It is certainly a pleasure chairing the Department of Computer Science at UC Davis, and I have enjoyed my first year in this position. The friendly and nurturing environment created our faculty, staff, and students makes this a better place.

The economic downturn has certainly impacted our resources and raised new challenges. While enduring the extra burden, we are continually making progress in enhancing the quality of our education and research.

Last year we had a successful recruitment effort. We were able to attract Dr. Ilias Tagkopoulos from Princeton University in the area of Computational Biology. After a one-year deferral, Ilias will be joining us starting July 1, 2009. I join our faculty, staff and students to welcome Ilias to our campus.

Our faculty has been making exceptional progress in their research efforts. The research expenditures during the 2007-08 fiscal year grew by about 60% from the previous year. Activities related to proposals and projects have gone up significantly and our faculty must be commended for their continued efforts. Highlights of some of these efforts are outlined in this newsletter.

We are seeing a change in the trend with a slight increase in the number of incoming undergraduate students. The size of our graduate program continues to be on the rise. Among other activities, we are planning on revamping our undergraduate curriculum by including areas of specialization that can be optionally pursued by the students. We are also in the process of formalizing the Senior Design Projects so our graduates will be better prepared to meet the needs of the industry and future of academia.

Involvement and support from our alumni will help us in a multitude of ways. I sincerely request our alums to email me their feedback and suggestions on how we can do better.

I invite you all to take a browse through our web site (www.cs.ucdavis.edu) and email me your suggestions and comments.

Sincerely,

Prasant Mohapatra
prasant@cs.ucdavis.edu
Navigating Immense Oceans of Data

“We are in the midst of an amazing technical revolution, particularly in the life sciences,” said Bernd Hamann, professor of computer science and associate vice chancellor for research in the UC Davis Office of Research. “Researchers are producing peta-, tera- and exa-scale data sets, big numbers; we cannot even conceive what these numbers mean,” he said. In fact, the world is swamped with digital information. “The problem is what to do with it all.” The situation poses intriguing challenges and opportunities for computer scientists who must develop ways to analyze, visualize and interact with the oceans of information.

“In fact, I think we have passed the break-even point,” Hamann said. “We are producing more data than the human mind can process in any meaningful way.”

However, engineers like Hamann are devising ways to transform information into computer graphics that reveal patterns and relationships. “But we have gone beyond that,” Hamann said. “We have created interactive real-time visualization systems that take the fullest advantage of the human visual system to comprehend complicated structures in three dimensions.” The Division of Mathematics and Physical Sciences, in collaboration with the College of Engineering, has developed the Keck CAVES (Center for Active Visualization in the Earth Sciences), a roomsized virtual environment that allows human beings to immerse themselves in a three-dimensional crystal, for example, zooming in and out, up and down, examining atoms and molecular bonds. Hamann is a lead researcher for the Keck CAVES team that is directed by geology professor Louise Kellogg.

We certainly already have very good statistical methods and automated data analysis systems,” Hamann said. “But this state-of-the-art technology takes advantage of the fact that the human visual system is still the best way to pick out the most interesting parts of three-dimensional data sets.” The Keck CAVES experience will also expand understanding of how the human brain and eyes process information. “Someday we will be able to model the human cognitive process and design computer systems that can do this just as well. But we are far, far away from that.”

In fact, data visualization itself is still a relatively new discipline, said computer science professor Kwan-Liu Ma. It builds upon knowledge from several areas of study, including computer science, signal processing, statistics, visual perception, art, and others. “I see this as the future of engineering research and education. We must cross over the boundaries of disciplines,” Ma said. “Something the College already does very well.”

Data visualization can manifest complex relationships and processes, reduce search time and memory load, and allow perceptual inference,” Ma said. “In the context of scientific discovery, these pictures enable scientists to not only validate their hypothesis but also see the previously unseen.”
Detecting the Onset of Alzheimer’s Disease

Researchers at UC Davis have launched an innovative study to determine whether closer examination of magnetic resonance imaging (MRI) scans can detect the onset of Alzheimer’s disease even before patients begin to show the symptoms of cognitive decline that are the hallmarks of the condition.

The study will also look at whether MRI scan analysis can be used to predict the likely rate at which Alzheimer’s disease patients’ brains will deteriorate, and how quickly they will lose their ability to think and reason.

“We want to ‘squeeze more juice’ out of brain MRIs that are used to detect the presence of Alzheimer’s disease,” said Owen Carmichael, an assistant professor in the Department of Neurology and adjunct professor in Computer Science. “We also want to predict the likely rate of decline.”

Alzheimer’s is a progressive and fatal brain disease affecting as many as 5 million Americans. It destroys brain cells, causing problems with cognition — memory, logical reasoning, and other mental skills. It is the most common form of dementia, and there is no cure.

There also is no definitive way of determining whether or not a person has Alzheimer’s. Currently, physicians ask patients to perform a series of cognitive tests to diagnose the condition. But some loss of memory is normal in healthy aging individuals, so it can be difficult early on to determine whether or not a person has Alzheimer’s.

MRI imaging is used to detect atrophy of a portion of the brain called the hippocampus, which is vital to learning and memory. But some atrophy — or shrinkage — of the hippocampus occurs in normal aging. Carmichael, who is the principal investigator for the study, hopes to use MRI to detect the distinct pattern of shrinkage across the hippocampus that occurs in Alzheimer’s.

“Alzheimer’s disease tends to make the hippocampus atrophy in a specific pattern — it spreads from one hippocampus region to another, killing cells as it goes. We can quantify not only the overall size of the hippocampus, but also local patters of hippocampus damage. That’s what I mean by ‘squeezing more juice’ out of the MRIs,” he said.

Carmichael and his colleagues will test a new, computational method of measuring atrophy in various sub-regions of the hippocampus to see whether Alzheimer’s produces distinct spatial patterns of hippocampal atrophy that would distinguish it from patterns of mild cognitive impairment found in normal aging.

“We hope that, using this technique, we can provide a method for differentiating people who will experience healthy cognitive aging from those who will experience cognitive decline due to diseases like Alzheimer’s. For those who will experience cognitive decline, we hope to predict its rate of progression,” Carmichael said.

The researchers will test the efficacy of the new computational MRI imaging method, called Localized Components and Analysis (LoCA), developed by Carmichael and colleagues Nina Amenta, an associate professor in the Department of Computer Science, and computer science graduate student Dan Alcantara.

The researchers will use LoCA to analyze MRI scans of 800 adults who are part of a large, publicly available database called the Alzheimer’s Disease Neuroimaging Initiative (ADNI). The database contains more than 4,000 MRI scans of the brains of Alzheimer’s patients, adults with mild cognitive impairment, and those without symptoms. They will examine whether the spatial patterns of hippocampal atrophy differ among the three groups.

They also will analyze in more detail the MRI brain scans of adults who underwent expensive, experimental imaging tests that try to detect aspects of Alzheimer’s pathology in the brain, to determine whether LoCA can tell the difference between those who appear to have the pathology, and those that do not. They will use the results of these comparisons to analyze additional MRI scans from the ADNI database, to see whether the method can predict rates of cognitive decline in Alzheimer’s.

“Once diagnosed, patients, physicians and families have no reliable method for anticipating how fast cognitive functioning will decline,” Carmichael said. “We hope that this method will change that.”

The study is funded by a three-year, $200,000 grant from the Dana Foundation, http://www.dana.org/.

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News & Awards

A Game Changing Performance

Dr. Kwan-Liu Ma is a game-changer, according to Hewlett-Packard. His research into “Visual Analytics Tools for Enterprise Information Management” was recently recognized with a 2008 Innovation Research Award from HP Labs, the company’s central research arm. This international competition - dubbed “the Olympics of research” by Prith Banerjee, director of HP Labs and senior vice president for research - was launched to promote innovation through collaborative research between industry and academia.

The Best and the Brightest

HP selected 41 professors from 14 countries doing research projects at 34 of the world’s top technical universities to receive these inaugural awards.

“Around the world, HP partners with the best and the brightest in industry and academia to drive open innovation and set the agenda for breakthrough technologies that are designed to change the world,” explained Banerjee. “HP Labs’ selection of UC Davis for a 2008 Innovation Award demonstrates outstanding achievement and will help accelerate HP Labs’ global research agenda in pursuit of scientific breakthroughs.”

Industry-Relevant Research

Awardees like Professor Ma will be funded to investigate some of the world’s most relevant business and technological challenges. HP anticipates their work will lead to innovative solutions in the areas of information explosion, dynamic cloud services, content transformation, intelligent infrastructure and sustainability.

Information Management

Information is the engine driving today’s enterprise. Managing that information is critical to the success of the modern organization. Providing the next generation of information management and knowledge discovery tools is the critical challenge facing the world. Professor Ma proposes to help solve this pressing problem by developing “interactive visualization techniques that can help manage and make sense of large unstructured, heterogeneous, and multidimensional data.”

Professor Ma received an award of $50,000 for the first year, which will support his research and the work of one post-doctoral candidate. The award can be renewed for a total of three years based on research results. With this award and recognition, Professor Ma continues to support the College of Engineering’s visionary plan to meet the information technology challenges of today and the next 50 years through innovative research, quality education, interdisciplinary collaboration, and strategic growth.

Welcome New Faculty

Ilias Tagkopolous

I have completed my PhD in the Department of Electrical Engineering at Princeton University in summer 2008. My research interests lie in the realm of quantitative and computational biology. I am particularly interested in exploiting engineering methods to study biological systems. During my PhD, I was working in the laboratory of Saeed Tavazoie. My first experience with biological modeling and computational biology was during my M.Sc. in Columbia University, where I worked closely with professors C. Zukowski (EE) and D. Anastassiou (EE) on developing a mixed signal IC that can simulate elementary gene regulatory and biochemical networks. After coming to Princeton, I collaborated closely with professor R. Weiss (EE) on stem cell differentiation/pattern formation and worked with professor D. Tank (Molbio) on the development and implementation of a wireless implantable electrode. Additionally I worked on a few other bioinformatics projects (clustering and classification of biological data) with prof. SY Kung (EE), Y. Kang (Molbio) and prof. D. Serpanos (EE).
Visualizing Open Source Software Development

CS graduate student Michael Ogawa has created short, colorful movies that show the development of open source software. With dancing points of light, rings of color and a soundtrack, the Code_swarm animations show how software such as the Python scripting language and the Apache Web server have developed from the contributions of different programmers.

Inspired by music videos, the objective of Code_swarm is to create an engaging visual representation of computer software accessible to anyone, said Michael Ogawa, who created the movies in the laboratory of Professor Kwan-Liu Ma at the UC Davis Department of Computer Science.

Computer software projects are among the most complex artifacts ever created by humans. Some of the most complex are “open source” programs that are created by a floating group of volunteers developing and making changes to different parts of the code.

In Ogawa’s videos, the names of those developers float across the screen and fade away if they stop contributing. Colored dots, representing new files, appear in random locations and fly toward the developer working on them, forming rings around the names. Developers working on the same or related files hover together; the names of those working on different parts of the software are farther apart.

“The viewer gets an impression of the dynamics of the project: Who the big players are, whether they work on the same or separate files and the scale of the project in time and space,” Ogawa said.

The animations show that there is no single, signature way to create open source software, Ogawa said. Some projects are the work of a single person for long stretches of time, some are guided by a small group and others are regularly worked on by a large group.

Ogawa calls Code_swarm an example of “organic information visualization,” which turns data into a living, breathing system. He chose music videos as a model for the final product because they are short, dynamic and interesting, in contrast with most academic videos, he said.

The Code_swarm software itself is now open source, hosted by Google Code. Examples of the videos can be found at http://vis.cs.ucdavis.edu/~ogawa/codeswarm/.

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“I’ve been studying software projects for a while now. Not the programming, but the people -- the way they interact with each other through collaboration and communication. My investigations have always been visual: I’ve built applications that create pictures of what is happening within software projects. But they have always had a rigid structure to them. Organic information visualization, coined by Ben Fry, is a different approach to information visualization. It eschews traditional data confinement in space and lets the elements play together in freeform and unpredictable ways. “

- Michael Ogawa
Researchers have hope of cheap, distributed zero-day worm defense

by Tim Greene

This article examines research completed by Senthil Cheetancheri (right), a former CS graduate student at UC Davis, which stated that zero-day computer attacks could be shut down by using inexpensive peer-to-peer software. This article was translated into multiple languages, appearing on Network World sites across the world.

Shutting down zero-day computer attacks could be carried out inexpensively by peer-to-peer software that shares information about anomalous behavior, say researchers at the University of California at Davis.

The software would interact with existing personal firewalls and intrusion detection systems to gather data about anomalous behavior, says Senthil Cheetancheri, the lead researcher on the project he undertook as a grad student at UC Davis from 2004 to 2007. He now works for SonicWall. (Learn more about intrusion detection and prevention products.)

The software would share this data with randomly selected peer machines to determine how prevalent the suspicious activity was, he says. If many machines experience the identical traffic, that increases the likelihood that it represents a new attack for which the machines have no signature.

The specific goal would be to detect self-propagating worms that conventional security products have not seen before.

“It depends on the number of events and the number of computers polled, but if there is a sufficient number of such samples, you can say with some degree of certainty that it is a worm,” Cheetancheri says. For that decision, the software uses a well-established statistical technique called sequential hypothesis testing, he says.

The detection system is decentralized to avoid a single point of failure that an attacker might target, he says. The task then becomes what to do about it, he says. In some cases, the cost of a computer being infected with a worm might be lower than the cost of shutting it down, in which case it makes sense to leave it running until a convenient time to clean up the worm, he says.

In other cases, the cost to the business of the worm remaining active might exceed the cost of removing the infected machine from the network, he says.

That cost-benefit analysis would be simple to carry out, he says, but network executives would have to determine the monetary costs and enter them into the software configuration so it can do its calculations he says.

End users would not program or modify the core detection engine, he says. “We don’t want to have humans in the loop,” he says.

He says he and his fellow researchers have set up an experimental detection engine, but it would have to be modified to run on computers in a live network without interfering with other applications and without being intrusive to end users, Cheetancheri says.

So far no one he knows of is working on commercializing the idea.

The software would be inexpensive because it would require no maintenance other than to enter the cost of each computer being disconnected from the network.
m4d c0wZ represent UC Davis at iCTF competition

Recently, 20 computer science graduate students, under the guise of the “m4d c0wZ,” represented UC Davis and participated in the 2008 UCSB International Capture The Flag (iCTF) Competition.

This event, which was essentially a multi-site, multi-team, international, organized hacking contest, involved 39 teams composed of graduate students from universities around the world, including groups from Russia, Italy, Germany, Austria, Argentina, Australia, and France. It traditionally involves a combination of “offensive” hacking to “capture a flag” (achieve some set of goals), defensive techniques (without causing denial of service), and solving a series of “challenges” (e.g., forensics, trivia). The UC Davis m4d c0wZ scored in the top half of the 39 universities, tying (after a technicality) with “The Tower of Hanoi” from Politecnico di Milano, Italy. This year’s winners were from Technische Universitaet in Berlin, Germany.

The team had a core of Security Lab students, but also had students from Theory, Visualization, and others who simply wanted to join in with fellow graduate students and put their heads together for this event. Several small groups worked to analyze a remote system, break into that system as stealthily as possible (detection causes points to be lost) and “defuse” a digital “bomb,” while several more groups worked to solve a series of mind-bending challenges. For example, one challenge involved an AVI movie file that they discovered had an unusual component in the middle. Decrypting the component involved an “instruction” suggesting that the “octalpus may have flipped the bits.” Finding another unusual portion of the file, the students wrote a program to invert every bit of the unusual part. But the result was unrecognizable. Was it another AVI movie? Yes it was. showing a guy (the “octalpus”) looking around the screen and occasionally opening his mouth with telephone tones coming out. One of the students slowed down the tones, downloaded a DTMF decoder, and fed the tones in. Another student decoded the resulting numbers from octal to ASCII and discovered that the octalpus was saying “w00t w00t w00t”. And what of the groups breaking into the remote system? They obtained root access and the ability to issue arbitrary commands, of course.

Recent Announcements

Ph.D. student Mark Gabel received a highly competitive 2008 Achievement Rewards for College Scientists (ARCS) Foundation Fellowship Award to recognize his outstanding academic achievements. The ARCS Foundation, Inc. is a national, nonprofit organization dedicated to raising funds for financial assistance to gifted and deserving students in the physical sciences and engineering.

Professor Zhendong Su has received an IBM Software Quality Innovation Award in the amount of $25,000 to support his research. “This award is highly competitive and recognizes the quality of Dr. Su’s program and its importance to this industry,” according to IBM, proposals for this program are invited from a few, carefully selected leaders in the field. These proposals are judged on technical merits and potential collaboration opportunities between faculty members and researchers at IBM.

The Office of Naval Research has funded the basic research of Professor Ian Davidson for $355,000 over 2.5 years. The research will fund Professor Davidson and two graduate students exploring the design of autonomous data mining algorithm and the analysis of performance bounds. ONR aims to apply these techniques to problems of predicting adversarial behavior.

SynapSense Corporation, cofounded by CS Associate Professor Raju Pandey and a leading provider of wireless energy efficiency solutions for the data center, recently announced that the company has received $7 million in additional investments. Capital GmbH joins SynapSense’s current investors participating in this financing, which include Emerald Technology Ventures, Sequoia Capital, American River Ventures, Nth Power and DFJ Frontier. SynapSense will use the proceeds from this investment to further technology development and expand market leadership of the company’s Wireless Data Center Monitoring and Energy Management solutions. Based in Folsom, Calif., SynapSense is a recipient of the United States Department of Energy 2008 Energy Innovator Award. For more information about SynapSense, visit www.SynapSense.com.
Our research program focuses on understanding macromolecular structures. We are interested in characterizing their shapes, and use this information to improve our understanding of their stability. We are also interested in characterizing the subset of sequence space compatible with a protein or nucleic acid structure: this is an indirect approach to understanding sequence evolution, both at the RNA and protein level. In parallel, we are involved in the development of new algorithms for predicting the structure of a protein, based on its sequence.

The genetic information encoded in the genome of an organism represents the blueprint for its development and activity; its implementation depends on the functions of the corresponding gene products (i.e., nucleic acids and proteins). Among these products, proteins play a central role as they catalyze most biochemical reactions, and are responsible, among other functions, for the transport of nutrients and for signal transmission within and between cells.

It is well-known that proteins function because they adopt a unique, native 3D conformation. While a direct relationship between sequence similarity and conservation of 3D structure has been clearly established for proteins, the relationship between their 3D structures and functions is much more complex. This complexity calls for more rigorous descriptions of molecular and cellular functions, and a better understanding of sequence-structure-function relationships. Efforts to unravel the latter currently focus on protein sequence analysis, as a consequence of the wealth of sequence data resulting from various genome projects. Data produced by these projects have already lead to significant improvement in predictions of both 3D structures and functions. However, we still stand at the dawn of understanding the information encoded in the sequence of a gene. In this paper, we focus on protein sequence representations and show how visualization can play a role in decoding gene information content.