Conduit

DEPARTMENT OF COMPUTER SCIENCE

BROWN

Next Generation Educational Software: Issues and Possibilities

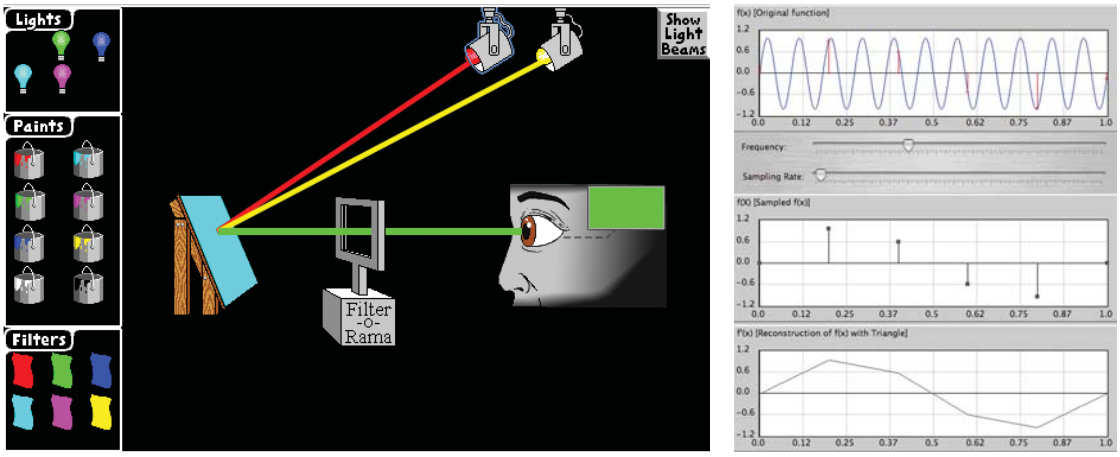

FIGURE 1 Exploratories (left) on color mixing, highlighting the differences between mixing light and mixing paint, and (right) on the Nyquist limit in signal processing, demonstrating the aliasing artifact in reconstructing a higher-frequency sine wave by a lower frequency sine wave arising from inadequate sampling frequency.

Andy van Dam holds the Thomas J. Watson Jr. University Professor of Technology & Education Chair and is Professor of Computer Science at Brown University. He is also Brown's Vice President for Research.

Rosemary Simpson is a professional indexer and an information structures designer.

Beginnings at Brown

In this article I describe some of the educational software projects my students and I have worked on over the last forty years, and elicit some of the common themes and strategies that connect the earliest projects with the work we are doing today. Included are interaction, simulation, modeling, multiple levels of detail, multiple points of view, and multiple information structures. The common thread that links all the goals and strategies is the use of interactive visualization to deal with complexity. While this article discusses only projects I've been personally involved with, it is important to point out that other faculty, students, and staff at Brown University have been in the forefront of visual, interactive, cross-disciplinary approaches to presenting and working with complex concepts since at least the sixties. I briefly cite some of this ground-breaking work first. CONTINUED ON PAGE 10

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Conduit

Notes from the Chair: the Latest News from 115 Waterman

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Queries about this publication can be directed to: laura_zurowski@brown.edu

Our campus mailing address is:
115 Waterman Street
Campus Box 1910
Providence, RI 02912

PUBLISHER
Industrial Partners Program,
Department of Computer Science

EDITOR-IN-CHIEF
Laura Zurowski

FACULTY EDITOR
Eugene Charniak

COPY EDITOR
Amy Leavitt

GRAPHIC DESIGN
John deWolf, Public Information Design

CONDUiT ON THE WEB
John Bazik
Kathy Kirman

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Greetings to all CS alums, supporters and friends!

With this fall issue of Conduit I offer my sincerest congratulations to all those undergraduate and graduate students who received their degrees in our commencement exercises last May. It was a pleasure having all of you as part of the CS "family," and I hope that you will keep us informed of your life trajectories and return to visit when you are in the Providence area.

New faculty

We are pleased to announce the addition of Professor Sorin Istrail to the department's faculty. Sorin comes from Celera, the company that, together with the publicly financed consortium, sequenced the human genome. He will be instrumental in the growth and development of the Computational Biology Center and help to provide new direction in research and teaching within the realm of Computer Science. Sorin will teach his first course at Brown this spring, and more on his background and research will appear later in this issue.

More new faculty

As the department continues to grow, this academic year will find us searching for two new faculty members in the areas of Computer Graphics and Machine Learning. As always, we are looking for the best and the brightest to fill the positions, and we will keep the positions open until we find suitable candidates.

Website changes

In early December, Brown's university-wide website will showcase a new look and feel. Lisa Strausfeld, a Brown art history and computer science concentrator and partner in the New York design firm, Pentagram, was chosen to lead the re-design efforts. To coincide with the deployment of the new university website, we have been working on improving the appearance and navigation of the department's website. By the time you read this, the site should already have some subtle and not-so-subtle improvements. My thanks go out to long-time department webmaster, (among many other things!) John Bazik, for his hard work and dedication to this task.

Undergraduate curriculum

The computer science faculty continues to reevaluate and consider alterations to the undergraduate curriculum. I'd like to extend my thanks to the number of alums who responded to Tom Doeppner's article, *Java, C++, and the CS Curriculum* that appeared in the May 2005 issue of Conduit. Your thoughts on how to best combine the traditions of computer science instruction with industry demands are always appreciated. Brown's engagement in this issue is part of a larger discussion taking place at leading universities throughout the nation. Ultimately, this undertaking will help us to determine how best to engage the emerging interdisciplinary nature of computer science with a traditional approach to core systems programming and engineering. This is an essential and difficult process but one that will ultimately ensure the strength and appeal of our department.

Renovations, reunions and the future

On Saturday, May 28th over three hundred alums, friends and faculty attended the department's inaugural reunion and networking reception. I am extremely pleased that so many of you decided to make our event part of your commencement weekend activities. As a result of this overwhelming success, you can now schedule Saturday, May 27th, 2006 as the date of the next reunion event! As those who attended the reunion can attest, the renovations to the 3rd, 4th and 5th floors are fantastic! The 3rd floor common-area and kitchen are spacious and well appointed, making it our new location of choice for social events. In the future, we hope to extend renovations to the first-floor lobby area to provide even more space for students to both work and relax. We'll be sure to keep you up-to-date on the latest news and developments in this area.

Keep in touch!

Eli Upfal
Chair, Computer Science Department

The Borealis Team Wins Best Demonstration Award at ACM SIGMOD

The Borealis team members who contributed to this article include **Yanif Ahmad**, **Bradley Berg**, Assistant Professor **Uğur Çetintemel, Mark Humphrey, Jeong-Hyon Hwang, Anjali Jhingran, Anurag Maskey, Olga Papaemmanouil, Alexander Rasin, Nesime Tatbul, Wenjuan Xing, Ying Xing,** and Professor **Stan Zdonik**.

The annual ACM SIGMOD Conference is one of the premier conferences on data management. This year's SIGMOD was held in Baltimore, Maryland from June 14–16. The first two days of the conference program included 24 project demonstrations (selected out of 71 submissions) from the top academic groups and research labs. For the first time in its history, SIGMOD included a "Best Demonstration" award in its program. A panel of judges selected three demonstrations based on criteria such as innovative functionality, contribution to the application domain, and the "gee-whiz" factor. The selected demonstrations were then presented in a special session on the final day of the conference in front of more than 100 people. We are delighted to report that the Brown Data Management group's entry on "Distributed Operation in the Borealis Stream Processing Engine" was selected as one of three best demos of the conference.

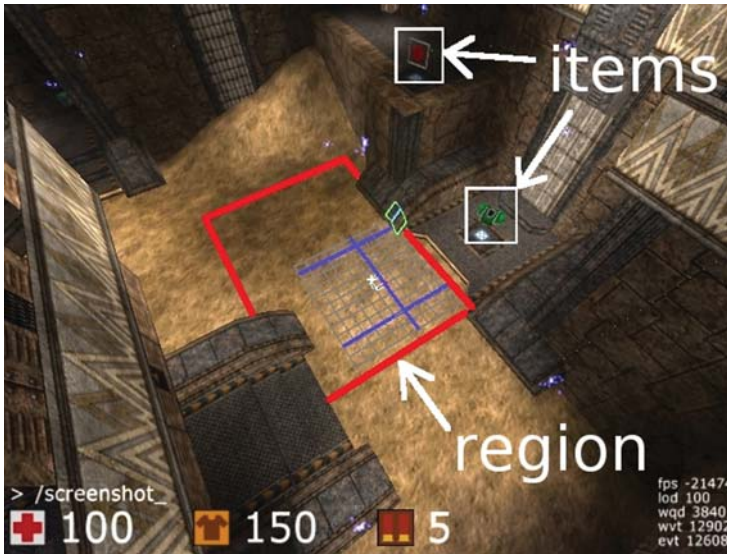


FIGURE 1 An image from "Cube", the Borealis-powered multi-player game.

Cube is an open-source, first person shooter game, wherein each player represents a combatant on a three-dimensional map.

Distributed stream processing with Borealis

Today's data-driven applications continuously produce large volumes of data in the form of data streams. Well-known examples of these include financial applications that use data streams to drive market models (e.g., for automated trading), sensor networks feeding environmental readings for monitoring purposes (e.g., to detect harmful toxins in sewer systems), and RFID-based inventory management and asset tracking.

The data management community has made substantial progress in designing data-flow-oriented systems that can provide the core low-latency processing needed by these applications. However, as these applications become more and more common, they continue to grow in scale, and the initial generation of stream processing systems falls short in addressing many performance and functionality related challenges.

Over the past two years, the Borealis team, which includes professors and graduate students from Brandeis, Brown and MIT, has been tackling these new challenges by extending its first generation stream processing system called Aurora, featured in the Fall 2002 issue of the Conduit. The Borealis group at Brown has concentrated on delivering an adaptive, high-performance and highly- available system to process data streams in a distributed fashion. The existing prototype has the capability to perform automatic load distribution as load and system conditions change, fail-over processing to healthy machines in case of failures, and deal with load spikes through intelligent load shedding.

A fun application: Borealis-powered Cube multi-player network game

During the demo, the Borealis team showcased the key features of their system by means of an innovative application of their stream processing technology: a multi-player network game named "Cube". Cube is an open-source, first person shooter game, wherein each player represents a combatant on a three-dimensional map. Players pursue one another shooting projectiles from their inventory of weapons. Players also participate in team competitions,

typically attempting to outscore the other team. The game shares the same key performance requirements as other canonical data stream applications: low latency (for interactive game play) and large volumes of data streams (position updates and actions from a distributed set of players).

For this demonstration, the team interposed Borealis at the network layer of the Cube engine. Cube's network messages are Borealis tuples, and Borealis implements the game server application logic. As an extension to the team play game features, the Borealis demo included the role of a commander who guides individual players based on aggregated information from all team players. The commander dynamically registers continuous queries to monitor the game state and implements a game strategy based on the results she gets. Hence, the queries serve as distributed triggers that are continually evaluated to track events of interest and notify the commander in her viewport. The commander view supports the selection of regions on the game map, players or items to query dynamically. Some examples of continuous queries are:

- Count the number of players in the selected region.
- Track the distance between a selected player and the nearest enemy.

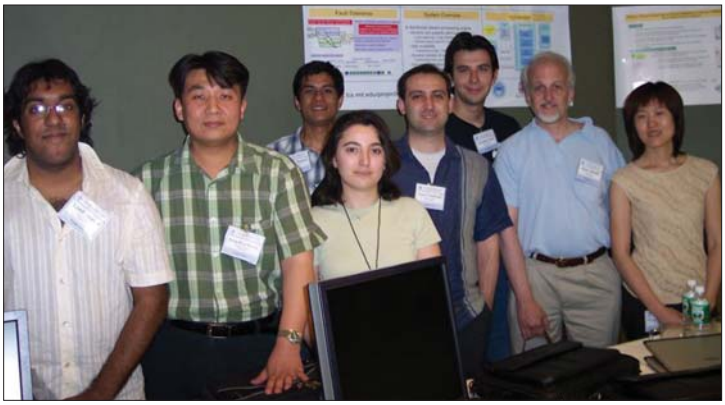
The team appeared to be quite enthusiastic and creative when it came to extending the game's features; some ideas included demonstrating the performance of the system by through a "Rambo"-like scenario where one character battles against numerous other players, and that character's capabilities would vary with the system load. Furthermore, this enthusiasm clearly carried through to testing the demo, and somehow the time spent on testing often seemed to exceed that of development and debugging. In the demo, Borealis ran on a local area network of five laptop machines in addition to two LCD panels and numerous pieces of tangled network cables—no wonder the team also won the first place award in the "most hardware" category! The queries for both the game and commander executed continuously in the background and were automatically distributed across the laptops. Additionally, one machine acted as a workload generator and introduced adjustable load into the system both in terms of the number of scripted players in the game world, and the frequency of updates from these players. Two critical on-site modifications seemed to give us the competitive edge—the subtle incorporation of background music combined with naming the game's players as some of the more opinionated members of the database community—in our version of a Celebrity Death Match.

Borealis into the Future, a Sneak Preview

The Borealis team continues to actively engage in stream processing research, and future directions include applying robust optimization techniques to system performance through resilient load balancing, n-way high availability schemes to improve the amount of resources for processing queries while maintaining the same availability guarantees as before, and parallel processing to support extreme resource scalability and speedup for arbitrary queries. The team plans to extend the demo to better capture the distributed nature of network games, and we intend to explore the ease of use of a data flow-oriented programming language to express a control logic for large numbers of AI-driven players. In terms of application domains, large-scale text processing and scientific computing display traits of stream-oriented applications combined with the need for data exploration and mining. Our research is often motivated by the requirements of specific applications, thus, the team is always interested in hearing suggestions for how data management requirements of applications may be well suited by a data stream model.

The Borealis team would like to thank the tstaff for their speedy provision of hardware, our collective officemates for putting up with our many screams of anguish during debugging sessions, and last but not least, our competitors for their help in preparing for our final presentation to the general audience—at the bar. **C!**

BELOW Team Borealis at SIGMOD: Yanif Ahmad, Jeong-Hyon Hwang, Anurag Maskey (Brandeis), Nesime Tatbul, Uğur Çetintemel, Alexander Rasin, Stan Zdonik, and Wenjuan Xing.



More Information

For more information on the Borealis distributed stream processing system, please visit:
www.cs.brown.edu/research/db/borealis/

A complete photo story of the Borealis demo can be found here (parental guidance recommended):
www.cs.brown.edu/research/db/photos/BorealisDemo/index.html

Fields of Experts for Modeling Natural Images

Professor **Michael Black**'s computer vision research focuses on estimating optical flow from sequences of images. **Stefan Roth** is a PhD candidate in Computer Science.

In Figure 1 (top) the text obscures parts of the image. "Restoring" this image involves removing the text and replacing it with what was covered. The problem is that we don't know the image values that were obscured. Consequently, there are many ways of filling in the pixel values in the text regions, each yielding a different image. Some of these images, however, look more "natural" than others. One possible image replaces all the red characters with random pixel values (Figure 1 (middle)); this doesn't look real, however, because it doesn't have the properties we expect of real images. Surfaces in the world give rise to continuous edges, corners, and smoothly varying regions.

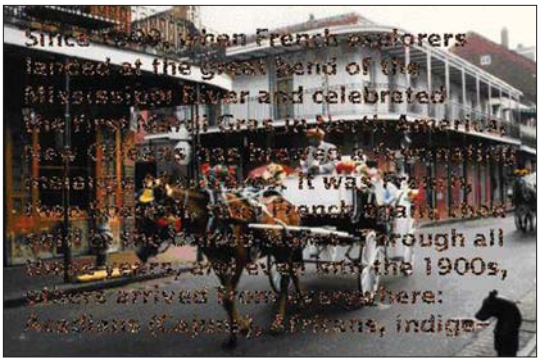


FIGURE 1 Image inpainting. There are many ways to remove the text in (top) by replacing the red pixel values by other values. A random replacement, however, does not look "natural" (middle). The replacement in (bottom), which looks much more natural, is generated automatically by our Field-of-Experts method.

If we had a probability distribution over all natural images that captured their inherent structure, we could say how "real" any given image is by computing its probability. For example, the image in Figure 1 (bottom) is much more likely to be a good, i.e. realistic, completion of the scene than Figure 1 (middle) with random noise.

This problem, which has a long history in computer vision, is often posed as modeling the *a priori* probability of an image. The standard formulation of this probability is as a Markov random field (MRF) in which a given pixel's value is assumed independent of the rest of the image conditioned on its nearest neighbors in the image. In other words, we assume that once you know the immediate neighbors of a pixel, knowing the rest of the image gives you no more information.

Formally, this is written as:

$$p(\mathbf{x}) = \frac{1}{Z} \prod_{\substack{\text{neighbors} \\ (x_i, x_j)}} \Psi(x_i, x_j)$$

where x is an image, Z is a normalizing constant, and Ψ is a potential function that looks only at neighboring pixels x_i, x_j in the image.

However, this violates our intuitions about images and the fact that surfaces and edges persist in space. As a result, these standard MRF models have only limited representational power and most often treat images as though they were piecewise constant. To capture the rich complexity of natural scenes, we need to model longer-range interactions that occur in larger image neighborhoods.

To that end, we have formulated a new probabilistic model of images that we call a Field-of-Experts (FoE) model. The model extends the notion of a neighborhood to much larger regions; we often use 5x5 image regions, though arbitrary sizes and shapes may be used. We then model the potential function as the product of a number of M "experts":

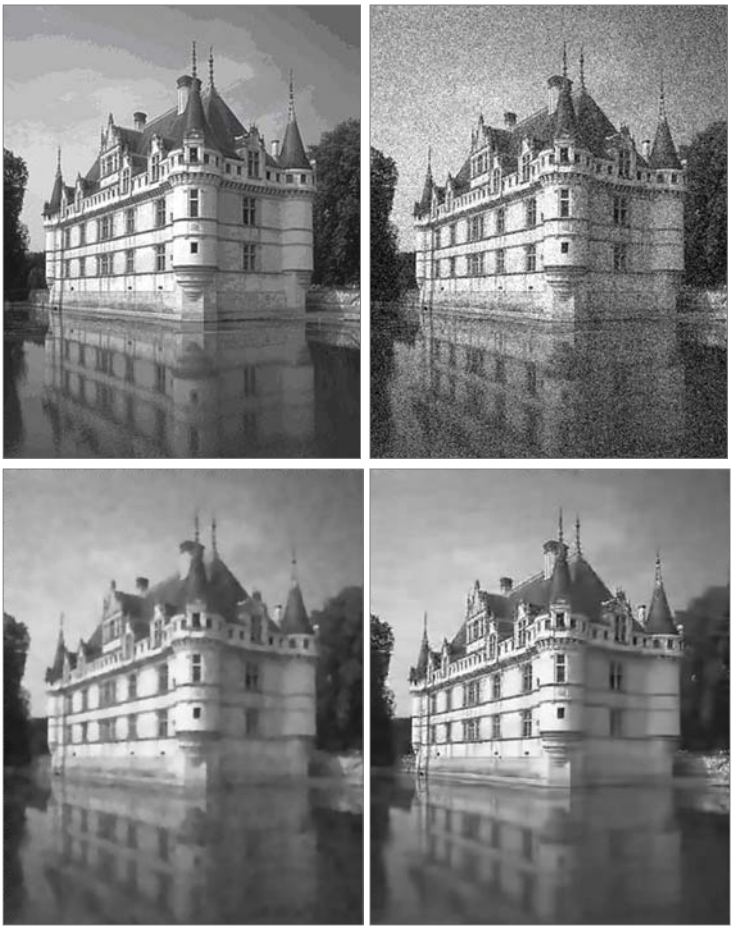
$$p(\mathbf{x}) = \frac{1}{Z} \prod_{j=1}^{N} \prod_{i=1}^{M} \phi_i(\mathbf{J}_i^{\mathrm{T}} \mathbf{x}_j)$$

where $\mathbf{x}_j$ is an nxn image region centered on pixel j, $\mathbf{J}_i$ is a linear filter that is applied to the image region $\mathbf{x}_j$ and ϕ_i is a function of the filter response.

It turns out that the response of any zero-mean linear filter applied to natural image regions has very simple statistics that are well fit by a Student t-distribution. Hence we take the ϕ_i to be t-distributions where the parameters of the distribution are learned from training data. The filters $\mathbf{J}_i$ are also learned from data. This learning problem is challenging when the MRF is formulated with large neighborhoods such as those here. To deal with this, we use an idea of Geoff Hinton's called contrastive divergence to learn the parameters that approximately maximize the likelihood of a set of training images under the FoE model.

Now that we have a feasible learning algorithm for high-order MRFs, the next problem involves using these models for inference, such as filling

"...this violates our intuitions about images and the fact that surfaces and edges persist in space."



in the text regions in Figure 1. Here we use simple gradient-descent methods to perform approximate Bayesian inference. We have applied this FoE model to the inpainting problem in Figure 1 as well as the classical image denoising problem illustrated in Figure 2.

FoE models extend the representational power of Markov random fields and allow us to learn the rich spatial statistics of natural images. We have also applied these ideas to modeling optical flow statistics, which allows us to compute image motion. These models may be useful for texture synthesis and image super-resolution. We are also exploring better inference methods using new techniques for nonparametric belief propagation. These new tools may be useful in improving images as diverse as X-rays or HDTV signals. **C!**

This work was supported by a gift from Intel Corporation, by NSF ITR grant 011367, and by NIH-NINDS grant R01 NS 50967-01 as part of the NSF/ NIH Collaborative Research in Computational Neuroscience Program.

FIGURE 2 Clockwise from top left: Original image; image with noise added; denoised with pairwise MRF; denoised with FoE.

More information

For more information, see:

Roth, S., Black, M. J., "Fields of Experts: A framework for learning image priors", IEEE Conf. on Computer Vision and Pattern Recognition, vol. II, pp. 860-867, June 2005.

Michael Black Receives NSF Robust Intelligence Grant

Robust intelligence rests on the ability to reason about missing, incomplete, ambiguous and corrupted data. This is particularly true in visual perception, where an intelligent system is faced with reasoning about the complexity of a changing three-dimensional world given only two-dimensional images. Bayesian inference has become popular for dealing with such problems because it provides a sound way of combining ambiguous sensor measurements with prior knowledge about the world. Priors represent the collected experience of a perceptual system, and by integrating heterogeneous sources of information in a statistically sound way enable such a system to respond robustly to novel situations. Markov random fields (MRFs) provide a powerful and popular formalism for representing visual priors. However, they have typically modeled only local, pairwise pixel interactions, which limit their modeling capabilities. This project aims at increasing the power and applicability of these models using larger pixel neighborhoods (cliques). The proposed Fields-of-Experts (FoE) model generalizes many previous MRF models, and all its parameters can be learned from real-world training data. Preliminary experiments have shown that, for example, image reconstruction applications benefit from such visual priors, but many other application domains have remained unexplored. The development of these statistical modeling tools will also have an impact on other domains outside machine vision where the need for modeling complex, high dimensional data arises.

Brown Licenses Internet ID Verification Technology to Startup Firm

Brown News Service

Brown University announced it has licensed a portfolio of Internet security technology to a group of entrepreneurs that have established IAM Technology Inc. As part of the agreement, IAM Technology is receiving a license to technology developed in Brown's Center for Geometric Computing by Roberto Tamassia, professor of computer science and director of the center, and Michael Goodrich, a center associate who is also a computer science professor at the University of California–Irvine. Brown will retain an equity stake in IAM Technology Inc.

The Brown technology, known as the Secure Transaction Management System (STMS), facilitates rapid, lightweight validation of identity assertions on the Internet and provides the basis for IAM's products. STMS, a distributed and secure infrastructure, is the result of years of basic research supported by a DARPA grant and funding from the National Science Foundation.

IAM Technology addresses a $50 billion problem of domain integrity on the Internet, providing validation of user identity that is inexpensive and rapid. IAM Technology plans to offer a security appliance based on the Brown technology in early 2006, which could become commonplace in most enterprise networks. The startup company will support continued research at the Center for Geometric Computing by Tamassia and Goodrich and their research associates Danfeng Yao and David Ellis, both Brown students.

"The evolution of this company and its product has been most exciting for Brown," said Charles Kingdon, associate vice president for technology partnerships at Brown. "What started as a review of technology for a targeted solution has evolved into a universal appliance for domain integrity. The demand for domain integrity and identity validation is urgent and has grown exponentially in recent years."

IAM Technology is directed by a group of veteran Internet entrepreneurs including George McQuilken, former CEO of RSA Security and Security Dynamics; David Croston, former CEO of mPKI; Bill Nyhan, former general partner of Anconcagua Co.; and John H. Nuber, a leading technology innovator.

"This is an ideal partnership, which we believe represents the future of university-based technology commercialization," said Croston. "This partnership began about one year ago with an option agreement that provided research funding to Brown for proof-of-principle and undertook collaborative analysis of the market. By supporting that ongoing research, our partnership led Brown and IAM Technology to the licensing agreement we are announcing today." **C!**

IAM Technology is based in North Hampton, N.H., with research offices in Providence.

"This is an ideal partnership, which we believe represents the future of university-based technology commercialization..."

Mesa Community College, Brown Receive NSF Advanced Technology Education Grant

Brown News Service

Mesa Community College (MCC) in Mesa, Arizona, one of the nation's largest community colleges, and Brown University have received a three-year, $600,000 Advanced Technology Education (ATE) Grant from the National Science Foundation (NSF) to bring a pioneering digital visual literacy (DVL) program into community college education.

> We expect to understand and communicate visually now in all domains, from personal correspondence to business and the sciences.

Work supported by the NSF ATE grant will focus on creating and testing instructional DVL modules for use in basic computer literacy and concepts courses. Initial modules will be used in courses at MCC, other Maricopa County community colleges, and selected venues educating American Indian and Hispanic students. The grant's evaluation component will provide data on effective adaptation and adoption of content that address the essentials of DVL.

The module content is based on research and teaching by Anne Morgan Spalter and Andries van Dam, both in Brown University's Department of Computer Science. Van Dam, a pioneer in computer graphics and co-principal investigator for the project, is Brown's vice president for research and the Thomas J. Watson Jr. University Professor of Technology and Education. "I am thrilled to have a partnership with MCC, an innovative community college that has already proven itself a leader in technology education. Dr. Sheoran has already helped to create several new curricular thrusts at MCC, and we look forward to working with her and her team at MCC and the BII."

Spalter, also a co-principal investigator for the project, is a visual computing researcher, adjunct faculty member and computer artist. "I never imagined it would be commonplace for people to carry a mobile phone capable of taking pictures and recording video," Spalter said. "We expect to understand and communicate visually now in all domains, from personal correspondence to business and the sciences."

The grant will bring together several years of research at Brown on the multidisciplinary roots of DVL. This work culminated in a spring 2005 experimental DVL course in Brown's Department of Computer Science titled "Visual Thinking/Visual Computing," funded by Atlantic Philanthropies. An educational software environment developed at Brown called the Graphics Teaching Tool (GTT) will help instructors bring DVL concepts to life. The GTT and Brown's instructional research have been funded by the National Science Foundation and Sun Microsystems Inc.

Initial courses using DVL modules are scheduled for spring 2006 at MCC. The corporate relationships that have been developed by BII will be used to identify linkages between DVL skills and specific knowledge-worker job functions. The DVL project is expected to affect tens of thousands of students enrolled in courses in community colleges in the short term and hundreds of thousands in the long term. **C!**

Further information:

DVL course: **www.cs.brown.edu/courses/cs024**

"Exploratories" research: **www.cs.brown.edu/exploratories/**

GTT: **graphics.cs.brown.edu/research/gtt/**

MCC's Business and Industry Institute: **bii.mc.maricopa.edu**

SIGGRAPH 2005 Conference

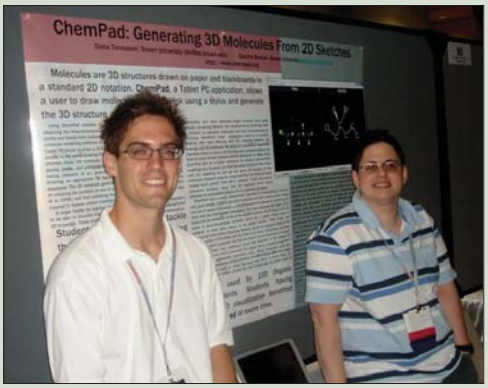
Three cs224 groups submitted their final projects to SIGGRAPH as posters this year. All three were accepted, and one of them, "Plausible Physics in Augmented Images" made it through the two rounds of the ACM Student Research Competition.

In "Plausible Physics in Augmented Images" the authors, Matthew Leotta and Kristin Boyle automatically reconstruct a 3D model from an unordered set of images. They augment the images with virtual objects and run real-time interactive plausible physics simulations with shadows and occlusion.

Using "Enviromosaics", authored by Salil Apte, Matthew Loper and Pat McNally, a user can create an image mosaic from only two images. This approach is also extended to the creation of video mosaics.

"Modular Dynamic Response from Motion Databases", authored by Jason Mallios, Neil Mehta, Chipalo Street, and Chad Jenkins, divides motion capture data into modular databases in a manner suitable for fast search and interactive control of a physically simulated humanoid that is subject to external forces. **C!**

TOP RIGHT CS undergrad Chris Maloney '06 and Sascha Becker '97 display the ChemPad poster.
TOP LEFT SIGGRAPH 2005 at the Los Angeles Convention Center.
BOTTOM Brown alum Kwesi Davis '98, Andy van Dam and Thema Bryant-Davis at the SIGGRAPH alumni dinner.



Posters, Papers and Sketches Presented at SIGGRAPH 2005:

Posters

Hierarchical G1 Smooth Surface Interpolation with Local Control Gabriel Taubin and William Klug (University of California, Los Angeles)

Image-Based Rug Patterns Daniel Crispell and Gabriel Taubin

Calibrating a Catadioptric Light-Field Array Gabriel Taubin and Daniel Crispell

FloatOmeter: User-Friendly Input of Floating-Point Numbers in Virtual Environments Matthias Kreiser, Jürgen P. Schulze and Andrew S. Forsberg

ChemPad: Generating 3D Molecules from 2D Sketches Dana Tenneson and Sascha Becker

The Graphics Teaching Tool for Non-Technical Students Dana Tenneson and Anne Spalter

A Haptic Interface for Creating Smooth 3D Curves With Varying Line Weight Daniel Keefe and David Laidlaw ACM Student Research Competition 2nd place award.

Modular Dynamic Response From Motion Databases Jason Mallios, Neil Mehta, Chipalo Street and Odest Chadwicke Jenkins

Papers

As-Rigid-As-Possible Shape Manipulation Takeo Igarashi (University of Tokyo), Tomer Moscovich and John F. Hughes

Defocus Video Matting Morgan McGuire, Wojciech Matusik and Hanspeter Pfister (Mitsubishi Electric Research Laboratories (MERL)), John F. Hughes and Frédo Durand (Massachusetts Institute of Technology Computer Science and Artificial Intelligence Laboratory)

Sketches

Vectorfield Isosurface-Based Reconstruction from Oriented Points Peter G. Sibley and Gabriel Taubin

Cave Writing: Toward a Platform for Literary Immersive VR Sascha Becker, Shawn Greenlee, Dmitri Lemmerman, Morgan McGuire, Nicholas Musurca and Noah Wardrip-Fruin

Defocus Difference Matting Morgan McGuire and Wojciech Matusik of Mitsubishi Electric Research Laboratories (MERL)

Inferring 3D Free-Form Shapes from Contour Drawings Olga Karpenko and John Hughes

Brown's pioneering efforts include Applied Math Professor Philip Davis' early visualization of number theory, Math Professor Tom Banchoff's work in 4D visualization[2], CS Professor Bob Sedgewick (formerly a Brown CS professor) and former Ph.D. student Marc Brown with BALSA[3], and former PhD student John Stasko's algorithm animations, with TANGO[16], CS Professor Steve Reiss's work in visual programming environments and program visualization[15], and CS Professor Roberto Tamassia's graph-drawing algorithms[18].

Throughout that period, my students and I have been developing educational software through our research in graphics and hypertext. Some graphics-related projects included a microprocessor simulator, MIDAS, and a 3D synthetic camera simulator, BUMPS, which in its fifth incarnation is now being used in CS123 (Introduction to Computer Graphics). Hypertext projects, which are not further mentioned in this article, included HES[5], FRESS[6], and Intermedia[19], the latter developed in IRIS (the Institute for Research in Information and Scholarship), a spinoff of the Graphics Group, and they all were created with educational applications in mind.

For the purpose of this article—to explore issues that must be addressed in next-generation educational software—I will narrow my focus to our more recent work in microworlds, gesture-recognition applications, and next-generation educational games. In addition, I need to stress that many genres have been and will be used for teaching complex concepts, including genres yet to be invented, and I make no claim that the ones I've chosen to describe here are the only ones or even the best ones. In each case the choice of genre arose out of the needs and resources available at the time.

Microworlds

Inspired in part by Alan Kay's powerful Dynabook vision[12] of the ultimate personal laptop computer, which would run simulations and even allow children to write their own simulations, and building on work in algorithm animation mentioned above, for the last decade we have been developing simple, single-concept simulation and exploration environments, often called microworlds. These highly interactive, simulation-based Java applets for teaching computer graphics, which we call Exploratories (see Figure 1, cover page), are built from reusable software components and can be embedded in a Web-based hypermedia environment or used as downloadable components in a wide variety of settings. Users can experiment with different variables through interface-exposed parameters. To date we have developed over fifty Exploratories for the introductory computer graphics course (http://www.cs.brown.edu/exploratories/).

Gesture Recognition Tablet PC Applications

Alan Kay's late '60s Dynabook vision of the ultimate personal laptop computer was a small hand-held device no bigger than a clipboard[12]. Note that the world had to wait until the 1980s to get laptops and until the early 21st century to get Tablet PCs with pens!

Just as with the simulation-based microworlds, the Brown computer graphics group has been experimenting with gesture-recognition user interfaces and applications for many years[20] and is currently developing gestural interfaces for the pen-based Tablet PC, which has given us a platform that lets us address issues of complexity in new domains and new ways.

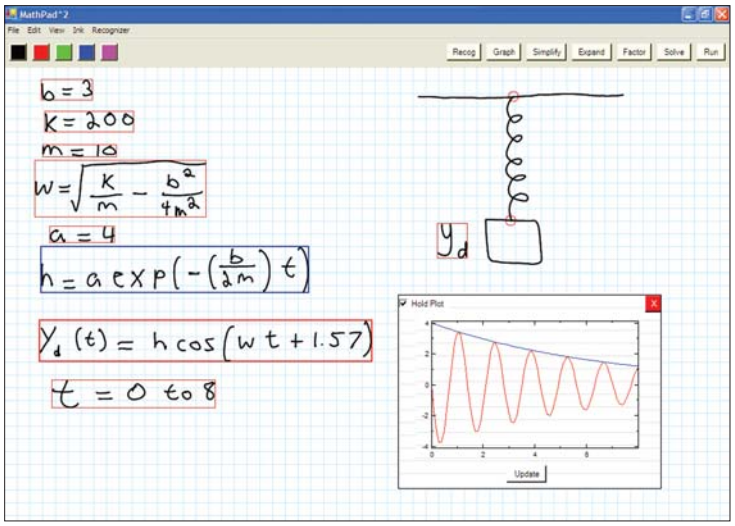


FIGURE 2 MathPad^2 sketching interface of a mass spring system

Our gestural interfaces extend the Dynabook gestural drawing and painting interface, by going beyond just storing "digital ink" to do gesture-recognition on that ink, thereby providing a semantic interpretation for each of the user's gestures.

To explore the possibilities of this notion, we chose two applications. The first, mathematical sketching as input to a math engine supports mathematical problem solving with sketching, visualization, and animation of simple 2D diagrams. The second addresses a key problem with learning organic chemistry, one that chemistry professors claim reliably differentiates those who can become chemists and those who can't—learning to translate 2D sketches you draw on paper into 3D models in your head.

MathPad^2

Mathematical sketching is a pen-based, modeless gestural interaction paradigm for mathematics problem-solving that derives from the familiar pencil-and-paper process of drawing diagrams to help formulate mathematical expressions. Users can also leverage their physical intuition by watching their hand-drawn diagrams animate in response to continuous or discrete parameter changes in their written formulas. Implicit associations that are inferred, either automatically or with gestural guidance, from mathematical expressions, diagram labels, and drawing elements drive the diagram animation. The modeless nature of mathematical sketching lets users switch freely between modifying diagrams or expressions and viewing animations. Mathematical sketching can also support computational tools for graphing, manipulating, and solving equations.

The MathPad^2 mathematical sketching application developed by Joseph LaViola as part of his PhD research[13] currently uses MATLAB as its underlying math engine and provides a fully gestural interface for editing. Expressions can be deleted, edited, and re-recognized in a fully modeless operation (see Figure 2, page 10).

ChemPad

Organic chemistry is the study of the structure and function of carbon-based molecules which have complex three-dimensional structures that determine their functions. Ideally, students would do all their thinking and drawing in three dimensions (3D), but whiteboards and paper notebooks support only 2D structures and projections of 3D and higher-dimensional structures. To compensate, organic chemists use a complicated

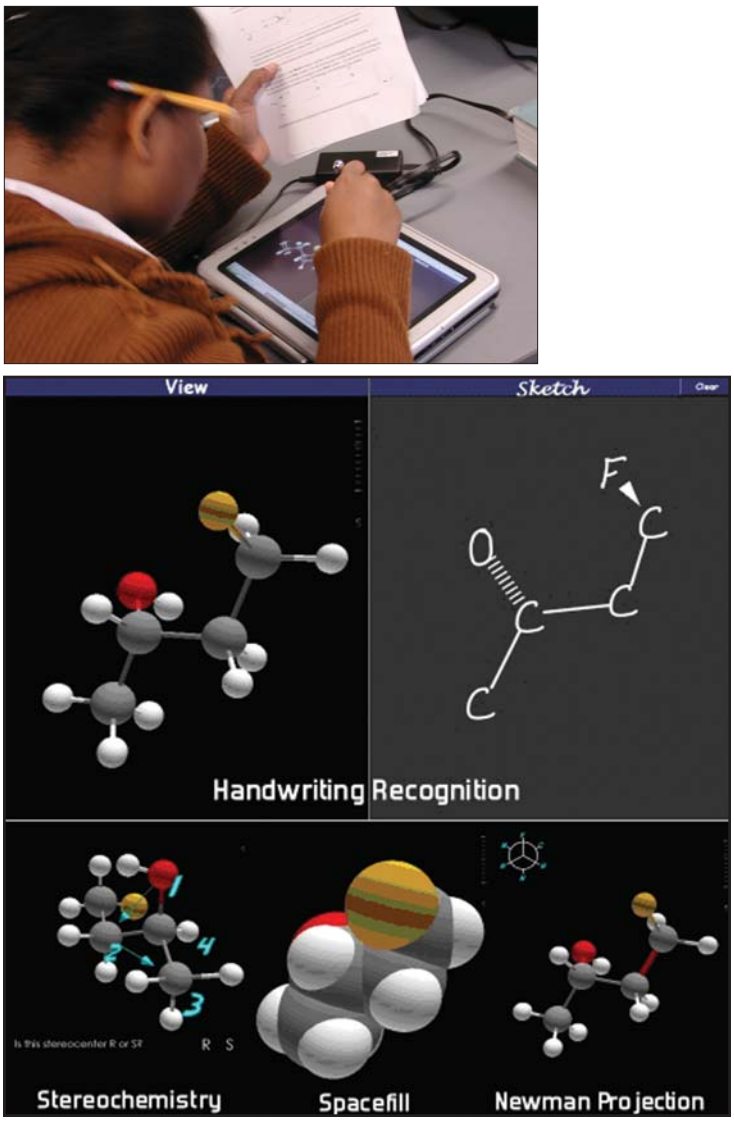


FIGURE 3 Top: a student works with ChemPad. Bottom: ChemPad sketching interface for drawing organic molecules. The hand-drawn sketch at top right yields the interpreted 3D model at the top left, which can be rotated automatically or manually with a virtual trackball using the pen. The bottom half shows alternative 3D views of the hand-drawn sketch.

2D schematic notation to show the spatial arrangement of atoms in a molecule. With practice and insight, beginning chemists can develop the ability to look at such a 2D schematic description of a molecule and automatically construct a mental model of its 3D structure. Teachers of organic chemistry identify this spatial understanding as a key determinant of whether students will succeed in organic chemistry.

Dana Tenneson has been developing as his PhD research project the ChemPad system, whose purpose is to help organic chemistry students develop an understanding of the 3D structure of molecules as well as the skill needed to construct a 3D mental model of a molecule that matches a 2D diagram (see Figure 3). ChemPad fosters this understanding by letting

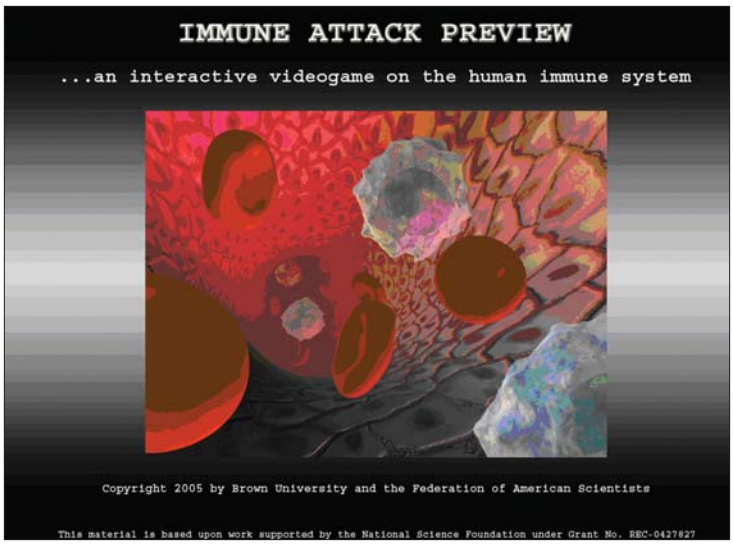


FIGURE 4 Immune Attack game splash screen

the student sketch a 2D diagram and then see and manipulate the 3D model it describes.

A pen-based interface is particularly appropriate for organic chemistry molecules because existing software tools in this area are difficult to learn and use. Drawing with pen and paper, though, is less than satisfactory: it is difficult to produce neat drawings, and it is difficult to erase and correct errors neatly. ChemPad addresses both these issues, with a simple interface that mimics drawing on paper and a "beautify" function that tidies up a student's drawing. In addition, since many of the structures that beginning students draw do not describe physically possible molecules, ChemPad can detect and indicate certain kinds of errors. Once completed, both 2D drawings and 3D models can be exported in formats readable by applications such as ChemDraw. Simulation capabilities are currently being added to the system so that the static ball-and-link 3D diagrams can start to approximate the actual dynamics of molecular interaction.

The ChemPad Rev 1.0 version was successfully field-tested by 100 Chem 35 (organic chemistry) students for four weeks during the spring 2005 semester. Student responses in anonymous surveys were very positive, and post-ChemPad exam results were significantly better than those of peers who did not use ChemPad.

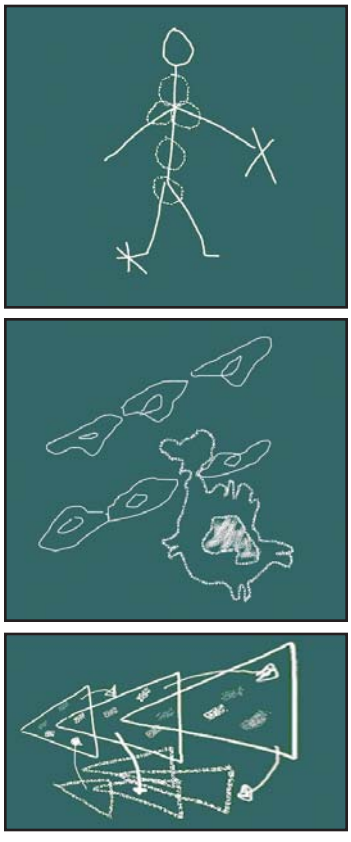


FIGURE 5 Blackboard sketches showing (1) the whole body as a stick figure with x marking locations where (2) local and related events are happening, here a monocyte squeezing through the blood vessel on its way to the site of an infection, and (3) immune system cascades representing the processes at locations in (1) and (2).

Games—Immune Attack

The study of human biological systems as they really are is, in some sense, the ultimate example of complexity and the difficulties of teaching, understanding, and doing research. To deal adequately with the multiple processes and multiple levels of detail with simulations that are accurate to the desired degree requires a level of sophistication that has yet to be achieved.

Microworlds such as Exploratories don't suffice for this task because they are isolated, single-concept modules that, at best, can be embedded into hypertextual structures to provide a larger frame of reference. Despite best efforts over the years to turn them into reusable components, they also are difficult to interoperate. Even more general applications such as MathPad2 and ChemPad don't suffice because they don't approach the issues of multiple processes happening simultaneously in different parts of the system and are not designed to handle multiple simultaneous levels of detail and points of view.

An approach to educational software design that has been gaining attention recently is what CS Professor Mike Zyda of USC calls "serious games"[22]. The respect accorded to this approach can be seen in the increasing number of programs, including new BS and MS game development majors at USC (http://gamepipe.isi.edu/MS-Game-Development/MS-Program.html), headed by Zyda, and video game-related degree programs at RPI (BS http://www.rpi.edu/dept/metasite/news/magazine/summer2005/feature1-pg4.html), CMU (Masters in Entertainment Technology, co-chaired by former Brown undergraduate, CS Professor Randy Pausch– http://www.etc.cmu.edu/), and Georgia Tech (BS in Computational Media).

In collaboration with the Federation of American Scientists (FAS) and Zyda's group at USC, and with NSF support, we at Brown are doing an educational game research project called Immune Attack (http://www.fas.org/main/content.jsp?form

Action=297&contentId=79). This game is designed to help high-school AP biology students learn the basics of immunology, a complex subject difficult to teach at any level. The highly multidisciplinary team includes immunologists, game designers, medical illustrators, and computer graphics researchers. Figure 4 shows a splash screen for the game as currently being developed.

Immune Attack combines cutting-edge interactive game technology with real-time simulations of immune system activities and 3D biological structures whose geometries change dynamically. The game presents an immersive world inside the body in which players race against time to fight foreign invaders ranging from minor infectious organisms in a finger to potentially lethal viral attacks. To provide a realistic environment, the game eventually will incorporate perspectives from such diverse domains as fluid mechanics, biochemistry, electrochemistry, pathology, and molecular dynamics.

Immune Attack will challenge students with progressively more difficult play in which success depends on an increasingly sophisticated grasp of immunological concepts. Advanced instructional technologies such as context-sensitive help, AI-generated characters that respond intelligently in real time to help the student learn problem approaches and objectives, and context-sensitive tutoring combined with content-rich debriefing sessions will move the student forward seamlessly.

The key visualization challenge presented by immunology teaching is complexity, specifically of immune reaction cascades, combined with the requirement for holding the global picture of the body in mind while at the same time focusing on a local process. The immune reaction cascades (see sidebar Game Technical Base: Identification of Friend or Foe—at the Nanoscale) involve dynamic processes whose "rules" change as a result of their own effects and those of other processes. The visualization issues concern not only the immunological processes but also the concepts describing them and the larger conceptual framework of the place of the immune system within the overall biofeedback system of the body. In addition, there is a notion of immunological memory that is as crucial to the body's functioning as is neurological memory.

These processes and concepts are extremely difficult for students to grasp at all, much less gain any real intuition about. Classroom instructors draw sketches, such as those in Figure 5 (page 12), to illustrate the dynamics of the local processes in the global context of the whole body, but the sketches aren't very helpful because they are linear, static, and 2D. The processes involve cells in different states with secondary and tertiary reactions that depend not only on the molecular environment, but also on which cells created the environment-altering factors. Figure 6 shows Immune Attack screen grabs of the events sketched in Figure 5(2).

Crucial matchmaking takes place in the lymph nodes between invading agents and the immune system components capable of dealing with them. When an alarm is spread from a site of infection, specialized messenger cells carry pieces of the invader to these nodes and try to find a specialized immune cell that matches or almost matches the invader's pattern. These specialists then swing into action. The problem is that there are 10^5 to 10^6 different kinds of specialists, few of which will match if the body has never encountered this type of pathogen before. The lymph nodes have a series of elaborate chambers stuffed with tens of thousands of specialist cells, and the messenger cell may need to grope through all of them to find a match to stimulate and expand and, on failing, move on.

FIGURE 6 A monocyte (in blue) about to squeeze through the blood vessel wall on its way to the site of an infection where it becomes a macrophage, as seen in Immune Attack.

Other issues include:

- The **size** differences of vast scale, such as those in the familiar film "Powers of Ten", with seamless shifts, in real time, from submicroscopic simple ions and amino acids measured in fractions of nanometers (2.54 x 107 nanometers/inch) to microscopic immune cells, measured in microns (2.54 x 103 microns/inch), to macroscopic organs such as the heart.
- The **reaction rates** of different active components of the immune system can vary over a broad range, ranging from nanoseconds to days.
- The **geometry** of the various components dynamically changes in real time in response to physically based demands and includes cell surfaces that have strange shape-shifting capabilities to engulf a molecule and bring it inside the cell.
- The same subject matter has multiple **domain**-specific visualizations.
- **Interaction** in real time over the whole spectrum of geometry, size, domain, and time scale.

Limitations of our approaches so far

Each of the genres presented so far met some of our goals and in so doing presented other challenges. Below I detail the specific advantages and limitations of each, and then present a concept that I call "clip models"—multilevel interoperable families of simulation-based modules–that aims to address some of the limitations of the work done so far.

Microworlds: Although microworlds have been useful adjuncts to the undergraduate computer graphics course, they fall short of the goals of a far more ambitious vision. Microworlds and Exploratories are restricted to single concepts with a small set of parameters. However, because they are component- and parameter-based, they illustrate some of the fundamental principles essential to fully functioning clip-model environments, and they open possibilities for evolving even more flexible structures. The combination of fluid and multi-POV (point of view) hypermedia information structures with component-based software architectures may provide a foundation to build upon.

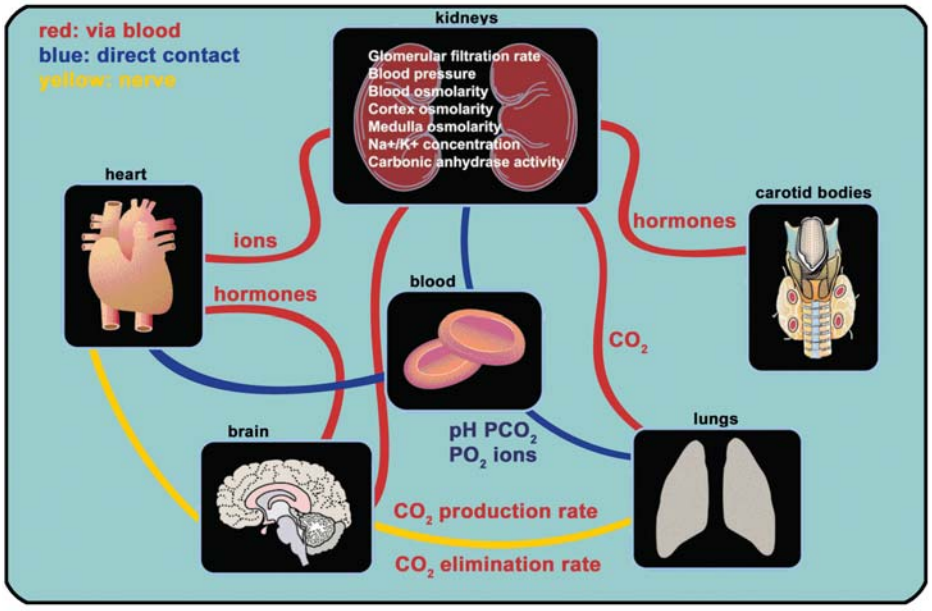


FIGURE 7 Elements in the system for control of oxygenation in the human body.

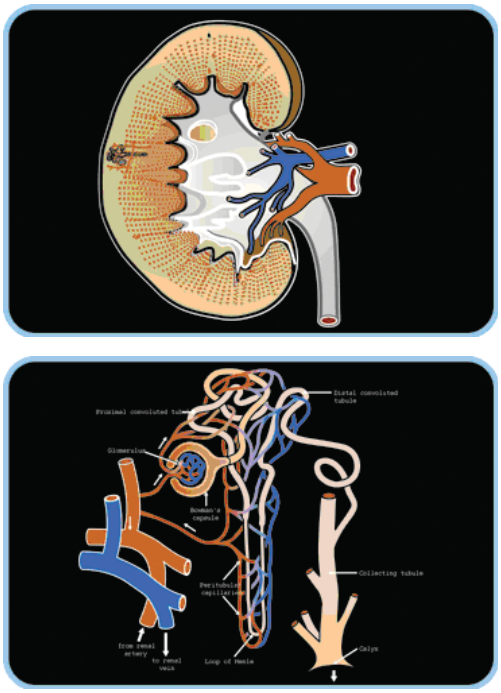


FIGURE 8 (a) A more detailed view of the kidney, a cross section with some of the internal structures; (b) A more detailed view of a nephron, the microscopic functional unit of the kidney.

Tablet-PC-based gestural interfaces: These post-WIMP interfaces are underdeveloped because the state-of-the-art in robust user-independent gesture recognition is still primitive. Furthermore, gesture sets are anything but self-disclosing, and they take considerable time to learn. Finally, our experiments thus far are essentially single-user in their orientation and don't facilitate a collaborative, team-based approach to learning.

Games: A first version of Immune Attack is expected for limited classroom testing by March 2006. Despite the considerable technical and instructional design challenges of this research project, it will still be a rather limited example of what is truly needed for genuinely flexible next-generation educational software. In particular, it will be a hard-wired precursor, not an actual example of the clip-model notion discussed below. Furthermore, the initial classroom testing will only implement and test the least complex two levels (in terms of both the underlying immunology and of game play) of the seven-level design. Thus, some of the most difficult problems such as multi-scale simulation of the immune system cascade will not yet have been engaged.

Clip Models—a strategy for managing complexity

Each of the genres—applets, applications, and games—that we've experimented with has a niche and a unique strength. None of them, however, deal with the complexity issues presented by systems of even moderate complexity, let alone the daunting problems involved in understanding the human system. The issues that must be addressed include, among others, ontology, simulation and visualization of subsystems at multiple levels of detail, interoperability of subsystems, and pedagogy.

Over forty years ago, Jerome Bruner proposed the radically new theory of education that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development."[4] While many have disputed the more extreme claims attached to that hypothesis, it is an admirable goal, though difficult to achieve. One way to implement it is through the "spiral approach to learning" common to formal education, in which a learner encounters a topic multiple times throughout her education, each time at an increasing level of sophistication. Furthermore, at any stage in her learning, she should be able to mix and match educational modules at different levels of sophistication within the same general topic area. Simpler modules can serve as over-

The Learning Federation

Henry Kelly, President of the American Federation of Scientists, Randy Hinrichs, formerly University Research Program manager, Microsoft Research and now Technical Computing Initiative GPM in Advanced Strategies & Policy, and I have set up The Learning Federation (http://www.thelearningfederation.org/), a nonprofit organization to explore issues in creating next-generation educational software and to direct a focused, sustained research investment effort to create such software. As a partnership joining companies, colleges and universities, government agencies, and private foundations, its purpose is to create an organization capable of providing a critical mass of funding for long-term basic and applied precompetitive research in learning science and technology. This research, to be conducted by interdisciplinary teams, is meant to lead the development not only of next-generation authoring tools but also of sample curricula for both synchronous and asynchronous learning.

The Federation's first task, sponsored by NSF, Microsoft Research, and HP, was to produce a Learning Science and Technology R&D Roadmap, loosely based on the highly successful Sematech Consortium (http://www.sematech.org/). The Federation roadmap describes a platform-neutral research plan to stimulate the development and dissemination of next-generation learning tools, with initial stress on postsecondary science, technology, engineering, and mathematics. The component roadmaps address five critical focus areas for learning science and technology R&D:

- Instructional design: using games and simulations in learning
- Intelligent question-generation and answering systems
- Learner modeling and assessment
- Building simulation and exploration environments
- Integration tools for building and maintaining advanced learning systems

The Learning Federation is currently in the early stages of fund raising for its ambitious research program, and is featured in the DOIT (Digital Opportunity Investment Trust) initiative being proposed to Congress in the current session[8].

Game Technical Base: Identification of Friend or Foe—at the Nanoscale

Henry Kelly

The following technical description of one component of an immunological cascade illustrates the importance of visualizing events that are happening on many physical scales, e.g., 30-micron macrophage and nanoscale receptor proteins, with bizarre shape changes unlike any engineered system, and the need to visualize a variety of chemical gradients and select the only one to follow.

Macrophages are the first responders of the immune system. Unlike the more sophisticated killers in this adaptive system, they are preprogrammed to track and attack infectious bacteria. The trick is to kill only invaders and not your own cells, using only chemical signals. This is no easy task, given the bewildering diversity of chemical signals swirling around in living tissue.

The surface of a macrophage makes a Navy missile destroyer look unprepared. On a 30-micron macrophage's surface (for comparison, a red blood cell is ~3 microns, where 25,400 microns = 1 inch), many different types of sensors (receptors) protrude through an undulating membrane. The sensors are small (typically 20-200 kDa molecular weight) and the presence on the surface of as many as 30 thousand of each sensor type gives the cell "total information situational awareness."

The attack may begin when the presence of a foreign body initiates a massive change in the behavior of one of the half billion or so monocytes (an immature macrophage) in a typical liter of blood by signaling the monocyte's nucleus. The nucleus activates the monocyte to change shape radically so that it can squeeze into small spaces between the cells of the artery wall—imagine a cat turning into jelly, squeezing through a hole the size of a dime and reappearing as a cat on the other side.

On the other side of the artery wall, the monocyte becomes an active macrophage, alert to search and destroy. First it must find its way to the site of the bad guys, using only its acute sense of smell (which in this case means receptors specialized for specific chemicals emitted only by bacteria and not your own cells). Following the smell means using yet a third set of receptors scattered in large numbers over the macrophage's surface, figuring out where the signal concentration is highest, and moving in the direction of increasing concentration.

views of a subject for review or to provide context when the intent is to go more deeply into related topics. Below I describe some of the technical and design issues involved in implementing such a spiral approach to education.

The kinds of modules I am most interested in here are **simulation- or rule-based modules** that create explorable models of subsystems and can be composed into increasingly higher-level subsystems. Such modules can help simulate most aspects and components of the natural and man-made worlds. For instance, when simulating subsystems of the human body at all levels, i.e., creating a complete "digital human"[7] from the molecular to the gross anatomical level, each subsystem must be treated and visualized at a level appropriate to its educational purpose. Thus, there is not just a single model/simulation for each component of the system, say the heart or kidneys, but a family of models/simulations for each component that vary in explanatory power and simulation fidelity.

I have coined the admittedly imperfect term "**clip model**" to help define this genre of modules. Clip models are analogous to clip art in that they are ready-made and are meant to be embedded in a presentation or other framework. Unlike clip art, however, clip models incorporate both geometry and simulation- or rule-based behavior. They are usable as standalone learning objects and, more importantly, unlike clip art, are designed ab initio to be combined into more complex models. Each clip model (or combination of clip models) is an interactive microworld meant for constructivist exploration and experimentation in the Kay[12] and Papert[14] sense.

The varied needs of audiences at many different levels of sophistication preclude a one-to-one mapping between a given concept (such as circulation of blood through the cardiovascular system) and a single clip model. For example, Figures 7 and 8 (page 14) show different **levels of detail (LOD)** of the kidney and its functions within the circulatory system. Thus, instructional designers must think in terms of creating not a single clip model for a given topic in a field, but of creating one or more elements of a family of interrelated clip models that cover a broad range of explanations and their representations. These models must correctly reflect the ontology and semantics of the subject matter at each point along the multiple axes of age, knowledge level, task, and individual learning style (in Howard Gardner's sense of multiple intelligences).

To add to the challenge, individual clip models must interact with other clip models at different levels of abstrac-

tion, still reflecting the complex interactions between the subsystems of the systems being modeled. Simulation science has not yet produced a sufficiently flexible framework for wiring together components of a simulation from various providers that were not designed to interoperate from the start. How to connect simulations from different problem domains, with different vocabularies and different conceptual models, for the same subsystem is still a difficult research problem. For example, simulating the heart's operation biochemically, electrochemically, and with computational fluid dynamics, while dealing with flexible (non-rigid) and time-varying geometry and both normal and abnormal behavior, is still a daunting problem. And then the problem of connecting the various heart models to the various lung, kidney and other connected models to have them interoperate is as yet untackled.

Even with a standard vocabulary, adaptive **multi-resolution (multi-scale) simulations** will be even harder to interoperate; e.g., how can they determine at what level of detail to share information? If we are running interactive simulations should we allow algorithms to run with graceful degradation in order to meet time requirements? What is the nature of such approximations? How can the valid operating ranges of particular simulations be determined? How can the simulations report when they venture beyond those ranges? If these simulations are to be used in real science, as I hope, they must have a mechanism for comparing them to experimental results and validating their calculations. How will a kidney model created by nephrologists at Johns Hopkins share data with a heart model from Stanford, or a lungs model from Caltech? How can a seventh-grade teacher in Nebraska use a fourth-grade teacher's set of human anatomy clip models as the basis for a more detailed model of the circulatory system? How can a researcher compare predictions made by a Stanford heart model and a Harvard heart model?

Other questions that a clip model framework must address include: how can simulations ensure that they get the data they need, in the format they need, regardless of the level of fidelity at which connected clip models are running their simulation? For example, how will a heart model cope with changing stiffness in the valves, if the valve model is not designed to adjust to stenosis? What protocols will keep all the simulation components synchronized in time, even if one runs in real time and another takes a day to compute a single timestep? Who will maintain the repository of code? Who will control the standards? How can interoperability be preserved when some components are proprietary? One group that has been addressing these kinds of problems, the Common Component Architecture Forum (http://www.cca-forum.org/), has defined a common-component software architecture standard. This standard includes component interface definitions, a component repository API, and a framework services interface specification, and guidelines for determining if a framework is CCA compliant. The goal is to facilitate interoperability on the component level.

Even more formidable challenges, however, arise with **multiscale interactive visualization**, where the state of the art considerably lags behind that of multiscale simulation. Further, consider the **ontological issues** involved: when you have one, or at most a small team of authors writing a single book targeted at a single audience, the domain specification as seen in the definition and relationships of concepts and terms is an important but manageable task. When you expand the context as described above, the situation becomes orders of magnitude more intractable, closely related to the massive undertaking by Lenat et al that the controversial CYC project embarked on twenty years ago. The Knowledge Web community is now starting to tackle the problem of identifying and encoding domain-specific ontologies for the Web; Holsapple and Joshi[10] describe a collaborative approach to designing an ontology that begins with independent ontological proposals from several authors and incorporates input from many contributors. Some sort of collaborative approach to ontological engineering will have to be used in order to build an ontology acceptable to many members of a given field.

Adding yet more complexity, the **variety of learning environments** in which such clip models will be presented must be accommodated. These innovative and, by their nature, emergent learning environments must be made available both online and onsite, for virtual and real classrooms, in synchronous and asynchronous modes, servicing both single on-demand learners and collaborative learners, either in impromptu virtual study groups or in formats yet to be defined.

Another dimension that must be explored more deeply is **team collaboration**; we know all too little about effective group learning using digital media and how to extend that learning into further learning in school or the workplace. Clearly, these requirements lead to a huge challenge in instructional design and learning technology.

All these pedagogical needs of clip models are a complicat-

ing factor that makes their design immensely harder than that of ordinary components in the standard software engineering sense. A potential approach to thinking about the problem may be to use an extension of the **MVC paradigm** of object-oriented programming to describe the necessary interrelationships between these different concept representations. Each concept or real-world object must be represented by a multitude of models (e.g., the heart as a pump, the heart as a muscle, the heart as an organ in the chest cavity), at widely different degrees of sophistication. Each model supports multiple views (e.g., simplified 3D models, realistic 3D models, 2D schematics, the sound heard through a stethoscope), and for each view multiple controllers that may present a learner-chosen UI style. Multiple models geometrically complicate the single-model paradigm of classic MVC.

Finally, even when we do learn how to deal with the individual challenges and to make them all work together as interoperating seamless wholes, we still face another intrinsically difficult hurdle: by their very nature, these models are **works in progress** and will undergo continual evolution as we learn more about the underlying science, e.g., the biochemistry, as well as about all the processes at all the different levels that must be considered. Thus, their design must take into account the certainty of obsolescence and change.

Conclusion

All the projects described in this paper share a vision of using interactive visualization to aid in understanding complexity, but they differ greatly in their characteristics and limitations. Clip models address the stated limitations of our work so far by using complexity to deal with complexity. While a simplification strategy is both useful, and indeed, necessary to begin to understand intractably complex phenomena and concepts, it falls far short of actually aiding in the understanding of that complexity. In fact, it can be dangerously misleading when it produces an illusion of understanding that is incorrect at best and potentially lethal at worst.

To return to our biology example, I believe that the creation of families of interoperable clip models that describe the human body as a system of interconnected biological components at all levels—from the molecular to the gross anatomical—will provide an unprecedented learning resource. Even though creating such families of clip models in a variety of disciplines will necessitate integrating work from thousands of contributors over decades, even a beginning but very ambitious and comprehensive effort, such as the Digital Human Project, at building biological system components will have a payoff. We should not be daunted by the sheer magnitude of the task but should make steady progress along a clearly articulated path.

Furthermore, clip models are not, by themselves, the answer: there is no magic bullet, no single style of educational content that can encompass the enormously diverse set of requirements for this agenda. Creating high-quality next-generation educational content across all disciplines and at all levels will require a Grand Challenge effort on a scale such as the Manhattan Project, the Man on the Moon (Apollo) Project, and the Human Genome Project. The U.S., European, and several Asian economies certainly have both the ability and the need to invest as much in creating exemplar interactive courses as they now do in video games and special-effects movies. Indeed, the U.S. Department of Defense is making significant modern IT-based investments in its training needs, mostly notably in "America's Army" (http://www.americasarmy.com/). The growing popularity of new BS and MS majors in game technology described earlier is a good sign as well. In addition, the Learning Federation (see sidebar on page 15) has begun working with the government with the DOIT (Digital Opportunity Investment Trust) report (http://www.digitalpromise.org/), which articulates a potential funding mechanism based on communication spectrum sales.

The payoff from the huge investment of time, energy, and money cannot be overstated. Beyond education, the clip-model architecture will help advance science itself. The architecture will enable the "development" aspect of R&D to rapidly integrate advances in basic research. We cannot predict the insights that will be revealed by happy accident when two or three unrelated strands of knowledge are unified in an integrated model, but can eagerly anticipate the leverage that will be gained from the synergy.

However, simply making the claim that clip-model architecture will help advance science is insufficient. Many questions need to be addressed before such an undertaking can proceed. For example, how can we deal with the vagaries of economic, and hence funding, cycles when we are talking about long-term efforts? Doom-sayers are proclaiming the death of e-learning just as 20 years ago AI was declared to be a failed illusion[21]. Can we, indeed, should we fight that perception and if so, how? Closer to home, how can we help instructors to adopt new ways of thinking and working when both

time and funds are limited? Should we even try? How do we harness the social and wired culture of our Net-Gen students?

At the recent Aspen Conference (http://www.educause.edu/forum/) the eminent researcher, technology futurist, and former director of Xerox PARC John Seely Brown suggested using an open source model for the huge effort that will be required to create clip models in a variety of disciplines. However, I believe that such a bottom-up effort can only succeed if it is preceded by a successful research effort to define an interoperability framework for simulation-based clip models and to establish a process for creating, testing, extending, and augmenting them. Note: in this context it is worth remembering that the open source poster child Linux is a Unix clone and is therefore based on years of funded Unix research and development.

There are multiple ways in which this necessary foundation work could happen–one is that Congress recognizes the enormous potential social impact of DOIT and thus supports it at an adequate level. The other is that through a combination of government and corporate funding, the research is done and the open source communities of practice emerge in which both professional researcher and amateurs submit juried entries. The open source experience to date shows us that the recognition of admired peers is a powerful motivating force that operates independently of more institutional motives such as promotion and income.

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Michael Black

This spring Michael Black attended the Cosyne conference in Salt Lake City to present work on the relationship between visual receptive fields in the brain and Markov random field models of images. For some reason, people in SLC kept saying "You're not from around here are you?"

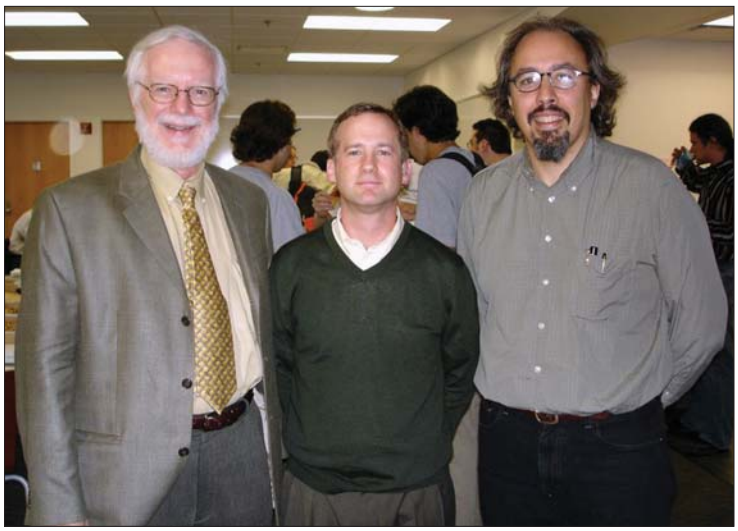
The main US computer vision meeting was held in June on Mission Bay in San Diego where Michael found time for a bit of sailing with Andrew Fitzgibbon of Microsoft Research Cambridge (photo).

He also attended the annual Engineering in Medicine and Biology conference in Shanghai China where two of his Ph.D. students (Frank Wood and Jessica Fisher) presented their papers. Additionally, Michael and his wife traveled to see the traditional gardens of Suzhou and to walk around the famous West Lake in Hangzhou.

Michael gave invited talks on probabilistically modeling the neural code for neural motor prostheses at the STEP Brain-Machine Interface Technology Workshop in Maclean VA and at the oddly named International Symposium on the Art of Statistical Metaware in Tokyo Japan. He also spoke about new work on "Fields of Experts" with Ph.D. student Stefan Roth at the MSRI Workshop on Learning and Inference in Low and Mid Level Vision in Berkeley. Additionally, Michael gave talks at the Salk Institute in La Jolla, the University of Maryland, University College London, and at the Royal Institute of Technology (KTH) and the Nobel Institute for Neurophysiology at Karolinska in Stockholm.

In April Michael appeared on BBC Radio 4, Science Frontiers, talking about Brown's work on "neuroposthetics", and he received a $316,000 grant from the National Science Foundation to support research on "Learning Rich Statistical Models of the Visual World for Robust Perception". Finally Michael made several visits to Intel Research where two of his Ph.D. students, Alexandru Balan and Leonid Sigal, spent the summer.

When in the Bay Area, Michael brings his skateboard and joins local longboarders who gather in the Stanford hills every Tuesday night.



Roger Blumberg

To celebrate both the 15th year of Andy's Educational Software Seminar (CS92) and the relative stabilization of the PC platform in K-12 classrooms, Roger produced a CD with more than a dozen programs designed by his students for local teachers (1998-2005). The CD is intended primarily for students and teachers in Grades K-8, but also includes programs for high school classrooms and even the CardioViz program designed for John Stein's Bio80 course at Brown. The CD will be distributed to the Providence libraries and to the schools with which CS92 has worked over the past 15 years.

Meanwhile, Roger's Computers and Human Values (CS9), part of Brown's First- Year Seminar program, began its fourth year, and the semester featured with a visit by cyborg author and Brown alum Michael Chorost '87. Chorost is the author of *Rebuilt: How Becoming Part Computer Made Me More Human* (Houghton Mifflin, 2005). In addition to talking with CS9 students, Mike also gave a "Cyborg Lunch" talk in the department (photo includes Professor Thomas Banchoff of Mathematics for whom Mike was an undergraduate TA to). Mike and Roger also presented the first talk in Brown's new "Academy in Context" dinner seminar series sponsored by the Graduate School.

Uğur Çetintemel

Uğur had a busy spring and summer. In early April, he traveled to Tokyo for the IEEE data engineering conference, with Yanif Ahmad, Jeong-Hyon Hwang, Olga Papaemmanouil, and Ying Xing. They ate lots of sushi and enjoyed Hanami. (Of course they also presented papers.)

In June, Uğur organized the 2005 ACM Mobile and Wireless Data Engineering Workshop (MobiDE) in Baltimore, which was a good chance to catch up with old friends from the University of Maryland. MobiDE was collocated with SIGMOD, one of the premier data management conferences, where the Brown Borealis group's fancy demo received the Best Demo award. Uğur is currently organizing the IEEE NetDB workshop, which aims to bring together networking and database researchers to foster research that draws heavily from both areas. The NetDB organization will largely be a Brown CS effort as John Jannotti is co-organizing, and they are using Shriram Krishnamurthi's Continue conference management tool to handle the submission and review process.

As usual, Uğur has done his share of serving on the program committees of various conferences, including VLDB '05, CollaborateCom '05, DEBS '05, and DMSN '05. He also became an associate editor of the ACM SIGMOD Record.

Amy Greenwald

Carmen Greenwald Boyan was born on 6/2/2005 (her big sister Ella's 2nd birthday!), weighing in at 6 lbs 2 oz. She spent her summer doing what all babies do: sleep, nurse, poop, and travel the world to computer science conferences. Her first trip was to Pittsburgh to see Mom give an invited talk at AAAI. The next week she ventured to New York to hear another of Mom's talks, this one at the Stony Brook Workshop on Game Theory and Computer Science. From there, she traveled directly to Edinburgh, Scotland, where she spent two delightful, albeit rainy, weeks with her whole family. In Edinburgh, Carmen followed Ella on a tour of the city's playgrounds, but in between swing sets she listened to talks given by her Mom's students: a plenary talk by John Wicks at UAI (Uncertainty in Artificial Intelligence) and a talk by Victor Naroditskiy at the largest IJCAI workshop, TADA (Trading Agent Design and Analysis). Four conferences in her first two months of life—a new record!

Maurice Herlihy

Maurice Herlihy completed a year-long sabbatical at the Microsoft Research Lab in Cambridge, England (photo). While there, he worked on software transactional memory support in C#, virtualizing hardware transactional memory, and techniques for reasoning about highly-concurrent data structures. He was able to tear himself away from the UK long enough to give the keynote address in PLDI '05 in Chicago.

John Hughes

Spike attended SIGGRAPH and was the co-author on two papers: one with Morgan McGuire and people at MERL and MIT, the other with Tomer Moscovitch and Takeo Igarashi, who is a former Postdoc, now at the University of Tokyo.

Philip Klein

Klein has been working in the area of optimization algorithms for planar graphs (e.g. road maps). His most recent result in this area is a linear-time approximation scheme for the traveling salesman problem in planar graphs (an NP-hard problem). That is, for any $\varepsilon > 0$, there is a linear-time algorithm that, for any planar graph with positive edge-lengths, finds a traveling-salesman tour of length at most $1+\varepsilon$ times the shortest tour. He is working to extend the techniques to handle vehicle-routing problems such as those arising in package delivery. You can find updates at http://www.rhodemap.org.

Shriram Krishnamurthi

This summer, my group of seven students did very interesting work, the most unusual of which was building a speech interface for DrScheme. To my delight (and maybe a little chagrin), they worked equally well while I was away in Europe for a month. The last week of that month was a vacation: we went to Grenoble to watch the Tour de France (and do some biking ourselves). I was reminded that Spike is a very dangerous man who should never be trusted under any circumstances when his recommended "modest warmup" ride proved to be rated a Cat. 1 climb, the second hardest kind, by the Tour.

The trip highlight was undoubtedly biking up to L'Alpe d'Huez (photo). The Alpe is one of the legendary climbs in all of cycling: 13.8km at over 7%, with 21 hairpin bends that are part of Tour lore. The day was gorgeously sunny, the view over the valley and of the surrounding peaks was spectacular, and there were dozens of cyclists around. There is a Grand Tour cycling tradition of painting the names of riders on the steepest routes, and the road still bore some of these names—some famous, some infamous, and some unknown. Fans paint messages, too. At one point with my lungs pounding,

stomach cramping and legs struggling to maintain a cadence, I looked down and saw just one word written on the road: "zen".

John Savage

John was fortunate to spend the last academic year on leave. He worked exclusively on research and professional activities after spending many years in service to the Brown faculty and the Department. He spent three months in the fall with his wife in Paris where he held an appointment at École Polytechnique. They also spent the month of April in Paris so that he could do research with a French physicist. Last fall, he gave invited talks at the

2004 Asilomar Conference on Signals, Systems and Computers, and in the spring, he spoke at a DARPA workshop on Law of Large Numbers Systems Design. He also presented a paper at the May, 2005 International Symposium on VLSI. Other travel in the spring involved two NSF proposal review panels and the NSF visiting committee for the Network for Computational Nanotechnology at Purdue University in mid-June. In addition, he traveled to Vietnam in early June on behalf of the Vietnam Education Foundation, a trip which is described elsewhere in this issue. It was a wonderful year that was very well spent.

Meinolf Sellmann

The Industrial Partners Program (IPP) and I organized the spring symposium on "The Future of Combinatorial Optimization" which was an exciting event that brought esteemed researchers and practitioners together at Brown.

Recent trips brought me to Prague, where the CPAIOR took place this year, a conference on the integration of methods from artificial intelligence and operations research, and to IJCAI 2005 in Edinburgh.

The spring semester was quite busy due to the invitation to serve on the program committees of CPAIOR, CP, and AAAI. A very important task was to prepare the proposal for the NSF Career grant. But now, after two weeks of hiking through the Italian Alps (photo), I feel refreshed and am looking forward to starting the fall semester.

Eli Upfal

In June Eli organized a workshop on Randomized Algorithms and Probabilistic Analysis in Bertinoro, Italy, which is Eli's favorite conference location. The meeting took place in a veritable XIIIth century castle in the center of a small, peaceful town on the hills not far from Bologna. While the technical talks were very good, the food, and in particular the evening grappa, were even better.

Eli went again to Europe in August to give an invited talk at the 12th International Conference on Random Structure & Algorithms in Poznan, Poland. The highlight of the conference, and why Eli finally made it to Poznan, was the 60th birthday celebration of Alan Frieze, Eli's longtime colleague and co-author on many papers.

Finally, Eli heard recently from his publisher that his book will be published in Chinese. The letter specified that it will be translated into the Chinese language using simplified characters. A Chinese student in the department explained to us that simplified characters are the written language used in mainland China, but not Taiwan. Simplified or not, Eli is not responsible for typos in that edition...

Andy van Dam

During the May 2005 Commencement Weekend, Andy and Debbie hosted a reunion of almost fifty former undergraduate research assistants who worked on Brown's first two hypertext systems in the late sixties and early seventies: HES - the Hypertext Editing System, and FRESS - The File Retrieval and Editing System, so punningly named with this Yiddish expression because it was a memory hog, consuming a whole 128KB (yes,

128KB, not MB) partition of a 512KB IBM System /360 mainframe to run a time-sharing version. Others worked on BUGS, the Brown University Graphics System, whose key component, SIMALE, was lovingly restored by its creator, Hal Webber, in time for its display in our computer museum that was inaugurated during the department's reunion in our renovated space on the third floor of the CIT.

Andy also published several articles and a new textbook (see description on page 24).

Andy and the graphics staff attended SIGGRAPH this August and he attended an Adobe sponsored "21st Century Literacy Summit" in San Jose this past April.

Finally, in hoping to improve Rhode Island's capacity for innovation, Governor Donald Carcieri appointed Andy as co-chair of the state's Science and Technology Advisory Council. The council will advise the Governor and General Assembly on science and technology matters.

Pascal Van Hentenryck

The MIT Press has just published Pascal's eighth book "Constraint-Based Local Search" (with Laurent Michel, PhD'98). As usual, Trina Avery proofread the manuscript expertly.

In August, Gregory Harm, then a junior in the department, went to Vienna for MIC-2005, where he presented his joint work with Pascal on an amazing facility location algorithm. He finished his presentation ten minutes early but spent the evening with some of the leading researchers in the field. Congratulations, Greg!

Peter Wegner

In March, 2005, Peter chaired a session on interaction at the Edinburgh Interactive Computing (FINCO) workshop. In June, he presented a paper on Interaction at the New Computer Paradigms conference in Amsterdam, and in July, he received an honorary award on Object-Oriented Programming at the Glasgow OOP conference.

Peter is currently working on philosophical principles underlying Truth of Descartes, Kant, and Bertrand Russell. He continues as editor of the Brown Faculty Bulletin, and encourages faculty contributions concerning their research and/or their evaluation of Brown as a teaching and research University.

New Faculty Profile: Sorin Istrail

Brown News Service

Sorin Istrail: Professor of Computer Science and Center for Computational Molecular Biology

The "Genome Era" started in 2001 when the Human Genome Project and Celera Genomics published the first assemblies of the human genome. Since then, high-throughput biotechnologies have generated genomic and proteomic data sets of unprecedented magnitude and complexity.

Emerging from this data is an "informatics renaissance" led by computer science's new algorithmic, visualization and computing paradigms.

Computational biology with insights from experimental molecular biology, physics, chemistry and economics is harnessing the complexity of biological systems by providing computational models and genomics tools that transform knowledge into scientific control over life science processes.

Sorin Istrail, in his role as senior director and then head of the Informatics Research Group of Celera Genomics, has been instrumental in the company's human genome research.

"We need to rethink and reteach, to cross computer science with the interdisciplinary work in wet and dry labs. The most exciting and novel courses will mix experiments with computation."

"My role was to lead the computational biology effort at Celera in the post-genome assembly phase. I built a dream team of genomic toolmakers. By creating powerful software libraries of tools for assembly comparison, annotation, mass spectrometry, SNPs and haplotypes, arrays, protein folding, and literature data mining, the informatics research team became, arguably, the leading computational biology group in the industry," Istrail said.

Celera's labs teemed with energy as some of the world's best scientific minds united in a common goal. "It was a once-in-a-lifetime experience and accelerated by at least 10 years the accessibility of genomes," Istrail said.

"I loved working with opinionated, workaholic overachievers who, when tasked by inspiring leaders with solving exceedingly hard problems, made lasting scientific advances as a team," he said. "This defines the Celera spirit—a spirit I would like to recreate in an academic setting."

"You need the smartest students, the best faculty, and they're here at Brown. We must work on the hardest problems."

"Biology is changing everything, especially computer science," Istrail said.

The next generation of computer scientists will need to be renaissance men and women, with interests and skills not only in computer science, but in biology, physics, chemistry, and economics. "We need to rethink and reteach, to cross computer science with the interdisciplinary work in wet and dry labs. The most exciting and novel courses will mix experiments with computation."

Istrail will hold the first chaired professorship at Brown's Center for Computational Molecular Biology. Before coming to the University, Istrail was a visiting associate at California Institute of Technology. He was at Celera Genomics from April 2000 through February 2005. Previously, he led the Computational Biology Project at Sandia National Laboratories (1992-2000), taught at Wesleyan University, and was a visiting scientist at MIT from 1985 until 1992. In 2000, he resolved a longstanding open problem in statistical mechanics, the Three-Dimensional Ising Model Problem. He is co-editor-in-chief of the Journal of Computational Biology, co-founder of the RECOMB Conference Series, co-editor of the MIT Press Computational Molecular Biology book series, and co-editor of the Springer-Verlag Lecture Notes in Bioinformatics book series. **C!**

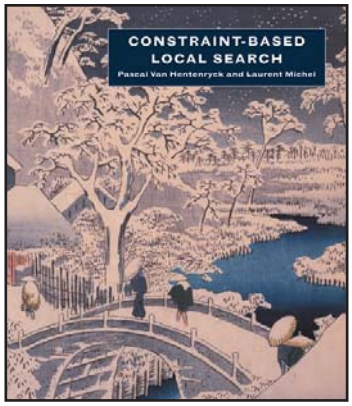
Further information:

http://www.cs.brown.edu/people/sorin/

Off the Shelf: Recent Publications by Faculty and Students

Constraint-Based Local Search

Authored by **Pascal Van Hentenryck**, Brown University and **Laurent Michel**, University of Connecticut
Published by MIT Press, 2005



The ubiquity of combinatorial optimization problems in our society is illustrated by the novel application areas for optimization technology, which range from supply chain management to sports tournament scheduling. Over the last two decades, constraint programming has emerged as a fundamental methodology to solve a variety of combinatorial problems, and rich constraint programming languages have been developed for expressing and combining constraints and specifying search procedures at a high level of abstraction. Local search approaches to combinatorial optimization are able to isolate optimal or near-optimal solutions within reasonable time constraints.

This book introduces a method for solving combinatorial optimization problems that combines constraint programming and local search, using constraints to describe and control local search, and a programming language, COMET, that supports both modeling and search abstractions in the spirit of constraint programming.

After an overview of local search including neighborhoods, heuristics, and metaheuristics, the book presents the architecture, modeling and search components of constraint-based local search and describes how constraint-based local search is supported in COMET. The book describes a variety of applications, arranged by meta-heuristics. It presents scheduling applications, along with the background necessary to understand these challenging problems. The book also includes a number of satisfiability problems, illustrating the ability of constraint-based local search approaches to cope with both satisfiability and optimization problems in a uniform fashion. **C!**

Object-Oriented Programming in Java: A Graphical Approach

Authored by **Kathryn E. Sanders**, Rhode Island College and **Andy van Dam**, Brown University
Published by Addison-Wesley, 2006

This introduction to Java programming by Andy van Dam and Kate Sanders brings realistic, object-oriented programming to the forefront. This early foray into object-oriented programming, not simply objects, from encapsulation through polymorphism supports the real-world applications of Java and enforces good, structured programming habits that will stay with students for a lifetime.

Its graphical approach, replete with graphics-based examples and exercises, provides valuable motivation for first-time programmers and captures students' attention through visually appealing applications. This book gives students the opportunity to gain realistic experience of writing larger programs that are systems of cooperating objects. It incorporates the newest Java 5.0 features including the standard Scanner class and offers extensive data structures coverage (stacks, queues, linked lists and trees).

Features Include:

- Focus on object-oriented design providing students with the realistic experience of writing programs that are systems of cooperating objects
- Early coverage of all important object-oriented concepts, including polymorphism
- An extensive use of graphical user interface and graphics examples
- Realistic and runnable programming examples
- Application programs including animations and games
- Complete chapter on design patterns
- Introduction to searching and sorting algorithms and analysis of algorithms
- Numeric and text-based computing covered in second part of book **C!**

Science Diversity Workshop

Assistant Professor **Amy Greenwald**'s research draws from and contributes to a variety of disciplines including AI, decision theory, game theory, and economics.

"Why do the sciences tend to lack diversity? And what can be done about it?" During the academic year 2004–2005, Dean of the College Paul Armstrong headed up a "Science Diversity Workshop" which was attended by 16 university administrators and faculty members from computer science, engineering, mathematics, biology, chemistry, physics, geology, and pathology. I represented the Computer Science Department. During the fall semester, we brainstormed about the reasons why the sciences tend to lack diversity, and during the spring semester, we brainstormed about solutions.

Many issues contribute to the lack of diversity in the sciences. Primary among them is that students from under-represented groups, including women, can experience "stereotype threat"—a fear that their behavior might reinforce a negative stereotype applicable to a group which they belong. Many (although not all) students of under-represented groups enter the classroom or office hours partly consumed by assumptions of inadequacy. By worrying about their presumed inadequacies, these students waste "processing" time and space, which negatively impacts their performance.

All Brown students are outstanding in some way, but some may have had less exposure to advanced math or science in high school, others may not have perfected their study skills, still others may not have developed enough confidence to seek extra help...

A second contributing factor is under-preparation. All Brown students are outstanding in some way, but some may have had less exposure to advanced math or science in high school, others may not have perfected their study skills, and still others may not have developed enough confidence to seek extra help, perhaps because of stereotype threat. Additionally, the lack of a "critical mass" of women and minority students in the sciences implies a lack of peer support, which adversely affects course retention rates. To address these issues, the workshop committee put forth the following proposals: mentoring groups, special first year seminars, rethink introductory sequences, and "smart start" summer programs.

Mentoring groups

We envision groups of four to six first or second year students, one senior, and one Brown faculty member meeting regularly to discuss things like study skills and research opportunities. This program could tie into the Meiklejohn and/or Curricular Advising programs, or the groups could be linked to large introductory courses and any existing study group systems. The intent would be to engender peer support for the student participants. By sharing skills and information, and perhaps even some part of their identities, mentoring groups could help provide students with a sense of belonging.

Special first year seminars

In addition to the existing selection of first year seminars, we could design more seminars in the sciences that rely on more progressive pedagogical models. Until recently, educators believed that they could provide all students with an equal chance to succeed by treating all students equally. While this assumption has some merit, traditional modes of instruction, where the professor is the unique source of knowledge, can create hostile learning environments. By offering to share power in the classroom, for example, these science seminars could attract a more diverse student body.

Rethink introductory sequences

Another popular idea, one which has already been adopted by the Computer Science Department, is to rethink introductory course sequences in the Sciences. In addition to CS 15–16, the CS Department offers CS 17–18. The former is an introductory, yet intense, course where students quickly learn to build modular, reusable, large-scale programs. In the latter course, students learn "alternative" programming languages, emphasizing the conceptual elegance of computer science. By offering multiple introductory sequences like these, scientific disciplines might be able to broaden their appeal.

Smart start summer program

A "smart start" summer program would help create alternative pathways into the sciences, particularly for under-prepared students. Two forms of smart start were proposed. The first would offer a reduced course load for first years with supplemental summer courses offered following the first year. Summer studies could be based on "lab" courses, and could involve team projects, preparing students to join research groups in the sciences later in their undergraduate careers. The hope is that such a program would relieve some of the pressures on, for example, first year engineers.

The second form of smart start would offer short summer courses prior to the first year. This program could involve several weeks of total immersion into one scientific discipline, or students could rotate through possibly three departments spending approximately one week in each. The intent of this pre-college program would be to help students develop a comfort level with some basic scientific material, as well as with their peers and the departments themselves before entering college. The goal of both smart start programs would be to help "level the playing field" for students of all backgrounds by sophomore year.

The overarching goal of the Science Diversity Workshop was to analyze the reasons why there is a lack of diversity in the sciences, and to devise ways in which to stimulate students' interest in the sciences, particularly students from under-represented groups. If implemented, the workshop committee's proposals could provide women and minority students with a positive introduction to science, dispel stereotypes about who can and cannot succeed as a scientist, and emphasize science as a fun and exciting part of everyday life, all of which are important steps towards achieving diversity in the sciences. **C!**

LEFT High school computer science teachers participate in the 2005 TeachScheme! workshop. Funding is in jeopardy for this important program.

An Uncertain Future for TeachScheme!

Assistant Professor **Shriram Krishnamurthi**

Ten years ago, a group of four began a small workshop series at Rice. We wanted to re-train high school teachers in modern computer science curricular techniques. Despite numerous surprises (not all positive), challenges and nay-sayers, the program has not only survived but thrived: at last count, TeachScheme! has hosted 529 participants, with positive evaluation percentages well into the nineties. While most attendees have been from US high schools, we've also hosted many professors, and welcomed educators from Canada, Mexico, Saudi Arabia, Switzerland, and Japan (and possibly a few other locations we've forgotten!) How many other outreach programs can claim that kind of success?

This year we hosted yet another TeachScheme! workshop at Brown—a tenth anniversary special. For a change, the organizers kept quiet and the attendees did all the talking. We ran the event as a two-day workshop populated entirely by past attendees who returned to give talks and demos of the many wonderful things they've done in their classrooms with what they learned from TeachScheme!. As a preview of the future—both technological and human—they also heard a research presentation by Brown PhD students Greg Cooper and Guillaume Marceau.

The event was really special as a reunion not only for past attendees, but also for us organizers—a total of 13 of us! There were several grad students who've been part of the program for many years. Steve Bloch, who has run TeachScheme! workshops at Adelphi, and Kathi Fisler of WPI, who co-organizes the Brown workshops (and ran one of her own at WPI this year), were there. In addition, Robby Findler of the University of Chicago, Matthew Flatt of the University of Utah, and Matthias Felleisen of Northeastern University were present. Matthias was the PhD advisor of Robby, Matthew and me, and he initiated this project while we were all at Rice. We've grown up and moved on to many other things, but TeachScheme! is still a very special glue that binds us.

One of the major challenges we now face is maintaining funding. We can run TeachScheme! workshops on as little as $25,000 a year, but even that sum is hard to raise. The NSF program that funded TeachScheme! no longer exists; indeed, the NSF doesn't really seem to have a model for sustaining successful educational programs. Sadly, corporate funding for such programs is virtually non-existent. In addition, most foundations have very narrowly focused criteria that we don't meet. The bottom line remains that without an infusion of funding, the program will be crippled. **C!**

A Vietnamese Experience

Professor **John E. Savage** joined the Brown University faculty in 1967. He is a founder of the Department of Computer Science and was its Chairman from 1985 until 1991.

In early June, I had an unusual opportunity to travel to Vietnam and visit Hanoi and Ho Chi Minh City (HCMC), a country and two cities that figured importantly in the history of the US circa 1970. My visit was sponsored by the Vietnam Education Foundation (VEF), an agency created by Congress in 2000 as a vehicle to repatriate most of a $146 million debt incurred by the South Vietnamese government before being overrun in 1975 and being repaid to the US by the Socialist Republic of Vietnam. Diplomatic relations were restored between our two countries in 1995. In 1967, Secretary of State Rubin negotiated a repayment of the debt as a condition for Vietnam to have access to international borrowing. In 2000, Senators John McCain, John Kerry, Bob Kerrey, Charles Robb, Max Cleland and Chuck Hagel, all veterans of the Vietnam War, co-sponsored the bill that created VEF. It's purpose is "to carry out an international fellowship program between the United States and Vietnam to enable Vietnamese nationals to pursue advanced studies in science, mathematics, medicine, and technology; to enable United States citizens to teach in those fields in Vietnam; and to promote reconciliation between the two countries."

ABOVE John Savage, Jaw-Kai Wang, Department of Molecular Biosciences & Bioengineering, University of Hawaii and Robert H. Bishop, Department of Aerospace Engineering & Engineering Mechanics, University of Texas at Austin..

...all of us came away believing that this process was far more effective in assessing student potential than the traditional written graduate school application process.

I visited Vietnam with ten other American scholars to conduct interviews for the VEF fellowship program which is run with the support of the Fellowship Office of the National Academies. They solicit applications (1,700 this year), filter them (400 in 2005), have selected students take a mathematics exam, and then further refine the applicant list to 120 students who are invited to interview both in Hanoi and HCMC. Each student was interviewed and evaluated by two Americans and a Vietnamese academic in a one-hour session. I personally sat with 24 students over four days. Approximately one third of the 120 applicants were more than qualified for admission to the best American graduate schools. We wrote letters evaluating applicants that will be sent to graduate schools on behalf of those students receiving fellowships, and all of us came away believing that this process was far more effective in assessing student potential than the traditional written graduate school application process.

In addition to conducting interviews, each American scholar was invited to give talks at Vietnamese institutions which provided another opportunity for us to get to know the Vietnamese people. We were also provided with tours of Hanoi, HCMC and Ha Long Bay, several hours by bus from Hanoi. Combined with our small group outings for dinner and sightseeing, we developed an initial appreciation of the Vietnam people, who were friendly and approachable. Vietnamese food is generally simple but very good. However, to truly sample the Vietnamese cuisine demands that one be adventurous. One of the great local delicacies is the beating heart of a snake! Among the sights that I took in were the "Hanoi Hilton," the prison in which many American aviators were held during the Vietnam War, including Senator McCain. The photo was taken of me and two other Americans at the entrance to the prison. **C!**

Combinatorial Optimization State-of-the-Art and Future Trends May '05 Industrial Partners Program Symposium

Assistant Professor **Meinolf Sellmann**'s research focuses on hard combinatorial feasibility and optimization problems as they arise in the context of real-world applications such as Airline Crew Scheduling, Automatic Recording and Capacitated Network Design.

The department's 34th Industrial Partner Program Symposium focused on combinatorial optimization. This branch of algorithmic computer science addresses tasks where a function needs to be optimized over a finite but extremely large set of values. One of the most famous examples of such a problem is the Knapsack problem that consists of finding a selection of items, each associated with a weight and a profit, such that the total profit is maximized while a given weight limit of the selection must not be exceeded.

ABOVE Symposium participants included: (top row) Bernard Gendron, Pascal Van Hentenryck, Irv Lustig, Meinolf Sellmann, (bottom row) Stefan Karish, George Nemhauser, and Heinrich Braun. Missing from photo: Andrew Davenport

While usually belonging to a class of computationally very difficult (so-called "NP-hard") problems, many combinatorial optimization problems are of utmost importance for industrial applications. For instance, when an airline company makes decisions regarding what flights it wants to offer, what specific airplane serves which flights, and which flights are staffed by specific crew members. These choices have a decisive impact on the profitability of an airline, and consequently, the transportation industry has traditionally been one of the most serious and most committed branches of industry that demands for intelligent decision support systems based on computers. In the past, the main goal of combinatorial optimization research is to develop algorithms that can solve real-size instances in affordable computation time.

Our symposium tried to give an overview of this exciting branch of computer science. A group of six outstanding optimization experts from industry and academia accepted our invitation to talk on this topic. The diversity of our speakers' backgrounds allowed a unique insight on this very active research area from many different perspectives.

> ...the main goal of combinatorial optimization research is to develop algorithms that can solve real-size instances in affordable computation time.

Methodological process and solver efficiency

Our first speaker, Irv Lustig from ILOG©, pointed out that although the research area is as old as computer science itself, tremendous improvements have been achieved in combinatorial optimization, especially over the past 20 years, that were thought to be totally out of reach before. Naturally, the steady acceleration of processors as well as the availability of ever larger storage devices has played an important role in this development. However, an equally substantial part of the computational gains that were accomplished must be attributed to the development of new algorithms (like interior point algorithms), hybrid approaches (like branch-and-bound augmented with cutting plane algorithms that were once considered impractical), and radically new methods such as constraint programming. This point was strengthened by Bernard Gendron, Professor at the University of Montreal and the current president of the Canadian Operations Research Society, when he reviewed the most important methodological advances in the realm of integer programming, column generation, heuristic methods, constraint programming, and hybrids thereof. He exemplified the methods on examples from urban mass transit and the airline and health care industries.

How to model optimization problems

In addition to the progress made in the efficiency of general purpose solvers and the development of advanced methods, Andrew Davenport from the IBM T.J. Watson Research Center revealed some success stories regarding problem specific algorithm development for the production planning and scheduling in the steel industry and the evaluation of bids submitted to complex discount auctions with side constraints. The latter application, especially, yielded to a very lively discussion regarding the problem definition that was, on an abstract level, reiterated during George Nemhauser's (Georgia Institute of Technology) talk on "Optimization

...modeling of real-world problems was identified as a severe challenge for all suppliers of algorithmic decision support systems..

in Sports Scheduling" where he reported on the challenges involved in providing schedules for ACC basketball and major league baseball. Despite all the computational progress that was made, the modeling of real-world problems was identified as a severe challenge for all suppliers of algorithmic decision support systems.

Heinrich Braun, development manager for optimization in supply chain management at SAP©, addressed this challenge by presenting SAP's Advanced Planner and Optimizer that was designed to reduce the customer effort in its daily use. One aspect was the automatic detection and rectification of customer defined objective functions that often incorporate rather arbitrary penalty terms. He also addressed the related problem of automatic explanation generation when a certain problem formulation proves infeasible or shows undesired and unexpected behavior. While the solutions provided for customers are valuable, issues like efficient modeling and being able to understand what the mathematical model actually specifies are core to consumer acceptance of optimization technology.

Along the same lines, Stefan Karisch, Vice President of Operations Research at Carmen Systems© reported in his talk on "Applying Optimization in the Transportation Industry" that one of the decisive advantages of Carmen Systems in its early years of existence was their ability to provide a rule language that allowed an airline planner to express airline specific rules and regulations in a generic manner. Until today, Carmen's core products that all other technology is built upon incorporate a rule engine and an interface that allows users to assess solutions quickly.

Quo vadis, combinatorial optimization?

Furthermore, agile discussions among our speakers, our IPP partners, and Brown researchers showed that research in combinatorial optimization is currently undergoing a shift. While solver efficiency will continue to be of great importance, the most important aspects that need to be addressed to increase the impact of algorithmic decision support include: 1. the effective modeling of optimization problems, 2. the provision of robust solutions, and 3. the accommodation of uncertain data. Upon its conclusion, the symposium substantiated that combinatorial optimization is a key technology that can provide significant competitive advantages, allow for responsible exploitation of resources, and generally improve operational efficiency.

I would like to thank our IPP directors John Hughes and Michael Black, our chair Eli Upfal, and Pascal Van Hentenryck for this unique opportunity to overview this important and powerful technology, the current state of the art, and the outstanding challenges of modeling real-world problems and accommodating uncertain data. Moreover, this event would not have been possible without the wonderful help of our IPP organizer Laura Zurowski, as well as Genie deGouveia, Lauren Relyea, Jennet Kirschenbaum, and Ionut Aron who all contributed greatly to make this day very pleasant for our IPP partners and visitors. Finally, my deepest thanks go to our speakers who took the time to contribute to another exciting IPP symposium at Brown. **C!**

Industrial Partners Program

The Industrial Partners Program (IPP) exists to provide avenues for interaction with the corporate technology community. Industrial Partners are introduced to the Department's research and development efforts and to our students. We seek to develop relationships with companies who share an interest in supporting faculty and students.

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

Collaborators
Cisco Systems

Premier Partners
IBM
Network Appliance
Microsoft
Sun Microsystems

Affiliates
ITA Software
Google
GTECH
VMware

Individuals
Edelman & Associates

For more information about the Industrial Partners Program, contact:

Michael Black
Professor and IPP Co-Director
Telephone: (401) 863-7600
Michael_Black@brown.edu

John Hughes
Associate Professor and IPP Co-Director
Telephone: (401) 863-7600
John_Hughes@brown.edu

Laura Zurowski
Program Manager
Telephone: (401) 863-7610
Laura_Zurowski@brown.edu

Unplugged

Eugene Charniak is Professor of Computer Science and Cognitive Science. His research is in the area of language understanding or technologies which relate to it, such as knowledge representation, reasoning under uncertainty, and learning.

Over Commencement weekend, the department had a reception for all its alums in honor of our expansion to the third floor of the CIT. It was a great success, and I gather this will become an annual event. I certainly had a good time.

It was fun talking to a lot of the students I have known over the years, but I did not talk to as many as I should have or wanted to. (I felt like writing "to whom I wanted", but I figured no one would know I was kidding.) Early in the evening I met Eric Albert and spent an inordinate portion of the event talking with him.

ABOVE Eugene never lacks for interesting stories or coffee mugs.

Long-time Conduit readers may remember Eric from a column I did years ago when he was featured in the NYT for his crossword puzzles and his computer program that creates them. Part of our most recent conversation was about some of the details of that program. For example, one of his most celebrated puzzles contained many words with doubled letters (like the two "t"s in "letters") but in every doubled combination one of the two letters was removed. A person might have a hard time coming up with many of these words, particularly ones with several doubles, but it is much easier for a program. Eric's program has, of course, a huge dictionary of words and phrases, and each one is given a score that reflects, in Eric's estimation, how "good" a word or phrase is. A dull word like "two" would not be very exciting and thus would get a bad score. Essentially, Eric just wrote a program that went though the dictionary, found every word with one or more doubles, and added a new "word" with one character removed from each double. The new word was then given a one-point improvement over the old for every double, which encouraged the program to use the word.

However, what really caught my attention was Eric's comment he has given up the crossword puzzle business and has a new career as a writer of erotica. Eric is a very straightforward person who can make this pronouncement without the slightest hint of defensiveness. This is something I cannot quite manage. So let me get my defensiveness over with at the start. Eric does NOT write pornography—material "without redeeming social value". He wants to write well, and it seems clear that he succeeds, since several of his pieces have been published in Simon & Schuster anthologies of erotic fiction. (I also just went to his home page (http://www.ericalbert.net/ and found myself laughing out loud. He is a very funny writer.)

At any rate, I asked him the natural question: how did he get from here to there? It seems that he has always been interested in human sexuality and when an upscale erotica shop opened near him, he would often visit the place. When it offered a course in writing erotica, he and his girlfriend signed up.

Originally, he says, he did not intend actually to write anything, but when everyone else was writing and reading their stuff, he felt he should participate. So he wrote something. The woman who taught the course liked it and asked him to submit it to the small magazine she publishes. It was then picked up by the editor of Simon & Schuster's erotica anthology. It was at that point that Eric, who had first published under a pseudonym, decided to shift to his real name.

Eric's girlfriend also wrote a strong story for the class and eventually she and Eric rewrote it jointly. The resulting piece, which Eric characterized as much more "hard-edge" than his, was rejected by the magazine that published Eric's work. However, Eric and Co. sent it to the Simon & Schuster editor, who wanted it for the anthology as well. They mentioned that there was only one problem, it had not been published; she said that they had two months to get it in print. So they wrote back to the magazine publisher explaining that they had this minor difficulty. For a small magazine to have its short fiction anthologized is a big deal. This time, it was accepted.

At the end of the conversation Eric said some very flattering things about me and his college career. At the time I just said, "Thank you." Only later did I realize that I should have asked him to put something in a foreword to one of his books—that he learned everything he knows from me. **C!**

The Dingers: Intramural Champions!

Loring Holden is a senior research software engineer. When he's not playing softball (or following the Red Sox) he can be found in the graphics lab.

The long drought is over for the Dingers, the computer science intramural softball team. After an eight year wait, the Dingers have finally won the coveted intramural championship t-shirts. No longer will opposing fans chant "ninety-seven, ninety-seven", but instead they will stand in meek awe of the Dingers.

ABOVE The Miken Freak bat gets a prime location in this team photo.
Top, l to r: Russ Bent, Dave Tucker, Don Carney, Frank Wood
Middle: Chad Jenkins, Steve Reiss, Daniel Acevedo, Bob Zeleznik
Bottom: Gary Withey (engineering), Dmitri Lemmerman, Joseph LaViola with Miken Freaks, Andy Simon, Dan Keefe
Not pictured: John Jannotti, Loring Holden

The Dingers won the first three games of the season 12-1, 12-1, and 17-14. But the day after Dr. LaViola's successful PhD defense (finally!), the Dingers had a rude awakening when they were blown out 12-3 by Ill Militia, a team full of ex-varsity baseball players and varsity athletes from the lacrosse and basketball teams (and possibly crew as well). The next game was a cruel loss against a team full of hockey players because the game ended with controversy. The Dingers thought the game was tied, but their opponents said they had won with a walk-off. The umpire sided with the opponents and made a quick escape in order to avoid an argument.

> ...the championship drive started by securing public funds to purchase a Miken Freak softball bat.

Luckily, the 3-2 record was good enough to put the Dingers into the playoffs. The semi-finals featured a rematch against Ill Militia, but this time manager Dr. LaViola had a trick up his sleeve. Before this game, the team would take batting practice. That seemed to be the answer, as Dmitri Lemmerman led off with a home run, with dingers coming later in the game from Dan Keefe, Dan Acevedo, John Jannotti, and Andy Simon. The Dingers went out to an early lead they never relinquished, avenging their regular season loss with a 17-11 win.

The finals were scheduled to be a best-of-three series, but due to rain and other scheduling issues, the game ended up being one nine-inning game as opposed to the usual six-innings.

Unfortunately, the opponents (Foul Balls, full of hockey players) insisted on using a "dead" ball, which prevented a repeat of the fireworks from the semi-finals. The Dingers went on to win 10-6, but not before Daniel Acevedo pulled his groin half way between third base and home, and hobbled the rest of the way to score. Unfortunately, this was after Daniel's initial plate appearance, and he missed the rest of the game.

Manager Dr. LaViola says the championship drive started by securing public funds to purchase a Miken Freak softball bat. The Miken Freak was crucial to the championship drive because the Dingers are "so old", says Dr. LaViola, that they needed an equalizer in order to compete with teams full of varsity athletes. The Miken Freak is a perfect equalizer as it is "banned in most softball leagues," says the manager, "the ball can leave the [Miken] at 100 mph". Perhaps the Miken Freak did not help with average, but it may have helped in the power department. The team batting average was down this year, but the at-bats per home run were at an all time low (in the four years that Dingers statistics have been kept), at 12.35. To put this in perspective, in his career, Barry Bonds was less efficient at hitting home runs, only hitting a home run for every 13.36 at-bats, so the Dingers are in pretty good company (ignoring the slight difference between major league baseball and intramural softball).

There were four years between the '93 and '97 Dinger championships, and then eight years until the '05 championship. Hopefully, future championships won't hold to this geometric progression, where we have to settle for championships in 2021, 2053, 2107, etc. The Dingers lose Dmitri Lemmerman and Russ Bent this year, but hopefully will be able to overcome these losses for a repeat in '06. **C!**

Department News and Happenings

Teresa McRann, the department's new undergrad recruiter

I'm a computational biology concentrator from Santa Rosa, CA. When I arrived at Brown after almost two years off from high school, the thing I wanted to do most was to try something new. Knowing almost nothing about computers (let alone computer science) I wandered into the first CS15 lecture and have been involved in the department ever since.

ABOVE Teresa brings a creative touch to everything she works on.

As a ScB candidate involved in multiple science departments (biology, chemistry, and computer science) I've gained a real appreciation for the study of science at Brown, and that's what brings me to this project. I hope to see the sciences continue to flourish – and continue to collaborate – in Brown's future, and in order for that to happen, we need students that are not only intelligent and hard-working, but also creative, and open to new ways of doing things. I believe that if we stay inspired by all that science has to offer, and put our best foot forward, not just to prospective students but also to each other, we will continue to succeed. **C!**

Sascha Becker departs GSTAFF

After three years of working as research staff for the Graphics Lab, Sascha Becker '97 is moving back to California, where she'll join other Brown alums, including Sarah Allen, David Tempkin, Sarah Bradley, and Eliot Winard, at Laszlo Systems. Sascha will be a senior software engineer and will build client-side interfaces for rich internet applications based on an open source java/xml framework.

About this new job, Sascha says, "Finally, a chance to make GUI's with antialiased lines, alpha-blended gradients, and smooth animation...and on a Mac!" Sascha can be reached at sascha@fullerbecker.com, and encourages undergrads looking for work to contact her. **C!**

TOP TStaff's Mark Dietrich and GStaff's Mark Oribello participated in the June 2005 ride-a-thon for the Diabetes Foundation.
MIDDLE AStaff's Jennet Kirschenbaum and Lauren Relyea enjoy a laugh with TStaff's Kathy Kirman at the August 2005 graduate student cook-out.
BOTTOM Brilliant women with a sense of humor! Artemis participants, young alumnae from Google and Professor Tom Dean strike a silly pose for the camera.

2005 Computer Science Graduates

The following students were graduated during the 26th Commencement Exercises on Sunday, May 29, 2005 at St. Stephen's Church.

AB Computer Science
Vesselin Arnaudov, honors, senior prize
Alexander Boutelle
Lee Butterman
Evan Hammer
Matthew Hatoun
Jonathan Hollinger
Kea Johnston
Shaun Joseph
Ethan Leland
Jamay Liu
Noah Massey
Michael Pozar
Judith Shabry
Eric Shashoua
Damien Suttle
Nancy Tom, honors
Robert Tzong
Christopher Wells
Shirlyn Wong
Vanessia Wu
Michael Zaitzeff

ScB Computer Science
Jonathan Bankard
Sarah Bell, senior prize
Edwin Chang
Benjamin Gojman
Edward Kern, honors
Stephanie Lee, honors, senior prize
Michael Leen
Anthony Newman
Michael Oneppo
Shirin Oskooi
Ivaylo Piskov
Cyril Saint Girons
Gabriel Taubman, honors
Michael Tschantz, honors, senior prize
Matthew Van Wormer
Xi Ling Wong
Peter Woo
Pawel Wrotek
Jason Ye, honors

ScB Computer Science-Economics
Lars Johansson
Danielle Karr, senior prize
Adam Samet

AB/ScB Computer Science
Yiannis Alexander
Haruyoshi Sakai, honors
Jonathan Warman

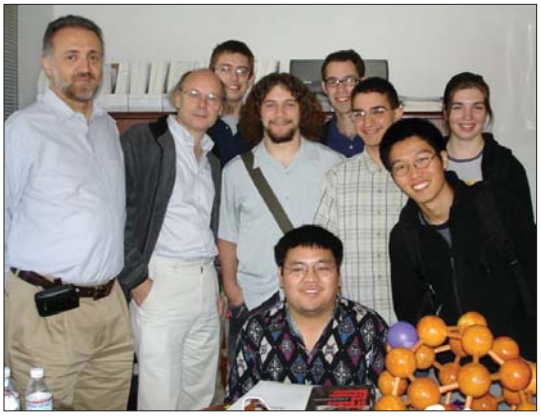
ScB Computational Biology:
Ethan Bromberg-Martin, honors

ScB Math-Computer Science
Benjamin Aisen
Miriam Goldberg
Harishabd Khalsa
Tom Petrillo

ScB Applied Math-Computer Science
Daniel Bookstaber, honors
Sophia Brueckner
David Eustis, senior prize
David Grabiner

ScM Computer Science
Stuart J. Andrews
Alexandru O. Balan
Melissa E. Chase
Christopher L. Chin
Christopher D. Cole
David J. Eigen
Andrea M. Fein
Jesse D. Funaro
Sharon Goldwater
Daniel H. Grollman
Peter W. Hopkins
Mark S. Humphrey
Anjali Jhingran
Zheng Li
Heng Lian
Casey A. Marks
Maria Meyerovich
Benjamin J. Mishkin
Philip G. Montgomery
Syung Youn Nam
Victor Naroditskiy
Shashank Ramaprasad
William H. Sheffler
Peter G. Sibley
Vadim A. Slavin
Jenine A. Turner
Alexander M. Zgolinski

PhD Computer Science
Yasemin Altun
Russell W. Bent
Donald P. Carney
David C. Gondek
Keith B. Hall
Joseph J. LaViola, Jr.
Emmanuel Renieris
Ioannis Tsochantaridis
Joel D. Young



TOP (left) The graduate student welcome back party took place in the new third-floor common area.
(right) 2005 PhD recipient Joe LaViola credits his academic success and fashion sense to AVD.
MIDDLE (left) Zeus, played by Aris Anagnostopoulos, presents a laurel wreath and rubber chicken to 2005 PhD recipient Manos Reniens.
(right) In September, Professor Sorin Istrail hosted a visit by C++ designer, Bjarne Stroustrup.
BOTTOM (left) Nothing like a little ice cream to make a few grad students happy!
(right) 2006 PhD recipient Morgan McGuire and Associate Professor John Hughes.

True Tales from the Tech World: CS Alums Tell-All!

Lise Pfau Ciolino graduated in 1985 with an ScB in Applied Math/ Computer Science.

From Software to Syrah

When someone inquires about your profession, how much do you simplify the answer? For much of my career, I often resorted to "I'm in software" rather than risk "I build real-time reasoning with uncertainty systems" or "My company provides business to business electronic commerce for operational resources." These days, however, my answer is always simply "I make wine"—and it's more of a natural career step than you might think!

ABOVE Lise is still busy with upgrades and testing—but there are some occupational differences between versions and vintages!

My freshman year I was hooked by my first Computer Science class (yes, Andy van Dam's CS11). I loved building software because of the intellectual challenge; the creative juices stirred as I formulated the "perfect" design, and of course, the user's profound appreciation of a product that I helped produce. After grad school, I went out into the wide world of software to do research, then startups—once, I actually joined a company that eventually made a profit. By then, I had made the fatal mistake of moving away from engineering and into management. The problem is that I like building products myself.

So my husband and I invested our software-earned nest egg into our own small business—a business that involved another passion of mine: wine. I always had a fascination with wine, passed down from my parents who enjoyed wine with dinner every night. I traveled to many gorgeous European wine regions, enjoyed the food, the wine, and the culture—but I was a computer scientist. When I moved to Silicon Valley, however, I realized that Californians (seemingly just like me) made some pretty awesome wine. So in my spare time, I took some classes at UC Davis and started making wine in a friend's Palo Alto garage. As it turns out, lots of good things start in garages in Palo Alto, and that first vintage won a silver medal at a prestigious amateur wine competition. I was hooked.

You see, creating fabulous wine is very much like building great software. Between growing grapes and making wine, it's incredibly intellectually challenging—horticulture, entomology, meteorology, biochemistry, and statistics are all fields one should dabble in, if not master. Although you can make wine without understanding why yeasts need nitrogen at the start of fermentation, long before they begin to look stressed—you'll make a better wine more consistently if you understand the science. There is so much to know about growing grapes and making wine, we decided to specialize in a single varietal, Syrah.

Like software, with wine you are continually producing upgrades—we just call them vintages. Every year, I am optimistic that I can make a more elegant, more smooth, more intense Syrah than I have done before, and usually I do, although Mother Nature throws many curve balls. Winemaking schedules are very much enforced by an unyielding higher power, thus no amount of pleading, graphs, or PowerPoint presentations will change the reality that harvest comes every year around the same time whether I like it or not!

Wine, like software, is part science and part art form. The scientific aspect is undeniable, but also creativity, experimentation, and just "feel" make the difference between a good wine and a great wine. In winemaking, you have to use all your senses to evaluate the fermentation and aging process—of the thousands of variables in making great wine, which one will make a difference this year, with these grapes, in this situation? I mix a bit of science, a bit of intuition, a bit of good luck, and liberally dose it with some great advice from winemaking friends.

Of course the main difference between Syrah and software is that grapes and wine are physical in nature. To have people enjoy the fruits of your labor, you can't just ftp it—you have to lug around a 50lb case of wine. But the beauty also lies in that physicality. There's the sight of the bright green new buds bursting in the spring, the fog rising over the vineyards in the morning, and the ripe purple grapes against the deep green foliage just before harvest. There are the wonderful aromas when you enter the wine cellar full of French oak barrels, and the heady scent of a winery brimming with fermenting

grapes. And of course, there's the smooth, silky texture and wonderful flavors of a Syrah that fills your mouth—particularly when you can ignore all the complexity in producing your product, and just sit back to enjoy a simple, wonderful glass of wine with some good friends.

Since the 2002 vintage, my husband and I have made wine and olive oil at Montemaggiore in Healdsburg, Sonoma County, California. Life doesn't get better than this – and the pleasures don't get more simple. If you want more insight into the simple life, e-mail me at lise@montemaggiore.com. Cheers! **C!**

ABOVE Bryan Cantrill '96, senior staff engineer at Sun Microsystems, has created an application called DTrace that offers real-time software diagnostics. "With DTrace," says Cantrill, "I can walk into a room of hardened technologists and get them giggling." Cantrill was recently named to the "Top 35 Under 35" list by MIT's Technology Review. Who's giggling now?

Seeing old friends at SIGGRAGH

Currier McEwen graduated in 1995 with an AB in Computer Science.

Hello,

I just saw Andy, Spike, Lee Markosian and a bunch of other current and former Brown folks at the annual SIGGRAPH Brown dinner in Los Angeles. There were quite a few new faces, including some new faces in the faculty. It was good to see everyone! On the work front, I just finished my 10th year at PTC, which is a Boston based software company that makes PLM and CAD software. Ken Drew works in my division as well. In the spring, I was promoted to Director of Software Development. In addition to managing a team of graphics and systems engineers I'm now a lot more involved in business and technology strategy and planning.

ABOVE Currier McEwen enjoys a ride through Acadia National Park in Maine.

On a more personal note, I recently finished the Pan Massachusetts Challenge, a charity ride to raise money for cancer research. Now I'm training for a bike trip in Southern France in early October. The photo is from a recent ride at Acadia National Park in Maine. Good luck to all the new students and best wishes to friends and former colleagues! **C!**

ABOVE Mark Humphry '05 and Danielle Karr '05 talk to students about FactSet at the September 2005 Career Fair.

True Tales from the Tech World: CS Alums Tell-All!

Michelle Neuringer graduated in 2000 with an ScB She would love to hear from old friends and can be reached at michellen@gmail.com.

Bells, whistles and a leather jacket

Hi Conduit,
This is Michelle Neuringer. You might remember me from such classes as CS15, where I turned the final project, Orbit, into a galaxy of fruits and vegetables. Or from CS32, where a British butler voice announced "Ms. Scarlet, it is your turn" in the final project, Clue. I look back on my Brown CS years as a time when I worked fast to get my class work done so that I could work twice as long on "bells and whistles".

ABOVE Andrew "Shoe" Schulak '99 and Michelle Neuringer '00 in Philadelphia.

Shortly after graduating in 2000 with a concentration in CS and a minor in "fun things" (poetry, TA-ing...), I moved to San Francisco to join a startup called iHarvest with a bunch of Brown CS people too numerous to mention.

iHarvest was acquired by Interwoven a year later, and so was I. I didn't think I'd last six months commuting one hour to Sunnyvale (even in Matt Chotin's VW, with toasty seats!) to park myself in a cube. I also didn't think that an Enterprise Content Management company would offer me a future in bells and whistles.

This week I celebrate my five year anniversary with Interwoven*. In the last four years, I've worked as a developer and now as lead user experience designer from various coffee houses and offices in San Francisco, New York, Austin and Chicago. I work with developers, customers and product managers to produce software that's both usable and appropriately fun. Our newest product, LiveSite, lets business users create web sites by dragging, dropping and customizing web building blocks. I'm hoping to get the British butler voice into the next release, but you know how it is with software companies and "feature creep".

In my free time I enjoy practicing bikram yoga, dancing and starting (and sometimes finishing) side projects. Keep in touch! **C!**

*1 year at iHarvest + 4 years at Interwoven = 1 leather jacket with the company logo!

TOP James Joaquin, Brown CS, '87, a serial entrepreneur (he recently sold his company Ofoto to Kodak) visited the department last spring to talk to students in CS24: Visual thinking/Visual Computing co-taught by Andy van Dam and Anne Spalter (on right). James is currently the CEO of xoom.com.
BOTTOM Taha Mohamedali '04 and Eric Zamore '04 combine work with fun while representing Microsoft at the University's fall Career Fair.

Jen Goree graduated in 1994 with an ScB She'd love to hear from former classmates and can be reached at jen.goree@alumni.brown.edu.

Public schools and public service

I'd be interested to hear more from other grads who have taken varied paths from their Brown CS degree. Here's what I've been up to:

A little over five years ago I moved up here to Seattle, joining the IT department of the Kent school district in order to see educational technology from the 'inside'. (My most recent occupation had been managing the software development group for a web publishing subsidiary of Pearson plc - owners of Addison Wesley, Penguin, Financial Times, etc.) Kent is a suburb of Seattle. The school district has 26,000+ students and 40 schools, roughly similar in size to the Providence RI school district.

I am the Director of Applications and Web Systems, which means I'm responsible for the core student, payroll and financial data systems, as well as the website and web infrastructure. I lead a staff of 13 which includes a manager, programmers, a DBA, and a support specialist. Right now our projects include expanding access to our data analysis tool, launching an intranet portal, launching a replacement project for our major data systems, and piloting a digital learning solution for a technology magnet middle school opening this fall. We also support homegrown web applications for everything from taking attendance to registering for staff development classes. It's quite a leap from way back when I was in CS192 (now CS092)!

I really enjoy my work. Delivering enterprise solutions on a school district budget is a huge and interesting challenge. I have a tremendous amount of variety on a daily basis, talking about everything from software engineering and data architecture to effecting change in education. I've participated in teams to brainstorm how to involve more students in technology support and to help plan the expenditure of an $18 million technology levy. And this is within a daily mission of helping a diverse population of students to succeed.

In my spare time, I volunteer with SmartGirls, a local organization that encourages girls to stay interested in math and science. This year I chaired the planning committee for the annual conference, and we had over 400 middle school girls doing everything from dissecting mosquitoes to building gliders—lots of fun.

As much as I enjoy what's going on here, due to family circumstances I will be moving back to New England at the end of September. I will miss my friends here and the beauty of the Northwest, but I am looking forward to being back 'home' on the east coast and to the new and interesting opportunities out there. **C!**

ABOVE Kit Colbert '03 and Mark Johnson '05 visit campus for the September Career Fair on behalf of VMware.
BELOW Return of the Googlers! Susannah Raub '04, Elizabeth Hamon Reid and Christine Davis '03, pose with Professor Tom Dean during the Artemis Project summer term.

Computer Science Fundraising Initiative

Support Computer Science

If you would like to contribute to the Computer Science Department's fundraising initiative, please visit http://www.gifts.brown.edu/ or contact:

Mr. Ralph Scala
Office of University Advancement
Brown University, Box 1893
Providence, RI 02912 USA
Telephone: 401.863.9833
Email: Ralph_Scala@brown.edu.

The Computer Science Department is embarking on an ambitious fundraising campaign that is an integral part of the university-wide Plan for Academic Enrichment. This comprehensive computer science initiative has two overarching goals:

- Supporting excellence in teaching, research, and scholarship through expanded opportunities for Brown's faculty and students.
- Renovating the Thomas J. Watson Sr. Center for Information Technology.

A Commitment to Excellence

In order to maintain Brown's excellence in Computer Science, the department seeks two endowed professorships with which it can reward outstanding senior faculty members and attract distinguished teacher-researchers to the University. To date, Computer Science has secured one endowed chair, generously funded by friends of Professor Andy van Dam.

The department also aims to increase the number of postdoctoral positions, the number of graduate students, and its available resources so that it can continue and expand its cutting-edge work in a variety of areas. Graduate students are involved not only in the department's research and teaching activities, but also in helping chart its course. They serve on several important committees and help organize seminars and lunches as well as recruiting and orientation events. Their experience and curiosity bring invigoration to the department and create another level of support for undergraduates.

In addition to faculty work and graduate student training, Brown's Computer Science Department also places equal emphasis on maintaining the quality of its highly ranked undergraduate programs. Members of the department understand that a top-notch faculty and exciting learning opportunities will attract the most promising undergraduate students to the computer science program.

Renovating the Thomas J. Watson Sr. Center for Information Technology

When it opened in 1988, the award-winning Watson Center for Information Technology housed both the Computer Science Department and Brown's Computer Information Services. In 2004, the University moved Computer Information Services to another location and dedicated the full space in the Watson Center to the Computer Science Department. The space has been redesigned to accommodate multidisciplinary research groups and students in related concentrations who must collaborate on projects.

The renovation, estimated at a total cost of $2.5 million, enhances every aspect of computer science education at Brown. It opens space on the 3rd, 4th, and 5th floors for modern technology and classrooms. Specifically, the renovation includes a state-of-the-art motion-capture laboratory, an algorithms laboratory, an Internet laboratory, and two systems laboratories.

The work also creates modern, integrated office space for new faculty, staff, graduate students, and undergraduate teaching assistants. In keeping with the notion of a community of collaboration, the faculty, staff, and student offices are now intermixed and open onto lounges and meeting areas. The meeting and study space in the building has also been expanded to promote faculty and student interaction. The redesigned space contains group working areas, comfortable chairs, large tables, and whiteboards for idea sharing. Refurbished conference space for symposia and graduate and undergraduate functions also contribute to increased collegiality.

A gift to the Computer Science Department's fundraising initiative will directly benefit the faculty members and students who drive the ongoing, innovative work in this discipline. Support for this priority also goes straight to the heart of Brown University's overall mission—to foster the intellectual and personal growth of our students and to collaborate on solutions to problems that affect our neighborhoods, our nation, and the world.

Alumni Happenings

Alumni discussion and networking groups

Join the CS discussion groups and stay in touch with each other and the department. "Lubrano" is a moderated e-mail announcement list promoting employment opportunities, professional development and continuing education offerings. To learn more and subscribe, visit: http://groups.yahoo.com/group/cslubrano/

"CS Atrium" is an unmoderated networking and discussion forum promoting professional and personal communication among alumni. Conversation is not limited to technical matters! To learn more and subscribe, visit: http://groups.yahoo.com/group/CSAtrium/

Conduit wants your stories!

If you enjoy reading Conduit, you'll have even more fun writing for Conduit! Your stories, research, news and photographs are always appreciated. If you have ideas, suggestions, or would like to contribute, please contact Laura Zurowski at lpz@cs.brown.edu.

December IPP Symposium

Managing the Fire Hose
Hosted by Professor Stan Zdonik
Tuesday, December 6th, 8:30am-6:00pm

This event is open to all alums. Attendance is free for all employees of our Industrial Partners Program (member list is located on page 29). To reserve a seat, email Laura Zurowski at lpz@cs.brown.edu. If you are not an employee of a partner company, but would like to attend the symposium, a suggested donation amount and payment instructions will be sent to you.

Abstract information and participating panelists can be found at: http://www.cs.brown.edu/events/talks/ipp.symp.html

Reunion 2006

Be sure to save Saturday, May 27th for the 2nd annual CS reunion and networking reception. Invitations and more information will be heading your way in the early months of 2006...

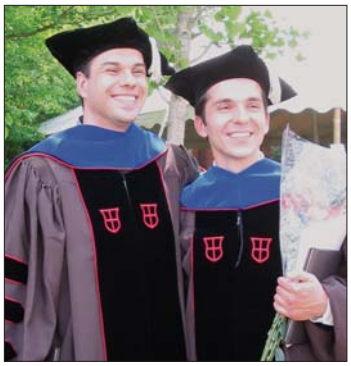







A very big Thank You! to everyone who attended the "first ever" computer science reunion and networking reception. Over 300 alums, faculty and friends stopped by to tour the newly renovated 3rd floor, eat, drink, socialize, and listen to some great live music (and a few people even danced!) We look forward to seeing you again in May 2006!

Fifth Annual Paris C. Kanellakis Memorial Lecture



ABOVE Kanellakis Fellowship and Computer Science PhD recipients Emmanuel Renieris and Ioannis Tsochantaridis are all smiles following the 2005 graduate school commencement ceremony.

"Geometric Optics, Linear Programming and Congestion in Sensornets"

Richard Karp, UC Berkeley
Thursday, December 8, 2005 at 4:00 P.M.
Room 368 (CIT 3rd Floor)
Host: Professor Philip Klein

We consider the problem of routing in a geographically distributed network of processors to minimize the maximum congestion at any node, or to optimize the trade-off between average path delay and maximum congestion. Instead of assuming a discrete model with nodes at known positions, we assume that the density of nodes is so large that we can adopt a continuous model, in which each communication path is a continuous curve in a region of the plane and congestion at a point corresponds to the limiting density of paths in a neighborhood of the point. Using an argument based on linear programming, we show that the problem is isomorphic to a problem in geometric optics, in which we interpret the communication paths as the minimum-time paths followed by light rays in a medium where the speed of light varies continuously. Our problem is then to specify the speed of light as a function of position so that the resulting minimum-time paths minimize maximum congestion. Once this function has been specified, the computation of minimum-time paths is a standard problem in the calculus of variations, but the problem of specifying the function is novel, and we give an approach based on the primal-dual algorithm of linear programming. The discussion will be accessible without requiring knowledge of calculus of variations or linear programming.

This is joint work with Christos Papadimitriou, Lucian Popa and Afshin Rostami.

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

Department of Computer Science
Brown University
Box 1910
Providence, RI 02912
USA