conduit!

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Brown University

TECHNOLOGY, TEACHING AND LEARNING IN HIGHER EDUCATION: A DIALOGUE

Chairman Tom Dean

Prologue

Brown may get into the distance-learning business. The university is currently discussing among the faculty and negotiating with possible business partners about whether and how Brown wants to make courses available on the World Wide Web. The hotly debated issues run the gamut from intellectual property rights to worries about the danger of commercialism and the threat to traditional, bricks-and-mortar institutions.

But long before anyone ever talked about business models for education on the Web, Brown was known for its innovative use of technology in the classroom and for its use of workstations, markup languages, graphics and animation, and interactive forums both in the classroom itself and as supplements for classroom experiences.

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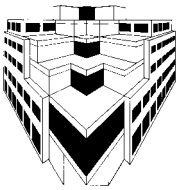
Many of us in computer science love to experiment with technology in the classroom and, for the most part, our students love to participate in these experiments. However, careful study of the pedagogical value of using various technologies is rare in general and almost non-existent in computer science.

The following discussion between Tom Dean (TLD) and Roger Blumberg (RBB) was prompted by a piece Roger wrote for last January's *The Teaching Exchange*, published by the Harriet W. Sheridan Center for Teaching and Learning at Brown. (The full text of Roger's piece can be found at *http://sheridan-center.stg.brown.edu/teachingExchange/*.)

Roger, who teaches CS92, our educational software course, often finds himself in the role of a critic regarding the use of technology. This is not really fair. Roger is, in fact, quite active in exploring the use of computer technology in education—he simply knows more about it than most of his colleagues in the CS department and he wants to educate those around him whose love of technology might distract them from tough thinking about its value. Roger's *Teaching Exchange* article, "Lessons from Consumerism: Faculty Thinking About Instructional Technology," begins with the following quotation from Nobel Laureate Octavio Paz:

> *The worship of the idea of technology involves a decline in the value of all other ideas.*



Perhaps a bit extreme, but it was used primarily for effect—to give pause, and possibly to temper the enthusiasm of technology zealots. The following dialogue (actually several discussions reconstructed and combined to achieve some semblance of coherence) occurred after Tom read Roger's piece and found his scholarly approach to the subject refreshing and possibly helpful in mapping out some strategies for employing technology in the classroom.

TLD: Distance learning is all the rage, but while it has some interesting opportunities and challenges, I believe it is only a small part of what we should be thinking about.

RBB: I agree, and I worry that people who advocate distance education as an obvious part of the university's future haven't thought through the issues very clearly. There seems to be a pervasive assumption, for example, that new technology by itself can somehow transform the "old" models of distance education (e.g. correspondence courses, or television and telephone "courses") into a qualitatively different educational experience.

TLD: I'm very interested in exploring more interactive learning environments and developing courses in which the collaborative component—both working on projects together and learning from one another—is central. This seems especially valuable in courses that require expertise and background from several disciplines, such as your "CS92: Educational Software" and David Laidlaw's "CS295-6: Scientific Visualization." Both of these courses also involve real problem solving and exposure to the people who need the problems solved. I'm currently reading *The Social Life of Information*, by John Seely Brown and Paul Duguid, and their remarks on learning and practice strike me as particularly pertinent to much of what we're talking about. Here's something I read last night:

> *Practice, then, both shapes and supports learning. We wouldn't need to labor this point so heavily were it not that unenlightened teaching and training often pulls in the opposite direction. First, they tend to isolate people from the sorts of ongoing practice of work itself. And, second, they focus heavily on information. (Ch. 5, p. 129)*

Boy, does that ever echo the comments I've heard from a number of our students. And I certainly empathize with them, recalling my own undergraduate frustrations trying to link the content of my courses with the events going on around me (in my first incarnation as a college student, I was a journalism student at Marquette University interested in social and political issues—I dropped out when I discovered how out of touch my teachers were with the real world). However, as excited as I am about such alternative ways of teaching, I'm also wary. First of all, my guess is that highly interactive courses would need smaller classes to be effective and hence require more time from existing faculty or more faculty.

RBB: When I planned the 1996 Hypermedia Teaching and Technology conference (*www.stg.brown.edu/edu/HTT96/*), I looked for successful K-12 and undergraduate models of distance education, by which I meant distance teaching/learning experiences that were comparable educationally (in the eyes of teachers and students) to experiences offered locally. I found very few, and those I did find showed your guess to be correct. The successful cases had been as or more expensive to carry out than had each institution involved offered its own course locally. On the other hand, some students in these distance education situations were pleased with the opportunity to learn from faculty to whom they would not have otherwise had access. Of course, not all students think this sort of televised access is worthwhile or even engaging.

TLD: In talking with students, I've also come to realize that some of them really like the more traditional chalk-talk style of teaching in which lecturers pace their presentation by writing on the board and modulate the presentation with a combination of text and diagrams on the board and a running monologue punctuated with questions and answers. Some students don't do well in group projects, while others bloom. And, practically speaking, we just can't do it all, meticulously tailoring the educational experience to each student's particular needs.

RBB: New technologies always seem to wreak havoc with the spatial and temporal

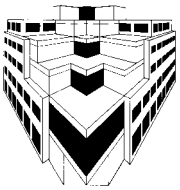
boundaries we accept as natural, often leaving us not remembering why exactly we do things the way we do, and what we're discussing illustrates this nicely. For example, how important is it really for a college class to convene? How important is synchronous communication to the educative experience? How important is the physicality of the traditional classroom to educational richness? How much control ought students to have over and in their educational experiences? It's interesting that these questions are not so different from recent controversial questions about college curricula (e.g., How important is it for students to study a common core of material or be exposed to a common set of questions/issues?).

One set of answers implied by what you say about students is that the different spatiotemporal features of educational environments probably have different value(s) for different learners. But I worry that if we treat all questions about educational communities as reducible to questions about individual "consumer" preferences, we lose something very valuable, or at least something that has characterized a successful model of liberal arts undergraduate education for several generations. In any case, I think the force with which the technology now calls our attention to these non-technical "aims of education" issues is impressive.

TLD: I see educational technology cropping up in many guises in our department, some of which seem inevitable and appropriate and others worrisome. Certainly our discipline requires us to provide courses in which students learn about technology or learn to use technology. Brown students also have a tradition of thinking about using technology to assist in learning. This also seems appropriate—for technologists to be generators of ideas for educational technology. Most of us are not trained to evaluate the value of such educational uses but, especially combined with the sort of training and experience you provide in CS92, it does seem reasonable for us to help generate ideas. For example, I think it's great that Tom Doeppner's "CS196-5: Networks" is experimenting with wireless computing as the primary means for sharing and annotating lecture notes and exchanging news and assignments; just putting the technology in the students' hands is a great motivator.

I suppose the area that I'm most concerned with is the actual use of technology in service of learning: fancy simu-

Tea Tsar Keith Hall took this digital photo of his fellow grad students at the weekly afternoon tea where "As always, a delectable selection of cookies, tea and hot chocolate" was served



lators, visualization tools, workstations in the classroom for displaying slides, animations, and supplementary information. All these technologies are fun to think about and they appeal to the nerdy tool user in most of us, but I've seen no convincing results that they have any real pedagogical value. But having just uttered the words, I have to admit I'm fuzzy on what having "real pedagogical value" really means.

RBB: You point to the great problem in educational technology: we know that the educational value of any tool is nothing *inherent* in the tool itself, but rather depends on the purpose to which it is put. But then what can we really say about the pedagogical value of using a tool *per se*? It may well be that "pedagogical value" is a many-place predicate involving a particular tool or technique, a particular teacher, a particular student, and perhaps even particular subjects, times and places. Similarly—and this was something I tried to make clear in the *Teaching Exchange* piece—we can't depend on the *technology* to give us conceptual clarity about our educational ends.

"we can't depend on technology to give us conceptual clarity about our educational ends"

TLD: I want to pick up on something you said earlier. Despite what we may think about the importance of content and the care we put into organizing our lecture notes, my guess is that these aspects really play a small role compared to the educational experience of working with other students and interacting with faculty and grad students in less structured circumstances. If this is true, then we should spend more time enhancing these aspects of the undergraduate experience and experimenting with alternative methods.

RBB: I agree that there are interesting possibilities for using living and study spaces at the University more creatively and to better educational effect, especially by integrating networked technologies. But I don't agree that organization and presentation of course content play a small role or should play a small role in the educational experience of an undergraduate; of course they *can* play a small role if these things are handled poorly!

TLD: It may be just the particular students I've been exposed to, but Brown students seem more than a little impatient with structured interaction and have little appreciation or stomach for subjects that require discipline. That's not to say they don't have drive, ambition or persistence; I think the problem is they don't trust that what we're teaching them and the problems they're being asked to solve are worth their time. I think they'd like to learn everything "by doing," and to be driven by solving particular problems, preferably cool problems like designing software for games and robots and potentially lucrative e-commerce applications. Here's another quote from the book by John Seely Brown and Paul Duguid:

> *People learn in response to need. When people cannot see the need for what's being taught, they ignore it, reject it, or fail to assimilate it in any meaningful way.* (Ch. 5, p. 136)

RBB: Their picture of learning here seems heavily cropped, and in any case I don't think it describes what goes on in college very accurately. For example, in a discussion of learning theories in CS92 this semester, the student leading the discussion (Gary Ault) began by asking everyone to give examples of what they had learned most recently. It was a great exercise and, as you can imagine, the examples were extremely diverse, and the range was far more broad than could be accounted for by any serious notion of "need." We learn all sorts of things all the time, especially but not only when we try to learn, and when we trust or simply admire a teacher we often learn things well before we really understand their significance. True, if we never have occasion to apply what we've learned or recognize its significance, we are "unlikely to assimilate it in any meaningful way;" but this says remarkably little about the *learning* part.

I also think it's worthwhile to distinguish between what the students are capable of doing and what they *want* to do at some

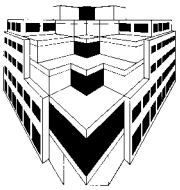
Tom Dean and Roger Blumberg continue their dialogue over coffee

particular stage of their education. Part of Brown's appeal to the many bright high-schoolers who apply is its willingness to let students' choices determine the better part of their undergraduate education, and no doubt a student choice model will favor fashion and hot topics—however you wish to categorize something like "e-commerce"—over traditionally or historically determined topics. Academic departments offering concentrations at Brown often need to temper student choice in order to have students complete work and have intellectual experiences the faculty considers important. Often these kinds of experiences and work are not especially popular with the students, but that doesn't mean the students cannot and do not benefit from the requirements, nor does it mean they wouldn't benefit even more were student preference not considered the most important arbiter of Brown's undergraduate experience.

TLD: I think the image some of the students have of the ideal academic experience is that they work on what are to them obviously relevant problems, they bang their heads against the problems and work with their smart colleagues, and then when they're really up against a barrier they come to us as the font of knowledge and are given the boost to surmount their hurdles. Faculty are occasionally useful in knowing about problems, contacts, or interesting tricks but are otherwise peripheral to the learning experience. The assumption is that when the students see the need then they'll apply themselves diligently to obtaining the necessary expertise. It's not obvious to me that this isn't an excellent way to run an institution of higher learning and that in many cases—or for many students—this might be the most effective method of teaching/learning.

RBB: Well, you've just described nicely the model for *graduate* higher education, and this raises the topic everyone seems to be dancing around these days, from distance-education folks to those who talk about the reinvention and/or corporatization of the university. The topic is this: What is an undergraduate education for and what should characterize the undergraduate (as opposed to the high-school or graduate-school) experience? I would argue that, once the Cold War ended and globalization became the dominant call to arms, most American universities set aside these questions, and have quickly become at a loss to answer them convincingly (as small colleges, perhaps, are not).

The question I think you are raising directly is this: leaving aside the fact that a graduate model for undergraduate education is not obviously applicable to many and perhaps most academic disciplines, should undergraduate education simply be a preliminary version of graduate education? Do you think this is desirable and would work in computer science?



My own view is that the computer science curriculum at an *undergraduate* liberal arts institution ought to provide and promote experiences that are broader, more philosophical/ historical and more diversely technical, than those found in the graduate CS curriculum. For example, I think undergraduate concentrators in CS ought to have some historical understanding of the field and of technology generally (e.g. so they can *interpret* the current e-commerce craze in interesting ways), and not just what they might pick up incidentally by reading *WIRED* or news on the Web or the trades. It's interesting to me that many students do seek out this sort of thing on their own, but it certainly isn't something integral to the CS experience here (or anywhere that I know of).

TLD: As you're aware, I'm taking a stance for the sake of discussion and paraphrasing some of the comments that students have made—students frustrated with being fed information they don't consider relevant. I certainly don't advocate abdicating our responsibilities to guide students and make sure that they have a solid foundation in computer science. We'll be spending a good deal of time discussing the curriculum at this year's faculty retreat. These discussions often center around traditional subject matter involving computational models, analytical techniques, design methods and the like, but the justifications are typically couched in terms of practice. I have no intention of pandering to the students' desire to work on nifty problems all the time, but I do think we can go a long way toward motivating and integrating the basic knowledge we believe our students need with practice. I also know from experience that a really seamless integration is hard to achieve.

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And I'm still talking about computer science; the integration of the broader topics of a liberal arts education is an even more daunting challenge. I'm always shocked at how difficult it is to engage our students on social or political issues as they relate to computer technology—all too often there are huge gaps in context that bring our conversations grinding to a halt. Too often their arguments are culled from *WIRED* or they parrot something they've read on a bulletin board. They have little knowledge of, respect for, or patience with the writings of long dead scholars. I'm exaggerating, but these stilted conversations leave me worried, because I would hope that Brown in particular would produce citizen-scientists who could broker the discussions between technologists and the broader citizenry. But we're moving too far afield.

RBB: On the one hand, I think that students' notions of "relevant" are often a trap; being in favor of relevance is as obvious as opposing "irrelevance," but we have to be careful about what we actually mean by the term. I know that the Columbia mathematics requirement was dropped in the 1960s as a result of student opposition to its "irrelevance"—one can reconstruct what they had in mind, perhaps, but it doesn't have very much to do with mathematics. On the other hand, I know that in computer science the situation is complicated by the fact that certain sorts of technical skills are expected of (and prized in) a Brown computer science concentrator and the field is changing in ways and with speed that one doesn't encounter in art history, philosophy and even physics. The question of how to balance foundations and topics courses, breadth and depth in the curriculum, is of course a difficult one in every discipline these days, and I know everyone in the Department is very grateful to you for taking all these ideas and the students' interests as seriously as you do.

TLD: Thanks, Roger. I've enjoyed these conversations and I hope we'll continue them. I'd like to see our discussion broadened to include the larger Brown community. Perhaps next year the CS Department could sponsor a distinguished speaker series on the use and evaluation

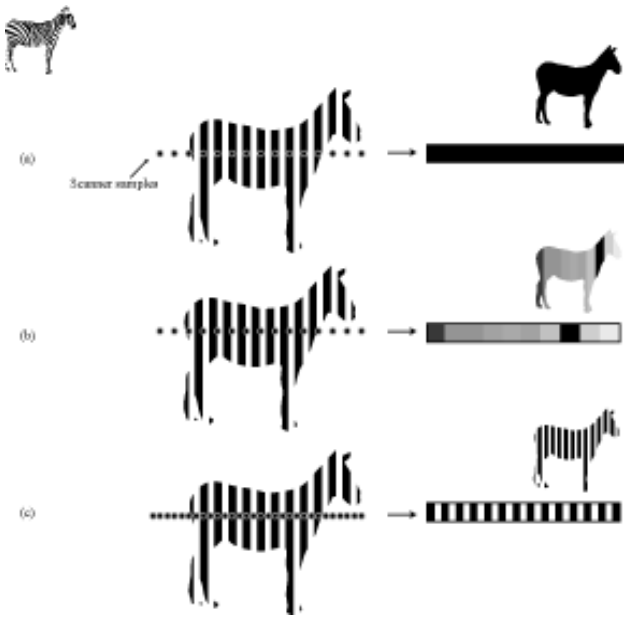
of technology in education. The new technologies and in particular their broad availability appear to provide amazing new opportunities, but they also require a lot of effort to assess and understand. Perhaps it might also be worthwhile sponsoring a university-wide forum on the broader social implications of computing and communication technologies. Sometimes I wonder if I'm just too close to the subject, so that it fills up my view of the world; but I can't help but believe the pundits when they predict that there is a revolution afoot—one spurred by technology but by no means controlled or guided by the technologists. I think it's essential for this revolution to be discussed and guided by as diverse a community as possible.

SIGGRAPH '99

John Hughes

When last I wrote about SIGGRAPH '99, I talked only about the technical papers, but there's lots more to SIGGRAPH than that—the show floor, the Brown reunion dinner, the film-and-video show, and (at a slightly higher level of respectability) the panels, the education program, and other venues for new ideas. Anne Morgan Spalter and Rosemary Simpson helped me prepare this summary of some of these other venues in which Brown folks were involved.

Andy van Dam was a member of a panel on "Scene Graph APIs: Wired or Tired?" that examined whether the "scene graph" model of graphics, in which a graphics display system maintains a model hierarchy in parallel to an application's model hierarchy, would survive in the long term. There's been substantial controversy on this topic and the panel was quite lively.



Scanning resolution and aliasing.

(a) The number of samples per inch is the same as the spacing of the black lines in the stylized zebra. In addition, in this case, they are perfectly aligned. The resulting zebra is entirely black. (b) The number of samples per inch is the same, but they are not aligned with the stripes. The areas contributing to each sample often include both black and white, resulting in a grayish final pixel value and an oddly striped zebra. (c) The number of samples is twice the number of stripes per inch and captures the striping. Even if it were offset somewhat, the striping would still be pretty good.

Course on Art and Computer Graphics

Anne Morgan Spalter gave a very popular course for artists, designers, and anyone curious about how the technical and artistic sides of computer graphics can come together, called "Why Does It Do That? 10 Mysteries of Computer Artmaking Revealed." The mysteries included "#1: What Am I Really Seeing When I Zoom In?," which led to a discussion of pixels as point locations and sample values (not little squares) and their use in photoediting. Art examples demonstrating the power of the pixel included Michele's Turre's "Me, My Mother, and My Girl, at Age 3," a photocomposite of three generations of her family all playing together as three-year-olds. Mystery #5, "What Resolution Should I Scan at and Why?," got particularly good feedback from attendees and was demonstrated with an interactive teaching applet for scanning a herd of zebras at different resolutions (see figure). Mystery #9, "Why Do Color Printouts Look So Different From Color on the Screen?," generated questions, discussion, and mutual sympathy amongst the audience members.

Scott Klemmer '99, who graduated with a double major in CS and Art/Semiotics and is now a Ph.D. student working on HCIs at Berkeley, was a co-presenter and designed the look and feel of the slides as well as several interactive demonstrations of concepts, such as the scanning applet mentioned above. Slides from the course (including artworks) and relevant sample chapters of Spalter's book **The Computer in the Visual Arts** can be seen at *http://www.cs.brown.edu/people/ams/mysteries/*.

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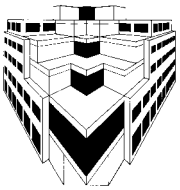


The Color Playground

The Playground, an interactive exhibit in the Education Program, showcased two series of interactive Java applets for teaching some aspects of color theory. The first, aimed more at artists, dealt with additive and subtractive color mixing; the second, aimed more at programmers (not that these categories are mutually exclusive!), presented color perception through a signal-processing approach. The Playground included original work by Jeff Beall (A.B. '96, Sc.M. '98), Adam Doppelt (Sc.B. '97), John Hughes, Jesse Kocher (A.B. '99), and Anne Spalter. The Color Playground Web site, which can be seen at *http://www.cs.brown.edu/exploratory-/ColorWeb/*, was put together by Robert Ben George, who also did considerable applet hacking, and Anne Morgan Spalter.

"Exploratories" Paper at the Electronic Schoolhouse

Rosemary Simpson presented a paper (written with Anne Morgan Spalter and Andy van Dam) "Exploratories: An Educational Strategy for the 21st Century" that addressed the question of what computer-based learning environment students of all ages will be immersed in five, 10, or 20 years from now. They advocated "exploratories"—which combine features of an exploratorium and a laboratory—as a part of that environment, and showed demos of some of the exploratories in CS123, the introductory computer graphics course, which has been used as a testbed to discover what sorts of interactive experiences work best to teach new ideas.

Food

And finally, there was record attendance at the Brown reunion dinner—about 90 people showed up, including current students, alumni/ae, babies (future graphics students?), former visiting faculty, and (of course) current faculty.

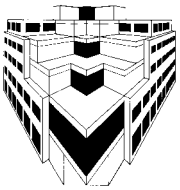
"LA BASTILLE"

Yes, that's really Tetris on an entire building!

A giant building, a video game, and a "final exam" for a career at Brown.

CS15 is widely known as "the course where everyone writes Tetris," so many of us had written our own versions in our first two months as freshmen. Now, with only a few months left before graduation, we had to prove we had actually taken something away from our college careers. If freshmen can put Tetris in a Java Applet, why shouldn't juniors and seniors be able to put it on the SciLi? What could better demonstrate our progress than taking our first major software project and scaling it up by four years of experience?

That attitude, in addition to a general will to turn imagination into circuitry, pushed the members of Technology House from the dreaming phase to the design phase in January of this year. Ten thousand Christmas lights were purchased before the second semester began; we didn't exactly have an industrial operating budget for this project (under $700 for the whole endeavor), and we couldn't pass up the post-holiday discounts. Wood was enthusiastically smashed to pieces to prepare the frames that would hang our lights in the library windows. Regular trips to the SciLi (Sciences Library) gave us a layout of each floor. Frequent discussions with deans won us the cooperation of the administration. Soldering irons were fired up for three months straight. In short, the Techhouse machine was in full gear—by the end of March, all but a few skeptics (the author included, I admit) really believed that Tetris would light up the SciLi before the semester was over.



But a tremendous number of design hurdles still stood in the way, even during spring break, when we finally wired up the building. Two Ethernet cables were carefully lowered from the library's 13th floor to our "base camp," where a Linux machine controlled the whole building from its parparallel port. Our plan was to run a carefully clocked five volts to controller boards on each floor; each board would watch the portion of the "bus" reserved for addressing, and store data into a local register when the address matched its own. Those registers were directly connected to relays that controlled the strings of Christmas lights, which got 120V power from outlets near the windows.

Part of the Tetris team (which actually included over twenty students) poses with Steve Wozniak, founder of Apple Computing, who came just to visit our display. From left : Brett Heath-Wlaz (CS '01), Ryan Evans (CS '00), Lord Woz, Clara Kim (Bio/RS, '02), Dan Morris (Neuroscience '00), Soren Spies (CS/EE '00), Neel Joshi (CS '00). Among others notably absent from this photo was head artist Nik Lochmatow (Art History '01)

Surprisingly, wiring went well. The switches were reliable. Even the software was completely functional, due, of course, to our fine training in extensible, well-commented code (that was actually a lie for the benefit of our professors; the code was complete swill). But as of a couple days before "opening day," slated for the first Friday in April, overall functionality was still pretty abysmal. We simply hadn't anticipated the immense challenges of running five volts up a 150' cable, nor had we anticipated the nondeterminism that results from having wires loosely connected to each other all over a building.

So we responded as all good CS majors would—we went two weeks without sleeping, and basically moved into the SciLi. We desperately ran up and down the stairs, soldering and re-soldering our boards, tweaking constants in our software, and generally adjusting every parameter that we could think to adjust. And, with literally an hour left before our already-postponed opening ceremony, we finally saw a successful diagnostic test.

All that was left was the "final exam"—a game of Tetris. There was a general attitude of "if this works, we can graduate." Our radio system was quiet when we announced to the team outside the building that we were about to link against "libscili" and give the final product a test run. After some hesitation, we ran the Tetris software that had patiently spent weeks waiting for the hardware to be ready, and the cheers over the radio told us that a semester of work had paid off. Tetris was on the SciLi, in 150' splendor.

The first time a Tetris piece successfully fell down our gameboards in CS15 was exciting. Seeing it on the SciLi was incredible. So now only one question remains: exactly how large is four years of experience at Brown? For what it's worth, "La Bastille" is approximately 50,000 times larger in area than CS15's average game of Tetris.

Maybe we should all stay for graduate degrees, and put Tetris on the moon.

—Dan Morris, on behalf of Technology House

The Faculty Retreat was held in April at URI's Whispering Pines Conference Center. In attendance (l to r), top row: Maurice Herlihy, Amy Greenwald, John Savage, Franco Preparata, Nancy Pollard, Tom Doeppner, Andy van Dam, and Roberto, Tamassia, bottom row: Tom Dean, Steve Reiss, Thomas Hofmann, and Philip Klein. This is a composite picture with the head shots taken from five separate takes

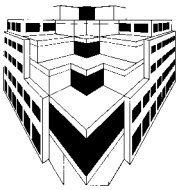
NEW CS FACULTY

Amy Greenwald graces a sculpture in the quad in front of the CIT building

From a very early age Amy Greenwald knew that computers and mathematics were for her. More than half the women in science are from families of all girls; as the oldest of three daughters, Amy certainly fits this profile.

When her father came home with a computer for his own amusement, it was Amy who played with it most. She was the first kid on the block to have a computer—an Apple II+. In the fourth grade she enjoyed programming on a PET computer that had a 4 x 6" screen and a cassette tape! By sixth grade she was handing in computer-generated science labs—her friends laughed when she said it was easier (easier, so long as she remembered to save her work!). Her superfast typing often crashed the system. Amy's middle sister, Carolyn, liked English and is now a lawyer; Michele, her youngest sister, is going to med school like her father. Her father is a research doctor and her mother has a PhD in psychology; with a PhD like her mother, Amy is pursuing a research career like her father.

As an undergraduate she undertook a dual-degree program, graduating from U. Penn. with Bachelor of Science degrees in economics and engineering. Her first research experience presented itself in her junior year when she put a summer internship from J.P. Morgan on hold, hoping to land a research job. She was offered a three-month position at the Weizmann Institute in Israel—a fabulous experience which led her to savor the researcher's way of life and turned her into a zealous traveler. After graduating, she won a Thouron Award, and spent a year at Oxford on scholarship completing an MSc in computation, specializing in logic, proof theory and programming languages.



She loves outdoor activities (backpacking, hiking, tennis, softball) and cultural activities, reveling in museums, castles, cathedrals and ruins. As traveling is a favorite pastime, Amy spent three months in southeast Asia after Oxford, deferring further graduate work. Then, admitted by places like Stanford, MIT and Cornell, she chose Cornell because both sisters were there. After two years, however, both sisters graduated and Amy split, taking a leave of absence to restore her equilibrium. After traveling the world, Amy found her home city, New York, to be her haven. She audited courses at CUNY before deciding to continue graduate studies at NYU. Still soul-searching, she audited a course on game theory and immediately saw a connection between it and distributed agent environments. This became the topic for her graduate work and current research.

Despite growing up on Long Island, Amy is a confirmed city-dweller. She misses New York City very much but finds that living in Boston gives her access to plenty of cultural activities, although the excitement of Manhattan is impossible to duplicate. She commutes by train and looks forward to the fun of riding the new Acela system. One of the big surprises Amy found in Providence was its abundance of excellent restaurants—on a par, she feels, with those in NYC. For a beach lover, she's certainly in the right state—her aunt owns property in Quonochontaug and she spends many hours on the beach. With nothing to distract her, Amy finds she does her best work to the sound of the ocean.

This promises to be a busy summer with at least five conferences, one abroad, and mentoring responsibilities for the Computing Research Association's Distributed Mentor Program, which places women interested in a research career with other women researchers in their area of interest. The program complements one of Amy's goals as a CS professor—to inspire young women to pursue degrees in math and science. To this end, she will be hosting two undergraduate women with research interests in AI this summer—one from Bucknell, the other from USC. The final two weeks of the summer will find her extended family at Quonochontaug for some well-deserved R&R in RI. When she returns, Amy is looking forward to the Grace Hopper Meeting of Women in Computing, to be held on Cape Cod in September.

ALUMNI EMAILS

MARY TAFFS '75

It's been a number of months since I wrote, flush with the excitement of selling my first two books to Awe-Struck E-Books. In the intervening months, those books have been published and are selling reasonably well. **Martha's Madness**, the first one out, was nominated for best e-book cover art and best e-published novel. It didn't win, but it was a huge thrill, anyway.

My third book came out electronically at the end of March. It's called **Stitches from the Heart**. I expect my next book to come out near the end of 2000. I'll also have a nonfiction piece in an electronic anthology called **Millennium Memories** coming out from DiskUs Publishing (a new publisher for me) in May. Sales of that anthology will benefit diabetes research. I felt very honored to be asked to write that piece based on my other writing. That story, tentatively entitled "A New Year's Eve to Remember," is very special to me, since it's the story of how my parents (both 30-something confirmed bachelors at the time) were arm-twisted into a blind date on New Year's Eve, 1948. My mother (now 86 and learning to walk again after a leg amputation last fall) helped me do justice to their story.

I heard from at least one old friend after ***conduit!*** was published, by the way—someone who'd been wanting an email address for me—so thanks for helping to reconnect us! *mtaffs@SpiritOne.com*

MICHAEL LITTMAN, PhD '96

I've had an exciting year. After three years at Duke, I received the Robert B. Cox Distinguished Teaching Award (1998-1999). It felt wonderful to be recog-

nized for teaching, which is something that is very important to me. On the research front, a group of us at Duke started a project in the fall of 1998 to use ideas from information retrieval and AI to solve crossword puzzles. The project was a lot of fun and it turned out quite well—the system averages around 98% letters correct on standard daily crossword puz-

Michael, center, with Amy Greenwald and visitor Justin Boyan at the pre-colloquium reception in March. Michael's talk was entitled "Solving Crossword Puzzles via Probabilistic Constraint Satisfaction"

zles. You can play with a web version of the crossword solver online at *one-across.com*. Our paper describing the work appeared in the big AI conference this past summer (AAAI-99) and was awarded best-paper honors. I was pleased to follow in the footsteps of a paper by Eugene Charniak and a group of Brown students (Curtis Hendrickson, Neil Jacobson, Mike Perkowitz), that won the best paper-award at AAAI-93.

Although I enjoyed my time at Duke immensely, I left in January to be closer to family. I'm now at AT&T Labs Research, in Florham Park, NJ. I still have a few graduate students I'm helping to finish up, but I'm excited about my new research environment. I even had the flexibility to pop up to Brown last week to give a research colloquium. It was great to be back—the place just keeps getting better! Best wishes.

mlittman@research.att.com

Which of these two bow ties went south?
(Answer on Page 21)

JONATHAN MONSARRAT

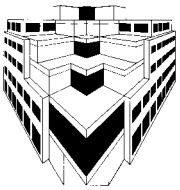
Hi everyone—It's hard to believe that, after spending my life emulating Dilbert, now I'm graduating with an MBA from MIT. It's a great way to "do cool stuff," which was my original motivation for programming, so in a sense it fits.

I fell into this by founding a company with a bunch of other Brown alums in 1994. Nobody else wanted to do the business side, so I became the CEO and it was one big coding and deal-making frenzy. Fortunately, the Internet was right around the corner and success has knocked on our door. Turbine Entertainment shipped its first game, Asheron's Call, in November through our publishing partner, Microsoft. It's a 3D MUD, like Dungeons & Dragons brought to the Internet with a community of 100,000 people. It's also a little like attending medieval role-playing summer camp. AC has become a hit and we've won a bunch of awards, which are listed in great detail at *http://www.turbinegames.com*. Yay us.

Brown Professor Andy van Dam is chairman of the board, and other Brown alums and faculty who have been involved include Profs. John Hughes and Tom Doeppner, former Prof. Rob Netzer, Mike Rubin, Tim Miller, Jeremy Gaffney, Kwesi Davis and Kristen McFadyen. Still working full-time at Turbine now are Tim Brennan, Justin Quimby, and Dave Javier.

The cool stuff I've been doing recently involves writing the new business plan for Turbine Entertainment, part-time. We want to become one of the "hot" Internet companies that causes traffic accidents as commuters frenetically call in their IPO buy order from their cell phones.

At MIT, I've been playing the MIT Beaver, which involves wearing a costume, danc-



ing around, and trying not to pass out from heat exhaustion. I'm currently working on a science fiction novel about ethically dangerous biotechnology in Mexico. The premise is based on the recent discovery that senility is not "normal" in the elderly. It's a disease called Alzheimer's. What if we discover someday that the process of aging itself can be cured? The book involves a prominent biologist who is drawn to Mexico—where research illegal in the US may take place—and is caught in a cabal of biotech companies performing various unethical and science-fiction-style modifications to the human body (like cloning, for example). Amy and I traveled to Mexico in December both as tourists and to gather information for the book. I learned a lot about the cultures and it certainly shook me out of my assumptions and stereotypes. Amy (Wiseman) and I are getting married this summer; she's a Texan studying psychology at Harvard.

Meanwhile, I'm doing a job search for full-time gainful employment. Hopefully I'll have a new hot startup to relate in a future ***conduit!***. For the story of how Turbine was founded, plus a lot of photos of pranks played in the Brown CS Department, see my web site at *http://www.monsarrat.com*.

I get a lot of emails from strangers asking how to start a company, and not so many letters from old friends at Brown. If you're in these groups I'd love to hear from you at *jon@monsarrat.com*. Still doing cool stuff—Jon Monsarrat

JOSHUA SPIEWAK, ScB '94, ScM '95

For the past 3-1/2 years I have been at Art Technology Group working with server-side Java to build an application server and commerce platform. Between the pace of Internet-time and the excitement of growing a small startup into a real company it is almost as much fun as completing a Brown CS degree. We have a number of Brown alums here: Jeff Vroom, Ross Knights, and Edith Pfister, to name a few. It was great visiting Brown again last spring for both the AndyFest and my 5th reunion. I finally married Michele in September of 1997 and we just bought our first house in Sharon, MA. Love to hear from people at *jss@atg.com*.

THE 24th IPP SYMPOSIUM "COMPUTING IN A WIRELESS WORLD"

Host Tom Doeppner

This was our second symposium on the general topic of mobile computing (the first was held in April 1994). The technology has made great strides in five and a half years: hardware is smaller, displays are better, and communication is faster (and less encumbering since wires have been eliminated).

Michael Wehrs of Microsoft led off the symposium with a engrossing talk on "Lifestyle Computing: The Next Wave." He argued that we are beginning to think of devices not as computers but as lifestyle appliances. Great strides have been made in the "traditional" uses of computer and communication technology, such as in web access (office, home, and mobile), support for mobile offices, etc. He went on to survey work being done at Microsoft on the new wave of mobile applications, including appliances for the car that not only perform navigational chores, but also assist in avoiding traffic and provide emergency communication even if the driver is incapacitated (due to an accident), all with "hands-off" and "eyes-off" interfaces with which drivers can interact without taking their eyes off the road.

Wehrs surveyed the recent growth in computing, pointing out the amazing statistic that Internet traffic doubles every ninety days. But, with newer technologies on the horizon for the PC platform, he said "the biggest impact of the computer revolution has yet to occur."

Jamey Hicks of Compaq's Cambridge Research Lab (CRL) spoke next, on "Physical Computing in a Wireless World." He described work by him and his colleagues on "wireless computing as a component of beyond-PC computing," by which he means that they are not replac-

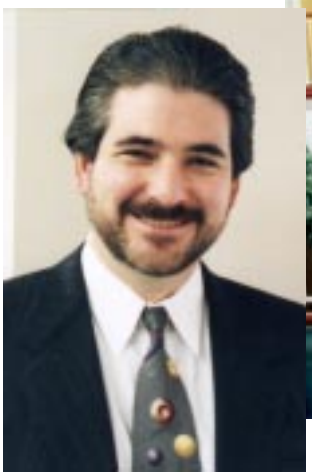
Peter Wegner was among those recently honored at an Emeritus dinner attended by University glitterati. CS Chair Tom Dean spoke extolling Peter's many contributions to the field—Peter was one of the earliest computer scientists to study the deep semantic issues in programming languages—and expressing our great relief and delight at his miraculous recovery from a life-threatening accident sustained last June. l to r: Judith Wegner, Peter, Tom and University Librarian Merrily Taylor. As you can see, Peter is in the pink!

ing personal computers, but adding functionality, interfaces, and behaviors that augment and go beyond what are provided by PCs. After an interesting discussion of the challenges of this area and a survey of the work being done, he described the Skiff Project of CRL, in which they have built a number of computing and communication components and used them for experiments in such areas as information appliances, robots, etc. They provided a number of their components to an autonomous robotics course at MIT and set students loose on a four-week project to build robots.

Jesse Hefter of GTE Labs spoke right after lunch on an important application area: empowering mobile workers through wireless technology. His company has a fair amount of its work force in the field, disconnected from the corporate network for long periods of time. Hefter described their Mobile Operations Trouble Ticketing System (MOTTS) that takes advantage of much current work in wireless and mobile technology to provide GTE staff with the information and communication required to do their jobs. An especially interesting aspect of this talk was that it showed how disparate technologies have been brought together to solve their problem.

Al Soares of the Foxboro Company spoke next on "Applying Wireless LAN Technology in Process Control Systems." His company, one of the leaders in the process control industry, is very much concerned with providing easy monitoring and control of their systems, which are used in a large number of industrial plants. Soares gave us an excellent introduction to process control systems, then showed how he and his colleagues have utilized wireless technology in such areas as routine maintenance, troubleshooting, factory acceptance testing, site acceptance testing, and walk-around inspections.

Don Stanford of GTECH Corporation was on next. He showed off his amazing collection of old and new wireless gear, and gave a highly entertaining and informative presentation on "Wireless Communi-



l to r: Mike Wehrs, Microsoft; Jesse Hefter, GTE Labs; Jamey Hicks, Compaq (CRL); host Tom Doeppner; Al Soares, Foxboro; Don Stanford, GTECH. Alex Morrow was unavailable at photo time

cations in Transaction Processing." He first went over the history of wireless technology (from Gilbert to Tesla to modern times) and then discussed how GTECH takes full advantage of wireless

Don's gear

for its amazingly large number of daily transactions. He described the nature of lottery transactions, focusing on the incredibly low tolerance for delay and error. Using wireless links is attractive to GTECH because they're reliable and quick to set up, they scale well, and they're relatively cheap.

The last speaker was Alex Morrow of IBM Research, speaking on "Socializing Nanocomputing." He took a broad view of wireless computing and focused on where the industry is going and on some of the associated social issues. After surveying the current state of the art, he examined industry trends, looking at a couple of important examples: "pervasive shopping" and automotive solutions (including not only the applications discussed earlier by Wehrs, but also such additional ideas as automatic scheduling of maintenance and ordering of needed parts). On the social side, he gave alternative rosy and gloomy views of the future, depending on how the Internet economy pans out, how well technology fosters or impedes representative government, whether privacy is strengthened or diminished as technology improves, and whether a potential technological gulf between haves and have-nots leads to worldwide unrest.

Roger Blumberg. In early June Roger will be a featured speaker in "Excavating the Archive: New Technologies of Memory," a colloquium on the state of digital archiving at the Parsons School of Design at the New School University in New York. In July, for the 14th consecutive year, he'll teach a mathematics course in the Summer Program for High School Students, at Columbia University.

Tom Doeppner. IPP member Microsoft Research gave Tom Doeppner a donation of cash, software, and 46 NEC MobilePro 800 mobile computers along with Proxim wireless cards and base stations for an experiment in his networking course (CS 196-5) this past

semester. Doeppner and students Neelu Bedi, Mike Boilen, Ryan Evans, Ben Garrett, David Grunwald, and Liye Ma developed software to distribute all course materials electronically in class and let them be viewed by the students on the mobile computers. By the latter part of the semester students were additionally able to take notes by annotating these course materials. The experiment was the first step towards building an electronic student notebook. Based on relatively inexpensive technology, such a notebook should simplify taking class notes, foster better interaction in lectures, promote more informed discussion, and ease collaborative work.

John Hughes. Spike went to Japan and was forced to rely on the kindness of strangers to get wherever he needed to go; namely, the University of Aizu-Wakamatsu, ITR research labs in Kyoto (where he saw our recent MSc alumnus Michael Kowalski), and the University of Tokyo, where he visited a couple of research labs and spent some time with Takeo Igarashi, who'll be here as a postdoc starting in June.

David Laidlaw. David and Barb are welcoming a new member to their family—Eliot James was born April 16. He weighed in at 8lbs 6oz—aside from associated experiments in sleep deprivation, everything is going OK.

John Savage. John was elected to a three-year term on the Faculty Executive Committee in which he will serve in successive years as Vice-Chair, Chair, and Past-Chair of the Faculty. He has just finished two years as Co-Chair of the Charities Drive at Brown and in January was elected to the Board of the Fund for Community Progress, one of the two charities in Brown's drive.

Steven Reiss. Steve has been busy working on his grant for software visualization. The previous NSF grant in this area has been supplemented by a generous one-year grant from Sun to study,

using visualization and analysis, the performance of large Java programs. So far, the visualization group has put together a suite of tools for collecting and storing trace information from both Java and C++ programs along with a new visualization package, Almost. In addition to this work, Steve has been busy teaching CS32, CS126 and CS234, running the faculty search, working with Simpli.com (written up in the ProJo this month), playing on the CS softball team, and doing the spring preparation and planting of his (slightly enlarged) garden.

Roberto Tamassia. Roberto received funding from DARPA for a $1.5M computer security project in collaboration with Michael T. Goodrich (Johns Hopkins) and Robert Cohen (Algomagic Technologies). He also received a gift from Microsoft Research in support of his teaching innovations in CS 16 (Algorithms and Data Structures).

Eli Upfal. Eli was a program committee member for the 32nd Annual ACM Symposium on Theory of Computing (STOC 2000), and for the 4th International Workshop on Randomization and Approximation Techniques in Computer Science (RANDOM 2000). He has been appointed chair of the ACM Doctoral Dissertation Award committee.

SOLVING PDEs ADAPTIVELY IN A DISTRIBUTED COMPUTING ENVIRONMENT

José Castaños with advisor John Savage after successfully defending his thesis and being awarded the traditional PhD poultry

José Castaños has just completed his Ph.D. thesis under John Savage's supervision. He built a system called PARED* *for the adaptive solution of partial differential equations (PDEs) in a distributed computing environment. A serial version of this system was developed jointly with Vasiliki Chatzi, who has just completed her Ph.D. thesis under the supervision of Franco Preparata. Vaso and Franco used PARED to study the behavior of* crystalline meshes, *a new type of mesh they invented.*

**PARED is a neologism formed from the words* parallel *and* red, *the Spanish (José's first language) word for* mesh.

Steering a Computation

Partial differential equations (PDEs) are used to describe physical problems such as fluid flow around an aircraft wing, the response of buildings to earthquakes, and automobile crashes. Many PDEs do not have known closed-form solutions. One of the methods for computing numerical approximations to the solutions of PDEs is the *finite element method*. Here the domain over which PDEs are defined is discretized by covering it with a *mesh* of geometric *mesh elements* (such as triangles in 2D and tetrahedra in 3D, the types of element used in PARED—see figure 1 on page 18) and a set of basis functions is introduced in terms of which the differential equation is transformed into a set of linear equations.

Since the error associated with a mesh element is directly related to its size, it is highly desirable to use small mesh elements in regions of high physical activity and large ones in regions of low activity. This is called *adapting the mesh*. Through mesh adaptation the available computing power can be steered to regions needing

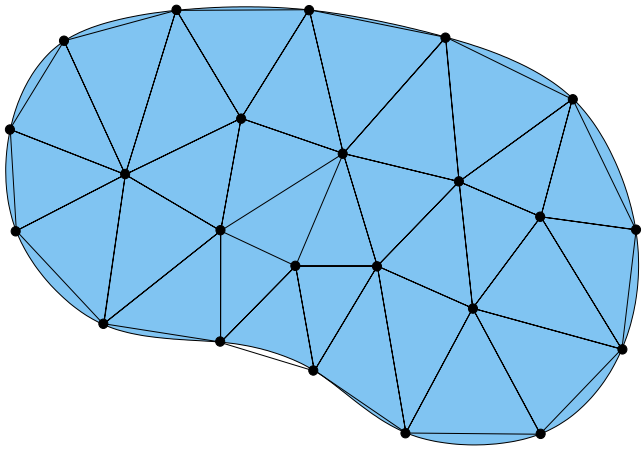


Fig. 1 Decomposition of a two-dimensional domain into a triangular mesh

it, thereby making the overall computation much more efficient. In our experiments modeling fluid flow by solving the Navier-Stokes equations, we have shown that adaptive meshes can have up to 20 times fewer elements than the best static mesh for the same problem. This leads to a dramatic savings in the total time needed to solve the system of equations.

Distributing the Workload

Because large problems involve many hundreds of thousands or millions of unknowns, they must be run in a parallel computing environment. Here the domain is decomposed among processors in such a way that every processor does about the same amount of work and communication is minimized. Parallelism creates new problems. In parallel we must locally adapt a mesh and rebalance the work so that it remains evenly distributed among processors. The solutions developed in PARED to these problems are described below.

"the domain is decomposed between processors in such a way that every processor does about the same amount of work and the communication is minimized"

Mesh Adaptation

Rivara's longest-edge bisection algorithm is used in PARED to refine mesh elements. A new vertex is placed at the midpoint of the longest edge in an element identified for refinement and a new edge(s) added from it to the vertices that are not on the element's longest edge. Each element containing the new vertex is itself also refined and the refinement is propagated to other mesh elements until each vertex is at the corner of a mesh element. Since the length of the edge being bisected increases at each step, this process terminates. This procedure generally prevents the angles in an element from becoming too small or large, both of which weaken the numerical approximation.

Since refinement of an element in one processor can be propagated to other processors, it is possible that two or more processors can choose to bisect the same edge at the same time. Also due to refinement propagation, it can be difficult to decide when adaptation is complete. In PARED these synchronization problems are solved completely. PARED also supports the parallel coarsening of mesh elements in regions of low physical activity.

We have proven that the refined mesh produced by the parallel version of PARED is the same as that which would be produced by a serial version.

Refinement History Trees

PARED uses an unusual representation for meshes. It starts with a coarse initial mesh small enought to fit on one processor that it adaptively refines. Attached to each coarse mesh element is a refinement history tree. The root of a tree contains its coarse mesh element; its immediate descendants are the elements into which the root element is refined, etc. Its leaves are the most highly refined elements into which the original element is refined. The solver works on these leaves. That is, the numerical approximation is based on the finest mesh. A mesh is coarsened by replacing each set of elements identified for coarsening by their parent in a refinement history tree.

Refinement history trees are used in workload rebalancing and migration of work after deciding where to send coarse elements and their descendants.

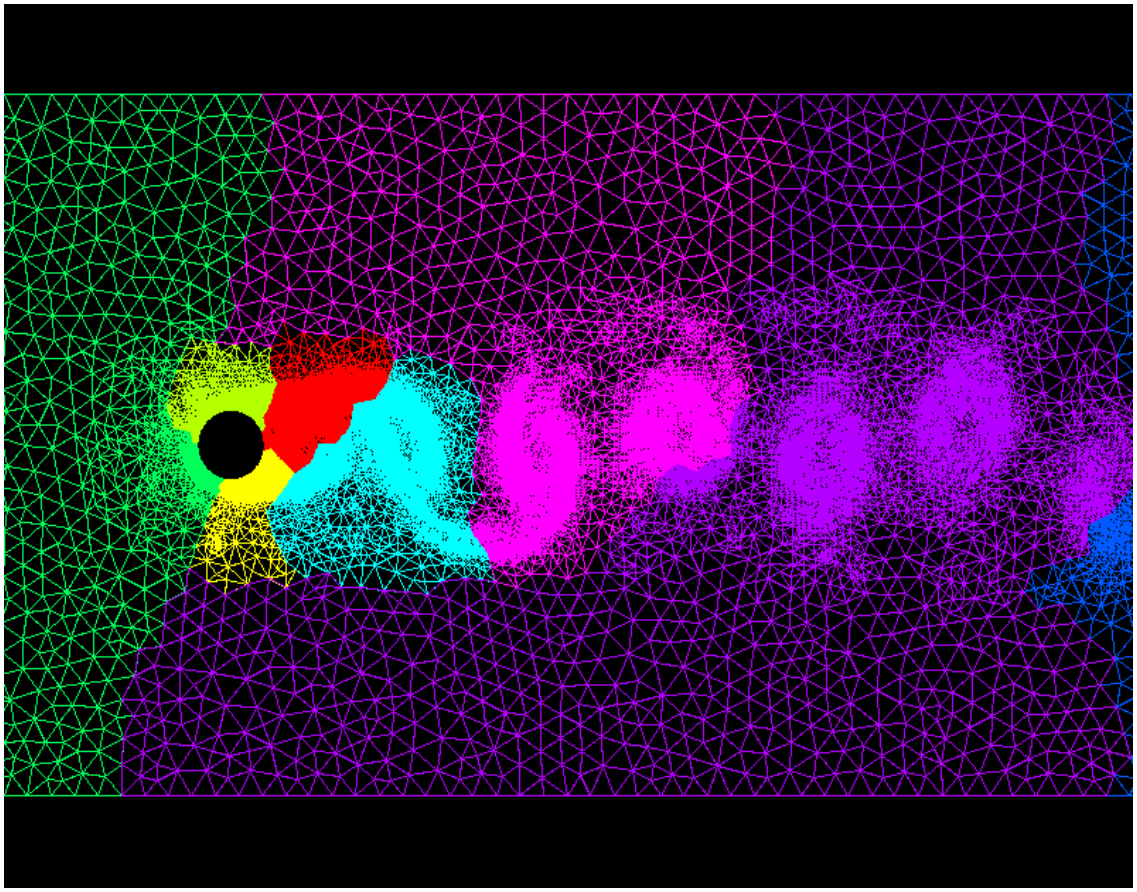


Fig. 2 Refined mesh at time t = 30 secs of incompressible fluid flow past a cylinder with Reynolds number Re = 250

Repartitioning a Mesh

After refining a mesh, the amount of computational work and interprocessor communication necessary may not be uniformly distributed across processors. Since PARED uses iteration to solve a linear system of equations, if one processor has a higher workload than another, the time to compute a solution increases. For this reason the workload must be rebalanced.

Workload rebalancing is an instance of the NP-hard graph-partitioning problem. Although good heuristics exist to find high-quality partitions, they generally don't parallelize well, so that small changes in a graph produce large changes in the assignment of work to processors and much data may have to move between processors to restore a workload balance. Since PARED makes small changes during an adaptation phase, this is a serious problem when solving large systems of equations. To address this problem, we developed a fast new heuristic that greatly reduces the number of elements that must move to restore balance. We used modeling and analysis to explain this good behavior.

Experimental Results

The PARED system has been extensively tested on a variety of problems. We have applied it to very controlled problems in which a disturbance moves in a predetermined way through a region of physical space, and have demonstrated that PARED adapts quickly and well to the disturbance. We have also applied it to the solution of the Navier-Stokes equations modeling fluid flow that resulted in a dynamic mesh that is very highly adapted to the motion of a fluid. A movie of this simulation is available at *http://www.cs.brown.edu/people/jes/pared/flow250.mpg*. One frame of this movie is shown above in Figure 2.

THE INDUSTRIAL PARTNERS PROGRAM INTRODUCES IPP SEMINARS

DATE	SPEAKER	PARTNER COMPANY	TOPIC
12/2/99	Jay Subrahmonia Manager, Pen Technologies	IBM	"Putting Pen to Smart Paper"
2/8/00	John SanGiovanni Windows CE Evangelist	Microsoft Research	"The Campus of Tomorrow: Exploring Windows CE in a University Environment"
2/22/00	Bowen Alpern Researcher	IBM Research	"The Jalapeno Virtual Machine"
3/8/00	Don Stanford CTO	GTECH	"Preparing Your Development Organization for the New Competitive Environment"

Jay Subrahmonia of IBM with IPP Director John Savage at the reception before her talk

Last fall we initiated a new facet of our Industrial Partners Program—IPP seminars. Partner companies (Compaq, EMC, Foxboro, GTECH, IBM, Latitude Communications, MERL, Microsoft Research and Sun) are invited to spend a day in the department, visiting faculty with whom they share research interests and giving a talk, often on their latest corporate endeavors. Afterwards there is time to showcase the company, talking about its culture, recruiting opportunities and directions.

See our website: www.cs.brown.edu/general /ipp/

CHARNIAK UNPLUGGED

Eugene Charniak

During his tenure here President Gee sent birthday cards to faculty members. (Question: do presidents of universities keep their title after they step down, like U.S. presidents? Or perhaps he is already president of Vanderbilt by the time this issue of ***conduit!*** comes out.) At any rate, I thought this was rather nice, so I suggested to Suzi Howe that we make or buy a very large birthday card for President Gee and get a lot of people in the department to sign it. When his birthday rolled around, we called up his office to find a time when we could give it to him. His secretary told us of a surprise birthday party they were planning and suggested we show up for it. This we did, and we print here one of Suzi's photographs of President Gee, me, and the card. The president announced his resignation four days later. I assume there is some cause-and-effect relation here.

The *Communications of the ACM* had on its January 2000 cover a list of the articles therein. There were many hot topics, like "Investing Online," but the one that

caught my attention was entitled (I reproduce the layout here):

Engaging Girls with Computers
via Software Games

Am I the only one who thinks that boys might object to this?

I have commented here on the many uses our atrium gets, and in particular on the students who use it as a study and work area. One day last semester I passed through and found one of our faculty members, David Laidlaw, at a table with his work spread out around him. Naturally I asked him why he decided to work there rather than his office. David's response was simple: his desk was too messy! This reminded me of the issue of

Which desk belongs to whom?

Answer on back page

David Laidlaw

Desk 1

John Savage

Desk 2

conduit! in which we showed two of the more piled-up desks and asked readers to identify the occupants. It also reminded me of Tolstoy's famous line to the effect that all happy families are the same, but all cluttered desks are cluttered differently. Suzi and I decided to test this proposition by repeating our desk shots, this time including some clean desks as well. The results of our investigation are pictured on pages 21-23.

Two ***conduit!***s ago I mentioned that Mike Mozer '81 had wired up his house so that his

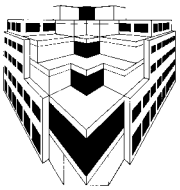
Administrative staffers Dawn Nicholaus (left) and Fran Palazzo check the champagne flutes for spots before setting up a thesis defense celebration

John Hughes

Desk 3

Tom Doeppner

Desk 4



computer could monitor where he was (using sound sensors), use this information to learn his patterns of behavior, and thus be able to automatically turn lights on and off, raise and lower the temperature in the house, etc. Well, like several Brown CS graduates before him (Eric Albert '80 and Edwina Rissland '69), Mike has made the back of the *New York Times*. But as opposed to Eric and Edwina, who both appeared in the business section, Mike appeared in, where else, "*House and Home*." I have decided that I too would like to get mentioned in the *Times*, but I am aiming for a big splash in Sunday's Arts and Leisure when Steven Spielberg options the movie rights to my ***conduit!*** column.

Speaking about Brown CS, in the media, there have been two other recent sightings. One was discovered by our chairman, Tom Dean, who somehow has time to read novels. He found the following in *microserfs*, a novel by Douglas Coupland about "a handful of misfit Microsoft employees."

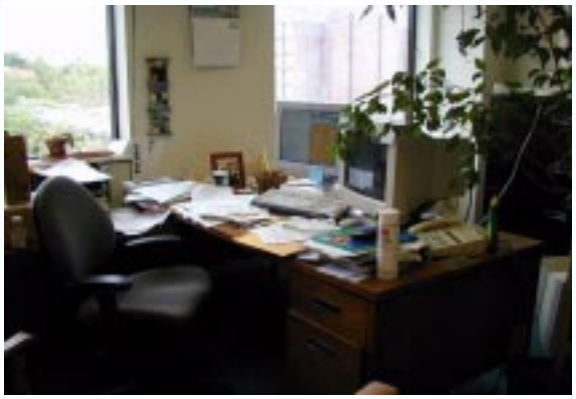
"We then got into a discussion of Nerd Schools and the end of the era of 'single-dose' education—and of course this led to a listing of schools that had the best nerd reputations.

- Cal-Tec (Extreme nerds; the Jet Propulsion Lab is just up the hill and around the corner. The big rumor is that they had to institute pass-or-fail grading because there were too many GPA-related suicides.)
- CMU
- MIT
- Stanford
- RPI (for undergrads)
- Waterloo
- UC Berkeley
- Dartmouth
- Brown—'Hipster nerd school with a good undergrad comp-sci program.'"

Andy van Dam

Desk 5

Franco Preparata



Desk 6

The other media attention came when a group of undergrads used the SciLi windows as a 10-pixel by 10-pixel display for a gigantic game of Tetris. This feat made the *New York Times*, the BBC, etc. It should solidify our reputation as a hipster nerd school, and will also be a nice example next year when I am discussing output devices in CS2, our computer literacy course. It definitely shows that when it comes to computer monitors, size is less important than resolution, unless you want to make the *Times*. (For those who missed this awesome sight, there will be repeat demos at this year's graduation.)

Finally, one of the Brown traditions that we have mentioned here is the bestowing of a rubber chicken upon each new Brown Computer Science PhD. I just got back from a conference where, among other things, I got up to date with two of my PhD students, Graeme Hirst '84 and Mary Harper '90. Both were commenting on their fond recollections of graduate student life here, and Mary mentioned that she still has her rubber chicken. (I believe Graeme graduated before the tradition was established.) Not only that, but she has been giving rubber chickens to her PhD students when they finish up. I suppose I am admitting to incipient geriatric sentimentality, but I was touched.

Laidlaw, 6; Savage, 3; Hughes, 5; Doeppner, 2; van Dam, 1; Preparata, 4.

conduit!

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