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SIGNALS

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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Hidden Treasure

ECE Faculty Write Much-needed Textbooks

By Chuck Benda

There's none of the glitz and glamour associated with writing best sellers—and often little by way of compensation—but current ECE faculty members have written their fair share of textbooks, many of them the best in the business.

At a large research institution, such as the University of Minnesota, with an international reputation for excellence, the institution's other missions—teaching and outreach—sometimes take a back seat to the research activities. A breakthrough in the laboratory is likely to be front-page news (at least in the science and technology press), whereas publication of a much-needed textbook typically isn't news at all. And yet, those very textbooks serve educational and outreach missions of the University, and at the same time, prepare the way for future generations of researchers. Fortunately, Electrical and Computer Engineering (ECE) Department faculty members appreciate the need for quality textbooks.

"It's not necessary for every faculty member to become involved in writing textbooks," says ECE Professor Sachin Sapatnekar, adding that there are other ways to carry out the educational portion of the University's mission. "But it is part of the institution's overall mission. Plus, I think it is an important way of making the Minnesota 'brand name' more visible in the wider academic community."

ECE Professor Stephen Campbell agrees with Sapatnekar, also pointing out that it is critical for researchers to write textbooks in order to ensure the subject matter is current and relevant.

"Textbooks that are written by people who don't do research are obsolete before they're in print," Campbell says. "Real 'cutting-edge' technology is what's happening in the research scientist's laboratory. Their work makes it to meetings and conferences a year later, to academic papers a year after that, and into textbooks two to three years after that. When faculty researchers write textbooks, they provide students with at least a chance to understand areas of technology that are very rapidly changing, and, in many cases, important to the economy, to industry, and to our country."

For the most part, the business of writing textbooks is not particularly lucrative. While some, widely used undergraduate texts, can yield a substantial return to the authors, most do not. And when it comes to writing textbooks for graduate level courses, the pay rate can border on the ridiculous. But, as ECE Professor David Lilja explains, there are other, better reasons to make time for this kind of writing.

"I think it's critical that we write these texts," he says. "It plays a huge role in shaping and guiding the way students learn—not only at the University of Minnesota, but at other institutions, too."

"Having textbooks that are as current as possible helps students get ready to tackle advanced work quicker," adds ECE Professor Keshab Parhi.

Judging from the number of textbooks written and/or edited by current ECE faculty members—for now, more than a dozen and a half and growing—

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Lilja to Succeed Kaveh as Department Head

Professor David Lilja will assume the duties of head of the Department of Electrical and Computer Engineering on May 1. Lilja replaces Professor Mostafa Kaveh, who had served as head of the department since 1990.

"I'm very honored and excited to have been chosen as the next head of the department," said Lilja. "We've got many challenges ahead of us as the University continues its strategic planning process and as we deal with historic changes in state funding. Fortunately, Professor Kaveh has left the department in excellent condition.

Kaveh accepted a three-year appointment as the Institute of Technology's Associate Dean for research and planning in March. His duties will include managing the college financial resources, as well as working to identify and promote major research opportunities for IT faculty and enhance collaborations between faculty and industry. You can read his farewell comments in his column. *("Inside Out," page 2.)*

Thank You and Farewell

How time flies when you are having fun! It has been nearly fifteen years since I was given the privilege of heading the Department of Electrical Engineering at a time of major rejuvenation and renewal. Much has changed in the intervening years, but what have remained constant are the support of our program and students by our alumni and friends and the dedication of the faculty and staff for moving the Department to the next level of excellence in teaching, research, and service. In 1993 I wrote my first column in the inaugural issue of *Signals*. In March, I accepted a three-year appointment as the Institute of Technology's Associate Dean for research and planning. This is my last column as department head,

SIGNALS

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Department Head

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PRODUCTION

Chuck Benda, *Managing Editor*
Dawn Mathers, *Designer*

which offers me a chance to review some of the major research activities in the Department during the past fifteen years.

It is useful to provide a perspective on the developments in our field over the past fifteen years, and the Department's activities in some of these developments. The transistor count in the leading microprocessor of 1990 was less than 2 million. This count today is approaching 1 billion, necessitating the recent flurry of activities in nano-electronics to deal with the tremendous device and feature-size reductions that are moving the technology toward the fundamental limits of physics. Before nanotechnology had crept into the popular lexicon, the Department was engaged in cutting-edge research in nanofabrication and molecular and nano-devices and has continued to do so (see *Signals*, 1993, 1996, 1997, 2001). Parallel developments in increasing magnetic storage densities to the incredible levels being used in disks and other storage devices today has benefited from the ground-breaking research by our faculty and students in the science and technology of magnetic storage (*Signals*, 1994). The complexity of designing circuits and systems with such mind-boggling complexity requires major contributions and creativity in the development of computer-aided design tools and techniques and, in special cases, mapping of algorithms to processor architectures. Examples of the Department's leadership in research and education in this area can be found in the descriptions of faculty research in the 1994, 2003 and 2004 issues of *Signals*. The ubiquity of wireless devices and networks was only a dream in 1990. Our faculty and students continue to make major contributions to the techniques and technologies to move wireless systems to greater speeds, higher reliability and lower energy consumption (*Signals* 2000, 2002). Examples of other critical contributions by our faculty and students over the past fifteen years include work on the applications of microelectronics to biomedical and bioanalytical devices and micro-electromechanical systems (MEMS) (*Signals* 1993, 1996, 2004), multimedia and storage systems (*Signals* 1996), materials, RF, optics and photonics (*Signals* 1995, 1997, 2000, 2002, 2005) and electric energy systems and power electronics (1995, 2002, 2003).

The past decade and a half has also been a time of considerable transfer of technology from our laboratories and significant entrepreneurial activities by our alumni and faculty. The results of a newly released survey show that the alumni of the Institute of Technology have founded more than 4000 active companies that are currently generating more than $90 billion in annual revenues. A significant number of these businesses have been founded by ECE alumni, and a list of these companies as well as examples of businesses founded by our faculty can be found in the 2002 issue of *Signals*. Each issue of *Signals* has also highlighted the contributions of at least one of our alumni who have founded businesses or otherwise have made major technical contributions to the field. The complete results of the Institute of Technology Founders Survey can be downloaded at http://www.it.umn.edu/media/IT_Founders_2005.pdf. I am also pleased to report that the Department's history book, a project led by Professor Jim Leger, is nearly complete, and we expect to have the book ready by Fall 2005. An announcement on the book will be posted on our web site, and we look forward to sharing this fascinating book with you.

This past year has once again been a time of major accomplishments by our faculty and students, a number of which have resulted in recognition inside and outside the university, a time of renewal with the new faculty who joined us this year, and those who have decided to become our colleagues next year. This year has also been one of sadness with the passing of two of our distinguished long-term faculty colleagues, Professors Allen Nussbaum and E. Bruce Lee. More on our colleagues who arrived this year, Chris Kim, Nihar Jindal, and Mihailo Jovanovic, and on the life and contributions of Professors Nussbaum and Lee are given in the following pages of this issue of *Signals*. We are very pleased that Drs. Marc Riedel (Ph.D. Caltech, now a post-doc at Caltech), Sang-Hyun Oh (Ph.D. Stanford, now a post-doctoral visitor at UC Santa Barbara) and

Professor Euisik Yoon (Ph.D. Michigan, now a faculty member at KAIST, Korea) will be joining us this coming year. More on these colleagues and their work will appear in the next issue of *Signals*.

We were thrilled by the election of our colleague, Professor Bruce Wollenberg, to the National Academy of Engineering. Bruce's work on electric power grids has had a major impact on the electric energy industry, and his books have been highly regarded educational resources in power systems. We congratulate Bruce on this much-deserved recognition of his many contributions.

I am very pleased to announce the appointment of our colleague Professor David Lilja as the new Head of the ECE Department, effective May 1, 2005. An internationally-recognized scholar on high-performance computer architecture and computer performance analysis, David has been a leader of our computer engineering group, a star teacher and mentor, and an outstanding citizen of the Department and the University. He brings to the job a tremendous vision for leading us to the next level of excellence in scholarship, teaching, and external engagement. Please join me in welcoming Professor Lilja as the new head of the ECE Department. He can be reached at lilja@umn.edu.

As I bid you farewell, I am once again reminded of the enormous generosity of our alumni and friends and the support of our industrial partners and advisors during the past fifteen years. I have had the pleasure meeting and/or communicating with many of you. The endowments that directly support our students and faculty have cumulatively increased in excess of twelve-fold during the past fifteen years. Your contributions have strengthened our department tremendously and I hope you take pride in the improvements of our program and our reputation. We appreciate your trust and will do our best to continue these improvements in the years to come. Thank you very much.

With my best wishes,
M. Kaveh
mos@umn.edu

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the opinions of Campbell, Lilja, Parhi, and Sapatnekar, are shared throughout the department. Following is a look at a number of ECE faculty members who have published textbooks, the reasons behind their choice to do so, as well as some of the trials and tribulations of seeing their projects through to publication.

MOHAMED-SLIM ALOUINI

A natural partnership.

When it came time to write a textbook in his area of specialization, it only seemed natural to Associate Professor Mohamed-Slim Alouini to team-up with former instructor Marvin K. Simon.

"We had written many papers and articles together on the topic, so it seemed natural for us to team up in order to collect all these articles and other material together in our textbook," explains Alouini. "I first met Marvin when I took a class from him when I was a Ph.D. student at Cal-Tech."

Co-author Simon is currently a senior research scientist at NASA's Jet Propulsion Laboratory in Pasadena, California. Although they had written extensively in this area, when he and Alouini decided to turn their collective efforts to a textbook, it took them a good part of a year—including most of the summer of 1999—to do the job right.

"We had to collect a number of other research papers on the topic, as well as find a way to incorporate a lot of tutorial material into the text," Alouini explains.

Their text—*Digital Communication Over Generalized Fading Channels: a Unified Approach to Performance Analysis*—was published by Wiley and Sons, Inc. in 2000. It wasn't long, however, before they recognized a need to revise their original effort.

"From 2000 to 2004 there was a tremendous amount of new research work done on the topic," Alouini says. "That includes work done by Marvin and by me, work done by some of my Ph.D. students, as well as work done by a number of other researchers around the world."

Alouini and Simon devoted much of their Spring and Fall in 2004 to revising their text, and it was republished with a shortened title, now simply: *Digital Communication Over Generalized Fading Channels*. The hardest part, according to Alouini, was formulating a good outline, and then simply getting started. Once that was done, the rest of the pieces fell into place, he says.

"There isn't a particularly wide audience for this book, since it focuses on a very specific area of research, but it covers most of the topics in the area—including the most recent ones—very thoroughly," says Alouini. "I don't use it in teaching my classes because I need something with a wider scope, but it is a good resource for both graduate students and researchers working in wireless communication systems. And, it can also serve practicing engineers."

STEPHEN CAMPBELL

A great experience—to go through one time!

Like many of his colleagues, Professor Stephen Campbell decided to write his first textbook—*The Science and Engineering of Microelectronic Fabrication*—because he couldn't find any good existing textbooks for the classes he was teaching; in this case, courses in basic and advanced microelectronics.

So in 1991, he began writing. And he kept writing. And writing. Five years and more than six hundred printed pages later, the first edition was published. He revised it once for the second edition, published in 2001, and he may revise it one more time, but that's likely to be the last time. And, he doesn't think he'll be writing any new texts any time soon.

"Not long after the text was published, I sat down and did a few calculations," says Campbell, smiling. "I figured I had been paid somewhere around a dollar an hour for my efforts."

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> "I felt compelled to write these books. And then, when you get a positive response from others, it's very satisfying."
>
> — DAVID LILJA

His tallies placed the time it took to write his text at about 5,000 hours. And yet, he's still glad he decided to do it.

"I don't think I'd tackle writing another textbook at this stage in my career," Campbell muses. "I think it's a great thing to do early in one's career. It really helped me gain exposure and establish my professional reputation."

It also bolstered his research program, he says. It helped secure funding, identify possible collaborators on research projects, and helped him move comfortably from topic to topic in his research.

"It keeps you on your toes," Campbell says, "because you're forced to review the literature outside your immediate area of interest."

And, although it certainly hasn't made him bundles of cash, after it had been on the market for a while, it became popular enough that it boosted that initial hourly pay rate several times over.

"At one time, the text was being used at about 50 schools in the United States, as well as schools in Western Europe, Korea, and elsewhere," Campbell says. "It's even been translated into Chinese."

In fact, it was named the "Outstanding Foreign Technical Book in China" in 2003. The text, which draws on Campbell's research and laboratory experience designing and fabricating microelectronic machines and other devices, surveys the gamut of techniques for fabricating micro or nano structures and devices of all kinds.

The most important reward Campbell has received because of the text he wrote, however, is the satisfaction of knowing he produced a book that became widely used, and offered students some exposure to material that was about as close to state-of-the-art as is possible in a textbook for a field as rapidly changing as microelectronics.

VLADIMIR CHERKASSKY

A labor of love.

"Writing graduate-level textbooks is one of the few human activities for which highly educated people willingly accept compensation below the minimum wage level," quips ECE Professor Vladimir Cherkassky, adding, however, that there are other valuable rewards. "The moral satisfaction of creating something that is useful to others helps make it worthwhile. As does the recognition you sometimes receive from others."

Cherkassky, working with Filip Mulier, one of his graduate students, wrote *Learning from Data: Concepts, Theory, and Methods* published by Wiley in 1998. The book he wrote, which took three years to complete, has been used for graduate level classes at several universities around the world, including Stanford University, Helsinki University of Technology, and Rensselaer Polytechnic Institute, to name a few. It examines various approaches to developing useful models from available (historical) data, where "useful" refers to models that have good generalization or prediction capability for future data. And, like many of the books written by his colleagues, Cherkassky's book was written because no other texts dealt with the subject adequately.

"At that time, much of what had been written about predictive learning was very esoteric; highly mathematical and theoretical," Cherkassky explains. "We wanted to produce a book that would be useful to students, as well as to engineers and practitioners."

In so doing, both Cherkassky and his co-author benefited in ways they didn't anticipate beforehand.

"Scientific papers are typically much more narrowly focused than textbooks," he says. "Writing a textbook forced us to broaden our view of this field. As we went forward, we began to better understand the connections between many of the subfields within our research specialty."

Cherkassky went on to explain that once a scientist begins to broaden his or her horizons and make those connections between the sub-specialties, a new picture of reality begins to emerge. It seems, while it might not be true that there is nothing new under the sun, even in the realm of cutting-edge science, there are very few completely original ideas.

"We discovered that there are some algorithms that were developed in one field, say neural networks, using a biological motivation, that are nearly identical to algorithms developed in another field (say, statistics) motivated by completely different principles," Cherkassky says.

He also noted that writing a textbook and broadening his view of scientific research enabled him to develop and present his perspectives upon the world in which he works.

"At some point in your academic career, rather than to simply continue to publish research papers, I think it's important to summarize your personal point of view of the field," he concludes.

DAVID LILJA

Bringing a new point of view to an old subject.

About eight or nine years ago, ECE Professor David Lilja began teaching a graduate level course in computer design, organization and architecture.

He soon discovered that his options were limited when it came to textbooks.

"There were no books available that covered what I wanted to cover in the way that I wanted to cover it," says Lilja. "It had become apparent to me that, as a field,

we didn't do very good job of using statistical tools to measure and analyze the results of our research. We often focused on things such as improving the clock rate, but seldom stopped to analyze our results to determine what the overall gains were. I wanted to provide students with that kind of an approach to our field."

The result was Lilja's first textbook: *Measuring Computer Performance; A Practitioner's Guide*. The text, which was published in 2000 by Cambridge University Press, has since been adopted by a number of schools around the world—and it is apparently still finding an ever-wider audience. Lilja, who said he was very pleased with the way the book turned out, noted that the publisher recently shipped a couple of dozen copies to Norway. Looking back, he finds the original motivation and the process of writing and publishing a textbook somewhat ironic.

In addition to the exposure and attention from around the world, Lilja noted another outcome that was quite unexpected.

"When I started, I viewed this book as a way to provide students with the necessary tools to do the kind of research I was doing," he recalls. "Since the book was published, however, I found myself expanding my research, and have since published six papers that are extensions of ideas that I first covered in the textbook."

Lilja also found himself motivated to join forces with fellow ECE Professor Sachin Sapatnekar on a second text, *Designing Digital Computer Systems With Verilog*.

"This one's a little more straightforward," Lilja explains. "It's for a senior level course, and it's intended to provide students with a lower level approach to computer organization from the hardware side of things. 'Verilog' is a programming language for designing hardware. While there are many books written on how to write Verilog, there were no books out there that teach students specifically how to design a processor using Verilog."

The motivation for writing both texts was similar: recognizing a need and filling it.

"You get a bee in your bonnet and sort of feel like you have to do it," he says. "I felt compelled to write these books. And then, when you get a positive response from others, it's very satisfying."

The next time Lilja starts teaching a class and can't find a suitable textbook, the students needn't worry about what they'll have to work from. Their professor will probably just write a new one.

NED MOHAN

Outside the norms.

ECE Professor Ned Mohan's first textbook (written with two co-authors, including ECE Professor William Robbins)—*Power Electronics: Converters, Applications and Design*—

achieved a rare level of success in the world of textbooks, becoming literally a bestseller. Now in its third edition, the book has been extraordinarily successful. It has been translated into Chinese, Greek, and Korean and used around the world, all of which took Mohan by surprise.

"We decided to write that first book—which was published in 1988—simply because the other available books and become pretty much outdated," Mohan says. "We didn't have any idea about how many schools even offered power electronics courses, let alone what the demand for a new text might be."

The demand, as it turned out was pretty high. At the height of its popularity, the book was being used in 105 colleges and universities in the United States alone, according to Mohan. The success of that first book convinced Mohan to keep on writing textbooks. He has since completed a book on advanced electric drives, and has self-published three other textbooks, an approach that has allowed him to provide those texts to University of Minnesota students free of charge.

"That first book took us about six years to write," Mohan recalls, "and it was a lot of work. But the success motivated me to keep going. It really benefits the students. When you bring your research into the classroom through a good textbook, it keeps the students involved and excited. And it gives them a much higher platform from which to go forward."

In the textbooks he has written and published since the first one, Mohan covers "twice the number of topics with twice the depth." The self-published texts are titled *Advanced Electric Drives: Analysis, Control and Modeling using Simulink®* (2001), *Electric Drives: An Integrative Approach* (2003), and *First Course on Power Electronics and Drives* (2003).

"The work can be very tedious," Mohan explains. "Especially developing the problems and solutions, and drawing the figures, and so on. But I've taken the approach that it just sort of comes with the territory.

"It's not that every faculty member should be writing textbooks," he continues. "But education is one of our primary missions—and writing textbooks is part of that. Students—especially undergraduate students—need good textbooks, and I think they should be written by people who are actively engaged in research and not just writers."

Mohan is currently working on a text in the area of power systems. In all likelihood, he will self-publish that book as well. But, if he ever sees that one of the self-published texts begins to show the universal appeal of his original text, he's likely to take it to a well-known academic publisher.

"That's the way to go if you want to get it publicized worldwide," he says.

In the meantime, the self-publishing approach seems to be working well. Besides, being able to offer his students the texts for free is something that just feels right.

KESHAB PARHI

Rising to the challenge.

Despite the fact that ECE Professor Keshab Parhi is a prolific writer, having written two textbooks, and written or edited five more books (not to mention the ongoing array of scientific and research papers that is the typical in the world of academia) he still finds writing textbooks a very challenging undertaking.

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Treasure, continued from p. 5

> "I wanted to create a book that would stand the test of time, by focusing on some of the underlying principles that do not change with time." —KASHAB PARHI

"It was easy enough to come up with the primary subject matter," says Parhi, referring to the process of writing one of his textbooks: *VLSI Digital Signal Processing Systems: Design and Implementation*, published in 1999. "By the time I taught the class six or seven times, working from published papers instead of a textbook, I had developed all the material I needed for the basic text."

That basic material, however, had to be supplemented with homework problems and exercises, according to Parhi, and it all had to be written in a way so that it wouldn't quickly become outdated.

"I wanted to create a book that would stand the test of time, by focusing on some of the underlying principles that do not change with time," he says. "The hardest part of writing the book was deciding on which topics to include in order to meet that goal."

Parhi also found it quite challenging to find a way to synthesize information that was outside his personal areas of expertise so that it could be presented in one or two lectures.

Roughly 40 percent of the material in the textbook is based Parhi's own research; the other 60 percent was developed from research and scientific papers. Oftentimes he had to read as many as 20 research papers on each of these areas in order to adequately cover the subject matter.

The challenges and hard work didn't take away from the personal satisfaction Parhi feels over having written a book that has become widely used and garnered a fair bit of acclaim.

"I get emails from around the world from people who have read my book," he says. "It is widely used, not only by students, but by practicing engineers, as well."

Now in its sixth printing, Parhi's textbook has been translated into Chinese and is used by universities in countries around the world, including India, Taiwan, Greece, and Holland. He was honored for the textbook with the 2004 Frederick Emmons Terman Award, presented by the Electrical and Computer Engineering Division of the American Society of Engineering Education.

Although it will eventually become outdated, it has done well to last this long. Time has already shifted some perspectives. When first published, the book was considered an advanced treatment of the subject matter, appropriate for use with accomplished graduate students. Today, it is considered more "introductory" and is used for first-year graduate courses and sometimes for undergraduate courses at the senior level.

And yet, Parhi did well in striving to write the book in a way that would stand the test of time. It is still considered the best textbook available on the subject matter, six years after it was first published.

Not bad in a realm of technology where "cutting-edge" often becomes passé in six months.

SACHIN SAPATNEKAR

He just keeps going, and going, and going!

Like many of his colleagues, ECE Professor Sachin Sapatnekar didn't get into the textbook writing business for the money.

"If you tried to do some sort of cost/benefit analysis before you started, you definitely wouldn't go through with it," he jokes.

And yet Sapatnekar has written, edited, or co-written five different textbooks, including one—*Designing Digital Computer Systems With Verilog* —with fellow ECE faculty member David Lilja.

"David was the major contributor to that book," says Sapatnekar, "but I was able to add to it because I had some expertise in complimentary areas. Each book has it's own story."

Some of the texts for which Sapatnekar served as a co-author were collaborations with either an advisor or a graduate student. One started out as a student's Ph.D. thesis. Another—*Timing*, for which Sapatnekar was the sole author—sort of grew out of the lecture notes he developed for a class he was teaching.

"The hardest part is getting all the details right," he says. "It's not that hard to put something together—you already have all your lecture notes to work from. But it's hard to put it together in a way that actually *works*."

The writing itself forced him to become more complete and thorough with his thoughts and ideas, according to Sapatnekar. And it pushed him to develop more expertise in areas outside his own research interests.

"I found myself spending lots of time looking information up," he says.

Although the financial returns on his investment of time in writing textbooks have been minimal, Sapatnekar believes that the effort has been well worth it. One ancillary benefit is the "notoriety" that comes with being a textbook author. It generates conversation at conferences, plays a minor role in securing research funding, and also helps attract top graduate students. Plus, Sapatnekar simply enjoys writing.

"It's been nice enough that now I'm doing it again," he says. "I'm helping to compile a handbook on the physical design of integrated circuits, for use with a graduate level course, as well as a reference book for practitioners."

Who knows when it will end?

GUILLERMO SAPIRO

Why don't you write a book?

When a visitor got a look at the lecture notes ECE Professor Guillermo Sapiro was using for one of his graduate courses, he suggested that he try to find a publisher and "make these into a book."

"He saw that my notes were fairly advanced," says Sapiro, who had taught the introductory graduate level course, as well as more advanced ones, on image processing a number of times. "It seemed like a good idea at the time. I didn't realize how hard it would prove to turn those notes into a decent textbook."

Sapiro didn't have any trouble finding a publisher. There weren't many other texts available on image processing using Partial Differential Equations, the topic of his lecture notes and area of research. He did struggle, however, with putting the "wrapping" on it, as he calls the process of polishing his notes and thoughts, and blending in his research scientist's expertise on the subject matter.

"Even though I had all the technical material gathered together, I still had to find a way to make it *look* nicer, and that was a lot of work," he says.

Fortunately, his publisher (Cambridge University Press) assigned a professional writer to work with him and help him smooth out the rough spots. The end result was: *Geometric Partial Differential Equations and Image Processing*, published in January 2001. One thing Sapiro enjoyed about writing a book for a graduate course was the greater freedom he was allowed in terms of injecting his own point of view, something that's not typically done with undergraduate texts.

"I did my best to make sure that the readers would understand that I was being subjective," he adds.

As is so often the case for textbook authors, the monetary rewards pale in comparison to the satisfaction of doing a good job, and the occasional bit of recognition one receives from those who have used the book.

"It's kind of fun when somebody shows up at a conference with the book in hand, walks up to you and says: 'Is this you?'" Sapiro says. "We don't write these things to make money. The goal is to make the material accessible to as many people as possible." ■

IN MEMORIUM

E. Bruce Lee, 1932 – 2005

E. Bruce Lee, the Vincentine Hermes-Luh Professor of Electrical and Computer Engineering and an Institute of Technology Distinguished Professor, passed away on April 15 at age 73.

Lee, who joined the faculty in 1963 as an associate professor, earned his bachelor's and master's degrees in mechanical engineering from the University of North Dakota in 1955 and 1956, respectively. He earned his Ph.D. degree in mechanical engineering from the University of Minnesota in 1960, and worked for Honeywell, Inc. for three years as a senior research scientist prior to joining the electrical engineering department.

Lee was promoted to the rank of full professor in 1966, served as the acting head of the Department of Computer Science 1969-1970, as the head of the Department of Electrical Engineering, 1976-1982, and again as the acting head of the EE Department in 1983-1984. He was a founder of the Center for Control Science and Dynamical Systems, and was its co-director for many years. His other academic appointments included Visiting Professor, Caltech, 1968, Senior Visiting Fellow, Science Research Council (England), 1968-1972, Visiting Professor, Technical University of Warsaw, 1976-1979, Universite de Montreal, Candada, 1978, and the University of Florida, 1983

Lee led the Systems and Controls Group in Electrical Engineering for many years. His reputation in this area helped attract some of the most outstanding control scientists and engineers in the world to Minnesota. He supervised more than 50 doctoral dissertations and numerous masters' theses. His book, *Foundations of Optimal Control Theory*, Wiley, 1967, co-authored with L. Markus, is considered one of the most influential textbooks in this area.

Lee was elected a Fellow of the IEEE in 1986 and a Foreign Member of the Polish Academy of Sciences in 2000. He received the Warsaw University of Technology Medal for the development of control theory and establishment of cooperative research with Polish scientists.

To honor Lee, the Department has launched a campaign to raise funds for the E. Bruce Lee Fellowship endowment. To contribute to this fund, contact the ECE Department or the University of Minnesota Foundation.

Allen Nussbaum, 1920 – 2005

Professor Emeritus **Allen Nussbaum** passed away January 5 at age 85. Nussbaum, who retired in 1988, joined the University of Minnesota Electrical Engineering Department faculty in 1962. He served as its director of Graduate Studies for more than two decades.

Nussbaum earned his bachelor's degree in chemistry (1939) and his master's degree in physics (1940) from the University of Pennsylvania. He served in the U.S. Air Force as a radar officer from 1941 to 1950. After completing his stint in the armed forces, Nussbaum went back to school at the University of Pennsylvania, where he earned his Ph.D. in solid-state physics in 1954.

In 1962, after a brief stint in the private sector, Nussbaum joined the faculty of the Electrical Engineering Department, where he specialized in the physics of heterojunctions and PN junctions, and advanced geometrical optics.

In addition to 35 scientific and educational papers, Nussbaum wrote eight books, and served on the editorial boards of *Solid State Electronics* and *IEEE Transactions on Education*. He was a Life Fellow of the IEEE. From 1971-72, he served as a Fulbright Visiting Professor at Hebrew University in Jerusalem.

Nussbaum is survived by his wife, Barbara; four children, three grandchildren, and a great-grandson. In his honor, family members established the Allen Nussbaum Scholarship Fund. Those wishing to contribute to this fund as a memorial can do so through the University of Minnesota Foundation.

Gary Glover (B.S. '64, M.S. '65, Ph.D. '69)

The Luck of the Well-Prepared

"I've been lucky all my life to end up in places and with jobs that turned out well for me," says Gary Glover, modestly accounting for a career that includes success at the highest levels of both private business and academia. "And I've been fortunate to get the opportunity to work with a lot of talented people who have been very enthusiastic and passionate about their work."

A bit of luck here, a fortunate encounter there—to listen to Glover, who is currently head of the Radiological Science Lab at Stanford University, you'd think his successful career is largely the result of happenstance. The events of his life, however, suggest that, as the saying goes, his "luck" was largely the result of preparation meeting up with opportunity. In fact, you might say he began preparing to get "lucky" at age five.

"It seems as if I've always been interested in electronics and electricity. Glover says. "I built my first radio at age five. My father helped me wind the coils."

Although he's not sure what ignited his passion for science and technology in the first place, he credits his father—a salesman with a penchant for tinkering with antique automobiles—for helping it along.

"He was always supportive, and often helped me with my projects," Glover remembers.

Before long, Glover had his own "laboratory" in the basement of their Minneapolis home. Among the projects he built in that lab during his grade school through high school years were a television camera, radio-controlled cars and airplanes, and an infrared tracker with a parabolic reflector. Glover's passion for science and technology didn't fade with his teenage years; in fact, it may have grown stronger.

"There was never any question in my mind that I would attend the University of Minnesota," he says. "I had visited some of the campus libraries a number of times as a high school student—and it was always this incredibly cool place I wanted to go to."

Glover likens his arrival on campus to the opening scenes of the "Mary Tyler Moore Show" television sitcom, in which Moore first steps onto the streets of Minneapolis and throws her hat into the air.

"I suppose it wasn't quite so dramatic," he recalls, " but I remember a palpable feeling that my time at the University was going to be nothing but one big, wide open opportunity."

Glover's time at the University met with—and in many ways, exceeded—his expectations. Among the faculty members he remembers most are Bill Peria and Keith Champlin. As an undergraduate, Glover worked as a technician in Peria's lab where he made good use of his talent for building things. At the same time, he got to observe Peria at work, giving him his first exposure to someone doing "good science." Champlin was Glover's graduate adviser, and an experience he remembers most from that encounter was a little less positive in nature—but it had an even bigger long-term impact.

"When I brought in the first draft of my master's thesis and showed it to Champlin, I think he was fairly horrified by my writing," says Glover. "He sat down with me and went over the first paragraph, word by word and together, we rewrote it. He taught me the importance of precision in writing scientific papers and it was a lesson I never forgot."

When Glover completed his education in 1969 (having earned his bachelor's, master's and Ph.D. degrees, all in electrical engineering, all from the University of Minnesota), the opportunities for academic positions were rather limited, so he took a job in the private sector. He went to work as a physicist for General Electric at their Corporate Research and Development Center in Schenectady, New York.

> "I remember a palpable feeling that my time at the University was going to be nothing but one big, wide open opportunity."

At first, he became involved with research related to hot-electron semiconductors, which paralleled the work he'd done for his Ph.D. thesis. But a tragic event in the mid-1970s changed everything.

"My lab partner's wife died of breast cancer," Glover remembers. "She was a very young woman, and it was very sad. It proved to be a defining moment in my career, as I decided to change the focus of my research and work on things that could more directly help people."

His research work at GE already included work on ultrasound, so Glover began studying ways that ultrasound could be used to scan for cancer cells within breast tissue. He built a breast scanner that he put in a hospital in Albany, New York. Then he began working on algorithms for use with X-ray Computed Tomography (CT). In 1977, Glover moved to GE's Applied Sciences Laboratory at its Medical Systems division in Milwaukee. There he continued his X-ray CT research for a

few more years, before moving on to magnetic resonance imaging (MRI).

"The Medical Systems laboratory was a great place to work," Glover says. "The people I worked with were really enthused about what they were doing. Our work was good basic science, engineering, and mathematics—and it was for something that could be really useful for humanity. We worked long hours, and were excited to do so."

Nonetheless, when he was approached to return to academia in 1990, he jumped at the offer. He had just completed a four-month sabbatical at Stanford, which had reignited his passion for university life, when he was offered the opportunity to start a radiological laboratory.

"Even though I had just built a new home on a beautiful lake, I debated all of about 20 milliseconds before I agreed to the change," Glover says. "It turned out to be just what I needed. I love students, and working with them, and it gave me the opportunity to continue my research in imaging."

Today, the Stanford Radiological Science Lab has 10 faculty members and houses some 60 graduate students, post-doctoral students and research scientists as well as additional technicians and support personnel. Counting the dozens of others who work in the lab using its MRI and computing facilities, Glover interacts with nearly 100 students on a regular basis.

In addition to heading up the Radiological lab, Glover holds faculty appointments in Stanford's radiology, biophysics, and neurosciences programs. He also has courtesy appointments in the electrical engineering and psychology departments. Glover's research has evolved to encompass the physics and mathematics associated with advanced magnetic resonance imaging. He has developed the methodology for mapping cortical brain function by imaging changes in the oxygen content in the blood within the brain. (Increased metabolic activity associated with brain activity impacts the oxygen content in the blood, which can be detected using the methods Glover and others have developed.)

Already this new form of MRI can help neurological surgeons in the preplanning stages of brain surgery, when they must attempt to determine what sort of activity is taking place in and around the surgery areas.

Among other honors and accolades, Glover has been named a fellow of the American Institute for Medical and Biological Engineering and the International Society for Magnetic Resonance in Medicine (ISMRM). The ISMRM awarded him its gold medal in 2000 for "significant research" in basic MRI physics. In 2001, the Radiological Society of North America gave him its Outstanding Researcher Award, citing him as a distinguished academic scientist in the radiological sciences "whose teaching and laboratory research are the gold standard of our profession."

More than anything else, it is Glover's passion for what he does that has driven him to success. He encourages his students to seek out that same passion. In fact, he has three pieces of advice he offers to every student he works with in his lab:

Be passionate about what you do; that will drive everything else.

Have fun.

Like each other.

It doesn't take very long, just talking to Glover, to realize he practices what he preaches.

At age 63, Glover has certainly earned the right to begin to taper down and consider a life of somewhat more leisure—but he has no such plans.

"I'm having a wonderful time, working with the students," he says. "It's fantastic.

"I don't plan to retire until they have to pry my pencil from my cold, dead hands."

He is, indeed, a lucky man ■

ALUMNI NEWS

Stein Wins Design Excellence Award

Richard Stein (1977) received a 2004 Medical Design Excellence Gold Award from the *Medical Device & Diagnostic Industry* (MD&DI) magazine for his work at Guidant Corporation in developing the Partner Rhythm Assistant. The Partner Rhythm Assistant is a handheld device that enables patients to control and activate their own atrial defibrillation. Used in conjunction with Guidant's Vitality AVT implanted defibrillator, the device notifies the patient when the defibrillator should be activated.

"Atrial fibrillation is a debilitating heart disease that results in a compromised lifestyle," says Stein, who is the principal system engineer for Guidant. "We felt there was a potentially large portion of the population that would remain conscious during it and would need to treat their own problem."

The Medical Design Excellence Awards, which are sponsored by MD&DI and Canon Communications, are considered the premier awards program for the medical technology community. The competition jury commended the Partner Rhythm Assistant for its ease of use and for giving patients more power and control over their own treatment.

"People want greater control over their own health than in the past," says Stein. "Ultimately, more patient control could lead to a cheaper healthcare delivery system."

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Something from Nothing

By Chuck Benda

Professor Guillermo Sapiro's "inpainting" algorithms can recreate damaged portions of art masterpieces, generate missing information from surveillance photos, eliminate a moviemaker's faux pas, and more.

It's almost the stuff of an alchemist's dreams: creating something from nothing. Or, more accurately speaking, creating something from next-to-nothing. For it is the areas of images next to the missing portions from which Electrical and Computer Engineering Professor Guillermo Sapiro and his research colleagues uncover the clues they need to generate the missing portions of the images.

For hundreds of years, art conservators have done their best to imagine and recreate damaged or missing portions of paintings. Their work, known as inpainting, is painstakingly laborious—and highly subjective. In essence, they are making their best guess. Although they haven't been at it as long as art conservators, mathematicians and other scientists have been fascinated by the challenge of trying to recreate missing portions of images for a number of years, as well. Following attendance at a French conference on imaging in the late 1990s, Sapiro decided he would take a stab at "partial differential equation-based interpolation of lost image regions," as the process is known in the language of mathematics.

"When I first decided to investigate this problem, one of my grad students and I visited the Minneapolis Institute of Arts to try to better understand how professionals restore paintings," says Sapiro. "We met with the head of the art conservation department and one of her assistants, asking all kinds of questions about how they go about restoring a damaged painting."

Sapiro, who is a University of Minnesota Distinguished McKnight Professor, made a few visits to the Institute. After watching the conservator at work, he began to get a feel for how the conservator went about restoring damaged paintings.

"She was working on a painting that had a portion of a bridge missing," he recalls. "Working from the edge of the missing portion, she first restored the outlines of the bridge structure, and then added the color and texture."

Sapiro and his research group then set about the business of mimicking the conservators approach through mathematics.

"We had to try to translate what she was doing by hand into algorithms, says Sapiro. "As we began to put it into math, we began to see connections to other, completely independent problems. Some of our equations turned out to be nearly identical to equations used to solve problems in fluid dynamics, and other fields. Once we started to notice these similarities, we were able to exploit them to refine our process."

The end result delighted Sapiro and his colleagues. Their algorithms didn't just enable them to successfully generate missing portions of images. They also possessed a certain aesthetic elegance, which can probably only be fully appreciated by serious mathematicians.

"The moment that we got to the equation that we're using now, it was so clean that it was beautiful," Sapiro recalls. "It's a very, very clean solution. We were able to explain it with just a single slide."

Their "clean" solution formed the basis for an automated inpainting software program that could not only be used to assist in the restoration of old paintings, but could also be used to restore, retouch, and enhance photographs (including espionage photos). In fact, some of the funding for Sapiro's research came from the Office of Naval Research because of their interest in being able to recover missing or damaged portions of surveillance photos—the quality of which is frequently compromised during transmission. Transmitting surveillance images can introduce problems such as blurring or spotting due to channel noise, or completely lose portions of the image during compression prior to transmission. The inpainting algorithms can recover much of this lost information. Sapiro is currently exploring new ways of encoding images so that much smaller quantities of data might be sent (allowing very high speed transmission rates) and still yielding photographs with high levels of resolution.

For image restoration applications—or for removing objects from images, an application that appeals to moviemakers who sometimes discover unwanted objects in the background in their movie scenes—the images must first be translated into a digital form, if they aren't already. The algorithms then analyze the structure, lines, color, and flow of the portions of an image surrounding the missing or damaged portions. The software then restores the missing portions pixel by pixel—working from the region borders inward—by interpolating "trends" in the progression of the image across the damaged or missing areas.

Of course, such software can't replace the work that the art conservators do—but it does provide them at least with a tool that can make their job quicker, easier, and perhaps help yield a better final result.

"Inpainting—whether it be on a watercolor or oil painting or some other medium—can be very difficult and time consuming," says Sapiro. "Our algorithms sometimes don't do as good a job as a conservator, but they could easily be used to do a computerized, simulated restoration that the conservator could then use as a guide for the actual restoration."

Before and after: the photo on the left was restored using Sapiro's inpainting algorithm.

On the other hand, in other applications—such as repairing or restoring damaged or altered photographs, or enhancing surveillance photographs—Sapiro's software could be the basis for completely automated systems that could do the job in seconds. While commercial software companies have developed tools commonly used by photographers and others to retouch photos and movie films, those currently in use are slow and require a large input of human labor. Some firms have begun to look at using the results of Sapiro's research to develop fully automated software to complete such tasks.

Since the results of his initial research into this area were first published in 2000, Sapiro's work has received a great deal of attention. Numerous articles have been published—in both the popular and the scientific press—detailing the enticing possibilities. (go to http://mountains.ece.umn.edu/~guille/inpainting.htm to view some of these articles, as well as more samples of images restored using Sapiro's algorithms.)

Sapiro's work on image inpainting is in part in collaboration with M. Bertalmio, V. Caselles, C. Ballester, A. Bertozzi, S. Osher, L. Yatziv,. J. Verdera, G. Haro, S. Rane, and K. Patwardhan. His work is supported by the Office of Naval Research, The National Science Foundation, the National Geospatial-Intelligence Agency, and the National Institutes of Health.

Leaving to others the commercial development of products based on his research, Sapiro has since expanded the scope of his original research on inpainting, developing techniques to add texture to the images, as well as to work with three-dimensional objects. He's also worked on inpainting software that can recover missing portions of images captured by multiple cameras, such as might be used in security systems. Currently, some of his efforts in this area are in video inpainting as well as still and video image colorization and re-colorization.

The applications for algorithms that can be used to repair, restore, or otherwise manipulate images are almost endless. Some other research areas Sapiro has begun exploring include:

- Image and other data compression for wireless transmission. Sapiro developed loss-less compression algorithms that were used by NASA to transmit all of their scientific data during the recent remote exploration of Mars (work with M. Weinberger and G. Seroussi). Furthermore, he's working on encoding algorithms that enable recovery of jpg images that could reduce transmission time and storage by as much as 30 percent
- Compression algorithms for elevation maps, which are being used by a company doing work for the Office of Naval Research and the National Geospatial-Intelligence Agency
- Brain and other medical imaging, including image processing for uses in tomography (In collaboration with biophysics researchers from the National Institutes of Health, S. Subramaniam and A. Bartesaghi)
- Analysis of high dimensional data (with F. Memoli, D. Rother, and others). One application for the analysis of high dimensional data would be medical imaging, proteins, and neurosciences.

Medical imaging presents other challenges, however, according to Sapiro, in that, by definition inpainting isn't about recovering original information, but rather about making something that looks nice. And making something that "looks nice" has limited value in medical imaging.

Despite all the progress he's made thus far, Sapiro doesn't see this rich area of research drying up anytime soon.

"We haven't solved all the problems related to inpainting—not by any means," he says. "But we have made some radical strides. And we've opened the doors to begin examining some challenging new problems. I feel very lucky to have the opportunity to get involved with this kind of research. It's very exciting."

And still, at least to most of the rest of us, a bit magical. ■

Senior Design Project

Keeping Plants Green and Growing

A cactus in the office of Professor Phil Cohen—overall coordinator for the senior design class—provided the inspiration for a project idea for the group of seniors under the advisement of Professor Jaijeet Roychowdhury.

"Professor Cohen and I were discussing possible project concepts for my design group," says Roychowdhury, "when I noticed that his cactus—which is really quite an impressive plant—wasn't doing very well. In fact, it looked to be dying."

The dying cactus gave life to a project idea for a group of students with which he would be working: design an automated, computer controlled plant-watering system that can be remotely operated. Although the basic concept sounds simple enough, Roychowdhury established project parameters that would test the design group and require them to solve problems in programming, hardware design, cost containment, and overall system innovation.

Roychowdhury directed the students to develop a plant watering system that included:

- The capability to water up to five plants
- Enough power to pump water to distances of 30 feet and heights of 12 feet
- A moisture sensor to determine when to water
- Control via a Linux computer
- The ability to provide remote notification regarding water levels in the supply tank
- An overall cost under $200

"The project presented them with a number of design choices and challenges—many of them involving subject matter they hadn't covered in any classes," says Roychowdhury.

One of the stickiest issues to be resolved, however, had to do with the cost constraints placed on the project and the matter of the pumps to be used to move the water from the

storage tank to the plants. Off-the-shelf pumps carried by most suppliers that could meet the project requirements typically cost in the neighborhood of $100, according to Roychowdhury.

Ben Fuchs, one of the senior students working on the project, came up with an ingenious solution: automotive windshield washer pumps. Not only were the compact units capable of meeting the pumping requirements, but they also had very low power requirements and they could be had for about $12 each.

Even so, the student team—which also included Josh Brechtel, Brittany Peterson, Ryan Pruess, and Andrew Ward—ran into a few other problems when it came to power supply. Originally, they designed and built their own printed circuit board, but supply lines to the pumps were not sufficiently robust to handle the current load, so the group switched to prefabricated strips.

"These students impressed me in a number of ways," says Roychowdhury. "The basic requirement was simply for them to design a system and get it working before the end of the semester. They went above and beyond the basic requirements in a number of ways."

Before the semester was half over, they had their system up and running, thus meeting their basic course requirements. And that included an up-front search (not required by Roychowdhury) for existing plant watering systems, which revealed that nothing was commercially available that met either the objectives or the price range of the product they sought to create. After they got their system running, they continued to go above and beyond what was required of them to refine their final product. That included packaging the entire system in an old computer case, fabricating a sturdy aluminum water storage tank, developing user-friendly software complete with a graphic user interface, and writing a user manual.

"They came up with a number of innovations along the way," says Roychowdhury. "It seems that whenever they ran into problems, they were able to solve them quickly, and usually in a very nice way."

One of those solutions was using specialty MOSFETS (metal oxide semiconductor field-effect transistors) to handle switching for the pumps—an innovation that resolved some of their power supply issues and helped them stay within cost constraints. (These MOSFETS—which are about the size of a paper clip—cost only $1 each.)

As the project evolved, Fuchs took on the role of group leader and, according to Roychowdhury, provided the driving force that helped the group succeed. For Fuchs, much of the work—such as fabricating the aluminum storage tank—was old hat.

"My brother and I have a complete metal shop in our basement and developed a lot of our knowledge and skill in this area building go-carts and four-wheelers and so on," says Fuchs, who enjoyed his role as a team leader.

Designing the circuitry wasn't anything new for Fuchs, either, who had tackled more complicated design projects as part of his internship for Cummins Power. Fuchs, who graduated in December, is now employed as an engineer for Cummins (a division of Cummins, Inc.) at their Fridley,

Minnesota facility. When it came time to debug the circuitry, however, Fuchs became stumped.

"It wasn't one of those predictable bugs," he says, "One of the engineers at Cummins helped me zero in on the problem."

By the time the design group finished, they had created a fairly polished product that, according to Roychowdhury, isn't very far removed from being market-ready. The system, which can also be plugged into a personal computer, can be set up to automatically monitor and water up to five plants for approximately one month. If the user is going to be gone longer than that, it also has the capability to notify someone via email if and when the water storage tank needs to be refilled.

"This was a remarkable group of students," says Roychowdhury. "I've advised senior design projects three or four times now, and I've never seen a group like this. They were enthusiastic and innovative and took great satisfaction in solving the problems they came up against. And, I think they left the project with more confidence and greater capabilities than they had going in." ■

FACULTY UPDATE

"Further Results on Selective Multiuser Diversity," a paper co-authored by Assistant Professor **Mohamed-Slim Alouini**, his graduate student Lin Yang and Professor D. Gesbert from Eurecom, France, received the Best Paper Award at the 7th ACM/IEEE International Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems in Venice, Italy, on October 7, 2004.

Professor **Georgios Giannakis** received the 2004 George Taylor Distinguished Research Award from the University of Minnesota Institute of Technology. Giannakis—along with co-authors and former students Z. Wang and Y. Xin—also recently received the IEEE Guglielmo Marconi Best Paper Award for "Space-Time Diversity Systems based on Linear Constellation Precoding."

The paper "Robust Adaptive Beamforming Using Worst-Case Performance Optimization: A Solution to the Signal Mismatch Problem," published in the IEEE Transactions on Signal Processing, February 2003, co-authored by Drs. S. Vorobyov and A. Gershman of McMaster University, and Professor **Tom Luo** has been selected to receive a Best Paper Award from the IEEE Signal Processing Society.

Professor **Jae Moon** has been elected a Fellow of the IEEE, effective January 1, 2005, for "contributions to signal processing and coding for magnetic recording."

Professor **Keshab Parhi** was selected by The Electrical and Computer Engineering Division of the American Society of Engineering Education (ASEE) as the recipient of the 2004 Frederick Emmons Terman Award. The Terman Award is bestowed annually upon an outstanding young electrical engineering educator in recognition of the educator's contributions to the profession. One of Parhi's graduate students, Xinmiao Zhang recently received awards for a pair of papers co-authored by Parhi.

The paper "Fast PLL Simulation Using Nonlinear VCO Macromodels for Accurate Prediction of Jitter and Cycle-Slipping due to Loop Non-idealities and Supply Noise," by graduate students Xiaolue Lai, Yayun Wan, and Associate Professor **Jaijeet Roychowdhury** has received the Best Paper Award of the 2005 Asian South Pacific Design Automation Conference, (ASP-DAC), held January 18-21 2005 in Shanghai.

Professor **Guillermo Sapiro** received a University of Minnesota 2004 Distinguished McKnight University Professorship. McKnight Professorships are intended to recognize and reward the University's most outstanding mid-career faculty. Sapiro also has been selected to serve on the editorial board of the SIAM interdisciplinary journal called "Multiscale Modeling and Simulation" (MMS), which was launched in 2003.

Assistant Professor **Beth Stadler** was elected to a three-year term on the Board of Directors of the Materials Research Society (MRS).

Professor **Randall Victora** has been elected the President of the IEEE Magnetics Society for the years 2009 and 2010. Professor Victora will serve the Magnetics Society as Secretary Treasurer in 2005 and 2006, and Vice President in 2007 and 2008.

Wollenberg Elected to NAE

Professor **Bruce Wollenberg** has been elected to the National Academy of Engineering (NAE) for "Contributions to control centers for electric power grids and to power engineering education." NAE membership is among the highest professional distinctions accorded an engineer. Only 74 new members and 10 foreign associates were elected to the NAE in 2005.

Wollenberg is Director of Graduate Studies for the Electrical and Computer Engineering Department, as well as director of the University of Minnesota Center for Electric Energy. He earned both his bachelor's degree (1964) in electrical engineering and his master's degree (1966) in mechanical engineering from Rensselaer Polytechnic Institute. He earned his Ph.D. degree from the University of Pennsylvania in 1974.

Prior to joining the ECE department, Wollenberg worked for Control Data Corporation, where he received their Technical Excellence Award. He is also a Fellow of the IEEE.

New Faculty Members

Trio of New Faculty Members Bolsters ECE's Research Strengths, Diversity

Assistant Professor **Nihar Jindal** began to feel at home rather early in the interview process.

"I immediately liked the 'family' atmosphere within the department," says Jindal. "You could tell right away that people really collaborated with one another and spent time together just talking about their research interests."

A native of the Bay Area of California, Jindal earned his bachelor's degree in electrical engineering/computer science from the University of California, Berkeley in 1999. He earned his master's (2001) and doctoral (2004) degrees in electrical engineering from Stanford University.

Jindal soon discovered that the familial and collaborative atmosphere he noticed during the interview process wasn't just for show. When he joined the ECE department faculty in the fall of 2004, he had already been included on two research proposals. Although Jindal has already published nearly 20 journal and conference papers, he was very appreciative of being included on the research proposals.

Jindal has received a University of Minnesota grant-in-aid to assist him in establishing a research program. He has yet to hire research assistants, but as he gets his program going, he hopes to explore the fundamental limits related to multiple transmitters and multiple receivers in wireless communications.

Jindal also has set some rather ambitious goals for the classroom. In fact, he began his teaching career this spring teaching a new advanced course—Multi-user Information Theory—based on his research interests. He also hopes to teach a probability course in the near future.

Although the Minnesota climate was a bit of shocker to this native Californian, Jindal is excited about the prospect of exploring his new home state. He and his wife have already made a visit to the North Shore of Lake Superior. And he hopes they will soon be able to make time for a trip to the Boundary Waters Canoe Area Wilderness. In the meantime, he has his hands full at the University.

"Usually, I'm pretty active as far as athletics," Jindal says. "I like to play basketball, tennis, and golf—I guess those things will have to wait for the time being."

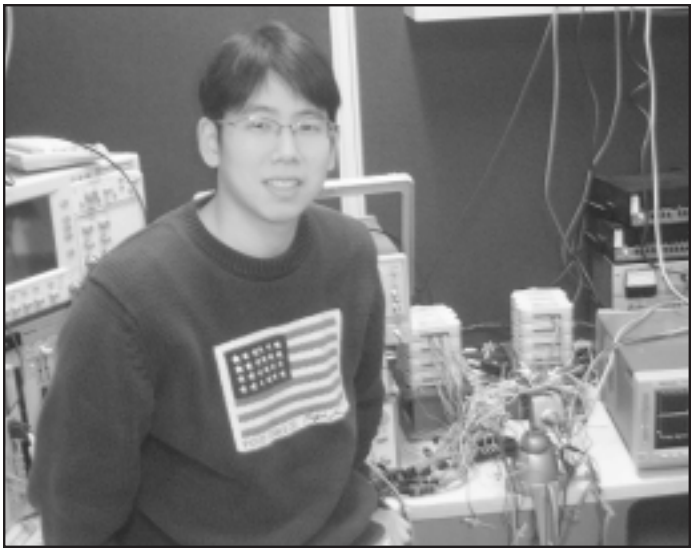
It's a good thing he also likes doing research and teaching.

It may be awhile before he finds much free time.

For Assistant Professor **Chris Hyung-Il Kim,** the Electrical and Computer Engineering Department at the University of Minnesota provided an almost ideal match. Kim, whose research specialty is very large-scale integrated (VLSI) circuit design, said there isn't another school out there that can compare.

"The program here is very diverse and strong," said Kim, who joined the ECE department faculty in fall 2004. "VLSI chip design is a fairly broad field, with many different sub-areas such

Nihar Jindal



Chris Hyung-Il Kim

> "I immediately liked the 'family' atmosphere within the department. You could tell right away that people really collaborated with one another and spent time together just talking about their research interests."
>
> —NIHAR JINDAL

as digital design, analog design, and computer architecture, for example. We have people in each field who are very good at what they're doing."

Born in Seoul, Korea, Kim earned his undergraduate degree (electrical engineering, 1998) and master's degree (biomedical engineering, 2000) at Seoul National University in his hometown. He earned his Ph.D. degree in electrical and computer engineering from Purdue University in 2004. Kim worked as a research assistant at Purdue and as a graduate technical intern for Intel Corporation.

He's already authored or co-authored more than 20 journal and conference papers and one book chapter. His work at Intel led to a patent for a sensor that can measure the manufacturing variability present on VLSI chips. He's excited about getting the opportunity to continue that research in Minnesota because of the opportunity he has to talk and collaborate with the ECE department's accomplished faculty.

"It's very difficult to solve research problems working from a single area of specialization," says Kim. "I believe that to be successful, you have to talk to others who work in different VLSI domains, and collaborate with them in order to come up with innovative ideas."

Since arriving at the University of Minnesota, Kim has received a grant-in-aid from the University and funding from Intel. He's already hired a couple of graduate students and is busy exploring possible ways to reduce the variability that's introduced to chips through manufacturing and develop more robust designs.

Although he hasn't had much time for his social life as of yet, Kim likes being in Minnesota for another reason. The Twin Cities offer many opportunities to try new restaurants and explore cultural events.

"Purdue's located in a pretty small town," he says. "I feel a bit more at home here."

The opportunity to collaborate—both in the department and with colleagues from other departments—played a big role in Assistant Professor **Mihailo Jovanovic's** decision to pursue an appointment with the ECE Department at the University of Minnesota.

"My research is at the interface of dynamical systems and control theory," says Jovanovic, whose research interests focus on the modeling, analysis, and control of spatially distributed systems. "It was really important to me to find a place that encourages interdisciplinary research. I expect at some point to collaborate with colleagues from the Institute for Mathematics and its Applications, Aerospace Engineering, and Mechanical Engineering—and all of those programs are strong here."

Jovanovic intends to research automated control systems for formations of unmanned vehicles that would enable them to achieve their control objectives simply by exchanging information with the vehicles in their immediate proximity. He also plans to study modeling and control of transition to turbulence in wall-bounded fluid flows (such as air flowing over the wing of an airplane or water over the surface of a submarine).

"This kind of turbulence creates skin-friction drag on airplanes, ships, and submarines," he says. "It causes large losses in fuel. We need to understand why it happens, and develop efficient control strategies."

Although now a permanent resident of the United States, Jovanovic is a citizen of Serbia and Montenegro. He earned his undergraduate degree (1995) and master's degree (1998) in mechanical engineering from the University of Belgrade. He earned his Ph.D. degree in 2004 from the University of California, Santa Barbara. Prior to joining the ECE faculty in December of 2004, he completed a three-month stint as a visiting researcher at the Royal Institute of Technology in Stockholm, Sweden.

Jovanovic—who was honored as the best student in his class of approximately 500 upon completing his undergraduate education at the University of Belgrade—approaches his teaching responsibilities with enthusiasm. He has received a lot of support from senior faculty members, such as Professor Tryphon Georgiou, who, along with some of Jovanovic's previous professors, shared lecture notes, homework assignments, and other advice on how to structure classes.

"Teaching a class the first time through requires a lot of work," he says. "It really helps junior faculty members to get support from those with more experience."

Like his fellow new faculty members, Jovanovic hasn't found himself with much free time on his hands, but if and when he does, he hopes to use it to get more active physically.

"I'm somewhat of a sports freak," he confesses. "I really like to work out and play soccer and basketball." ■

2004-2005

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