

Department Facts

Introduction

Northwestern University, chartered in 1851 as an independent institution of higher education in Illinois, has grown to be one of the strongest research universities in the U.S. The University has two campuses: one in Evanston and one in downtown Chicago, 12 miles south of the Evanston campus. The 239-acre Evanston campus is located in a beautiful setting stretching more than one mile along Lake Michigan in Chicago's "North Shore" suburban region. The 20-acre Chicago campus, located just to the east of Chicago's "Magnificent Mile" of Michigan Avenue, is the site of Northwestern's McGaw Medical Center and School of Law.



Overall, the University has 2,500 faculty and 17,800 students (including 3,500 graduate students) on the two campuses. According to the 2000–2001 U.S. News and World Report survey, Northwestern is ranked 13th among U.S. universities for undergraduate education. Comparably ranked universities in this survey include Columbia, Cornell, University of Chicago, and Rice.

Northwestern's Evanston campus is the site of its Weinberg College of Arts and Sciences, School of Education, School of Social Policy, School of Music, School of Speech, Medill School of Journalism, Kellogg Graduate School of Management, and Robert R. McCormick School of Engineering and Applied Sciences. McCormick is ranked 19th nationally in 2000–2001 by the U.S. News. Comparably ranked engineering schools include Penn State, University of Maryland–College Park, Rensselaer Polytechnic, and UCLA.

The Department of Electrical and Computer Engineering (ECE) is part of the McCormick School of Engineering. According to the 2000–2001 U.S. News survey, the ECE Department is ranked 19th. Comparably ranked departments in this survey include UCLA, University of California–San Diego, Penn State, and University of Minnesota–Twin Cities.

Degree Programs

The ECE Department offers two undergraduate programs leading to B.S. degrees, one in electrical engineering (EE) and one in computer engineering (CompE). ECE also offers a graduate program in electrical and computer engineering leading to the M.S. and Ph.D. degrees. In addition, it offers a professional Master's degree program in the area of Information Technology (MITP).

Faculty and Staff

During 1999–2000, the ECE Department numbered 28 full-time faculty members (16 professors, nine associate professors, and three assistant professors). Of these, five are chaired professors and three are University professors of teaching excellence. Nine ECE faculty are Fellows of the Institute of Electrical and Electronics Engineers (IEEE); two are Fellows of the Optical Society of America (OSA); one is a Fellow of the Society of Photo-Optical Instrumentation Engineers (SPIE); one is a Fellow of the Association of Computing Machinery (ACM); and one is a Fellow of the American Association for the Advancement of Science (AAAS). Six ECE faculty have received PYI, NYI, or CAREER awards from the National Science Foundation. Finally, two emeritus faculty are members of the National Academy of Engineering.

The ECE Department has a staff of 19 including secretaries, computing-services staff, and staff for the MITP program.

Students

During 1999–2000, the ECE Department numbered 253 undergraduate students, up from 239 students in 1998–99. Of these, there were 110 students in EE (compared with 112 during 1998–99), and 143 students in CompE (compared with 127 in 1998–99). About 17% of our undergraduate students were female, and about 6% were African-American or Hispanic. A total of 20 B.S.E.E. and 20 B.S.Comp.E. degrees were granted.

The quality of our undergraduate students continues to improve. In 1999, the entering McCormick freshman class had an average SAT score of 1384 and a median score of 1400, which compares favorably with the best engineering schools in the U.S. The average student's high-school ranking was in the upper 5% of his or her class.

During 1999–2000, the Department also numbered 173 graduate students (compared with 163 in 1998–99). Of these, 143 were M.S./Ph.D. or Ph.D. students, and 30 were terminal M.S. students. About 20% of our graduate students were female, and about 3% were African-American or Hispanic. A total of 25 Ph.D. and 39 M.S. degrees were granted.

Space

The ECE Department occupies about 50,000 square feet in the Technological Institute which houses the McCormick School of Engineering. Of this total, about 8,100 square feet are assigned to instructional labs; 25,000 square feet are for research labs; 3,400 square feet are for computing labs; and the rest are assigned to faculty and departmental offices. The space comes to about 1,560 square feet per faculty, or 140 square feet per student.

Computing Facilities

The ECE Department has excellent computing facilities. This includes several powerful servers, 14 high-performance HP workstations, 14 high-performance SUN workstations in the ECE Wilkinson Lab, and 20 new personal computers in the ECE Engineering First lab. The Department has upgraded most of its computers in the last two years. Research computers in the Department include 70 high-performance HP and SUN workstations connected via a high-speed ATM network, and three parallel computers. The latter include a 16-processor IBM SP-2, an 8-processor IBM J-40, and an 8-processor SGI Origin 2000. All departmental computers are linked to the University's 622 Mbps OC-12 SONET network.

Undergraduate Curriculum Highlights

ECE Department. In the past three years, the ECE Department has significantly updated and strengthened its undergraduate curricula in EE and CompE. One aspect of this progress is the complete revision of these curricula. Each curriculum now incorporates an introductory freshman course (with an associated exciting hands-on lab) which communicates to the students a broad early overview of, and motivation for, EE or CompE. Further, each curriculum now incorporates a specific set of five fundamentals courses which provide students with a solid foundation in either EE or CompE. All subsequent courses in each curriculum are electives.

The ECE Department has also updated and strengthened its undergraduate labs in EE and CompE. 25 Hewlett-Packard and Sun workstations and 20 personal computers were acquired for the computing labs. In addition, with funding from Hewlett-Packard, the Department acquired 15 computer-controlled lab stations, each consisting of a high-quality wideband digital oscilloscope, a digital logic analyzer, a function generator, and dc power supplies (all integrated with a personal computer for equipment control and data acquisition). Further, with funding from Motorola, the Department initiated a new lab in wireless communications .

Finally, all of the CompE courses now use commercial-grade computer-aided design (CAD) tools from Mentor Graphics. Courses in this group include logic design, computer architecture, VLSI design, and independent-study projects. In addition, many of the EE courses in networking, communications, and signal processing are now using software packages in MATLAB for their design and analysis problems.

McCormick School. In 1997, the McCormick School innovated a core freshman / sophomore engineering curriculum called *Engineering First*. Previously, engineering students were not exposed to their field during their freshman and sophomore years, taking instead basic courses in physics, chemistry, and mathematics in a manner largely disconnected from any engineering perspective.

However, under the Engineering First curriculum, the study of mathematics, physics, and computer programming is carefully integrated with examples and problems drawn from various fields of engineering during a sequence of four quarter-length courses designated *Engineering Analysis*.

In addition, under the Engineering First curriculum, there is a two-quarter freshman sequence of courses designated *Engineering Design and Communications* (EDC). Here, each section of 16 students is team-taught by two professors, one from the Writing Program of the Weinberg College of Arts and Sciences, and the other from the McCormick School. EDC is project-based and team-based, with real design problems solicited from clients both inside and outside the University posed to small (four-person) student teams. While conducting their projects, the students learn the principal methods of engineering design, key aspects of team dynamics and project management, and the written and presentation skills appropriate for an engineering environment.

Research Activities

ECE Department research funding has approximately tripled in the past four years. Research funding per year was \$3.2 million in 1995–96, \$4.2 million in 1996–97, \$8.6 million in 1997–98, \$9.4 million in 1998–99, and \$8.3 million during 1999–00. With 28 full-time faculty members in the Department, the last value translates to an average funding level of \$296,000 per faculty member per year, which compares favorably to the top ten departments in the U.S..

Research in the ECE Department spans a wide variety of disciplines essential to the growing information technology field. To ensure strength in the fundamental technical areas of this field, the ECE faculty are organized in the following core Groups:

- Solid-State Engineering
- Photonic Systems and Technology
- Networks, Communication, and Control
- Signal Processing
- Parallel and Distributed Computing
- VLSI Design and CAD

Further, to explore emerging research areas which overlap a number of the traditional electrical and computer engineering disciplines, the Department contains six interdisciplinary research Centers, including:

- Center for Dynamic Systems and Control
- Motorola Center for Communications
- Center for Optimization Technology
- Center for Parallel and Distributed Computing
- Center for Photonic Communications and Computing
- Center for Quantum Devices

Sections to follow will summarize the Department's activities in each of its core technical Groups and interdisciplinary research Centers.

Advisory Board

Prof. Jacob Abraham
Dept. of Electrical and Computer Engineering
University of Texas
Austin, TX 78712

Dr. Tom Anderson
Hewlett Packard Corporation
10500 Ridgeview Court
MS 49UD-OC
Cupertino, CA 95014

Prof. Arvind
Laboratory for Computer Science
Massachusetts Institute of Technology
545 Technology Square
Cambridge, MA 02139

Dr. David Carney
33 Big Spring Road
Califon, NJ 07830

Mr. William Cooper
Intel Corporation
Corporate Recruiting, RR5-503
4100 Sara Road
Rio Ranch, NM 87124

Prof. Ed Davidson
Dept. of Electrical Engineering and Computer
Science
University of Michigan
Ann Arbor, MI 48109

Prof. Edward McCluskey
Dept. of Electrical Engineering
Stanford University
Stanford, CA 94305

Mr. Paul McLellan
V.P., Strategic Technology
Cadence Design Systems, Inc.
555 River Oaks Parkway, MS/7-2
San Jose, CA 95134

Dr. John Dever
10050 East Mountainview Lake
No. 36
Scottsdale, AZ 85258

Mr. Dennis Fernandez
Fernandez & Associates
1047 El Camino Real
Suite 201
Menlo Park, CA 94025

Prof. Mary Jane Irwin
Dept. of Computer Science and Engineering
Pennsylvania State University
227 Pond Laboratory
University Park, PA 16802

Prof. Leah Jamieson
Dept. of Electrical and Computer Engineering
Purdue University
West Lafayette, IN 47907-1285

Dr. Norman P. Jouppi
Compaq – WRL
250 University Avenue
Palo Alto, CA 94301

Prof. Steve Kang
Dept. of Electrical and Computer Engineering
University of Illinois
1406 West Green Street
Urbana, IL 61801

Dr. Frank Splitt
710 South William
Mount Prospect, IL 60056-3959

Dr. Ron Stout
Lucent Technologies
263 Shuman Boulevard
Room 1F-208
Naperville, IL 60566

Ms. Christina Peterson
University Program Manager, DSP
Texas Instruments
12203 Southwest Freeway, MS 722
Stafford, TX 77477

Mr. Thomas Ryan
Engineering Manager
Tellabs Operations, Inc.
1000 Remington Boulevard
Bolingbrook, IL 60440

Prof. Ron Schafer
Dept. of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0250

Dr. Marc Snir
Sr. Mgr., Scalable Parallel Systems
IBM T. J. Watson Research Center
P. O. Box 218
Yorktown Heights, NY 10598

Dr. John Spencer
Mgr., University Curriculum Program
Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

Mr. Dick Taylor
Sr. V.P., Digital Systems Division
Tellabs Operations, Inc.
4951 Indiana Avenue
Lisle, IL 60532

Dr. Bill Tetzlaff
Sr. Mgr., Operating System Technology
IBM Corporation
P. O. Box 704
Yorktown Heights, NY 10598

Mr. James Tucker
V.P., Global Business Development
Open Port Technologies
676 North St. Clair
Chicago, IL 60611

Dr. Patrick White
800 Safeguard Building
435 Devon Park Drive
Wayne, PA 19087

Dr. Kenneth Zdunek
V.P., Networks and Software Research
Motorola Labs
1301 East Algonquin Road
Schaumburg, IL 60196

ECE Department Contact Information

U.S. Mail / FedEx Address:	Department of Electrical and Computer Engineering Northwestern University 2145 Sheridan Rd. Evanston, IL 60208
Telephone / Fax / WWW:	Telephone: (847) 491-5410 Fax: (847) 491-4455 URL: http://www.ece.northwestern.edu
Chairman:	Prof. Prith Banerjee banerjee@ece.northwestern.edu (847) 491-3641
Chairman's Secretary:	Ms. Nancy Singer nancy@ece.northwestern.edu (847) 491-5410.
Director, Administration:	Ms. Deneen Bryce deneen@ece.northwestern.edu (847) 491-3376
Director, Graduate Program:	Prof. Larry Henschen henschen@ece.northwestern.edu (847) 491-3338
Secretary, Graduate Program:	Ms. Judy Stein judy@ece.northwestern.edu
Graduate School application requests:	http://www.imgweb.northwestern.edu/img/gsapreq.html grad@ece.northwestern.edu
Director, Undergraduate EE Program:	Prof. Alan Sahakian sahakian@ece.northwestern.edu (847) 491-7007
Director, Undergraduate CompE Program:	Prof. Alok Choudhary choudhar@ece.northwestern.edu (847) 467-4129
Director, Publicity, Alumni, and Industrial Relations:	Prof. Allen Taflove taflove@ece.northwestern.edu (847) 491-4127

Director, Computing Facilities: Prof. Abe Haddad
ahaddad@ece.northwestern.edu
(847) 491-8175

Director, Instructional Labs: Prof. Chi- Haur Wu
chwu@ece.northwestern.edu
(847) 491-7076

Center Contact Information

Director, Center for Dynamic Systems and Control: Prof. Abe Haddad
ahaddad@ece.northwestern.edu
(847) 491-8175
www.ece.nwu.edu/~ahaddad/control.html

Director, Motorola Center for Communications: Prof. Aggelos Katsaggelos
aggk@ece.northwestern.edu
(847) 491-7164

Deputy Director, Center for Optimization Technology: Prof. Jorge Nocedal
nocedal@ece.northwestern.edu
(847) 491-5038
www.mcs.anl.gov/home/otc

Director, Center for Parallel and Distributed Computing: Prof. Prith Banerjee
banerjee@ece.northwestern.edu
(847) 491-3641
www.ece.nwu.edu/cpdc

Director, Center for Photonic Communications and Computing: Prof. Prem Kumar
kumarp@ece.northwestern.edu
(847) 491-4128

Director, Center for Quantum Devices: Prof. Manijeh Razeghi
razeghi@ece.northwestern.edu
(847) 491-7251
<http://cqdece.nwu.edu>

Research Groups

Overview

Research in the ECE Department spans a wide variety of disciplines essential to the growing information technology field. To ensure strength in the fundamental technical areas of this field, the ECE faculty are organized in the following core Groups:

- Solid-State Engineering
- Photonic Systems and Technology
- Networks, Communication, and Control
- Signal Processing
- Parallel and Distributed Computing
- VLSI Design and CAD

Each group:

- Formulates its own graduate admissions and financial aid recommendations to the Department's Graduate Director;
- Assigns an initial adviser to each incoming graduate student;
- Determines its graduate course offerings;
- Determines its academic performance, examination, and research requirements for the awarding of the M.S. and Ph.D. degrees;
- Identifies opportunities for research collaboration among ECE faculty members, frequently resulting in the submission of research proposals to funding agencies.

Graduate students benefit from their group's relative autonomy because progress toward the M.S. or Ph.D. degree is planned and monitored by a small and cohesive group of faculty specializing in the student's precise technology area.

Solid-State Engineering

The Solid-State Engineering Group focuses primarily on the science and technology of semiconductors for quantum structures and devices operating from the far infrared to the ultraviolet. Quantum devices are fabricated using the most advanced semiconductor synthesis technologies (MOCVD, MBE, gas source MBE, etc.) and microfabrication techniques (high-precision photolithography, e-beam lithography, RTA, reactive-ion etching, etc.). The devices are fully tested at each step in the fabrication process using such advanced characterization techniques as diffraction, SEM, TEM, photoluminescence, and the Hall effect. Most of the research is performed within the Center for Quantum Devices in a clean-room environment similar to that found in industry.

The quantum devices designed and constructed by this Group are in great demand by government and industry. They are used in a vast range of applications, including fiber-optic and free-space communications, aerospace remote sensing, night vision, astronomy, monitoring of

engines and other heat sources, full-color displays, optical data storage, medical applications, and chemical analyses. Other research activities include the synthesis, characterization, and modeling of high-temperature superconductors, conducting oxides and polymers, thermoelectric materials, and solid-state materials for optical and microwave communications.

The Group's faculty and their research interests are:

Chris Jelen (Ph.D., Northwestern University). Assistant Professor.

- Detectors and sensing systems, including ultraviolet, visible, and infrared detectors; quantum devices; nanolithography.

Carl Kannewurf (Ph.D., Northwestern University). Professor.

- Measurement and analysis of electronic transport and related properties in high-temperature superconductors; transparent ceramics; mixed electronic-ionic conductors; intercalated polymer systems; thermoelectric materials for refrigeration applications.

Nathan Newman (Ph.D., Stanford). Associate Professor.

- Fabrication of novel semiconductor, superconductor, and dielectric devices; characterization and modeling of surface, interface, and bulk phenomena within these structures; improvement of a wide range of electronic devices having applications in communications, medical diagnostics, defense, and consumer electronics.

Manijeh Razeghi (Ph.D., Orsay University, France). Walter P. Murphy Professor. Group Coordinator. Director, Center for Quantum Devices. Fellow, Society of Photo-Optical Instrumentation Engineers (SPIE).

- MOCVD and MOMBE growth of III-V and II-VI semiconducting multiple quantum wells and superlattices; optical, electrical, and structural characterization of semiconductors; solid-state physics; modeling and fabrication of discrete photonic and electronic devices; optoelectronic integrated circuits; characterization, modeling, and fabrication of quantum structures and quantum devices.

Photonic Systems and Technology

The Photonic Systems and Technology Group focuses on microcavity lasers, nanostructures, quantum and nonlinear optics, integrated optics, fiber-optic and infrared waveguide devices, fiber-optic communications, computational electromagnetics, and imaging through turbulence. Special emphases include: applications of novel quantum amplifiers in optical communications, imaging, and cryptography; devices for terabit per second WDM and TDM optical networks; and applications of computational techniques in integrated and nonlinear optics, microwave technology, and biomedical engineering. A sophisticated laboratory has been established to fabricate micron-scale photonic devices and circuits.

The Group's faculty and their research interests are:

Seng-Tiong Ho (Ph.D., MIT). Associate Professor. Recipient NSF CAREER Award. Fellow, Optical Society of America (OSA).

- Quantum optics; nonlinear optics; ultrafast optical devices; microcavity lasers.

Prem Kumar (Ph.D., State University of New York at Buffalo.). Professor. Group Coordinator. Director, Center for Photonic Communications and Computing. Fellow, Optical Society of America (OSA).

- Nonlinear and quantum optics, laser and atomic physics, fiber-optic communications, and networks.

Mary Philips (Ph.D., MIT). Associate Professor.

- Lightwave communication techniques and crosstalk in wavelength-division systems for cable TV networks.

Martin Plonus (Ph.D., University of Michigan). Professor. Fellow, IEEE.

- Superresolution imaging through atmospheric turbulence; double-passage imaging techniques; wave propagation through turbulence; image restoration; adaptive optics; structure of atmospheric turbulence.

Allen Taflove (Ph.D., Northwestern University). Professor. Charles D. McCormick Professor of Teaching Excellence. Director, Center for Computational Science and Engineering. Fellow, IEEE.

- Theory and application of computational electrodynamics in modeling ultrafast electronic and optical devices, microwave and optical wave scattering, biomedical phenomena and devices, and geophysical electromagnetic phenomena.

Bruce Wessels (Ph.D., MIT). Walter P. Murphy Professor. Joint appointment with the Department of Materials Science and Engineering.

- Synthesis and characterization of electronic and photonic materials and devices; compound semiconductors; materials preparations; defect studies by deep-level transient spectroscopy; MOCVD processing of ceramic superconductors.

Horace Yuen (Sc.D., MIT). Professor. Joint appointment with the Physics Department. Recipient 1996 Quantum Communications Award.

- Optical communications; theoretical quantum optics; measurement theory; cryptography.

Networks, Communication, and Control

The Networks, Communication, and Control Group focuses on communications, telecommunications and communication networks, and control theory. Specific areas of study include: mobile wireless multi-user communication; spread-spectrum wireless communications; wireless networks; resource allocation and routing in communication networks; data network protocol design; network performance modeling and analysis; detection, estimation, and filtering with applications to communication and control systems; multimedia applications; nonlinear and robust control; and stochastic hybrid systems.

The Group's faculty and their research interests are:

Randall Berry (Ph.D., MIT). Assistant Professor.

- Wireless communications, data networking, information theory.

Randy Freeman (Ph.D., University of California, Santa Barbara). Assistant Professor. Recipient NSF CAREER Award.

- Control systems; controller synthesis methods for systems having significant nonlinearities and uncertainties; nonlinear control design; adaptive controllers for system stability and improved performance; design of robust nonlinear control systems; game theory.

Abraham Haddad (Ph.D., Princeton). Henry and Isabelle Dever Professor. Director, Center for Dynamic Systems and Control. Fellow, IEEE. Fellow, American Association for the Advancement of Science (AAAS).

- Analysis, modeling, estimation, detection, and control of stochastic systems; applications to communications systems and networks.

Michael Honig (Ph.D., University of California–Berkeley). Professor. Group Coordinator. Fellow, IEEE.

- Communications; signal processing; networks; spread-spectrum wireless communications systems; interference suppression and multiuser detection; multiple-access techniques; resource allocation to support integrated services.

Aggelos Katsaggelos (Ph.D., Georgia Institute of Technology). Ameritech Professor. Director, Motorola Center for Communications. Fellow, IEEE. (See Signal Processing Group.)

C.-C. Lee (Ph.D., Princeton). Professor.

- Digital communications; communication network performance modeling and analysis; distributed multi-sensor detection and estimation.

Signal Processing

The Signal-Processing Group focuses on the digital representation and algorithmic manipulation of speech, audio, image, and video signals. Specific topics within this general area include image and video processing, recovery, compression and transmission; multimedia signal processing; filter design; rank-order operators; medical and biomedical signal processing; medical imaging; and algorithms for medical instrumentation.

The Group's faculty and their research interests are:

Arthur Butz (Ph.D., University of Minnesota). Associate Professor.

- Digital signal processing; median and related filtering.

Michael Honig (Ph.D., University of California–Berkeley). Professor. Fellow, IEEE. (See Systems, Networks, and Communications Group.)

Aggelos Katsaggelos (Ph.D., Georgia Institute of Technology). Ameritech Professor. Group Coordinator. Director, Motorola Center for Communications. Fellow, IEEE.

- Multidimensional digital signal processing; digital image and video processing; video coding and transmission; computational vision; implementation of signal-processing algorithms; multimedia signal processing.

Thrasos Pappas (Ph.D., MIT). Associate Professor.

- Image and multidimensional signal processing; analysis of medical images and algorithms for image and video segmentation; perceptual image and video compression, model-based half-toning, color printing, and video / audio integration for teleconferencing.

Alan Sahakian (Ph.D., University of Wisconsin–Madison). Professor. Charles D. McCormick Professor of Teaching Excellence. Joint appointment with the Department of Biomedical Engineering.

- Instrumentation; signal and image processing for medical and aerospace applications; automatic detection and treatment of atrial cardiac arrhythmias by implanted devices.

Parallel and Distributed Computing

Faculty in this area have interests in parallel and distributed computer architectures, systems, and applications including compilers and runtime systems, input-output and disk organization, performance analysis tools, database and transaction systems, on-line analytical processing, and data mining. Additional interests include the development or optimization of parallel algorithms for applications in science and engineering such as VLSI design, computational geometry, solution of partial differential equations, general scientific computing and visualization, optimization applied to both man-made and natural systems (transportation, weather forecasting, etc.), robotics, and computer vision.

The Group's faculty and their research interests are:

Prith Banerjee (Ph.D., University of Illinois at Urbana–Champaign). Walter P. Murphy Professor. Department Chairman. Director, Center for Parallel and Distributed Computing. Fellow, IEEE. Fellow, Association of Computing Machinery (ACM). Recipient F. E. Terman Award. Recipient NSF PYI Award.

- Parallel algorithms for VLSI computer-aided-design applications; parallelizing compilers for distributed-memory multiprocessors; parallel architectures with emphasis on fault tolerance.

Alok Choudhary (Ph.D., University of Illinois at Urbana–Champaign). Professor. Group Coordinator. Recipient NSF PYI Award.

- High-performance computing and communication; I/O, compiler, and run-time systems for high-performance computing; multimedia systems; databases.

Lawrence Henschen (Ph.D., University of Illinois at Urbana–Champaign). Professor.

- Theorem-proving; deductive databases; automated reasoning; use of meta-level reasoning in guiding search mechanisms of automated reasoning programs; distributed heterogeneous databases; intelligent assistants / tutors.

W.-C. Lin (Ph.D., Purdue). Associate Professor.

- Computer vision; pattern recognition; neural networks; computer graphics.

Jorge Nocedal (Ph.D., Rice University). Professor. Bette and Neison Harris Professor of Teaching Excellence. Co-Director, Optimization Technology Center.

- Distributed computing over the Internet; scientific computing; design and analysis of algorithms; software development; numerical solution of large-scale nonlinear optimization problems; application of nonlinear optimization to weather forecasting, pollution modeling, optimal design, and chemical engineering.

Peter Scheuermann (Ph.D., State University of New York at Stony Brook). Professor.

- Physical database design; parallel I/O systems and distributed file systems; data warehousing; database applications for the Web; distributed and federated database systems; data mining.

Valerie Taylor (Ph.D., University of California–Berkeley). Associate Professor. Recipient NSF NYI Award.

- Performance of parallel scientific applications; computer architecture; visual supercomputing environments.

C.-H. Wu (Ph.D., Purdue). Associate Professor.

- Robotics; CAD/CAM; industrial control; automated manufacturing; neural networks; computer graphics and images; automated medical instrumentation; surgical robot systems.

VLSI Design and CAD

Faculty in this area have interests in developing digital hardware for complex systems. This involves investigating how best to design integrated circuits, processors, and computing systems to deliver the highest performance at reasonable cost and power consumption. This also involves consideration of how advances in process and circuit technology drive future hardware implementation. Research areas include: ASIC and digital hardware design; microprocessor design; embedded-systems design; FPGA architectures, systems, adaptive computing, and applications; CAD software and algorithms for physical design; logic and behavioral synthesis; CAD theory; CAD for low-power design; parallel algorithms for VLSI CAD; and other emerging areas of VLSI design and CAD.

The Group's faculty and their research interests are:

Prith Banerjee (Ph.D., University of Illinois at Urbana–Champaign). Walter P. Murphy Professor. Department Chairman. Director, Center for Parallel and Distributed Computing. Fellow, IEEE. Fellow, Association of Computing Machinery (ACM). Recipient F. E. Terman Award. Recipient NSF PYI Award.

- Parallel algorithms for VLSI computer-aided-design applications; parallelizing compilers for distributed-memory multiprocessors; parallel architectures with emphasis on fault tolerance.

Alok Choudhary (Ph.D., University of Illinois at Urbana–Champaign). Professor. Group Coordinator. Recipient NSF PYI Award.

- High-performance computing and communication; I/O, compiler, and run-time systems for high-performance computing; multimedia systems; databases.

Yehea Ismail (Ph.D., University of Rochester). Assistant Professor.

- Interconnects, noise, innovative circuit simulation, and related circuit-level issues in high-performance circuits.

Majid Sarrafzadeh (Ph.D., University of Illinois at Urbana-Champaign). Professor. Fellow, IEEE.

- VLSI design; computer-aided design; high-performance architectural design; design and analysis of algorithms; computational complexity; FPGA and reconfigurable computing; hardware for digital signal processing.

Interdisciplinary Research Centers

Overview

In addition to its research groups, the ECE Department also is involved with six interdisciplinary research Centers:

- Dynamic Systems and Control
- Motorola Center for Communications
- Optimization Technology
- Parallel and Distributed Computing
- Photonic Communications and Computing
- Quantum Devices

These Centers allow exploration of emerging research areas which overlap a number of the traditional electrical and computer engineering disciplines.

In contrast to the Department's research Groups, the Centers have no academic or administrative role in a graduate student's progress toward his or her M.S. or Ph.D. degrees. However, the Centers substantially benefit their affiliated students by providing unusually wide-ranging and long-term opportunities for financial support and technical collaboration.

The centers routinely facilitate close collaboration with students, faculty, and research professionals affiliated with other McCormick departments; University departments outside McCormick; the University's other multidisciplinary centers; other universities; federal national laboratories; and private industry. Such collaboration enables affiliated students to broaden their research experiences and expose themselves to a wide range of career opportunities.

Center for Dynamic Systems and Control

The Center for Dynamic Systems and Control involves educational and research activities of faculty and students in several departments of the McCormick School, including Chemical Engineering (ChemE), Electrical and Computer Engineering (ECE), Industrial Engineering and Management Sciences (IEMS), and Mechanical Engineering (MechE). Students in this program have an unusual opportunity to perform cutting-edge, interdisciplinary research in the fields of systems, control, and manufacturing processes. Specific research areas include process control, robotics, operator-assisted devices for assembly, haptic interfaces, manufacturing systems, scheduling, and logistics. Although each student must register in one of the participating departments, the curriculum and research opportunities draw upon the offerings of all departments represented in the Council.

Affiliated Northwestern faculty include: J. Edward Colgate, MechE; Randy Freeman, ECE; Abraham Haddad, ECE (Director); Michael Mavrovouniotis, ChemE; Michael Peshkin, MechE; and Mark Van Oyen, IEMS.

Motorola Center for Communications

The Motorola Center for Communications, established in Aug. 1998, has a wide variety of interests addressing important issues of the telecommunications industry. These include:

- Efficient compression, encoding, and transmission of multimedia data;
- Efficient allocation of wireless channel resources to multimedia network traffic, including voice, packet data, and video;
- Enhancement of the capabilities of current wireless technologies such as code-division multiple access (CDMA) used for mobile cellular voice services;
- Rapid design and manufacture of high-quality, small-size, low-power, application-specific processors for image and multimedia signals;
- Encryption of data for security and privacy.

As part of the Motorola Center, industrial and McCormick researchers and students develop strong collaborations and are educated in the latest telecommunications techniques. Affiliated Northwestern faculty include: Michael Honig, ECE; Aggelos Katsaggelos, ECE (Director); C.-C. Lee, ECE; and Horace Yuen, ECE.

Center for Optimization Technology

The Center for Optimization Technology is a joint enterprise of Argonne National Laboratory and Northwestern University. It was founded in 1994 with support from Northwestern and the U.S. Department of Energy. The Center's mission is to: (1) increase awareness of the benefits of the latest optimization techniques among potential users in industry, government, and academia; and (2) make these techniques widely available by providing advanced distributed-computing and software environments. These goals are being achieved by combining the best optimization algorithms, modern computational tools and interfaces, and the power and reach of the Internet.

Center activities currently focus on the Network-Enabled Optimization System (NEOS), consisting of a comprehensive optimization software library, interfaces and servers that allow users to run this software either locally or remotely over the network, and a guide to optimization technology on the World Wide Web. The Center's products are designed to help at each problem-solving stage: modeling real-world applications, solving mathematical problems, and interpreting the results. Users are able to download software from the NEOS Library and run it on their own hardware. The NEOS Server also offers users a novel alternative: remote solution of optimization problems on the Center's computational facilities via communication using the World Wide Web, email, and ftp. In this mode, users supply a problem description and data. Then, the NEOS Server chooses the appropriate software, solves the problem, and returns the results. This facility has already been used by hundreds of students and professionals worldwide.

The Center has a variety of research collaborations with industry and government ranging from logistics planning, power-generation schedules, optimal placement of elements in computer chips, scheduling of operators in a telephone pool, and optimal pricing of seats for airlines. Affiliated researchers from Northwestern University include: John Birge, Dean, McCormick School of Engineering; Collette Coullard, IEMS; Mark Daskin, IEMS; Robert Fourer, IEMS; Sanjay Mehrotra, IEMS; and Jorge Nocedal, ECE (Deputy Director). Affiliated researchers from Argonne National Laboratory include Jorge More and Steven Wright (Director).

Center for Parallel and Distributed Computing

The Center for Parallel and Distributed Computing conducts leading-edge, fundamental science and engineering research aimed at providing a sound basis for the technology of parallel and distributed computing. Founded in 1996, the Center's research focuses on all aspects of this technology area — namely, parallel architectures, parallel compilers and software, parallel algorithms and applications, parallel and distributed database systems, and parallel I/O systems.

Currently, the Center has the following computing resources: a 16-processor IBM SP-2 distributed-memory message-passing multicomputer; an 8-processor IBM J-40 shared-memory multiprocessor; an 8-processor SGI Origin 2000 distributed shared-memory multiprocessor; and 50 high-end Hewlett-Packard Unix workstations (models C-110, C-180, and B-132). All of the workstations and parallel-processing computers are connected together to form a large distributed-computing infrastructure by 4 Cisco LS1010 ATM switches. Affiliated researchers from Northwestern University include: Prith Banerjee, ECE (Director); Alvin Bayliss, Applied Math; Ted Belytschko, CivE and MechE; Alok Choudhary, ECE; Yehea Ismail, ECE; Jorge Nocedal, ECE; Peter Scheuermann, ECE; Allen Taflove, ECE; and Valerie Taylor, ECE. Affiliated researchers from Argonne National Laboratory include Ian Foster and William Gropp.

Center for Photonic Communications and Computing

The Center for Photonic Communications and Computing (CPCC) is the newest center in the ECE Department. Founded in the fall of 1999, the primary goal of CPCC is to conduct cutting-edge fundamental science and engineering research that will lead to the development of advanced photonic communication and computing systems. Specifically, the focus of research is on optical and optoelectronic systems that push all current technological limits. General goals include: (a) attainment of optical data transmission and processing rates exceeding one terabit per second; (b) attainment of levels of integration allowing thousands of optical devices to be fabricated on one chip; and (c) pioneering of radically new ways to accomplish optical communication, signal processing, and computing by exploiting the fundamental laws of nature. CPCC also provides a venue for collaboration, coordination, dissemination, and promotion of research and teaching activities in the above areas both inside and outside the University.

Research at CPCC is conducted in many state-of-the-art laboratories located within the McCormick School. These include the Quantum Communications and Cryptography Lab, the Fiber-optic Communications Lab, the Quantum and Nonlinear Optics Lab, the Opto-electronics Lab, and the Quantum Electronics Lab. These labs house many advanced solid-state as well as optical-fiber laser systems, including several sources of picosecond and femtosecond duration pulses. In addition, a wide variety of optical, electro-optic, fiber-optic, and electronic instruments are available for ultrahigh speed (10–100 GHz) measurements and diagnostics. CPCC researchers also have access to the advanced facilities of the Materials Research Center of Northwestern University.

Affiliated researchers from Northwestern University include: Anupam Garg, Physics; Seng-Tiong Ho, ECE; William Kath, Applied Math; John Ketterson, Physics and ECE; Prem Kumar, ECE (Director); Alan Sahakian, ECE and BiomedE; Ken Spears, Chemistry; Allen Taflove, ECE; Bruce Wessels, Materials Science and ECE; and Horace Yuen, ECE and Physics. Other affiliated researchers include: Mauro D'Ariano, University of Pavia, Italy; Antonio Mecozzi, Fondazione Ugo Bordoni, Rome, Italy; and Ricardo Horowicz, University of Sao Paulo, Brazil.

Center for Quantum Devices

Since its founding in Sept. 1991, the Center for Quantum Devices (CQD) has been a model of high-level research and academic excellence in semiconductor research and application, bridging the gap between academia and industry. Research at CQD is multidisciplinary and industry-oriented, involving advanced work in areas as diverse as material synthesis, physical characterization, device fabrication, and modeling. Students benefit from exposure to this research and its applied technologies, fostering future leaders in research and technology transfer. CQD is the only institution in the world that has developed optoelectronic materials and devices operating throughout the visible and invisible light spectrum, often realizing first-of-a-kind breakthroughs. Successful collaborations have been formed with major universities, international industries, small businesses, and national laboratories. Funding for CQD activities is provided by private industry and government agencies.

CQD is equipped with many facilities for modeling, epitaxial growth, material characterization, device fabrication, and device characterization. CQD's semiconductor growth capabilities are housed in a new 5,000-square-foot clean room and currently include five metallorganic chemical vapor deposition systems (including commercial systems from EMCORE and AIXTRON) and two molecular beam epitaxy systems (from EPI). State-of-the-art equipment for material characterization includes a high-resolution five-crystal X-ray diffractometer, a field-emission scanning electron microscope, an atomic force microscope, Fourier-transform photoluminescence and absorption spectrometers, several photovoltage spectrometers, a deep-level transient spectrometer, a Hall-effect system, and an electrochemical capacitance voltage profiler. Device fabrication facilities include a photolithography laboratory, wet chemistry facilities, a plasma-etching system, several thermal and electron-beam evaporators, surface profilers, and bonding devices. Affiliated researchers from Northwestern University include: Robert Chang, Materials Science; Chris Jelen, ECE; Carl Kannewurf, ECE; John Ketterson, Physics and ECE; and Manijeh Razeghi, ECE (Director). Gail Brown of the U.S. Air Force is an affiliate researcher outside of Northwestern.