *C* or better; 330 with a grade of *C* or better recommended.

**435-3 Software Engineering.** Principles, practices, and methodology for development of large software systems. Object-oriented principles, design notations, design patterns and coping with changing requirements in the software process. Experiences with modern development tools and methodologies. A team project is an integral part of this course. Prerequisite: 330 with a grade of *C* or better; 306 with a grade of *C* or better recommended.

**436-3 Artificial Intelligence I.** Search and heuristics, problem reduction. Predicate calculus, automated theorem proving. Knowledge representation. Applications of artificial intelligence. Parallel processing in artificial intelligence. Prerequisite: 311 and 355 each with a grade of *C* or better.

**437-3 Expert Systems.** This course is designed to provide students with an introduction to expert systems theory. Topics covered include knowledge representation, methods of inference, reasoning under uncertainty, and inexact reasoning (fuzzy logic). A practical introduction to expert systems programming serves to reinforce and clarify the theoretical concepts. Prerequisite: 330 with a grade of *C* or better, or consent of the instructor.

**438-3 Bioinformatics Algorithms.** This course is an introductory course on bioinformatics algorithms and the computational ideas that have driven them. The course includes discussions of different techniques that can be used to solve a large number of practical problems in biology. Prerequisite: 330 with a grade of *C* or better.

**440-3 Computer Networks.** Design and analysis of computer communication networks. Topics to be covered include queuing systems, data transmission, data link protocols, topological design, routing, flow control, security and privacy and network performance evaluation. Prerequisite: 330 with a grade of *C* or better; 306 recommended.

**441-3 Mobile and Wireless Computing.** Concepts of mobile and wireless systems are presented. These concepts include, but are not limited to, Routing and Medium Access for Mobile Ad hoc and Wireless Sensor Networks, Mobile IP, Wireless LAN and IEEE 802.11. Hands-on group lab experience is an integral component in the course. Prerequisite: 330 with a grade of *C* or better, or consent of the instructor.

**447-3 Introduction to Graph Theory.** (Same as Mathematics 447.) Introduction to theory of graphs, digraphs, and networks and applications to electrical systems and computer science. Topics include blocks and cutpoints, Eulerian graphs, trees, cycle and cocycle spaces, planarity and Kuratowski's Theorem, connectivity and Menger's Theorem, Hamiltonian graphs, colorability and Heawood's Theorem, flows in networks and Ford-Fulkerson Theorem, critical path analysis. Prerequisite: Mathematics 349 or consent of instructor.

**449-3 Introduction to Combinatorics.** (Same as Mathematics 449.) An introduction to combinatorial mathematics with computing applications. Topics include selections and arrangements, generating functions, recursion, inclusion and exclusion, coding theory, block designs. Prerequisite: Mathematics 349 or consent of instructor.

**451-3 Theory of Computing.** The fundamental concepts of the theory of computation including finite state acceptors, formal grammars, Turing machines and recursive functions. The relationship between grammars and machines with emphasis on regular expressions and context-free languages. Prerequisite: 311 and 355 each with a grade of *C* or better or graduate standing.

**455-3 Design and Analysis of Computer Algorithms.** An extensive treatment of the design, analysis and complexity of algorithms. Lower bound arguments, divide-and-conquer techniques, greedy algorithms, dynamic programming, graph theoretic algorithms, PRAM algorithms, and NP-completeness and approximation algorithms. Prerequisite: 330 with a grade of *C* or better or graduate standing.

**471-3 Introduction to Optimization Techniques.** (Same as Mathematics 471.) Nature of optimization problems. General and special purpose methods of optimization, such as linear programming, classical optimization, separable programming, integer programming and dynamic programming. Prerequisite: 202 and Mathematics 221 and 250.

**472-3 Linear Programming.** (Same as Mathematics 472.) Nature and purpose of the linear programming model. Development of the simplex method. Application of the model to various problems. Duality theory. Transportation. Assignment problem. Postoptimality analysis. Prerequisite: 202 and Mathematics 221.

**475-6 (3, 3) Numerical Analysis.** (Same as Mathematics 475.) An introduction to the theory and practice of computation with digital computers. Topics include the solution of nonlinear equations, interpolation and approximation, solution of systems of linear equations, numerical integration, solution of ordinary differential equations, computation of eigenvalues and eigenvectors and solution of partial differential equations. Prerequisite: (a) Mathematics 221 and 250 and Computer Science 202 or equivalent programming proficiency; (b) Mathematics 305 and Computer Science 464a.

**484-3 User Interface Design and Development.** Problems and processes in the design of highly usable systems. Understanding stakeholders, requirements, tasks, prototyping, evaluation, guidelines and design process and heuristics. Interactive software concepts and implementation considerations. A group project is an integral part of this course. Prerequisite: 306 with a grade of *C* or better.

**485-3 Computer Graphics.** Principles and techniques of computer graphics. Interactive graphics software development using a modern graphics standard. Topics include: primitives, transforms, clipping, modeling, viewing, rendering, texture, animation and ray tracing. A group project is an integral part of this course. Prerequisite: 306 with a grade of *C* or better; Mathematics 150 and 221 are recommended.

**487-3 Software Aspects of Game Development.** This course focuses on software implementation and development aspects of game production including: software process, system architecture, frameworks, entity management and interaction design, game design, production and business issues as well as technical foundations in graphics modeling and rendering, collision detection, physics, artificial intelligence, and multiplayer techniques. Prerequisite: 330 with a grade of *C* or better.

**490-1 to 6 (1 to 3 per semester) Readings.** Supervised readings in selected subjects. Prerequisite: consent of instructor and department.

**491-1 to 4 Special Topics.** Selected advanced topics from the various fields of computer science. Prerequisite: consent of instructor.

**492-1 to 6 (1 to 3 per semester) Special Problems.** Individual projects involving independent work. Prerequisite: consent of department.

**493-1 to 4 Seminar.** Supervised study. Preparation and presentation of reports. Prerequisite: consent of instructor.

**498-1 Senior Project in Computer Science I.** Selecting and planning a team project which is representative of a project graduates may encounter in their professional employment. This involves team formation, project selection, project planning, proposal writing, and proposal presentation. Prerequisite: Senior status in Computer Science, including completion of or concurrent enrollment in at least two other 400-level Computer Science courses.

**499-1 Senior Project in Computer Science II.** A continuation of 498. An exercise in the design, implementation, and deployment of a group project culminating in a presentation to the computer science faculty. Prerequisite: 498.

**501-3 Advanced Computer Architecture.** Hardware and software elements of multiprocessors, multicomputers, pipeline and array machines, data flow architecture and other state-of-the-art architectures. Design principles related to machine structures, interconnection networks, control software and hardware, data storage and access. Prerequisite: 401.

**502-3 Design and Analysis of VLSI Systems.** This course covers the theory, technology, fabrication and design of digital integrated circuits as they are commonly used in modern digital computers. The topics covered include techniques for solving problems occurring in VLSI and ULSI layouts, built-in self-testing, design for testability and logic synthesis. The course also treats additional selected advanced topics. Prerequisite: 401 and either 402 or consent of instructor.

**503-3 Fault-Tolerant Computing Systems.** An introduction to different aspects of fault-tolerance in computing systems. Concurrent checking techniques. Redundancy techniques. Evaluation methods. System-level diagnosis and fault-tolerant VLSI architectures. Prerequisite: 401.

**504-3 Testing of Integrated Circuits and Systems.** This course provides a detailed treatment of digital systems testing and testable design. Topics covered include fault modeling, fault simulation, testing for stuck faults, testing for bridging faults, delay faults, IDDQ faults, functional testing, built-in testing, design for testability, logic and system level diagnosis and PLA testing. Prerequisite: 401 and either 402 or consent of instructor.

**511-3 Formal Specification of Programming Languages.** A survey of modeling techniques and Meta languages for the formal specification of the syntax and semantics of high-level programming languages. Prerequisite: 311.

**512-3 Declarative Programming.** An advanced level course on nonprocedural programming with emphasis on logic programming, pure functional programming, and the characteristics of the declarative style common to these two paradigms. Topics include logic programming, functional programming, implementation consideration for each along with current research topics in the areas. Prerequisite: 311.

**514-3 Advanced Operating Systems.** Rigorous treatment of advanced topics in operating systems. Multiprocessors and distributed operating systems. Highly concurrent machines. Performance analysis of memory management and scheduling algorithms. Recovery techniques in distributed computation. Security in operating systems. Prerequisite: 414.

**516-3 Advanced Compilers.** A continuation of 416 including advanced topics in lexical and syntax analysis, error recovery, semantic analysis, code optimization and compiler compilers. Prerequisite: 416.

**520-3 Advanced Topics in Parallel & Distributed Computing.** An advanced treatment of parallel and distributed computing; review of hardware and software considerations for parallel computation; development and analysis of parallel algorithms (with particular attention to the communication and synchronization costs associated with parallel algorithms); effect of granularity on performance; a comparison of the parallel and distributed programming paradigms including a detailed study of the central features of each approach; software systems for distributed computing including exposure to one or more distributed programming environments; the direction of parallel computing as suggested by recent, high level parallel languages; parallelizing serial programs; parallelizing compilers; future directions of parallel and distributed computing systems. The course will include a student project. Prerequisite: 420.

**530-3 Advanced Data Base System.** A detailed treatment of advanced topics in data base systems including, but not limited or restricted to, relational database theory, query optimization, recovery techniques, concurrency control, distributed database systems, security and integrity and database machines. Prerequisite: 430.

**532-3 to 6 Topics in Information Systems.** A detailed study of two or three topics relevant to information systems. Topics may include but are not limited to sorting, searching, information retrieval and automatic text processing, database security and encryption, distributed databases and data communication. Prerequisite: 430 and consent of instructor.

**533-3 Data Mining Techniques and Application.** This course will provide the techniques of data mining and knowledge discovery in databases. Fundamental principles and techniques of data mining are explained as well as their potential in Bioinformatics application. Major topic areas are: data preparation, association rule

mining, data classification/prediction, data clustering, and web mining. Prerequisite: 430 or consent of instructor.

**536-3 Artificial Intelligence II.** Theorem proving, the Resolution Principle, strategies, and achievements. Program verification. Natural language processing. Other selected topics. Prerequisite: 436.

**537-3 Advanced Topics in Expert Systems.** This course is designed to provide students with advanced topics in expert systems theory. Topics covered include: knowledge representation, methods of inference, reasoning under uncertainty, and inexact reasoning (fuzzy logic). A practical introduction to expert systems programming serves to reinforce and clarify the theoretical concepts. Prerequisite: 330 or consent of instructor.

**540-3 Advanced Computer Networks.** Topics include routing protocols used in internet; data compression techniques; telecommunication systems – its services, architecture and protocols; high speed networks; routing protocols in mobile ad-hoc networks; and a detailed performance analysis of different window flow control and congestion control mechanisms using queuing theory. Prerequisite: 440 with a grade of C or better, or consent of the instructor.

**553-3 Formal Languages and Automata.** The Chomsky hierarchy of formal grammars and the corresponding classes of automata. Turing machines and basic concepts of computability. Recursive and recursively enumerable languages. Closure properties. Undecidable problems about Turing machines and context-free languages. Deterministic context-free languages and the construction of LR parsers. Prerequisite: 451.

**555-3 Computability and Complexity.** Turing machines and other models of computation. Computable functions. Church's thesis. Solvable and unsolvable problems. Introduction to complexity theory including the classes P and NP. Polynomial time approximation algorithms for NP-complete problems. Prerequisite: 451.

**570-3 to 9 per topic (3,3,3) Topics in Operations Research.** (Same as Mathematics 570.) **(a)** Netflows. Builds on network and generalized network models for the transportation, transshipment, assignment, shortest path, and maximal flow. Prerequisite: 472 or Mathematics 472. **(b)** Advanced computer simulation. Review of GPSS. Advanced topics in GPSS. Generation of random variates. Validation, parametric, and nonparametric tests. Design of experiments, optimization, parameter tuning. Analysis of variance, spectral analysis, and variance reduction. Prerequisite: 470 and Mathematics 480 or 483. **(c)** Large scale linear programming. Advanced L.P. techniques for sparse matrices and reinversion routines. Prerequisite: 472 or Mathematics 472. **(d)** Nonlinear programming. Integer programming with branch and bound and cutting plane methods for solving integer-programming problems. Basic dynamic programming with emphasis on the methods and applications. Prerequisite: 472 or Mathematics 472.

**572-1 to 12 Advanced Topics in Numerical Analysis (same as MATH 572).** Selected advanced topics in numerical analysis chosen from such areas as: approximation theory; spline theory; special functions; wavelets; numerical solution of initial value problems; numerical solution of boundary value problems; numerical linear algebra; numerical methods of optimization; and functional analytic methods. Prerequisite: consent of instructor.

**585-3 Advanced Topics in Computer Graphics.** Study of computer graphics for realistic image synthesis. Object modeling and associated data structures. Advanced rendering techniques such as raytracing and radiosity. Efficiency considerations. Image composition and compression. Current advances and research problems in realistic computer graphics. Prerequisite: 485.

**586-3 Pattern Recognition and Image Processing.** An introduction to the area of computer vision for the purpose of restoration, segmentation, encoding, analysis and recognition of pictures. Topics include: image transforms, edge detection, smoothing, filtering, pseudo-coloring, syntactic methods in scene analysis, parametric decision theory, non-parametric decision theory, linear discriminant functions, parameter estimation, supervised learning and unsupervised learning. Prerequisite: 220 and Mathematics 380 or consent of instructor.

**590-1 to 9 Readings.** Supervised readings in selected subjects. Graded *S/U* only. Prerequisite: consent of instructor and department.

**591-1 to 9 (1 to 3 per topic) Special Topics.** Selected advanced topics from the various fields of computer science.

**593-1 to 4 Seminar.** Preparation and presentation of reports. Graded *S/U* only. Prerequisite: consent of instructor.

**598-3 Graduate Project.** A practical exercise in the design, implementation, documentation and deployment of a project. This project can be done through internship, work/study, or a supervised project.

**599-1 to 5 Thesis.** Minimum of three hours to be counted toward a master's degree. Prerequisite: consent of department.

**600- 1 to 24 Doctoral Dissertation.** Dissertation research. Hours and credit to be arranged by the student's academic advisor. Graded *S/U* only. Prerequisite: Admission to Ph.D in computer science program.

**601-1 per semester Continuing Enrollment.** For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or research paper. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis, or research hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded *S/U* or *DEF* only.