COMPUTER SCIENCE, DOCTORAL (CS)

CS 800 PhD Dissertation (2 credits)
A matriculation course to maintain student's full-time status; charging tuition for one credit hour; and contributing zero credit hour towards the degree.
Course Rotation: NYC, PLV, GC, and Online: Fall and Spring.

Prerequisites: Computer Science PhD candidacy; having completed 36 credit hours in CS PhD.

CS 801 Advanced Algorithms (4 credits)
Advanced topics in data structures and computational complexity, including randomized algorithms, dynamic programming, recurrence relations, amortized analysis, network flow algorithms, and approximation algorithms and NP-completeness will be discussed. This course covers both fundamental techniques and applications.
Course Rotation: Spring

CS 802 Research Seminar (2 credits)
Research seminar by domain experts, and student presentations on research papers.
Course Rotation: Fall.

Prerequisites: Computer Science PhD candidacy.

CS 804 Independent Research (1-4 credits)
The student will work closely with the advisor to conduct literature survey, identify a research problem with solution methodologies, and create a clear research plan for the dissertation.
Course Rotation: Fall and Spring.

CS 806 Dissertation Preparation (4 credits)
The student will work closely with the advisor to develop the dissertation research proposal for defense.
Course Rotation: Fall and Spring

CS 810 Advanced Introduction to Parallel and Distributed Computing (4 credits)
Parallel computing theory: Parallel Random-Access Machines (PRAMs), Amdahl's law for theoretical speedup limits, Petri Nets; parallel vs. distributed computing: speedup, fault-tolerance, resource-sharing; parallel architectures: data f1ow, instruction-level pipelining, embedded multicore systems, shared-memory multiprocessors, distributed-memory multicomputer, interconnection networks; distributed systems: client-server systems, cluster computing, computing grids, cloud computing; parallel and distributed programming with industry standard MPI (Message Passing Interface); and parallel algorithms. Students are expected to implement an advanced project.

CS 811 Advanced Principals of Programming Language (4 credits)
Concept underlying the design of traditional and modern programming languages; language paradigms (imperative, object-oriented, functional and logic); cross-language interoperability on the .NET and JVM platforms; semantics (operational and denotation); type systems (polymorphism, inference, and abstract types); garbage collection; multiprocessing; formal syntax of programming languages using BNF and EBNF grammars, scanning, parsing and the compilation process; use of Lex and Yacc for the functions of scanning and parsing. The course involves substantial programming assignments in different programming languages (C, ML, Prolog, Scala, F# as representatives) and a significant amount of reading. Students are expected to implement an advanced project.

CS 812 Advanced Concepts and Structures in Internet Computing (4 credits)
Integrated bands-on coverage of fundamental concepts and technologies for enterprise and Internet computing. Topics include data storage; XML data specification, parsing and validation; data and language translation; networking and web technology overview; software framework technology for controlling software system complexity; and a roadmap for the enterprise computing technologies. Students are expected to implement an advanced project.
Course Rotation: Fall.

CS 813 Advanced Complier Construction (4 credits)
Implementation of high-level programming languages. Topics to be covered include concepts and comparison of programming languages, lexical analysis, parsing, code generation and optimization. Emphasis will be placed on the formation structures and algorithms required to implement compilers and their us and performances in other applications. Students will be expected to implement a compiler. Students are expected to implement an advanced project.

CS 814 Advanced Logic Formal Verification (4 credits)
A survey of the logical foundations of mathematics, the mechanization of the reasoning, and relationships to computer science. Propositional logic and first order logic; decision procedures for equality; notions of proofs and models; model checking and theorem proving based techniques; completeness theorem; Hoare logic and application of logic to formal software verification, i.e., the use of logic to specify properties of programs and techniques to prove their correctness. The course will include the use of state-of-the-art tools to prove some small programs, the implementation of a small theorem prover in a functional programming language, and a significant amount of reading of recent research results. Students are expected to implement an advanced project.

CS 816 Introduction to Big Data Analytics (4 credits)
Overview of Big Data technologies, applications, and market trend. Fundamental Big Data storage and processing platforms, such as Hadoop, and IBM System G for Linked Big Data. Big Data upload, storage, distribution, and process with HDFS, HBase, KV stores, document database, and graph database. Important analytics and visualization algorithms on different platforms. Large-scale machine learning methods that are foundations for artificial intelligence and cognitive networks.
Course Rotation: : PLV; Fall

CS 823 Advanced Database Management Systems (4 credits)
Advanced theory and applications of databases, including the relational calculus, functional dependence, query optimization, schema normalization and concurrent databases.
Course Rotation: Fall; NY and PLV

CS 824 Advanced Applications Development with .NET and Web Services (4 credits)
Introduction to.NET web technologies through C# .NET for people with basic programming skill. Topics include object-oriented programming, exception handling, delegate, multithreading, graphic user interface, web programming with ASP .NET, database programming with ADO .NET, web services, and Microsoft Visual Studio .NET IDE. Students are expected to implement an advanced project.

CS 827 Advanced Artificial Intelligence (4 credits)
Theory and data structures and algorithms related to artificial intelligence and heuristic programming. Topics include description of cognitive processes, definition of heuristic vs. algorithmic methods, slate space and problem reduction, search methods, theorem proving, natural language processing and pattern recognition techniques. Students are expected to implement an advanced project.

CS 830 Advanced Intelligent Agents (4 credits)
Autonomous software agents are used in many areas, from shopping bots to security bots and personal assistants. This course teaches the basic programming skills necessary to program autonomous agents using a rule-based system. Basic knowledge engineering skills and the design of agent-based programs are covered, including the use of software that learns from its own experiences. Students are expected to implement an advanced project.
Course Rotation: Fall.

CS 831 Mathematical Modeling of Software Artifacts (3 credits)
Concepts abstraction relations, invariants, non-determinism, inductive definitions are covered extensively in this course. The students understand the strengths and weaknesses of certain models and logics including state machines, algebraic and process models. The students learn how to select and describe appropriate abstract formal models for certain classes of systems, and reason about the correctness of refinements be able to prove elementary properties about systems described by the models introduced in the course.
Prerequisites: Familiarity with mathematical logic, set theory, and discrete mathematics.

CS 834 Advanced Computer Networking and the Internet (4 credits)
This course provides a modern, top-clown approach to the study of computer networking and the Internet that begins with application-level protocols and then works down the protocol stack. The most important topics from each layer follow. Application Layer: the WEB and HTTP, FTP, SMTI', DNS and Socket Programming. Transport Layer: UDP, TCI' and Congestion Control. Network Layer: Link State Routing, Distance Vector Routing, 1Pv4, RlP, OSPF, BGP, IPv6, Multicasting, and Mobile IP. Local Area Networks: Ethernet and IEEE 802.11 and Personal Area Networks: Bluetooth. Students are expected to implement an advanced project.
Course Rotation: Fall

CS 836 Advanced Optical Communications and Networks (4 credits)
This course studies Optical Communications and Networks. The key principles and building blocks of Optical Communications and Networks arc studied in detail with the first part of the course of focusing on Optical Communications and the second part of the course focusing on Optical Networks. Topics on Optical Communications include: Light Propagation in Optical Fiber, Loss and Bandwidth, Chromatic Dispersion, Nonlinear Effects, Solutions, Couplers, Isolators and Circulators, Multiplexers and Filters, Optical Amplifiers, Transmitters, Switches and Wavelength Converters. Topics on Optical Networks include: Client Layers ofthc Optical Layer (SONET/SDH, ATM, IP, and Storage-Area Networks), WDM Network Elements, WDM Network Design, Control and Management, Network Survivability, Access Networks, Photonic Packet Switching and Deployment Considerations. Students are expected to implement an advanced project.
Course Rotation: Fall.

CS 837 Quantum Computing (4 credits)
This will be a Pace University leading edge computing course for Computer Science PhD advance masters students. This quantum computing course will demonstrate that Seidenberg School is providing a leading-edge computing technology education to its students, thus making Pace University competitive with major universities in the greater NYC area.
Course Rotation: NYC & PLV: Spring [2018].

CS 839 Advanced Mobile Application Development (4 credits)
This course surveys the specificities of the development of native applications for different mobile platforms including phones and tablets. The software engineering of application development including user-centered design, testing and quality assurance will be emphasized, Students will learn how to design and develop applications for the Android platform, The following topics will be covered: user interface, events processing, services management, location based facilities, accelerometer and other sensors, network/web access, and sound and multimedia. The parallel with iPhone development will be presented, the distribution of mobile applications and business models for monetization will be covered. A significant project is integrated in the course. Students are expected to implement an advanced project.
Course Rotation: Fall

CS 840 AdvanceAd Computer Vision (4 credits)
This course covers advanced research topics in computer vision. Building on the introductory materials covered in the Computer Vision pre-requisite class, this class will prepare graduate students in both the theoretical foundations of computer vision as well as the practical approaches to building real Computer Vision systems. This course investigates current research topics in computer vision with an emphasis on recognition tasks and deep learning. Topics include optical flow, object tracking, object recognition, bag-of-features representation, deep neural networks, etc. We will examine data sources, features, and learning algorithms useful for understanding and manipulating visual data.
Course Rotation: Fall; NY and PLV

CS 843 Advanced Mobile Innovations for Global Challenges (4 credits)
This course familiarizes students with the development of mobile innovations addressing social and global challenges in areas such as health, micro finance, education and civic activism. Students will be introduced to research in the social considerations in mobile application development, ICT4D (Information and Technology for Development), and M4D (Mobile for Development) through readings, class discussions and a series of talks. The Mobile Web, and SMS and Voice solutions will be presented in that context. Students will leverage their technical knowledge with social insight, creativity and ingenuity to develop prototype with social impact along with its deployment plan (taking into accounts the real world limitations) and a business model, with the guidance of local partners from NGOs and the industry, and successful social entrepreneurs. Students are expected to implement an advanced project.
Course Rotation: Fall

CS 844 Advanced Web Computing (4 credits)
Internet and web technology overview. The tiered web architecture. Web server set up and configuration. Separating data structures and data presentation with cascading style sheets. JavaScript for client data validation and HTML document object model manipulation. Java software for servlet components. Separating computation from data presentation with JavaServer Pages. Session data management and Java persistence service. Computation abstraction with Struts. Server-side GUI abstraction/reuse and data validation with Java Server Faces. Ajax for more interactive and smoother web interactions. Web application security. Students are expected to implement an advanced project.
Course Rotation: Fall

CS 846 Advanced Service-Oriented Computing (4 credits)
Internet as a service delivery platform. Utility computing. Functions of XML and web services for B2B system integration. Web service framework. Declaring platform-independent service API with WSDL. Encapsulating service invocation with SOAP. Implementation and consumption of web services on Java platform Implementation and consumption of web services on MS.NET platform. Cross-platform system integration. Web service security. Specifying business processes with XML dialect BPEL. Business process modeling for automated business process integration, coordination and execution. Students are expected to implement an advanced project.
Course Rotation: Fall

CS 847 Advanced Game Model Design and Animation (4 credits)
3DSMax, and Maya to develop models; Polygon Creation; Triangulation; Character Modeling; Skeletons; Bone systems; Skinning; Character animation; Facial animation. Programming models to timet ion. Students arc expected to implement an advanced project.
Course Rotation: Fall.

CS 848 Advanced Enterprise Computing (4 credits)
Server scalability and robustness. Introduction to mainframe computing. Separating data presentation generation and business logic with application and servers. Software framework for Enterprise JavaBeans. Scalable business logic implementation with Enterprise Session JavaBeans. Event-driven system integration with message-driven Enterprise JavaBeans. Matching object domain and model relational data model. Enterprise server system security and deployment. Server virtualization as cloud services. Students are expected to implementation advanced project.
Course Rotation: Fall.

CS 849 Adv Intro Distributed Cmptng (4 credits)
Overview of scripting and programming languages used in available 3D game engines. Programming constructs of the 3D game engine and their relations with the models and levels; Programming the player and host to move around, swim, fly, and jump dynamically and randomly. Students are expected to implement an advanced project.
Course Rotation: NYC: Fall

CS 850 Advanced Grid Computing (4 credits)
Parallel vs. distributed computing. Multiprocessor and multi-computer architectures. Parallel programming languages and algorithms. Shared-memory and message-passing programming. Distributed architectures. Socket-level and software-framework based programming. Cluster-based computing. Grid computing architecture and tools. Service-oriented grid computing. Students are expected to implement an advanced project.
Course Rotation: Fall.

CS 852 Advanced Secure Web Application Development (4 credits)
Internet and web security overview. Securing web servers, application servers, and database servers. Client-side vs. server-side web application input validation. Java security policy and certificate management. Running Java applications through Java security manager. Defining Java security policies based on code base and code signature. Secure web application session management. SQL injection prevention. URL hacking prevention. Secure web application development life cycle and maturity model. Web application auditing. Blackbox vs. whitebox web application security testing. Secure web application deployment. Students are expected to implement an advanced project.
Course Rotation: Fall.

Prerequisites: Listed prerequisites or permission of instructor to register.

CS 853 Advanced Cryptography and Computer Security (4 credits)
This course covers the most important issues and topics in the huge area of cryptography and computer security. Topics include: Mathematics of Cryptography, Traditional Symmetric Key Ciphers, Modern Symmetric-Key Ciphers. DES, AFS, Asymmetric-Key Cryptography, RSA, Rabin, ElGamal and Elliptic Curve Cryptosystems, Message Integrity anrl Message Authentication, Cryptographic Hash Functions, Digital Signature, Entity Authentication and Key Management. Student's are expected to implement an advanced project.
Course Rotation: NYC: Fall

CS 854 Advanced Security in Computer Networking (4 credits)
This course evokes the most immortally issues and topics in the area of network security. A good balance between theory and practice is sought. It covers attacks and threats in computer networks, including network mapping, port scanning, sniffing, DoS, DDoS, reflection attacks, attacks on DNS and leveraging P2P deployments for attacks, operational security, including firewalls and intrusion-detection systems. It also takes a layered approach to network security covering topics that include: Security at the Application Layer: PGP and S/MIME, Security at the Transport layer: SSL and TLS, Security at the Network Layer: IPSec. Students will use software tools to participate in an importamt simulated lab component that includes packet sniffing, network mapping, firewalls, SSL and lPsec. Student's are expected to implement an advanced project.
Course Rotation: Fall

CS 855 Pattern Recognition and Machine Learning (4 credits)
This course focuses on the fundamental concepts, theories, and algorithms for pattern recognition and machine learning. Diverse application areas such as optical character recognition, speech recognition, and biometrics are discussed. Topics covered include supervised and unsupervised (clustering) pattern classification algorithms, parametric and non-parametric supervised learning techniques, including Bayesian decision theory, neural networks, support vector machines, nearest neighbor, and genetic algorithms.
Course Rotation: Fall

CS 896A Topic: Computer Vision (4 credits)
This course will present the fundamental concepts and techniques of digital image processing and its applications. Digital image processing techiques including enhancement, fillering, morphoplogym and segmentation and will be discussed The course will also expose students to MATLAB as an image processing tool. MATLAB-based course assignments will be used to illustrate and practice image processing techniques. Students will gain hands-on experiences on how to process and analyze digital images using MATLAB.
Course Rotation: NY: Spring.