Department of Computer Science (CSCI)

Chair: Nicholas T. Karonis

Graduate Faculty

Hamed Alhoori, assistant professor, Ph.D., Texas A&M University
Kirk Duffin, associate professor, Ph.D., Brigham Young University
Raimund Ege, associate professor, Ph.D., Oregon Graduate Institute for Science and Technology
Reva Freedman, associate professor, Ph.D., Northwestern University
Philippe J. Giabbanelli, assistant professor, Ph.D., Simon Fraser University
Minmei Hou, associate professor, Ph.D., Pennsylvania State University
Nicholas T. Karonis, professor, Ph.D., Syracuse University
Michael E. Papka, professor, Ph.D., University of Chicago
Jie Zhou, professor, Ph.D., Concordia University

Master of Science in Computer Science

For admission to the master's program in computer science, students must have a bachelor's degree in computer science or a closely related field. Students without such a background may also be admitted, but may be required to take deficiency courses and earn a grade of B or higher in each. Deficiencies should be resolved in the first year and do not normally carry graduate credit toward the degree.

Students pursuing the M.S. in Computer Science must complete at least 31 semester hours. Students have the option of completing the M.S. degree in Computer Science by taking only courses or by combining coursework with a master's thesis.

Students who are planning to continue their studies through the department's doctoral program must choose the thesis option. Students who write a master's thesis may receive credit for up to 6 semester hours of CSCI 699.

A program of study designed by the student and the adviser must be approved by the Department of Computer Science.

Students must obtain prior departmental approval to apply courses not offered by the Department of Computer Science to their programs of study. No more than 8 credit hours may be outside the Department of Computer Science.

Check departmental information for any additional requirements.

The student learning outcomes for this degree are located at
http:// www.niu.edu/assessment/clearinghouse/outcomes/index.shtml.

Requirements

Students must complete the required number of hours in each of the following areas:

I. Survey (1)
II. Programming (3)
III. Systems (3)
IV. Theory (3)
V. Specializations (6)
VI. Electives (15)

Total (31)

Graduate-level courses for which there exists an undergraduate equivalent (typically courses that are offered as 400/500 classes) shall not constitute more than 50% of the hours applied toward a master's degree.

Details for each category are listed below.

I. Survey

Students must complete the following course:

CSCI 600 - Big Ideas in Computer Science (1)

II. Programming

Students must complete one course from the following or substitute another course with departmental approval.

CSCI 501 - Programming Principles in C++ (3)
CSCI 502 - Programming Principles in Java (3)
CSCI 503 - Programming Principles in Python (3)

III. Systems

Students must complete one course from the following:

CSCI 511 - Database Concepts (3)
CSCI 512 - Computer Networks (3)
CSCI 513 - Software Engineering (3)
CSCI 514 - Operating Systems (3)
CSCI 515 - Principles of Compilers (3)

IV. Theory

Students must complete one course from the following:

CSCI 601 - Theory of Computation (3)
CSCI 602 - Design and Analysis of Algorithms (3)

V. Specializations

Students must complete two courses from the following.

Data Analytics:
CSCI 636 - Pattern Recognition and Data Mining I (3)
CSCI 639 - Network Theory (3)
CSCI 641 - Big Data Analytics (3)
CSCI 642 - Information Storage and Retrieval (3)
CSCI 646 - Modeling and Simulation (3)
CSCI 656 - Artificial Intelligence (3)
CSCI 657 - Natural Language Processing I (3)

Graphics and Visualization:
CSCI 626 - Human Computer Interaction (3)
CSCI 627 - Data Visualization (3)
CSCI 630 - Computer Graphics Modeling (3)
CSCI 631 - Computer Graphics Rendering (3)
CSCI 633 - Digital Image Processing and Analysis (3)

High Performance Computing:
CSCI 661 - Parallel and Distributed Programming Models (3)
CSCI 662 - Programming Non-Traditional Architectures (3)

Bioinformatics:
CSCI 651 - Graph Theory and Applications (3)
CSCI 652 - Algorithmic Bioinformatics I (3)

VI. Electives

Students must complete sufficient semester hours of electives to fill out their program. Elective course work includes CSCI courses in the range 500-798 that have not been used to satisfy another requirement. Students may take up to 8 semester hours from other departments in courses relevant to the student's program, subject to departmental approval.

Students who are planning to continue through the department's doctoral program must take CSCI 701 - Research Methods in Computer Science, as one of their electives of the M.S. in Computer Science, preferably as early as possible.

Doctor of Philosophy in Computer Science

Students seeking admission to the Ph.D. program in computer science must meet all the requirements for admission to the Graduate School; must have a baccalaureate or master's degree in computer science or a related field; and should have a background equal to that required for the B.S. degree at Northern Illinois University.

Requirements

A program of study designed by the student and the adviser to meet the course requirements specified below must be approved by the Department of Computer Science. Each student must complete at least 90 semester hours of graduate course work.

Students must obtain prior departmental approval to apply courses not offered by the Department of Computer Science to their programs of study. No more than 12 credit hours may be outside the Department of Computer Science.

Check departmental information for any additional requirements.

The student learning outcomes for this degree are located at
http:// www.niu.edu/assessment/clearinghouse/outcomes/index.shtml.

The requirements for the Ph.D. degree are as follows:

I. Requirements for the M.S. in Computer Science with thesis option (31)
II. Research methods course (3)
III. Advanced coursework (12)
IV. Dissertation (24-44)
V. Electives (0-20)

Total (90)

Graduate-level courses for which there exists an undergraduate equivalent (typically courses that are offered as 400/500 classes) shall not constitute more than 50% of hours, exclusive of dissertation hours, applied toward a doctoral degree.

Details for each category are listed below.

I. Requirements for the M.S. in Computer Science with thesis option (31)

Students must complete the M.S. program in Computer Science with the thesis option at NIU, or its equivalent elsewhere.

The department will assess all work done at other institutions and may recommend a waiver of 30 semester hours for an M.S. completed elsewhere. In addition, subject to the rules of the Graduate School, the department may recommend acceptance of transfer credit for other appropriate graduate courses.

II. Research methods (3)

Students must complete the following course.

CSCI 701 - Research Methods in Computer Science (3)

A student who has already taken this course as part of the M.S. degree in Computer Science must take 3 additional semester hours of electives instead. If a student has taken an equivalent course elsewhere, the student's advisor may recommend to the department that this requirement be waived, in which case the student must take 3 additional semester hours of electives instead.

III. Advanced coursework (12)

Students must take four courses chosen from the following.

Data Analytics:

CSCI 637 - Pattern Recognition and Data Mining II (3)
CSCI 647 - Advanced Discrete Simulation (3)
CSCI 658 - Natural Language Processing II (3)
CSCI 659 - Intelligent Interactive Systems (3)

Graphics and Visualization:

CSCI 628 - Information Visualization (3)
CSCI 629 - Scientific Visualization (3)
CSCI 632 - Advanced Computer Graphics (3)
CSCI 634 – Computer Vision (3)
CSCI 635 – Virtual Reality (3)

Bioinformatics:

CSCI 653 - Algorithmic Bioinformatics II (3)

IV. Dissertation (24-44)

Students must complete a minimum of 24 semester hours of the following course:

CSCI 799 - Doctoral Research and Dissertation.

V. Elective Course Work (0-20)

Students must complete sufficient semester hours of electives to fill out their program. Elective course work includes CSCI courses in the range 500-798, excepting 699, that have not been used to satisfy another requirement. Students may take up to 12 semester hours from other departments in courses relevant to the student's dissertation and subject to department approval.

Language/Research Tool Requirements

Students fulfill this requirement by passing the two courses listed below.

Since computer programming is a required tool for a Ph.D. in Computer Science, successful completion of CSCI 601, CSCI 602 or CSCI 603, or departmental approval, as required by the M.S. in Computer Science, counts as one of the research tool courses.

CSCI 701 - Research Methods in Computer Science, counts as the other research tool course.

Qualifying Examination

The qualifying examination for the Ph.D. consists of writing and successfully defending a master's thesis in Computer Science in the department. If a student has written and defended a master's thesis before entering the program, the student's Ph.D. advisor will advise the department on whether the student has satisfied this requirement. Students are generally expected to pass the qualifying examination by the end of their second year in the program. Students who fail the examination may, with permission of the department, repeat it once.

Candidacy Examination

The candidacy examination for the Ph.D. consists of writing a dissertation proposal and successfully passing an oral examination based on that proposal. Students are generally expected to pass the candidacy examination within two years of the completion of the qualifying examination. Students who fail the examination may, with permission of the department, repeat it once.

Dissertation Committee

The department chair, in consultation with the chair of the doctoral committee and the student, will nominate a doctoral committee to be appointed by the dean of the Graduate School. This committee will consist of three to five members. Adjunct graduate faculty may serve on the doctoral committee; a majority of the committee, however, must be regular members of the graduate faculty in the Department of Computer Science.

Oral Dissertation Defense

An oral examination on the dissertation will be conducted by the dissertation committee according to Graduate School regulations. Students must be enrolled for at least 2 semester hours of credit in the semester in which the examination is taken. Students who fail the examination may, with permission of the department, repeat it once.

Certificate of Graduate Study

Mobile Programming

This certificate is designed to provide study in programming mobile devices such as the iPhone, iPad, and Android phones. The certificate is open to all graduate students. Students must maintain good academic standing in the university, achieve a minimum grade of B in each certificate course, and complete all certificate course work within six calendar years. All course requirements for the certificate must be completed at NIU. Depending upon a student's prior programming background, successful completion of deficiency courses may be required before the student is allowed to enroll in any certificate courses. With department approval, some or all of the certificate courses may be applied toward graduate degree requirements in the department. The Department of Computer Science reserves the right to limit enrollment in any of the certificate courses.

Requirements

Course work from the following: (11)

- CSCI 521 - iOS Mobile Device Programming (4)
- CSCI 522 - Android Mobile Device Programming (4)
- One of the following: (3)
  - CSCI 523 - Advanced iOS Mobile Device Programming (3)
  - CSCI 524 – Advanced Android Mobile Device Programming (3)

Course List (CSCI)

501. PROGRAMMING PRINCIPLES IN C++ (3). Fundamental elements of the object-oriented model. Techniques for object-oriented design studied with an opportunity to synthesize these concepts and apply the methodology through the object-oriented programming language C++. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 240, CSCI 241, or CSCI 340. PRQ: Admission to the graduate program in computer science or consent of department.

502. PROGRAMMING PRINCIPLES IN JAVA (3). Object-oriented programming in Java, including class definitions, collections, streams, I/O, multi-threading, graphical applets, and Internet-based distributed client-server database applications. Implementation using an editor (on Linux) and an IDE (e.g., NetBeans on Windows). Students will demonstrate mastery of these concepts through the writing of professional-quality object-oriented Java programs using appropriate software and libraries. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 470. PRQ: Admission to the graduate program in computer science or consent of department.

503. PROGRAMMING PRINCIPLES IN PYTHON (3). Application of programming principles using the Python language. Covers fundamental elements of the object-oriented model, briefly introduces the functional programming paradigm, and illustrates concepts with a Python workflow including IPython Notebooks. Extensive laboratory work. PRQ: Admission to the graduate program in computer science or consent of department.

504. PROGRAMMING PRINCIPLES IN .NET (3). Comprehensive introduction to windows programming and server-side web programming using the Microsoft .NET development platform. Topics include programming in the C# language, the .NET Common Language Runtime, .NET Framework classes, ADO.NET, ASP.NET, Web Service, and cryptographic techniques. By the end of this course, students are expected to be able to build interactive Windows and Web applications with database storage. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 473. PRQ: Admission to the graduate program in computer science or consent of department.

505. PROGRAMMING PRINCIPLES IN PERL (3). Perl as a high-level, general-purpose, interpreted, and dynamic programming language. Topics include text processing and file manipulation. Extensive laboratory work. May not be taken by students with undergraduate credit in CSCI 490K. PRQ: Admission to the graduate program in computer science or consent of department.

511. DATABASE CONCEPTS (3). Principles of database design. Comparison of the features of currently available database systems, as well as an introduction to current research in database technology. Role of database systems in both batch and on-line environments. PRQ: Admission to the graduate program in computer science or consent of department.

512. COMPUTER NETWORKS (3). Basic principles and topics of fundamental importance in the technology and architecture of data and computer communications. Focus on key topics in principles, design approaches, and standards. Compares and contrasts the applications of these topics in specific areas of current technology. PRQ: Admission to the graduate program in computer science or consent of department.

513. SOFTWARE ENGINEERING (3). Software development and engineering methods, including requirements gathering, specification, design, implementation, testing. Software life cycle models and process such as team development, agile methods. Use of development tools and automated support environments. PRQ: Admission to the graduate program in computer science or consent of department.

514. OPERATING SYSTEMS (3). Basic operating system abstractions, mechanisms, and their implementations. Operating system support for concurrent processes and threads and their synchronization. Resource management for CPU, memory and I/O. Distributed services, including communication across a network and the client-server model, and distributed operating systems. CRQ: CSCI 501 or consent of department.

515. PRINCIPLES OF COMPILERS (3). Introduction to parser and compiler construction. Topics include formal languages and grammars. Lexical analyzers. Parsers, including stack-based, bottom-up, top-down, recursive descent, and table driven approaches. Code generation for arithmetic expressions, basic variables, decisions, loops, functions. Symbol tables, error checking. Register allocation techniques. Arrays and records, recursion, scope, object-oriented issues, I/O. Exception handling. Optimization techniques. Extensive laboratory work with a focus on compiler development. CRQ: CSCI 501 or CSCI 502 or consent of department.

521. iOS MOBILE DEVICE PROGRAMMING (4). Comprehensive introduction to building applications for mobile devices that use Apple's iOS operating system. Topics covered include application of Model-View-Controller design architecture, graphics, rich media content, multithreading, networking, and interaction with hardware sensors. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 321. PRQ: Admission to the graduate program in computer science or consent of department.

522. ANDROID MOBILE DEVICE PROGRAMMING (4). Android application programming including use of a standard integrated development environment, debugging, user interface creation, and multithreading and network applications. Instruction in coding, running, and debugging a variety of applications using software emulators as well as tethered hardware devices. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 322. PRQ: Admission to the graduate program in computer science or consent of department.

523. ADVANCED iOS MOBILE DEVICE PROGRAMMING (3). In-depth coverage of advanced programming for mobile devices that use Apple's iOS operating system. Topics include exception handling, memory and thread management, databases, and web services. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 427. PRQ: CSCI 521 with a grade of C or beter or consent of department.

524. ADVANCED ANDROID MOBILE DEVICE PROGRAMMING (3). In-depth coverage of Android application programming topics that builds on the foundations taught in CSCI 522. Topics may include accessing JSON from a web service, creating and accessing an on board database, using location and map services as well as exploring new hardware and software options. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 428. PRQ: CSCI 522 with a grade of C or beter or consent of department.

528. WEB DEVELOPMENT (3). Introduction to design and programming of web applications. HTML (including HTML5) and CSS. Basic server-side programming, (i.e., HTTP requests, responses and state). Client-side programming, (i.e., document object model updating using Javascript or equivalent). Client-server integration, (e.g., Ajax). Extensive laboratory work. One major programming project for each of the four sections in the course. May not be taken by students with undergraduate credit in CSCI 475. PRQ: Admission to the graduate program in computer science or consent of department.

600. BIG IDEAS IN COMPUTER SCIENCE (1). Lectures and discussions of current research and technical developments in computer science for beginning graduate research students. Topics will emphasize open problems and recent scientific advances. Content may vary to reflect research advances in areas such as data analytics, scientific computing, graphics and visualization. S/U grading. PRQ: Admission to the graduate program in computer science or consent of department.

601. THEORY OF COMPUTATION (3). An introduction to the theory of computation. Topics in this course will include automata, formal languages, and computability theory. May not be taken by students with undergraduate credit for CSCI 462. PRQ: Admission to the graduate program in computer science or consent of department.

602. DESIGN AND ANALYSIS OF ALGORITHMS (3). Advanced techniques for the design and analysis of algorithms with emphasis on computational problems that are central to both theory and practice. Techniques include divide-and-conquer recurrences, dynamic programming, greedy algorithms and other computational strategies. Concepts will be illustrated in pseudocode or a high-level programming language. PRQ: Admission to the graduate program in computer science or consent of department.

607. PRINCIPLES OF COMPUTER SECURITY (3). Survey of security considerations as they apply to computer and information systems. Topics include access control, security models and architecture, physical security, networking security, cryptography, disaster mitigation and recovery, and legal and ethical issues. PRQ: Admission to the graduate program in computer science or consent of department.

608. TELECOMMUNICATIONS AND NETWORKING SECURITY (3). Survey of security threats and countermeasures as they apply to a telecommunication and networking system. Topics covered include network security threats, security protocol and implementation, firewall design, wireless network security, and network security architecture. PRQ: Admission to the graduate program in computer science or consent of department.

609. COMPUTER SECURITY MANAGEMENT (3). Survey of security considerations as they apply to the management of business processes and information. Topics include planning, policies, protocols of security practices, access models and frameworks, incident response plans, asset protection and recovery. PRQ: Admission to the graduate program in computer science or consent of department.

610. CISSP REVIEW (3). Preparation for the Certified Information Systems Security Professional certification exam. Topics include the 10 domain areas of the CISSP exam.

612. NETWORK APPLICATIONS PROGRAMMING (3). Principles used to develop networking software and case studies of existing network applications. Includes principles of sockets programming and alternative strategies of network programming. Assignments include implementing several programming projects on a UNIX-based system. PRQ: CSCI 501 or consent of department.

614. VIDEO GAME DESIGN AND DEVELOPMENT (3). This course is an introduction to the theory and practice of video game design and programming. The course will integrate a number of components from the discipline of computer science, in particular; computer graphics, human computer interaction, networking, artificial intelligence, computer aided instruction, computer architecture, software engineering and databases. Students will work on both individual and group projects in the design and development of video games. Extensive laboratory work. PRQ: CSCI 630 or consent of department.

626. HUMAN COMPUTER INTERACTION (3). Introduction to the study of human-computer interaction, presenting historical information and abstract knowledge and how to apply it in the everyday world. Students will gain an understanding of the term user and how to construct an incredible user experience. As part of the course students will be exposed the cognitive components that influence the experience, how to design for these components given a desired outcome and how to evaluate the final product. PRQ: Admission to the graduate program in computer science or consent of department.

627. DATA VISUALIZATION (3). Introduction to the study of data visualization with a focus on computer-based design approaches and techniques for manipulating and visualizing data. A variety of data sources and corresponding visualization techniques will be examined covering scientific, social science, financial, and medical data, for an overall introduction to data analytics. Tools at all levels will be used, ranging from off-the-shelf desktop software to homegrown solutions. Extensive laboratory work. CRQ: CSCI 501 or CSCI 502 or CSCI 503 or CSCI 504 or CSCI 505 or consent of department.

628. INFORMATION VISUALIZATION (3). This course will focus on computer-based design approaches and techniques for manipulating and visualizing data as it relates to information visualization. A variety of data sources and corresponding visualization techniques will be examined covering abstract, business and social data. Tools at all levels will be used, ranging from off-the-shelf desktop software to homegrown solutions. A computer programming background is required. Extensive laboratory work. PRQ: CSCI 627 or consent of department.

629. SCIENTIFIC VISUALIZATION (3). This course will focus on computer-based design approaches and techniques for manipulating and visualizing data as it relates to scientific visualization. A variety of data sources and corresponding visualization techniques will be examined covering scientific and medical data. Tools at all levels will be used, ranging from off-the-shelf desktop software to homegrown solutions. Basic familiarity with computers is necessary. Extensive laboratory work. PRQ: CSCI 627 or consent of department.

630. COMPUTER GRAPHICS MODELING (3). Introduction to algorithms for creating high level computer graphics models from low level primitives. Topics include hierarchical primitive composition, linear and non-linear transformations, superquadrics, particle systems, fractal modeling, L-systems and graftals. Curves and surfaces including Bezier, rational Bezier, B-splines, NURBS, subdivision surfaces. Implicit surface generation, constructive solid geometry, volume modeling, image-based modeling. Strong programming component with a focus on algorithm implementation. Extensive laboratory work. CRQ: CSCI 501 or CSCI 502 or consent of department.

631. COMPUTER GRAPHICS RENDERING (3). Introduction to fundamental algorithms of rendering computer graphical images. Emphasis on scan conversion approaches. Topics include color systems, basic primitive rendering techniques, 2D and 3D projective transformations, the graphics pipeline, clipping, scan conversion techniques, depth effects, lighting models, material properties, attribute mapping, image-based rendering. Strong programming component with a focus on algorithm implementation. Extensive laboratory work. CRQ: CSCI 501 or CSCI 502 or consent of department.

632. ADVANCED COMPUTER GRAPHICS (3). Advanced algorithms and techniques in computer graphics. Topics include acceleration structures, radiometry, high dynamic range (HDR) rendering, camera models, adaptive sampling, reflection models, noise generation, light transport models, global illumination, procedural model generation, procedural animation. Topics will also be taken from current research literature. Strong programming component with a focus on algorithm implementation. Extensive laboratory work. PRQ: CSCI 630 or CSCI 631 and CSCI 501 or consent department.

633. DIGITAL IMAGE PROCESSING AND ANALYSIS (3). Introduction to general principles and algorithms on digital image processing. Topics include concepts and algorithms of image enhancement, image segmentation, morphological image processing, image transforms, image registration and image feature extraction. Algorithms on 3D and higher dimension image processing and analysis will be discussed. Students learn to apply materials by implementing and investigating image processing algorithms. Extensive programming and team-based research projects. Extensive laboratory work. CRQ: CSCI 501 or CSCI 502 or consent of department.

634. COMPUTER VISION (3). Algorithms in computer vision. Topics include feature detection of points and lines, 2D to 3D geometric inference, solution of camera parameters, shape from motion and optical flow, shape from shading, depth from stereo, and object tracking. Strong programming component with a focus on algorithm implementation. Extensive laboratory work. PRQ: MATH 232 or equivalent and MATH 240 or equivalent and CSCI 633 or consent of department.

635. VIRTUAL REALITY (3). Introduction to the area of virtual and augmented reality. Given the ever increasing power of computers and enhancements of display technology, it is now possible to simulate and augment reality. The course will review the history, introduce the relevant issues (related to perception and believability), provide introduction to both software and hardware. Finally, an overview of the application space will be explored. Students will be expected to develop both virtual and augmented reality applications and work on a group final project. Extensive laboratory work. PRQ: CSCI 630 or consent of department.

636. PATTERN RECOGNITION AND DATA MINING I (3). Concepts and algorithms in pattern recognition and machine learning. Topics include pattern clustering and classification, feature extraction and selection. Data mining applications in various domains will be considered. PRQ: Admission to the graduate program in computer science or consent of department. CRQ: CSCI 501 or CSCI 502 or CSCI 503 or consent of department.

637. PATTERN RECOGNITION AND DATA MINING II (3). An in-depth exploration of recent research in the area of pattern recognition and data mining, building on the introductory course to pattern recognition and data mining. Topics include the advanced variants of neural networks, deep learning, ensemble learning, reinforcement learning and online learning. Advanced unsupervised learning methods as well as cluster validation will also be discussed. Extensive reading on latest research in the area and programming projects. Extensive laboratory work. PRQ: CSCI 636 or consent of department.

639. NETWORK THEORY (3). Covers recent research on the structure and analysis of networks, and on models and algorithms that abstract their key properties. The three main topics are network analysis and mining (e.g., community detection, degree distribution), design of networks (e.g., small-world and scale-free models), and networks as computational models (e.g., disease spread, fuzzy cognitive maps). Students will learn and apply research tools in network theory to work on open problems (e.g. in social networks, biological networks or telecommunication networks), and will perform extensive programming in the course of their research experience. Extensive laboratory work. CRQ: CSCI 503 or consent of department.

641. BIG DATA ANALYTICS (3). Surveys the foundations of big data analytics, reviews relevant research, and introduces the algorithms and methods used to derive valuable predictions and insights from data. Merging theory with practice, the class covers foundational topics while providing hands-on practical experience with useful languages, toolkits, and frameworks. The course topics include, but are not limited to: big data management and processing techniques, algorithms for big data analytics, social media mining, recommendation systems, statistical methods, and models. Extensive laboratory work. CRQ: CSCI 503 or consent of department.

642. INFORMATION STORAGE AND RETRIEVAL (3). Focuses on the theory, design, implementation and evaluation of information retrieval systems and techniques. It covers web crawlers, link-based ranking algorithms, retrieval models, relevance feedback, text indexing, text categorization, digital libraries, search engines, and web search. Extensive laboratory work. CRQ: CSCI 503 or consent of department.

646. MODELING AND SIMULATION (3). Introduction to computational techniques for the design and analysis of computer simulations. Modeling paradigms (continuous models such as system dynamics and discrete models such as agent-based models), their implementation in a general purpose modeling environment, and the design and analysis of computer experiments (e.g., factorial design, Latin hypercube sampling). Extensive programming and team-based research projects. Extensive laboratory work. CRQ: CSCI 503 or consent of department.

647. ADVANCED DISCRETE SIMULATION (3). An in-depth exploration of recent research in the area of discrete simulation, building on the introductory course to modeling and simulation. Focuses on discrete paradigms including cellular automata, agent based models, and network models. Topics are updated each time the course is offered based on research developments, and may cover aspects such as hybrid models, spatial simulations, large-scale simulations, or in the interplay of simulations with areas such as interactive visualizations. Extensive reading of research articles and team-based project. Extensive laboratory work. PRQ: CSCI 646 or consent of department.

651. GRAPH THEORY AND APPLICATIONS (3). Introduction to graph theory and applications. Topics include trees, cycles, paths, colorings, connectivity, matchings, coverings, planar graphs, network flows, and their applications to sciences. PRQ: Admission to the graduate program in computer science or consent of department.

652. ALGORITHMIC BIOINFORMATICS I (3). Comprehensive introduction to methodologies and applications of computational problems in bioinformatics, especially in comparative genomics. Topics include sequence alignment at genome-wide, genome comparison without alignment, genome rearrangements, detection of genomic signals, repeat analysis, and other computational problems. Introduction to molecular biology and algorithm design and analysis will be included. Course projects involve high-level programming languages. Extensive laboratory work. CRQ: CSCI 501 or CSCI 502 or CSCI 503 or CSCI 504 or CSCI 505 or consent of department.

653. ALGORITHMIC BIOINFORMATICS II (3). In-depth exploration of computational problems in bioinformatics, building on top of the introductory course to algorithmic bioinformatics. Topics may change each time the course is offered based on recent research development. Focus on computational and comparative genomics, including large-scale alignment, repeat analysis, detection of genomic signals, and other computational problems. This course requires extensive reading of research papers and programming projects. Extensive laboratory work. PRQ: CSCI 652 or consent of department.

656. ARTIFICIAL INTELLIGENCE (3). Heuristic algorithms for solving real-world problems and approximating human intelligence. Basic concepts and methods for knowledge representation, heuristic problem solving and automated learning. Exposure to a variety of domains in which artificial intelligence is used. Extensive laboratory work. CRQ: CSCI 503 or consent of department.

657. NATURAL LANGUAGE PROCESSING I (3). Methods for computer processing of human language at the character, word and sentence level. Basic algorithms for spell checking, part of speech tagging and parsing. Approaches to research in NLP, including selection of machine learning algorithms and statistics. Extensive laboratory work. CRQ: CSCI 503 or consent of department.

658. NATURAL LANGUAGE PROCESSING II (3). Advanced topics in computer processing of human language. Topics may vary by semester. Possible topics include spoken language understanding and generation, statistical machine translation, and language processing of large-scale files, including reference resolution and question answering. Extensive laboratory work. PRQ: CSCI 657 or consent of department.

659. INTELLIGENT INTERACTIVE SYSTEMS (3). Concepts, system design and tools to build systems that interact with users using free text and retrieve information from a database using a logic engine. Design and implementation of the database and logic engine, the computational semantics and pragmatics necessary to conduct a state-of-the-art dialogue, and sentence and turn generation in context. Extensive laboratory work. PRQ: CSCI 657 or consent of department.

661. PARALLEL AND DISTRIBUTED PROGRAMMING MODELS (3). Topics will include message passing on distributed memory architectures and multithreading. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 490K. CRQ: CSCI 501 or consent of department.

662. PROGRAMMING NON-TRADITIONAL ARCHITECTURES (3). Topics include programming hardware accelerators like general purpose graphic processing units and field programmable gate arrays with an emphasis on applying these architectures to computer applications in modeling, simulation, and computational sciences. Extensive laboratory work. May not be taken by students with undergraduate credit for CSCI 490E. CRQ: CSCI 501 or consent of department.

680. TOPICS IN COMPUTER SCIENCE (3).
A. Artificial Intelligence
B. Computer Graphics
D. Operating System Principles and Practices
E. Programming Language Concepts and Methods
G. Database Theory and Applications
J. Storage Technology and Architectures
K. Computer Systems
M. Computer Applications
N. Programming Techniques
Q. Image Processing
U. Computer Security
V. Windows Programming. Each lettered topic may be repeated to a maximum of 9 semester hours when subject changes. Students may repeat multiple lettered topics, each to its maximum. PRQ: Admission to the graduate program in computer science or consent of department.

690. INTERNSHIP (3-6). Work in a computer-related industrial environment. Normally only available to students who have no prior computer-related work experience. May be repeated to a maximum of 6 semester credit hours. No more than 6 semester hours in CSCI 690 and/ or CSCI 696 may be included in the master's degree. S/U grading. PRQ: Consent of department.

695. SEMINAR IN COMPUTER SCIENCE (3). May be repeated to a maximum of 9 semester hours as topic changes. PRQ: Consent of department.

696. RESEARCH AND DEVELOPMENT INTERNSHIP (1-6). Work as a paid intern. Reading and preparation of a paper under faculty supervision. May be repeated. No more than 3 semester hours in CSCI 696 may be included in the master's degree. S/U grading. PRQ: Admission to the graduate program in computer science and consent of department. Consent is competitive.

697. GRADUATE READING IN COMPUTER SCIENCE (1-6). Individual reading in computer science. May be repeated to a maximum of 6 semester hours. PRQ: Consent of department.

699. THESIS (1-6). Master's thesis. May be repeated to a maximum of 6 semester hours. PRQ: consent of department.

701. RESEARCH METHODS IN COMPUTER SCIENCE (3). This writing-intensive course covers the main aspects related to performing research in computer science: performing literature reviews in computer science, designing ethical and technically sound research projects for both experimental and theoretical computer science research, identifying and pursuing funding opportunities, and reporting scientific results to professional and lay audiences in forms ranging from presentations to (open source) software and articles. Topics related to being a member of the scientific community will also be introduced, such as the editorial process, seen both from the author's and editor's viewpoints. PRQ: Admission to the graduate program in computer science or consent of department.

799. DOCTORAL RESEARCH AND DISSERTATION (1-15). May be repeated to a maximum of 60 semester hours. Student must accumulate 24 semester hours prior to graduation. S/U grading. PRQ: Candidacy for the doctoral degree and consent of chair of doctoral committee.