

Conduit

DEPARTMENT OF COMPUTER SCIENCE
Brown University // Vol. 27

An illustration of a woman with brown hair in a bun and glasses, wearing a white t-shirt and blue jeans, sitting on the floor. She is holding a young girl with dark hair and a purple shirt, who is also sitting on the floor. They are both looking at a book held by the girl. The scene is set in a room with a grey wall and a wooden floor. There are some drawings on the wall, including a spiral and a stick figure.

toymaker

IN MEMORIAM: PETER WEGNER

AN INFLECTION POINT:
HCRI LOOKS AHEAD TO SIROS 3

IGNITECS @ BROWN

Notes From The Chair



BY UGUR CETINTE MEL

It's a pleasure to be writing to all of you again just a few months after our last issue came out. I wrote my most recent note as we were preparing for Commencement, but with this issue, we're changing the publication cycle. Instead of the end of the academic year, we'll be coming to you at the end of the calendar year, so our next issue will appear in late 2018.

I'd like to start with the exciting news that Computer Science is now the single largest concentration at Brown! Last May, we handed out a record number of 205 diplomas, easily beating our previous records of 168 a year ago and 131 two years ago. This is an increase of 22% just from last year and 56% in only two years! This interest is a testament to how exciting and powerful computer science has become as a discipline and career path, as well as our Department's continued commitment to offering a CS program that's second to none. Our preliminary enrollment numbers already indicate growth of ~8% from last year.

As we welcome a record number of students to Brown CS this fall, I'd like to specifically thank my colleague, John Hughes (Spike), who has agreed to serve as our Associate Chair. Spike's leadership and support will be critical in addressing the needs of our growing and increasingly diverse community.

I'd also like to welcome Ellie Pavlick, who will join our faculty this summer. Ellie recently received her PhD from the University of Pennsylvania and will be doing a postdoc at Google Research before coming to Providence. Ellie works on natural language processing, machine learning, and crowdsourcing. She'll strengthen our efforts in these areas and

help us connect with other Brown groups, including Public Health; Cognitive, Linguistic, and Psychological Sciences; and Economics. We're planning to recruit several new faculty members this year, focusing on data science and computational biology, in collaboration with the Data Science Initiative.

Other good news includes special recognition that our faculty members received at the end of last semester. Maurice Herlihy and Tim Kraska won, respectively, Brown's inaugural Research Innovation and Early Career Research Achievement Awards. We're delighted that the research accomplishments of our colleagues have been acknowledged with these two (out of a total of just five) prestigious, university-wide awards.

Unfortunately, I also have sad news to share: our colleague, Peter Wegner, passed away in July. Peter came to Brown almost 50 years ago, and he was a founder, a friend, and a remarkable computer scientist. His commitment to Brown CS and his continued participation, even after he retired, have always been a blessing and inspiration for all of us. We will greatly miss him.

As we approach the 40th anniversary of the founding of our Department, the CIT is bustling with people and activity. We're looking forward to the year ahead and we'll continue to share exciting news and stories as they develop.

Conduit

Vol. 27

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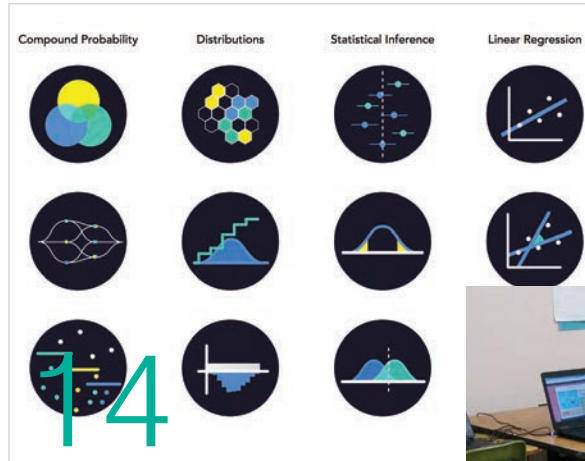
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toymaker

It's half past noon in CIT 368 on May 18, 2017. After fourteen years of Senior Lecturer Barbara Meier's computer animation classes at Brown, after months of focused effort, we have something very new, a first: *Toymaker*, a seven-minute animated short.

Every seat is full, and much of the floor. The lights are dimmed. In darkness, there's room for multiplicity. The student who started the whole thing is here with her team of thirteen. There's the teacher and mentor who didn't just advise but worked the long hours alongside them; here's the composer who wrote the score and helped perform it. Classmates from RISD as well as Brown are gathered, friends and friends of friends, and the colleagues and experts who are maybe the only ones to fully understand the scope of what's been accomplished.

But why subdivide the ineffable? The flickering screen makes us all spectators again. We're drawn to the high spire, the telescope, to humankind's mastery of art or science on the grandest scale, but also to the personal and small: the studio in all its clutter, the Wozniakian garage, or

here, the string of fleeting moments that tell a much bigger story.

We're ready to wonder again. Barb's about to hit the ► button.

Take a moment to see it for yourself: go to <https://vimeo.com/242488116> and use contoyduit17 for the password.

Not Knowing What The Recipe Would Make: Barbara Meier

Before story, history: Barb traces her interest in animation to when she was twelve or thirteen. Her parents disapprove of most daytime television, so she watches when they aren't home, and is awed by the hand-drawn work that she sees in an animated film festival. At first, a career as an animator seems as unlikely as becoming an Olympic skater, but in the years that follow, Barb finds herself returning to the idea that animation is just drawing on paper. "It didn't have to be this mysterious process," she says. "I felt like it was an actual possibility."

But there's plenty of mystery to come along a zigzagging career path. Studying computer science as a Brown undergrad, Barb sees the potential for using



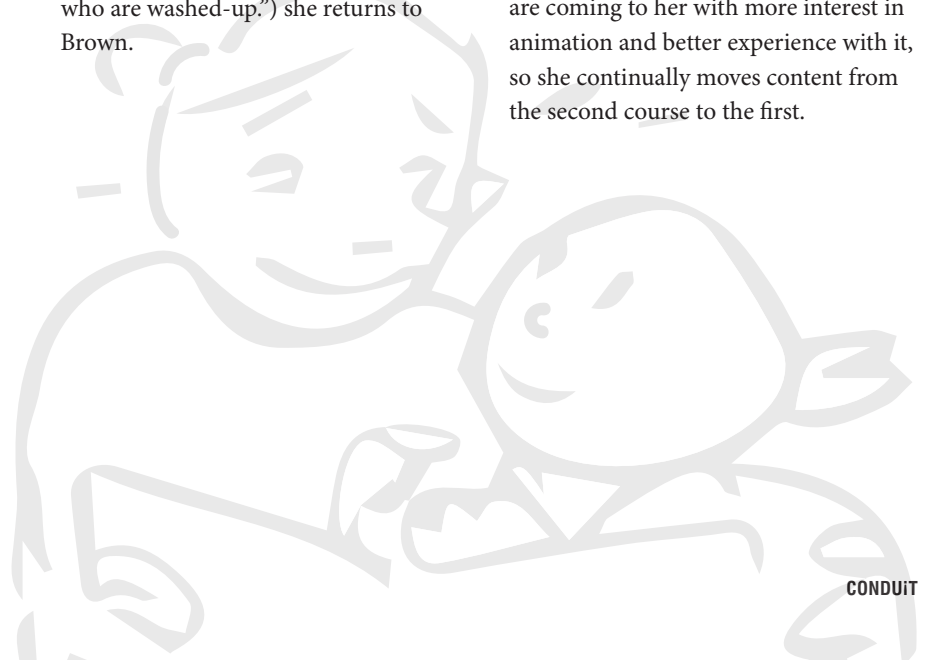
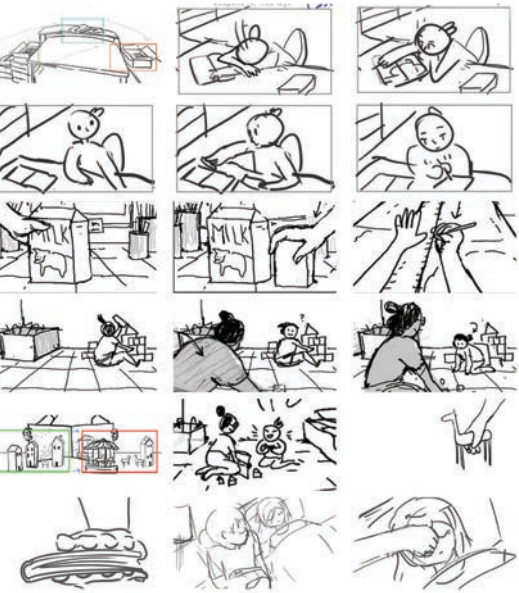


computer graphics (CG) in animation and is drawn to auteur animation's ability to realize the vision of a single artist. She credits Andy van Dam for encouraging her to apply to the Brown CS Master's program, and postgraduate work follows at RISD, the School of the Museum of Fine Arts in Boston (their curriculum replicates the working life of an artist, an idea that Barb returns to later in her own teaching), and the Art Center College of Design in Pasadena.

Barb chooses animation in part because of its immediacy: "It was this idea that you could draw on paper, it wasn't this mysterious process."

Industry work catches Barb's attention first, and she spends almost a decade in California, creating animated effects and digital matte paintings. It isn't easy: long hours, constant pressure to work faster and lower costs, extremely narrow margins. "I knew it wasn't going to sustain me forever," she says. "I wanted kids, a life. It was a really great ride, but I thought I could take what I'd learned everywhere and bring my industry experience to students, even if I didn't know what the recipe would make." A book about making a career change had recommended teaching, and with more than a little hesitation (Barb remembers saying, "No, not that! That's for people who are washed-up.") she returns to Brown.

Barb agrees to take on CS 195-9 (now CS 125) in mid-July of 2003. Beyond any doubt, it's trial by fire. She remembers frantically picking software for the course in August, trying to prepare lectures with two small boys running around the house, finishing her notes an hour before the class begins. She says, "The one thing I think I did well was setting up a structure and creating assignments. Right away, I saw the students doing really good work, exceeding expectations on every task I gave them." Graduates of the course often continued working with Barb independently, which sparked the need for a second course, CS 128 Intermediate Computer Animation. One trend continues year after year: students are coming to her with more interest in animation and better experience with it, so she continually moves content from the second course to the first.



CS 125 presents students with the new challenge of creating a short film at the end of the course. “But they’re really bare-bones,” Barb says, smiling. “It’s an important project because it forces students to tackle all parts of the film, even those they’ve barely practiced. If they pause to polish one area, they’ll never finish the rest. CS 128 addresses the desire to go back and do it right, to learn the artistic and technical skills at a deeper level. The price is that lavishing more time on every stage of production makes it impossible to finish a short film at the end. The ultimate dream is to flex the deeply-honed skills to finally make a high-quality short film.”

Occasionally, some students follow that dream.

Portraits From Life: Nellie Robinson

“One of the main things I got out of CS 125,” says Nellie Robinson, “was working as a team on our one-month short. I wanted to repeat the experience.” That was the start of *Toymaker*.

Since graduating in May (she has a dual degree from RISD), Nellie has been working at Ingenuity Studios in Los Angeles. As a kid, we find her working with crafts (turning tissue boxes into apartment buildings, building a tiny playground out of concert tickets) and drawing portraits from life: “I always enjoyed drawing, but I never thought about how it could be applied to other things.” She doesn’t take any CS courses in her first year at Brown and RISD, but learns Processing, a programming language built on Java for the art and design community. “I really liked looking at the output of code I’d written, the visual aspect,” she says. “Maybe I was drawn to computer animation because it’s squarely between the technical and the artistic.”

That summer, Nellie interns at Pixar, and CS 125 follows. It’s motivation enough for a big project of her own, so she goes to Barb in November of 2015 with a pitch for a new class. The reaction?

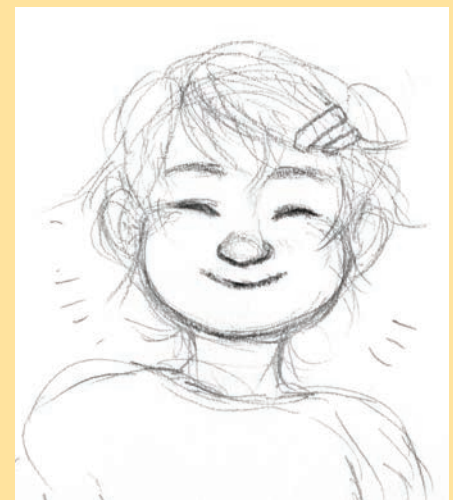
“Ugh, not again!” Meier laughs, pantomiming despair by putting a hand to her forehead and slowly lowering her head to her desk. In the past, students have asked her for a third class, to work on bigger projects: it was offered once, in 2011. “I was wearing too many hats, producer and director, and it was frustrating in many ways. Unintentionally, we set ourselves up to fail. When Nellie came to me, I gave her a choice, and when she picked a class instead of a group independent study project, I set very high bars: lots of monitoring throughout the process, at least ten people on the team, and having one person as the sole producer.”

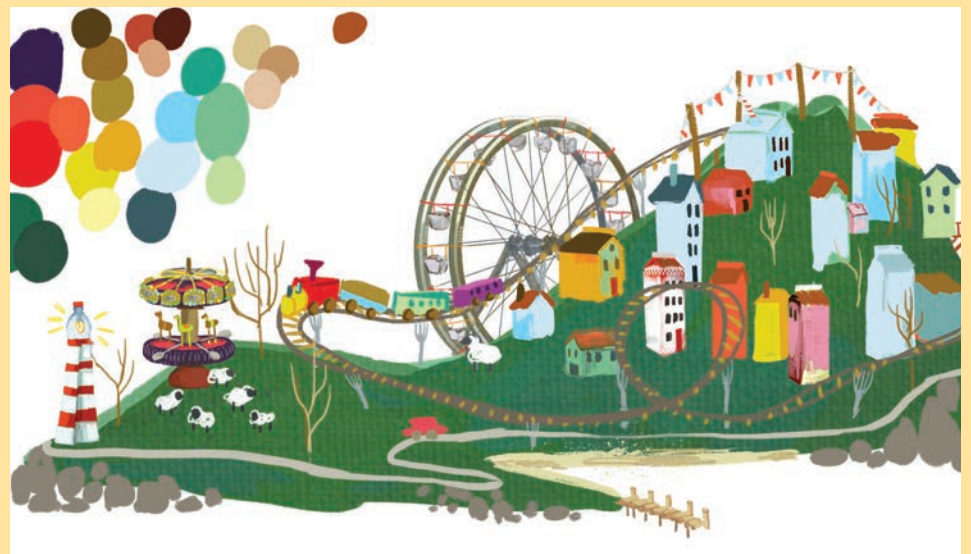
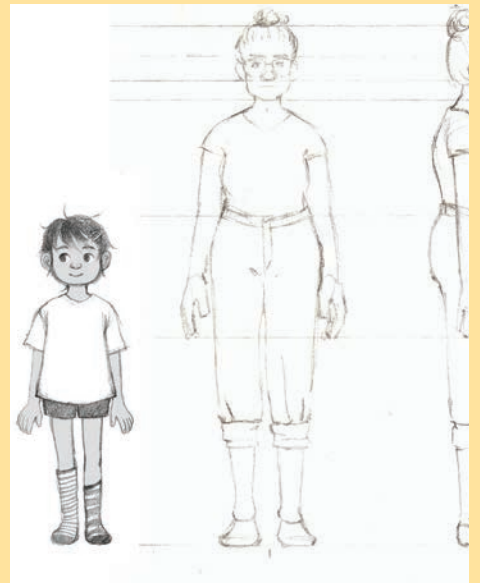
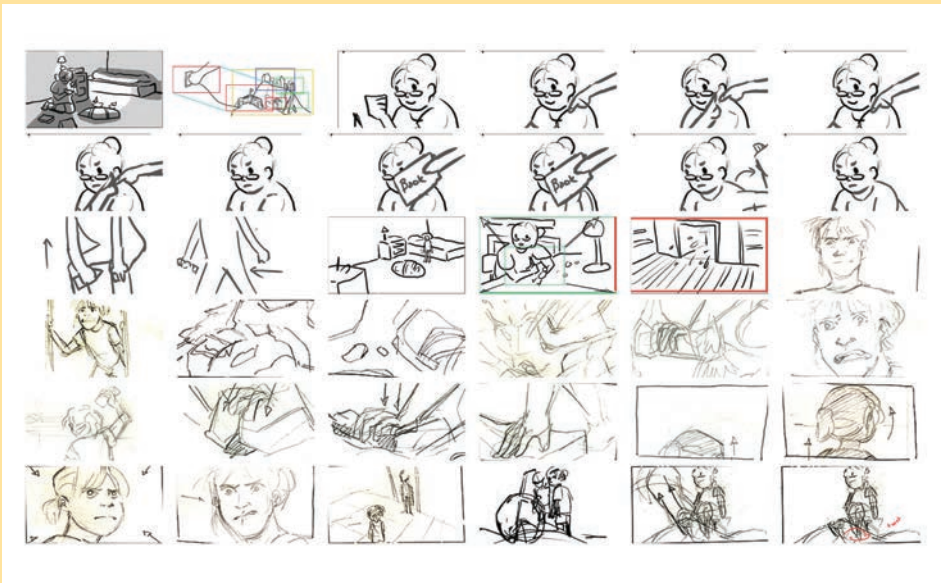
And so it begins. “At the start,” Nellie says, “it felt entirely reasonable.”

Spring And Summer: Pre-Production

Take a look at *Toymaker* again, focusing on nothing but the textures: the dull plastic handle on the cheap pair of scissors that we all own, clumped and gummy glue, the glint of a paperclip. But there’s more. Look closer. See how paint feathers at its edges into woodgrain, or how age and reuse turn a soda bottle’s perfect transparency into translucence, or –quick, you only have seconds to admire it– the hundreds of crisscrossing scores that a utility knife makes in the slightly nubbly rubber of a tabletop-protecting mat.

In the spring of 2016, Robinson has her story, so she brings it to Megan Jerbic of RISD, who begins turning it into a script. Nellie starts working with other RISD friends (Mariel Rodriguez and Julie Kwon on character design,







The team (from left back): Melanie Ambler, Vivian Morgowicz, Yoo Jin Shin, Megan Jerbic, Emily Reif, Emma Herold, Barb Meier, Felege Gebru, Ray Muñoz (from left front), Irene Tang, Nellie Robinson, Kenji Endo, Ben Nacar, Luci Cooke. Not pictured: Dash Elhauge, Simon Jones, Julie Kwon, Mariel Rodriguez, Michelle Zhuang.

Michelle Zhuang and Yoo Jin Shin on set design), and soon it's time for choosing color palettes and designing objects that will make up the *Toymaker* world. "The main feed for the visuals," she says, "was the DIY mentality. I'm really interested in repurposing objects, turning trash into fantasy worlds." As a possible aesthetic influence, Nellie cites the stop-motion work of Laika Entertainment: "Objects have flaws. There aren't a lot of perfect perpendiculars, it's kind of wonky – you can tell the materials of everything."

Her original idea for the cast of characters is an old man and his daughter: "That was the first thing that came to mind, but the artists pointed out, and I agreed, that it was a trope that's been done a lot, the old craftsman neglecting his kids. Turning the toymaker into a working single mother is more nuanced and relevant. We're instantly aware of her work/life balance, and this

places more importance on the difference between providing for her daughter and connecting with her daughter."

It's a notion that makes it easy to understand how Nellie's mentor might have been drawn to the project. "I want to change how people look at the seemingly small issues of everyday life," Barb writes in a recent Artist Statement, "but those that affect us and our relationships in some of the more profound ways."

Summer: Much More Than A Community

Summer arrives, and Nellie has managed to gather enough people to meet Barb's requirement.

"If I'd stopped to think about it," says Kenji Endo (now Head TA for CS 125, he's graduating in the spring of 2018), "maybe

I wouldn't have thought *Toymaker* was feasible. But it was so cool! Nellie has a great artistic eye and technical skill. And the people drew me in, the sense of community."

It's time to meet the team. Thanks to prior work with Barb, the students know the production pipeline of animation inside and out: Meier immediately assigns each phase of the project to one or two leaders and possibly a "worker bee" or two under their direction. Each leader has to define their job and their team's goals. The poster for *Toymaker* lists everyone in alphabetical order: Luci Cooke, Dash Elhauge, Kenji Endo, Felege Gebru, Emma Herold, Simon Jones, Barbara Meier, Vivian Morgowicz, Ray Muñoz, Ben Nacar, Emily Reif, Nellie Robinson, Yoo Jin Shin. Megan Jerbic, Julie Kwon, Mariel Rodriguez, and Michelle Zhuang also contributed to the script, storyboards, character design, prop design,

and set design; Melanie Ambler and Irene Tang accompanied Ben Nacar on the *Toymaker* score.

“I think Nellie said it in a Facebook post,” says Barb. “The whole reason wasn’t to make this film but to make it with these people. The students were already a community from taking classes together, but they were much more than that at the end. The hard work came out of not wanting to let each other down.”

At the beginning, did it ever feel too ambitious, even impossible? Nellie thinks for a moment: “I’m not sure, but if it did, that feeling definitely increased as time went on. When something is pushed back a few days, it pushes back everything else. The whole project felt slightly more unreasonable each week.”

Fall: Modeling, Shading, Character Modeling, Rigging, Layout, Blocking


And the weeks are already going by. For a visual, picture the MS Lab, which serves as home base. No matter which hour of the day or night it may be, Nellie and the others have gotten used to seeing at least one member of the *Toymaker* team at work whenever they walk in.

The leaders have set up the assignments for their worker bees, but sometimes all hands are needed. Modeling is one of the biggest pieces of the puzzle, and it involves creating the geometry of everything in the set based on sketches, then applying textures, color, surface properties. Set dressers are putting the props into place, just like they’re moving into a new apartment: walls, doors, shelves, down to the last detail. The shading of an object depends on where it sits in the set and how it’s used. The spine of a book on a shelf that never gets read doesn’t take much time, but the shaders kick into high gear on certain objects that drive the story, that we see again and again.

Kenji says that he likes tackling technical challenges from an artistic angle. “We’re making everything in this world from scratch,” he says. “We’re responsible for time of day, the mood. The architecture of the world helps tell the story.”

The layout process turns the storyboard into shots: it could be a one-to-one ratio, or a shot might be made up of as many as six storyboard panels. Blocking, the positioning of characters, begins with all of them in T-pose, with their arms straight out. There’s not an actual camera to be found, of course, but the team is agonizing over close-ups and long shots like any Hollywood director.

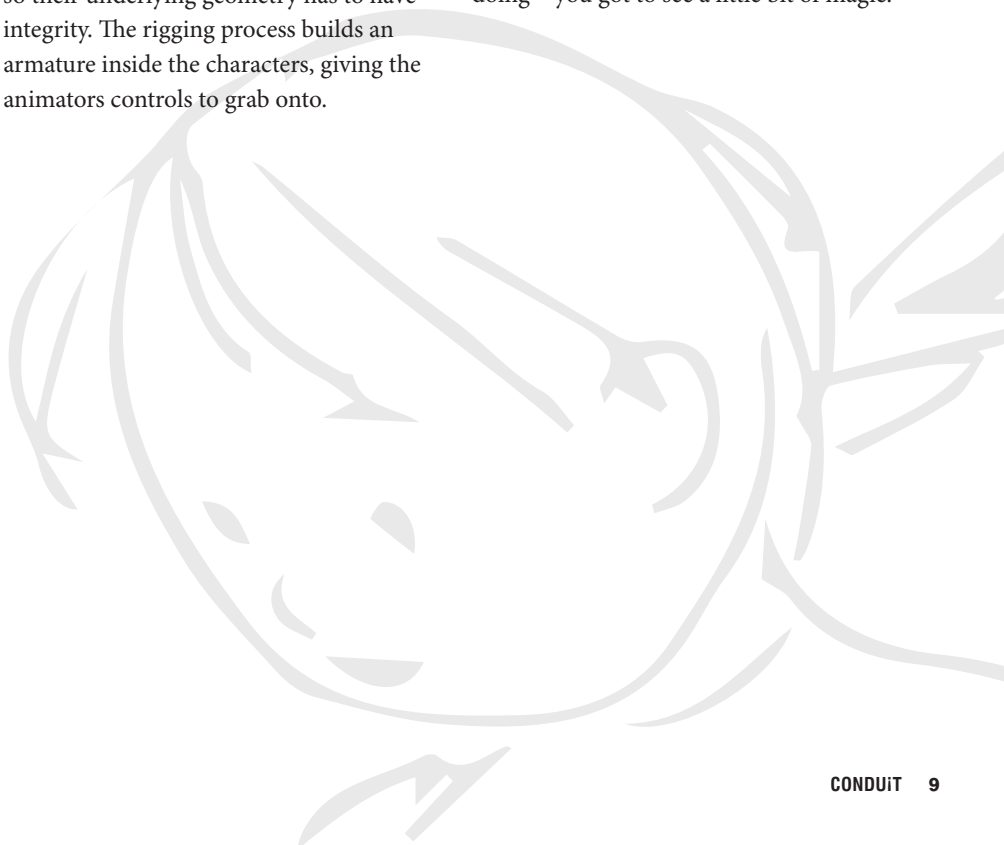
Eventually, the storyboard is replaced with quickly-rendered blocking shots. “It’s really tough,” Barb says, “because what you have is crude and what you want is very high-level. It’s like editing a paper to adjust the arguments before the grammar is completely there.” Character modeling is another big technical challenge: it’s a lot more complicated to make a person than a coffee cup. They might be too tall, too old, too cute, and soon they’ll have to move, so their underlying geometry has to have integrity. The rigging process builds an armature inside the characters, giving the animators controls to grab onto.




“The whole reason wasn’t to make this film but to make it with these people.”

At various points in time, Nellie explains, many of the students are working on the project almost every day. On many nights and weekends, Barb works from her home in Barrington, her coffee intake slowly increasing; at other times, the students wrestle the file system and work remotely, separately. But every week starts the same way: a look at everyone’s work, two and a half hours of detailed critiques. “It was really fun to go in depth in our reviews every week, to iterate and improve over time,” says Kenji. “Everyone got to specialize in their favorite area, but we all learned more about each component of the project, even if we weren’t working on it.”

“I loved that part,” Nellie says. “I was surprised every week by what people were doing – you got to see a little bit of magic.”





Nellie says, “I was surprised every week by what people were doing – you got to see a little bit of magic.”

The Music Drives Things: Ben Nacar

Brown CS alum Ben Nacar is one of the first people to join Nellie’s team: Barb emails him an invitation in May, 2016. (She knows him from his work on an advisee’s capstone project.) His contributions begin early, but we deliberately turn to him just now, in the middle of the action. Until we have a sense of the textures, the props, the production work that’s going on around him as he writes the score, it’s impossible to see how the music springs from the deepest core of the story.

Go back to *Toymaker* again and listen. A picture book open on a girl’s lap shows a fairground lit with the nearer stars of carnival lights, the far ones tiny and sunk in indigo sky. There’s only a piano playing in the background; the midway calliope is just your imagination. But did you catch that little flourish as Angela’s hand moves over the carousel? Later, just shy of one minute into the short, Ben has exactly seven seconds to capture all the subtleties of *this* mother looking back at *this* sleeping girl in *this* moment. Listen to what he does with it.

“I was really drawn to the story,” he says. As a kid, Ben dabbles in filmmaking, telling stories with stuffed animals. “We moved

the animals around with nylon threads that we hoped people wouldn’t be able to see, but they could anyway! I went back to those memories of just playing, imagining, reading Robert Louis Stevenson – trying to recapture that. The world of *Toymaker* is very vivid but fragile. Maria is doing work but her heart isn’t in it: even when they’re happily reading in bed, it’s a little sad. When the village comes to life, it’s a separate melody, more emotions.”

One of Ben’s early tasks is to create a mock soundtrack as a reference. He uses bits of Beethoven, the *Firefly* soundtrack, John Williams, but it’s “a bit of a chore” because it reminds him how far he’ll have to go for the results he wants. “I had to ask early on what the instrumentation would be,” he explains. “It’s more intimate than a regular Hollywood blockbuster – an orchestra would be overkill. I looked at eastern European music, which historically was often used in animation, but traditional classical is my idiom, so I went with piano, violin, and cello, letting myself be influenced by klezmer and other traditions rather than trying to duplicate a particular style.”

Ben describes himself as a melody-centric composer, and as the team starts feeding him materials (only sketches at first), he begins drafting just a couple of lines: capturing character and mood, then extrapolating from there. Tara Fislser (daughter of Professors Kathi Fislser and Shriram Krishnamurthi) and team member Emily Reif star in a live action demo that gives

him a sense of timing and flow, and within a week, he has a rough draft of the first half. The second follows a week later. Starting at the beginning of October, Ben’s there at every weekly meeting, and not as a silent partner: “I loved being involved in the process...I really felt like part of the whole.”

He has a practice session with his musicians in late autumn, and the final recording session at the end of January. “By then,” Ben says, “the timing was pinned down and the animators had to work from what I’d done. It’s the opposite of live-action films, but animators and composers work much more in parallel. At that point, Barb and the others and I agreed that we had to lock the timing so I could proceed. The script inspires the music, not the other way around, but the music drives things, not so much the plot as the emotional content of the film.”

With his score in the background, production work goes on. And as our conversation with Ben winds down, we ask him about being part of the *Toymaker* team. In retrospect, what was the entire experience of working on the short like? “Every time I go back to it,” he says, “it feels special. That’s a mark of success for me.”

continued on page 32



Upper Left // Ben Nacar composing

Upper Right // Part of Ben's *Toymaker* score

Middle Left // Filming a live-action version of the story for layout and animation reference with Emily Reif as Maria and Tara Fidler as Angela, with Nellie Robinson and Simon Jones on camera

In Memoriam:
PETER WEGNER, 1932-2017

Peter came to Brown almost fifty years ago, in 1969, and we remember him with great respect not just as educator, theorist, historian, and researcher, but as one of the founding members of Brown Computer Science.

It is with great sadness that we share the news that Peter Wegner, Professor Emeritus of Computer Science, passed away on July 27 following a brief illness. Peter came to Brown almost fifty years ago, in 1969, and we remember him with great respect not just as educator, theorist, historian, and researcher, but as one of the founding members of Brown CS.

Born in St. Petersburg to Austrian parents, Peter was present in Vienna for the terrifying days of the *Anschluss* and *Kristallnacht*, and escaped the Holocaust on the special trains known as *Kindertransports*. Graduating from Regent Street Polytechnic in London, he studied mathematics at Imperial College of London University, organizing the University of London Philosophical Study Group, which sponsored lectures by such luminaries as C.E.M. Joad, J.B.S. Haldane, and Karl Popper. This interest in philosophy continued throughout Peter's life, and philosophical analysis was a frequent component of his scientific work.

Later, at Cambridge University, Peter completed a graduate program in Numerical Analysis and Automatic Computing, also working with Professor Maurice Wilkes on the EDSAC computer, now widely seen as the first practical general-purpose stored-program electronic computer. It was during his stay at Cambridge that Peter met his future wife, the late Judith Romney, and received a Post-Graduate Diploma in Numerical Analysis and Automatic Computing at a time when there were no Master's or doctoral programs in computer science anywhere. He is believed to be one of the world's first two or three CS postgraduates.



After working at the Prudential Insurance Company, Pennsylvania State University, MIT (Wegner worked with Fernando Corbato on the Multics project, for which Corbato would later receive a Turing Award), the London School of Economics, and Cornell University, Peter came to Brown in 1969, accepting a position with tenure. During his time at Brown CS, he supervised six doctoral students and taught numerous courses, particularly in the areas of programming languages, software engineering, and theoretical computer science.

Peter was the author of several books, including *Programming Languages, Information Structures, and Machine Organization*, one of the significant texts of the discipline's early history, concerned with the very nature of computing. He continued writing until his death, publishing *Interactive Computation: the New Paradigm* (with Dina Goldin and Scott A. Smolka) in 2008.

He was also the editor of the ACM Curriculum Committee's *Curriculum 1968*, which provided recommendations for CS academic

programs. It was an effort more than a half-decade in the making, and its effects on computer science education are still being felt today. Peter's close involvement with the organization continued for decades: he served on multiple committees, led its Publications division, and was later named a Fellow of the ACM and given a Distinguished Service Award for "focusing the field's intellectual energy" through his commitment to research and publishing. Four years later, he received the Austrian Cross of Honor for Science and Art, 1st Class. For more than a decade, he was also one of two editors of the *Brown University Faculty Bulletin*, where he wrote on Russian literature and continued his love of philosophy with essays on Popper and Russell.

"I have always been in a position," Peter Wegner once said, "of trying to understand new ideas when they entered my life." Interviewed just a year before his death, he urged computer scientists to focus on the opportunities of the field: "Sometimes we work too hard trying to do things we can't do and neglect the things we can. In computer science we work with possibilities and hope we'll someday be able to solve them."

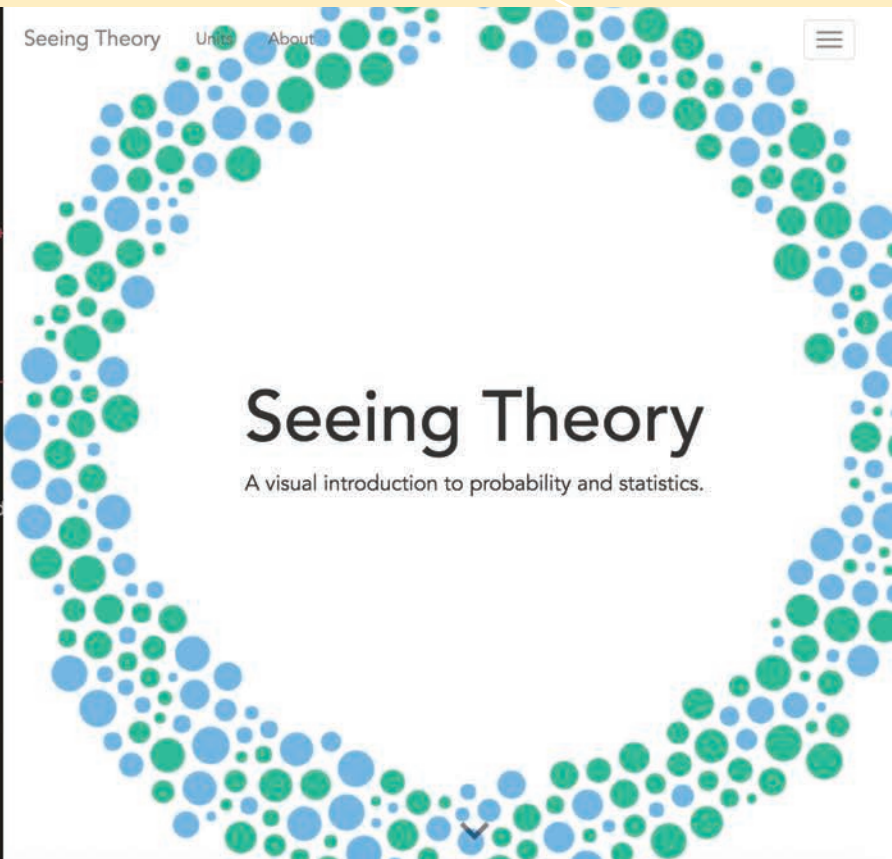
Brown CS sends our condolences to the entire Wegner family. Peter was a founder and a friend, and we have benefited for decades from his eagerness to contribute, his participation through questioning, and his hope of unifying bodies of knowledge. He will be greatly missed and long remembered.

You can read an autobiography of Peter's days before coming to Brown at: <http://bit.ly/2vSwgwM>

Seeing Theory: Teaching Statistics Through Interactive Web-Based Visualizations

by Daniel Kunin

```
37 nodeEnter.append("text")
38   .attr("x", -10)
39   .attr("dy", ".35em")
40   .attr("text-anchor", "end")
41   .text(function(d) { return d.name })
42   .style("fill-opacity", 1e-6);
43
44 // Transition nodes to their new position.
45 var nodeUpdate = node.transition()
46   .duration(duration)
47   .attr("transform", function(d) { return "translate(" + d.y +
48
49 nodeUpdate.selectAll("circle").each(function(){
50   d3.select(this).attr("r", 4.5);
51 });
52
53 nodeUpdate.select("text")
54   .style("fill-opacity", function(d) { return d._top ? 1 : 1e-
55
56 // Transition exiting nodes to the parent's new position.
57 var nodeExit = node.exit().transition()
58   .duration(duration)
59   .attr("transform", function(d,i) {
60     if(typeof(d.parent)!='undefined') return "translate(" + d
61     else return "translate(" + d.y + "," + d.x + ")";
62   })
63   .remove();
64
65 nodeExit.select("circle")
66   .attr("r", 1e-6);
67
68 nodeExit.select("text")
69   .style("fill-opacity", 1e-6);
70
71 // Update the links...
72 var link = containerComb.selectAll("path.link")
73   .data(links, function(d) { return d.target.name; });
74
75 // Enter any new links at the parent's previous position.
76 link.enter().insert("path", "g")
```



The purpose of Seeing Theory is not to replace a student's textbook, but provide an additional resource that allows students to independently explore concepts and build intuition.

I was holding TA hours for an introductory CS course when one of my fellow TAs told me that my website, Seeing Theory, had crashed. He'd seen a post on the Brown CS Facebook group about the statistics-teaching platform that I'd been developing for nearly a year, but the link wasn't working. My heart sank.

Did I accidentally delete something? Or maybe something changed in the permissions? What did I do? I immediately checked the student server that was hosting my site and confirmed everything was in order. It didn't make sense. The website was up, but the server wasn't responding.

Then I saw what was happening: there was too much traffic. Three days earlier, a professor from John Hopkins University had tweeted about Seeing Theory, and for the first time since publishing the project, I had users from states other than Rhode Island. 72 hours later, there were tens of thousands of views to the platform from all over the world.

Who knew statistics could be so popular?

Seeing Theory is an online platform for learning probability and statistics through explorable concept visualizations. The platform is split into five units, with three visualizations per unit, covering the first semester of an introductory statistics course. Visualizations range from flipping a biased coin to investigating correlation in famous datasets. Each visualization builds upon the previous one, and likewise, each unit builds upon the previous unit, much like a textbook. However, the purpose of Seeing Theory is not to replace a student's textbook, but provide an additional resource that allows students to independently explore concepts and build intuition.

The project developed directly from two classes I took in my sophomore and junior year as a Brown undergraduate. The first was an introductory statistics course I took with Applied Math and Computer Science Professor Caroline Klivans. Despite a strong math background, I struggled to comprehend

the material and had trouble developing the intuition behind many of the fundamental concepts. As a visual learner, I wished I had more resources available to me to help build this intuition.

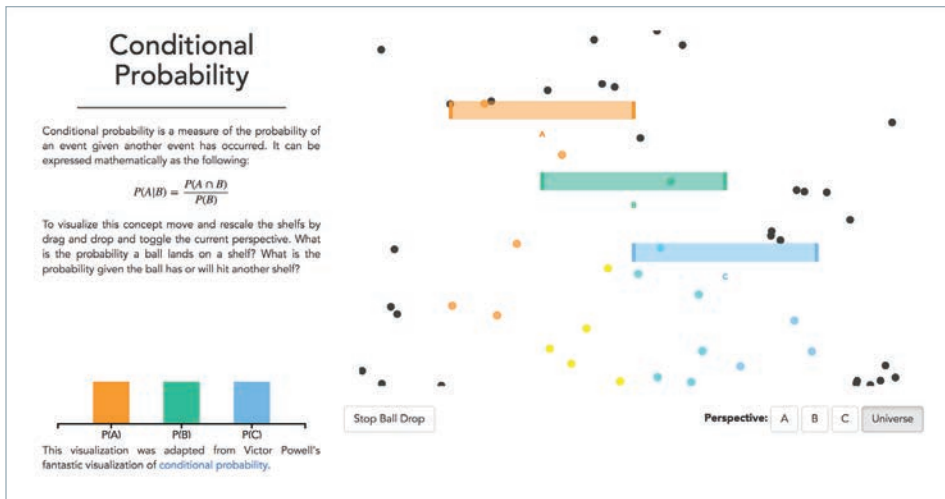
The second class was an introduction to web development that I took with Computer Science Professor Steve Reiss. This class culminated in a final project where students worked in groups to develop a web application. When looking through the list of possible final projects, one stood out:

"The goal of this project is to develop a series of 'applets' that would be used in conjunction with a new, for-credit undergraduate introductory statistics course...each applet would present and reinforce a statistical concept that had been taught previously in 'lecture.' The concept reinforcement will come via the student's ability to interact with the applet in both a prescribed (by the instructor) and exploratory ways."

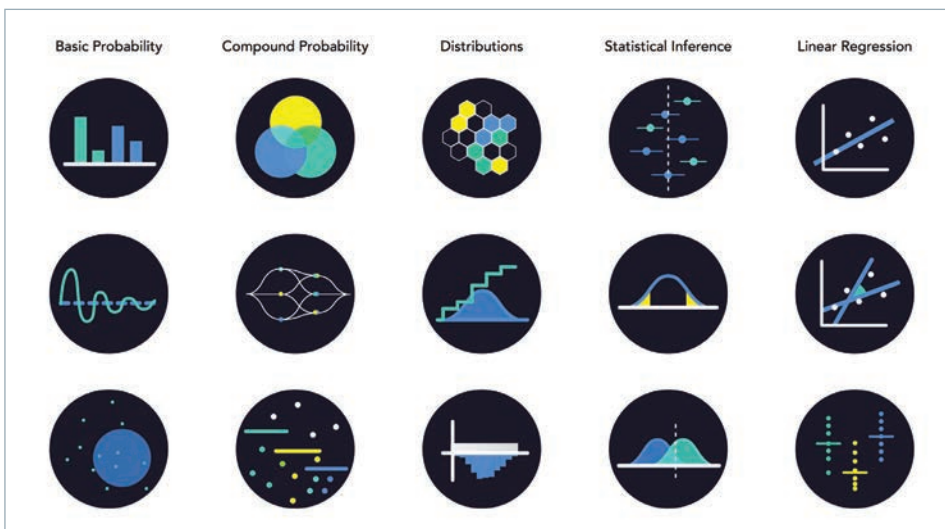
This was the additional resource I needed when taking my first statistics course nearly a year earlier, and now I had the tools and opportunity to build it. I signed up for the project and was placed with two other students: Madeleine Johnson (Computer Science, Brown, 2016) and Jingru Guo (Industrial Design, RISD, 2017). Together, we worked on the first version of what would eventually become Seeing Theory: A Visual Introduction to Probability and Statistics.

I took my first computer science course at Brown in the fall of my junior year. I was an intended Biochemistry concentrator at the time, but realized that I needed at least a basic understanding of computer programming. I decided to take one introductory course and fell in love. By the time I graduated I'd taken five more computer science courses and was a teaching assistant for two more.

It was the project focus and emphasis on peer collaboration that I found extremely unique and captivating in my computer science courses, and this was especially true



A visualization from Seeing Theory



Some of the Seeing Theory units

in the web development class that launched Seeing Theory. My collaboration with Madeleine and Jingru was invaluable in creating the initial framework and user experience for the website. Additionally, the opportunity to work with a student from RISD led to a larger emphasis on the design aspect of Seeing Theory, which has been essential to its success.

Developing Seeing Theory was only half the challenge; equally important was getting the platform integrated into courses and curricula. To do this, I first turned to

professors at Brown University. I reached out to my previous statistics teacher, Professor Caroline Klivans: she agreed not only to advise me throughout the development of the project, but also pilot Seeing Theory in her statistics courses.

Professor Klivans provided invaluable advice on which concepts students struggled with based on her experience as a statistics educator. She also connected me to other professors in the Applied Math and Computer Science Departments who were possibly interested in my work. Thanks to

her guidance, Seeing Theory is currently being used in two of the largest statistics courses at Brown University.

I also contacted math blogs, journals, and data scientists to inform them of the platform. Since its development, Seeing Theory has received over one and a half million page views from users in all fifty states and nearly every country in the world. I've met with professors from other universities, including MIT, about incorporating Seeing Theory into their curriculum, and was even approached by a publishing company to discuss the possibility of adapting Seeing Theory to a physical textbook.

Seeing Theory remains an ongoing project and I have been collecting feedback and suggestions from students, educators, and invested users. I've incorporated many of these suggestions and will continue to do so. Moving forward, I plan on continuing to develop the platform part-time with two other Brown graduates, Tyler Devlin and Daniel Xiang, and with RISD graduate Jingru Guo. Our team of four plans on further developing the written content and expanding the platform into machine learning concepts. We also plan on having the platform translated into multiple languages, including Spanish and Mandarin Chinese.

The unique interdisciplinary and collaborative environment of Brown University's Computer Science Department fostered the creation of Seeing Theory, which began as an experiment in explorable education and has since become a demonstration of the need for new approaches to statistics education.



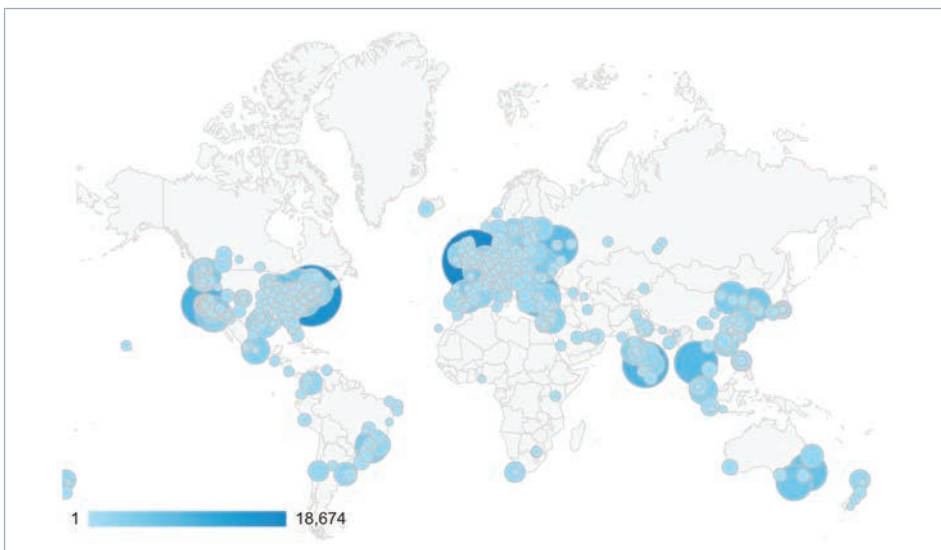
Developing Seeing Theory was only half the challenge; equally important was getting the platform integrated into courses and curricula.

Set Theory

Set Theory is a branch of mathematics concerned with the description and definition of sets, which are collections of objects. In the context of probability theory, we use set notation to describe compound events. Below is a set calculator*. Build a set by pressing on the different events and operators, then press submit to see your set highlighted in the Venn diagram. You can also move and resize the circles by drag and drop.

You might notice that certain combinations of sets and operators result in the same highlighted section in the Venn diagram. Set identities are laws of set theory that allow you to simplify set algebra. See the following link for a complete list of [set identities](#).

*Please note there are still some small errors in the calculator currently being fixed.



Top // Tyler Dae Devlin, Dan Xiang, Daniel Kunin, Jingru Guo

Middle // A visualization from Seeing Theory

Bottom // Global locations of Seeing Theory users

An Inflection Point: HCRI Looks Ahead To SIRoS 3

by Jesse C. Polhemus

“SIRoS 1 was when the question really struck me,” remembers HCRI Co-Director, Professor Michael Littman of Brown CS. “How do we keep the value of humans, of people, from declining? We’ve known for a long time that we’re at an inflection point, and the first SIRoS really drove the point home for me.”

He’s talking about the Societal Implications of Robotics Symposium, first held by Brown’s Humanity-Centered Robotics Initiative (HCRI) in 2015. Every two years, the conference has been bringing together scholars and practitioners from multiple disciplines to examine the difficult questions of a future society where robots are part of everyday life. SIRoS 3 is scheduled for 2019.

“For so long,” explains HCRI Associate Director Peter Haas, “robotics had always been a research endeavor, with ethics and other issues as more of an afterthought, but SIRoS 1 saw people who are making a big difference in the field talking to each other and considering ethical implications for the first time.”

The ideas that Michael references above are highlighted in a keynote address (“Robotics, Empowerment, and Equity”) delivered at SIRoS 1 by Illah Nourbakhsh of the Robotics Institute at Carnegie Mellon University.

Littman explains that it included an early mention of a concept that’s been repeatedly making news in 2017: guaranteed basic income. “This was an extremely important realization,” Michael says. “Because of robots, the work that had been done by people is being done by infrastructure. Some politicians rail against immigrants, but you could argue that computer scientists are causing the problem: the value of people is going down. This is exactly the kind of idea that arises when the research community broadens its outlook to include societal issues.”

A second keynote (“How the Law Will Think About Robots (And Why You Should Care)”) by Bill Smart of Oregon State University, a Brown CS PhD alum, bookended three panel discussions with small groups of leading robotics researchers, economists, philosophers, psychologists, legal scholars, and even representatives of funding agencies. “It was really exciting to



Julie Shah, MIT Aeronautics and Astronautics and CSAIL; Milind Tambe, University of Southern California Engineering and Computer Science; Ernest Davis, New York University

see the field changing,” says Peter. “SIRoS 1 helped us understand that robotics isn’t just research: it’s becoming applied research, with sociological issues rising to the forefront.”

You can watch videos of both keynotes here: <http://bit.ly/2wajwPu> and <http://bit.ly/2hrxAkx>

SIRoS 2: Seeing Through Their Eyes

A small, padded cube is flying toward you from across the auditorium. There’s a microphone inside: you catch it, use the voice amplification to share your thoughts with the group, and then throw it to someone else. It’s a good illustration of a key difference between SIRoS 1 and 2. Like its predecessor, the second conference dealt with the difficult questions of how to ensure that robotics has positive effects on society, with talks on healthcare robot policy, algorithmic bias, the legality of autonomous

weapons systems, and more, but the approach was a bit less traditional.

“We had more panel discussions,” says Michael, “but we really focused on having people make shorter position statements so we could allow the audience to push back. It helped create a shared perspective, and it felt outside the norm of academic meetings — much more playful. Increasing the size and diversity of our audience let us see problems and challenges through their eyes. It was extremely satisfying to bring this community together.”

As with SIRoS 1, the topics discussed have only increased in relevance in the days since. As just one example, the juxtaposition of the ethical dilemma known as the Trolley Problem with the rise of self-driving cars, first proposed by SIRoS 2 speaker Gary Marcus in 2012, has entered the public consciousness sufficiently that it spawned a popular Internet meme and eventually

entire web sites devoted to collecting variants of that meme. And research is already underway, including some by HCRI Co-Director, Professor Bertram Malle of Brown’s Department of Cognitive, Linguistic, and Psychological Sciences (CLPS).

You can read Bertram’s paper here: <http://bit.ly/2fn7yyd>

“Problems like this have been discussed in academic circles before,” says Peter, “but it was wonderful to see strategies and possible answers presented. People see the future coming, and they’re thinking about when robots will be prolific, and they’re proposing solutions.”

“This year’s SIRoS 2 also served as a preconference to the We Robot conference, which has discussed legal and policy questions concerning robots for five years now,” adds Bertram. “This is an important partnership we hope to build on. Thoughtful

science should inspire thoughtful law and policy initiatives.”

You can watch videos of ten SIROs 2 talks here: <http://bit.ly/2uz2Q2c>

SIROs 3: Showing Leadership

“One of the important things we have to do for SIROs 3 is make sure that we have enough seating,” laughs Peter. “The quality of our speakers has really been fantastic, and we’re looking to continue finding the best ideas from around the world. We’re planning for growth.”

And the growth of the conference mirrors the expansion of the Humanity-Centered Robotics Initiative as a whole. It’s continuing to facilitate collaboration among Brown researchers by providing access to robots, robotic research, and building spaces, and Peter explains that HCRI has recently formed corporate partnerships with Hasbro and Sproutel, along with external funding to support them. The goal is to serve as an interface with Brown Robotics for the two companies, to help them understand our evolving robotic future from HCRI’s unique perspective.

“Robotics is at an inflection point,” he says, “like computing was in the 1970s. It’s not just the purview of a select few any longer, so we have to keep looking toward the future in the broadest sense. It’s a real opportunity for Brown to show leadership: interdisciplinary work is what we do well, and HCRI and SIROs are great examples.”

Michael agrees: “All the pieces are in place for robots to have a dramatic effect on individuals, but we don’t have a crisp structure yet. SIROs is about aiming the rocket before it goes off the launch pad. It might sound playful, but it’s deadly serious to me. Robotics needs more roboticists, but just as much, it needs more sociologists. Right now is when we need the interdisciplinary approach.”



Upper left // Michael Littman, Brown CS, and Bertram Malle, Brown CLPS

Upper right // Rebecca Crootof, Yale Law School

Middle // Elizabeth Phillips, Brown HCRI; Peter Haas, Brown HCRI; Claudia Rébola, RISD Industrial Design

Bottom // Julie Shah, MIT Aeronautics and Astronautics and CSAIL; Milind Tambe, University of Southern California Engineering and Computer Science

igniteCS @ Brown

by Natalie Reed and Eric Rosen

As President Obama has said, “Computers are going to be a big part of our future...and that future is yours to shape.” Technology is one of the fastest-growing fields today, solving problems in every industry while impacting our everyday lives. Despite this, computer science is not yet adequately taught in most K-12 schools, particularly not in underserved school districts such as Providence and Central Falls in Rhode Island. Led by Professor Amy Greenwald, a group of undergraduate and graduate students who have a passion for computer science, both as an intellectual pursuit and as a path to a stable financial future, have come together to bridge the education gap by creating **BROWN’S GOOGLE IGNITECS INITIATIVE.**



Four igniteCS mentors teach a Nathan Bishop Middle School CS-Integrated Science Class about genes by having students program their own Punnett Square solvers

Serving elementary, middle, and high school students, Brown's igniteCS chapter focuses on empowering students through skill acquisition, including programming tools and basic algorithmic thinking. Initiatives vary from in-school programs to after-school clubs to district-wide weekend club meetings. The purpose of these initiatives is to provide as many students as possible with knowledgeable mentors who can help them start or continue on their path to learning CS.

Eric Rosen, one of the student organizers for igniteCS, looks back on the program:

“In the spring of 2017, I volunteered with a fellow mentor at Central Falls Middle School to teach 5th-7th graders about computer science in an after-school club. On our first day, we spent most of our time learning about the students' favorite subjects, their hobbies, what they enjoyed and disliked, and what their general thoughts

were about computers. Mostly we spent the day in an open discussion, which was a lot of fun to joke around with the kids and learn their personalities.

We learned pretty quickly that this particular group of students really enjoyed video games, and in particular a lot of them played Minecraft. So my partner and I spent the next week creating a Minecraft-themed curriculum that integrated core CS ideas into it. For example, when we came back the next week, we started the class by breaking down how crafting an item, like a pickaxe, in Minecraft can be thought of as a process of steps (AKA: an algorithm). We were able to actually break out a game of Minecraft and play together as a class, connecting each step of the process to a 'step' in our algorithm.

Not only did the students have a ton of fun getting to play with us, they also quickly grasped the idea of an algorithm and started to try applying the concept to other things

in the game, such as detailing an algorithm to build a house. As quickly as we were able to write out the steps of our algorithm, students were asking and trying to make their own personal algorithms for things they like to do in Minecraft.

It was amazing to teach the students core CS thinking concepts, but I also got to have a lot of fun seeing how to apply algorithmic thinking to problems in Minecraft that I hadn't considered but the students wanted to know. The kids had a lot of fun playing Minecraft, but they also walked away seeing how ideas from CS and Minecraft were related, which is extremely important for setting the foundation of a passion for STEM – getting to connect your hobbies with a subject is a really fun way to learn. I like to think that as much information as we teach the students, we as mentors get to learn so much from them since there's so much freedom to personalize what our clubs teach, and how it's taught.”



Natalie Reed, one of igniteCS's student teachers, shares her experience:

“This past semester, I helped run Coding Girls with four fellow student mentors. The club met every Sunday for two hours. Though on the surface the club simply taught basic programming concepts like functions and conditionals, the mentors and I really aimed to inspire our students to develop a passion for computer science. Not only were we looking to bridge the computer science education gap, but also the gender gap in computer science by targeting middle-school girls.

In order to reach a diverse group of students, we partnered with many of the local middle schools and libraries directly. We also used the theme of storytelling to try to demystify the foreign and complex field of computer science.

Because our goal for the camp was for the students to enjoy CS, we tried to partner every coding concept with a fun storytelling game or exercise. We started each class with these ‘unplugged’ storytelling games (no computers involved). Then, the computer science concept was introduced and the students were able to use the stories they had come up with in the exercise to create an animation using the computer science concept of the day. I was amazed at how creative the students were!

At the end of the club, the students were able to complete a final project to show off their storytelling and programming skills alike. Each project was amazingly unique to the student. We had projects about mystical dance battles, discovering new worlds, and the cast of *Hamilton* fighting for supreme control of Mars.”

This past year was a great launch of Brown’s Google igniteCS chapter and we’re looking

forward to continue to make an impact in the following academic year. Many of our initiatives this past year will become annual events, like our Classical High School After School Club, Calcutt Middle School After School Club, and Coding Girls Camp. We’re also looking to expand our initiatives to reach more students and further inspire our past students. This summer, we launched our website, brownignitecs.wordpress.com, in order to maintain our connection to our students and give them a way to continue to learn after the class. We’re looking forward to continuing our initiative to inspire students to learn computer science this coming fall and can’t wait to get the season started. We’re always looking for more student mentors to organize or teach events, so if you’re interested, please apply by going to <https://ignitecs.withgoogle.com/register> and using V7L4QWD6 as the Brown CS group code.

Ellie Pavlick

Joins Brown CS As Assistant Professor



I think if I'd really had a chance to explore CS in high school, I would've gone into it sooner because it provides this common skill set that can be applied to so many areas.

Brown CS has just added another new faculty member: Ellie Pavlick is joining us as Assistant Professor in the summer of 2018. "I'm still interested in economics," she says (Ellie has a BA in that field and a BM in saxophone performance), "but I felt like it was much messier." Maybe so, but after sitting down to talk for an hour, it's clear that Pavlick in no way finds messiness to be a source of discomfort. An expert in crowdsourcing and paraphrasing, studying language in all its complexity has allowed her to use what she calls a problem-driven approach, combining sprawling interests in a world where no two words mean the same thing.

If you think that description sounds like a good fit for Brown University, you're not alone. "I love the broad interests at Brown," says Ellie. "Understanding language is a deep, difficult interdisciplinary problem. Academia lets you play that long game. And getting to work with students means less uniformity. Each student has their own interests, so they help you get involved with a lot of different things."

Pavlick's own involvement with computer science came surprisingly late. "I've always been interested in multiple things," she says. "I find it hard to feel fulfilled with just one area. I think if I'd really had a chance to explore CS in high school, I would've gone into it sooner because it provides this common skill set that can be applied to so many areas." During undergraduate studies at Johns Hopkins, using LaTeX and MATLAB sparked Ellie's interest in the field. Soon after, participation in Women in CS events helped her find an advisor and start new research projects. After graduation,

when one of her professors transferred to University of Pennsylvania, she followed, giving up plans for a Master's in favor of a PhD.

Natural language processing and crowdsourcing appealed to Pavlick from the beginning: "People speak and understand human language, not programming languages, which is what computers quote-unquote 'speak'. I find it really exciting: our language is very complex, and it's not designed for talking to computers. It's full of not just commands but implications and feelings. Can we get computers to unpack all of that implicit meaning?"

Driven by my own interests, I pull Ellie into a side discussion of writerly craft and whether any two words can mean exactly the same thing. Does she see herself as a writer? "Definitely. I like working with language because it's an incredible mix of structure and freedom. I used to think I'd end up as more of an artsy person...even when I write up research, which I guess is technical writing, I really enjoy it and probably overthink it. People can be very imprecise with language, but we can also be very particular about how we say what we say. That has gotten less attention from an AI perspective. People write and speak with the expectation that the reader or listener is a human, so we use a lot of hints and cues to indicate our opinions and impressions and these are completely lost on computers."

And that person-to-computer communication, ultimately at a seamless level, is coming, Ellie thinks, but the timeframe is tough to estimate. "We've made incredible progress in AI on things that look

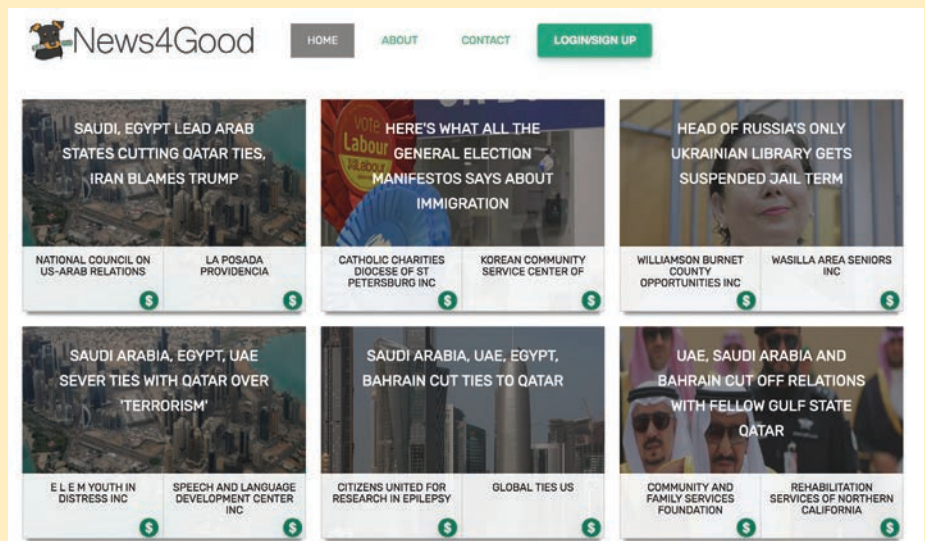
Building News4Good: A First Take At Software Engineering For Four Undergrads

by Elaine Jiang

like language understanding,” she says, “but the models are shallow. As a field, we’ve just started a conversation about modeling intents and goals, but computers haven’t even begun to understand how human language expresses differing personalities and similar but distinct goals.”

The way to get there, Pavlick says, is to make computer science even more interdisciplinary than it already is: “We can’t just keep cranking away at what we’re doing. Natural language processing is a young field, and it’s hard to predict what kind of knowledge is needed next. People coming into CS with different interests and perspectives provides the raw ingredients we need for progress, for the next advance.”

And having a different methodology is equally important. “One question I get a lot,” Ellie says, “is if deep learning will solve all of our problems. ‘Isn’t language solved?’ As computer scientists, we sometimes fall into this love affair with a certain method. We find an exciting model and start looking for things to apply it to, and then want to report on what’s going well. What I like about Brown is the problem-driven approach, which drives you to collaborate and forces you to question and to choose the best methods from a large, interdisciplinary set of possible methods. Research should be based around the things we don’t know how to do.”

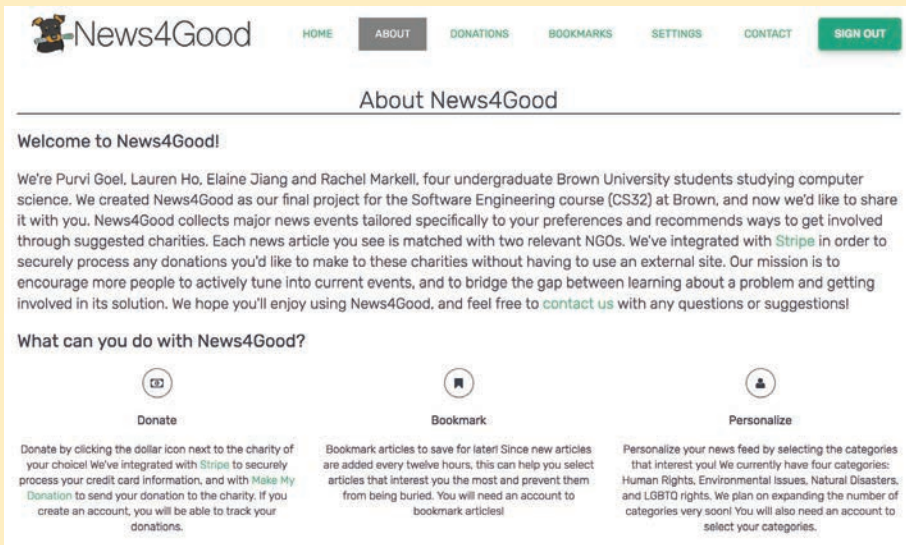


Screenshot of the News4Good home page

As college students living in a fast-paced society, we’re expected to stay informed about what’s going on in the world. And for the most part, we do. And while, sure, sometimes we join a protest or participate in a heated discussion on Facebook, for the most part we (at least the members of our project team) consume our news passively. We scroll through articles on our way across campus, briefly moved by whatever we read, and then – nothing. From this realization sprang News4Good, a website devoted to actively engaging users with the articles they read. The site (news4good.us) features articles pulled from over 60 diverse news sources, each tailored to match the user’s interests, and each matched with two related charities that the user can donate to directly through our app.

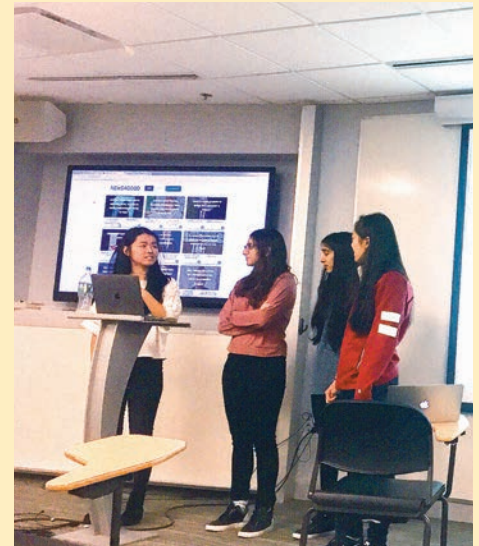
News4Good was our final project for the class CS 32 Introduction to Software Engineering. As the course progressed, we gained experience building web applications from scratch, from their underlying data structures to their user interfaces. What began as just a school project turned into a product we hope to continuously improve and share with others.

Before we actually started designing our project and coding it, we polled the Facebook community to gain insight into our friends’ news-reading habits and the current barriers that discourage them from donating to charities they care about. The majority of our survey respondents said that they would be more likely to donate to a charitable cause if they believed in it and



Left // Screenshot of the News4Good about page

Right // Elaine Jiang, Rachel Markell, Purvi Goel, and Lauren Ho presenting News4Good during the final demo



could do so conveniently. From our initial surveys and user interviews, we discovered that the biggest challenges for News4Good were:

Relevance: People only want to donate to charities and Non-Governmental Organizations (NGOs) they know about and care about, so article and charity matching must be as accurate as possible

Trustworthiness: Many of our peers mentioned that a secure form of payment was highly important to them, as well as transparency in how their donations will be allocated

We decided that the goal of News4Good was to create a space that allows people to easily access and securely donate to charities related to events they care about.

Next, we had to figure out how we were going to divide up the project between the four of us. This surprisingly turned out to be a new experience for all of us because in the past, nearly all of our projects were done solo in order to help us build the confidence and independence to write a program from start to finish. Since News4Good is backend-heavy –the bulk of the project was its algorithms– we agreed to have three of us

(Purvi Goel, Rachel Markell, Lauren Ho) focus on coming up with those algorithms, and one of us (Elaine Jiang) design the user interface.

We gathered thousands of news articles from various news Application Program Interfaces (APIs) as a training set, used Natural Language Processing to develop categorization and matching algorithms based on this training set, and structured a database to store all this information. The simple charity donation process, however, was not seeming as feasible. We had decided to use Stripe, a company that would allow us to securely process payments from users through their API, but there was still the problem of where to send the money. We had created a database of almost 20,000 charities using the OrgHunter API, but the charities didn't provide the type of information that would make it easy to generically route money to them.

Serendipitously, while we were contemplating this problem, we were also corresponding with MakeMyDonation, the parent company of the OrgHunter API. After answering some of our questions, they mentioned that they also provide a way to donate to the charities in their API. We sent hundreds of emails back and forth, signed a contract, and

began incorporating donations into our website. We still used Stripe to safely process user payments, but instead of sending the payment directly to a charity, we sent it to MakeMyDonation along with some metadata that would allow them to handle the actual donation.

During our final presentation to our professor, JJ (John Jannotti), and the head TAs, we were able to demonstrate the donation process from our website. With JJ's encouragement, we decided to continue working on News4Good, and we're hoping to partner with NGOs in Providence to reach more people. Our next steps would be to offer more categories of news and add location sensitivity into our charity matching. We have enjoyed this process of using software engineering as a tool to create something we believe in, and we're very excited to see how far we can take this project.

Bootstrap Teaches Rigorous Data Science In An Introductory Computing Module For K-12 Students

by Shriram Krishnamurthi and Emmanuel Schanzer



From a deluge of job openings to new university programs, Data Science has become a hot topic. But if it's so important, why wait until a student enters university to introduce it?

Children are natural data scientists! They argue about who was the greatest quarterback, the most successful singer, which chain has the best pizza. These questions quickly shift to *data*: did athlete X win more trophies than athlete Y, are Grammy nominations or albums-sold a better indicator of talent, and so on. As they mature, they want to know whether a law is racist, or whether the outcomes of going to a particular college justify the extra student

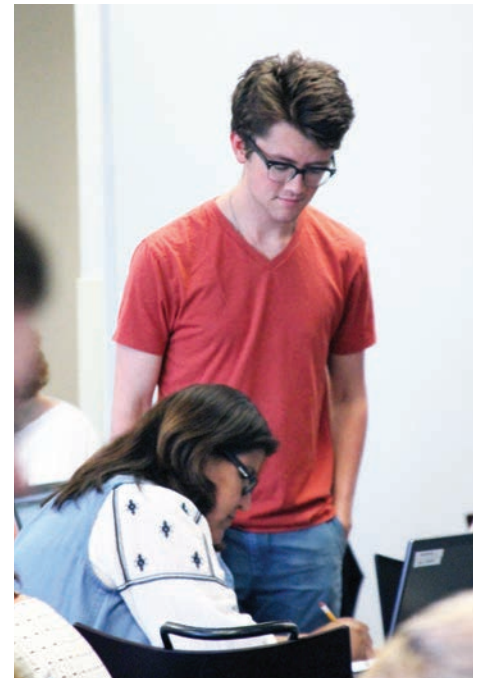
loans. In a world that's data-rich, what these students need isn't data. It's the ability to ask questions and make meaning from that data.

Bootstrap is one of the only groups in the CS Education field that builds our own curriculum, software, and *programming tools*. (More on this below.) This gives us a unique opportunity to fill that gap, with a programming language that makes operations on tabular data (literally,

spreadsheets) accessible without the overhead of teaching loops. We've leveraged our world-class language development team to bring rigorous Data Science to an *introductory* computing module. And since our unit of data storage is a spreadsheet, there's a smooth on-ramp for teachers who are comfortable with Microsoft Excel and Google Sheets.



Left // Teachers at a recent teacher training event in Providence



Right // Sam Dooman, Brown CS alum and now Master's student, one of the original coordinators who helped get Bootstrap:Data Science off the ground

World-Class Pedagogy In A True Introductory Course

Thanks to seed funding from Bloomberg, a Bootstrap:Data Science course is already being piloted at several middle schools and high schools. In Rhode Island, high school students used our module to compare college acceptance rates for high schools across the state. 6th-graders in North Carolina studied the role that Data Science plays in things like credit card fraud detection. By lowering the barrier to entry, Bootstrap:Data Science is a true introductory course, which addresses learning goals that make it suitable in a number of mainstream classes:

Statistics classes can use Bootstrap:Data Science to cover core concepts in statistics, such as measures of center (mean, median, mode), and visualizing data (line, bar, and scatter plots)

Business classes can use the Data Science module to make inferences about sales, profits, and customer demand, porting existing spreadsheet-based coursework to our programmed lessons

Civics and **Social Studies** classes can use Data Science to explore the role of data in government and social policy, exploring the impact of things like stop-and-frisk, the Electoral College, and third-party voting on the world around them

Even with a powerful tool and a flexible curriculum, a successful course still needs an effective pedagogy. Bootstrap builds on a world-class pedagogical technique developed over decades at the university level, which has been proven to work with students of all ages and abilities via our Bootstrap:Algebra course. More than 20,000 students each year use our structured approach to problem solving (~45% female, ~50% students of color), and we're excited to bring this approach to Data Science.

Equity, Rigor, And Scale

The motivation for a K-12 Data Science curriculum is clear, but building such a curriculum requires careful thinking about software, pedagogy and curriculum. To blend in with mainstream courses, these curricula should be designed to fit comfortably within existing content strands, and aligned to national and state standards for statistics, CTE, and/or business.

Professional-grade tools like Stata and R offer powerful features, but aren't explicitly designed to be child-friendly or teacher-friendly. At the opposite extreme, spreadsheets have deep roots in educational settings, but lack the programming component, and some of the features, necessary to build a rigorous introductory Data Science course.

Current attempts to fill the gap in the middle have students program various loops over two-dimensional arrays. Making for-loops and nested data structures a prerequisite for

Data Science immediately limits the possible audience of students to a small, elite group, and burns valuable time that could be spent addressing the standards-alignment of mainstream courses. If a Data Science module needs a few weeks to introduce for-loops and two-dimensional arrays, that's weeks of time spent before a teacher can address the needed standards for bar, pie and scatter plots, measures of center, or linear regression. This approach rules out scale (only a small percentage of students and teachers are ready for this material) and equity (asking students to self-select into these courses only reinforces existing stereotypes). What's needed is a holistic approach to Data Science that has all three: equity, rigor, and scale.

Questions That Teachers And Students Care About

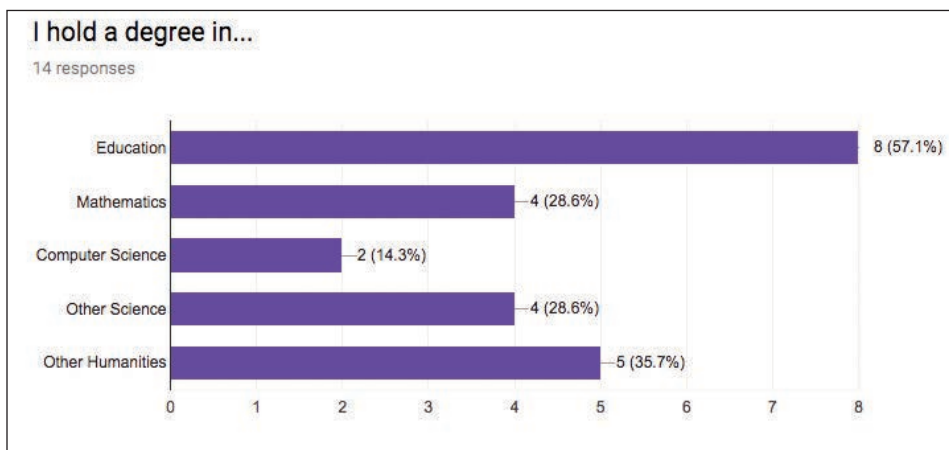
This summer, Bootstrap held its first-ever teacher professional development training for Bootstrap:Data Science at CSPdWeek. In an early indicator of the curriculum's potential, the majority of these applicants were not CS teachers, nor were they being assigned to teach a CS class (see chart below)! The training covered introductory programming, visualization using half a dozen chart types, the core statistical concepts mandated by most state and national standards (mean, median, mode, linear regression, r-squared, etc), and table queries.

Staying true to our belief that Data Science must be about more than the tool, the course emphasized the *thinking and writing* side of things, encouraging teachers to focus on making meaning rather than just writing code. Some investigated the relationship between home ownership and income. Others looked into whether or not louder pop songs tended to have faster beats. In every case, teachers encountered outliers, surprising trends, and more complex relationships than they anticipated.

Just as their students will, these teachers *focused on questions they cared about*, and used the Data Science concepts they learned to search for answers in the data. By the end of the week, they had created detailed reports of their analysis, which they presented in front of an audience. They found themselves thinking about fitting the material into their own math, business, computing, *and social studies* classes, and gave us invaluable feedback about how to make the curriculum even better. We still have more to learn and much to do, but we believe that we've found a great starting point for an authentic, accessible curriculum: using computation as a vehicle for thinking, talking, and writing about data.

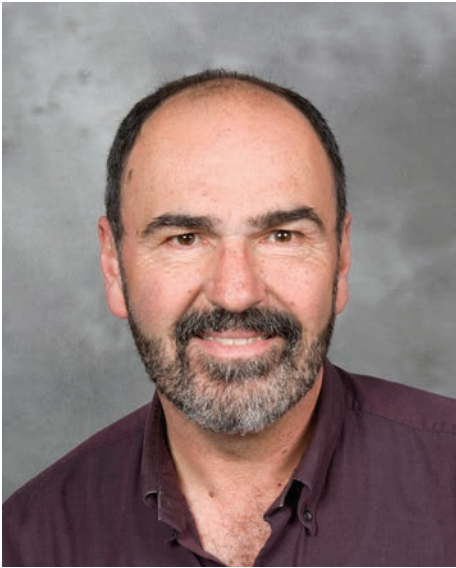


Teachers at a recent teacher training event in Providence



Max Salvas

Retires After Thirty-Four Years



Being around students has made me more aware of how times and cultures change, and it's helped me keep a younger mind. And I've just had a great time here, I've really enjoyed it.

Today, a hand-crafted desktop machine with a Max Built logo is one of the CIT's most familiar sights. They're all the work of Senior Electronics Technician Max Salvas, who retired this spring after spending more than half his life with Brown CS. "Things looked a little different in 1983," he says. In those early days, Max explains (it's hard to imagine in an era where many of us have a laptop, a desktop, a smartphone, and maybe a tablet), large segments of the Brown CS community didn't even have a computer of their own.

Initially working for Dave Durfee, one of Max's first tasks was to install a large batch of Apollo workstations in the Foxboro Auditorium of Kassar House. "It was quite a bit of work," he says, "very meticulous." This was a time in which replacing a single power supply required labeling every wire, an hour's work, to avoid mistakes that could fry an entire circuit board.

The years that followed brought multiple hardware revolutions. The first wave of new machines consisted of about thirty Digital MicroVAXes, each with a thin Ethernet connection and 300 MB of storage. 1988, when the CIT was built, saw the arrival of Sun workstations. "We stuffed them into a room that was originally designed as a teaching lab," Max remembers. "CRTs back then probably weighed about seventy-five pounds each." In the wake of the Sun era, with Linux gaining popularity, Max provided the solution that earned him an award under the Staff Bonus Program for Extraordinary Achievement: custom-built desktops that would be routinely upgraded. In less than a year, more than 225 Max Built machines entered service, providing four times the computing power and twice the memory of

the systems they replaced, at half the cost of store-bought models. We've been using them, upgraded each year, ever since.

"He was the one-man equivalent of Dell," says Professor Stan Zdonik, who over the years has shared dozens of cups of coffee with Max and former Director of Information Technology Jeff Coady. "We became friends not just because of computing but because we all love tools and working with our hands. Max's breadth of knowledge is incredible, and it goes far beyond computer hardware: he's fixed everything from flat-screen televisions to electric staplers. He's generous in the broadest sense, with his time and also his expertise. I honestly don't know what we'll do without him. There'll never be another Max."

Over a long career, what moments stand out? "For some reason," Max laughs, some of his favorite memories stem from the computing and multimedia requirements of one Andy van Dam. Due to high enrollment, students attended one of Andy's classes in both the Sun Lab and the Moon Lab, and in order for everyone to participate, Max worked with Mark Oribello and other students to refocus cameras, activate and deactivate microphones, and switch audio and video back and forth from room to room in real time whenever a question was asked.

"It was a very complex setup," says Max. "There was always some issue or another, and we'd scramble to figure out what could have possibly gone wrong. It wasn't perfect, but we got things to be as good as they could possibly be." To enable one memorable skit, they switched seamlessly from a previously-recorded video of Andy walking down



Left // Trent Green, Bob Zeleznik, Frank Pari, Donald Johwa, and Max Salvus
Right // Max during the Great Precarious Filesystem Shift



Thayer Street in a Darth Vader costume to the moment when he stepped into the classroom, still in full Sith regalia.

In another packed van Dam class, with multiple students crowding around each Apollo workstation and some even forced to sit on the floor, someone would inevitably disconnect a cable without noticing it. On a token ring network, this meant that everything would grind to a halt. Even with troubleshooting accelerated by switches that could bypass multiple computers at a time, Max felt the weight of hundreds of eyes every time he had to walk down a row and test each machine with a null modem. “There was plenty of pressure,” he says. “Even three minutes can feel like a very, very long time.”

Kathy Billings, TStaff Project and Financial Manager, remembers Max’s “surgical precision” as he recently transported every piece of the IBM GPFS filesystem cluster on a special cart that he’d chosen for the task. “Max is Max,” she says. “He doesn’t have anything to prove because he’s always gotten things done right. He always has a solution, and he gets along with everybody. He’s able to explain complex things without techspeak, he wants to help, and he’s calm. There have been a few times when I was in his office, ranting, and he always knew how to let go of things that weren’t important.”

Letting go of Max himself is going to be more difficult: Kathy says she’s happy that she’ll still see him and his wife socially, at concerts and meals in favorite restaurants. John Bazik, Director of Information Technology, is interviewing to find Max’s successor and already missing him: “Many times, we would’ve been lost without Max. He runs the whole hardware show, and he’s basically been a division unto himself for decades. From hundreds of Max Builts to the legendary Godzilla failure, when he found a hardware problem that even Sun wasn’t aware of, he’s saved us huge amounts of money. Max has gone so far above and beyond his job description that it’s hard to measure.”

But the days of stripping a Sun workstation down to the center plane and troubleshooting SCSI card by SCSI card are gone. “Things are different now,” Max says. “Changing components, or even upgrading components, it’s not the same as soldering them piece by piece. My soldering iron’s in the drawer!” But the constant change has been positive, and even had personal benefits. “The thoughts of the young are different. Being around students has made me more aware of how times and cultures change, and it’s helped me keep a younger mind. I still listen to WBRU! And I’ve just had a great time here, I’ve really enjoyed it.”

Max has always kept busy in his personal life as well: day-hiking, touring local breweries (Long Live Beerworks is next on his list), and playing the sport of kings. “We own golf clubs,” he jokes. “I wouldn’t say we golf.” After a vacation home in New Hampshire proved to be not enough of an adventure after a decade of ownership, Max and his wife bought a thirty-foot RV, and have plans to see Yellowstone, the South Dakota badlands, Mount Rushmore, and even range as far as Utah.

“Fast, good, and cheap: with Max, you can pick all three,” says Department Chair Ugur Cetintemel. “His skills and dependability are legendary — we’ve all turned to him for help at some point. We’re very lucky to have had someone like him as part of our community for so many years.”

And now it’s time to say good-bye. Throughout an hour-long interview, everything has been quiet. Technology in the CIT, almost as if showing respect, has performed remarkably free of errors. But just as I’m getting up, we hear a quiet ring from a back-pocket cell phone. Someone needs help, and of course, they just called Max.

Toymaker continued from page 10

Winter And Spring: Animation, Lighting, Shading, Sound

Technically, animation starts in the last week of November. The leads are assigning shots to animators, and each student's work has to join with work from the student before them and the one after. If one of those two finishes first, and the merge doesn't look good, the animator in the middle may be forced to redo their shot.

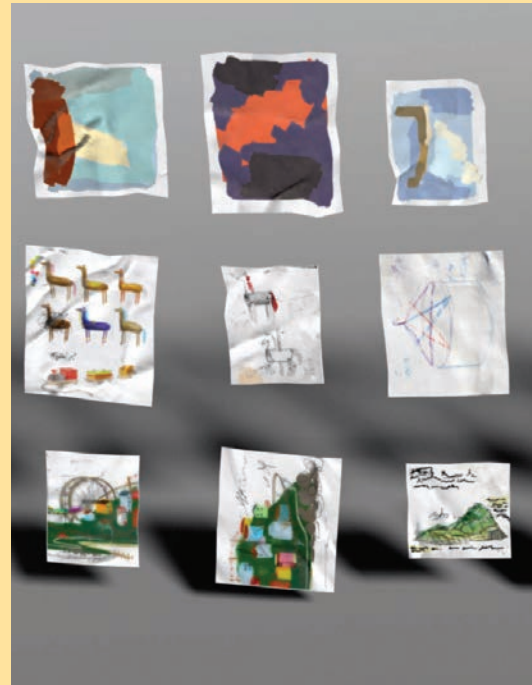
This is when we see real emotions come out of the characters: here are the corners of the mouth for Angela's mad face, and here's Maria thinking about something. *What about those eyelids, are they too open?* According to Barb, animation is different from any other part of the pipeline: people who struggled with modeling may turn out to be natural animators, and vice-versa.

Two-thirds done is Meier's rough estimate for where things are at the end of the year. Only an approximate 20% of the work is creative at this point, and the rest is babysitting the rendering, cleaning up the little things. Thousands and thousands of renders. A broken render farm that can't

be fixed until next year's software update. The rig for Maria's hands isn't right, and they have to work joint by joint. The students and Barb can recollect this phase pretty clearly: a long slog, they call it. The swamp.

January means completing 95% of the animation so they can move on to final lighting and rendering. Communication among the team members is constant. Barb says, "We messaged each other our latest versions during the week, but we waited to make final decisions in our group meetings. When we got together, everyone had so much respect for the other people at the table, and you'd hear 'good enough, good enough' go around the room. For some decisions, we just let time run out, and that's not always a bad way to do things. If nobody proposes something different to what's currently on the table, that's the way it goes."

Lighting is being adjusted and finessed even as the final 5% of animation is winding down. At first, it's the lighting for a room, a whole scene; later, it gets adjusted in minute detail, shot by shot.





“Every technical detail is there to tell a better story,” Kenji says. “Animation tells a visual story, designed to create emotion, empathy, through these technical details. Throughout the project, Barb gave incredible feedback for ongoing improvement, and she had such dedication and belief that we could complete this.”

Lighting tests continue until the clock runs out, but Barb remembers the end of animation as a milestone. Her family remembers it as the time period where they’d ask her what was for dinner and she’d think it was still lunchtime. “At this point in the project,” she says, “we had almost all the pieces, but it still takes hundreds of hours to go from 90% to 100%. Whether it gets done depends on the huge dedication of the students who continue to work on the project even after the official course is over.”

Late spring is for Foley recording, sound effects, making sure the little details that add realism don’t overshadow the expressive score. Lighting and shading are still being tweaked all the way into May. Glass objects are still too bright; remembering that particular struggle, Barb puts her hand to her mouth and pretends to shout across a room: “Someone turn down that jar!”

And then one day, it’s done. (That day is May 17, the day before the screening.)

“Pretty crazy” is how Nellie describes the screening. “It was the first time a lot of us had seen it final-final, with music, sound effects, color correction.”

“I couldn’t stop thinking about the computer hours that had gotten crunched,” Kenji remembers. “We had only 20 computers working on the short, 10,000 frames and about an hour to render each frame – around 10,000 computer hours to just render it once. And we got up to version 5 or 6 of most shots. There were

so many points when it seemed like we wouldn’t finish or it wouldn’t be up to the standard we were looking for. So I was really, really proud of it. It didn’t hit me until the screening that it was a Brown/RISD first.”

“It reminded me that I really like *doing*,” Barb says. “A lot of what faculty members do is help students do things, so it was wonderful to be in the zone and get stuff done. I went into animation in the first place because I wanted to make things.”

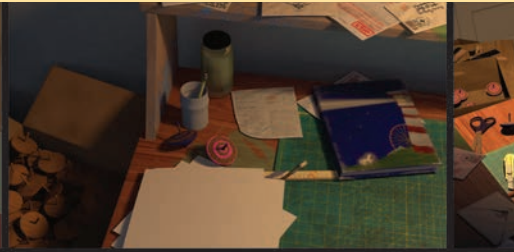
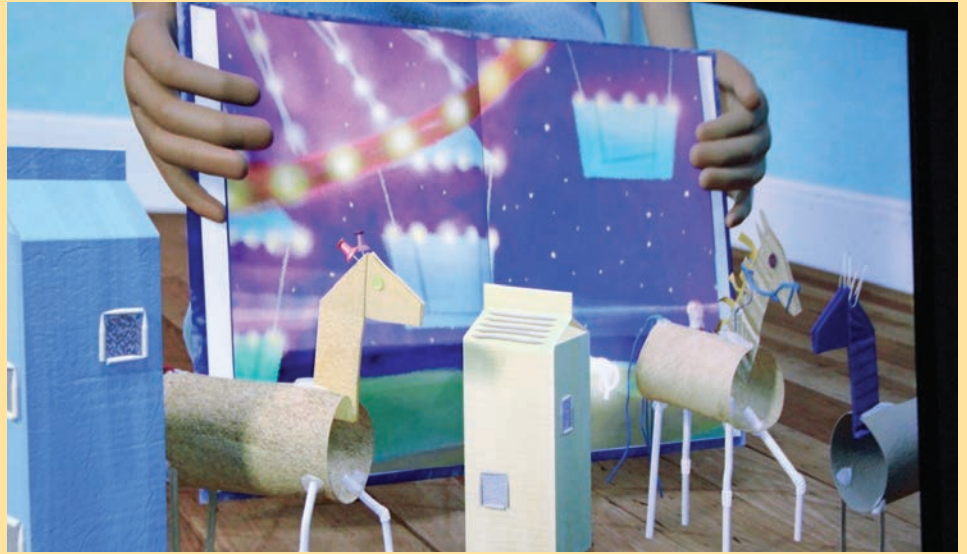
Animation A Bit Differently

With those numbers alone (10,000 frames, 10,000 hours of rendering), *Toymaker* astounds the layperson, but what about the expert? A week after its debut, Barb shows the short to eight alums at Commencement. Some of them have known her for her entire teaching career.

“When I saw the video file that Barb was opening, my jaw dropped,” says Mike Ravella. Now a Technical Director at Pixar, he came to Brown with no experience in art or computer graphics. “It was just incredible. You never see students even at the top animation schools do seven-minute shorts.”

“It was always competitive to get into Barb’s classes,” he remembers, “but these kids are insanely more qualified than we were. When one of my friends and I made our short, we tried to be conservative. We put a lot of love into it, and we were so excited to make something, but it still didn’t come out as well as we’d hoped. *Toymaker* is what I wanted to do, but that team of people didn’t exist that year. It does now, and the community that Barb has fostered is only on the rise. It’s self-sustaining: with more grads, students see more and more role models, so the career path looks viable to them.”

But the biggest challenge, Mike says, is animation’s barrier to entry: “And I want to



toymaker
and independent studies screening

Thu. May 18th, 12:30pm, CIT 368
Hosted by: Barbara Meier
Snacks after!

BY MONITOR BY LUIGI COLOMBO
"FLEAS" BY FELIX GERBU
"DANCE" BY EMMA HEROLD
"LOOKING OVER THE FENCE" BY EMILY REIF
"MILKSHAKE SAVED THE DRAGON" BY RAY WARD



see more kids get this opportunity, because Barb does such a great job breaking that barrier down! But she can only do so much teaching alone. When I heard that *Toymaker* was more about collaborating with friends and less about winning awards, it reminded me how Barb does animation a bit differently. She has the same focus on craft as other schools, but this is deeply personal for her. Animation is art to Barb, and anything from her students has a lot more heart, and it speaks to people better than something thrown together for a demo reel.”

The proof that it’s speaking to people occurs at that very same screening. Stunned by a plot twist, an alum’s five-year-old son voices his thoughts in a whisper heard throughout the room: “She’s breaking all the things the mom made!”

I Hope It Happens Again

The posters went up a few days before the screening.

Brown and RISD get credit at the top, the thirteen names are all the same size at the bottom, and just below that is a tiny postscript, a point of pride in technique and local habitation: “ARTISANALLY RENDERED IN PROVIDENCE, RI”. The title appears in gleaming white script, but the scene is subdued, even dim. Mother and daughter are sitting on the floor with a book, Angela stretching a little as kids do to make up for lack of height. Light is coming from stage left, but the sun is low. Near the ceiling the blue-green wall is black. The white mopboard has gone pink; soon it’ll be gray. Disrupting any sense of staginess or calculation in the pose or the scene, the animators have tucked one of Angela’s drawings behind

her head, semi-observed, throwing off the symmetry a little. All the months of work have culminated with a complete lack of pretense.


“There’s a reason why we were able to do it,” Barb says. “I put a structure in place that made it possible to be successful, and we had the right group of students. After working ten or twelve hours in the lab, they’d go to a movie together. They’re friends who deeply cared about the project and each other.”

So, what’s next for Nellie? “I don’t know,” she says, but it has to involve computer graphics tools and collaboration. “You can’t do this work alone.” She pauses. “I’m glad this actually happened. I hope it happens again.”

“I hope so, too,” says Ben. “I hope Barb’s willing to put up with me again!”

Months later, three words recur when we ask Barb if there’s anything else to say: “I don’t know. I just re-rendered the video today, actually. I’d love to run the class again and make another short, but it’s tricky because I have my other courses to teach. A project like this requires a lot of specific creativity and problem-solving to produce a quality film, compared to a typical two-week learning assignment in the intro course where mistakes are small and soon forgotten. It’d be great to have someone else come in and teach the intro course on a visiting basis now and then. But this was really a showpiece for what Brown CS can do. It was aspirational, but we had specific things in place to make it work. Based on what we learned, projects like this can only get better.”

And she’s been doing this for more than three decades. The best gardeners, Barb



“There were so many points when it seemed like we wouldn’t finish or it wouldn’t be up to the standard we were looking for.

So I was really, really proud of it.”

admits, are people in their sixties and seventies, because they’ve seen more growing conditions. A grin breaks out: “Yeah, I’d like to do something like this again.”

It’s the last week of summer and everyone’s coming back to campus. The screening was almost four months ago, but the posters are still hanging up in the CIT (mother and daughter leaning close in that late light) and new students will see them. Some won’t make the cut for CS 125 but will get in next year, some won’t get as far as they wanted in four years but make it to Pixar anyway, and some will have the idea and form the team and Barb will have to start drinking more coffee again.

Four months later and counting, nobody seems in any hurry to take them down.

Department Awards And Honors

Each item below is just the headline of an entire story for you to read, complete with photos and links and additional resources. **For full versions, please follow individual links or visit www.cs.brown.edu, where they're featured at either CS News or CS Blog.**

Arumugam, Karamcheti, Gopalan, Wong, Tellex Help Robots Follow Spoken Commands <http://bit.ly/2tCjUE1>

Bootstrap Brings The Next Generation The Data Science They'll Need <http://bit.ly/2nAtN5m>

Bootstrap Takes The Spotlight At A National Week Of Professional Development For K-12 Teachers <http://bit.ly/2uD5xUe>

Bootstrap Teaches Rigorous Data Science In An Introductory Computing Module For K-12 Students <http://bit.ly/2wxdCIB>

The NYT Interviews **Stephen Brawner** And **Shriram Krishnamurthi** About Computational Thinking <http://bit.ly/2qpQyEf>

Brown CS Announces Major Achievements In Data Science <http://bit.ly/2nG7DeG>

Brown CS Returns To The Cyber 9/12 Student Challenge <http://bit.ly/2rfNLEz>

Brown CS Faculty Earn Sloan Fellowships Four Years In A Row, For A Total Of Eight <http://bit.ly/2lJA4eu>

Brown CS Researchers Look To Add Statistical Safeguards To Data Analysis And Visualization Software <http://bit.ly/2r9MnEx>

SR Education Group Ranks **Brown CS** Third Nationwide For CS Master's Programs <http://bit.ly/2pGubS2>

More **Brown University Students** Are Majoring In CS Than Any Other Subject <http://bit.ly/2pJNSal>

Tiffany Chen Has Been Named A Women Techmakers Scholar <http://bit.ly/2rZKTgt>

Lauren Clarke Wins A Brown University Excellence Award <http://bit.ly/2kA5zqw>

Brown Receives \$1.5M To Establish A **Data Science Research Institute** <http://bit.ly/2it762z>

Geopipe, Co-Founded By **Thomas Dickerson**, Wins \$100K At The NYU \$300K Entrepreneurs Challenge <http://bit.ly/2r1RkvO>

Discover, Opening 5/12: Showcasing Remarkable Interdisciplinary Work To Enable New Collaboration <http://bit.ly/2pKaTZe>

Laura Dobler Has Been Named An Office Of Institutional Diversity And Inclusion Administrative Fellow <http://bit.ly/2kmjVrO>

Tim Edgar Publishes A New Book: Beyond Snowden <http://bit.ly/2wJF46y>

Erway, K p c , Papamanthou, Tamassia Earn The #4 Rank For 2009 Security Papers <http://bit.ly/2ruUmZE>

Pedro Felzenszwalb And Alum **David Blei** Talk About AI With The ACM <http://bit.ly/2k3ITve>

Rodrigo Fonseca And Collaborators Win An NSDI Test Of Time Award <http://bit.ly/2ogXI9u>

Rodrigo Fonseca Has Been Promoted To Associate Professor With Tenure <http://bit.ly/2l7pSg8>

Esha Ghosh Wins An Inaugural Microsoft Research Dissertation Grant <http://bit.ly/2tkmdz0>

Ian Gonsler, Jeff Huang, And Stefanie Tellex Win OVPR Seed Awards <http://bit.ly/2lJB4G1>

Connor Gramazio Will Give An Invited Talk At OpenVis Conf <http://bit.ly/2m0ulm3>

Amy Greenwald Gives A Keynote Address At Microsoft's Faculty Summit 2017 <http://bit.ly/2wTvXcX>

Hack@Brown 2017: Students, Faculty, And Mentors Will Gather For A Weekend Of Building And Creativity <http://bit.ly/2jRqWAK>

DARPA Looks At New Work From **HCRI** And Bertram Malle On Teaching Robots Moral Norms <http://bit.ly/2s13h8Q>

Brown CS Alum **James Hendler** Has Been Honored By The Association Of Moving Image Archivists <http://bit.ly/2sp0h6l>

Maurice Herlihy Gives A Keynote Address At PODC 2017 (Slides Included Below) <http://bit.ly/2v1PnQM>

Jeff Huang Finds Out How Gamers Get Good <http://bit.ly/2lPrdpM>

John Hughes Becomes Our Associate Chair <http://bit.ly/2unkny9>

The Humans To Robots Lab Contributes To A New Exhibit At London's Science Museum <http://bit.ly/2qKmnim>

Kamara And Papamanthou's Work Is #10 For Citations In Security Research From 2012 <http://bit.ly/2pEhQNC>

Kamara's Work On Searchable Encryption Is The 35th Most-Cited Security Paper Since 1981 <http://bit.ly/2qZrgAv>

Caroline Klivans Disproves A 35-Year-Old Conjecture <http://bit.ly/2mTBYqq>

Caroline Klivans Is Promoted To Senior Lecturer <http://bit.ly/2mimwqW>

George Konidaris Collaborates To Help Robots See In Three Dimensions <http://bit.ly/2gLiVQM>

Tim Kraska Receives A Sloan Research Fellowship <http://bit.ly/2loI9EO>

Krishnamurthi And Quay-de la Vallee Look At App Store Insecurity In Fast Company <http://bit.ly/2jijnxts>

Shriram Krishnamurthi Will Receive An Honorary Doctorate From Universit  della Svizzera Italiana <http://bit.ly/2m3woSR>

Shriram Krishnamurthi Will Serve On The Communications Of The ACM Research Highlights Editorial Board <http://bit.ly/2sFdYvl>

Celebrating 25 Years Of **Michael Littman's** Contribution To The First Email Attachment <http://bit.ly/2ne6U89>

Michael Littman Chats With Neil deGrasse Tyson About AI And Society <http://bit.ly/2kLcFEk>

Brown CS Alum **Aimee Lucido** Speaks Out About Industry Sexism <http://bit.ly/2ldVzKL>

Markell, Picard, And Tipperman Earn KPCB Fellowships, Setting A Brown CS Record <http://bit.ly/2n5ZL9G>

Brown CS PhD Alum **Charalampos Papamanthou** Has Won An NSF CAREER Award <http://bit.ly/2rMgUcj>

Alexandra Papoutsaki Lands A "Dream Job" At Pomona College <http://bit.ly/2mFaHKU>

Faculty Notes

Sorawee Porncharoenwase Wins The Randy F. Pausch Computer Science Undergraduate Summer Research Award <http://bit.ly/2mCAfG8>

Franco Preparata Will Be The Keynote Speaker At An Upcoming Collège De France Symposium <http://bit.ly/2pxbxHH>

Alum **Sarah Sachs** Tackles Impostor Syndrome With A Little Help From Michelle Obama <http://bit.ly/2kHf9Wv>

Startup@Brown Returns On September 30, 2017 <http://bit.ly/2ykKDbP>

Stefanie Tellex And Baxter Provide Local Kids With A Glimpse Of The Future Of Robotics <http://bit.ly/2hYvtVk>

Stefanie Tellex Has Been Named The Joukowsky Family Assistant Professor Of Computer Science <http://bit.ly/2ri7Bk5>

Stefanie Tellex Serves As An Advisor For A New Children's Book About Robots <http://bit.ly/2vyHQQv>

Stefanie Tellex Wins A CAREER Award For Robots That Help People <http://bit.ly/2q2qZjF>

Tellex, Rosen, And Whitney Use Social Feedback To Help Robots Fetch Objects Intelligently <http://bit.ly/2mSXSxX>

Eli Upfal Receives The President's Award For Excellence In Faculty Governance <http://bit.ly/2kXLQII>

Eli Upfal Publishes A Much-Expanded Second Edition Of Probability And Computing <http://bit.ly/2tQPfKc>

Upfal, Binnig, Kraska, Van Dam Win A \$3.1M DARPA Grant To Build New Data Exploration Software <http://bit.ly/2oQ5eQ5>

Peter Wegner Receives A Recognition Award For His Work With The Faculty Bulletin <http://bit.ly/2njwAwV>

SORIN ISTRAIL

Sorin hosted in January a mini-symposium ("The Regulatory Genome") honoring the memory of Professor Eric Davidson, his biology professor, mentor, and closest friend, who passed away in 2015. Two speakers of distinction gave two extraordinary lectures: Professor Ellen Rothenberg, Albert Billings Ruddock Professor of Biology, University Professor, California Institute of Technology; and Professor Caleb "Tuck" Finch, ARCO/William F. Kieschnick Professor in the Neurobiology of Aging, University Professor, University of Southern California.

In April, Sorin attended the Keystone Conference on "Genome Instability and DNA Repair" held in Santa Fe. In May, he traveled to Hong Kong for the 21st RECOMB Conference. In June, he traveled to Bucharest, Romania, to chair the mini-symposium in honor of Professor Sergiu Rudeanu's 82nd birthday. Professor Rudeanu was his former PhD co-advisor, together with the late Professor Solomon Marcus. Together with colleagues from the University of Bucharest's Department of Computer Science, a celebration followed the next day in memory of Professors Solomon Marcus and Grigore Moisil, the beloved founders of Computer Science in Romania.

From Bucharest, Sorin went to Turku, Finland, to attend the "Magic in Science" Symposium, a celebration of the 75th birthday of Professor Grzegorz Rozenberg of Leiden University (van Gogh Land). His friendship with Grzegorz started 37 years ago at the ICALP conference in Graz, Austria, when Grzegorz was 37 years old – magic! At the Symposium, Sorin had a reunion after 37 years with Professor Arto Salomaa.



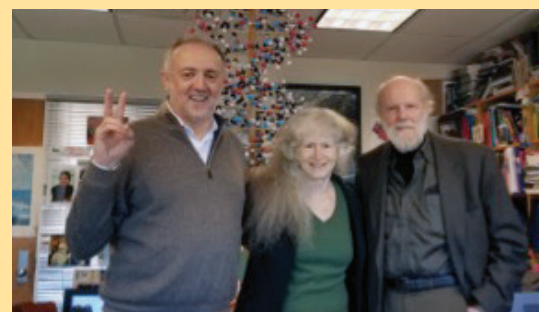
Bucharest in June, 2017: Professor Sergiu Rudeanu and Sorin



June, 2017: Professor Arto Salomaa and Sorin



June, 2017: Sorin and Professor Grzegorz Rozenberg



January, 2017: Sorin with Ellen Rothenberg and Tuck Finch – Eric Davidson in Memoriam!

Faculty Notes continued...

SHRIRAM KRISHNAMURTHI



A photo from Shriram's travels: a view of the Vierwaldstättersee ("Lake of the Four Forested Cantons") from Brunnen



Teachers learning to teach Bootstrap on Day Three: Emma Youndtsmith, in the blue shirt, is leading the class



Adam Newall is in the black shirt, teaching, with Dorai Sitaram in the purple shirt at right



From an idea by Banyan Ren, a Pyret party after Professional Development, with shark bait, fish-and-chips, an anti-scurvy anchor by Kielan Donohue, and Pirate's Booty

DAVID LAIDLAW

David Laidlaw enjoyed his sabbatical last academic year. He was able to spend the time on improvements to the Yurt virtual reality display at CCV and on writing a number of research proposals, e.g. for scientific uses of VR and for interactive ways to compensate for human foibles in the research process. He also took some time to breathe again, without the constant interruptions that accompany teaching, advising, reviewing, etc. He recently presented a virtual tour of Brown's VR display to an audience of about 100 at a Gordon Research Conference. He and Barbara Meier spiced up their summer with a bicycling and "hill walking" (aka hiking in the US) trip to Scotland, bagging three Munros and cycling about 350 miles around the west and the Highlands.

BARBARA MEIER

This past year my advanced animation students produced *Toymaker*, a seven-minute animated short film, a breakthrough achievement for Brown and CS. In addition, I advised the student-run 2D and 3D video game engines courses. The students do a great job keeping the game engines courses going and are revamping a significant portion of the 2D course for this fall, but course design is a big ask for undergraduates. We would welcome CS alums and friends to contribute to these courses at any level: giving a guest lecture (our videoconferencing capabilities are quite nice), updating and revising the curricula, or even coming to teach for a semester or longer.

In other news, last May, I attended FMX (an animation, effects, VR, games conference) co-located with the International Trickfilm Festival in Stuttgart, Germany. Despite dastardly weather (I hear the grape harvest for wine is ruined), it was great to catch up with old visual effects friends and take a peek behind the scenes where I used to work in Hollywood. Summer brought much-needed respite from teaching and advising with playtime in Scotland where David Laidlaw and I cycled and hiked with our teenage son Eliot. As one might imagine, we encountered steep hills, brisk winds (but nearly always tailwinds, by design!), lush greenery, many forms of precipitation including a new one to us: mizzle, whiskey, haggis (no thank you), and sheep.



Barb and David in the Scottish Highlands

JOHN SAVAGE

I was immensely pleased that the Department decided to recognize my first 50 years at Brown by hosting an event on my behalf. I was surprised and delighted to learn that the University had agreed to raise funds for a Chair in my name and especially pleased to learn that my daughter had played a central role in launching this initiative. As a founder I've long wanted the Department to have more Chairs so that we can retain outstanding faculty and recruit same. This is another important step forward.

For me this event was a time to take stock of the progress that we have made. The Department is now in a very good place. For some time direction of the Department has been in the hands of a new generation of leaders. I am immensely proud of the excellent judgment that they have shown in all respects, but particularly faculty recruiting, as well as their devotion to the highest standards of research, scholarship, and instruction. The culture that we developed in the early years has served us extremely well. We are producing outstanding students and provide an excellent environment in which to nurture and develop young faculty members.

It has been my honor to serve as a member of this community and hope to continue for another 50 years.

You can look at John's slides at: <http://bit.ly/2w3IEcp> • You can read John's remarks at: <http://bit.ly/2xsq8Z1> • You can watch videos of all speakers at: <http://bit.ly/2wyhGM4>



Paul Savage, Patricia Savage, and John Savage at John's anniversary celebration



Larry Harper presents at John's event



Ugur Cetintemel offers a toast to John as guests gather in CIT 368

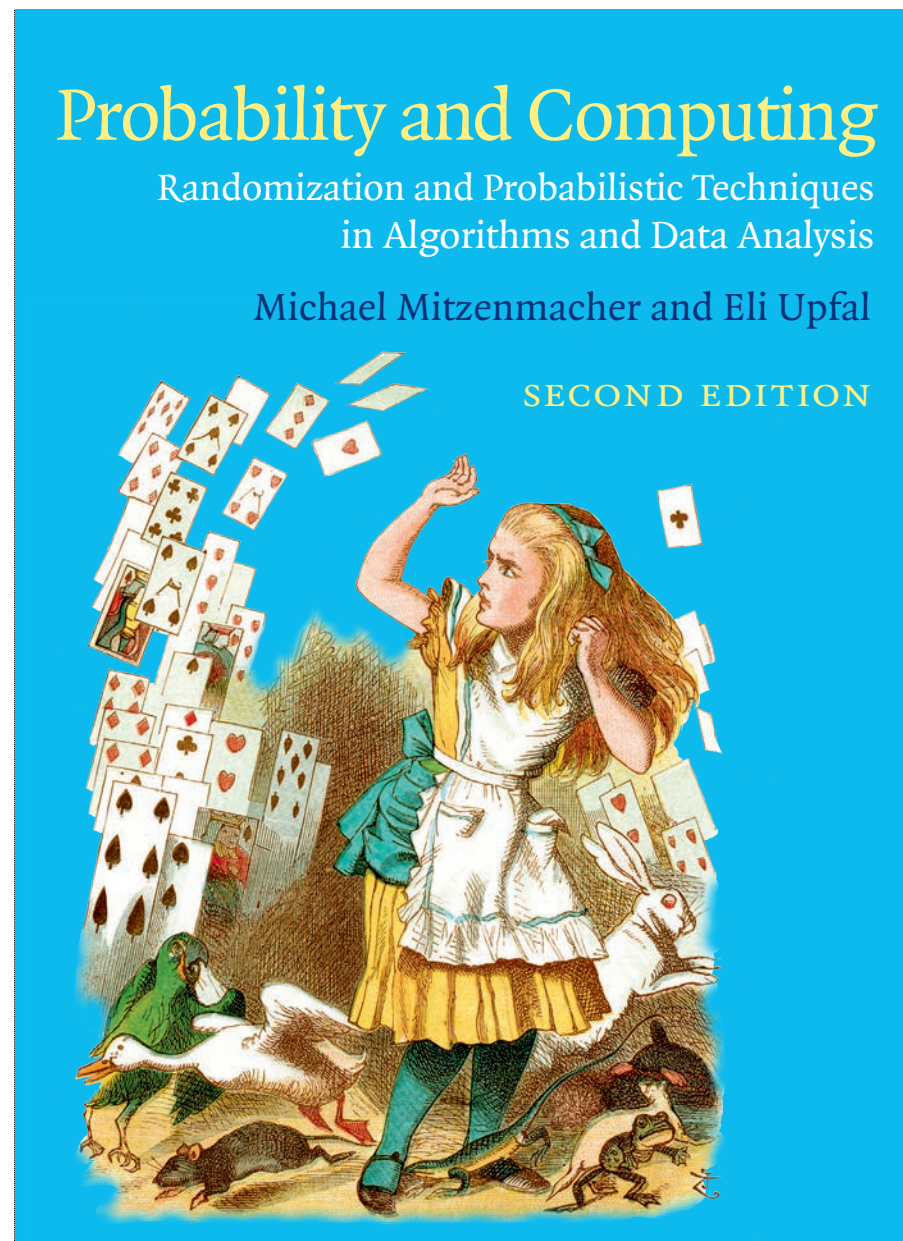
ELI UPFAL

Eli Upfal (with Michael Mitzenmacher of Harvard University) has just released a significantly larger second edition of his widely-used textbook, *Probability and Computing: Randomization and Probabilistic Techniques in Algorithms and Data Analysis*. It's already receiving high praise from experts in the field: Stanford University's Donald E. Knuth says, "This textbook provides a rigorous yet accessible introduction to fundamental concepts that need to be widely known. The new chapters in this second edition, about sample size and power laws, make it especially valuable for today's applications." Richard Karp of University of California, Berkeley, explains that his favorite course that he's taught there is based on *Probability and Computing*: "Students appreciate the clarity and crispness of the arguments and the relevance of the material to the study of algorithms."

Readers of the book need only an elementary background in discrete mathematics, and the new material covers such topics as normal distributions, sample complexity, VC dimension, Rademacher complexity, power laws and related distributions, cuckoo hashing, and the Lovasz Local Lemma. A full list of contents includes:

- Events and probability
- Discrete random variables and expectations
- Moments and deviations
- Chernoff and Hoeffding bounds
- Balls, bins, and random graphs
- The probabilistic method
- Markov chains and random walks
- Continuous distributions and the Poisson process
- The normal distribution
- Entropy, randomness, and information
- The Monte Carlo method
- Coupling of Markov chains
- Martingales
- Sample complexity, VC dimension, and Rademacher complexity
- Pairwise independence and universal hash functions
- Power laws and related distributions
- Balanced allocations and cuckoo hashing

Eli explains that the book's new subtitle (it changes from "Randomizing Algorithms and Probabilistic Analysis" to "Randomization and Probabilistic Techniques in Algorithms and Data Analysis") is significant. "The new material is mostly related to the theory of machine learning and data analysis," he says, "following their growing importance in CS. We want students to learn the best modern techniques and applications, so we provide many new exercises and examples, including programming-related ones that provide training in solving these kinds of problems."



The image above is © 2017 by Cambridge University Press

Alum Updates

FOTEINI BALDIMTSI

After graduating with a PhD from Brown CS in 2014, I have started working as an Assistant Professor in the Department of Computer Science at George Mason University, where I do research and teach about cryptography, security, data privacy, and blockchain technologies.

In April 2017 I gave a TEDx talk about cryptography and blockchain in my hometown of Thessaloniki, Greece. The talk is a practical guide on how blockchain has brought about the revolution of Bitcoin, a currency that is not printed on paper by a bank but created by users who “run” Bitcoin software around the world. What else can we expect by this amazing technology and how will it change the way transactions are made in the 21st century? In my attack I attempt to discuss the opportunities and risks and invite everyone to appreciate cryptography’s contribution to the digital age.

Foteini’s slides are available at: <http://bit.ly/2xl3pP4>

A video of Foteini’s talk (in Greek, with English subtitles) is at: <http://bit.ly/2vis3OV>



Foteini giving her TEDx talk

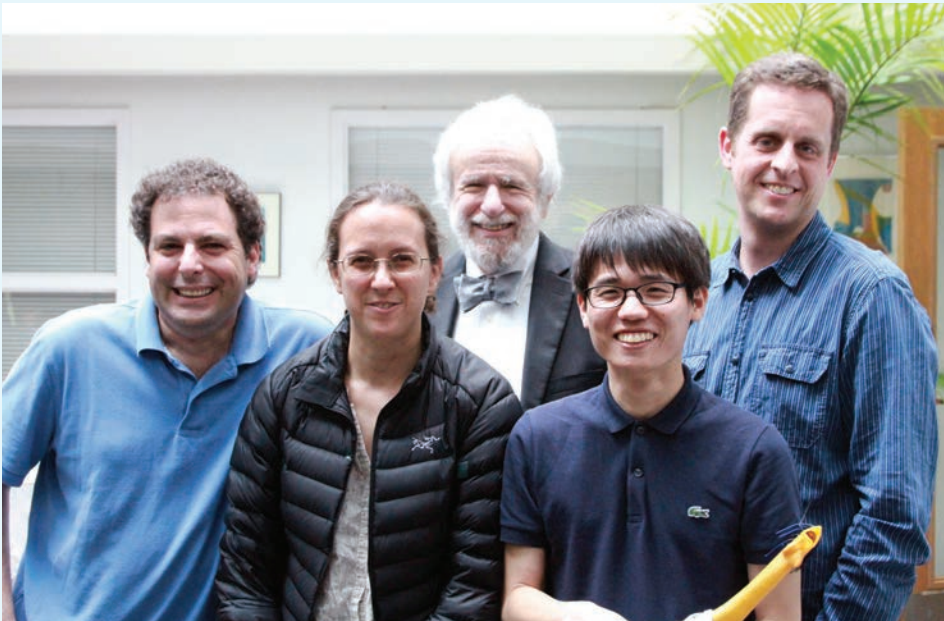
MATT LERNER

There wasn’t a dry eye in the house after Ralph Ruiz married his partner Brian in Seattle. I think Andy van Dam liked the picture because it shows three Brown CS grads having a great time together more than 20 years after graduating (Yikes!).



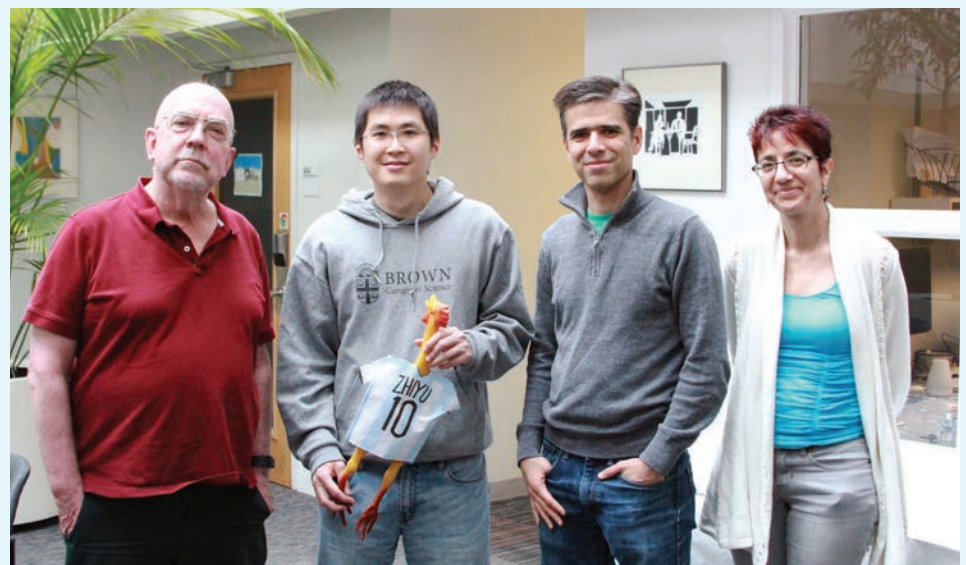
Matt Lerner Brown CS '97 (VP Product and Design at Redfin), Ralph Ruiz Brown CS '95 (Software Engineer at Hearsay Social), Ely Greenfield Brown CS '96 (Sr. Principal Scientist at Adobe)

Recent PhDs



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- DK Choe
- Connor Gramazio
- Zhiyu Liu





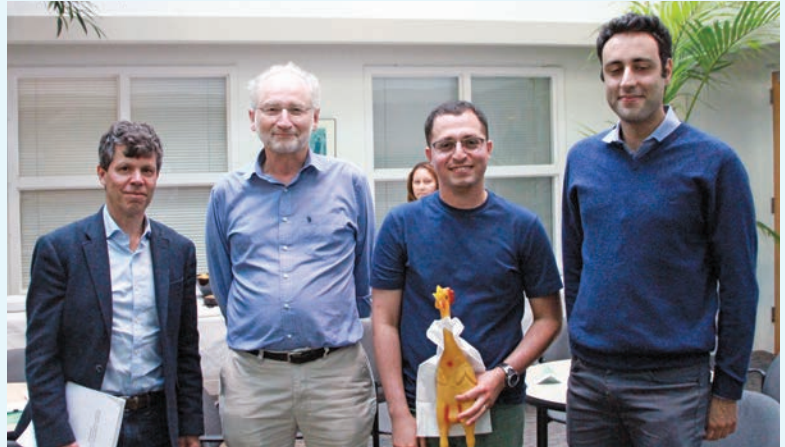
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Hannah Quay-de la Vallee

Ahmad Mahmoody

Marcelo Martins

Jeroen Chua



Around The Department

Adding a personal touch to the Brown regalia



Tom Doeppner at Commencement 2017

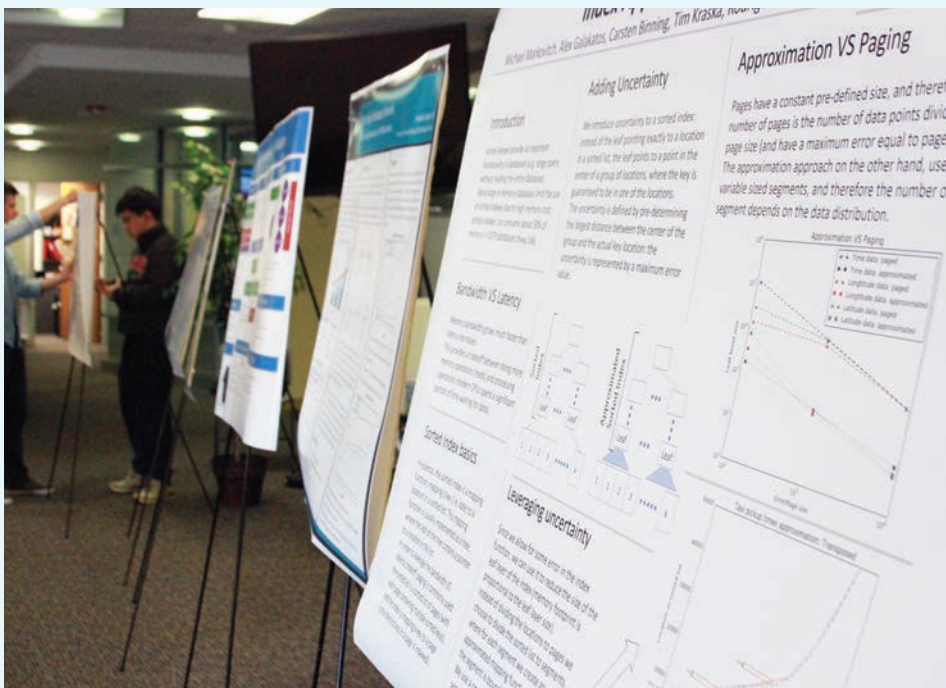


PhD student Jiwon Choe presents her poster on programmable routers for Rodrigo Fonseca's CSCI 2950-U Special Topics on Networking and Distributed Systems class

Shriram Krishnamurthi "hooding" Hannah Quay-de la Vallee



Abraham Peterkin presenting research



Final projects for CSCI 2950-U



Rajesh Jayaram answers questions

Around The Department



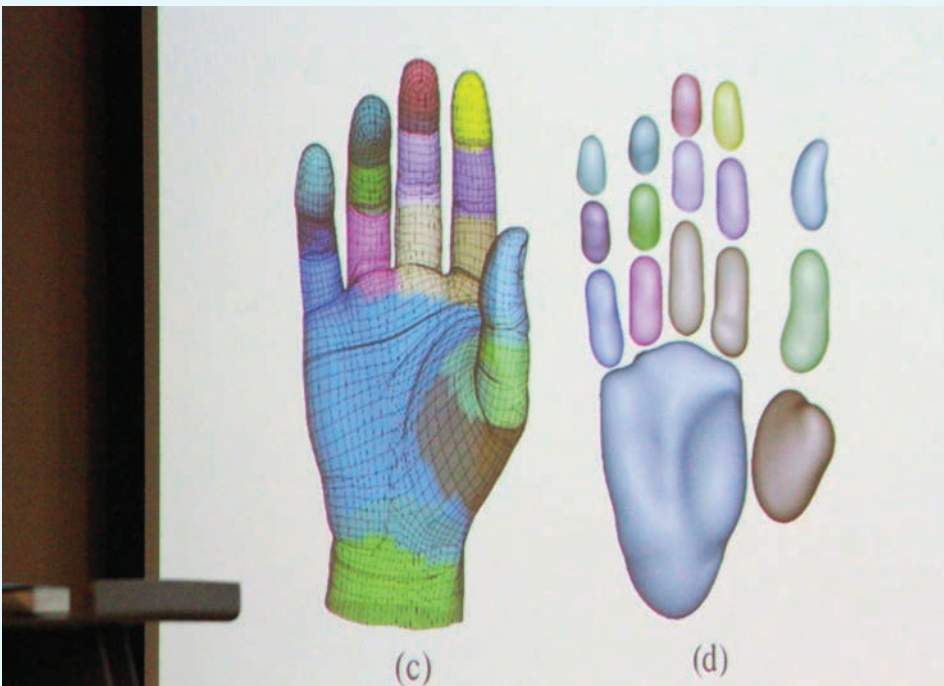
Scenes from the Cyber 9/12 Student Challenge in Washington, DC, with John Savage and members of his team: Qiheng Chen, Clarissa Clem, Sarah McNeil, and Alexandra Paul



Taking photos for the student-produced Brown CS 2017 Yearbook



Christian Giancarlo, presenting his final project for John Hughes's CS 224 Interactive Computer Graphics course



More student work from CS 224



John Hughes

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Providence, RI

Staying In Touch

- Send a blank email to alumssubscribe@cs.brown.edu to join the Brown CS Alum Email Group, which we'll use to occasionally share updates. It's only for alums, and members can't e-mail each other, so you don't need to worry about a high volume of messages.
- Visit our web site (www.cs.brown.edu), which we update daily with news and stories.
- Visit (and please be sure to like) our Facebook page (www.tinyurl.com/browncsfb).
- Follow us on Twitter (www.twitter.com/browncsdept).

Industry 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.

The department wishes to thank our Industrial Partners for their support:

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Paul Edelman,
Edelman & Associates



For more information about the Industry Partners Program, contact:

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To learn more about the IPP, visit:
<http://www.cs.brown.edu/industry>

Ping!

Let us know what's happening in your life! Submit your news by email to conduit@cs.brown.edu or by mail to:

Conduit

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