Conduit

A RESEARCH AND ALUMNI NEWS MAGAZINE
Department of Computer Science, Brown University // Vol. 22 No. 1

Perspectives on Online Learning

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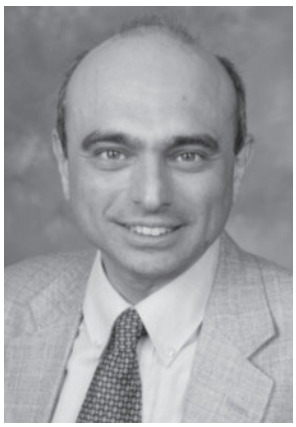
Notes from the Chair: the Latest News from 115 Waterman

Greetings to all CS alums, supporters and friends.



The spring semester is speeding by and the CIT is bustling. Great things continue to happen in the department and I am thrilled to be able to share the highlights with you.

More than 80 graduates are expected to receive diplomas at this year's commencement on May 26, compared to 70 in 2012, 54 in 2011 and 48 in 2010. We are delighted by the increase in the number of Brown students who have chosen computer science as their major and are thrilled to see this trend continuing.

I am excited to announce that we'll be welcoming Stefanie Tellex as an Assistant Professor in the Fall semester. Her expertise in probabilistic graphical models, human-robot interaction, and grounded language understanding is highly synergistic with our strategic research priorities and we look forward to her leading new interdisciplinary projects.

Congratulations are in order for Maurice Herlihy who was recently named a member of the National Academy of Engineering as well as the recipient of the IEEE Computer Society's W. Wallace McDowell Award. Maurice's pioneering work on processor synchronization and transactional memory can be found in action in the latest generation of Intel processors and IBM supercomputers.

I am also delighted to share that Barb Meier has been selected to receive the Philip J. Bray Award for Excellence in Undergraduate Teaching in the Physical Sciences. Barb teaches computer animation courses that are known campus-wide as some of the most rewarding courses offered at Brown. In addition to teaching technical skills, Barb inspires students to demonstrate them through meaningful and personal expression, thus broadening the appeal of computer science to a new and diverse generation of Brown students, especially those straddling the technical/artistic fence. Congratulations Barb!

Finally, I would like to thank Amy Tarbox, who has served as editor-in-chief of Conduit for six years in addition to being our Manager of Industrial and Alumni Affairs and Special Projects. Amy is moving to Brown's CareerLAB so while she will be greatly missed in the department, she will continue helping our students achieve their career goals.

Please share your professional and personal stories for inclusion in upcoming issues of Conduit. Your support of and participation in departmental activities are always appreciated and we are grateful to have such a close community—thank you!

Roberto Tamassia
Plastech Professor of Computer Science
Chair, Department of Computer Science

Conduit
Vol. 22 No. 1

Published twice yearly by the Department of Computer Science at Brown University, *Conduit* is distributed free to all computer science alumni, faculty, staff, students and industrial partners.

Queries about this publication can be directed to:
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Campus Box 1910
Providence, RI 02912

Publisher
Industrial Partners Program, Department of Computer Science

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Printing and Distribution
Brett Turner, Information Services
Brown Graphic Services

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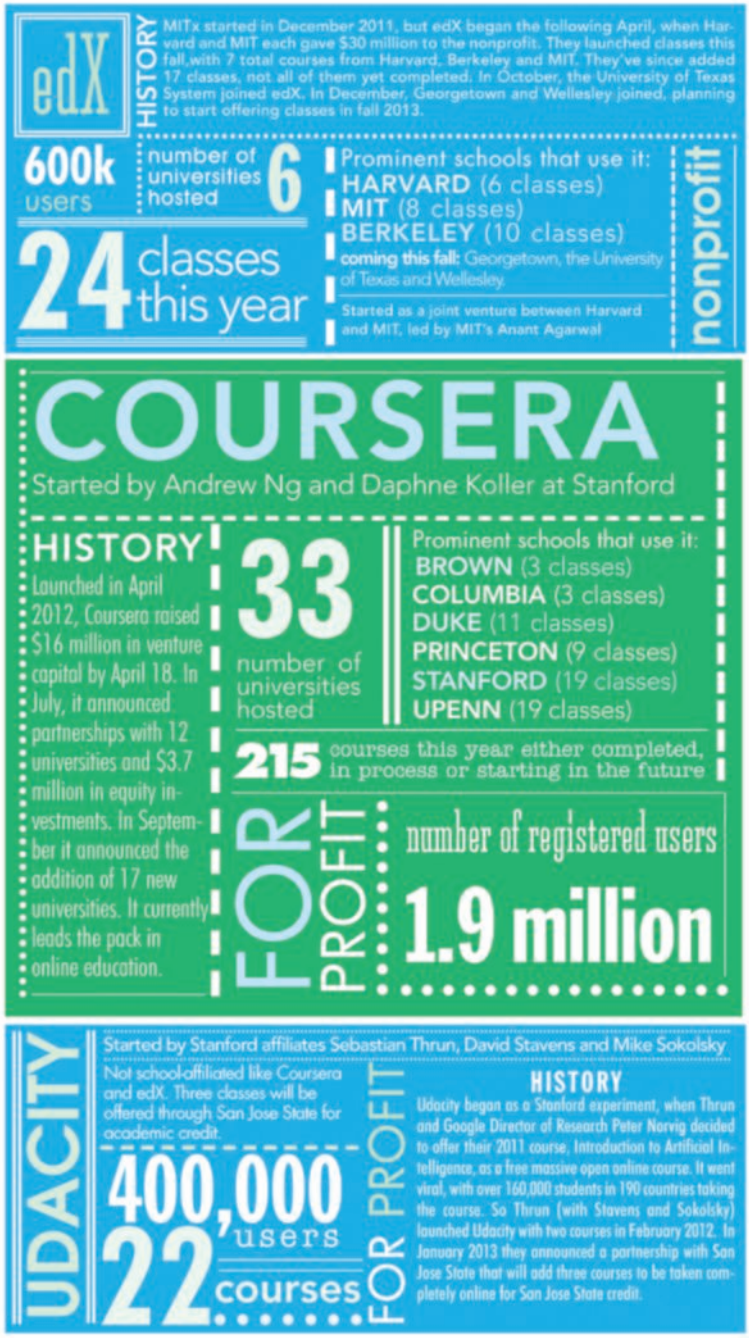
MOOCs: An Overview

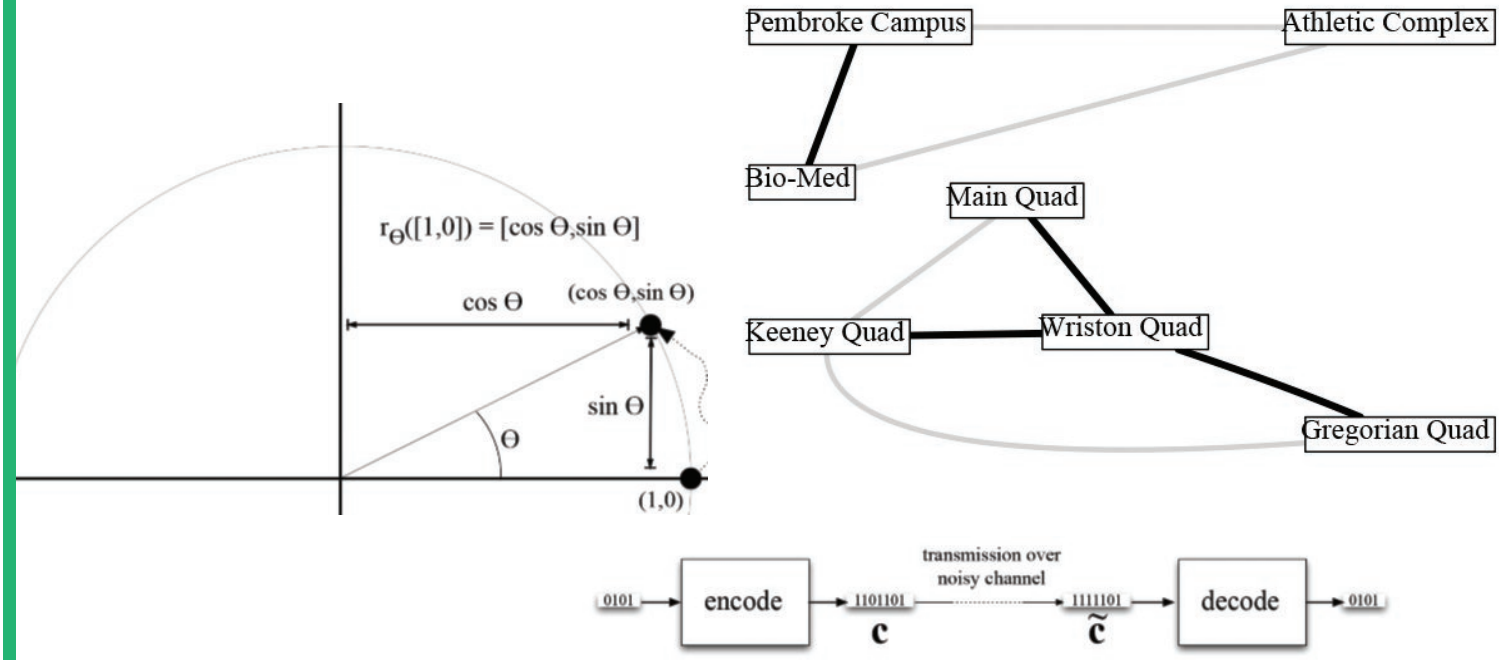
BY ROSEMARY M. SIMPSON



MOOCs (Massive Open Online Course) are interactive online courses that typically are free and open to anyone with an Internet connection. Like earlier free online course offerings, e.g., MIT's OCW (Open CourseWare) initiative, they provide resources such as videos, recommended readings, and problem sets. They differ from these earlier online courses in two major ways: the courses are designed for online use instead of being copies of on-site existing courses, and they are structured around interactive social networks, called user forums.

Currently there are three major MOOC vendors: Coursera (www.coursera.org), edX (www.edx.org), and Udacity (www.udacity.com). While the format for the three is similar, Udacity differs from Coursera and edX in that it does not have a calendar-based schedule; students may start a course at any time.

The figure above from Stanford (http://www.stanforddaily.com/2013/02/05/a-look-at-online-education-coursera-edx-and-udacity/online-education-page-1/) summarizes key components: history, number of universities, number of courses, number of students, and whether they are for-profit or non-profit.



BY PHILIP KLEIN

Coding the Matrix GOES ONLINE

I am currently engaged in porting my Matrix course to Coursera. The Matrix course is an introduction to linear algebra through programs, data and proofs. Students learn about vectors, matrices, and vector spaces in the traditional way (by hand calculation with small examples and by writing mathematical proofs), and also through implementations and working with real data.

Educators talk about different learning modalities: visual, auditory, etc. For students of computer science, writing and running programs is another learning modality. In the Matrix class, reading and writing programs can help a student understand concepts ranging from very basic, such as vector addition, to more sophisticated ideas, such as matrix decomposition. Also, it is motivating for a student to turn her understanding of mathematical concepts into a program that actually runs and does something useful (or at least fun).

A crucial part of the course is the labs, in which the students carry out a series of programming and data-processing tasks to achieve a goal, such as constructing and testing an error-correcting code, removing the perspective from an image, or compressing an image. The Coursera edition is called Coding the Matrix. It will be taught this summer. Unfortunately, with this edition I will not be able to cover the more advanced topics we study in the Brown University course, but I hope in the near future to provide a follow-on mini-course that does.

I'm finding it very challenging to develop a course designed for an online audience. Fortunately, there are some remarkable people here at Brown who are helping this project succeed, at the Sheridan Center and at Media Technology Services.

A companion textbook, also called *Coding the Matrix*, will become available soon, together with online resources such as datasets and program templates. I hope to make it easy for colleagues at other universities and especially computer science departments to teach similar courses. Linear algebra is so useful in so many areas of computer science—e.g. machine learning, algorithms, computer vision, to name just a few—we don't want our students to miss out. One way to motivate them is to teach a course that employs their skill and interest in programming and explores fun applications of linear algebra.

Why COURSERA

BY ROSEMARY M. SIMPSON

What sets Coursera apart from my other experiences with distance learning (MIT's OCW, Stanford's video courses, Khan Academy[1])? All previous venues shared the essential qualities of being free, providing rich video resources, being available on demand, and not being restricted by prerequisites or tied to a syllabus (although Khan does supply a context graph of recommended relationships). Coursera courses provide, in addition to all of this, a focus on interaction among all participants that pervades the structure and experience of the course.

USER FORUMS: These are the primary mechanisms through which students interact with each other, the community TAs, and the professor(s). They provide a chance to ask questions and engage interactively with the answers. In addition, forum users frequently volunteer their expertise by recommending resources and providing insights that can be both surprising and very helpful. This is the key difference between the Coursera student experience and the experience of watching videos in other, non-interactive online courses: MIT-OCW and Stanford Video lectures provide no interaction, no community, while Khan Academy, with its very different focus and granularity, has some minor interactive responses to specific videos. Coursera's user forums are relevant to the entire course and comprise many thousands of highly engaged participants.

In the beginning I was interested just in the videos and tended to ignore the forums, feeling I didn't want to waste my time with others as ignorant as I. However, I found that I was very, very mistaken: the Coursera forums have become a resource that is unique in my experience and has provided both guidance and enriching ongoing dialogue/debate I've never before experienced. Some forum members have become friends with whom I continue to expand my understanding.

STUDY GROUPS: These provide a second interaction mechanism, and may be online and distributed or co-located. At the beginning of each course students are strongly encouraged to form study groups based on whatever criteria they find congenial. The study groups become in effect small cohesive communities where ideas are explored in a safe space and people get to know each other. Again, initially I scorned the study groups, thinking I preferred to work things out on my own, and again I was wrong. This time around, in Keith Devlin's "Introduction to Mathematical Thinking," the study group I've formed with a friend who is also taking the course is turning out to be enormously helpful; he and I debate our differing reasons for assignment answers, egg each other on to support our positions, and uncover new resources, which we then post to the forum.

PEER REVIEW: This is a third form of interaction, one which—justifiably in my opinion —is very controversial. My experience is that while *doing* a peer review is quite valuable in the same way that attempting to teach is a very powerful way to learn, peer review responses are not so useful. My opinion was unfortunately reinforced early on by a disastrous experience with idiotic peer reviews, or non-reviews, of an essay I'd spent a week researching and writing. However, engaging in rebuttal and the subsequent interactive dialogue has been quite useful.

[1] Coursera is one of three major vendors of MOOC (Massive Open Online Course) courseware that have come to prominence in the last year. Since I have direct experience with just Coursera, I have only referenced it in this article. For a brief overview and comparison of three vendors – Coursera, EdX, and Udacity – see the article "MOOC vendors: A Comparison Overview" on page 4.

Issues

From my perspective as a student, the major problems involve structural inadequacies in search, forums, and resources.

SEARCHES: The most critical defect in Coursera is the brain-dead search facility, which is a simple string-only search over the titles and text of the forum. You cannot search on the names of posters—e.g., you cannot find all posts by a particular person—you cannot search the rest of the course site, and you cannot do simple Booleans such as "find this but not that," much less take advantage of regular expression patterns. Many subject-specific user forums use Google search, which while not perfect is much more useful than the current Coursera search; Coursera should do the same.

Searches should be faceted, e.g., search on post author, date, ..., the scope should be the full course website, and they should be able to be saved and then used for search refinements. The same automatic visualization tools that should illustrate the evolving forum graph structure (see below) could be used to visualize the results of searches and sub-searches. Structure/relationship visualization is a key tool in gaining deep understanding.

FORUMS STRUCTURE: Issues and possible solutions include the following points.

1. It is currently impossible to track all threads. Forum software needs to automatically assign author-editable tags to entries, and from that develop an emergent substructure among the threads. Threads should be sortable by tag, creation and modification date, author, and title;
2. The current structure is like a rigid class hierarchy and needs cross-cutting views; it should be a graph structure to reflect the emerging multiple POV (point-of-view)s and LOD (level-of-detail)s;
3. The community TAs need a tool for traversing the forums effectively and adding intermediate structure as needed, beyond the automatic evolution suggested in Point 1;
4. There should be a topics forum that is independent of lecture and assignment and could have automatic links into relevant lectures and other forum threads. Obviously, the topics forum needs to evolve deep structure as the course proceeds; and
5. An evolving linked visualization of the interacting threads graph would be extremely valuable. The NSDL Science Literacy Maps (http://strandmaps.nsdl.org/) illustrate one possibility. StrandMaps would be a great addition to the courses.

In sum, what is needed is a combination of full-faceted search plus an evolving forum structure with multiple points of view.

RESOURCES: In general, the resources are a fairly traditional set of lectures and recommended readings. The videos I've seen tend to be straightforward, high-quality lectures. The exception to this pattern is a modern poetry course with videos of hour-long close reading discussions by the professor and several graduate students sitting around a conference table. However, in the courses I've taken so far there is no metalevel visualization of context, no use of 2D or 3D visualization of the dynamics of the material, much less the forum threads, no set of relationship graphs among themes, no real integration or connections with the larger domain. In short, there is no reference to or exploration of the ecology of which the subject is part. It is as if hypertext had never been invented. Finally, while forums can be a rich source of recommendations for books, people, and websites, they too lack this awareness of any larger frame of reference.

Strategies

WHY PEOPLE TAKE THE COURSES: Reasons for taking the courses, which are especially diverse with Coursera due to its heterogeneity and interactivity, include: testing the waters, curiosity, need for community, opportunity to get questions answered, and gaining perspective, as well as a serious intent to complete all the material. Further, as the Coursera courses have progressed, professors are realizing that their target audience is primarily adults, often adults with many other obligations. Thus, the current tendency is to close a course to new enrollments at the end of the course but to keep it accessible to those who did enroll at least until the next time the course is given. Prof. Devlin, for example, has decided to keep the fall 2012 site of his mathematical thinking course open. It would be nice if Coursera established a policy of keeping the course materials on a persistent basis, like the MIT OCW, Stanford video, and Khan Academy materials.

WORKING WITH THE FORUMS TO COUNTERACT RIGIDITY: As mentioned above, the forum structures are rigid, like a rigid class structure, and badly need cross-cutting and refactoring capabilities. In the absence of facilities for doing this, I've developed workaround strategies that help compensate for and manage the sometimes overwhelming chaos of thousands of unstructured threads.

First of all, from the beginning of a course in which I intend to be seriously involved, I take advantage of the forums' latest posts list on the forum home page. This lets me track new threads of interest, as well as interesting people and community TAs (remember that it is not possible to search on names). I then subscribe to threads that seem promising and capture content I want to save and work with on my local system.

In addition, in the General Discussion forum I've established threads for topics, experts, and resources I think are important and keep these threads foregrounded by periodically posting to them and providing links to related forum posts I've discovered during my daily prowls of the forum.

SEARCH: Unfortunately, there is little that can be done with the brain-dead search facility. A further frustration is that when you subscribe to a thread and an email arrives with a new post or comment, clicking on the link takes you not to the post but to the top of the thread, and because you can't search on the name of the poster, you are reduced to attempting to discover where the comment is coming from by either scrolling down the thread or trying to enter a string from the comment into the search engine.

Experiences from an Online Course Offering

BY SHRIRAM KRISHNAMURTHI

In Fall 2012, I offered my course CSCI 1730. This is a junior-, senior-, and beginning-graduate-level course in programming languages (not in how to program, but rather in linguistic mechanisms). Together with my PhD student (and graduate TA) Joe Politz, I decided to offer it online in addition to in-class.

My primary goal was to understand this new teaching medium. As someone who runs very interactive classes and teaches solely by writing on a board, I had long been convinced that my teaching methods would simply never work with a remote audience. Having maintained this position for many years, I felt it important to experiment and learn how to adapt: everyone of a certain age (or pop culture sensibility) recognizes the phrase, "video killed the radio star."

I did **not** do it for the reasons that the founders of Coursera have proclaimed: that they had almost no student engagement in their classes, they were tired of telling the same old jokes, and so on. One might conclude from their narrative that teaching and learning at Stanford must be a terrible experience; though a more charitable (and much more likely) reading is that they are exaggerating for corporate effect.

Hype and exaggeration apart, I do believe higher education is at a potentially critical juncture. Against this backdrop, Brown is engaging in a large planning effort, investing significant energy and resources on campus space. We are fortunate to be having this discussion after the MOOC (Massive Open OnLine Course, the idea of teaching courses through electronic media to large numbers of students—as personified by courses on Coursera, Udacity, EdX, and other organizations) phenomenon has begun; it would be unfortunate if it did not significantly affect these conversations, especially due to the impact on the classroom (which I think is likely to be enormous).

THE ONLINE COURSE, AND BROWN'S VALUE ADDITION

It was always clear that we could not offer exactly the same course as we gave Brown students. One of the important parts of my course is a set of open-ended written assignments. I consider these extremely important in measuring student understanding of the material, but we almost certainly lacked the resources to grade them for the online students. Nor were we willing, as many MOOCs are, to "grade" using simple computer-driven textual analysis; we wanted to read the responses in depth. Thus the courses differed, and we were able to point to tangible differences—beyond the evident intangibles—between the Brown and online offerings.

CERTIFICATION LEVELS

Because we were not offering Brown's course in full, we were free to customize our course to different online clientele. Instead of grades (which would suggest having done the equivalent of the Brown course), we publicized three different "certification levels:"

Lite: Completing a sufficient number of daily quizzes (but no more)

Mezzanine: Beyond Lite, completing the minor project that occupies the first month

Ninja: Beyond Mezzanine, completing the major project that occupies the remaining two months

When we noticed that many of our initial sign-ups were professional programmers, we added a fourth:

Sprint: The minor project, and quizzes during its duration

The Sprint option enabled people to engage intensively for one month, and then disengage fully from the course and return to their professional and other lives. The completion numbers indicate that this was a wise addition.

BY THE NUMBERS

We had about 1650+ signups initially. In keeping with all other MOOCs, attendance dropped off rapidly (especially after we made the opening assignment especially hard). Our completion ratio was about what one might expect for an upper-level technical course: 80 students finished, distributed as follows:

Lite: 23

Sprint: 23

Mezzanine: 32

Ninja: 2

The distribution of sign-ups looked like a heat-map of computer science: large clusters in the US Northeast, the Pacific Northwest, and Northern and Southern California; a strong showing in the London area; and an especially strong cluster in India's technology hub (and my hometown), Bangalore (now known as Bengalooru). We were surprised by the relative lack of sign-ups from China, Japan, and Korea, but attributed this to our publicity methods and to potential language difficulties.

The distribution of finishers was not at all the same. We had one each from Argentina, Australia, Tanzania (a Dutchman who has lived there for a long time doing missionary work with his doctor wife), Thailand, China, Finland, Belarus, Hungary, Romania, Belgium, Spain, and Portugal. Only Russia, Germany, Canada, Japan, and India, other than the US, provided multiple finishers; the Indians were distributed around the country, in no way matching the distribution of sign-ups. The American finishers also did not correspond to the sign-up distribution, with a very strong showing from the Midwest and Northeast, nobody from the US Pacific Northwest, and one each from Northern and Southern California. In general, therefore, tech hubs seem to offer masses of enthusiasts whose initial interest does not translate into completion. (To our delight, though, we had at least one person on each settled continent!)

I also analyzed the finishers by self-described occupation. "IT" means anyone in the computing industry; "student" could mean anywhere from high-school upwards, though I don't believe any of the high-schoolers who enrolled got very far. Note that some people did not provide this information.

Lite: IT: 6; students: 8; mathematician: 1

Sprint: IT: 13; students (graduate-level): 2; finance: 1

Mezzanine: IT: 14; students: 3; research scientist: 1; stay-at-home dad: 1; associate professor: 1

Ninja: IT: 2

IN TERMS OF PRIOR EDUCATIONAL EXPERIENCE:

	High school	*Bachelor's degree*	*Post-bachelor degree*
Lite	4	5	3
Sprint		9	8
Mezzanine	8	9	7
Ninja			2

The ages were distributed as follows; though we had several in the 13–18 age range sign up, none of them survived the course:

	19-25	*26-34*	*35-50*	*Over 50*
Lite	5	3	3	1
Sprint	3	8	5	1
Mezzanine	5	12	7	
Ninja		1	1	

At sign-up, we also asked people what their likelihood was of finishing each of the certification levels. Suffice it to say these expectations greatly outstripped reality (not least because roughly 1500 participants failed to complete any level).

THE BOTTOM LINE

I expected my in-class experience would remain largely unchanged, while I would learn most from the online component. The exact reverse was true. The online component went along mostly predictable lines, with few surprises. In contrast, the provision of videos had a dramatic and (in my mind) undesirable effect on the in-class experience: of sixty students, only about twenty attended class regularly.

Many students attributed their lack of attendance to the "early" hour of the class: 10am on MWF. As a card-carrying computer scientist, I'm guilty of having had similar views as an undergraduate. However, the same course has been offered at 10am for years, and attendance was always close to perfect, and this year's class didn't seem especially different in constitution. *In short, there is the potential that the provision of videos will have a significant impact on class attendance, even in relatively interactive, discussion-oriented classes.*

PUBLICITY

We made our decision during the summer preceding the course, well before Brown's Coursera announcement. We therefore had to do all publicity ourselves. We made announcements on some mailing lists, and on our own social media pages. We did not employ any other means of advertisement, such as purchasing Google ads. It was never our goal to bulk up with large numbers of students (we were frankly surprised when sign-ups first crossed 100!), so other means of advertising made no sense.

FORMAT

I normally put all my course material online, without any firewall (like the abominable Blackboard and its siblings). What changed is that we created mechanisms for grading online student work (more on this later), and also published videos of all the classes. Rather than create off-line video snippets (as used in flipped classrooms), we simply recorded class and published it in full. Some online students reported that they enjoyed the sense this gave of actually being in the class.

To avoid visibility problems, I changed from writing on the board to writing on a tablet computer projected on a screen: nearly the same writing experience for me, but with perfect visibility on video. (Indeed, the tablet offered some advantages a whiteboard does not, such as the ability to move a block of text from one location to another.) To protect the privacy of students, we recorded from the back of the room so their faces were not seen.

After every class, we converted the videos and published them on YouTube. Online student discussion took place on Piazza, where Brown students were welcome (but most did not actively participate, at least not by name).

PLATFORMS

Instead of sticking with one packaged platform, we used a variety of online media: Google Plus, Google Documents, Google Groups, Batchgeo (to make maps), Dropbox (to share videos), Piazza (for discussion), JotForm (for uploading solutions), Brown Computer Science facilities, and software we wrote. We chose to do this so we could better understand from scratch what tools such an effort needs, and not be hemmed in by one platform. Because I had a staff of world-class problem solvers, I was confident we could fight our way out of any tight corners, and this approach indeed worked well.

STUDY GROUPS

We felt it was important to help people form local study groups, and many students were interested in this, too. Lacking a platform to do this for us, we created an open Google Map that any participant could edit, so they could drop pins indicating where they were and find one another. This worked well enough, and several study groups sprang up around the world.

ONLINE STUDENT BEHAVIOR

The online students generally behaved in exemplary fashion. Once we had weeded out the "tourists" (my term for those who were never going to be serious students in the class), the remainder were often genuinely grateful for the class experience, and were far less demanding than I expected. Indeed, I think they were undemanding to the point of hurting their educational experience.

I was especially afraid of being pestered with email messages of the "i dont know how to install ur software" variety. These never materialized. The few people who contacted us by email had good reasons and kept it brief and on point. We would actually have enjoyed more interaction with some of the online students.

The beginning of the semester was problematic on Piazza. Because there was nothing much to do, the online students turned it into yet another Web discussion site (perhaps to shake out their anxieties), holding forth vapidly on the course topic and much else. I believe this turned off many Brown students, in response to which we created a Brown-only announcement mailing list. Perhaps if we had performed better crowd control initially, Piazza would have remained the single forum everyone used.

I encountered only one moment of angst: when a male online student made an inappropriate remark responding to a female online student. I caught this within an hour of its appearance (during which time it had received fewer than twenty views), deleted it immediately, and posted a chastising comment on the discussion site. Happily, the female student stayed with the course

until the very end, and remained a strong contributor.

There was just one sense in which online students were very demanding: in digital formats. We initially expected we would simply upload our videos to YouTube. But some students complained they couldn't easily access YouTube, or wanted the video for off-line viewing (e.g., while commuting to and from work), so we had to make a direct link also accessible. Some wanted low-resolution versions of the video due to weak Internet access. Some wanted access to the digital version of what I wrote on the "board." Some even wanted *only audio* access to the lectures. Keeping all these different needs satisfied was a significant and constant burden. Surveys suggested each of these formats was useful to just enough students to be worth continuing to provide, and once we had begun to offer one we couldn't take it away.

The timing of our homeworks had an interesting and unintended consequence. Because I was redesigning the course from scratch, many of the projects were brand new and needed debugging. We put out assignments on Fridays. Most of the online students, being working professionals, did them immediately, and helped us find and fix most of the problems. Thus, by the time most Brown students got to the assignments, they encountered much better versions of them.

STAFFING

I did not have any additional resources to teach the online offering. My regular course staff consisted of my grad TA and six undergrad TAs. I informed the undergrad TAs that, because this was a project being run by my grad TA and me, they were under no obligation to participate. Though they largely did not help with Piazza, the video recording and publication was handled almost entirely by them. (These videos obviously benefited the undergrads also, but without them there would have been no online course at all, so in that sense the UTAs were indispensable. To wit, I'd like to thank Liam Elberty, Jonah Kagan, Peter Kaufman, Scott Newman, Jon Sailor, and Varun Singh.)

COMPARISON TO COURSE GRADES

Several people have asked me how these certification levels correspond to letter grades. They don't at all, because the Brown students had to do additional work (the written home works). However, very loosely, doing a reasonable job on the written home works, combined with completing the Sprint requirements, earned a C; doing better on the written home works and completing the Ninja requirements at a reasonable level earned a B; and doing well on both the written home works and the Ninja requirements earned an A. In short, the grade requirements for Brown students were much higher than for online students (which is why we created entirely different names rather than using letter grades). Despite this, Brown students did much better than the online students: 40 A's, 7 B's, 8 C's, and 8 NC's (in a non-required course).

GRADING

Because we only graded the programming-related assignments for online students, all their grading could be automated. Most online programming courses have students upload programs that are run by grading scripts. We decided that we didn't want the headache of dealing with potentially malicious programs (it may help—or hurt—that Joe and I both do computer security research), nor the expense of running these programs on a cloud provider. We therefore instead handed out a binary program for each assignment that would run the same checks on the students' own machine, and report the results back to us. (As Joe pointed out, this puts the trust relationship in the right direction: we have no reason to trust them, but if they don't trust us enough to run our program, why are they taking a course from us?)

Of course, when the students are reporting their answers to us, it's too easy for them to cheat. We therefore embedded a little ad hoc cryptographic protocol—Joe appositely labeled it "craptography"—in the grading programs to make this difficult. Our goal was not to create something impregnable, but rather to prevent casual and, indeed, all but determined cheating. This process worked well in retrospect.

WHO GAINED FROM THIS EXERCISE?

I gained the most. I got to experiment with what is clearly an upcoming challenge to our profession. I got the opportunity to reach out to whole new segments of the computing population. (We already have a new master's student applicant from this online audience, and I wouldn't be surprised if some of the participants end up becoming PhD applicants down the road.)

Joe and the other course staff also learned a lot about the needs and demands of online teaching platforms. One TA, in particular, has a deep interest in MOOCs, and has been considering job offers from companies such as Coursera and Khan Academy. For these students it was a valuable real-world software requirements-gathering experience.

The benefits for Brown students were probably fewer, but that is also because we worked to insulate them from the online crowd. I do think the students benefited some from interactions, especially with professionals. For instance, they got to see some important differences between how they and professionals tackled some tasks, and at least some students found this thought-provoking.

My wife pointed out one subtle benefit for Brown. Over the years, I've found it difficult to explain the chasm between our courses and those almost everywhere else (in the world). Offerings like this give the world a window into what we do, and let them judge just how demanding (and good) our courses are. This raises the profile of our students with potential employers and others who need to evaluate them. By not only being uncompromising in the quality of our courses but by also showing that there's more to a Brown course than what is offered online, we also signal to the best students worldwide that we are a place where they might feel at home.

Checking in with New Faculty Member Tim Kraska

BY MARK NICKEL, BROWN PAUR

Tim Kraska Assistant Professor of Computer Science

Even everyday living—smart phones, EZ Passes, credit card purchases—now generates a gush of data. Machines for storing it and software for making sense of it may not be keeping up with the petabytes. Tim Kraska is rethinking how and why we use Big Data.

Tim Kraska has seen the future, and it looks an awful lot like Big Data.

"Big Data is for sure the hot area, but not only in computer science. It is hot everywhere," he said. "That is one of the big differences. Big Data is the next frontier of innovation for everyone."

That may no longer be news. Scientists at CERN analyzed data by the hundreds of petabytes in their search for the Higgs boson. Even Hollywood producers have entered the petabyte sphere—one billion megabytes—for the rendering process of a movie. The explosion of data has rendered many traditional techniques obsolete.

Sheer size is an obvious problem. "Working on megabytes is really easy, but even working on gigabytes is still hard," Kraska said. "Petabytes are a whole different story, so that's the scaling problem. But data is not necessarily so structured anymore. It may consist of images, plain text, videos, audio signals. How to query that data, how to make sense out of it, is another significant problem. We really need to rethink how we use Big Data."

That has been an organizing principle throughout Kraska's career. As a graduate student in his native Germany (Westfälische Wilhelms–Universität Münster, Master of Information Science, 2006), he worked on a proposal for continuous XQuery processing that was accepted by the World Wide Web Consortium for the XQuery 1.1 standard. XQuery processes structured text, virtually anything that is accessible in XML. His PhD work (ETH Zurich, 2010) got him into building large database applications for the cloud. Since March 2010, he has been at the University of California–Berkeley's AMPLab as a postdoctoral scholar.

Crowd-sourcing is another of his Big Data interests—giving computers access to human computation, effectively turning the human-computer relationship on its head. "There are certain tasks a computer is really, really good at and other tasks that people are really good at," Kraska said. "For example, it takes an awful lot of work to train a computer to identify a person in an image. Humans, on the other hand, are extremely good and fast at doing that. With crowd-sourcing, a computer can ask certain questions of humans and get the answer. It's a super-powerful way of including humans in the system for tasks at which humans are particularly good."

Kraska will begin his work at Brown in January 2013. He was attracted to Brown because of its size and supportive environment and by the quality of students and faculty.

"I have met some of the faculty at conferences, but I hadn't collaborated with anyone," he said. "It was funny, though. When I came out to interview, I started a collaboration with one of my interviewers —whether they accepted me or not."

Kraska's curriculum vitae includes a note that he is a certified ski instructor. Did anyone tell him that the highest point in Rhode Island is all of 812 feet? Is there a chance he could be disappointed with the Ocean State?

"No, no. They told me all about that; I am prepared," Kraska said. "I stopped teaching sometime ago, but maybe there will be a chance to organize a ski seminar to the Rocky Mountains someday."

Faculty Notes

SHRIRAM KRISHNAMURTHI

Shriram spent winter break with family first attending a Dagstuhl seminar, then taking a family vacation to catch some snow in Innsbruck. It was a balmy 50 degrees around Christmas in Innsbruck. They returned to Providence to a several-inch snowstorm.

In January Shriram visited Rome for the first time. Highlights: what to pick? Was it the hour spent inside the Sistine Chapel? Or watching AS Roma play Inter Milan from the cheap seats of the Curva Nord in the Stadio Olimpico, surrounded by colorful flares and equally colorful Italian curses? Or the view of sunset behind St. Peter's from the hotel room balcony? Was it eating contorni? Emerging from the bustle of Termini to be startled by the Thermae Diocletiani? Or discovering the gran caffè at Sant'Eustachio (thanks, Andrew Ferguson)? He was actually there to attend POPL, deliver a keynote, and pick up an award, but you can tell where his heart really was. (It's still wandering somewhere between Sant'Eustachio and the Pantheon.)

A building around the corner from Andrew Ferguson's favorite espresso shop, aka, the Pantheon.

DAVID LAIDLAW

David is teaching CS16 for the third time this Spring. As always, the sixteen CS16 TA's are making the job fun and helping the class be awesome. At the same time, a new virtual reality Cave is under construction. By the Fall it should be displaying its 140 million stereo pixels to early users, including students in cs137. Please keep your fingers crossed—we need all the luck we can get!

The custom aluminum superstructure for Brown's new virtual reality room is complete! Now we just have to attach all the pieces, including 70 HD stereo projectors.

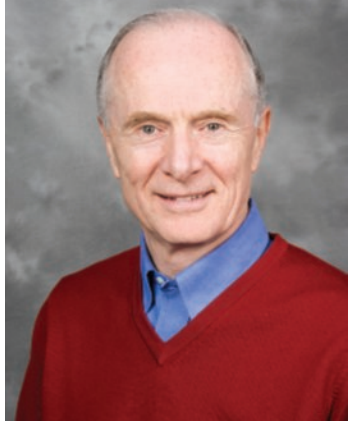
JOHN SAVAGE

John Savage continues to be active in cybersecurity policy discussions. In June he participated in the Cyber Doctrine Workshop run by the Battelle Institute that led to the publication of the book **#CyberDoc: No Borders – No Boundaries** by the Potomac Institute Press. In June he also served on the Cybersecurity and the Law panel at the USENIX Hot Topics in Cyber Law in Boston. In September he was a panelist at the Cyber Norms Workshop 2012 held at MIT. In November he was the keynote luncheon speaker at the Second Annual Conference run by the Advanced Cyber Security Center in Boston. He continues to serve on the Nominations Committee of the Faculty and the Executive and the Faculty Search Committees of the Department. In the fall he taught Models of Computation and in the spring is teaching Cybersecurity and International Relations. During the current academic year he is running a Cybersecurity Colloquium series under the auspices of the Watson Institute for International Studies at Brown where he is a faculty affiliate.

ERIK SUDDERTH

This fall, Brown's new Institute for Computational and Experimental Research in Mathematics (ICERM) held a program on "Computational Challenges in Probability." Erik co-organized a September workshop and tutorial, which brought experts from around the world to discuss recent innovations in Bayesian nonparametric machine learning. Erik's fall sabbatical gave him ample time to work on research collaborations with the many visitors which this ICERM program brought to Brown.

In December, Erik's research group traveled to Lake Tahoe to present four papers at the Conference on Neural Information Processing Systems (NIPS). This spring, his new graduate course will introduce students to the fundamentals of probabilistic graphical models, a framework for learning compositional models of complex systems.



Cybersecurity needed in the public domain

BY MARK NICKEL, BROWN PAUR

John E. Savage, the An Wang Professor of Computer Science, shared his views on what can and should be done to ensure cybersecurity at the national level. Savage is active in cybersecurity from both a policy and technology point of view, having spent the 2009-10 academic year in the U.S. Department of State as a Jefferson Science Fellow.

John E. Savage

"We need a research and development effort that brings new cybersecurity solutions into the public domain and encourages their implementation."

In a major policy speech delivered last week, Secretary of Defense Leon Panetta sparked a new discussion of cyberwarfare threats, warning that cyberattacks "could virtually paralyze the nation." The three-part response Panetta outlined emphasizes new cyberwarfare capabilities in the Department of Defense, new policies and organizations across the federal government, and stronger partnerships between the government and international partners and domestic industry.

I would add a fourth area of emphasis. We need a research and development effort that brings new cybersecurity solutions into the public domain and encourages their implementation.

The need for publicly available security solutions was illustrated by the Shamoon virus attack last summer. This virus virtually destroyed at least 30,000 computers at the Saudi Arabian Oil Company Aramco and Qatar's Ras Gas Company. Although the computers were not controlling oil and gas production, they probably contained valuable business data, the loss of which could severely impact business operations. Businesses like these need solutions that will allow them to protect and access their data and to continue operating during and after cyberattacks.

Another recent attack illustrates the need to make sure known defenses are widely implemented. U.S. financial institutions were hit by "denial of service" attacks designed to flood websites with bogus requests that overwhelm server capacities. Researchers have published techniques to prevent such flooding attacks, but they have not been widely deployed even though they are considered inexpensive. This underscores the need to bring technology researchers, government, and industry representatives to the table to make sure cutting-edge solutions make it into widespread use.

Finally, and perhaps most importantly, government and industry need to share best practices. Panetta noted in his speech that the United States has made great strides in addressing the attribution problem—the problem of identifying the origin of cyberattacks. Identifying attackers is essential if the United States must justify retaliation against a serious cyberattack, so it's encouraging that strides are being made. But those advances aren't of much use to the private sector if they are considered as classified information.

Effectively preparing the private sector for cyberattack may require the relaxation of security classifications on some material. While classification provides the government with a tactical advantage in defending the nation, one has to weigh this against the strategic value of a secure global Internet. Decisions about such matters are not easy but they are important.

Department Awards and Honors

HERLIHY HONORED AS NAE MEMBER

Maurice Herlihy, professor of Computer Science, has been named a member of the National Academy of Engineering (NAE). Herlihy was honored for his work on concurrent computing techniques for linearizability, nonblocking data structures, and transactional memory. Election to the NAE is among the highest professional distinctions accorded to an engineer. Academy membership honors those who have made outstanding contributions to "engineering research, practice, or education, including, where appropriate, significant contributions to the engineering literature," and to the "pioneering of new and developing fields of technology, making major advancements in traditional fields of engineering, or developing/implementing innovative approaches to engineering education."

ANNA LYSYANSKAYA ELECTED TO THE BOARD OF DIRECTORS OF THE INTERNATIONAL ASSOCIATION FOR CRYPTOLOGIC RESEARCH

The International Association for Cryptologic Research (IACR) , a non-profit scientific organization whose purpose is to further research in cryptology and related fields, elected Anna Lysyanskaya to its Board of Directors in a recent election.

Cryptology is the science and practice of designing computation and communication systems which are secure in the presence of adversaries.

The 2012 election was held October 1 through November 15 to fill three of nine IACR Director positions. In total, 270 out of 518 members cast their vote for Anna. Her priorities while on the Board are: (1) High quality research and its effective dissemination, (2) mentoring, (3) dialogue with related research communities, industry, standards and funding agencies.

ROBERTO TAMASSIA NAMED AAAS FELLOW & ACM FELLOW

The American Association for the Advancement of Science, "Triple A-S" (AAAS), an international non-profit organization dedicated to advancing science around the world by serving as an educator, leader, spokesperson and professional association, recently elected Roberto Tamassia to Fellow for "distinguished contributions to algorithms and data structures, particularly for pioneering work on graph drawing, and to computer science education as the author of influential textbooks."

The Association for Computing Machinery (ACM), the world's largest educational and scientific computing society, recently elevated Roberto Tamassia to Fellow for "contributions to graph drawing, algorithms and data structures and to computer science education."

Roberto, who joined the department in 1988, works on information security, design and analysis of algorithms, graph drawing, geometric computing, data management, and information visualization. He is the Plastech Professor of Computer Science and the Chair of the Department. He is also the Director of Brown's Center for Geometric Computing. He has published textbooks on the subjects of algorithms, data structures, graph drawing, and computer security and more than 230 research articles in the above areas. He has given more than 70 invited lectures worldwide.

Roberto is an IEEE Fellow and the recipient of a Technical Achievement Award from the IEEE Computer Society for pioneering the field of graph drawing. He is listed among the 360 most cited computer science authors by Thomson Scientific, Institute for Scientific Information (ISI). His research has been funded by ARO, DARPA, NATO, NSF, and several industrial sponsors. He co-founded the Journal of Graph Algorithms and Applications and the Symposium on Graph Drawing. He serves regularly on program committees of international conferences. Roberto received the PhD degree in electrical and computer engineering from the University of Illinois at Urbana-Champaign.

Each year the Council elects members whose "efforts on behalf of the advancement of science or its applications are scientifically or socially distinguished." The honor of being elected a Fellow of AAAS began in 1874 and is acknowledged with a certificate and rosette.

In addition to organizing membership activities, AAAS publishes the journal "Science," as well as many scientific newsletters, books and reports, and spearheads programs that raise the bar of understanding for science worldwide.

Roberto joins the Department's two other AAAS fellows, John Savage and Andy van Dam and the Department's nine other ACM Fellows: Tom Dean, Maurice Herlihy, Philip Klein, Franco Preparata, John Savage, Eli Upfal, Andy van Dam, Peter Wegner and Stan Zdonik.

STEFANIE TELLEX JOINS THE DEPARTMENT AS ASSISTANT PROFESSOR

The Department is delighted to announce the addition of Stefanie Tellex to the faculty roster as an assistant professor, starting in the fall semester.

"We are very excited to welcome Stefanie to the department," said Chair Roberto Tamassia. "She has outstanding creativity and unbounded energy. Her expertise in robotics and natural language understanding is highly synergistic with our strategic research priorities and we look forward to her leading new interdisciplinary projects."

Eugene Charniak added, "I think it is great that Stefanie is coming to Brown. Her research area (human-robot communication) is exciting, and her approach (graphical models) is exactly right."

"Stefanie has been a tremendous contributor to robotics and artificial intelligence in her young career," said Chad Jenkins. "She has demonstrated a unique ability to find new approaches to solve hard technical problems while also improving the quality of human-robot interactions. We are thrilled to have such a rising star."

Stefanie received her PhD, M.S., M.Eng and S.B. from MIT and is currently working as a research scientist in the MIT Computer Science and Artificial Intelligence Laboratory. She was also a Postdoctoral research associate at MIT where she was the technical lead for the Interpretation of Spatial Language project, developing a language understanding system for robotic mobile manipulators. Stefanie's current research interests include probabilistic graphical models, human-robot interaction, and grounded language understanding.

According to Stefanie, "I'm very excited to be joining the Brown Computer Science department. The CS department's interdisciplinary environment provides new perspectives and tools to address the multi-faceted problems of human-robot interaction and language understanding. I look forward to engaging with students and faculty from diverse backgrounds to address these challenges."

Stefanie joins our other three new faculty members, Michael Littman, Tim Kraska and Paul Valiant.

CS FACULTY CO-HOST HUMAN-ROBOT INTERACTION SYMPOSIUM

Members of the CS department, including Pedro Felzenszwalb, James Hays, Chad Jenkins, Michael Littman and Eli Upfal, participated in the Initiative in Human-Robot Interaction's inaugural symposium on Monday, December 10. The symposium was organized by Chad, Michael, and Bertram Malle (CLPS) and was sponsored by the Department of Computer Science, the Digital Society Initiative, the Research Initiatives Office, and the Technology Ventures Office. The theme of the event was Fundamental Problems and Societal Solutions.

The symposium's goal was to build a broad network of Brown scholars whose work speaks to issues of Human-Robot Interaction (HRI) and to draw attention to Brown's existing capabilities and resources to advance innovative, high-impact research, teaching, and technology in this emerging field. It showcased current activities in five thematic areas: Perception, Decision, Interaction, Action, and Impact.

The field of HRI raises fundamental questions about cognition and action in humans and robots and their increasingly sophisticated interactions. HRI research is inherently multidisciplinary and calls for contributions from science, the arts, and industry. HRI is also nationally recognized for its transformative impact on society. Applications of HRI to healthcare and medicine, service industries, manufacturing, and scientific exploration have the potential to enhance human productivity and enrich our quality of life.
The symposium featured 20 informal ten-minute faculty presentations spanning diverse fields in the basic sciences, arts, humanities, and applied technology, setting the stage for rich HRI collaborations at Brown.
"I think the symposium was a big success," said Michael Littman. "It showcased some of the diverse and fascinating work going on all around campus."

Recent PhD

Jennie Duggan

Department Hosts 12th Annual Paris C. Kanellakis Memorial Lecture

Cynthia Dwork at the start of her talk.

On December 6, 2012, Cynthia Dwork, Distinguished Scientist at Microsoft Research, delivered the 12th Annual Paris C. Kanellakis Memorial Lecture. This lecture series has been held annually by the department in honor of Paris on or around his birthday. In a standing-room only lecture, Dr. Dwork kindly devoted an introduction to Paris, mentioning their close friendship and how much she misses both him and his wife, Maria Teresa Otoya.

The talk, titled "Differential Privacy: Thwarting Big Data's Evil Twin," discussed the problem of how to reveal accurate statistics about a population, while still preserving the privacy of individuals. Differential privacy is a rigorous and "ad omnia" definition of privacy that, intuitively, hides the presence or absence of any individual, or small group of individuals, in the data set. Unlike many previous definitions, differential privacy is not binary; instead, privacy loss is quantified, and can be controlled. This quantification, together with powerful composition theorems, permits complex private analyses to be constructed from simple differentially private primitives, or "building blocks."

The talk defined differential privacy, described some basic techniques, and presented a recent result that echoes the speaker's first collaboration with her friend, Paris Kanellakis. A reception followed the lecture, where Dwork met several current and former Kanellakis Fellows from Brown and MIT and spent time talking with them, sharing memories of Paris and providing advice for successful completion of PhD studies.

Cynthia is widely known for placing privacy-preserving data analysis on a mathematically rigorous foundation. Dr. Dwork has also made seminal contributions in cryptography and distributed computing, and is a recipient of the Edsger W. Dijkstra Prize, recognizing some of her earliest work establishing the pillars on which every fault-tolerant system has been built for

Kanellakis Memorial Lecture *continued*

Left // Maurice Herlihy introduces Cynthia.

decades. She is a member of the U.S. National Academy of Engineering and a Fellow of the American Academy of Arts and Sciences.

The Paris C. Kanellakis Memorial Lecture series honors Paris Kanellakis, a distinguished computer scientist who was an esteemed and beloved member of the Brown Computer Science department. Paris joined the department in 1981 and became a full professor in 1990. His research area was theoretical computer science, with emphasis on the principles of database systems, logic in computer science, the principles of distributed computing and combinatorial optimization. He died in an airplane crash on December 20, 1995, along with his wife, Maria Teresa Otoya, and their two young children, Alexandra and Stephanos Kanellakis.

Kanellakis Fellows past and present pose with speaker Cynthia Dwork, host Maurice Herlihy and Chair Roberto Tamassia.

Around the Department

Above // Eugene Charniak's Topics in Computational Linguistics course had a special visitor last semester when Chinua Achebe, the David and Marianna Fisher University Professor and Professor of Africana Studies, attended class. Dr. Achebe recently passed away. Eugene and the department were especially grateful for the opportunity to have worked so closely with him. Eugene has been awarded an NSF grant to explore the Igbo dialects of Southern Nigeria using statistical machine learning, which was also the topic of this year's class. Prof. Achebe and his son, Dr. Ike Achebe, directed the building of the corpus of spoken Igbo the class used for its work.

Above Right // Professor Steve Reiss views the poster session for his CS1320: Creating Modern Web Applications course.

Alumni Update

JILL HUCHITAL '89 AND KAREN SMITH CATLIN '85

To celebrate National Engineers Week (Feb 17–23, 2013), the Anita Borg Institute (http://anitaborg.org/) published a series of interviews with female engineers. Two Brown CS alums were honored to be part of the series: Jill Huchital '89 and Karen Smith Catlin '85. In their interviews, Jill and Karen spoke about why they enjoy being engineers, described an exciting project they had worked on, addressed why it is important to have women engineers, and shared advice for other women. You can read their interviews on the Anita Borg web site.

Jill Huchital's interview: http://bit.ly/ZAwYsW

Karen Smith Catlin's interview: http://bit.ly/15xP5QO

SUNIL MALLYA '11

Neon gets more people watching videos by selecting thumbnails that people want to click. Neon was founded on research conducted at Brown through the Center for Vision Research (CVR). The team includes a number of scientists and engineers from at Brown, Sunil Mallya, Sophie Lebrecht, Michael J. Tarr, and David Sheinberg. Neon's thumbnail selection algorithms are based on models of how the brain perceives images and can determine which image people prefer. Neon recently raised a seed-round of venture funding and looks forward to growing the product and company in the Bay Area.

www.neon-lab.com

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Industrial Partners Program

The IPP provides a formal mechanism for interactions between companies and students in the CS Department. Member companies benefit from superior visibility in the Department, exclusive access to event/interview space in the CIT Building and assistance with recruiting events; students benefit from specific information about opportunities for summer internships and permanent employment.

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