

# Computer Science

IN THE COLLEGE OF SCIENCES

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## Faculty

**Shangping Ren**, Ph.D., Professor of Computer Science,  
Chair of Department

**Leland L. Beck**, Ph.D., Professor of Computer Science, Emeritus

**John L. Carroll**, Ph.D., Professor of Computer Science, Emeritus

**Marie A. Roch**, Ph.D., Professor of Computer Science

**Mahmoud Tarokh**, Ph.D., Professor of Computer Science, Emeritus

**Tao Xie**, Ph.D., Professor of Computer Science

**Carl F. Eckberg**, Ph.D., Associate Professor of Computer Science

**Xiaobai Liu**, Ph.D., Associate Professor of Computer Science

**Wei Wang**, Ph.D., Associate Professor of Computer Science

(Graduate Adviser)

**Roger E. Whitney**, Ph.D., Associate Professor of Computer  
Science (Graduate Adviser)

**Chen Song**, M.S., Assistant Professor of Computer Science

**Hoa T. Vu**, Ph.D., Assistant Professor of Computer Science

**Yang Xu**, M.S., Assistant Professor of Computer Science

## Associateships

Graduate teaching associateships in computer science are available to a limited number of qualified students. Application blanks and additional information may be secured from the chair of the Department of Computer Science.

## General Information

The Department of Computer Science offers graduate study leading to the Master of Science degree in computer science. The areas in which courses are offered include architecture, artificial intelligence, computer science theory, informatics, software, systems, and systems modeling.

Master's level research projects are available in the following areas of computer science: artificial intelligence and machine learning, bioinformatics and medical informatics, computational complexity, computer vision, databases, distributed systems, formal languages, high performance computing, multiprocessing, operating systems, signal processing, and web applications. Specialized laboratories exist for bioinformatics, microprocessor architecture, and robotics and intelligent machines.

A master's degree in computer science provides education and creative experience to prepare graduates for advanced professional employment in industry or government, or for college-level teaching.

## Admission to Graduate Study

All students must satisfy the general requirements for admission to the university with classified graduate standing, as described in Admission and Registration. In addition, for fully classified graduate standing students must complete Computer Science 560 and 570 or equivalent. Classified graduate standing is prerequisite to all 600- and 700-level courses; conditional graduate standing is possible. Students convicted of plagiarism or cheating on examinations may lose classified graduate standing.

Students applying for admission should electronically submit the university application available at <http://www.calstate.edu/apply> along with the application fee.

All applicants must submit admissions materials to SDSU Graduate Admissions.

Refer to section on Admission to Postbaccalaureate and Graduate Study in this bulletin for further details.

## Graduate Admissions

The following materials should be submitted as a complete package directly to:

### Graduate Admissions

Enrollment Services  
San Diego State University  
San Diego, CA 92182-7416

1. Official transcripts (in sealed envelopes) from all postsecondary institutions attended;
  - Students who attended SDSU need only submit transcripts for work completed since last attendance.
  - Students with international coursework must submit both the official transcript and proof of degree. If documents are in a language other than English, they must be accompanied by a certified English translation.
2. GRE scores (<http://www.ets.org> SDSU institution code 4682);
3. English language score, if medium of instruction was in a language other than English (<http://www.ets.org> SDSU institution code 4682).

## Advancement to Candidacy

All students must satisfy the general requirements for advancement to candidacy as described in Requirements for Master's Degrees.

## Specific Requirements for the Master of Science Degree

(Major Code: 07011) (SIMS Code: 773801)

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Requirements for Master's Degrees, the student must meet the following departmental requirements:

1. Complete a minimum of 30 units of 500-, 600-, and 700-level courses selected with the approval of the adviser. One to three units of Computer Science 798 may be added to the 30 minimum units required, when used for an internship or practical training. All programs must include at least 24 units chosen from computer science and mathematics.
2. Students must select Plan A (Thesis) or Plan B (Comprehensive Examinations) as described below. (Selecting Plan A is contingent upon having a minimum 3.5 GPA in courses applicable to the master's degree, and upon finding a full time computer science faculty member to supervise the thesis. The number of students that can be accommodated in Plan A is limited by faculty resources.)

### Plan A (Thesis)

(Major Code: 07011) (SIMS Code: 773803)

- A total of 30 units of 500-, 600-, 700-level courses as follows:
- a. At least 15 units from Computer Science 600- and 700-level courses excluding Computer Science 797, 798, 799A. A 600-level electrical engineering course or one of the mathematics courses listed below in the ALC area of study may replace one 600-level computer science course.
  - b. Students select two areas of study from the areas listed below, and take at least two courses from each area.
  - c. Three units of Thesis (799A), and an oral presentation and defense.

With approval of the graduate adviser, students may take Computer Science 798 as preparation for Computer Science 799A (Thesis).

### Plan B (Comprehensive Examinations)

A total of 30 units of 500-, 600-, 700-level courses as follows:

- a. At least 18 units from Computer Science 600- and 700-level courses excluding Computer Science 797, 798, 799A. A 600-level electrical engineering course or one of the mathematics courses listed below in the ALC area of study may replace one 600-level computer science course.
- b. At least one course from four of the following five areas of study: PFL, OSA, ALC, ISR, and DSW.
- c. Comprehensive examinations in three subjects selected from automata and formal languages; database management systems; data structures and algorithms; intelligent systems and robotics; numerical analysis; operating systems and architecture; programming languages. Under certain conditions, students may substitute additional coursework for one or two of the three required examinations, or replace two examinations with an approved project. Further information is available on the department website.

Full-time international students on Plan B who have completed all their required coursework must show progress in at least two areas of study each semester (until they have completed all but one). This can be done by either taking qualifying examinations or additional coursework, which must be preapproved by the graduate adviser.

### Areas of Study

**(PFL) Programming and Formal Languages:** Computer Science 520, 532, 537, 540, 583, 605 [or Computational Science 605], 620, 635, 636, 705.

**(OSA) Operating Systems and Architecture:** Computer Science 572, 574.

**(ALC) Algorithms and Complexity:** Computer Science 558, 562, 600, 609, 660, 662, 664; Mathematics 525, 625, 626, 667, 668, 693A, 693B.

**(ISR) Intelligent Systems and Robotics:** Computer Science 550, 553, 556, 559, 581, 582, 653, 656, 657, 682; Statistics 702.

**(DSW) Distributed Systems and Web Technology:** Computer Science 503, 514, 545, 546, 547, 576, 580, 615, 645, 646, 648, 666.

## Advanced Web and Mobile Applications Development Certificate

(Offered through SDSU Global Campus)

(SIMS Code: 773806)

The advanced certificate in Web and Mobile Applications Development provides students with the specialized knowledge that is important in the development of Web and mobile computer applications. Students will study and gain experience with the languages and frameworks that are most commonly used in developing these applications, with the design of user interfaces and software systems, and with associated topics such as networking, hosting infrastructure, and security. They will also learn the fundamental principles on which these topics are based, so that they will be prepared for the new technologies that are constantly being developed.

The admission requirement is a bachelor's degree in computer science or a closely related field. Individuals with an equivalent knowledge of the background materials through work or self-study may be accepted into this program at the discretion of the program director.

The certificate requires completion of at least four courses (12 units) with the approval of the program adviser selected from Computer Science 545, 546, 547, 645, 646, 648. At least two of the four courses must be at the 600-level.

For more information, contact the Department of Computer Science at <http://www.cs.sdsu.edu>.

## Courses Acceptable for Master's Degree Program in Computer Science (CS)

*Refer to Courses and Curricula and Regulations of the Division of Graduate Affairs sections of this bulletin for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.*

### UPPER DIVISION COURSES

#### CS 503. Scientific Database Techniques (3)

Prerequisites: Computer Science 310 and Mathematics 245.

Fundamental data models for handling scientific data, including flat file, indexed compressed files, relational databases, and object oriented databases, and their associated query technologies; e.g. file formats, input/output libraries, string searching, structured query language, object-oriented structured query language, hypertext markup language/common gateway interface, and other specialized interfaces. Designed for computational science students. Computer science majors must obtain adviser approval. See Computer Science 514.

#### CS 514. Database Theory and Implementation (3)

Prerequisites: Computer Science 310 and Mathematics 245.

Database systems architecture. Storage structures and access techniques. Relational model, relational algebra and calculus, normalization of relations, hierarchical and network models. Current database systems.

#### CS 520. Advanced Programming Languages (3)

Prerequisites: Computer Science 237, 310, and 320.

Object oriented programming, concurrent programming, logic programming. Implementation issues.

#### CS 530. Systems Programming (3)

Prerequisites: Computer Science 237 and 310.

Design and implementation of system software. Relationship between software design and machine architecture. Topics from assemblers, loaders and linkers, macro processors, compilers, debuggers, editors. Introduction to software engineering and review of programming fundamentals and object oriented concepts. Large project in object oriented programming is required. Not acceptable for the M.S. degree in computer science.

#### CS 532. Software Engineering (3)

Prerequisites: Computer Science 320 and 530.

Theory and methodology of programming complex computer software. Analysis, design, and implementation of programs. Team projects required.

#### CS 537. Programming for GIS (3)

Prerequisite: Computer Science 310 or Geography 484.

Customization of Geographic Information Science application development platforms with emphasis on object oriented programming and component architecture. Prominent examples are Map Objects with Visual Basic, Map Objects with Java. Considerable programming effort required, especially in Graphical User Interface development.

#### CS 540. Software Internationalization (3)

Prerequisite: Computer Science 310.

Principles, techniques, and resources for design and implementation of software localizable to multiple languages and/or cultures, including detailed examination of internationalization features provided by one or more widely used modern programming languages.

## Computer Science

### **CS 545. Introduction to Web Application Development (3)** (Offered only through SDSU Global Campus)

Prerequisite: Computer Science 310.

World Wide Web application development. XHTML, CSS, JavaScript, client-side and server-side scripting, PHP and CGI programming with Perl. Application integration with SQL database systems.

### **CS 546. Human Computer Interfaces (3)** (Offered only through SDSU Global Campus)

Prerequisites: Computer Science 310 and 320.

Common interface idioms and support available for loose integration into aesthetically appealing and practical, efficient interaction between humans and machine. Editors, browsers, games, networking sites, posting boards, etc. Principles that are ubiquitous among tools for HCI development.

### **CS 547. Programming and Scripting Languages for Web Applications (3)** (Offered only through SDSU Global Campus)

Prerequisites: Computer Science 310 and 320.

Principles and practice of dynamic and scripting and functional languages used in web applications. Basic language concepts, data structures in dynamic languages, code structure, code quality, testing, string manipulation, dynamic code generation.

### **CS 550. Artificial Intelligence (3)**

Prerequisites: Computer Science 310 and either Mathematics 245 or 523.

Heuristic approaches to problem solving. Systematic methods of search of the problem state space. Theorem proving by machine. Resolution principle and its applications.

### **CS 556. Robotics: Mathematics, Programming, and Control (3)**

Prerequisites: Computer Science 320, Mathematics 254, knowledge of the C programming language.

Robotic systems including manipulators, actuators, sensors, and controllers. Kinematics of planar robots. Design and implementation of robot joint controllers. Robot programming languages and environments, and robot command interfaces.

### **CS 558. Computer Simulation (3)**

Prerequisites: Computer Science 310 and Statistics 550.

Methodology of simulation for discrete and continuous dynamic systems. State-of-the-art programming techniques and languages. Statistical aspects of simulation. Students will design, program, execute, and document a simulation of their choice.

### **CS 559. Computer Vision (3)**

Prerequisites: Computer Science 310 and Mathematics 254.

Algorithms and computer methods for processing of images. Visual perception as a computational problem, image formation, characterization of images, feature extraction, regional and edge detection, computer architectures for machine vision.

### **CS 560. Algorithms and Their Analysis (3)**

Prerequisites: Computer Science 310 and Mathematics 245.

Algorithms for solving frequently occurring problems. Analysis techniques and solutions to recurrence relations. Searching and sorting algorithms. Graph problems (shortest paths, minimal spanning trees, graph search, etc.). NP complete problems. Not acceptable for the M.S. degree in Computer Science.

### **CS 562. Automata Theory (3)**

Prerequisite: Mathematics 245.

Definition of finite automata. Classification of finite automaton definable languages. Minimization of finite automata. Nondeterministic finite automata. Sequential machines with output. Regular sets and expressions. Introduction to grammars.

### **CS 570. Operating Systems (3)**

Prerequisites: Computer Science 310, 370, and knowledge of the C programming language.

File systems, processes, CPU scheduling, concurrent programming, memory management, protection. Relationship between the operating system and underlying architecture. Not acceptable for the M.S. degree in Computer Science.

### **CS 572. Microprocessor Architecture (3)**

Prerequisites: Computer Science 370 and knowledge of the C programming language.

Architecture of state-of-the-art microprocessor. Internal pipeline, internal cache, external cache, and memory management. Programming a uniprocessor. Communication among computers in a distributed environment. Architecture and programming of a multiprocessor system.

### **CS 574. Computer Security (3)**

Prerequisites: Computer Science 310, Mathematics 245, and credit or concurrent registration in Computer Science 570.

Principles of computer security and application of principles to operating systems, database systems, and computer networks. Topics include encryption techniques, access controls, and information flow controls.

### **CS 576. Computer Networks and Distributed Systems (3)**

Prerequisite: Credit or concurrent registration in Computer Science 570.

Basic networking concepts to include seven-layer reference model, transmission media, addressing, subnetting and supernetting, networking devices, LANs and WANs, internetworking, distributed processing, and client-server model. Basic concepts and protocols of TCP/IP protocol suite and basic Internet services.

### **CS 581. Computational Linguistics (3)**

(Same course as Linguistics 581)

Prerequisite: Computer Science 320 or Linguistics 571 or 572 [or Big Data Analytics 572].

Basic concepts in computational linguistics including regular expressions, finite-state automata, finite-state transducers, weighted finite-state automata, and n-gram language models. Applications to phonology, orthography, morphology, syntax. Probabilistic models. Statistical techniques for speech recognition.

### **CS 582. Introduction to Speech Processing (3)**

Prerequisite: Computer Science 310.

Fundamentals of speech processing and speech recognition. Physical aspects of speech production and perception. Mathematical models for speech recognition. Corpus development: data collection, processing, and evaluation. Applications of speech processing and associated research topics.

### **CS 583. 3D Game Programming (3)**

Prerequisite: Computer Science 310 or equivalent programming background.

Development of programming skills using software environment of a game engine and its scripting language. 3D concepts for game play, modeling, and programming. Roles needed in software development team. Contrast creation of original 3D object models for game world with incorporation of pre-created generic models.

### **CS 596. Advanced Topics in Computer Science (1-4)**

Prerequisite: Consent of instructor.

Selected topics in computer science. May be repeated with the approval of the instructor. See *Class Schedule* for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree. Maximum credit of six units of 596 applicable to a bachelor's degree. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

## GRADUATE COURSES

**NOTE:** Classified graduate standing is expected for all graduate courses.

### **CS 600. Methods in Bioinformatics, Medical Informatics, and Cheminformatics (3)**

(Same course as Bioinformatics and Medical Informatics 600)

Prerequisites: Three units of calculus and graduate standing.

Computer, mathematical, and engineering techniques for bioinformatics, cheminformatics, and medical informatics. Techniques used in microarray data analysis, gene and protein sequence alignment, and classification techniques in medical decision making.

**CS 605. Scientific Computing (3)**

(Same course as Computational Science 605)

Prerequisites: Graduate standing and knowledge of the C programming language or FORTRAN or Computational Science 526.

Parallel programming using message passing to include high performance computing and MPI language extensions.

**CS 608. Programming Problems in Bioinformatics (3)**

(Same course as Bioinformatics and Medical Informatics 608)

Prerequisites: Computer Science 310 with a grade of C (2.0) or better.

Coding bioinformatics algorithms for biological data analysis.

**CS 609. Computational Genomics and Bioinformatics (3)**

(Same course as Bioinformatics and Medical Informatics 609)

Prerequisite: Computer Science 503 or 514.

Biological and genomic data. Application of computational algorithms to biological questions. Post-genomic techniques in annotation and comparison of microbial and eukaryotic genome sequences.

**CS 615. Spatial Database (3)**

Prerequisite: Computer Science 514. Recommended: Computer Science 560.

Strategies for databases in which locations are prominent. Access strategies such as quadrees and R-trees. Topological and other spatial extensions to query languages. Spatial models like non-intersection. Oracle spatial features. Object and object-oriented databases.

**CS 620. Formal Languages and Syntactic Analysis I (3)**

Prerequisites: Computer Science 310, 320 or 520, and 562.

Regular, context-free, context-sensitive, and general grammars. Corresponding machine model recognizers. Chomsky and Greibach normal forms. Closure, decidability and undecidability properties.

**CS 635. Advanced Object-Oriented Design and Programming (3)**

Prerequisite: Knowledge of an object-oriented programming language.

Advanced topics in object-oriented programming and design, code reuse, building class libraries, quality of objects, coupling, cohesion, design patterns, distributed objects.

**CS 636. Management of Software Development (3)**

Prerequisite: Computer Science 532.

Managing software projects. Modern software management process models. Project planning, cost estimation, tracking and control, staffing, risk management, and software process improvement.

**CS 645. Advanced Web Application Development (3)**

(Offered only through SDSU Global Campus)

Prerequisite: Computer Science 545.

XHTML, CSS, JavaScript, client-side and server-side scripting, Java servlets, JSP, Frameworks. Server systems and development tools appropriate for large, complex project. SQL database via JDBC.

**CS 646. Mobile Application Development (3)**

(Offered only through SDSU Global Campus)

Prerequisite: Computer Science 560.

Design and implementation of applications for smart mobile phones and mobile devices. May be repeated with new content. See *Class Schedule* for specific content, including device types. Maximum credit six units applicable to a master's degree.

**CS 648. Advanced Topics in Web and Mobile Applications (3)**

(Offered only through SDSU Global Campus)

Prerequisite: Computer Science 545.

Advanced technologies, issues, and concepts in Web and mobile software development. May be repeated with new content. See *Class Schedule* for specific content. Maximum credit six units applicable to a master's degree.

**CS 649. Big Data Tools and Methods (3)**

Prerequisites: Computer Science 550 and either Computer Science 503 or 514 with a grade of C (2.0) or better in each course.

Analyze, curate, search, and visualize big data. Apache MapReduce and Spark, distributed databases and messaging/streaming, electronic notebooks, NoSQL databases, programming languages, statistics.

**CS 653. Data Mining and Knowledge (3)**

Prerequisite: Computer Science 320.

Foundations of data mining and knowledge discovery. Diverse methods, algorithms, design techniques and application practice including statistical and Bayesian methods, pattern recognition, clustering, knowledge discovery in data sets, machine learning, neural networks, rough and fuzzy sets.

**CS 656. Advanced Robotics (3)**

Prerequisite: Computer Science 556.

Computer-based techniques for low-, medium-, and high-level robot control including sequential and parallel schemes for robot dynamics, robot programming and robot task planning.

**CS 657. Intelligent Systems and Control (3)**

Prerequisite: Computer Science 530 or 560.

Genetic and evolutionary algorithms, genetic programming and applications, fuzzy logic and approximate reasoning, rule-based inference engines, intelligent path planning and applications to robotics, dynamic systems and their simulations using Simulink, conventional control and intelligent control, intelligent agents, autonomous and multi-agent systems.

**CS 660. Combinatorial Algorithms and Data Structures (3)**

Prerequisite: Computer Science 560.

Algorithm design techniques. Network flow and matching. Complexity analysis. NP-completeness, reductions among NP-complete problems. Approximation algorithms for NP-complete problems such as the traveling salesman problem.

**CS 662. Theory of Parallel Algorithms (3)**

Prerequisites: Computer Science 560 and Mathematics 254.

Models for parallel computation. Parallel algorithms for several common problems including sorting, searching, graph problems, and matrix problems. Complexity of parallel algorithms. Lower bounds on parallel complexity.

**CS 664. Theory of Computability (3)**

Prerequisite: Computer Science 562.

Turing machines and other formal models of computation. Recursive function theory. The Ackermann function. Solvable and unsolvable problems.

**CS 666. Advanced Distributed Systems (3)**

Prerequisite: Computer Science 570.

Design of distributed systems including abstract models, algorithms, and case studies of real-world systems. Group research related to distributed systems.

**CS 682. Speech Processing (3)**

Prerequisites: Graduate standing, Computer Science 310, Mathematics 254, Statistics 551A.

Algorithms and methods for processing of speech. Feature extraction, human speech production and perception, pattern recognition for acoustic and language modeling as applied to automatic speech and speaker recognition.

**CS 696. Selected Topics in Computer Science (3)**

Prerequisite: Consent of instructor.

Intensive study in specific areas of computer science. May be repeated with new content. See *Class Schedule* for specific content. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

**CS 705. Advanced Parallel Computing (3)**

(Same course as Computational Science 705)

Prerequisite: Computer Science 605 [or Computational Science 605].

Libraries, numerical methodology, optimization tools, visualization of results, MPI and GPU computing models. Applications conducted on CSRC student cluster and NSF XSEDE computing resources.

## Computer Science

### **CS 790. Practicum in Teaching of Computer Science (1) Cr/NC**

Prerequisite: Award of graduate teaching associateship in computer science.

Supervision in teaching computer science. Lecture writing, style of lecture presentation and alternatives, test and syllabus construction, and grading system. Not applicable to an advanced degree. Required for first semester GTA's.

### **CS 792. Curricular Practical Training (1) Cr/NC**

Prerequisites: Approval of graduate adviser and SDSU International Student Center.

Supervised work experience. Maximum credit three units applicable to a master's degree in computer science.

### **CS 797. Research (1-3) Cr/NC/RP**

Prerequisites: Six units of graduate level computer science courses.

Research in computer science. Maximum credit six units applicable to a master's degree.

### **CS 798. Special Study (1-3) Cr/NC/RP**

Prerequisite: Consent of staff; to be arranged with department chair and instructor.

Individual study. Maximum credit six units applicable to a master's degree.

### **CS 799A. Thesis or Project (3) Cr/NC/RP**

Prerequisites: An officially appointed thesis committee and advancement to candidacy.

Preparation of a project or thesis for the master's degree.

### **CS 799B. Thesis or Project Extension (0) Cr/NC**

Prerequisite: Prior registration in Thesis or Project 799A with an assigned grade symbol of RP.

Registration required in any semester or term following assignment of RP in Course 799A in which the student expects to use the facilities and resources of the university; also student must be registered in the course when the completed thesis or project is granted final approval.

### **CS 799C. Comprehensive Examination Extension (0) Cr/NC**

Prerequisite: Completion or concurrent enrollment in degree program courses.

Registration required of students whose only requirement is completion of the comprehensive examination for the master's degree. Registration in 799C limited to two semesters.

For additional courses useful to computer scientists, see:

Mathematics 523	Mathematical Logic
Mathematics 542	Introduction to Computational Ordinary of Differential Equations

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## Counseling and School Psychology

Refer to "Education" in this section of the bulletin.