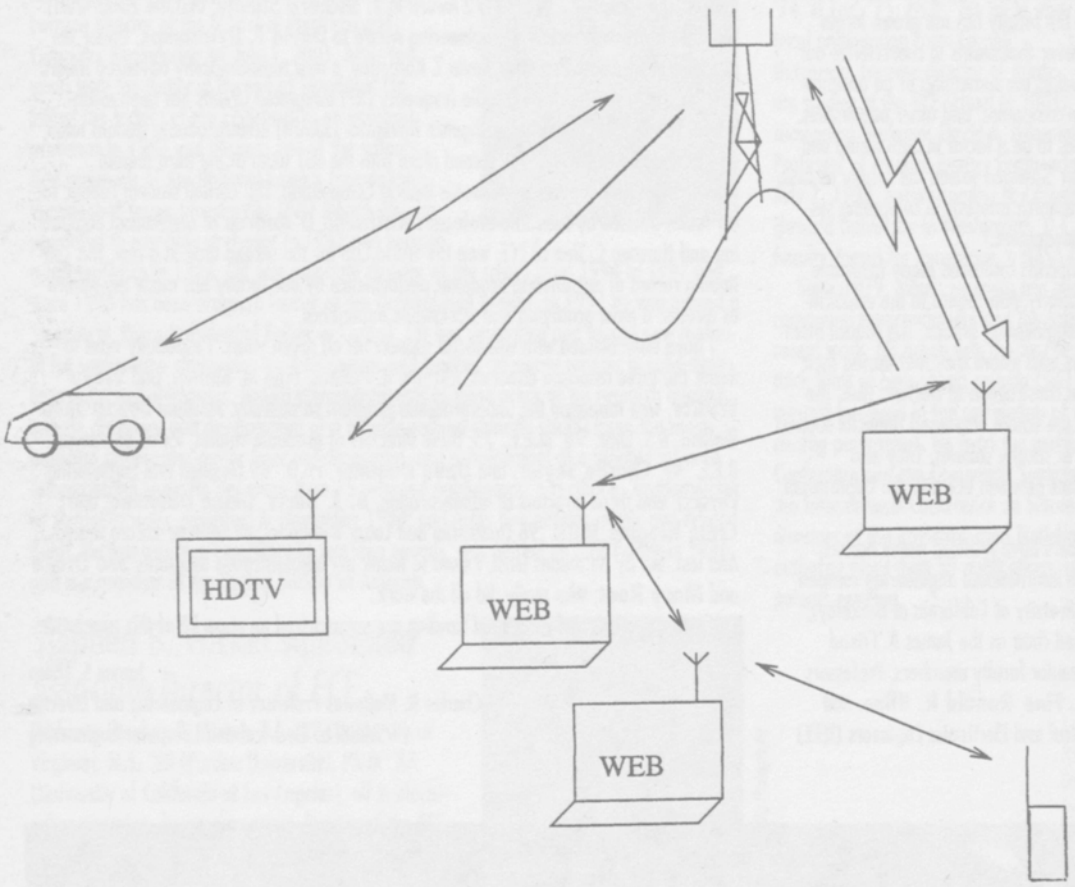
CONNECTIONS

A Report from the School of ELECTRICAL AND COMPUTER ENGINEERING • Cornell University

Digital Signal Processing Research

in the School of Electrical and Computer Engineering



This sketch illustrates the merging of communications and computing devices, coupled with wide use of the Internet, which has the potential to offer seamless exchange of data and information, teleconferences, worldwide communication, video on demand, and distortion-free transmission of images. All of these facilities require high-quality satellite and fiber-optic transmission and receiver systems that must have capabilities far beyond those of conventional radio and telephone services. The digital revolution has brought these communication wonders into nearly routine use, but many obstacles to high-quality performance remain. For example, transmission of images must not be distorted by necessary signal compression techniques, high-definition television (HDTV) must have adequate filters to eliminate distortion from man-made objects and terrain features, digital scanning and processing of images must eliminate interference patterns, and the ever-increasing number of users must not create communication "gridlock." Problems such as these are addressed by the digital signal processing (DSP) research described in the articles in this issue.

Sketch courtesy of Lang Tong

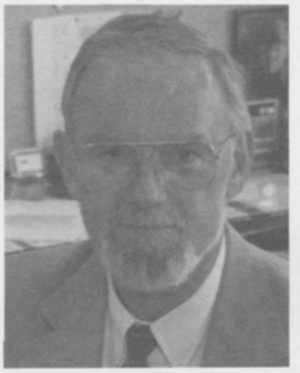
This tenth edition of *Connections* features the challenging research of our digital signal processing (DSP) research group, relates the history of computer technology in the EE/ECE School, and considers the impact of new analytical techniques in the DSP field on the ECE School. The "Positive Feedback" section contains news of recent alumni activities. Other items of interest to alumni are listed below in the table of contents. Please fill out the information coupon on page 31 of this newsletter, clip it, and mail it to us. We want to hear what you are up to.

Simpson (Sam) Linke, editor

SUMMER 2001

In This Issue

Report from the Director



Doug Hicks, Engineering Publications

James S. Thorp

This report marks the end of my seven years as director of the department that became the School of Electrical and Computer Engineering (ECE) on July 1, 2000. **Clif Pollock**, who has done such a great job as academic program leader for the Duffield Hall Project Management Team, became director of ECE on July 1, 2001. During my term of office, in addition to planning for Duffield Hall, faculty recruiting has been the major activity. Seventeen new members have been added to the faculty, including two acceptances for July 1, 2001. In spite of this record hiring program, the faculty has not grown larger because of retirements and the constant faculty turnover that seems to characterize our field. Having had only one employer for 39 years makes me something of an anachronism. We have lost faculty to big companies, start-up companies, and other universities. The problem of two-career families in Ithaca continues to be a factor in both hiring and retaining faculty. **Martin Burtscher** and **W. Evan Speight** joined the faculty as assistant professors on July 1, 2000, with teaching and research interests in computing systems. (See page 4 for biographical sketches of our newcomers.)

The 2000 ECE Advisory Council Report to Dean Hopcroft contained many favorable comments about recent progress in the school, particularly with regard to the establishment of the wireless communications and computer engineering groups. The council members were impressed with the young faculty members with whom they met during their visit, and they were pleased to learn of the imminent construction of Duffield Hall. The report discussed the urgent need for more space for the school, increased financial support from the university, and improvements in the status of faculty salaries. They also expressed concern about the uncertainty of interactions between ECE and the Department of Computer Science.

During this past academic year, ECE faculty members have received many honors, established new projects, and advised students in two international engineering competitions. Professor **Michael C. Kelley**, Ph.D. '70 (University of California at Berkeley), physics, has been appointed to an ECE School endowed chair as the James A. Friend Distinguished Professor of Engineering. Four of our senior faculty members, Professors **Toby Berger**, **Lester F. Eastman**, **Terrence L. Fine**, **Ronald R. Kline**, and **Thomas W. Parks** received the Institute of Electrical and Electronics Engineers (IEEE) Third Millennium Medal. From 1997 to 2000, all eight of our then assistant professors, **Mark A. Heinrich**, **Sheila S. Hemami**, **Edwin C. Kan**, **Kevin T. Kornegay**, **Rajit Manohar**, **Bradley A. Minch**, **Norman C. Tien**, and **Venugopal V. Veeravalli**, had received Faculty Early Career Development (CAREER) grants from the National Science Foundation (NSF). Professors Kan and Veeravalli were also awarded the prestigious Presidential Early Career Award for Science and Engineering (PECASE). The following professors received Excellence in Teaching honors for 2000: the **Michael Tien** '72 Award to **Zygmunt J. Haas** and Sheila S. Hemami; the James and Mary Tien Award to **Paul M. Kintner Jr.** and Clifford R. Pollock; the **Ralph S. Watts** '72 Award to **J. Richard Shealy**; and the 2000–2001 Tau Beta Pi/Cornell Society of Engineering Award to **David F. Delchamps**. Under the direction of Associate Professor Kevin T. Kornegay, a new technologically advanced laboratory for designing and testing radio frequency (RF) integrated circuits has been established. The Big Red Artificial Intelligence Navigator (BRAIN) undergraduate student team, also advised by Kevin, tied for second place with the MIT team at the third annual International Autonomous Underwater Vehicle Competition. The Cornell student robotic soccer team, advised by Associate Professors **Raffaello D'Andrea** of mechanical engineering and Norman C. Tien of ECE, won the World Cup for the second time in a row. This continuing record of outstanding academic performance by our faculty has made my tenure as director a most gratifying and worthwhile experience.

I have been blessed with wonderful support for all seven years. I especially want to thank the three associate directors, Clifford R. Pollock, Paul M. Kintner, and **Steve Wicker**, who managed the undergraduate program so skillfully. Assistant Director **John Belina**, B.S. Engr. '74, M.E.E. '75; three directors of graduate studies, **Paul McIsaac**, B.E.E. '49, **Charlie Seyler**, and **Dave Hammer**, Ph.D. '69 (Applied and Engineering Physics); and three directors of administration, **B. J. Bortz**, **Diane Downing**, and **Craig Higgins**, M.ILR. '96 (Industrial and Labor Relations), all deserve sincere thanks. And last, but by no means least, I want to thank my administrative assistants **Sue Drake** and **Mary Root**, who really did all the work.

Current projects and associated funding are summarized on page 18 of this newsletter.

James S. Thorp
Charles N. Mellowes Professor of Engineering and Director
School of Electrical and Computer Engineering

Photo by Robert Thomas

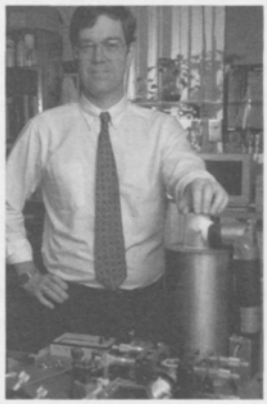
Photograph of past EE directors plus new ECE director at Jim Thorp's retirement reception in Moakley House on June 23, 2001. From right to left in chronological order: Herbert Carlin, Conrad Dalman, John Nation, James Thorp, and Clifford Pollock. Absent: Joseph Ballantyne and Noel MacDonald.

Jim Thorp Retires as Director of ECE

When Jim retired on July 1, 2001, as director of the School of Electrical and Computer Engineering he had completed seven years of service that Dean John Hopcroft has described as "an outstanding job providing leadership and vision for the department, fostering collegiality and hiring top-quality new faculty members." The ECE faculty and members of the ECE Advisory Council all concur in this assessment of Jim's excellent tenure in the director's chair. Managerial characteristics that contributed to Jim's success are his thorough understanding of the goals and aspirations of every academic unit in the school, his skillful guidance of the faculty during debates on various issues, and his ability to provide clear answers to specific policy questions posed by faculty members or by critical visitors such as accreditation examiners. Jim can take satisfaction in knowing that his leadership has left the school in sound condition and prepared for new achievements. We offer best wishes for Jim's projected well-earned sabbatical and future success upon his return to teaching and research.

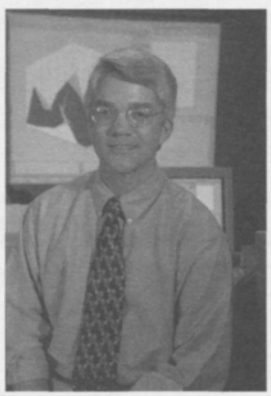
Clifford R. Pollock Appointed New Director of ECE

Frank DiMeo, Cornell University Photography



Professor Clifford R. Pollock, B.S. '76, M.S. '79, Ph.D. '81, all in electrical engineering from Rice University, the Ilda and Charles Lee Professor of Engineering, became director of the School of Electrical and Computer Engineering on July 1, 2001. After two years with the National Bureau of Standards Clif joined the faculty of the EE School as an assistant professor in 1983 and became one of the school's first recipients of the National Science Foundation's Presidential Young Investigator (PYI) Award. He was promoted to associate professor in 1987 and became a full professor in 1993. Clif was associate director of the school from 1994 to 1997 and since 1996 has been program leader of the Duffield Hall Project. In 1997 he was named a Stephen H. Weiss Presidential Fellow at Cornell. Clif has developed and taught new material for sophomore- and junior-level EE courses and teaches advanced courses in solid-state lasers and optoelectronics. Recent accomplishments in these areas of his research interest include discovery and development of a tunable sodium chloride (NaCl) laser, the most powerful stable color-center laser yet discovered, and development of a tunable infrared femptosecond laser. He has more than 75 refereed publications; a textbook, *Fundamentals of Optoelectronics*, published in November 1994; and holds five patents in this and related fields. He has won five Excellence in Teaching awards, was named an IEEE Fellow in 1996, and is a member of the Optical Society of America.

Stephen B. Wicker Appointed Associate Director of ECE



Frank DiMeo, Cornell University Photography

Professor Stephen B. Wicker, B.S. '82 (University of Virginia), M.S. '83 (Purdue University), Ph.D. '87 (University of California at Los Angeles), all in electrical engineering, became associate director of the ECE School on July 1, 2000, succeeding Professor Paul M. Kintner Jr., B.S. '68, physics (Rochester), Ph.D. '74, physics of the northern lights (Minnesota). In 1996, Steve came to Cornell from the Georgia Institute of Technology as an associate professor of electrical engineering and was promoted to full professor on July 1, 1999. He teaches and conducts research in wireless information networks, digital communications systems, and error control coding with emphasis on the development and application of advanced technologies for data links and multiple-access protocols in wireless networks. He is a senior member of IEEE; a member of the IEEE Communications, Information Theory, and Vehicular Technology Societies; and was elected to the Board of Governors of the IEEE Information Theory Society in 1996. Steve is the author or coauthor of several texts and more than 130 publications in refereed journals and conference proceedings, mostly on coding theory and error control protocols. He holds a patent on an analog neural-net Viterbi decoder, and, together with other colleagues, has several patents pending on related decoders.

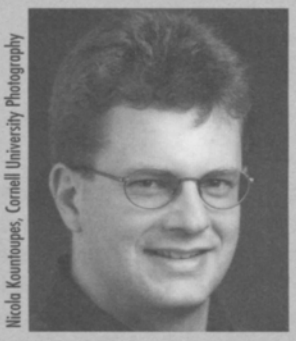
Michael G. Spencer Appointed Director of Graduate Studies

Nicola Kountoupes, Cornell University Photography

Professor Michael G. Spencer, B.S. '74, M.Eng. '75, Ph.D. '80, all in electrical engineering from Cornell University, became director of graduate studies in the ECE School in 2001, succeeding Professor David A. Hammer, Ph.D. '69, applied physics, the J. Carlton Ward Professor of Nuclear Energy Engineering. Mike joined the EE School as a full professor on July 1, 1999. Before coming to Cornell he was a professor of electrical engineering at Howard University in Washington, D.C., where he received the White House Initiative Faculty Award for Excellence, a NASA Certificate of Recognition, and other honors.

Since 1979, Mike's research has been concerned with epitaxial and bulk growth of compound semiconductors and the fabrication of discrete devices from these materials. In recent work, his group was the first to produce conducting aluminum nitride (AlN) and thick films of beta silicon carbide (SiC) by the bulk sublimation technique. His particular interest has been in the correlation of device performance with material growth and processing parameters. He is on the permanent committees for the Electronic Materials Conference and the Compound Semiconductor Conference, has helped to initiate and form the International Conference on Silicon Carbide and Related Materials, and is one of the directors of the NSF-sponsored National Nanofabrication Users Network (NNUN). He has authored more than 50 publications, coauthored three U.S. patents, and has several patents pending.

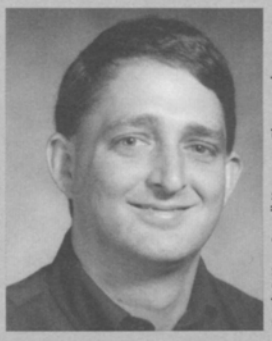
Martin Burtscher


Nicola Kountoupes, Cornell University Photography

B.S./M.S. '96 (Swiss Federal Institute of Technology [ETH] Zurich), Ph.D. '00 (University of Colorado at Boulder), all in computer science, joined the ECE School faculty in July 2000 as an assistant professor. From 1998 to 1999, during his doctoral studies, he served as head teaching assistant and instructor in data structures and algorithms in the Department of Computer Science at the University of Colorado at Boulder. Martin teaches in the area of computer systems and directs his research toward high-performance microprocessor architecture, instruction-level parallelism, and compiler optimizations. Today's high-end, high-speed processors spend a lot of time waiting for memory. Predicting what will have to be done next allows them to execute useful instructions during these idle periods, which can significantly improve their performance. An important focus of Martin's research is the design, evaluation, and improvement of predictors to perform this function. He is a member of the IEEE and its Computer Society, a member of the Association for Computing Machinery (ACM), and has several publications in his fields of interest.

Martin occasionally plays the piano and the flute. His personal hobbies include biking, water sports, and hiking. Because he is from Switzerland, skiing is a favorite pastime of Martin's. He admits to having visited our local Greek Peak but laughingly calls it a "bunny hill."

W. Evan Speight


Frank DiMeo, Cornell University Photography

B.S. '91 (Stanford University), M.S. '94, Ph.D. '98 (Rice University), all in electrical engineering, joined the ECE School faculty in June 2000 as an assistant professor. As a graduate student at Rice University he was a research assistant from 1991 to 1997 during which time he designed and implemented the first software distributed shared-memory system for use on Windows NT clusters. From 1997 to 2000 he was a postdoctoral research scientist at Rice where he led a team of researchers in the development and implementation of the Brazos system as a parallel program environment for use on networks of PC workstations and servers. His research interests center on distributed computing, parallel processing, computer architecture, location-independent data access, and operating systems research. He is a member of the Computer Systems Laboratory at Cornell, one of the leaders of the distributed-systems group in the ECE School, and teaches in the area of digital logic design and in specialized computer architectures. Evan is a member of the Association for the Advancement of Computing in Education, the Association for Computing Machinery, the IEEE Computer Society, and has many publications in his areas of interest. Evan's personal hobbies include camping, hiking, soccer, and scuba diving. He is currently in the process of obtaining his private pilot's license.

Scott E. Coldren Appointed Graduate Field Coordinator


Provided by Scott Coldren

Scott E. Coldren came to Cornell from the Syracuse, New York, area in the fall of 1998 when his wife, Kathryn, accepted a position with the Statler School of Hotel Administration. After college, Scott had experienced five years of customer service background rooted strongly in both management and direct sales before joining the Computer Science Department on campus. He assumed his present position as graduate field coordinator in the ECE School in July 2000.

In the past year he has made several important changes in the operation of the graduate office and in the admissions process. Two of the most dramatic accomplishments have been the inclusion of an online preapplication form that is available on the web (www.graduate.ece.cornell.edu/pre-app/) and the creation of a graduate application processing system that allows faculty members to review graduate applications conveniently on their desktop computers. These new procedures have been very successful and are a prelude to additional improvements that are planned for the future.

Scott says he has always been greatly interested in music. Skilled on drums, he has played in several pickup bands with friends over the years.

ENROLLMENT AND GRADUATION STATISTICS

Undergraduate Program

year	*sophomores*	*juniors*	*seniors*	*degrees*
98–99	119	136	162	136
99–00	136	146	124	107
00–01	157	169	130	116

M.Eng. (Electrical) Degrees

20	8	46	74
18	7	39	64
36	7	37	80

M.S./Ph.D. Program

year	*applicants*	*admissions*	*total enrollment*	*degrees*
98–99	423	31	138	18 Ph.D., 10 M.S.
99–00	562	32	160	27 Ph.D., 19 M.S.
00–01	600	32	155	18 Ph.D., 14 M.S.

Note: Undergraduate students now affiliate with the school when the first term of sophomore math and physics is completed.

These figures indicate that over the past three years, the undergraduate program has increased moderately and enrollments in the M.Eng. (Elec.) and M.S./Ph.D. programs have remained unchanged on average.

Computer Technology in the ECE School

"I had my first class in Engineering Problems today. When I walked into the classroom the first thing I saw was a large white ruler hung along the top of the blackboard. It was about 10 feet long and covered with black scale markings. The top and bottom of the ruler were fixed and the third section in the middle could be moved back and forth. Our instructor said it was a teaching 'slide rule,' and when we got our own small versions they would help us tremendously throughout our engineering careers."

—Excerpt from a freshman engineer's first letter home, circa 1930

In those days and well into the mid-1960s, engineering students were easily recognizable by the ever-present leather cases that contained their indispensable slide rules. EEs of the electric-power persuasion were particularly proud of their K&E "log-log-deci-trig with hyperbolic functions" rules that were designed to facilitate the solution of transmission-line problems. In the early 1970s when the versatile Hewlett-Packard and Texas Instruments hand-held calculators became readily available and relatively inexpensive, the slide rule era came to an end. It is possible that many of today's engineering students may never have seen one. The hand calculator is still a useful tool for routine calculations, but the personal computer is the centerpiece of the digital revolution.

Computer technology first appeared in the EE School in 1950 when Professor **Malcolm McIlroy** '23, who had joined the faculty in 1947, established his pipeline network analyzer in the basement of Franklin Hall. In addition to conducting research on fluid flow, Mac acquainted the faculty with his analog device (described in some detail on page 24 of *Connections* 1997) and urged several EE faculty members and Dean of Engineering **S. C. Hollister** to consider development of similar analogs for analysis of electric-power networks. In 1953, an ac power-network calculator (described on page 5 of *Connections* 1996) was purchased by the College of Engineering from the Westinghouse Electric Corporation and was installed in Phillips Hall when the EE School occupied the new building in 1955. The calculator was to provide system analysis service to electric-power utilities, serve as an instructional tool in power-system courses, and offer opportunities for power-system research.

Digital computers on campus at the time were represented by several International Business Machines card–programmed calculators (IBM/CPC) that were used primarily for accounting purposes. A CPC unit installed in Phillips Hall next door to the power-network calculator was designated as the Cornell Computing Center under the direction of Dr. **Richard Lesser** of the Department of Mathematics. The CPC unit was a noisy neighbor as it sorted thousands of IBM cards (see Figure 1) to perform its assigned tasks, but Dick Lesser assured the network-calculator operators that better machines were on the way and predicted that their big analog device would soon be obsolete. When Professor McIlroy used the CPC unit to compare a mathematical solution of a fluid-flow problem with his pipeline analyzer solution to the same problem, he obtained essentially identical results. He found the CPC to be very slow but agreed with Lesser that an advanced digital computer would eventually supplant his analog device. In one of his last teaching assignments in 1956, Mac conducted a seminar, EE 4815, Fluid Network Analysis, that featured digital computer methods.

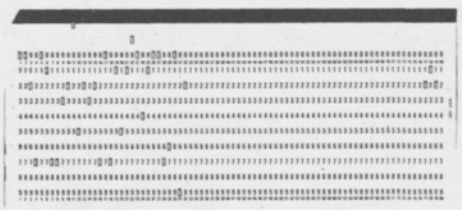


Figure 1. This famous "IBM punched card" served as input, output, and memory for the CPC units of the period.

The first of many major computer upgrades occurred in 1958 with the installation in Phillips Hall of an IBM 650, a machine with a high-speed magnetic drum memory that could invert a 50 x 50 matrix in only 40 minutes (an incredible performance at the time). On one occasion the 650 was programmed to assist the power-network calculator in the solution of a power-system stability problem, and **Ravi Sudan**, then a visiting professor in the EE School, applied it in computations related to a study of a complex turbogenerator regulator problem. In 1960, the 650 was moved to Rand Hall, the new home of the Computing Center.

Computers in the EE curriculum were first mentioned in the *Cornell Announcements* of 1952–53 for an elective course, EE 4123, Electronic Circuit Elements, followed in 1954 by a description of course EE 4810, Introduction to Electronic Computers. Both courses, taught by Assistant Professor **Al Jackson**, were concerned principally with analog computers applied to the study of control systems. Al later designed and built the Cornell Electronic Analog Computer (CORE-AC), a small working unit based on these principles (see page 6 of *Connections* 2000).

In the early 1960s, computer courses in the EE School gradually moved from analog to digital mode. Associate Professor **Norman Vrana**, M.E.E. '51, taught EE 4810 as a course in analog computers for several terms before beginning his long-term concentration in the school on courses in digital computer design. In 1961, Assistant Professor **H. C. Torng**, M.S. '58, Ph.D. '60, introduced course EE 4820, Switching Theory and Digital Computers, which was described in the *Cornell Announcements* of that year as a course in "switching devices, logical formulation and realization of combinational switching circuits, number representation and codes, simple memory devices, counters, shift registers, and arithmetical units in a digital computer."

By 1963, H. C., by then an associate professor, added course EE 4821, Switching Systems, which offered an integrated study of switching systems including general-purpose digital computers and an introduction to the general theory of learning machines. In the following year, H. C. changed the two courses to EE 4587–88, Switching Systems I and II, thereby firmly establishing digital computers as an elective area of study in the EE curriculum.

In 1964, the first mention of the Cornell Computing Center appeared in *Announcements*, with a description of the computer facilities available for use by students and faculty, including a Burroughs 220 digital computer and Control Data 1604 and 160A systems. The IBM 650, initially housed in Rand Hall, had been replaced with these units, and they, in turn, were superseded in 1966 by more advanced systems installed in Langmuir Hall at the Tompkins County Airport. Direct lines to this "mainframe" were made available to remote computer terminals in several buildings on campus.

Progress in Computer Study

The remote terminal that was used primarily by engineering faculty and students was housed in Room B7 Upson Hall complete with IBM-card readers, keyboard card punchers, and card-to-paper printers. Although those facilities were primitive by today's standards, their presence allowed the introduction of direct use of computers in the engineering college.

In 1966, under the new Division of Basic Studies (DBS), all engineering freshmen were required to take Eng. 104, Introduction to Engineering, which included an introduction to digital computing, use of the Cornell computing language CORC, and computer applications.

In 1968, the language was changed to CUPL until a revised DBS sequence of courses was adopted and the course became ENGR 105, Elements of Engineering Communication, with FORTRAN as the official language. In 1972, when the Department of Computer Science began to offer CS 100, Introduction to PL/1, in which problems assigned to be programmed in that language were processed on the computer, the first eight weeks of ENGR 105 were made identical to CS 105.

By 1978, a new course, DBS 105, Introduction to Computer Programming, was entirely identical to CS 105. In the same year, ELE 230, Introduction to Digital Systems, became the first required computer course in the upperclass EE curriculum. Alumni of the period will recall the computer "gridlock" that resulted from the massive use of the remote terminal by the students in those courses.

In the 1970s, the field of digital computing became a definite presence in the EE School. When the power-network calculator in the EE School was decommissioned, Professor **Sam Linke**, M.E.E. '49, and his students used the Upson Hall terminal to analyze electric-power systems on the mainframe computer. Because of the heavy computer traffic, the turnaround time for the solution of a problem was usually about 24 hours. Control courses in the school also made use of the mainframe with similar delays. Several EE elective courses in computer engineering became well established in this period as the earlier courses began to concentrate on digital techniques. Norm Vrana taught EE 674, Analog and Hybrid Computation, and EE 676, Computer Structures, and H. C. Torng taught EE 675, Switching Circuits and Logic Design, and EE 677–78, Computer Architecture and Design I and II.

In 1975, Associate Professor **Chris Pottle**, one of the founders of the Cornell Department of Computer Science, who had previously developed a widely used computer language called CORNAP, introduced EE 624, Computer Methods in Electrical Engineering, which explored techniques for solving electrical engineering problems on the digital computer.

At the end of the decade *Cornell Announcements* reported that the university central computing facilities now included an IBM 370/168 system, a Digital Equipment Corporation (DEC) System 2060, and "two recently installed data communication networks (TELENET and TYMNET) that give Cornell computer users access to computing facilities in 40 states as well as Mexico, Canada, and Europe," a clear indication of things to come. In the remote terminal in B7 Upson the era of the IBM card finally came to an end with the installation of relatively modern workstations.

Engineering Publications

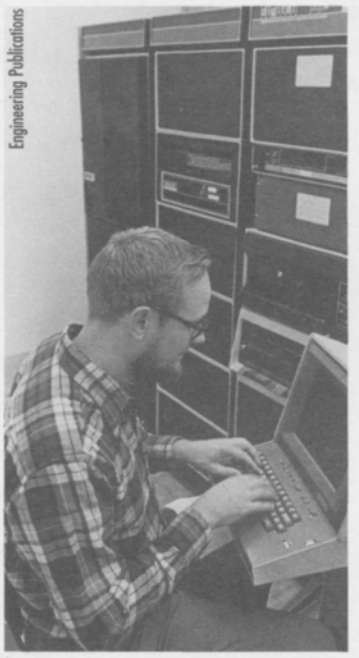


Figure 2. Associate Professor Chris Pottle is shown operating the PDP11/40 minicomputer in Phillips Hall.

Coincident with the development of the computer engineering curriculum in the EE School, increased dependence on computers for both instruction and research suggested a need for local computing facilities.

In the early 1970s, the systems group installed a then top-of-the-line PDP11/40 minicomputer in Phillips Hall (see Figure 2) and used it productively for several years. The Kettering Power Systems Laboratory, established in Phillips Hall in 1976, included a VAX11/750 digital computer that could be accessed from remote workstations in the building. The VAX was particularly useful to students in the power-system analysis courses who could insert their data using screen monitors and keyboards and obtain virtually instant turnaround from the printer in the Kettering Lab, a procedure that was a precursor of today's commonplace Internet usage.

In 1983, the school acquired a Data General Corporation MV 8000 computer that supported workstations throughout the building to form the first computer network in Phillips Hall (see Figure 3). The following year saw the installation of a dozen Macintosh personal computers (PCs) fitted with a logic-works program to form a local area network (LAN) for the required course EE 230. The former strictly laboratory format was replaced with a simulation of logic design capability that was augmented afterwards by the addition of programmed logic devices. Students could then design logic circuits and obtain output devices in the form of real chips that could be tested in real circuits.

Engineering Publications

Figure 3. The initiation of the first computer network in the college attracted the attention of Dean of Engineering Tom Everhardt and several faculty members. The central processing unit (CPU) was housed in Phillips Hall in the room to the right of the workstations.

By the end of the 1980s, computer engineering had become a well-established area of study in the EE School. In addition, basic engineering studies, now known as the Office of Undergraduate Affairs, recognized the importance of computers in all engineering studies by adding to the computer requirement of ENGR 100 at least one additional course with a significant amount of computer application, either as a distribution course from the "scientific computing" list or as part of a field program. The computer language in use at the end of the decade had become PASCAL, to be followed after several years by the C language.

At the present time, JAVA is the language of choice together with some instruction in METLAB. EE 308, Fundamentals of Computer Engineering, was taught by Assistant Professor **Miriam E. Leeser**, B.S.E.E. '80, as an EE core requirement. Norm Vrana's highly popular elective courses, EE 475, Computer Structures, and EE 476, Microprocessor Systems, were in full swing; H. C. Torng introduced two new courses, EE 545 and EE 546, Computer Networks and Telecommunications I and II; and Chris Pottle offered a new course, EE 576, Parallel Processing, the study of architectures related to the development of "supercomputers," machines designed to provide high computation rates for large scientific problems. Associate Professor **Tony Reeves** introduced an interesting new computer area with EE 547, Computer Vision. Not surprisingly, the 1986–87 issue of *Cornell Announcements* listed computer engineering for the first time as an "area of concentration" in the field of electrical engineering with 14 required or elective courses.

Computer Study Matures

During the past 10 years, the presence of newly appointed computer-oriented faculty members and the acquisition of high-quality computer facilities have created major changes in electrical engineering education in the school. In 1991, Director **Noel MacDonald** organized the effort to allocate and renovate three third-floor classrooms in Phillips Hall for centralized classroom computer usage. Under the direction of Professor Emeritus Norm Vrana, one room was installed with Macintosh PCs, another with Hewlett-Packard (HP) Vectra PCs, and the third with HP workstations (see page 10 of *Connections* 1992). This facility made it possible for any EE course to employ computers directly in classroom activity or labs as well as for outside class assignments. Over the years, the original workstations have been upgraded regularly as new equipment became available. EE faculty members in diverse fields have taken advantage of the expanded facilities to integrate computer techniques into their design and laboratory courses and require students to use the workstations to solve assigned problems and develop projects. This trend toward computer-aided instruction was further enhanced two years later in the EE School by the installation of the undergraduate teaching laboratory that makes use of leading-edge technology and instrumentation and incorporates state-of-the-art practices found in leading electrical and electronics industries. Through connections to the Phillips Hall computer network (EENet), each component of the laboratory has remote access to the university computing center now located in the Theory Center in Rhodes Hall. (See page 10 of *Connections* 1994 for additional information about the teaching lab.) In 2000, the Intel Computer Systems Teaching Laboratory was established to support both teaching and research in computer systems (see page 22 of *Connections* 2000). During this period of expansion, state-of-the-art computer equipment was brought to our laboratories through the efforts of Emeritus Professors Norm Vrana and H. C. Torng, who negotiated generous grants of computer hardware and software from Hewlett-Packard, Intel, Apple, Altera, Sun, Digital Equipment, and Motorola Corporations.

An examination of the advanced courses now offered in the school reflects the profound influence of computer technology on the curriculum. Graduate and undergraduate students who wish to concentrate on computer engineering may choose their electives from a wide variety of available subjects and can augment their studies with appropriate courses offered by the Department of Computer Science. Students with interests in other EE disciplines can elect computer courses that will acquaint them with the impact of computer technology on their particular fields of choice. ELE 476, Digital System Design Using Microcontrollers, is a popular course in this category taught by Senior Research Associate **Bruce Land**, Ph.D. '76 (Neurobiology & Behavior and Electrical Engineering). Students working in pairs design, debug, and construct several small systems that illustrate and employ techniques of digital system design acquired in previous courses (see Figure 4).

As the now properly named School of Electrical and Computer Engineering enters the twenty-first century, faculty members and their graduate and undergraduate students all benefit from the availability of these creative techniques and powerful tools that facilitate the study of fundamental principles in all areas of electrical and computer engineering.

Sam Linke
Professor Emeritus
Electrical and Computer Engineering

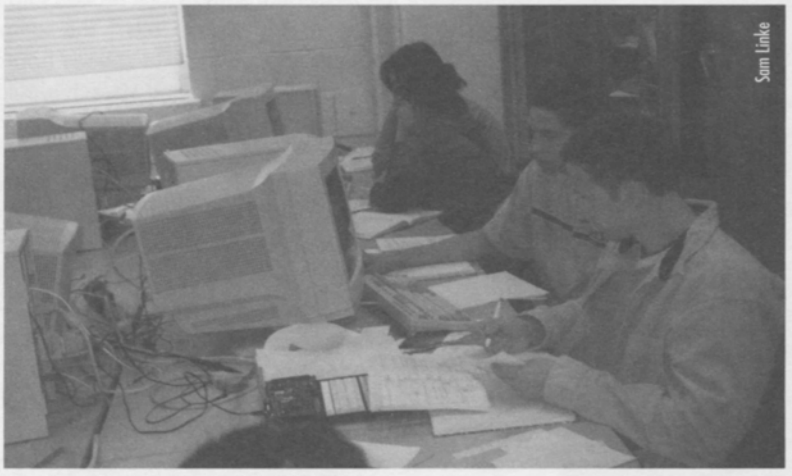


Figure 4. Students in Dr. Bruce Land's digital design lab concentrate on their projects.

The Digital Signal Processing (DSP) Research Group in the School of Electrical and Computer Engineering consists of four professors, **Sheila S. Hemami**, **C. Richard Johnson Jr.**, **Thomas W. Parks**, **Lang Tong**, and their graduate students. Associate Professor **Adam W. Bojanczyk**, who is concerned with application of mathematical techniques to analytical procedures, also contributes to the research of the group. DSP research in the ECE School has been substantially augmented in recent months by the receipt of major funding from several agencies as a result of successful research proposals prepared by members of the group. Members of the Space Plasma Research Group, Professors **Donald T. Farley**, **Michael C. Kelley**, and **Paul M. Kintner**, have special interest in DSP because their remote instrumentation techniques are highly dependent on accurate wireless communication with multiple sources of digital information. The principal research areas of the DSP group are described in the following four articles.

Frank DiMeo, Cornell University Photography

VISUAL COMMUNICATION

Directed by Sheila S. Hemami

A unique distance learning program conducted by a major university provides a "virtual classroom" in which a professor augments a lecture with a variety of modern electronic visual aids, presents physical demonstrations either by remote control or by oral directions to assistants, responds to questions from the class, and even directs questions to specific individuals in the classroom. In principle, this imagined scenario is now technically feasible, but an actual working classroom would require elaborate multimedia visual and audio communication facilities that may be severely limited by bandwidth availability. The ultimate success of such an elaborate distance learning program would be heavily dependent on image compression techniques that reduce bandwidth requirements without introducing image distortion.

Within the past decade, the advent of the Internet and associated facilities for the rapid interchange of massive quantities of information have inspired the development of appropriate technologies to meet the demand for high-quality, low-distortion video. Satellite TV and fiber-optic cable systems have increased signal transmission capabilities far beyond those of conventional telephone services. Terminal equipment such as personal computers and monitors, Power Books, hand-held computers, scanners, and printers now provide excellent full-color images. Consequently, it would appear that visual communication systems have attained quite satisfactory levels in both transmission and presentation functions.

As in all large utilities that provide services to the public, the magnitude of the worldwide multimedia communication system and its extremely rapid growth in the past decade have introduced major operational limitations, principally in the necessity for compression of the rates of signal transmission to allow use of available bandwidths. All modern visual communication transmission is now in digital form where the individual signals are broken into samples, and each sample is composed of a number of digital "bits." The samples are transmitted at rates measured in bits per second (b/s) at speeds appropriate to the signal being transmitted. For example, wideband speech would require about 200 kilobits per second (kb/s), still images would require up to 19 megabits per second (Mb/s), and standard TV rates could be as high as 200 Mb/s. The bit rate for the upcoming high-definition television (HDTV) is of the order of 700 Mb/s. For multimedia applications, even advanced communication channels cannot easily accommodate bit rates at these levels so that some form of image compression is required. In practice, bit-rate reductions of as much as 100 to 1 have been found to provide storage and transmission capabilities without loss of quality.

Image compression is a complex process that begins with the insertion of a signal into an encoder that uses appropriate coding algorithms to obtain the desired reduction in bit rate. The compressed signal is transmitted to a decoder that employs decoding algorithms to restore the signal to original form. The standard algorithm for compression of still pictures is known as the Joint Photographic Experts Group (JPEG) algorithm. The standard for video is the Motion Pictures Experts Group (MPEG) algorithm. The primary objective of Professor Hemami's research is to apply these standards and to develop new techniques to enable high-quality reliable visual communication for all users regardless of their individ-

ual network connections, available bandwidths, qualities of service, or terminal capability. Users should have the ability to access still images, video clips, and multimedia information services, and to use interactive visual communication services, all with optimal representation to maximize performance, overcome poor transmission, and obtain the highest visual quality.

Associate Professor Hemami has become well known for her research in the field of visual communication, particularly in studies related to application-specific video and still-image coding and transmission. Areas of current interest involve the development of algorithms for coding techniques that span large quantities of information with a wide range of bandwidths. The resulting coded data must be robust to errors and to varying degrees of loss across multiple network segments. Particular research topics include multirate video coding and transmission, compression specific to packet networks and other lossy networks, and psychovisual considerations.

Professor Hemami received the B.S.E.E. degree from the University of Michigan in 1990 and the M.S. and Ph.D. degrees in electrical engineering from Stanford University in 1992 and 1994, respectively. During her last year at Stanford, she was a member of the technical staff at Hewlett-Packard Laboratories in Palo Alto, California. She joined the Cornell faculty as an assistant professor of electrical engineering in 1995 and was promoted to associate professor in 2000. She received a National Science Foundation Early Career Development Award in 1997, was named the Eastman Kodak Company Term Professor of Electrical Engineering in the same year, received a national award, the Eta Kappa Nu C. Holmes MacDonald Outstanding Teaching Award in 2000, and is the current director of the Visual Communication Laboratory in the ECE School. She has authored or coauthored more than 50 articles that have appeared in refereed journals or in conference proceedings.

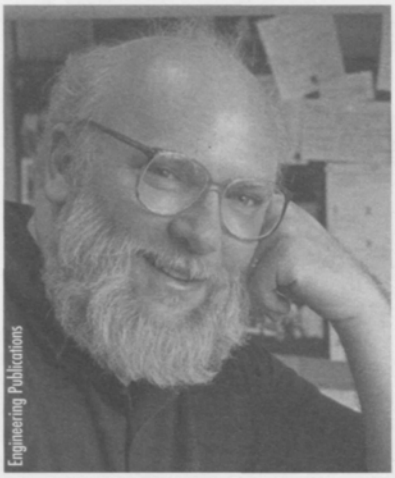
Under Professor Hemami's direction, the Visual Communications Laboratory is concerned at present with psychophysical experiments and resulting analyses that quantify human sensitivities to distortions in images transmitted at low bit rates. Examples of visual quality obtained at various bit rates by means of appropriate algorithms are shown in Figures 5a and b. A casual observer would find only small differences between the two photographs. However, relatively little work has been done explicitly on very low bit rates.

Most recently, an extensive psychophysical evaluation was completed at the Visual Communication Laboratory to characterize and quantify human sensitivity to compression artifacts (annoyances) in wavelet-compressed images at extremely low rates. Wavelet compression is the technology adopted for JPEG-2000, the next-generation still-image compression standard. The results of the study have demonstrated that these sensitivities can be parameterized and well predicted by characteristics of the images, and have been applied to develop quantization strategies that produce low-rate compressed images with higher perceptual quality than were previously obtainable. These results are currently being extended to medical images in joint work with the Cornell College of Veterinary Medicine. Another current research project is to quantify viewer responses to various visual defects that appear in low bit rate video, both at full-frame rate and at reduced-frame rate, based on psychophysical experimentation. The results will be used to design a quantization strategy to achieve good visual quality at these low bit rates.

Photos courtesy of Sheila Hemami

Figure 5a. Balloon image compressed to 0.1 bits/pixel using a commonly accepted quantization strategy optimized for subthreshold perception.

Figure 5b. Balloon image compressed to 0.1 bits/pixel using a suprathreshold-optimized quantization strategy. Regions such as the sky are smoother, and artifacts around sharp edges are less severe.



Engineering Publications

BLIND EQUALIZATION

Directed by C. Richard Johnson Jr.

The next decade will see the transition from analog to digital television in the United States and the corresponding emergence of high-definition television (HDTV) as the dominant broadcast mode. These prospects have stimulated the research group supervised by Professor Johnson to focus on blind equalization, a key enabling technology in the development of terrestrial-broadcast HDTV receivers.

Blind equalization mitigates channel distortion by filtering the received signal. The filtering process attempts to extract the transmitted sequence of symbols by counteracting the effects of intersymbol interference (ISI), thereby improving the probability of correct symbol detection. In digital communications, ISI is a critical manifestation of distortion where the detection of a symbol is corrupted by external symbols transmitted before and after the desired symbol. In wired communications, information-bearing signals transmitted between remote locations often encounter signal-altering physical channels such as coaxial, fiber-optic, or twisted-pair cable. In wireless communications, signals may be distorted by fixed man-made objects, passing aircraft, terrain features, the atmosphere, and oceans (see Figure 6).

Because channel characteristics at start-up are commonly unknown or change over time, the equalizer filter is a structure that must be adaptive in nature. Classical equalization techniques, in use in telephony since the late 1960s, employ transmission of a "training signal," known in advance to the receiver, during a periodically recurring time slot. The receiver adapts the equalizer so that its output closely matches the known reference training signal but the inclusion of such signals sacrifices valuable channel capacity. Certain communication channels such as mobile receivers may also require frequent training signal episodes. A more efficient technique employs adaptive blind-equalization algorithms without the need for training signals. Since their introduction in the 1980s, blind-equalization algorithms have been applied to pulse amplitude–modulated and frequency-modulated signals and microwave radio and have been realized in very large scale integrated circuits for HDTV set-top cable and terrestrial-broadcast demodulators. The most widely used blind-equalization technique, the constant-modulus algorithm (CMA), has been used successfully in many applications, including emerging wireless communication technology.

Professor C. Richard Johnson Jr. is widely known as a leading investigator in adaptive parameter estimation theory and applications of digital signal processing to telecommunications systems. During the past 10 years his research has emphasized the application of blind equalization. One thrust of his recent activity has been to improve digital TV reception through adaptive receiver design based on blind-equalization algorithms. He gives particular attention to CMA with a view toward gaining insight into its properties, many of which still require rigorous theoretical examination. He is also interested in adaptive receiver design for other "last-mile" wired technologies for residential broadband reception, including digital subscriber loops (DSL), a promising technique that allows high-speed Internet connections over ordinary twisted-pair telephone lines without interfering with regular telephone service on those lines.

Rick received the B.E.E. degree with high honors from Georgia Institute of Technology in 1973, and the M.S. and Ph.D. degrees in electrical engineering from Stanford University in 1975 and 1977, respectively. From 1977 to 1981 he was an assistant professor of electrical engineering at Virginia Polytechnic Institute and State University at Blacksburg. He joined the Cornell faculty as an associate professor of electrical engineering in 1981, was promoted to full professor in 1987, and

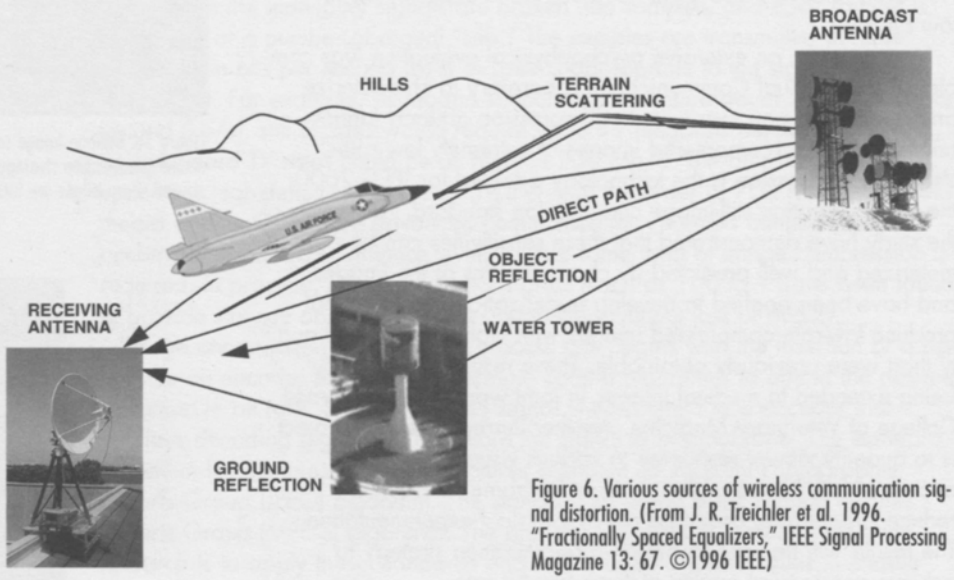


Figure 6. Various sources of wireless communication signal distortion. (From J. R. Treichler et al. 1996. "Fractionally Spaced Equalizers," IEEE Signal Processing Magazine 13: 67. ©1996 IEEE)

Courtesy of John Treichler and IEEE.

served as associate director of the School of Electrical Engineering from 1988 to 1991. Rick was selected as the 1982 Eta Kappa Nu Outstanding Young Electrical Engineer, and in the following year received the Eta Kappa Nu C. Holmes MacDonald Outstanding Young Electrical Engineering Teacher Award. He is also a 1996 recipient of the Cornell University College of Engineering Michael Tien '72 Excellence in Teaching Award. In 1989 he was named a fellow of the Institute of Electrical and Electronic Engineers (IEEE) "for contributions to adaptive parameter estimation theory with applications in digital control and signal processing." Over the last decade Rick was a visiting professor and visiting scientist at academic institutions in Grenoble, France, Canberra, Australia, Göteborg, Sweden, and California. He has served as a distinguished lecturer of the IEEE Signal Processing Society and was a member of the Board of Governors of the IEEE Control Systems Society from 1990 to 1992. He has served as an editor of the *International Journal of Adaptive Control and Signal Processing* and as an associate editor for *Systems and Control Letters*, the *IEEE Transactions on Acoustics, Speech, and Signal Processing*, the *IEEE Transactions on Automatic Control*, and *Automatica*. He is the director of the Blind-Equalization Research Group (BERG) in the ECE School and has authored or coauthored more than 300 articles that have appeared in refereed journals and conference proceedings.

The BERG is concerned at present with characterization of the performance of adaptive algorithms, such as CMA, for blindly updating fractionally spaced equalizers (FSE). The objective is to develop a theory that will be useful in practical equalizer design for high-data-rate digital communication systems. To this end the group has assessed the effects of equalizer-length specification, channel noise, channel near nonidentifiability, and source distribution nonuniformity on the behavior of CMA-FSE. Recent studies have focused on the CMA initialization problem, in part through a characterization of CMA's regions of convergence. Low-cost consumer applications motivate development of blind-equalization techniques that require minimum implementation cost. Parallel work concerns the analysis of decision-feedback equalizers, with emphasis on robust methods of blind adaptation and characterization of the effects of error propagation on coded systems. Other thrusts are aimed at linear and nonlinear equalization of multiuser communication procedures such as code-division multiple-access (CDMA) systems. BERG has established a web site (backhoe.ece.cornell.edu/BERG/) that includes subsections containing measured and experimental data, simulation tools, and tutorials available to researchers and students at other institutions.

Rick's research has been supported every year since 1979 by the National Science Foundation. Since 1990, companies that have also supported his research group include Applied Signal Technology in California, Lucent/Bell Laboratories in New Jersey, NxtWave Communications in Pennsylvania, Fox Digital in California, and Aware in Massachusetts.

IMAGE PROCESSING

Directed by Thomas W. Parks

Many "old-timers" in the electric power turbogenerator industry still recall a spectacular multimillion-dollar disruption that occurred when a large 250 MW machine self-destructed as it was placed online under full-power output for the first time. Rotating at 3600 rpm, the massive rotor of the generator exploded and hurled huge pieces of iron and copper through the stationary windings of the stator. During manufacture of the machine the rotor had been carefully "balanced" in a test bed, but instrumentation of the time was unable to detect inherent flaws in the structure of the rotor. Modern technology readily allows detection of defects in materials under stress such as in machine rotors, space shuttle components, and building structures under seismic conditions, but the collected data are now generally converted into digital form. Proper interpretation of the data requires that images of the resulting charts and graphs be free of errors that may be introduced during their preparation. Digital image–processing techniques applied to graphical presentations ensure that the essential accuracy of critical data is maintained.

This ability to process images digitally has introduced major changes in photography, particularly in color reproduction. Although ordinary cameras will remain in wide use for the foreseeable future, photography experts predict that eventually all film will be scanned and processed digitally. Similarly, the popular new digital cameras for both still and moving pictures are highly dependent on image-processing techniques. The obvious advantages of digital cameras over conventional ones are counterbalanced by factors such as limitations owing to the physical structure of the camera digital sensors known as charge-coupled devices (CCD). Resolution beyond that of sensor capabilities can be achieved by image processing. For example, standard smoothing procedures often result in noticeable distortions along edges and sharp features in an image. Investigators have found that improved images may be obtained by constructing and applying an appropriate image reconstruction algorithm that allows edges to support color information and color channels to support the edges.

Robert Barker, Cornell University Photography

Figure 7a. Initial image.

Photos courtesy of Tom Parks and Eastman Kodak Company

Figure 7b. Enhanced image achieved by interpolation techniques.

Enhancement of photo quality, accurate printing of large images, zooming, cropping, and other procedures of digital photography are heavily dependent on an important digital image–processing tool known as image interpolation. As the popularity of digital photography increases, the need for good interpolation techniques will be essential. Studies of interpolation techniques will also help in the development of better tools in other areas of signal processing such as image encoding and image "demosaicing" (image reconstruction from CCD color samples).

A central objective of Professor Parks' current research is to develop new approaches to image interpolation so as to gain insight into the design of interpolation filters. Because image interpolation is concerned with the problem of recovering missing samples of a signal, it is useful to apply the theory of optimal recovery, a technique that is used to estimate the missing samples of a signal. This examination of the interpolation problem from the viewpoint of filter design in the context of optimal recovery has led to the useful concept that optimal recovery of an individual sample is equivalent to the optimal recovery of the whole signal. Recent developments concerned with methods of wavelet-domain interpolation are also based on the theory of optimal recovery. Two additional new methods make use of data-adaptive directional interpolation, a technique that relies on the fact that interpolation works best when it is done along edges in an image rather than across them. Figures 7a and b illustrate an enhanced image obtained by interpolation techniques.

Professor Parks is widely known for his research in the fields of signal theory and digital signal processing, including digital filter design, time-frequency analysis, group theory, multirate systems, and acoustic signal processing. While on sabbatical leave at Eastman Kodak he developed an interest in image signal processing that has led to recent research on wavelet analysis, data compression, signal reconstruction, digital filter design, pattern classification, image interpolation techniques, and interpolation filter design. He is also interested in array processing for sonar and seismic applications.

Tom received the B.E.E. degree from Cornell University in 1961, worked for two years at the General Electric Advanced Electronics Laboratory in Ithaca, and received the M.S. and Ph.D. degrees in electrical engineering in 1964 and 1967, respectively, both from Cornell. In 1967 he joined the faculty of Rice University in Houston, Texas, as an assistant professor of electrical engineering, rose to the rank of full professor, and returned to Cornell in 1986 as a full professor of electrical engineering. Tom is a recipient of the Alexander von Humboldt Foundation Senior Scientist Award and has been a Senior Fulbright fellow. In 1982 he was named a fellow of the IEEE for fundamental contributions to digital filter design and signal processing. In 1988 he received the Society Award and the Technical Achievement Award of the IEEE Acoustics, Speech and Signal Processing Society, and in 2000 he was awarded the IEEE Third Millennium Medal. He has been a member of the administrative committee of that society and an associate editor for the *IEEE Transactions on Acoustics, Speech and Signal Processing*. Tom is coauthor of a book on the fast Fourier transform and a book on digital filter design, both published by John Wiley and Sons, and is coauthor of laboratory manuals for digital signal processing. He has authored or coauthored about 100 articles that have appeared in refereed journals or in conference proceedings.

The Signal Processing Laboratory that Tom has established in the ECE School is concerned with research on image interpolation, multirate filter design, and period estimation applied to predictive maintenance of a large class of vibrating structures. The laboratory has become a central resource for the image interpolation community, thereby enabling researchers to assess the quality and the merits of the many different interpolation algorithms that have been published in the literature. A web site has been established (www.ece.cornell.edu/~splab) that contains images and results obtained from a variety of interpolation techniques and includes an image database of both gray and color-photo compact disk–quality images that are useful for testing interpolation algorithms. Interpolation researchers in other institutions have been invited to post their results on the web site.

Frank DiMeo, Cornell University Photography

WIRELESS COMMUNICATION AND NETWORKING

Directed by Lang Tong

In a recent Op-Ed article in the *Ithaca Journal*, the Tompkins County emergency radio communications network was declared to be far below modern standards. Large areas in the county are still unreachable, but in regions where cellular telephone reception is satisfactory there is a serious lack of ability for agencies to communicate with one another: firefighters may not be able to talk to sheriff's deputies, who may not be able to talk to Ithaca police, who cannot talk to an ambulance service in a situation where all four are needed. The presence of these interactive communication difficulties in this relatively simple local wireless network suggests that similar conditions exist in many widespread networks and indicates the need for some advanced form of communication "traffic control."

On a worldwide scale, the merging of communication and computing devices with the Internet offers users unlimited potential through high-speed fiber-optic and cable links for teleconferences, video on demand, the World Wide Web, and the Internet telephone. In recent years, the proliferation of wireless access to these well-established services has introduced formidable technical problems that will require solutions based on new theory and sophisticated signal processing techniques. Wireless sources for multimedia networks are not only diverse and time varying in nature but may also include data, voice, and video signals. Consequently, receivers must be adaptive to these conditions as well as to traffic patterns, channel variations, and varying quality-of-service requirements.

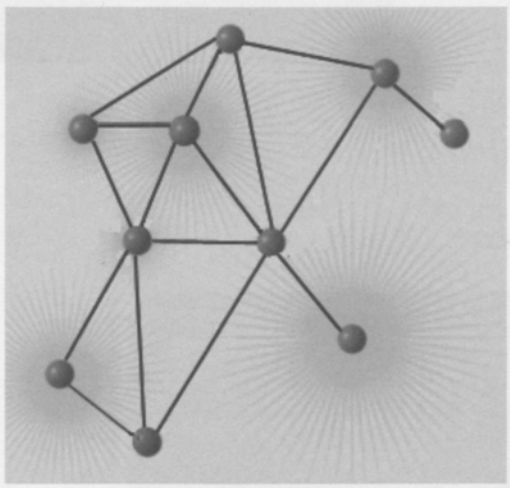


Figure 8. Generic ad hoc network architecture. (Courtesy of Lang Tong and Gohan Mergen)

One approach to improved network performance makes use of training signal and blind-equalization techniques (see page 10) applied to the asynchronous transfer mode (ATM) of operation where one or more users in the network may be silent for extended periods of time. Wireless ATM offers the flexibility of assigning bandwidths on demand for multimedia traffic, is compatible with land-line ATM, and provides error protection measures that are critical in a wireless environment. Signal processing techniques are used to expand conventional equalization algorithms by incorporating higher-layer protocol information into their design, thereby allowing more efficient use of bandwidths through operation between training-based and blind equalization.

The use of random-access ad hoc network architecture, a wireless configuration without predetermined topology or a central control unit, is an alternative technique that has demonstrated improved access to the Internet. In the ad hoc network example shown in Figure 8, all of the distributed nodes are connected by a common broadcast channel and every node is functionally equal. Any two nodes connected by a solid line within the interconnected portion of the network can communicate with each other directly.

The two isolated nodes, however, require packets of data to be relayed by intermediate nodes. Regulated access to the shared physical links in this random-access network can be provided by a protocol, known as Media Access Control (MAC), that allows each node to transmit at will. In a typical MAC protocol a node first senses the channel and transmits only if there is no other active transmission. The first node aborts the transmission once it realizes that another node is transmitting. It then waits for a time before retransmitting the packet. Because fading and other channel impairment in a wireless network make it difficult to determine if another active node exists, signal collisions often occur, resulting in loss of network throughput.

Professor Lang Tong is a well-known researcher in the area of adaptive signal processing and communications with emphasis on high-performance transceiver designs for broadband wireless multimedia systems. He is also interested in statistical techniques for adaptive interference mitigation and equalization, parameter estimation, multiuser detection, medium-access control in random-access networks, and performance analysis. His current research is concerned with application of signal processing techniques to attain efficient network resource allocation by estimation and prediction of communication traffic patterns.

Lang received the B.S. degree from Tsinghua University in Beijing, China, in 1985 and the M.S. and Ph.D. degrees from the University of Notre Dame in 1988 and 1990, respectively, all in electrical engineering. Following a year as a postdoctoral research affiliate at Stanford University, he was an assistant professor in the Department of Electrical and Computer Engineering at West Virginia University from 1991 to 1993 and an assistant professor in the Department of Electrical and Systems Engineering at the University of Connecticut, Storrs, from 1993 to 1997, followed in 1997 by promotion to associate professor. In 1998 he became an associate professor of electrical engineering at Cornell. During his years at the University of Connecticut he was the principal investigator for more than a dozen sponsored research programs in his areas of interest. In 1993 he won the Outstanding Young Author Award of the IEEE Circuit and Systems Society, and in 1996 he received the U.S. Office of Naval Research Young Investigator Award. In 2000 he received a National Science Foundation grant for research in adaptive signal processing in the wireless asynchronous-transmission mode (ATM). He has held several IEEE editorial positions and has organized a number of IEEE conferences. Lang has authored or coauthored more than 120 articles that have appeared in refereed journals, book chapters, or in conference proceedings.

Lang's research group is currently investigating various roles of signal processing in wireless systems and networks. Specific applications include receiver designs for ad hoc networks, packetization techniques for multimedia broadcasting, and adaptive receivers for high-definition television (HDTV), cable, and digital subscriber loop (DSL) systems. Current and recent research projects include channel and quality-of-service adaptive multimedia wireless ad hoc networks, adaptive signal processing in wireless ATM and other asynchronous packets, blind equalization for terrestrial HDTV broadcasting, and fast converging blind equalization for wireless communication. The overall research goal of the group is to apply these signal processing techniques to the modeling of multimedia network traffic.

The challenge imposed by the demands of modern multimedia communication may be compared to the dilemma faced by a professor in a crowded classroom who is attempting to answer a flurry of questions from the floor, announce the date of the next quiz, respond to a student's request for an appointment, and arrive at an important committee meeting on time. Our harried professor can at least be grateful that his or her constituents are together in one room rather than being located around the globe and highly mobile.

FOUR NOTABLE EE ALUMNI REFLECT ON THEIR CAREERS

WE INVITE SUGGESTIONS OF ADDITIONAL WORTHY ALUMNI AND ALUMNAE FOR FUTURE ISSUES OF *CONNECTIONS*.

Charles Harrington, Cornell University Photography

Wilson Greatbatch received the B.E.E. degree in 1950 from Cornell University and the M.S.E.E. degree from the University of Buffalo in 1957. After graduating from Cornell, Wilson spent a year on campus with the Department of Psychology Animal Behavior Farm, transferred in 1952 to the Cornell Aeronautical Laboratory in Buffalo as an associate engineer, and later became an assistant professor of electrical engineering at the University of Buffalo. In 1957 he joined Tabor Instrument Corporation in North Tonawanda, New York, and also began to experiment in his private workshop in a small barn where, in 1958, he invented his renowned implantable cardiac pacemaker. In 1965 this invention was cited by the National Society of Professional Engineers as one of the greatest engineering contributions to society of the past 50 years. Wilson left Tabor in 1960 and began his extensive private ventures in the fields of medical instrumentation, electrochemistry, genetic engineering applied to HIV research, and nuclear fusion. He has more than 200 patents in these fields, has been awarded three honorary Sc.D. degrees, and received the Lifetime Achievement Lemelson-MIT Prize in 1996. In February 2001 the National Academy of Engineering awarded Wilson the Russ Prize, jointly with Earl E. Bakken, inventor of the nonimplantable pacemaker, "for saving, extending, and improving the quality of human lives through the engineering development and commercialization of implantable heart pacemakers."

Wilson comments:

Several times each week I sit back and tell myself, "I'm glad I went to Cornell."

I think back to the dedicated teachers who pounded so many hours of math, chemistry, and physics into us when all I wanted to do was design antennas. Yet now, most of my career has been dedicated to the chemistry of lithium batteries, the electrochemical polarization of physiological heart electrodes, and the physics of nuclear fusion.

I think back to the physics instructor who took time to draw on the board the "U-shaped" energy display of the atomic series, with the right-hand leg of the U indicating the very high fission energy of the A bomb, but the left-hand leg of the U being far higher with the fusion energy of the H bomb. Then I go back to my problem of today, "How do I get to 'break even' when fusing two ions of helium-3 into one ion of helium-4?" The fuel is nonradioactive, the process is not permanently radioactive, and the residue is nonradioactive. In fact the residue is helium-4, the gas they put in kids' balloons.

Wilson comments: Several times each week I sit back and tell myself, "I'm glad I went to Cornell."

I think back to my decision to take six hours of physiology in the Vet School, probably just because it was there, but without much thought for using it in the future. Then in February I got the Russ Laurette award from the National Academy of Engineering for inventing the cardiac pacemaker.

I think back to my part-time job instrumenting 100 sheep and goats at the Cornell Psychology Department Animal Behavior Farm. (The only honor I got in my undergraduate days was the fact that I had more kids than anyone in my class!). I was grateful for the job, mostly so I could feed my family. But then a few years later I got the chance to build all the amplifiers for the first USA monkeys to fly in space, because I knew what conditioned reflex was.

It was the vast breadth of my Cornell experience that made all these things possible. So, back to the nuclear helium-3 fusion process. Who knows? Maybe we can change the next millennium with helium-3 fusion power.

I'm glad I went to Cornell.

Jeffrey C. Hawkins received the B.S.Engr. degree in electrical engineering from Cornell University in 1979. Following graduation he joined Intel Corporation in Santa Clara, California. He held key technical positions there until 1982 when he transferred to GRiD Systems Corporation, a pioneer in mobile computing, where he worked on the first laptop computer and created GRiDTask, a high-level programming language, and associated applications. Jeff left GRiD in 1986 for a year's study in neurobiology at the University of California at Berkeley. During this period he wrote and later patented a pattern classifier that worked as a hand-printed character recognizer, an early version of current recognizer systems. He returned to GRiD as vice president of research where he served as the principal architect and designer of the GRiDPad, a rather large and unwieldy early version of a hand-held computer. In January 1992, Jeffrey left GriD Systems, founded Palm Computing, and began the intensive development of new hardware and software that resulted in the invention of the Palm-Pilot. His invention of GRAFFITI, a simple text-entry method that makes handwritten characters recognizable by software, was a major breakthrough in the creation of the device. The Palm products were launched in 1994 and have become enormously successful. In 1995 Jeff sold his company to modem manufacturer U.S. Robotics but remained for a time to develop modifications to the original models. In 1998 he cofounded Handspring, Inc. to produce palm-sized, hand-held computers that are based on the same operating system as the Palm-Pilot but employ expandable hardware that allows add-on applications. Handspring's newest offering is the Visor Edge, one of the thinner and lighter devices on the market. In the computer industry Jeff is viewed as a visionary designer who essentially reinvented the hand-held computer market. He holds nine patents for various hand-held devices and features. His current position is chairman and chief product officer of Handspring. In September 2000 Jeffrey was honored by Cornell University as Entrepreneur of the Year, an award that recognizes the achievements and qualities of a Cornellian who best exemplifies the ideals of entrepreneurship.

Frank DiMeo, Cornell University Photography

Jeffrey comments:

An engineering degree is a great start to a variety of careers. Most businesses today require engineering skills whether it be in manufacturing, information systems, or product design. Even general management positions from the CEO on down are well served with an engineering background. An MBA degree coupled with an engineering undergraduate degree is a very valuable combination. So whether one is planning a career as a practicing engineer or hopes to move into other endeavors, I highly recommend considering an engineering undergraduate education.

In my own case I received a B.S.E.E. from Cornell in 1979. Early in my career I held positions in marketing, product marketing, software design, and engineering management. I have started two successful companies, Palm Computing and Handspring. Ironically, I have never been a practicing electrical engineer, but throughout my career I have found my engineering education very valuable. Admittedly, an engineering undergraduate education is not the easiest course to pursue. Yet it represents a great foundation for almost any career.

Jeffrey comments:
An engineering degree is a great start to a variety of careers.

Irwin Mark Jacobs received the B.E.E. degree in 1956 from Cornell University and the M.S. and Sc.D. degrees in electrical engineering from MIT in 1957 and 1959, respectively. Following a period as an assistant then associate professor of electrical engineering at MIT and as a professor of information and computer science at the University of California, San Diego, Irwin cofounded the LINKABIT Corporation in 1968 and in 1972 resigned his professorship in order to devote full time to the corporation. As president, CEO, and chairman, he guided the company through its growth and eventual merger with MIA-COM Corporation and remained with the organization until 1985 when he founded QUALCOMM. As chairman and CEO, he led QUALCOMM into national and international activities in mobile satellite communications and digital wireless telephony to become one of the major communications entities in the world. An important technical concern of his company is the maximization of the capacity of cellular communications channels. The procedure, called code-division-multiple-access (CDMA), was conceived by Irwin and his colleagues and can transmit many conversations through a single channel, depending on the available bandwidth, by encoding each call with a unique electronic identifier and then breaking it into discrete fragments. The fragments of all the conversations are transmitted simultaneously in haphazard fashion and recombined into the original messages at the receiving end. CDMA has been characterized as a "communications multilane highway."

Irwin is a fellow of the Institute of Electrical and Electronics Engineers (IEEE), a member of the National Academy of Engineering, and the coauthor of *Principles of Communication Engineering*, the first comprehensive textbook on digital communications. His many awards include the IEEE Alexander Graham Bell Medal and the Ernst & Young Leadership Award for Global Integration by the Computerworld Smithsonian Award Program. In 1994 Irwin received the United States National Medal of Technology Award, the highest award bestowed by the U.S. president, "for extraordinary achievements in the commercialization of technology for the development of human resources that foster technology commercialization."

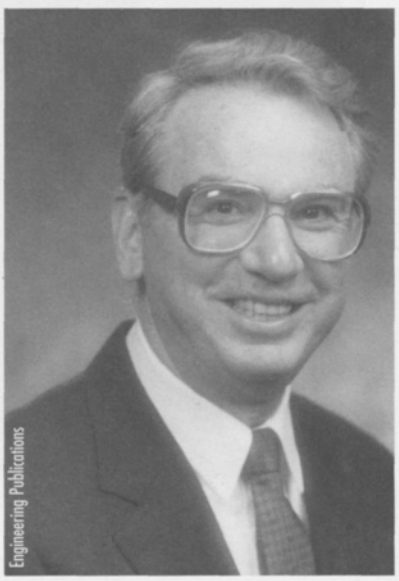
Irwin comments:

Ever since I left teaching for industry in 1972, I've been forecasting a decade of exciting developments in communications, and each year this decade has moved out one year. A major constraint on realizing this potential and introducing new products is the shortage of talented and well-trained engineers, especially with strong fundamentals in electrical engineering. For those interested in managing or starting a company, it is my experience that electrical engineering provides an excellent base for the quantitative aspects of business, for making key decisions regarding product choice and resource requirements, and for marketing high-tech products.

An engineering education, particularly one that stresses fundamentals and the development of an engineering intuition, is a great stimulus to creativity. I am able to trace several of my "light bulb" experiences back to key information I was taught in EM theory and antennas at Cornell and information and probability theory at MIT. Concepts of course become useful products through the other attribute of an engineering education, which is to stress quality, usefulness, cost, and time to market but not perfection.

Without the willingness of Cornell's electrical engineering department to take a chance on a mid-sophomore-year transfer from Hotel Administration, and then to encourage a flexible, rich, and exciting schedule, I would not have become a successful engineer. Key professors in electrical engineering, mathematics, and engineering physics gave me the knowledge and encouragement for a successful entry into graduate school and teaching. Of equal importance to my career in industry, Cornell's engineering cooperative program gave me the background and motivation to apply my classroom experiences to practical problems.

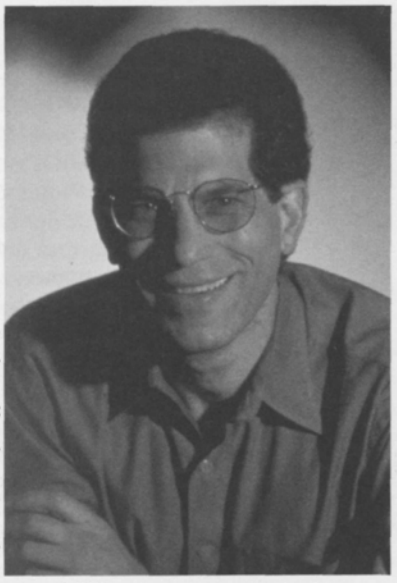
Irwin comments:
Ever since I left teaching for industry in 1972, I've been forecasting a decade of exciting developments in communications, and each year this decade has moved out one year.



Engineering Publications

Jonathan J. Rubinstein received the B.S. Engr. degree in electrical engineering in 1978 and the M.E.E. degree in 1979, both from Cornell University, and the M.S. degree in computer science in 1985 from Colorado State University in Fort Collins. When he assumed his present position of senior vice president of hardware engineering at Apple Computer in February 1997 he brought more than 20 years of computer design experience acquired during his service with several major computer industries in the United States.

Following graduate study at Cornell, Jon joined the Hewlett-Packard Company where he was the architect of the HP 9000 series-300 family of workstations, was a member of the design team for the HP 9836 workstation, and helped define the engineering and pre-production test processes for new products. In a transfer to Stardent Computer Corporation, he managed processor development for the Titan graphics supercomputer family and was the designer and architect of portions of the Stardent 3000 and 2000 computer systems. His established reputation as a computer designer brought him an offer to become vice president and general manager of hardware and vice president of hardware engineering at NeXT Computer Company where he was responsible for product development and was instrumental in defining the new product development process for the company. Afterwards, Jon became the executive vice president and chief operating officer of FirePower Systems, a developer and manufacturer of Power PC–based computer systems, where he was responsible for strategic planning, engineering, manufacturing, sales, and marketing for that company. At Apple, Jon reports directly to the CEO and leads the company's hardware engineering team responsible for the development of all of Apple's hardware products. He holds several patents in a variety of computer systems and is the author of several articles that have appeared in computer industry publications. He is a senior member of the IEEE and a member of the Association for Computing Machinery.



Gary Parker, courtesy of Apple Computer, Inc.

Jon comments:

When I entered Cornell, my only goal was to graduate and get a chance to build stuff. At that point in my life, I didn't really appreciate the education I was receiving nor did I understand the impact technology and engineering would have on our economy and on our lives. With the perspective that time gives you, I can say unequivocally that the engineering education I received was top notch. This opinion is reinforced by observing my coworkers and associates in the industry. It is clear that as an engineering school, Cornell does an outstanding job.

Engineering as a discipline is a balance of art and science. It is an art form to design really great products, but science is required to allow those products to be manufactured in volume while being reliable and useful. I would say that we have clearly accomplished that balance on the products developed at Apple over the last few years; PowerBooks and iBooks are great examples. These products required extensive engineering ability and creativity on the part of all involved.

It is now clear that engineering, and especially electrical engineering, is an extremely important discipline to the future of this country and the world. In order to be truly successful as an engineer, a great education is almost mandatory. A solid grounding in engineering principles and a knowledge of what has come before is essential. With the excellent education I received, I have achieved my original goal to build really cool stuff!

Jon comments:
When I entered Cornell, my only goal was to graduate and get a chance to build stuff.

Project Notes

PSerc Aids Utility Economic Analysis

One of the ECE School's responsibilities under the Power Systems Engineering Research Center (PSerc) consortium (described on page 13 of *Connections* 2000) is the development of a detailed layered-network model associated with the future electric power business. Among other requirements, the model must integrate, to the extent possible, the impact of the new competitive market structure on the electric utility industry.

Professor **Robert J. Thomas** and his associates have developed a smart-market computer format, called POWERWEB, as an experimental economics device. The model is used to test the performance of various auctions as individual generator owners submit offers of energy sales to a power-supply system. Among other accomplishments, Cornell operators of POWERWEB made early predictions of some of the energy problems that have occurred in California.

Program on Silicon Microdisplays Initiated

This three-year, $4 million program is funded jointly by the Advanced Technology Program of the National Institute of Standards and Technology (NIST) and Rainbow Displays of Endicott, New York. The Cornell portion of the program, under the direction of Professor **J. Peter Krusius**, will develop and apply a microtiling concept to achieve a demonstration model of a high-definition television display with a resolution of 1920 x 1080 pixels, 24-bit color, and 60 Hz frame rate. Even higher resolutions are expected from the application of this seamless microtiling technique. Rainbow Displays, a company founded by Peter and colleagues, has previously developed and successfully demonstrated seamless tiling of active-matrix liquid-crystal display elements on transparent glass substrates. The resulting 40-inch diagonal-size color direct-view displays are currently in preproduction manufacturing.

New Telecommunications Laboratory Established

A technologically advanced laboratory for designing and testing radio frequency (RF) integrated circuits has been established in the ECE School with the cooperation and endorsement of four major telecommunications corporations. The facility, named the Cornell Broadband Communications Research Laboratory (CBCRL), is directed by ECE Associate Professor **Kevin T. Kornegay**, who also organized the industrial partnership. The equipment for the laboratory donated by the IBM Corporation, Agilent Technologies, Cascade Microtech, and Cadence Design Systems, is valued at more than $2 million. IBM and Cadence have also provided state-of-the-art design tool software that would be of multimillion-dollar value if made available to industry. Kevin says that CBCRL will be used for future research and to train the next generation of RF engineers, help recruit high-quality students for the undergraduate and graduate programs, secure additional funding from industry and the government, and assist in faculty recruitment.

CU Scores in Automated Small-Submarine Competition

The Cornell Big Red Artificial Intelligence Navigator (BRAIN) team won second place in the third annual International Autonomous Underwater Vehicle Competition held July 2000 at Lago Durado, Florida. Cornell's submarine took first place in the Safety of Design, Technical Merit, and Craftsmanship categories and tied for second place overall with MIT. First place overall went to the University of Rhode Island. The BRAIN team, advised by ECE Associate Professor **Kevin T. Kornegay** and assisted by ECE Lecturer **Bernie Hutchins**, B.S.Engr. '67, consisted of 42 students, mostly undergraduates, from the departments of Electrical and Computer Engineering, Computer Science, Mechanical and Aerospace Engineering, Applied and Engineering Physics, and Operations Research and Industrial Engineering and from the College of Arts and Sciences. The challenge was to locate autonomously and retrieve a 12-inch-diameter orange ring, submerged in a murky lake, without any communication between the submarine and any person or computer on shore once the vessel entered the water.

Correction

On page 8 of *Connections* 2000, Associate Professor **Zygmunt J. Haas** was inadvertently excluded from the list of faculty members who contribute to the research of the information technology group in the ECE School. The article about Professor Haas on page 9 of *Connections* 1999 clearly shows that he is indeed an important contributor to information technology research. The editor regrets the error.

Recent Faculty Accomplishments

Most of the awards listed below were announced at the College of Engineering Fall 2000 Awards Ceremony and Faculty Reception on September 19, 2000.

• Professor Joseph M. Ballantyne (optoelectronic devices and materials) reports that his most significant academic contribution for the 1999–2000 year was the development and teaching of a complete set of new laboratory experiments for course EE 315, Electronic Circuit Design. Although the starting point was the Berkeley Course, all of the experiments were changed substantially and adapted for EE 315 lab equipment.

Joe developed completely new and original procedures for one experiment and major portions of two others, and he taught both lectures and laboratories when the course was given in the spring 2000 term for the first time. In research, Joe's leadership resulted in an award of one of the five Defense Advanced Research Projects Agency (DARPA) Optoelectronic Centers for the study of on-chip preprocessing of biological and chemical warfare agents with integrated optoelectronic microsystems. This $4.5 million, four-year grant will result in the establishment of the Center for Biochemical Optoelectronic Microsystems (CBOM), which will involve Cornell, the University of Rochester, and Harvard. Joe also made significant progress in development of materials for direct-bandgap laser structures for monolithic use on silicon for future "systems on a chip" and for bringing optical communication to the level of silicon chip technology.

• Lecturer John C. Belina (bioelectronics), assistant director of the ECE School, has been developing several team-oriented projects that provide interesting and challenging design assignments while giving M.Eng. and undergraduate students a chance to practice their organizational skills and learn something about project management. The goal of the RoboCAM project is to create a wireless, remote-controlled web camera that will survey developments on the engineering quad from a suitable vantage point remote to Phillips Hall. Students in John's course ECE 490, Practicum in Product Development and Systems Engineering, design a remotely accessible, home automation or security system that includes technical design and components of a normal business plan to introduce real-world constraints into the effort. John's Electrocardiogram Measurement and Analysis Project (EMAP) concentrates on the search for a marker of susceptibility to sudden cardiac death, the nation's number-one killer. This summer, students will implement algorithms, previously developed at Cornell, that will allow use of data files from cardiologists anywhere in the world.

• Professor Toby Berger (information theory and communications), the Irwin and Joan Jacobs Professor of Engineering, together with Professor W. B. Levy of the Neurosurgery Department at the University of Virginia, have shown the neural firing behavior observed in the primary cortex of animals, after the receipt of a new sensory stimulus, is describable by means of an Ising model with a nonuniform external field, which corresponds to the distribution over possible environments being sensed and an interconnection structure given by the neural synapse connections. Toby and one of his doctoral candidates have demonstrated for the first time that rate distortion theory can be successfully formulated for quantum sources, but they find that a mathematical proof is a challenging problem.

Together with another doctoral candidate, Toby has shown, also for the first time, that all information sources are "nearly successively refinable." Results of the study appear to be independent of the statistics of the data source. Toby was a recipient of the IEEE Third Millennium Medal.

• Associate Professor Adam W. Bojanczyk (computer engineering, parallel architecture, and algorithms for signal and image processing) and his research group have analyzed finite precision effects on the performance of sample covariance matrix inversion methods. These new results have been added into their software package for automated finite precision analysis of space-time adaptive-processing systems.

• Professor Hsiao-Dong Chiang (analysis and control of nonlinear systems with applications to electric-power networks) has developed constructive homotopy (mathematical space configuration) methods for finding all or multiple dc operating points of nonlinear circuits and systems.

• Associate Professor David F. Delchamps (control and system theory) reports that his research program in intelligent and hybrid dynamical systems has moved in some interesting directions over the past four years. Such systems mix continuous and discrete variables and often feature massively parallel architectures along with even-driven dynamics and collective phenomena. His group has come to recognize the central importance of evolutionary computational approaches to the modeling, analysis, and control of such systems. Current research that applies dynamical systems techniques to problems in cognitive science and learning theory has continued to play a role in their investigations. Dave was selected as this year's winner of the Tau Beta Pi and Cornell Society of Engineers 2000–2001 Excellence in Teaching Award, and he also received a Michael Tien '72 Excellence in Teaching Award.

• Professor Lester F. Eastman (compound semiconductor materials, devices, and circuits), the John LaPorte Given Professor of Engineering, achieved a new state-of-the-art level of pulsed and continuous amplifier microwave power density, using undoped polarization-induced high-electron-mobility transistors of AlGaN/GaN. This level was more then five times greater than for other transistors. A patent has been submitted for the invention of Si3N4 passivation of the devices. Lester was a recipient of the IEEE Third Millennium Medal.

• Professor Donald T. Farley (radiowave and upper atmospheric physics), the J. Preston Levis Professor of Engineering, took on the job of assistant director for space and atmospheric sciences (SAS) of the Arecibo Observatory in Puerto Rico in September 1999. He has found the task interesting and hopes to have a positive impact on the SAS Program.

• Professor Terrence L. Fine (information theory, inference, and decision making in the presence of uncertainty) was appointed director of the Center for Applied Mathematics in July 1999. Terry and one of his students have constructed the first simulation process for the unconventional probability concept of interval-valued probability. This effort is likely the first simulation of any probability concept other than familiar Kolmogorovian numerical probability. It is hoped that simulation methods will encourage applications of interval-valued probability. Terry was a recipient of the IEEE Third Millennium Medal.

• Associate Professor Zygmunt J. Haas (wireless communication and networks, mobile systems) introduced a novel framework for security in ad hoc networks. Based on the notion of threshold cryptography, the procedure allows authentication to be carried out in a communication environment characterized by very rapid changes of topology including frequent partitioning of the network nodes. Zygmunt received the Michael Tien '72 Excellence in Teaching Award for 2000–2001.

• Professor David A. Hammer (plasma physics, controlled fusion, intense ion beams), the J. Carlton Ward Jr. Professor of Nuclear Energy Engineering, reports that his group has made substantial progress toward achieving an understanding of the explosion of fine metal wires by short high-current pulses. Their work is affecting future directions in experiments conducted by their sponsor, Sandia National Laboratories in Albuquerque, New Mexico, to generate very high power x-ray pulses from cylindrical arrays of fine wires for application to inertial confinement fusion.

• Assistant Professor Mark A. Heinrich (computer architecture) innovated the concept of a two-level active memory system consisting of an active memory controller that handles cache coherence for the system, and an active memory system that performs data-intensive parallel computation. He also created a case study on the accuracy of architectural simulation that shows weaknesses in common simulation techniques and their effect on performance results predicted by architectural simulators. Mark received a five-year Faculty Early Career Development Award from NSF for his project "Flexible Architectures for Data-Intensive Computing." He also received the IEEE Student Branch Teacher of the Year Award for 1999–2000 and the Michael Tien '72 Excellence in Teaching Award for 2000–2001.

• Associate Professor Sheila S. Hemami (application-specific compression techniques for packet networks, networking aspects of visual communication, and multirate coding and transmission) received the Michael Tien '72 College of Engineering Outstanding Teaching Award for 1999–2000. Her group has made substantial advances in understanding human perception of suprathreshold compression-induced distortions, and has incorporated the results into new compression algorithms that exhibit significantly better visual quality at low bit rates. Sheila was promoted to associate professor with indefinite tenure on November 1, 2000.

• Professor C. Richard Johnson Jr. (adaptive control and signal processing) supervises the Blind-Equalization Research Group (BERG) at Cornell. He reports that during the 1999–2000 academic year he successfully arranged the participation of the BERG in a collaborative research and commercialization project on digital television receivers with Fox Broadcasting, Philips Research Lab, and the Telecommunications Engineering Group at the Australian National University. In addition, the BERG received gifts from Applied Signal Technology, Lucent Technologies, NxtWave Communications, and Aware, along with funding from the National Science Foundation for research on channel equalization and interference rejection in communications systems such as digital subscriber loops, cellular telephony, cable modems, and multiple-antenna microwave radio receivers.

• Assistant Professor Edwin C. Kan (modeling and fabrication of nanometer-scale devices) received a five-year Faculty Early Career Development Award from NSF in August 2000 and the Presidential Early Career Award for Science and Engineering (PECASE) in Washington, D.C., in October 2000. He reports major findings in the use of metal nanocrystals for very large scale integrated (VLSI) circuit technology, including improved floating gate, reduction of contact resistance and

ECE School Research Funding

Total research funds expended in 1997–98	$13,370,224
Total research funds expended in 1998–99	$17,387,886
Percent increase	30.0%
Total research funds for 1999–2000 (as of June 30, 2000)	$20,556,217
Percent increase	18.2%

In addition, the school has received gifts and equipment valued at over $3 million in the past academic year in support of faculty research, teaching, and special projects from Agilent, Applied Signal Technology, Cadence, Cascade, Compaq, Eastman Kodak, Ford Motor Company, GTE, IBM, Intel, Keithley Instruments, Lockheed-Martin, Lucent, Lutron Foundation, Motorola, Nortel, NxtWave, Tekronix, Teledyne, and many others. These generous grants from corporations and foundations, coupled with equally commendable gifts from many individuals, aid the recipients in their teaching and research and make it possible for the ECE School to establish and maintain a leading edge in the discipline.

improvement of thin-film binding. The Systems-on-a-Chip Project targeted at co-location of computing, communication, control, power, sensing, and actuation has also been making steady progress. The first chip demonstration has shown promising results for a major breakthrough in device concepts.

• Professor Michael C. Kelley (upper atmospheric and ionospheric physics) has been named the James A. Friend Family Distinguished Professor of Engineering. He also continues as a Stephen H. Weiss '57 Presidential Fellow. Mike has supervised his students in a series of experiments involving long-lasting meteor trails and space weather. Results of both of these studies have been featured in special issues of *Geophysical Research Letters* that were published in 2000.

• Professor Paul M. Kintner (atmospheric plasma physics) received the James and Mary Tien Excellence in Teaching Award for 2000–2001, served as chairman of the Engineering College Curriculum Governing Board (CCGB), and was awarded a $288,000 research grant from the Office of Naval Research Defense University Research Instrumentation Program (DURIP). Paul is a member of the National Aero-nautics and Space Administration (NASA) Headquarters Sun-Earth Connection Advisory Committee within the Office of Space Science.

• Professor Ronald M. Kline (history of technology and electrical engineering) was promoted to full professor in the Colleges of Arts and Sciences and Engineering effective January 1, 2001. Ron was on sabbatical leave for the 2000–2001 academic year. Under a grant from the Science and Technology Studies Division of the National Science Foundation he has been doing archival research and conducting interviews for a project on the history of information theory in the United States. He has visited archival collections in New York City, Boston, Philadelphia, and London. Interviews were conducted in Honolulu, Hawaii, at the November 2000 IEEE International Symposium on Information Theory and Its Applications. Ron was a recipient of the IEEE Third Millennium Medal.

Figure 9. Image produced by microtiling technology.

• Associate Professor Kevin T. Kornegay (computer-aided design for VLSI circuits) was promoted to associate professor with indefinite tenure on November 1, 2000. Kevin reports that he has developed a novel fabrication process to form deep cavities in single-crystal silicon carbide (SiC), a process that was used to build one of the first SiC piezoresistive strain gauges intended for jet engine pressure-sensor applications. In a recent work he presented a strong argument for the existence of quantum-billiard chaos. This mode of chaos has additional application to membranes stretched across a closed loop, to a thin plate clamped to the loop, or to transverse magnetic field (TM) modes propagating in a metal-walled waveguide. Kevin was an invited attendee to the Fifth Annual Symposium on Frontiers of Engineering conducted by the National Academy of Engineering.

• Professor J. Peter Krusius (solid-state electronics, semiconductor devices and systems, and electronic packaging), and his group have opened a new direction of research with a large program on silicon microdisplays. The three-year, $4 million program is jointly funded by the Advanced Technology Program of the National Institute of Standards and Technology (NIST) and Rainbow Displays. The Cornell portion of this project covers the development of a unique silicon microtiling technology (see Figure 9). The objective is to develop silicon color microdisplays for highest resolution and quality image applications such as graphics, color video, and digital cinema. The goals of the project will be reached through tiling of many smaller microdisplay components into a single large and visually seamless display assembly. (See page 18 for more details of this project.)

• Professor Richard L. Liboff (physics of microsemiconductor devices and solid-state plasmas) reports that Addison-Wesley has given the green light for publication of the fourth edition of his best-selling quantum mechanics text. This latest edition will include a new chapter addressing quantum computing, which, in turn, involves binary numbers and logic gates. A new text, *Primer for Point and Space Groups*, is on contract with Springer-Verlag. This topic has strong applications to solid-state devices. In research, his latest publication is on the "hexagon quantum billiard," which has applications to the nitride compounds.

• Professor Noel C. MacDonald (micro-electromechanical and nanoelectromechanical systems) has joined the faculty of the University of California at Santa Barbara but remains an adjunct professor in the ECE School. He makes frequent visits to the campus to consult with his graduate students.

• Assistant Professor Rajit Manohar (asynchronous VLSI design, computer architecture, parallel computing) received a five-year Faculty Early Career Development Award from NSF in August 2000, the Tau

Beta Pi/Cornell Society of Engineers Excellence in Teaching Award for 1999–2000, and the Michael Tien '72 Excellence in Teaching Award for 2000–2001. Rajit reports that he designed a collection of new representations for integers that resulted in low-energy asynchronous datapaths.

• Assistant Professor Bradley A. Minch (analog and digital VLSI circuit design) received a five-year Faculty Early Career Development Award from NSF in August 2000. He reports that he has devised a new folded floating-gate metal-oxide semiconductor (MOS) differential-pair topology that simultaneously provides wide input and output voltage ranges on a low-voltage power supply. Brad anticipates this circuit will have a wide range of applications ranging from microelectromechanical systems (MEMS) sensor interfaces to wireless communication systems.

• Professor Thomas W. Parks (signal theory and digital signal processing) has developed a new procedure for estimating the period and waveform for a periodic signal. He has received a donation from Texas Instruments Corporation of nine TMS320C5402 Digital Starter Kits (DSK) for use in the EE 425 laboratory. Tom received the IEEE Third Millennium Award.

• Associate Professor Alfred Phillips Jr. (quantum mechanical devices, optical switches, and process modeling) has shown that some key results of quantum mechanics can be interpreted in an alternative way and has been trying to discover or create theoretical implications of the alternative interpretation. He plans to make this work public after the theoretical implications, if any, are determined. Al and his student Alan Renaud are making progress with an embodiment of Seth Lloyd's general description of quantum computers but are not convinced that they have solved the problem of decoherence.

• Professor Clifford R. Pollock (lasers and optoelectronics), the Ilda and Charles Lee Professor of Engineering, continued as faculty program leader for the design of Duffield Hall with responsibility for securing faculty input and approval for the design of the new facility and assisting in the development of the required environmental impact statement. Clif also taught EE 210, Introductory Electric Circuits, to 350 engineering students over two semesters and received the James and Mary Tien Excellence in Teaching Award for 2000–2001.

• Associate Professor Anthony P. Reeves (parallel computer systems, computer vision algorithms) and his group have developed a database system for collecting and analyzing medical information on lung cancer. The recent strong interest in screening for lung cancer using computed tomography (CT) technology has been spurred by recently published studies from the ongoing Early Lung Cancer Action (ELCAP) program of the Weill Medical College of Cornell University. The group's collaborative research with the ELCAP project has resulted in the establishment of a unique Internet-accessible database that receives information from an international consortium of medical research groups. (See www.icscreen.med.cornell.edu/ for more information.) Several guest speakers from the Weill Medical College are involved in a recently developed graduate-level course, Computer Analysis of Biomedical Images.

• Professor Charles E. Seyler Jr. (space-plasma physics, theoretical and computational plasma physics) prepared a major full-length paper based on completion of a significant part of his NSF and NASA-sponsored research projects. The goals of the projects are to understand the origin of broadband extremely low-frequency waves that have been found in Earth's auroral regions. These waves are believed to be responsible for the heating and acceleration of oxygen ions in the topside auroral ionosphere. The accelerated ions spiral upward owing to the magnetic mirror force and create a significant source of oxygen ions in the magnetosphere. Charles also revised the design project for the freshman course ENGN 114, Introduction to Engineer-ing. This year's students were able to design and implement an AM radio transmitter-receiver in one semester.

• Professor James R. Shealy (development of compound semiconductors) received the Ralph S. Watts '72 Excellence in Teaching Award for 2000–2001. During calendar year 2000, while he was on sabbatical leave, Dick oversaw the start-up of two new research projects and continued to supervise his graduate students. He also interacted with colleagues at Harvard University and developed technical oversights and research opportunities with researchers at Raytheon Corporation in the area of transistors. Strong contacts were established with Raytheon and Welch Allyn Corporations that will assist Dick and his students in garnering continued funding for future research from these industries.

• Professor Chung-Liang Tang (lasers, optoelectric devices, nonlinear and coherent optical processes), the Spencer T. Olin Professor of Engineering, reports that the interest of his group's research during the past year has been in the areas of high-speed all-optical switches and routers using vertical cavity semiconductor lasers and spin electronics and hole dynamics in the mid-infrared spectrum.

• Professor Robert J. Thomas (control techniques for large-scale networks, analysis of microelectromechanical systems) received the Ruth and Joel Spira Excellence in Teaching Award for 2001 and was awarded the IEEE Third Millennium Medal. Bob reports that he has completed experiments that offer a new explanation for the high price spikes seen in California, New York, New England, and other electricity markets.

• Professor James S. Thorp (estimation and control of discrete linear systems applied to electric-power networks), the Charles N. Mellowes Professor of Engineering and former director of the School of Electrical and Computer Engineering, reports the development of a simulation model of cascading outages in the bulk electric-power system that produces statistical behavior similar to that of the historical 15-year data of the National Electric Reliability Council (NERC). The model is based on a Markov process produced by random "hidden failures" in the electric-power protection system coupled with a load-flow model. The overall simulation model can be used to determine when improvements should be made to the protection system.

• Associate Professor Norman C. Tien (microelectromechanical systems [MEMS] for radio frequency circuits and optoelectronics) received a five-year Faculty Early Career Development Award from NSF in August 2000. He was promoted to associate professor with indefinite tenure on November 1, 2001. Norman was on a leave of absence at the University of California at Davis during the 2000–2001 academic year.

• Professor Sandip Tiwari (electronic and optical semiconductor devices and compound semiconductors), the Lester B. Knight Director of the Cornell Nanofabrication Center (CNF) in Knight Laboratory, lists the following significant developments in center research during the past year: (a) development of a new silicon-trench ideal responsivity, high-frequency and low-voltage photodetector that is compatible with silicon technology, (b) identification of the interface state-induced phenomena in single-electron sensitive electronic structures, and (c) a new reconfigurability-based implementation of architecture using ultrasmall silicon device structures.

• Associate Professor Lang Tong (digital signal processing algorithms, estimation theory, wireless communication systems) was promoted to associate professor with indefinite tenure on November 1, 2000. Lang reports that his group has developed new packetization techniques and receiver structures for data transmission over interference channels that has led to the filing of four patents. He has also received a five-year, $4.2 million grant from the Office of Naval Research as the principal investigator for the multidisciplinary university research initiative on Channel and Quality of Service (QoS) Adaptive Multimedia Wireless Ad-Hoc Networks.

• Professor Stephen B. Wicker (wireless information networks, digital communication systems, error control coding, and cryptography) reports that his research focuses on the development and application of advanced technologies for link and network protocols in wireless information networks. His current interests include the application of artificial intelligence and expert systems to the development of cross-layer protocols for self-configuring, adaptive systems. Example projects include the use of Bayesian networks to model and predict user tendencies. Such models are used to increase the efficiency of resource allocation, mobility management, and routing protocols. In another ongoing project, Steve uses evolutionary game theory to implement efficient resource allocation in ad hoc wireless networks. The goal is to have an efficient resource usage strategy emerge as an equilibrium point in a partially cooperative, time-varying communication environment.

Paul R. McIsaac Retires

Paul R. McIsaac, a member of the EE School faculty for 41 years, became professor emeritus on July 1, 2000.

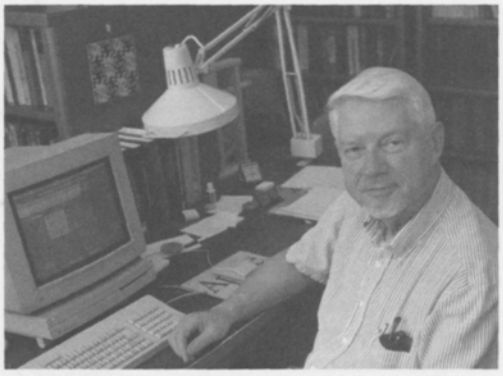
After returning from two years in the U.S. Navy, Paul received the B.E.E. degree from Cornell University in 1949 and the M.S.E. and Ph.D. degrees from the University of Michigan in 1950 and 1954, respectively, all in electrical engineering. During the 1951 academic year, he was a Rotary Foundation fellow at the University of Leeds, England. Following completion of his doctoral study Paul spent the next five years as a research engineer in the Microwave Tube Division of the Sperry Gyroscope Company in Great Neck, New York. In 1959 he came to Cornell as an associate professor of electrical engineering and was promoted to full professor in 1965.

Paul's career at Cornell has been devoted to teaching, research, and service to the EE School, the College of Engineering, and the university. He helped to develop the junior-level courses EE 303 and EE 304, Electromagnetic Fields and Waves I and II, which he taught numerous times during academic years. In addition, he taught the first of these courses to engineering cooperative students during 30 summer sessions. He also regularly taught the sophomore-level course EE 210, Introduction to Circuits. He taught a graduate course, EE 583, Electrodynamics, with the goal of giving first-year graduate students a thorough understanding of the fundamentals of classical electrodynamics and the electrodynamics of continuous media. As well, he taught a graduate course, EE 584, Microwave Theory, with the goal of applying modal theory to waveguides, cavities, and microwave junctions. His research is centered on electromagnetic theory and the analysis of structures for application to microwave, millimeter, and optical devices and systems. The objective of this research is to explore the properties of general classes of structures using as a basis the symmetry operations (both spatial and nonspatial) belonging to the structure and its constituent media. These symmetry operations determine, to a large extent, the electromagnetic characteristics of a structure. Uniform and periodic waveguides and transmission systems and multimode junctions and coupling systems are included. Over the years Paul has directed the research of many graduate students in these and related fields.

Paul has been highly regarded by his students as an excellent and dedicated instructor. In attempting to explain some of the more esoteric concepts in Maxwell's Equations, Paul found that his knowledge of modern art provided him with useful classroom analogies. For example, one can draw an analogy between the photons that make up an electromagnetic signal and the myriad dots of color used in neo-impressionist paintings (e.g., by Seurat), or to the blobs of color used by the abstract expressionist Rothko. In the former case, adding or subtracting a few dots does not appreciably alter the painting; this is analogous to classical electrodynamics, which assumes vast numbers of photons (valid through the millimeter range). In the latter case, adding or subtracting a single blob creates a new painting; this is analogous to the realm where few photons are involved and quantum electrodynamics must be used (at light frequencies).

Paul served two separate terms as coordinator of graduate studies in the EE School from 1962 to 1965 and from 1973 to 1975 before becoming associate dean in charge of research and graduate education for the College of Engineering, a position he held from 1975 to 1980. From 1984 to 1987 and again from 1992 to 1995 Paul was the coordinator of graduate studies in the EE School, the only Cornell EE professor who has been in that office four times. From 1965 to 1966 he was a visiting professor at Chalmers University of Technology in Göteborg, Sweden, and from 1987 to 1988 he spent another sabbatical at the Royal Institute of Technology in Stockholm. Over the years he has consulted with the Westinghouse Electric Corporation in Elmira, New York (1959–65), the Cornell Aeronautical Laboratory in Buffalo, New York (1960–63),the Sperry Gyroscope Company in Great Neck, New York (1961–65), and the Hampton Institute in Hampton, Virginia (1968–70). Paul is a member of the IEEE and of Sigma Xi and has authored or coauthored more than 40 refereed journal and conference papers.

Engineering Publications



During his undergraduate days Paul and a classmate, **Alan Markham**, B.E.E. '49, were control room operators of the Cornell radio station WHCU, which had one studio in downtown Ithaca and another one in a small cabin located in the former Minns Garden where Malott Hall now stands. Because the daily live broadcast of the Cornell Agricultural Farm and Home Hour coincided with the Columbia Broadcasting System (CBS) soap operas, one of Paul's operating duties was to transcribe the soaps for later rebroadcast. Paul says he heard a lot about "The Adventures of Helen Trent" while those transcriptions were in progress. Paul also recalls that the Farm and Home Hour always started with a live broadcast of the Cornell Library tower chimes. This feature was accomplished by means of a live microphone in the hands of an assistant operator who was usually stationed near a public telephone booth adjacent to the tower. In addition to the chimes concert, listeners were occasionally treated to some interesting conversations emanating from that telephone booth.

During the five years that Paul worked for Sperry he played the French horn with the Huntington Symphony Orchestra, an amateur group of local engineers and other professionals who were also competent musicians. Paul says proudly that the orchestra produced some fine concerts under the direction of Thomas Pickering, the inventor of the Pickering loudspeaker. As often happens, Paul has not played for many years and, in fact, gave his horn to his son. Paul and his wife, Lou, are patrons of the arts, enjoy Bailey Hall concerts, and are frequent visitors to museums in this country and abroad. In addition to a fondness for classical music, Paul admits listening to jazz occasionally, providing it is of the pre-1950s variety. They are both fond of theater and often visit the Stratford Summer Festival in Ontario, Canada. Paul and Lou also enjoy art appreciation as a pastime, with interests that range from primitive to modern art.

In retirement, Paul plans to continue research and writing in his field of interest. Paul and Lou expect to continue residing in Ithaca, visit their children in Denver, Colorado, Washington, D.C., and London, England, and they travel abroad occasionally with particular interest in renewing acquaintances with sabbatical colleagues in Sweden.

William Mutch

Figure 10. Joan Manning attended by her EE/ECE graduate representatives. From left to right: Dave Hammer, Don Farley, Charles Seyler, Ralph Bolgiano, Ben Nichols, Joan Manning, Toby Berger, Sam Linke, Chuck Wharton, Paul McIsaac. Absent: H. C. Torng.

Joan Manning Retires

Joan Manning, executive assistant to the ECE graduate field representative, retired in the summer of 2000 after 41 years with Cornell University. Joan came to the EE School in August 1959 as the fourth-floor secretary in Phillips Hall and assumed her duties in the graduate office in 1966. In her time in the latter position she managed the graduate office for 12 separate grad representatives who maintain that Joan knew all the details related to graduate study in the school. Indeed her office has been called "Miss Manning's Finishing School for Inexperienced Graduate Field Reps." The photograph in Figure 10, taken during her retirement party on September 6, 2000, shows Joan with most of the grad reps with whom she worked during her years of service. Former graduate students will remember her melodious voice on the telephone and in her office as she graciously responded with knowledgeable answers to their questions. In retirement, Joan will continue to reside in her home in Freeville, New York, and pursue her long-term hobbies of oil painting and gardening.

David W. Woodard Retires

Dave Woodard, senior research associate in the ECE School, retired in December 2000 after 21 years of service. Dave received the B.S. degree in electrical engineering from Princeton University in 1962, the M.S. degree in physics from Rutgers University in 1964, and the Ph.D. degree in applied physics from Cornell University in 1979. From 1962 to 1965 he was a member of the technical staff at the David Sarnoff Research Laboratory working under the supervision of Dr. George D. Cody. Results of his studies there of the "anomalous" resistivity of niobium-tin above its superconducting transition became the subject of his master's thesis and, after publication in *Physical Review Letters*, the subject was sometimes referred to in the literature as the "Woodard-Cody anomaly." Following three years as a graduate student at Cornell, Dave became a principal engineer with Cayuga Associates, founded by Professors Conrad Dalman, Lester Eastman, and Charles Lee, until 1979 when he joined the EE School as a senior research associate in the Microwave Research Group headed by Professor Eastman. His research has been in the area of microfabrication of gallium arsenide (GaAS) microwave and photonic devices and in optical nonlinearities caused by intersubband transitions in quantum wells.

During retirement Dave plans to remain in Ithaca, continue some house projects, do some traveling, avail himself of the free study benefit at Cornell, and pursue his hobbies of sailing, music, biking, swimming, and rowing.

Raymond C. Ink Retires

Ray Ink, manager of technical services and research support, retired on January 1, 2001, after 41 years of service to the EE School. After graduating from Ithaca High School in 1955, Ray's first assignment in the school was as a mechanician with the Cornell Cable Project at the Mitchell Street High-Voltage Laboratory under Professor Joe Rosson. When the project was completed in 1963, he transferred to Phillips Hall and continued as a mechanician until 1980 when he became the building manager for Phillips Hall and the Knight Laboratory. In that position he was a valuable source of information about facilities in Phillips Hall and became particularly knowledgeable and effective as monitor of safety practices and procedures in the school.

Ray is active in Masonry and has served as past master and past grand lecturer of the Cayuga–Tompkins County District Lodge. During the winter months he continues to enjoy his snowmobile. Ray says that he spends much of his spare time maintaining his personal property and his pond and in cutting, splitting, and selling firewood. We wish him many happy retirement years.

In Memoriam

We are saddened to report the death of Professor Emeritus **Charles A. Lee** at age 78 on June 11, 2001, in Ithaca, New York, after an extended illness. A full account of Charles's distinguished career will appear in the next *Connections*.

Mrs. **Elma Scutt Weaver**, 65, a former administrative assistant in the ECE School, died on November 15, 2000, at the Cayuga Medical Center in Ithaca, New York, after a long illness. Elma had her first association with the school in 1953 as an administrative aide in Franklin Hall. She resigned in 1963 but would do occasional typing at home for members of the EE faculty. She rejoined the staff in October 1978 as administrative assistant to Professor **Lester Eastman**'s microwave research group and remained in that position until her retirement in 1998. In her private life she was noted for her love and devotion to children. She will be long remembered by faculty members and graduate students for her careful and conscientious attention to detail and her gentle personality.

Staff News

Vickey A. Beaver was appointed in September 2000 as webmaster in the ECE School where she is currently in the process of updating and streamlining the ECE web site. In 1994 she joined Transamerica Corporation in Nashville, Tennessee. In 1996 the company centralized and relocated to Dallas, Texas, where she developed her computing skills and became a help desk analyst and webmaster for their department of network services. In November 1999 Vickey joined the Office of Sponsored Programs at Cornell with responsibility for maintaining their web site for funding operations. She is a member of the HTML Writers Guild, the Higher Education Web Professionals of New York, and the Cornell Editors' Group and serves on the editorial board of *PawPrint*, a Cornell community newspaper, to which she contributes a column called "Net Notions." Vickey enjoys writing stories and poetry, playing the piano, reading, practicing the martial arts, and traveling when time allows.

Marjorie Bissett, B.S., horticulture (Pennsylvania State University), joined the ECE Accounting Office on May 30, 2001, as an administrative assistant, succeeding **Denise Merrick-Treat**. Marjorie returned to the United States recently after living on the island of St. Kitts for two years while her husband attended veterinary school. In her spare time she works at the Cornell Plantations in floral design. A softball enthusiast, Marjorie plays in three softball leagues in Ithaca.

Cheryl B. Francis, formerly accounts representative in the ECE Accounting Office, was promoted to research accountant IV in the school in October 2000. She has taken on new responsibilities and challenges in both administrative and financial areas. (See page 23 of *Connections* 2000 for a summary of Cheryl's background at Cornell.)

Andrew P. Gardner, B.S., business administration and accounting (SUNY Fredonia), joined the ECE School on August 3, 2000, as an accounting assistant for the research groups of Professors **Robert J. Thomas** and **Lester F. Eastman**. His primary responsibility is to handle the accounting for the Power System Engineering Research Center, directed by Bob Thomas, and for the research group directed by Les Eastman. When time allows, Andy enjoys home brewing, surfing the Internet, and interacting with challenging computer games.

Sandra L. Goodwin, B.A. '68, English and education (SUNY Cortland), succeeded **Beverly Phillips** in August 2000 after 12 years at Cornell in the offices of the University Registrar and the Dean of Students, the Department of Materials Science and Engineering, and the College of Agriculture and Life Sciences. Her past work in these positions has given her experience in undergraduate information and procedures that is of great value in her new post. Sandi says that her principal avocations are knitting and reading.

Albert (Skeeter) Heidt assumed the position of manager of technical services and research support upon **Ray Ink**'s retirement. He is also a member of the ECE Safety Committee. Skeeter joined the EE School in 1992 as a research support specialist with senior research associate **Bill Schaff**, B.S.Engr. '78, Ph.D. '84, in Professor **Les Eastman**'s group. Skeeter continues to enjoy his personal hobby of rebuilding antique motor cars.

Dorothy J. Palladino, B.S., health and sociology (Regents College, SUNY Cortland), A.A.S., business administration (Tompkins County Community College), joined the ECE School on August 9, 2000, as accounts representative III, succeeding **Amy Duval** who has accepted a position with the Department of Computer Science. Before coming to Cornell, Dorothy spent seven years in social services with the Tompkins County Human Services Coalition and had previously been employed for 17 years with the Smith-Corona Company in Cortland, New York. Her responsibilities include purchasing, procurement cards, capital equipment, and school accounts reconciliation. In her spare time Dorothy is studying for a master's degree in health care policy at SUNY Albany, and she enjoys gardening, cooking, walking, playing tennis, and traveling.

Beverly Phillips, undergraduate field coordinator for ECE and assistant to the associate director, retired in August 2000 after 21 years of service at Cornell with the last four years spent in the ECE School. Bev, an avid golfer, has moved to Henderson, North Carolina, where she plans to continue with her favorite pastime and to return to Ithaca for the golf tournaments. We wish her many happy retirement years.

Zhila Sadri, B.S., sociology (Shiraz University, Iran), M.S., public administration (University of Southern California), associate degree in accounting (Elmira College), joined the ECE School on October 19, 2000, as research accountant IV. Zhila came to Cornell in 1994 and joined the Sponsored Funds Accounting Division of the Controller's Office as a research accountant with responsibilities in the grant, contract, and restricted funds areas. She has assumed a series of accounts and contracts and has worked on the school's research cost-share reporting. Zhila says that she is a soccer mom at present and likes to play tennis when time allows.

Paul M. Schuh was appointed computer operations network/UNIX administrator in the ECE School on May 1, 2000, where he is responsible for the development and maintenance of the 15 core systems that support the approximately 800 workstations and laboratory computers and the 900 faculty, student, and administrative staff terminals in the ECE School. A Gulf War veteran, Paul spent six years in the U.S. Army Signal Corps and one year with the J. B. Hunt Transportation Company before enrolling in the University of North Carolina in Asheville. After college he joined New Era Technologies in Asheville and remained with that company for six years developing and deploying wireless Internet connectivity systems for metropolitan areas. He spent the following year with DSL.Net in New Haven, Connecticut, as a senior UNIX systems administrator before transferring to Cornell. Recently he became a Certified Information Systems Security Professional, a designation held by fewer than 2,500 people worldwide.

He is studying to obtain his amateur radio license and is also developing several Internet domain names. Paul collects DVDs and paints miniatures when time allows.

More Tales From the Past

Your tales from the past are always welcome. Send us your favorite stories about professors, labs, classes, projects, stunts, or whatever you think made the EE School a special place. Further examples of the Matthews Criterion, as demonstrated at Cornell, are also of interest. We'll print 'em as space allows.

Several latent memories have been triggered by recent issues of *Connections* that have related EE students' experiences as operators of the Cornell University radio station WHCU. Two EE alumni mentioned elsewhere in this issue, **Paul McIsaac** '49 and **Wilson Greatbatch** '50, were both active participants in the daily operations of the station, and a delightful letter from **Beatrice Mead Hagedorn**, B.E.E. '42, gives us still another glimpse of that remarkable station's history. Bea writes:

"When my husband, **Alfred A. Hagedorn**, E.E. '41, and I read the last *Connections* we were surprised that there were no female WHCU employees mentioned in the "Positive Feedback" section. During my senior year I worked at the station as a control engineer at the downtown studio. Professor **True McLean** had asked me to learn how to cut records, and when I had done so he asked me to work as a control engineer, a job that I enjoyed very much. I was on duty at the station when Pearl Harbor was bombed. Wow! That was indeed a memorable day. Since it was Sunday, a day which usually was given over mainly to CBS concerts, there was great excitement instead of music. The teletype machine was on practically all day with shocking news reports, some true and some untrue. I could hardly wait to get to my phone in Balch to call my parents. I had heard that Mitchell Field on Long Island was under attack, which, of course, turned out to be incorrect.

Later in my career at the station, Professor McLean informed the media that I was the first female WHCU engineer. The result of that announcement was somewhat unexpected. A newspaper, the *Brooklyn Citizen*, printed the following headline: ***Amityville Girl, 22, Co-Ed at Cornell, Is First Radio Control Operator of Sex.*** Subsequently, the April 11, 1942, issue of the *New Yorker* magazine, in one of their familiar bottom-of-the-page comments, repeated the headline and added, 'She's fighting a losing battle.' My classmates had a great time teasing me with that. In spite of that, I thought other girls in EE would work at WHCU, but none were mentioned in *Connections*. I'm happy so many females are in engineering now." (See Figure 11 for a photo of Bea at the WHCU console.)

Figure 11. Beatrice Mead Hagedorn, WHCU control engineer.

The query in last year's "Tales" about the infamous WVBR takeover and "War of the Worlds" broadcast brought forth accounts of the incident from **Charlie Meyer,** E.E. '55. Charlie writes that the event took place during finals week of 1952. It is described by **Joan Steiner Stone**, A.B. '55 , co-president of the Class of '55, in class recollection notes:

"This is how I remember the event, with a few remembrances provided by **Bill Ellison**, L.L.B. '54: I was a member of WVBR, the campus radio station that stayed on the air all day and all night playing mostly classical music during finals. Bill Ellison, a fellow member and announcer, and I had taken a study break over coffee at Japes. Bill suggested that I return to the station with him, but I felt the need for more studying and went back to Dickson. Bill went on to the station located at the time in the lowest level of the Straight overlooking Wee Stinky Creek. A little later, as I was studying in a friend's room to the sounds of WVBR, a voice broke into the program over a recording of 'Hiroshima, Nagasaki.' The voice sounded like an announcer telling us that enemy airplanes (Russian, I think) had bombed a couple of places in France and were crossing the ocean to bomb this country. I went to my room, turned on a Syracuse station, and heard only normal broadcasting. I also knew the voice on WVBR was not Bill's nor that of anyone else I recognized. I was concerned about this strange activity but did not know what else I could do at the moment.

"As it turned out, a group intent on performing a humorous prank had broken into the station, tied up the engineer, the announcer on duty, and Bill, who had just come in. **Bill Gratz**, B.M.E. '54, on hearing the broadcast in his room, ran up to see what he could do and was also tied up. Bill Ellison tells me they were handled roughly and did not think of it as a lighthearted episode.

"The next morning I learned that the 'prank' had some serious consequences. Students who were involved in ROTC thought it was war and expected to be called up. Many tore up their study notes since they figured they wouldn't get to take the

exams. Foreign students, especially those from France, became very concerned about their families, stopped studying, and tried to reach them by phone. (Remember in those days it was not easy to make a call to another country.)

"When it became known that this event had been a prank, there was a lot of consternation as well as relief. The people who planned and participated in the stunt were mostly seniors, and they were disciplined. I remember they did not graduate on time, but I don't recall what other, if any, disciplinary action was taken."

Charlie's supplemental account follows, but we still don't know if any EEs were involved in the prank:

"The WVBR broadcast appeared to be legitimate and spread rapidly through the dorms, fraternities, and sororities. But the climax occurred when all ROTC students were ordered to report in uniform the next morning to Barton Hall at 7:00 a.m. sharp. To some people that was putting it on a little thick, and veracity began to wane.

"One little-known aftermath of the story was that WVBR was visited by the Federal Communications Commission (FCC) radio inspector from Buffalo. He measured the signal strength and found it well in excess of what FCC rules allowed. The university administration ordered the station off the air until it had a way to measure its signal strength and comply with the law. In those days WVBR was an AM 'carrier current' station. It had no antenna or license, but low-power transmitters coupled a little bit of signal into the power lines. If one lived close enough to the right power lines, the station could be heard.

"To comply with the law, WVBR bought a field-strength meter, the same kind used by the FCC, for $761.80. That was a lot of money in 1952, more than half the cost of a new car. The meter allowed adjustment of the low-power transmitters, and the station returned to the air for the fall term. WVBR has come a long way since then."

The article on control technology in the EE School in *Connections* 2000 evoked a couple of interesting comments that add pertinent details to the early history of that discipline. **Dave Bechtold**, E.E. '38, writes: "Figures 1 and 2 show a servomechanism lab setup which appears to me to be a B29 gun turret and gunsight mockup. An early part of my World War II service was at Lowry Field, Denver, Colorado, where we learned and then taught the operation and maintenance of the gun turrets used in B17s and B24s. We then were in the first group introduced to the new remote-controlled gunfire-control system on the forthcoming B29 which hadn't even flown at the time. I found this all highly interesting and new to me in 1942 as the word 'servomechanism' hadn't even been compounded in my Cornell EE days just a few years earlier, from 1934 to 1938. So I have to ask if the pictures are indeed of that turret and gunsight setup." [Dave, I can't confirm for sure that the turret in the photos is from a B29, since the equipment and associated documentation are both long gone. Your guess is probably right. The vintage is certainly correct since the turret was already here when I arrived at Cornell in 1946.—Ed.]

And this note from **Bob Hufnagel**, B.E.E. '55, Ph.D. '59: "It was with special interest that I saw the photo of the COREAC analog computer shown on page 7 of *Connections* 2000. I had a graduate assistantship in 1957 to design and supervise the construction of this machine. Professor Al Jackson was my supervisor. I still have copies of his notes of encouragement with suggestions on improving the design. Before the machine was finally completed, I used it to do the experimental part of my Ph.D. thesis on feedback-control systems with aperiodic sampling. I graduated before the unit's final completion and general use, and thus had never seen the photo that appeared in *Connections*."

Sam Linke

The annual ECE School Alumni Breakfast was held on Saturday, June 9, 2001, from 7:45 to 9:30 A.M. in the Phillips Hall lounge. Alumni, companions, and friends joined members of the ECE School faculty and staff for an event that is always a festive and memorable occasion.

Positive Feedback

•**David J. Bechtold**, E.E. '38, retired vice president of operations, GPU Energy, and now living in Johnstown, Pennsylvania, recalls his early experiences with World War II control devices similar to the one shown in the article about servomechanisms in *Connections* 2000.

•**Beatrice D. Mead Hagedorn**, B.E.E. '42, and her husband, **Alfred A. Hagedorn**, E.E. '41, are both retired from positions with Mid Colorado Investment Co. and live in Colorado Springs. Bea relates her experiences as a radio control operator at WHCU.

George Victor Wintress, B.E.E. and M.E. '54, M.S.E.E. (San Diego State University), president, Wintress Engineering Corporation, San Diego, California, attended the Cornell Society of Engineers (CSE) Engineering Manufacturing Seminar in Hollister Hall, met with master of engineering students in the manufacturing option, toured the Cornell Nanofabrication Facility, and received an overview of the Duffield Hall Project.

•**Robert E. Hufnagel**, B.E.E. '55, Ph.D. '59, retired scientist now living in Albuquerque, New Mexico, recalls his work with Professor **Al Jackson** in the development of the COREAC analog computer described in *Connections* 2000.

Victor E. Clarke, B.E.E. '55, CEO of Gables Engineering, Coral Gables, Florida, visited the campus in late September 2000, conducted the CSE Engineering Manufacturing Seminar in Hollister Hall, met with master of engineering students in the manufacturing option, toured the Cornell Nanofabrication Facility, and received an overview of the Duffield Hall Project.

•**Charles B. Meyer**, B.E.E. '56, senior staff engineer, Maxtor Corporation, Longmont, Colorado, in response to an editorial query in *Connections* 2000, provides a wealth of information about the infamous takeover of radio station WVBR in the spring of 1952.

Frederick W. Kremkau, B.E.E. '63, M.S. '69 and Ph.D. '72 (University of Rochester), professor and director, Center for Medical Ultrasound, Wake Forest University School of Medicine, Winston-Salem, North Carolina, writes that he has enjoyed his academic career in ultrasound and feels that Cornell gave him a wonderful foundation for his productivity as the field has grown.

Harry Clifton (Clif) Ames III, B.E.E. '64, M.E.E. '68, department manager, Environment and Energy, U.S./Kobe Steel Company, Lorain, Ohio, has retired and is living in Reedville, Virginia. He writes that people say he had to retire in order to take care of his 60-year-old Chris Craft cruiser.

A LINK BETWEEN ALUMNI AND THE SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

In this issue we are continuing the Positive Feedback feature of previous years. The first nine issues of *Connections* triggered a gratifying number of responses. We hope that this issue will stimulate even more readers to return the coupon at the end of this newsletter. The bullets (•) preceding some of the names in the following listing refer to respondents who are mentioned in the "Tales" feature in this issue.

Note for Internet surfers: The ECE School home page may be found at www.ece.cornell.edu. The College of Engineering URL is www.engineering.cornell.edu. The e-mail address for *Connections* is SL78@cornell.edu.

Note: Our alumni file is somewhat incomplete. If you know of EE School alumni who are not receiving *Connections* please urge them to send their names and addresses to Jeanne Subialka, B.S. '99 (ILR), Engineering Public Affairs, 248 Carpenter Hall, Ithaca, NY 14853-5401.

ece ONLINE NEWS

Check Out the New ECE Web Page

The ECE School web page has been extensively modified. The current version contains a guide for enrolled and prospective students, an updated alumni section, and general information about the school and faculty. Visit the new site at www.ece.cornell.edu.

ECE Alumni Online

Alumni may visit the site by clicking on the ECE ALUMNI link of the main ECE School web page.

James O. Moore, B.S. Engr. '64, M.S.E.E. '69 (Rensselaer Polytechnic Institute), director of corporate technology, Moore Products Company, Spring House, Pennsylvania, has retired and is living in Worcester, Pennsylvania. Jim will be the chairman of the CSE Conference in April 2002.

Francis D. Mcleod Jr., B.S. Engr. '65, lecturer, ECE, Cornell University, was a faculty adviser, together with **Albert R. George**, the J. F. Carr Professor of Mechanical Engineering, to the Cornell Formula Society of Automotive Engineers (SAE) Racing Team that swept the collegiate design competition in May 2001.

Thomas B. Silliman II, B.E.E. '69, M.E.E. '70, president, Electronic Research, Chandler, Indiana, was interviewed on the ABC-TV program "20/20" on April 6, 2001. His company designs and builds TV and microwave antennas for installation on very tall buildings. Tom was shown 1,500 feet above ground installing an antenna on the slender tower on top of the Empire State Building.

Jesse J. Jenner, B.S. Engr. '69, J.D. (Harvard University), attorney, Fish and Neave, New York City, was a member of the panel "Aspects of Entrepreneurship" at the CSE conference on April 7, and he led a discussion on "Safeguarding Intellectual Property."

Glenn R. Thoren, B.S. Engr '72 (EP), M.E. '73 (EP), Ph.D. '81 (EE), director, Strategic Technology Development, Sanders, a Lockheed Martin Co., Nashua, New Hampshire, was the CSE Engineering Conference chairman, April 5–7, 2001.

Daniel S. Simpkins, B.S.E.E. '80, M.E.E. '81, founder and president, Salix Technologies, Gaithersburg, Maryland, spoke on the topic "Forecasting the Impact of Future Technologies on Communications and Social Trends" at the CSE Conference on April 5 in the Phillips Hall lounge.

James J. Ricotta, B.S. Engr. '81, M.B.A. (Harvard University) founder and CEO of Internet Software, Sightpath, Waltham, Massachusetts, spoke on the topic "Founding and Funding a Venture-Backed Startup" at the CSE Conference on April 6 in Barnes Hall.

Thomas J. Owens, B.S. Engr. '83, M.E.E. '84, lt. colonel, New York Air National Guard, 138th Fighter Squadron operations officer, Syracuse, New York, was on campus during the 2000–2001 academic year to study for the M.B.A. degree.

David F. Welch, Ph.D. '85 (EE), chief technical officer of SDL, San Jose, California, the Silicon Valley pioneer in semiconductor laser and optoelectronic technology, spoke on the topic "The Emergence of the Fiber-Optic Communication System" at the CSE Conference on April 5 in B17 Upson Hall.

Michael L. Goguen, B.S. Engr. '86, M.S.E.E. (Stanford University), general partner, Sequoia Capital, Menlo Park, California, gave the introductory talk to the Inventors' Fair at the CSE Conference on April 6 in the Upson Hall lounge.

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- ■ Contributions to the Eminent Professors' fund
- ■ Contributions to the Joseph L. Rossen (Papa Joe) Memorial Fund
- ■ Establishment of one-year fellowships for professional master's students
- ■ Engineering Cooperative Program
- ■ Job placement of Cornell EE School seniors or graduate students
- ■ Other _____

Eminent Professors' Fund

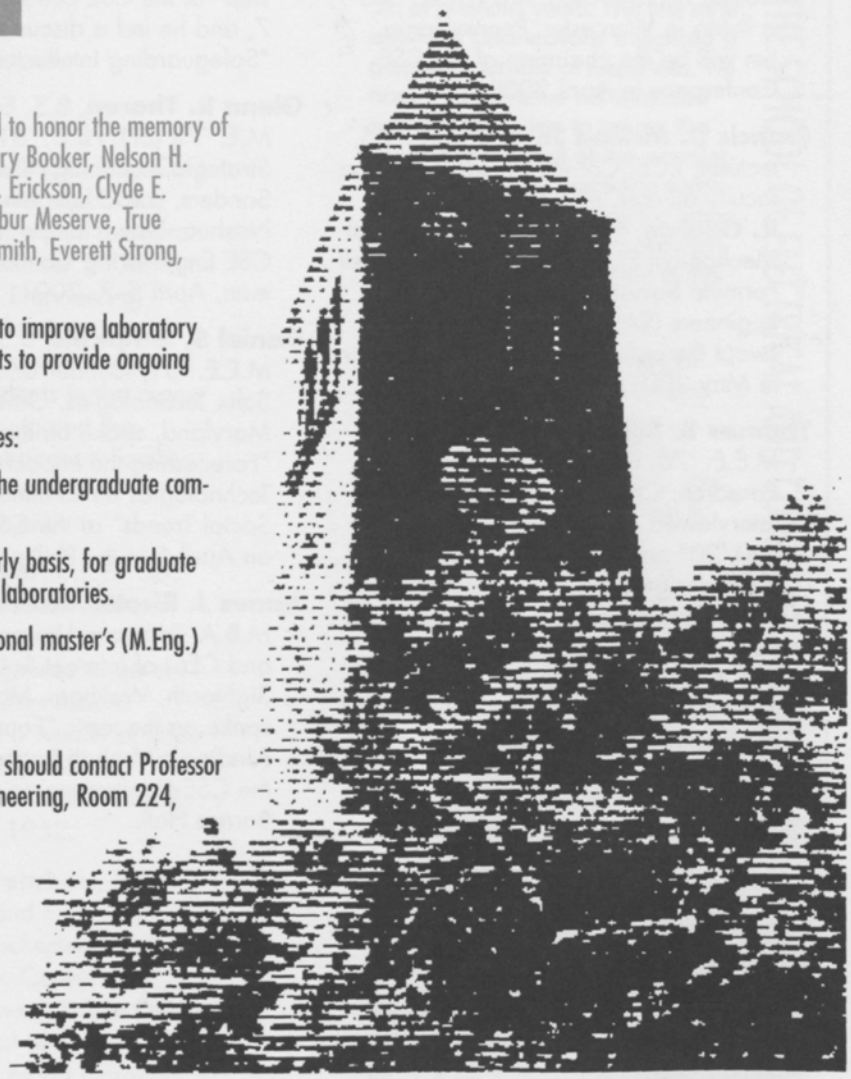
Nine years ago the EE School established the Eminent Professors' Fund to honor the memory of notable members of the EE faculty of past years such as professors Henry Booker, Nelson H. Bryant, L. A. Burckmyer, Walter W. Cotner, Casper L. Cottrell, William H. Erickson, Clyde E. Ingalls, M. Kim, Charles A. Lee, Michel G. Malti, Malcolm S. McIlroy, Wilbur Meserve, True McLean, B. K. Northrop, Robert Osborn, Joseph L. Rosson, Howard G. Smith, Everett Strong, Joseph G. Tarboux, and others whom alumni may recall.

The objectives of the fund are twofold: (1) to acquire specific grants to improve laboratory and research facilities in the ECE School and (2) to establish endowments to provide ongoing financial support for undergraduate and graduate students.

The ECE School has given high-priority status to the following activities:

- Establish an endowment fund to supplement the operating costs of the undergraduate computing center and the undergraduate teaching laboratory.
- Establish an endowment fund to provide financial support, on a yearly basis, for graduate and undergraduate students who serve as teaching assistants in our laboratories.
- Establish one-year fellowships to support candidates for the professional master's (M.Eng.) degree in electrical engineering.
- Establish a fund to support M.Eng. (Electrical) research projects.

Alumni who would like to contribute to the Eminent Professors' Fund should contact Professor Clifford R. Pollock in care of the School of Electrical and Computer Engineering, Room 224, Phillips Hall.



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