UNIVERSITY OF MINNESOTA

Department of

Computer Science & Engineering

at the University of Minnesota

40 Years of EXCELLENCE

PHOTO BY PATRICK O'LEARY

INSTITUTE OF TECHNOLOGY
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PHOTO BY RICHARD G. ANDERSON

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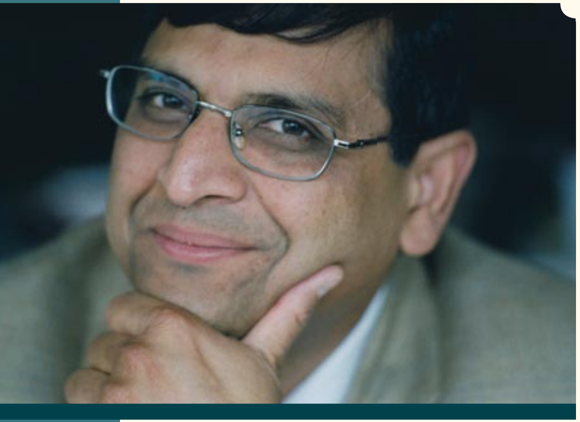


A Message from the Department Head

The University of Minnesota's Computer Science and Engineering (CSE) department has reached an important milestone – its 40th anniversary. From its modest beginnings as a graduate program in 1967, it has become one of the most interdisciplinary and dynamic departments in the college, University, and the computer science field.

The CSE department builds upon the glorious history of computing in Minnesota, which includes the first general purpose computer, Atlas, developed by Engineering Research Associates (ERA), a number of computing giants, including Unisys, Control Data, and Cray Research, as well as a thriving software industry.

The department has grown to almost 40 faculty members who provide leadership and expertise in nearly all major areas of computer science and engineering. Annual research expenditure has steadily grown, and is currently around $8 million.

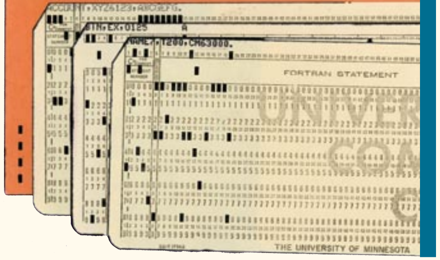
In 2007, CSE was ranked third in the Faculty Scholarly Productivity Index in a study reported in *Chronicles of Higher Education* and ranked ninth for Citation Impact of Published Research Papers by *Science Watch*. CSE is one of only five computer science departments in the nation with multiple recipients of the Presidential Early Career Award for Scientists and Engineers (PECASE).

Over the past 40 years, accomplishments of our faculty, students, and alumni have advanced the field of computer science and expanded its boundaries. Their hard work, an enterprising spirit, and numerous accomplishments have played a key role in defining the department. Books and software authored by CSE faculty, students, and alumni are used worldwide. They have also co-founded numerous successful companies.

Research conducted in the department receives frequent coverage in national and international popular media and is highlighted by funding agencies such as the Army, NSF, and NASA. The department is very proud of the accomplishments of its faculty and students who played a part in this distinguished and still-growing legacy.

This booklet has been prepared to commemorate this milestone and to highlight the major achievements and accomplishments of the department. We hope that you will enjoy reading this booklet and will share it with others who are interested in learning about CSE at the University of Minnesota.

— Vipin Kumar, CSE Department Head and William Norris Professor



A History of Innovation: 40 Years of Excellence

IN THE CSE DEPARTMENT

PHOTO BY PATRICK O'LEARY

From punch cards to multicore processors, computer science and engineering at the University of Minnesota has come a long way. In fact, the inception of the department can be traced back decades to the early days of computing, in which many Minnesotans played a pivotal role.

EARLY DAYS OF COMPUTING

In this country, computers began as general purpose programmable devices almost exclusively used for code breaking for the National Security Agency NSA and the Navy during World War II. After this, men and women trained by the military in the operation and design of computing devices moved to companies that were primarily contractors for the NSA.

In Minnesota, the history of computing can be traced back to this post war era, when some of the most advanced computers were being developed in St. Paul by the Engineering Research Association ERA . Co founded by computer pioneer and visionary William Norris and comprised of several engineering graduates of the University, including Seymour Cray, ERA was a dominant player in the nascent computing industry of the time. ERA also holds the claim of developing the first general purpose computer, Atlas 1, delivered to NSA in 1950 – a fact that remains largely unknown, since Atlas was classified until 1977. Several of the computer industry power houses in the 60-year history of computing can be traced to

ERA, including Unisys, Control Data Corporation CDC , and Cray Research.

Meanwhile on the University campus, there was a growing interest in computing and its application to mathematics, physics, chemistry, and economics. Several departments, along with local companies like Honeywell Aeronautics, were making use of the University's Reeves Electronic Analog Computer (REAC), which was state-of-the-art in 1949. The REAC was in constant demand and it soon became clear that the University needed to expand its resources. In 1955, a gift of 400 hours of usage on the ERA 1103 from Sperry-UNIVAC, a company formed by the merger of ERA and Eckert Mauchly Computer Corporation, sparked the beginnings of the Department of Computer Science.

The University needed a director to manage the new gift and other computing resources – enter Professor Marvin L. Stein, hired as a professor in the Mathematics department in 1955 and named to fill this position (see interview on page 8). Upon arrival, Stein immediately began the development and instruction of a course in high speed computation, which some consider to be the start of the University's computer science curriculum.

Throughout the next 10 years at the University interest in computing and the acquisition of computing devices continued to grow. In 1958, the University acquired its first digital computer – a UNIVAC 1103, housed in the Numerical Analysis Center in the Experimental Engineering building, a site now occupied by the Departments of Computer Science and Engineering (CSE) and Electrical and Computer Engineering (ECE). The acquisition of the UNIVAC 1103 and other computers led to increased computer use on campus and additional computer classes being offered by the Institute of Technology's (IT) Mathematics department.

The Early Years

1947 The University introduces new numerical analysis and control devices courses.

1955 The University gains time on a ERA 1103 computer.

The Mathematics department creates a high-speed calculator computation class.

1958 The University acquires a UNIVAC 1103 computer.

BIRTH OF THE DEPARTMENT

In response to the increasing focus on computational research and education not covered in the mathematics program, in 1967 the University of Minnesota established a graduate program for Computer and Information Sciences. Professor William D. Munro served as the Director of Graduate studies. By 1969, several students were awarded master's degrees, and the first doctorate degree in computer science was awarded to Duane Zimmerman. The Numerical Analysis Center was also renamed the University Computer Center during this time to reflect the changing focus and responsibilities of the center.

In the spring of 1970, the University formally established the Department of Computer Science. Stein served as acting department head, until the fall of 1971 when Professor J. Ben Rosen replaced Stein as head of the newly established department. By the late 1970s, the department also offered two bachelor's degree programs in IT and the College of Liberal Arts CLA . The department was recognized as a leader in the area of numerical analysis, one of the major areas of research in computer science at the time, which also served as the foundation for the field of computational science.

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
The University establishes a Computer and Information Sciences graduate program.		Department awards first master's and doctoral degrees.	First academic year for the department.					The department forms the Computer Science Associates (CSA) group.	

Construction of the new Computer Science building underway, circa mid-1980s.

IMAGE COURTESY OF UNIVERSITY ARCHIVES

THE FORMATIVE YEARS

The 1970s and 1980s were times of tremendous growth and excitement in the field of computing throughout the world. The Twin Cities and the surrounding areas were a major hub of the computing industry with headquarters or a significant presence of computing giants such as CDC, Cray Research, Honeywell, IBM, and Unisys. This unique environment continued to provide a significant boost to the computing related research and academic activities at the University and in the department.

The presence of supercomputing industry leaders in the area, such as CDC and Cray, helped the University attain a leadership position in high performance computing. In 1981, the University became the first academic institution to acquire a Cray-1, widely considered the world's first super computer. A few years later, the University of Minnesota Supercomputing Institute MSI was founded with the mis sion of serving as a focal point for collaborative research on supercomputing within the University and the state. MSI helped attract many leaders in computational research to Minnesota, including CSE faculty and former department head, Yousef Saad. Many CSE faculty served as founding fel lows of the institute and continue to play a major role in its research activities.

To nurture and maintain a strong relationship with the local computing community, the department founded the Computer Science Associates (CSA) group in 1975. The group consisted of representatives from local indus try, including CDC, Cray Research, Honeywell, IBM, and Unisys. Since then, the group has grown significantly and continues to advise, assist, and support CSE in identifying

CSE EXCELLENCE: BY THE NUMBERS

- Ranked 3rd in the Faculty Scholarly Productivity Index. (*Chronicles of Higher Education*, January 2007)
- Ranked 9th for Citation Impact of Published Research Papers. (*Science Watch*, January 2007)
- Current department faculty members have authored more than 2,500 refereed publications, including 800 journal articles.
- CSE faculty are among the most cited authors. More than 11,000 citations of just 10 CSE faculty authored papers and books. (Google Scholar, August 2007)
- Ranked 15th for annual number of conferred doctorates. (*CRA Research News*, January 2007)
- 16 CSE faculty members received the NSF Faculty Early Career Development (CAREER) Award, since the inception of the program in 1995. This number of awards is among the highest for Computer Science departments nationwide.
- One of only five CSE departments in the nation with multiple recipients of the Presidential Early Career Award for Scientists and Engineers (PECASE).
- Alumni have founded more than 180 companies.

IMAGE COURTESY OF MARVIN STEIN

Interim IT Dean Frank Verbrugge (left) and Marvin Stein (right) inspecting magnetic tape.

1977

1978

1979

1980

1981 — Cray Research Inc. endows a $100,000 lecture series.

The University Supercomputing Institute (MSI) acquires a Cray-1 supercomputer.

1982

1983 — The department showcases research in its first Research Review Symposium.

1984

1985 — The department receives $3.62 million NSF CER grant. (See page 6)

needs of Minnesota businesses and industry, as well as pro mote a better public understanding of the department and its programs in the community.

The department has benefited from strong local high-technology companies in many ways, including their financial support for various programs. In 1981, a $100,000 donation from Cray Research Inc. launched the Cray Distinguished Speaker Series, which continues to bring world leaders in computer science to the University of Minnesota. Generous endowments from CDC and Qwest formerly US West established the William Norris Chair in large scale comput ing and the Qwest endowed Chair in networking and tele communications. Both of these endowments have helped to recruit and retain distinguished faculty in the department.

During this time, computer science departments nation wide continued to grow and evolve in response to the changing needs of the fast growing computing field. Class enrollments swelled, but there was a shortage of faculty, and laboratory facilities were inadequate for teaching and research at most universities. At the University, Lind Hall, home of the computer science department, was becoming inadequate for the rapidly expanding department.

The Minnesota Legislature recognized the importance of good facilities for a strong computer science department, and in 1985 allocated $42.8 million to build a 160,000-square-foot Electrical Engineering and Computer Science building. The two departments moved into the new building, completed in 1989, enabling frequent research collaborations across the departments. In addition to new facilities, the depart ment also won a large infrastructure research grant from the highly competitive Coordinated Experimental Research CER program of the National Science Foundation NSF in 1985. This high performance computing research project, headed by Professor Sartaj Sahni, was followed by additional large infrastructure grants from NSF in 1994 and 1995, led by Professors Ahmed Sameh and David Du, respectively.

In 1989, high-performance computing (HPC) research at the University received a major boost with the Army's award of a five-year, $65 million HPC Research Center (AHPCRC), which was competitively renewed twice. CSE faculty made significant contributions to the center's interdisciplinary research, and led the center as directors for nine years dur ing its 18 years at the University.

Building on the rich history of computing in Minnesota, in 1980 the University of Minnesota's Charles Babbage Institute CBI took on the role of preserving information related to the development of computing in Minnesota and throughout the world. CSE Professor Arthur Norberg served as the founding director of CBI, which continues to archive and research the history of computing worldwide.

Faculty Awards

NATIONAL AND INTERNATIONAL AWARDS

1 AAAS Fellow
1 ACM Fellow
6 IEEE Fellows
2 ACM Distinguished Engineers, Scientists, and Members
2 IEEE Technical Achievement Awards
16 NSF CAREER Awards
2 PECASE Awards

UNIVERSITY AWARDS

1 Award for Outstanding Contributions to Post-baccalaureate, Graduate, and Professional Education
1 Distinguished Women Scholar Award
1 Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education
1 Outstanding Mentor Award

HONORARY CHAIRS AND PROFESSORSHIPS

2 McKnight Professorships
9 McKnight Land-Grant Professorships
1 McKnight Presidential Fellows Award
1 IT Distinguished Professor
2 William Norris Land-Grant Chairs in Large-Scale Computing
2 Qwest Land-Grant Chairs in Telecommunications
1 ERA Land-Grant Chair in the History of Technology

COLLEGIATE AWARDS

1 George W. Taylor Award for Distinguished Research
2 George W. Taylor Career Development Awards
1 Charles E. Bowers Faculty Teaching Award
1 College of Continuing Education - Distinguished Teaching Award

1989

The Army awards the AHPCRC to the University. (See above)

The new building at 200 Union Street S.E. opens.

CDC establishes the William Norris Land-Grant Chair in Large-Scale Computing.

Qwest/U.S. West establishes the Land-Grant Chair in Telecommunications.

1986 1987 1988 1989 1990 1991 1992 1993 1994 1995

RECENT GROWTH

During the 1990s, the field of computing went through major transformations. Mainframe computers were largely eclipsed by those based on microprocessors, and the Internet changed the way society functioned. In the Twin Cities, this transformation led to considerable restructuring of the computing industry, into a large number of relatively small software companies.

The department went through a tremendous expansion over the past 15 years, benefiting from significant investments by the University and the state. The department grew from about 22 faculty members in 1992 to almost 40 today, and it significantly diversified its research interests into areas such as robotics, data mining, software engineering, human computer interaction, and emerging areas such as biomedical informatics. As a major contribution to this growth, the Minnesota Legislature granted 12 new faculty positions in response to a proposal by then department head Pen Chung Yew to improve the computing education and research infrastructure at the University.

The department also benefited from and contributed to the formation of the Digital Technology Center DTC , which integrates research, education, and outreach. The DTC was formed as part of a campus-wide initiative in 1997 by the University's then President Mark Yudof to reestablish Minnesota as a leader in areas of digital technology and to strengthen the state economy. Launched in 2002, the DTC fosters interdisciplinary and collaborative research across campus and with industry partners, to serve the educational and industrial needs of Minnesota and the nation. Since its inception, CSE faculty have played a significant role in DTC, including heading major industrial consortiums such as DISC (see page 10), the Center for Safety, Security, and Rescue Research Center (SSR-RC) (see page 11), and the DTC Data Mining Consortium DDMC .

To expand its scope in education and better serve the needs of the community, the department established a new master's degree program in software engineering MSSE in 1996. Started under the leadership of CSE Professor Mats Heimdahl, the MSSE program prepares students to become software engineering leaders, and continues to receive high marks from alumni and local industry. In 1997, the Computer Science and Electrical Engineering departments formed a joint program in computer engineering, resulting in a name change for both departments to the Department of Computer Science and Engineering CSE and the Department of Electrical and Computer Engineering ECE .

In 1997, the department hosted its first biennial open house to bring together alumni, industry friends, students, and faculty, and to showcase its research, education, and service activities. In 1999, the department established the CSE Distinguished Alumnus Award to be presented biennially to an accomplished graduate of the department. Ted Johnson (B.S.'82) was the first recipient of this award.


HOME PAGE
A NEWSLETTER FROM THE UNIVERSITY OF MINNESOTA DEPARTMENT OF COMPUTER SCIENCE
DMRC Grows Up

1996

Net Perceptions founded. (See page 9)

Masters of Science in Software Engineering (MSSE) program is created. (See page 14)

The department publishes its first newsletter, then called *Home Page*, later renamed *Soundbyte*.

1997

The department name changes to Computer Science and Engineering.

The first department Open House and Technology Forum.

1998

The department forms the Women in Computer Science group. (See page 15)

1999

Ted Johnson receives the first CSE Distinguished Alumnus Award.

The University creates an Institute of Technology minor requirement with all core courses from CSE.

2000

2001

Linda and Ted Johnson, an architecture and CSE alumnus, found the Digital Design Consortium (DDC).

2002

The Digital Technology Center (DTC) launched.

2003

2004

Administration of the MSSE Program moves to CSE.

The department creates the University of Minnesota Software Engineering Center (UMSEC).

POISED FOR THE FUTURE

Since its modest beginnings, the department has made tremendous progress and become one of the most vibrant and interdisciplinary departments in the college, University, and computer science field. Over the past four decades, the department has awarded more than 4,000 bachelor's, 1,400 master's, and 399 doctoral degrees. CSE faculty and graduates have formed more than 180 companies in Minnesota and beyond. Some examples are Visio Corporation, co founded by CSE alumnus Ted Johnson; Net Perceptions, co founded by Professors John Riedl, Joseph Konstan, and former graduate students Brad Miller and David Gardiner; and Recon Robotics, co founded by Professor Papanikolopoulos and his students (see page 10).

The department is very proud of the accomplishments of its faculty and alumni who played a part in this distinguished and growing legacy. The CSE department is truly poised for a bright future.

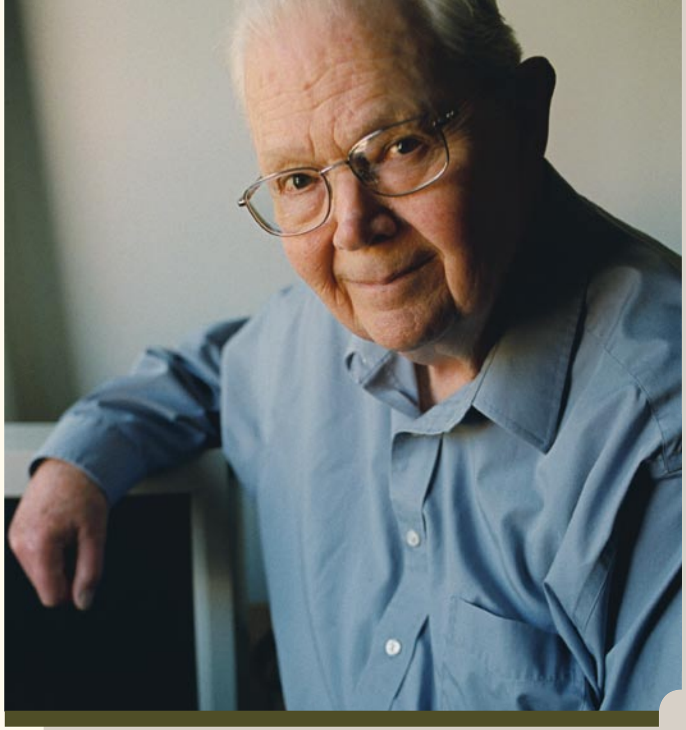


PHOTO BY RICHARD G. ANDERSON

Dr. Marvin Stein

CSE FOUNDER

No one knows the history of computer science at the University of Minnesota better than Professor Emeritus Marvin Stein, one of the founders of the department. Stein helped push University administration to see the importance of investing in the education of computing and computing research.

Stein joined the faculty at the University of Minnesota in 1955 following his doctoral work at the University of California Los Angeles UCLA . He worked on the foundations of matrix iterative methods that lie at the heart of computational modeling in modern engineering.

Stein said that back then the promise of computing was lost on some people, but he could see the potential. "People didn't think that working on machines to solve problems was a good idea," he said with a coy grin. At that time there were only six computers in the country and there were few classes on the subject. That was about to change.

In 1955, the University was granted 400 hours on a ERA 1103 computer. "The machine was about 60 feet long, weighed 17 tons, and was about 28 feet wide at its largest point," Stein said of the mammoth computer. Also during that year, the University's Mathematics department created a class for high speed computation. In the class, which Stein taught, students learned about the use of computing machines, called "electronic brains" by some at that time. Stein lobbied for the University to acquire more time on computing equipment and eventually to purchase its own computers, which it did later in 1958.

In the early 1960s, the University saw an increase in computer usage. Stein and a group of faculty members then began to notice the need for new areas of computational research not covered in mathematics. " Students wanted to be computer scientists, not mathematicians," he said. So, he and Munro lobbied the Institute of Technology for an official program, and soon it became a reality.

In 1967, the University authorized the establishment of a graduate program for Computer and Information Sciences. Munro served as the Director of Graduate studies. Thanks to Stein and Munro's persistence, by the spring of 1970 the new Department of Computer Science prepared for its first official academic year in 1970-1971. Stein served as acting department head, until Professor J. Ben Rosen became department head in the fall of 1971.

Stein continued on as a Professor until 1997, when he retired and became a Professor Emeritus. Now 83, he lives in a nearby campus neighborhood with his wife, Ruth, and is still no stranger to faculty and staff. When he's not in his CSE office, he said he spends as much time as he can with his grandchildren and great grandchildren.

The Security in Transportation Technology Research and Applications (SECTTRA) program is established.

Professor Nikolaos Papanikolopoulos and students found the company Recon Robotics. (See page 10)

The department marks its 40th anniversary at the open house.

2005 | 2006 | 2007

software & technologies

NET PERCEPTIONS

Building on their research success in collaborative filtering in the GroupLens project, Professors John Riedl and Joseph Konstan and graduate student Brad Miller pioneered the commercialization of recommender systems. In partnership with post doctoral student David Gardiner and University Psychology post doctoral student Steven Snyder, the group formed a company called Net Perceptions – one of the University's most successful information technology start-ups. The business quickly built a customer list of top tier Internet companies, including Amazon.com and CDnow, as well as traditional companies such as Brylane and GUS. These companies used the Net Perceptions software to recommend personalized information and product suggestions to their customers, based on the customers' purchase histories, browsing behavior, and product ratings. At its peak, Net Perceptions was one of Minnesota's leading information technology companies with a market capitalization of more than $1 billion.

NET PERCEPTIONS

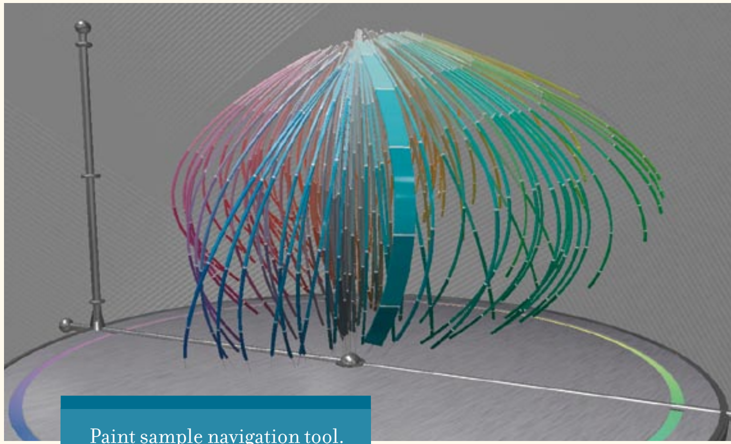
METIS: SOFTWARE FOR GRAPH PARTITIONING

Graph partitioning is central to a variety of applications in high performance computing, data mining, and computer aided design. Professors George Karypis and Vipin Kumar, along with their students, developed highly effective and efficient solutions for graph partitioning. Their software, called Metis and ParMetis, consists of serial and parallel partitioning libraries. These are used extensively, worldwide by academic institutions, national research labs e.g. Los Alamos, Lawrence Livermore, and Army Research Lab , and by commercial organizations under licensing agreements e.g. HP, Sun Microsystems, IBM, Boeing, Ford, NEC, and the Numerical Algorithms Group . These libraries have enabled parallel execution of some of the largest computational simulations performed to date, and they are routinely included in various Unix distributions, such as FreeBSD and Linux. Related work on hypergraph partitioning led to the hMetis library, which is considered state of the art in VLSI circuit partitioning. Papers by this group are among the most cited research articles in the area of graph and circuit partitioning, according to Google Scholar.

A PASSION FOR PAINT

Professor Gary Meyer and doctoral students Clement Shimizu and Seth Berrier created two software programs that can be used to adjust and manipulate paint complexity in different kinds of light, tweaking everything from hue and saturation, to gloss, and addressing the complexities in metallic paint – a unique feature of this technology. The software packages allow users to realistically visualize paint color on different surfaces under a variety of lighting conditions. In 2006, Meyer and Shimizu licensed their software to DuPont to aid in paint color development for the automotive industry. Meyer and Berrier also developed their software program for Benjamin Moore Paints in 2006, where it is used as a color selection tool in retail stores.

IMAGE COURTESY OF SETH BERRIER



Paint sample navigation tool.

AJANTA

Professor Anand Tripathi and doctoral student Neeran Karnik (Ph.D. '98) created Ajanta, a Java based system for programming secure mobile agent based applications over the Internet. A mobile agent is a transportable program in the network capable of migrating autonomously from node to node, performing computational tasks on behalf of a user. The Ajanta system provides mechanisms for secure and robust transportation and execution of mobile agents in the network. A few hundred researchers throughout the world have acquired the Ajanta system. It has been used for supporting research projects in network monitoring, pervasive computing, distributed collaboration systems, and active networking.

CLUTO

Professor George Karypis created CLUTO, a software package licensed by the University for data mining, clustering datasets of varying dimensions, and analyzing the characteristics of clustered data. CLUTO has three different classes of clustering algorithms and provides tools for analyzing the clusters to better understand the different clusters and the relation ships between the data assigned to each cluster. Since its release in 2002, CLUTO has become one of the most widely used software packages for clustering, especially for domains such as text mining and market basket analysis.

INTELLIGENT STORAGE

The University's Digital Technology Center Intelligent Storage Consortium DISC , led by Professor David Du, addresses problems related to the architecture and application of large scale, distributed storage systems. This premier research center brings together academia, industry, and public sector agencies to conduct advanced research with practical applica tions. DISC members have developed intelligent storage technologies, whereby networked devices have the ability to recognize, categorize, and modify locally stored data. These technologies translate to faster data retrieval from a more automated interface at lower cost. The group's key CSE participants include Professors Yongdae Kim, Jon Weissman, and Mohamed Mokbel.

PLANNING AN ESCAPE

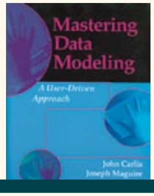
Professor Shashi Shekhar and his students developed the Capacity Constrained Route Planner CCRP algorithms and Web based software to identify routes and schedules to quickly move a large population of people either in or out of an area. Shekhar and his stu dents used this CCRP methodology to help the Minnesota Department of Transportation MnDoT prepare evacuation plans for the Twin Cities in 2005. In one example, Shekhar worked out an evacuation plan for the Monticello, Minn. nuclear power plant – the hypothetical disaster being an attack on the plant. The plan identified evacuation routes through nearby highways that limited congestion.

PDDP: SCALABLE CLUSTERING SOFTWARE

In 1998, Professor Daniel Boley developed Principal Direction Divisive Partitioning PDDP , a portable software package for unsupervised data mining. This fast, scalable approach can find unanticipated groupings within very large data sets. The software has been acquired by hundreds of users all over the world, and has been used in many applications from forest cover satellite data, to toxicology prediction for com mercial chemicals, to an analysis of the alcohol laws in all 50 United States.

BRINGING THE SCOUT TO THE MILITARY AND BEYOND

Professor Nikolaos Papanikolopoulos developed the COTS Scout robot with his students in 2002. The cylindrical, pint-sized robot can be thrown into hazardous environments and move around to provide visual feedback to a remote opera tor. Currently used by the military in reconnaissance mis sions, this technology puts robots, not soldiers, in harms way to gather visual intelligence. Manufactured from inex pensive, commercial off-the-shelf (COTS) components, the COTS Scout is a high tech, low cost version of the original University Scout developed in 1999 in cooperation with other CSE faculty and local industries. In 2006, Papanikolopoulos and students founded the company Recon Robotics, making the COTS Scout commercially available to military, police, and security agencies.

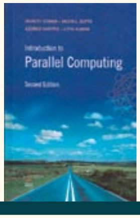


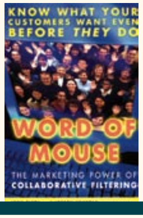
SAFETY AND SECURITY

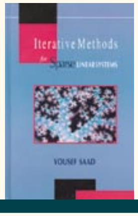
The National Science Foundation NSF Safety, Security and Rescue Research Center SSR RC is a consortium of universities and companies, directed by Professor Richard Voyles and Program Director Vassilios Morellas, with the participation of several CSE and ECE faculty members. The center's mission is to conduct medium term research for commercialization in robotics, video surveillance, wireless sensor networks, and related technologies in support of homeland security and emergency response. The center promotes the technology, provides training and education, and works closely with policy and decision makers to set research directions appropriate to the needs of the user community.

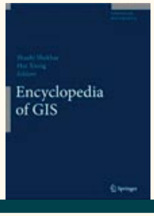
OPTIMIZING APPLICATION CODE FOR HIGHER PERFORMANCE

Professors Pen Chung Yew, Wei Chung Hsu and Antonia Zhai, and their students developed speculative compilation techniques for the industry supported open-source Open64 compiler. Used on high performance microprocessors and multicore processors, these compilation techniques allow general purpose applications to take advantage of multicore technologies for improved performance. This group also developed the ADORE/COBRA dynamic compilation system to re optimize binary code at runtime for singlecore and multicore processors. These works have been supported by Intel, Hewlett Packard, Sun Microsystems, IBM, NSF and the United State's Defense Advanced Research Projects Agency DARPA .









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Education & outreach

Whether they are teaching in the classroom or organizing robot dog dance competitions, organizing a student-run Web service business or letting students design a virtual reality world, CSE faculty members are always striving to find new, innovative ways to teach.

PHOTO BY RICHARD G. ANDERSON

Dedicated teaching faculty (from left to right) Chris Dovolis, Carl Sturtivant, Phillip Barry (seated), Charles Swanson, and John Collins.

The department offers a rigorous education in computer science and engineering. Further, since the field is increasingly interdisciplinary, the curriculum can also be tailored to unique interests and goals. In addition, CSE faculty and graduate students are making tremendous strides advancing department outreach to women and minority groups through the creation of programs, school visits, and other mediums.

UNDERGRADUATE AND GRADUATE PROGRAMS

The department offers a broad undergraduate curriculum based on the theory and methods of computer science and engineering, and on its application to real world problems. Students are offered instruction through labs, lectures, seminars, colloquia, and hands-on research by internation ally renowned faculty who are active in research in nearly all areas of computer science and engineering. Dedicated teach ing faculty, such as Phillip Barry, John Collins, Chris Dovolis, Carl Sturtivant, and Charles Swanson, play a major role in the education and guidance of students in their academic careers.

Bachelor's degrees and undergraduate minors are offered through the Institute of Technology IT and the College of Liberal Arts CLA . In addition, a computer engineering major is offered through a partnership with the Department of Electrical and Computer Engineering. Undergraduate degree programs have a number of core classes and electives that allow students to work closely with faculty. Students are given the opportunity to take part in the Undergraduate Research Opportunities Program and the selective Honors

PHOTO BY ROBYN WHITE

Undergraduate students in a robotics lab program Sony AIBO robot dogs to dance.

MAKING THEIR MARK

CSE Undergraduate Students Gain Business Savvy

In 2004, Professor John Riedl, co-founder of the Web services company Net Perceptions, struggled with how to provide undergraduate students with "real world" experience. To solve the problem he devised an innovative approach to education – a year-long class in which students run a Web service business, later named Chipmark.

Each year, Riedl selects approximately 12 of the best computer science students for the class who are given the opportunity to build software for the project. The Web service allows users to access their Internet bookmarks from anywhere in the world. For example, if someone travels and wants access to bookmarks remotely, all they need to do is log on to the Chipmark Web site.

The class is set up like a company in which the students have various titles and roles. According to Riedl, the service has 20,000 users worldwide, but the students have the capacity to support more than 10 times that volume. The innovative class has been exceptionally beneficial for students entering the workforce. Riedl said members of industry have been thrilled about the Chipmark class and its development of enterprising students. "They're excited to hear about the experience they're getting building something real," he said. As a result, Chipmark graduates have gone on to land excellent positions in major companies nationwide and gained admittance to prestigious graduate programs.

PHOTO BY ROBYN WHITE

Professor John Riedl working with a student in Chipmark.

program as well. In addition, the department helps IT and CLA students with professional development by notifying them of job openings, company visits, and other opportunities. Students gain valuable experience by participating in academic research and through internships with local and national companies.

As part of the highly competitive graduate program, approximately 70-80 new graduate students are enrolled each fall from a pool of approximately 900-950 applicants. Students have the opportunity to hone their knowledge of computer science, while focusing on the research specialty of their choice. The graduate program offers the degrees of Master of Computer Science M.C.S., Master of Science in Software Engineering M.S.S.E., Master of Science M.S. and Doctor of Philosophy Ph.D. in computer science. Graduate students take a variety of courses and carry out original research under the supervision of faculty. They also gain valuable experience by participating in cutting edge academic research and through internships with local and global high tech companies. Many CSE graduate students go on to become faculty members at top universities and senior leaders at major companies throughout the world.

THE MSSE PROGRAM

The Master of Science in Software Engineering (M.S.S.E.) is a two-year graduate program designed for full-time working professionals who want to enhance their software engineering skills. As they move through the program, MSSE students gain a solid software engineering background, have the opportunity to advance their careers, are able to network with others in their field, and earn a degree from a major research University. Professor Mats Heimdahl is the director of the University of Minnesota's Software Engineering Center (UMSEC) and led the development of the MSSE program, a contribution which earned him the University's Award for Outstanding Contributions to Post baccalaureate, Graduate and Professional Education. John Collins currently serves as the MSSE program's director of graduate studies.

The MSSE Program started in 1997 as a collaborative effort between the department and the University's Center for the Development of Technical Leadership (CDTL). In 2004, the CSE department took over all aspects of the program administration through UMSEC.

For Heimdahl, teaching working professionals has been a fun change. "You have to work with these students very differently than undergrads," he said, adding that the MSSE students are particularly outspoken. In many MSSE classes, thanks to the energetic classroom dialogue, the students learn as much from each other as they do from faculty.

The MSSE curriculum builds critical thinking skills through a solid understanding of the theoretical methods, principles, and tools essential when dealing with software development issues and processes. Topics include requirements engineering, project management, quality assurance, and database management systems.

"It's a rigorous curriculum," Heimdahl said. Individuals such as Adjunct Faculty member Dick Hedger and members of the local software engineering group TwinSpin were essential to creating such a successful program.

PHOTO BY TIM RUMMELHOFF

PHOTO BY ROBYN WHITE

Professor Nikolaos Papnikolopoulos teaches Tali Rose, 9, and other children about the Scout Robot at the Minnesota State Fair.

OUTREACH

According to local and national reports, there is a growing demand for science and technology workers, but low interest among young students in science and technology fields. To assure that the University can help to meet the demands of industry and have success in cultivating future innovations, CSE faculty are making an investment in the future and working to alleviate this problem.

As a major departmental goal, faculty are working to interest young students – women and minorities, in particular – in college and computer science. Faculty and graduate students host campus visits, routinely visit local K-12 schools to talk with students, participate in statewide outreach programs geared at piquing student interest in science and technology, and support events and groups that encourage this mission – focusing much of the outreach on robotics. For example, in the fall of 2006 at St. Paul's Science Museum Professor Maria Gini and doctoral student Shana Watters met with young students and gained their interest in learning about science and technology using robotics.

PHOTO BY PATRICK O'LEARY

Students watching the robot dance competition.

In another effort to reach young students, CSE doctoral student Kelly Cannon created the University of Minnesota's Technology Day Camp in 2005. It is an annual five-day summer camp held in August, specifically targeting middle school girls and minorities groups – demographics that are underrepresented in high-tech fields. As part of the camp, students are bussed to the University campus where they complete both software and hardware projects. Past projects include building lunchbox boomboxes with circuit boards and MP3 players, programming robot dogs to dance, and designing movies using unique programs targeted to students in the middle grades.

Students are encouraged to take home at least one of their camp projects to share with family and friends. After completing the camp, many students report an increased interest in attending college, pursuing a career in a high-tech field, and a strong feeling of accomplishment. Since its inception, the camp has grown dramatically in popularity. It received significant media coverage on television, in magazines, and newsletters. Enrollment has climbed from 15 students to 25 in 2007. The camp is staffed and organized by the department's graduate students and boasted approximately 30 graduate student volunteers in 2007. Camp sponsors include the University's Center for Distributed Robotics and the Digital Technology Center.

In addition to cultivating potential future female computer scientists through programs like these, the department also focuses resources on supporting current women CSE students. The department's Women in Computer Science organization is a support group that hosts meetings and events focused on professional issues for female students, such as how to interview for a job. Professor Maria Gini advises the group, whose goal is to promote and enhance the visibility of accomplishments of women in computer science and address issues that contribute to the retention and recruitment of women in the sciences.

BIENNIAL TECHNOLOGY FORUM AND OPEN HOUSE

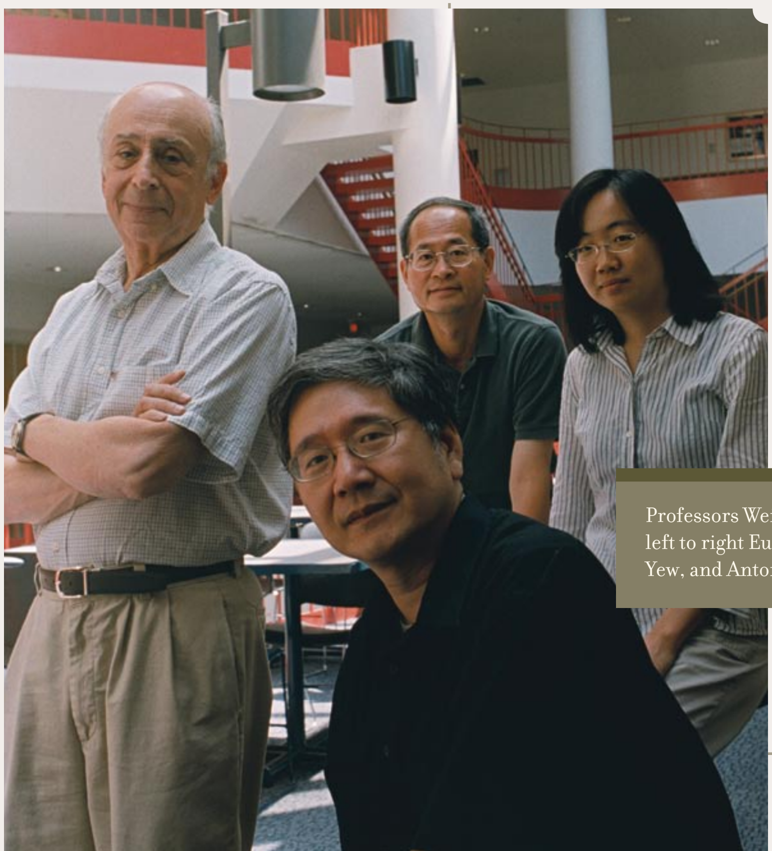
The department hosts a Technology Forum and Open House every two years to connect faculty and students with alumni, members of industry, and other colleges and universities. The event, which draws hundreds of people, is held in partnership with CSA. Current departmental research activities are demonstrated during the day by faculty and students. Industry representatives demonstrate state of the art technology. In addition to research exhibits, the event includes keynote speeches and panel discussions on emerging topics.

Research Areas & project HIGHLIGHTS

Architectures & Compilers

Small, powerful processors have revolutionized the world. They are embedded in cars, toys, and even our bodies to help make life safer and easier. They are used in parallel computers to analyze massive datasets, like those from the Human Genome Project.

PHOTO BY RICHARD G. ANDERSON



Professors Wei-Chung Hsu (front), then from left to right Eugene Shragowitz, Pen-Chung Yew, and Antonia Zhai.

W. Hsu, E. Shragowitz, P. Yew, A. Zhai
While engineers continue to make processors smaller and faster, department researchers develop ways to harness the full computational power of these modern architectures. Their work enhances system performance by optimizing machine code to best utilize available resources, such as multiple processors. This research focuses on program analysis for parallel computers, code generation, speculative thread execution, translation, and static and dynamic compiler optimization.

RESEARCH HIGHLIGHT

Efficiency and Speed: Making the Best Use of Computers

A new desktop PC with its multicore processor claims a processing speed of several gigahertz, but it is the way the software runs on these processors that tells the true tale of speed and efficiency. This is also the case for high performance parallel computers and small scale embedded processors. Each of these platforms and their applications warrant different optimization techniques both at component and systems level to make the system run faster and/or minimize power consumption. Professors Wei Chung Hsu, Antonia Zhai, and Pen-Chung Yew have developed dynamic compilation and speculative optimization techniques to improve performance for a wide range of applications.

Code optimization for general purpose computing is extremely difficult, as an optimization strategy for one application may slow things down for another. Memory access and code scheduling, which determines the next instruction to be executed, are the two most common bottlenecks of computational speed. Cache memory and out of order execution can be used to alleviate these bottlenecks, as long as the machine code is correctly optimized. However, this is significantly more complex on today's highly pipelined processors. Hsu and Yew address this problem with dynamic compilation, in which program code is continually recompiled into optimized machine code based on a run time analysis. Industry is starting to adopt this work, which significantly impacts program speed and efficiency.

Computational speed is also improved by using parallelism, whereby the processors of a multicore system share the workload of a single application. This thread level parallelism is emerging as the primary focus for improved computational speed on general purpose computers, because processors are approaching their operational limit with respect to clock speed and power consumption. Hsu, Yew, and Zhai are at the forefront of this emerging technology, creating infrastructure and compilation techniques that exploit the full potential of multicore systems. One major focus is thread level speculation, which anticipates code dependencies to determine eligibility for parallel execution. Industry strongly supports their research to improve general purpose processing performance. Their work has been funded by Intel, Hewlett Packard, Sun Microsystems, IBM, the Defense Advanced Research Projects Agency DARPA , and the National Science Foundation NSF .

Professors Zhai and Yew collaborating on a project.

PHOTO BY RICHARD G. ANDERSON

BIOINFORMATICS & COMPUTATIONAL BIOLOGY

Biology exposes complexity beyond human comprehension. Computers help to interpret biological data, increasing our understanding of biological systems. This can lead to better diagnosis and management of diseases, expedite the search for medical cures, as well as improve plant yield and aid in the design of biofuels.

D. Boley, J. Carlis, R. Janardan, G. Karypis, R. Kuang, V. Kumar, C. Myers

Department researchers in this area work alongside biological and medical researchers studying diseases such as malaria and HIV, the virus that causes AIDS. Their work has the potential for medical breakthroughs that can save lives. Another major focus is the development of clustering and classification algorithms for the analysis, categorization, and prediction of protein structure, which impacts screening, diagnosis, and drug discovery. These and other scientific applications in genomics and proteomics require new methods for data analysis and visualization, prompting new research directions in data modeling and in database management systems. This research group has a growing collaboration with the Mayo Clinic and the University of Minnesota's College of Biological Sciences and Medical School.

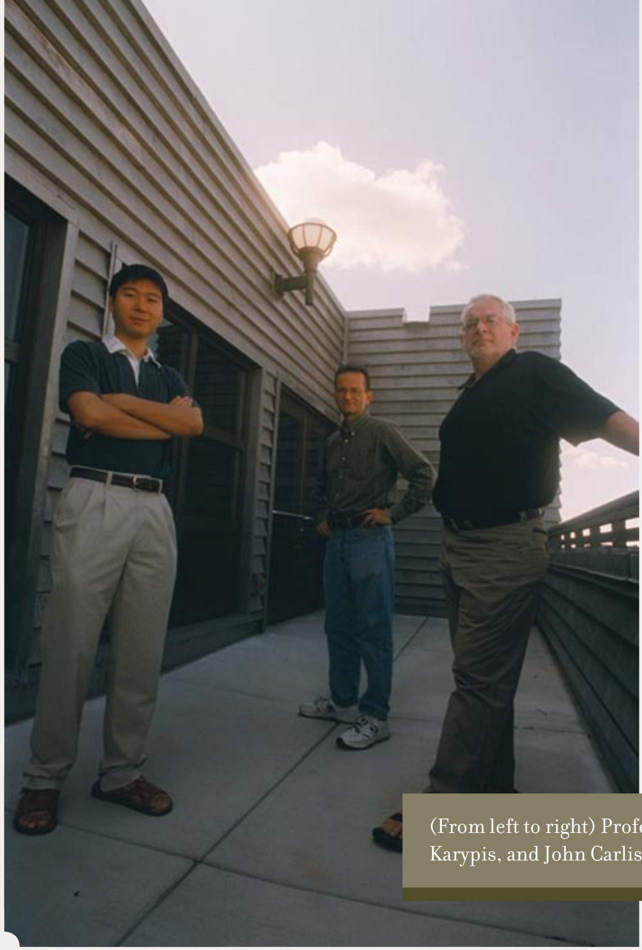
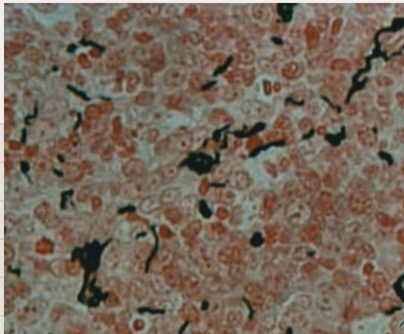


PHOTO BY RICHARD G. ANDERSON

(From left to right) Professors Rui Kuang, George Karypis, and John Carlis.



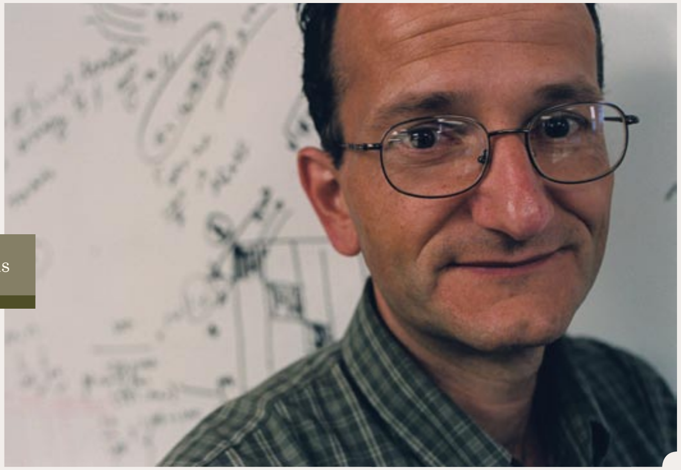


PHOTO BY RICHARD G. ANDERSON

Professor George Karypis

RESEARCH HIGHLIGHTS

Drug Discovery and Protein Structures

Discovering new and effective drugs is a complicated science. Professor George Karypis uses machine learning to analyze chemical compounds to see which ones are good candidates for drugs. This is done by using methods developed to analyze the activity results obtained from initial in vitro testing of 50,000-60,000 existing chemical compounds. This research discovers how the proteins respond to the various compounds and identifies the compounds' characteristics that make them good drug candidates. This identification will help in further testing of chemical compounds on proteins. This work has been tested successfully against various protein targets associated with cancer, ulcer, blood clots, pulmonary hypertension, and depression. In a related project, Karypis and Professor Rui Kuang's research predicts the shape of protein structures from their amino acid sequence and reveals how protein structures interact with each other, DNA, and other small molecules. By discovering a protein structure, scientists get a better idea of its functions and its role in the overall biological network. Karypis envisions these two projects joining together to help make advances in medical treatments, as well as drug development.

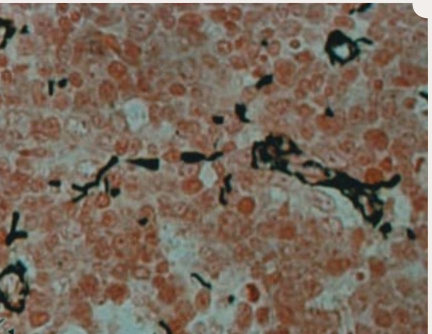


PHOTO BY RICHARD G. ANDERSON

Where Medicine and Computational Analysis Collide

When some people hear the term database they think client management – a system filled with phone numbers and addresses. But while many businesses and individuals use databases for these reasons, Professor John Carlis uses databases and data modeling techniques to analyze medical information. Carlis finds effective ways to pull out and visualize desired information from a seemingly insurmountable volume of data. These projects often involve gargantuan, complicated datasets, and their solutions draw from many other disciplines within computer science, such as data mining, database management, machine learning, and optimization. This work impacts visualization techniques involved with microbiology in the study of HIV and neuroscience in Alzheimer's disease research. Recently Carlis began a project to help University medical researchers analyze saliva data from people with oral cancer. His work helps discover biomarkers for the early detection of this type of cancer.

PHOTO BY RICHARD G. ANDERSON

Professor John Carlis (left) teaching two graduate students.

Data Mining, Databases & Geographical Information Systems (GIS)

Whether searching the Web or identifying patterns in global climate, faculty specializing in data mining, databases, and geographical information systems (GIS) can help find the answers. Their research focuses on identifying, extracting, and visualizing desired information from large data sets.

A. Banerjee, D. Boley, J. Carlis, G. Karypis, V. Kumar, M. Mokbel, S. Shekhar, J. Srivastava

This research group has broad, varied interests, but the unifying goal is to find patterns in data that are too massive for humans to sort through. More specifically, they develop algorithms for anomaly and pattern detection, predictive modeling, query processing, and spatial data analysis. This work draws from various areas including graph theory, learning, and numerical analysis. This research impacts several domains, such as bioinformatics, cyber security, global climate data analysis, sensor networks, transportation, and the Web. Researchers in this group have extensive connections with industry and national labs, providing a rich source of problems, data sets, and experience for students.

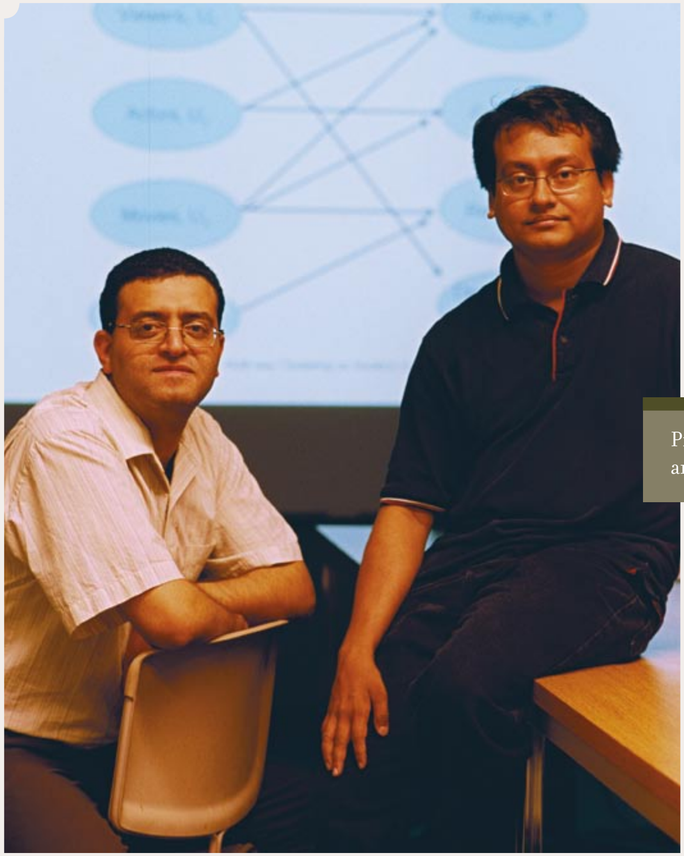


PHOTO BY RICHARD G. ANDERSON

Professors Mohamed Mokbel (left) and Arindam Banerjee (right).

RESEARCH HIGHLIGHTS

Finding a Needle in a Haystack

CSE researchers are world leaders in the development of effective and efficient algorithms for data mining and their application to a broad range of problems.

CSE Professors Shashi Shekhar and Jaideep Srivastava have worked with students for nearly five years on sorting, analyzing, and digitizing 46 years worth of data – including notes, checksheets, and video – collected by famed chimpanzee researcher Dr. Jane Goodall in the tropical forest of Tanzania's Gombe National Park. The data, which outlines everything from mating habits to food choice, and location, are housed in the Jane Goodall Institute's Center for Primate Studies JGI CPS on the University's St. Paul campus. Shekhar, Srivastava, and their students worked with Dr. Anne Pusey, director of the JGI CPS, to create a searchable database of Goodall's video footage, housed in the DTC. This collection of data is used by researchers to find patterns in everything from female grouping habits, to male aggression, and mating habits associated with the Simian Immune Deficiency Virus (SIV).

In other projects, Professors George Karypis, Vipin Kumar, and Shekhar use spatio temporal data mining techniques to discover global climate patterns. Funded by NASA, NSF, and the National Oceanic and Atmospheric Administration, the project uses satellite observations of Earth's landmasses, oceans, and atmosphere to discover patterns that capture complex interactions among ocean temperature, air pressure, surface meteorology, and terrestrial carbon flux. As part of this project, CSE researchers developed new algorithms to identify sudden changes in the Earth's leaf cover. NASA collaborators Chris Potter and Steve Klooster used these algorithms to build a 17-year history of large-scale natural disasters, such as forest fires, floods, ice storms, and landslides, and to estimate how much of the current rise of carbon dioxide in the atmosphere is attributable to these disasters.

In an online application of data mining for social structure and content analysis, researchers develop a deeper understanding of social networks. This has applications in blog analysis, recommendation systems, Web search, and targeted marketing. The Data Analysis and Modeling Research Group, led by Professor Arindam Banerjee, developed techniques for the analysis of multirelational content and structural data from social networks. In one project with Oak Ridge National Labs, the group analyzes content and the community structure of political bloggers to better understand the influence of opinions in social networks.

(From left to right) Professor Shashi Shekhar, graduate student Mete Celik, Dr. Jane Goodall, and Professor Jaideep Srivastava.

PHOTO BY ROBYN WHITE

graphics & visualization

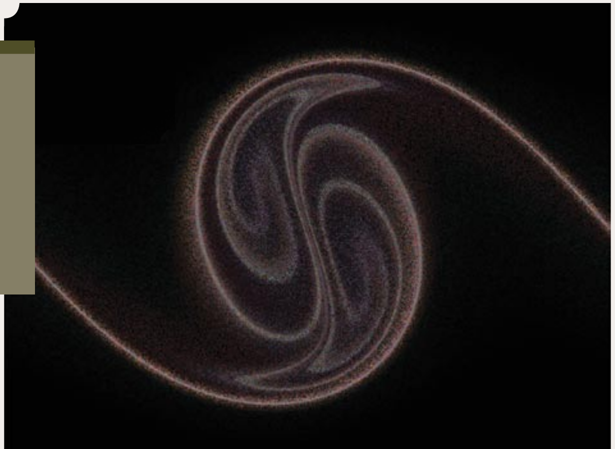
No longer just for entertainment, graphics and computer visualization help people experience a virtual world in a way that brings new skills and knowledge to the physical world.

V. Interrante and G. Meyer

Researchers in graphics and visualization are focused on creating computer images that effectively communicate information and design the color and appearance of new products. Drawing from research in human vision, faculty members develop visualization techniques that improve color generation and shape representation and perception in virtual reality. These techniques are used to help people with low visual abilities navigate, improve the effectiveness of training scenarios for medical students and military personnel, and enhance the architectural design process. Specifically, research in this area focuses on the design and implementation of algorithms for volume visualization, for relaying 2-D and 3-D flow data, and for non-photorealistic renderings. Additional emphasis is on color reproduction in image generation by simulating refraction, scattering, and interference.

PHOTO BY RICHARD G. ANDERSON

Professors Victoria Interrante (left) and Gary Meyer (right).



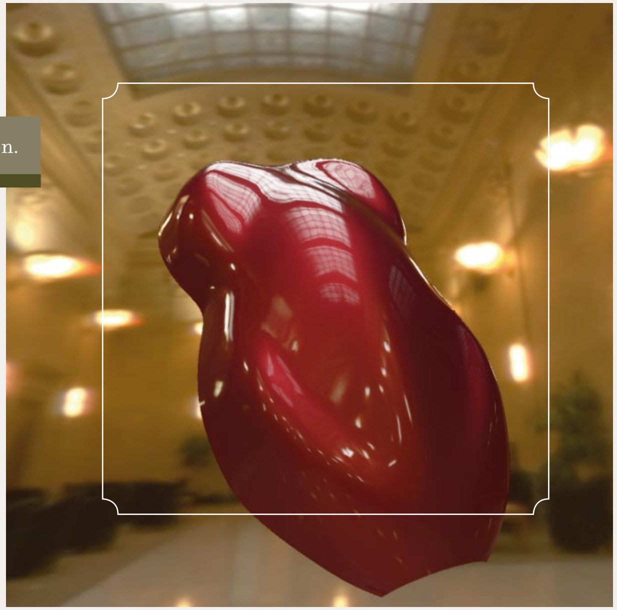
COURTESY OF VICTORIA INTERRANTE

Pointillist visualization of nanoparticles in formation from work with Sean Garrick (Mechanical Engineering) and Patrick Coleman Saunders (CSE grad student).

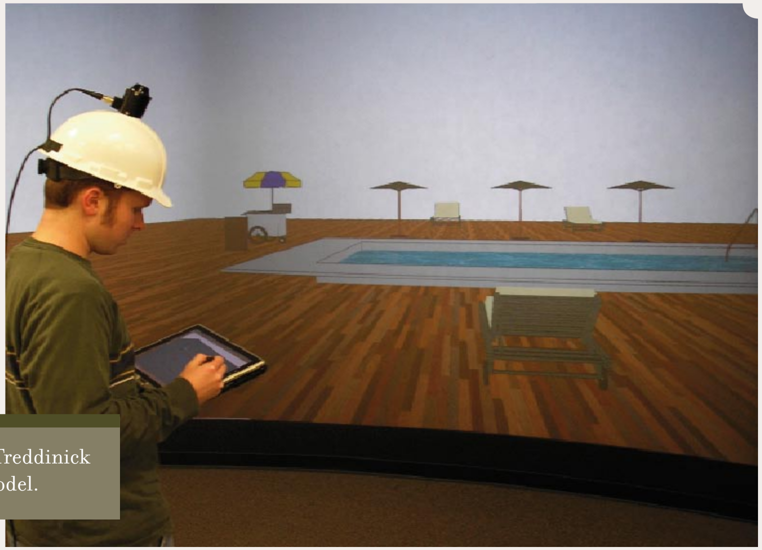
RESEARCH HIGHLIGHTS

Design in Another World

For an architecture student, nothing could be better than being able to walk into a building you've designed before it is built. This is being made possible by research conducted in the University's Digital Design Consortium Virtual Reality Laboratory, located in the Digital Technology Center DTC and funded through a generous gift from Linda and Ted Johnson, an Architecture and CSE alumnus, as well as the DTC and NSF. As part of the Immersive Design Research Program, Professor Victoria Interrante and Architecture Professor Lee Anderson work with students to refine virtual reality technology and design techniques. Interrante also conducts experiments on spatial understanding in 3-D virtual environments. Currently, virtual reality technology is used for training purposes by medical students and soldiers. Through advancements in virtual reality technology, Interrante is trying to make it easier for people to interpret what they're seeing in the virtual world as real. This will simplify the process of taking virtually learned skills into the real world.


COURTESY OF GARY MEYER

Meyer's color reproduction simulation.

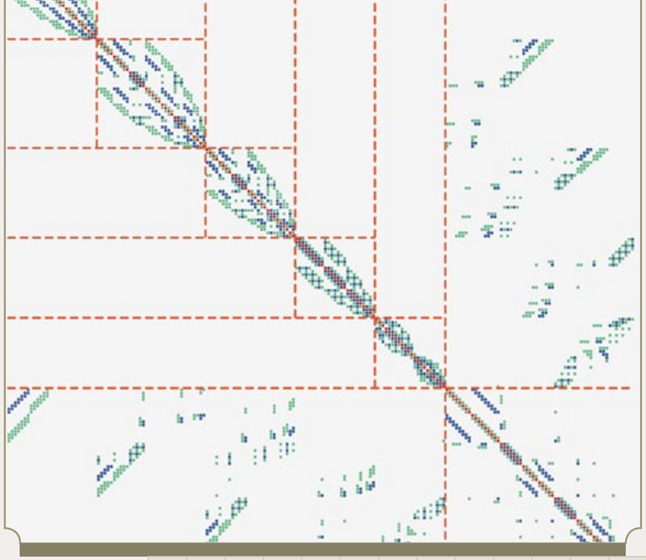

COURTESY OF VICTORIA INTERRANTE

Graduate student Ross Treddinick with an architectural model.

Bringing Color to Virtual Environments

Professor Gary Meyer brings virtual color to virtual environments. His research improves the use of color in computer graphics, with a focus on accurate and efficient reproduction of color in synthetic images. Meyer's work explores how the knowledge of color perception and processing in the human visual system can be used to improve computer based color synthesis. His work also significantly improves the simulation of the natural phenomena that influences color, such as refraction and scattering, in synthetic images. Meyer developed algorithms that determine the visual significance of image defects as a picture is created, which leads to the more efficient production of computer images and improved color realism. Recently, Meyer's research team developed computer based systems to aid the user in visualizing and modeling paint color. A unique element of this work is that it addresses the complexities of metallic paint, which has more dramatic highlights than nonmetallic paint.

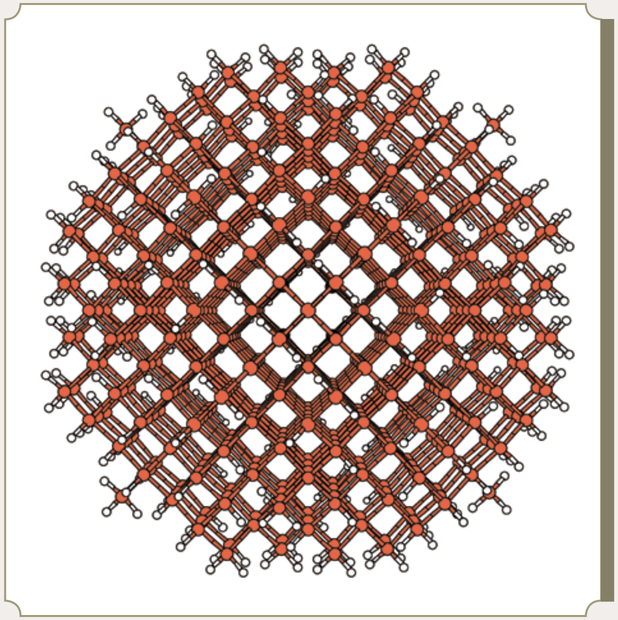
HIGH performance COMPUTING

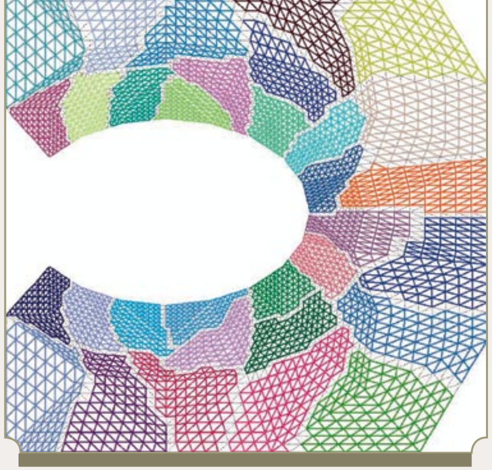


The potential of thousands of processors working in parallel to solve a problem seems limitless. This scale of computing can be accomplished with supercomputers and distributed systems, but the difficulty lies in the efficient and effective division of labor. Researchers are developing techniques and tools to best utilize the available processing power, regardless of scale.

D. Boley, A. Chandra, G. Karypis, V. Kumar, Y. Saad, J. Weissman

This research impacts engineering, physics, biology, ecology and any discipline that requires large-scale data analysis. These technologies open up new research directions in other scientific fields and significantly change the methods and approaches to scientific discovery. This research group is exploring grid computing, parallel algorithm design, performance analysis, and sparse matrix algorithms for large-scale scientific and engineering simulations. Software libraries developed by the group are used extensively worldwide in industry, academia, and research labs.





RESEARCH HIGHLIGHTS

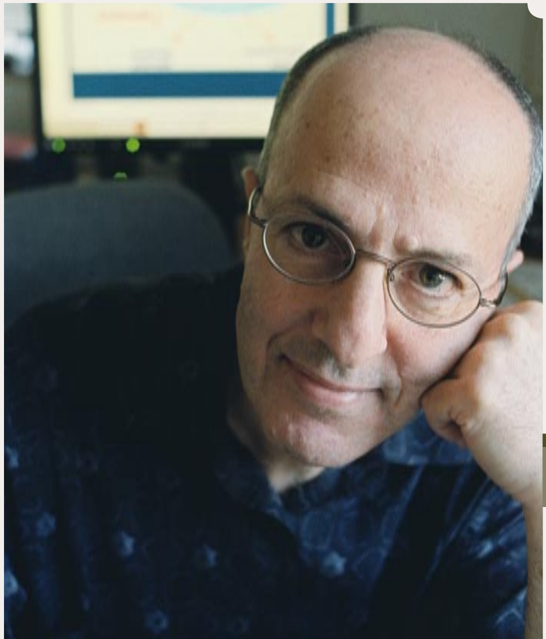
Solving Problems with the Grid

To solve increasingly complex problems in science, engineering, and medicine, researchers are turning to a technology that couples resources and people, computers and networks, and data and computation. A distributed systems paradigm, known as the Grid, provides a unifying framework allowing diverse, heterogeneous computing resources to be integrated securely and reliably to solve emerging problems. The Distributed Computing Systems Group is led by Professor Jon Weissman. On a project co led by Professor Abhishek Chandra, they develop fundamental tools to transform a large collection of unreliable computers across the Internet into a stable reliable Grid platform. In a project with Citilabs Inc. and the Minnesota Department of Transportation MnDot , Weissman's Grid work is applied to the problem of simulating urban traffic and passenger travel flow patterns in the Twin Cities to identify significant relationships between population, travel, activities, time, and geography. In another project, Weissman's group is helping the University's Medical School to use Grid technology to construct a network for performing clinical eligibility trials. The goal is to support distributed, secure queries across thousands of clinics to identify subjects for studies of diseases like diabetes.

Algorithms: Meeting the Demands of Science and Engineering Simulations

Numerical simulations of materials at the nanoscale-level require something far more computationally powerful than an average personal computer. It also requires sophisticated software that can account for all the intricacies of such systems within a reasonable timeframe. Professor Yousef Saad has built a substantial set of elegant algorithms and software for this and other problems in scientific computing. Members of his team routinely use massively parallel computers to tackle the most demanding computational tasks. Saad's longest standing project relates to sparse matrix methods. In the early 1990s he developed SPARSKIT, a general toolbox for working with sparse matrices and solving sparse systems of linear equations. More recently, SPARSKIT gave way to pARMS and ITSOL, two packages which offer parallel and iterative methods for solving linear systems. These packages provide general solution techniques that can be used in industrial and academic applications. In the very different arena of quantum mechanics, the PARSEC software package is a collaborative research project with material scientist, Dr. Jim Chelikowsky from University of Texas Austin. PARSEC was recently tested to simulate the interactions of 10,000 atoms – a scale previously unachievable. This work can help find new materials for the nanoscale computational devices of the future.

PHOTO BY RICHARD G. ANDERSON



Professor Yousef Saad.

Human Computer Interaction (HCI)

The Internet connects people from all over the world at a scale and pace that has never been possible before. The availability and volume of information and opportunities for knowledge sharing seems endless. Department researchers are finding ways to make Web resources more useful and effective, and to help people interact with online technology.

PHOTO BY RICHARD G. ANDERSON

(From left to right) Professors Joseph Konstan, Loren Terveen, and John Riedl.

J. Konstan, J. Riedl, L. Terveen

This research group specializes in collaborative and social systems — computing systems that help people interact and work together. Some research is focused on online social networking groups, such as MySpace and YouTube. Other work focuses on recommender systems, which recommend new movies or books to users based on their previous searches. More technically speaking, this research involves the development of algorithms and interfaces for online and mobile personalization, applying social science theories to the design of online community infrastructure, and research on collaboration and online social behavior. Faculty also collaborate with other scientists to address pressing challenges in public health, bioscience, and other areas.

RESEARCH HIGHLIGHTS

Online Communities

In an age where chatroom acquaintances and online user names dominate the social circles of many throughout the world, the study of online communities and Internet usage is becoming more and more compelling. Professors Loren Terveen and John Riedl, and students are studying the online community of Wikipedia, a free online encyclopedia featuring more than 7 million articles in 200 languages. The site is unique, because it is a shift away from the use of professional editors, allowing anyone to manipulate the information, which can add both accurate and erroneous information. Terveen and Riedl are investigating various aspects of the usage and impact of Wikipedia content. Their study has revealed that one tenth of one percent of Wikipedia editors account for more than half of the value of the encyclopedia, as measured by word views. Also, few edits inflict damage on the content, but while damage is typically fixed quickly, the amount of damage to Wikipedia is increasing over the years. Taken together, these results suggest that vandalism on Wikipedia is a relatively small problem today, but that research is needed to contain that damage in the future.

PHOTO BY RICHARD G. ANDERSON

Professor Joseph Konstan (right) and B. R. Simon Rosser (left), a University professor in the Division of Epidemiology and Community Health, working on the Men's Internet Health Study.

Fighting HIV in Cyberspace

Computer science researchers are finding new ways to use technology to save lives. For more than five years CSE Professor Joseph Konstan and B. R. Simon Rosser, a University professor in the Division of Epidemiology and Community Health, have been creating computer systems to help prevent the spread of HIV. Through the Men's Internet Study MINTS , Konstan, Rosser, and a team of scientists from across the University created a multiphased, interdisciplinary project researching the behavior and patterns of men who use the Internet to seek male sexual partners. In phase I of the study the group built an online survey targeting Latino men, because they are one of the highest risk groups for HIV. Konstan and the team are now developing an online intervention program designed to reduce sexual risk taking and sexually transmitted infections. This new software aims to change the user's attitude and behavior. Konstan said he hopes that the program creates a genuine online experience that promotes healthier sexual behavior and encourages people to take fewer risks in sexual encounters outside of cyberspace.

Networks, Systems & Security

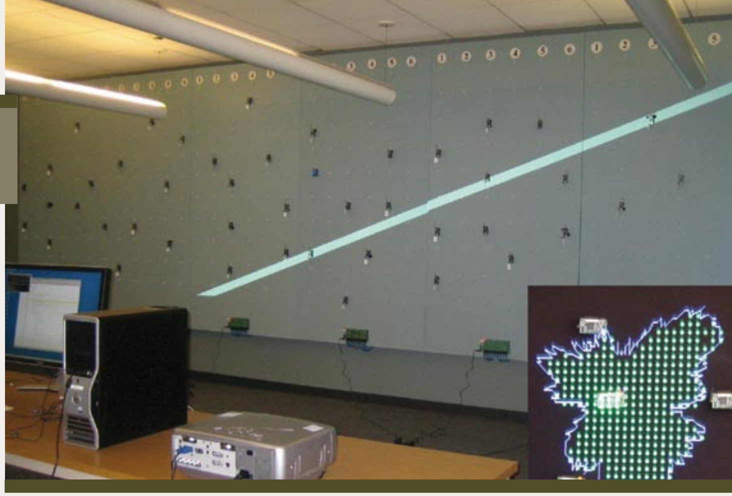
Everyone is connected — figuratively and literally — through the Internet, cell phones, and networked wireless devices. In any one day, people venture through hundreds of processors that are communicating and exchanging data.

A. Chandra, D. Du, T. He, N. Hopper, Y. Kim, A. Tripathi, J. Weissman, Z. Zhang

The availability, reliability, and security of computer connections are all a crucial part of a successful network. Department researchers in this area work to improve these essential qualities for current and future Internet, wireless, sensor, peer-to-peer, and large-scale storage networks. Research in this group encompasses both the infrastructure and the storage and movement of data through a network, leading to the development of innovative theories and techniques, efficient and scalable mechanisms and protocols, and novel network architectures and services for enhancing a variety of communication networks and systems.

PHOTO BY RICHARD G. ANDERSON

(From left to right) Professors Tian He, Anand Tripathi, David Du (seated) Abhishek Chandra, Nicholas Hopper (seated), Yongdae Kim, Zhi-Li Zhang.



A 360-node Wireless Sensor Network running MSP and SAM.

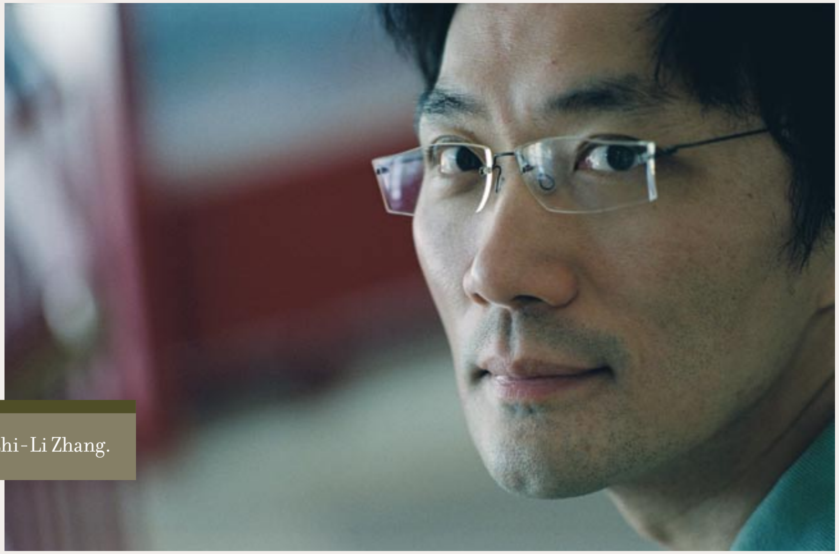
COURTESY OF TIAN HE

RESEARCH HIGHLIGHTS

Improving Internet Infrastructure

When streaming video over the Internet, average users are oblivious to the labyrinth the data must navigate to get from one end to the other. As Internet usage grows with the advent of applications like Internet video, IPTV Internet TV and VoIP voice over IP , the current network infrastructure will struggle to meet the demands of more users, busi nesses, and advanced services. In addition, despite the rapid expansion in capacity and advances in technologies, the current Internet still remains essentially a network provid ing only the basic connectivity service. It also shows signs of strain in meeting the require ments of emerging services and user demands. To address these issues, Professor Zhi-Li Zhang and his students are developing novel algorithms, architectures and mechanisms towards a Service Oriented Internet, a new framework that maintains reliable, secure and manageable services, and will scale with the growth of the Internet. They are developing new addressing, robust routing, flexible and secure service delivery components to pro vide better support for the requirements of many Internet services and enable emerging and new Internet services to be created and deployed with greater ease.

PHOTO BY RICHARD G. ANDERSON



Professor Zhi-Li Zhang.

Wireless Networks: Gathering Data

Wireless sensor networks help to gather data that would be otherwise arduous or dangerous to collect. These networks consist of thousands of low cost sensor nodes and are used in many applications such as intelligent battlefields, haz ard response systems, and environmental monitoring. The Minnesota Embedded Sensor System Group, led by Professor Tian He, has made remarkable progress in this domain. They have designed and implemented a suite of event driven local ization methods, such as Spotlight and MSP, to pinpoint the locations of tiny sensors at little cost, which provide a step ping stone for location based sensor applications. To assist long term deployment of sensor systems, they have designed new techniques, such as uSense and DSF, to allow efficient scheduling and communication over extremely low duty sen sor networks. These techniques achieve orders of magnitude lifetime extension for energy constrained sensor nodes. In addition, He and his students also develop user tools, such as in situ Sensor Area Modeling, to ease the design process, deployment, and maintenance of sensor networks. This work broadens the community of users by making wireless sensor networks practical for many applications including agron omy, environmental science, medicine, and urban security.

ROBOTICS & ARTIFICIAL INTELLIGENCE (AI)

No longer science fiction, artificial intelligence and robotics are commonplace in medicine, space exploration, military intelligence, and education. The defining feature of these systems is the ability to interact with and react to their environment.

A. Banerjee, M. Gini, N. Papanikolopoulos, S. Roumeliotis, P. Schrater, W. Schuler, R. Voyles

Department researchers in robotics and artificial intelligence improve the sensory, perception, motion, and communication capabilities of robots and computers. One primary focus of this group is distributed, mobile robotics – when teams of robots cooperate to achieve various tasks, such as urban search and rescue, reconnaissance missions, monitoring human activities for security, and space exploration. Researchers also focus on developing multi-agent systems for supply chain management that predict market demand and then set production, prices, and sales goals to maximize expected profit. Researchers tackle these crucial applications by exploring and refining estimation theory, mobility mechanisms, multi-agent communication, speech recognition, machine learning, and economics.

Professors Maria Gini and Nikolaos Papanikolopoulos holding robots.

PHOTO BY RICHARD G. ANDERSON

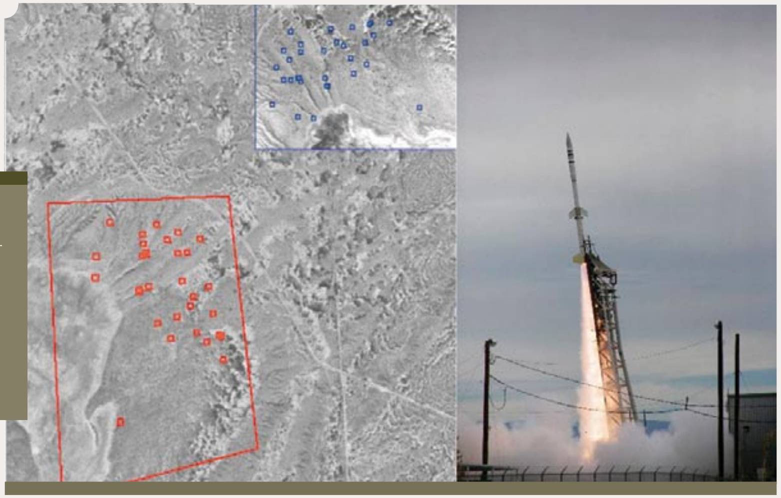
RESEARCH HIGHLIGHTS

Magnificent Machines

The department's extensive and innovative research in mobile robotics and artificial intelligence is used to keep people out of harm's way in the real world. Robots developed in the department aid the military in reconnaissance efforts and crawl through disaster sites for search and rescue training. Advanced sensor technologies improve spacecraft landing on Mars and enhance human computer communication.

PHOTO BY RICHARD G. ANDERSON

Professors Nikolaos Papanikolopoulos, Maria Gini, and Richard Voyles started the design and development of the Scout robot in 1998, along with their students and local industry. This resulted in the development of a large collection of robotic mechanisms and sensing technologies. Currently in use by the military, the Scout can be thrown into almost any environment to gather video images to relay back to a remote operator. In related work, Voyles and his students developed the TerminatorBot, which is a crawling and manipulating robot that helps in rescue efforts in densely rubbled environments. These robotic platforms can be used in multi robot systems that exhibit coordinated behaviors to achieve a single mission.



COURTESY OF STERGIOS ROUMELIOTIS

(Right)The sounding rocket experiment develops pin-point landing capabilities for the next generation of planetary exploration spacecraft. (Left) A terrain and map features images tracked for spacecraft position estimation. This project is a partnership with MARS Lab, the University of Minnesota, the Jet Propulsion Lab, and NASA.

In the application of planetary exploration, Professor Stergios Roumeliotis is working on a project with a team of students that is improving landing precision, thus getting spacecraft closer to designated targets. The project is sponsored by NASA, the Mars Technology Program, and Advanced Entry, Descent and Landing AEDL Technologies. This work involves the development and investigation of estimation techniques for aiding inertial navigation of NASA spacecraft using images of the planet surface. Their techniques achieved a three orders of magnitude reduction in landing uncertainty. To help develop advanced landing software, the research team uses a small helicopter that simulates the motion profile of a rocket that would be used in space.

Professor William Schuler works on another aspect of artificial intelligence – to help people communicate with computers. Schuler integrates contextual information, phonology, syntax, and referential semantics into a unified statistical language model, which improves the recognition accuracy of spoken language interfaces. He uses robots and mobile sensors to gather environmental information for the language model. Schuler said he aims to fundamentally change the way people interact with machines and unlock the creativity and ingenuity of users who don't have formal programming experience.

Software Engineering & Programming Languages

In an ideal world, software will work as it is intended to, but software bugs and malicious hackers make for a very different reality. This makes software engineering a crucial discipline.

M. Heimdahl, G. Nadathur, E. Van Wyk

Research in software engineering and programming languages focuses on developing tools and techniques to ensure software quality and enhance programmer productivity. There are varied methods for achieving this, such as refining software development methodology, developing and applying techniques for testing and verification, and designing new languages and formalisms that facilitate programming and reasoning about programs. The faculty members in this group conduct cutting-edge research in many of these areas through the University of Minnesota Software Engineering Center (UMSEC), a highly successful center that integrates software engineering research, education, and outreach.

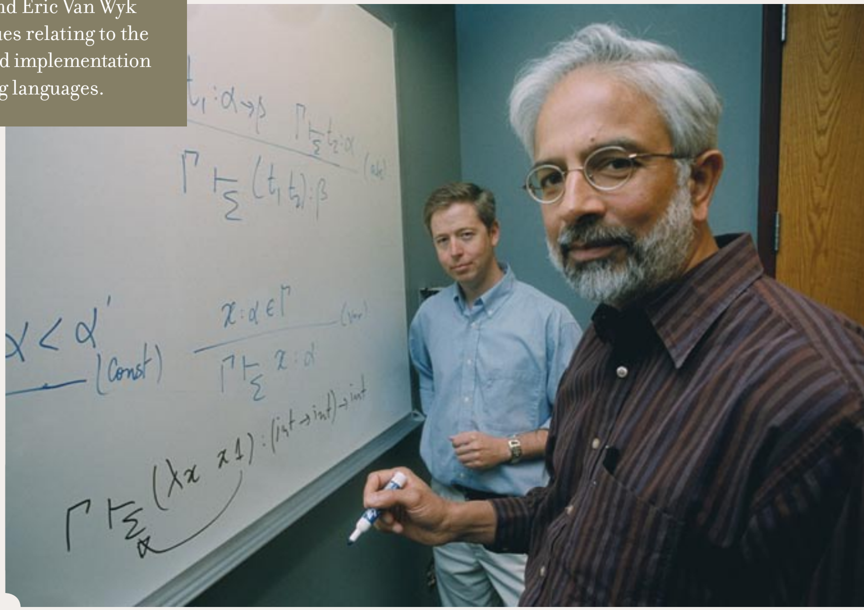
Professors Mats Heimdahl, Gopalan Nadathur, and Eric Van Wyk.

PHOTO BY RICHARD G. ANDERSON

RESEARCH HIGHLIGHTS

Safety in Software and Beyond

To build a computer system, the requirements on the system must be translated from the informal language of humans into the formal language of computers – a difficult process plagued by errors of omission, ambiguity, and inconsistencies. If done incorrectly, there could be costly and potentially disastrous problems in safety critical applications, such as avionics and medical devices. Professor Mats Heimdahl's Critical Systems Group remedies this problem through formal methods, techniques for proving or disproving whether safety-critical software meets its requirements. In a project with Rockwell Collins and NASA Langley Research Center, Heimdahl and a former graduate student Michael Whalen (Ph.D. 2005) led the development of a technology that allows engineers to verify that models of software captured in Simulink and Stateflow possess desirable properties. Using this technology, Whalen helped prove that a commercial aircraft display window manager software system met its requirements - assuring that it worked properly.



Professors Gopalan Nadathur (foreground) and Eric Van Wyk working on issues relating to the development and implementation of programming languages.

PHOTO BY RICHARD G. ANDERSON

Raising the Level of Computer Languages

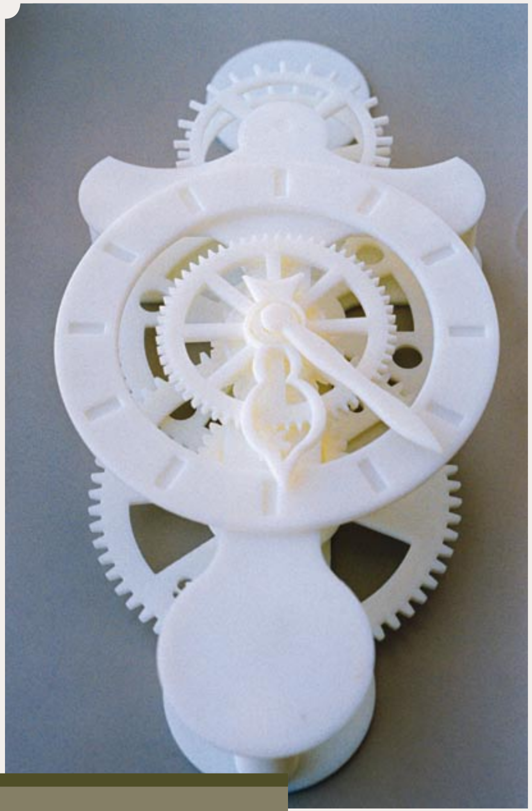
Reasoning about computer programs and their relationship to specifications is central to providing assurances about the security and correctness of software. Professor Gopalan Nadathur develops languages and tools for encoding such computations. Using a higher order logic as a foundation for programming, Nadathur collaboratively pioneered a new approach to representing and manipulating complex syntactic objects, such as programs, specifications, and proofs. This approach lies at the heart of λProlog pronounced Lambda Prolog , a programming language co designed by Nadathur. To support an ambitious exploitation of the techniques the language supports, Nadathur and his research group turned their attention to efficiently implementing the many new programming language features in λProlog. The result of this work is the Teyjus system, which has been used in several research and teaching projects in Europe, Japan, and the United States. Current collaborative work with scientists in Australia and the French computer science institute INRIA seeks to further develop logics and systems for reasoning about λProlog programs. This work has important applications in verifiable translation and authentication of program specifications.

Theoretical Foundations

Research in the theoretical foundations of computer science helps define and expand the computational limits of modern computers.

A. Banerjee, N. Hopper, R. Janardan, Y. Kim, G. Nadathur, E. Van Wyk

Often the algorithm that produces the optimal solution to a problem is not tractable, either surpassing memory capacity or requiring too much processing time, thus an approximation is needed. Faculty in this area focus on a wide range of computational problems to find more efficient and accurate solutions or to formalize the problem and its solution. The range of foundational topics that are being pursued in the department include geometric computing, cryptography, learning theory, computational logic, and programming languages theory. Several group members are also actively engaged in leveraging their research into other application areas, and as a result, have produced a large collection of software in use today by academia and industry.



MODEL COURTESY OF STRATASYS, INC.

P3-D Prototype generated via Rapid Physical Prototyping.

RESEARCH HIGHLIGHTS

Improving Computer Aided Design and Manufacturing

In manufacturing, the time and cost it takes to bring a product to market can be over whelming. Professor Ravi Janardan developed efficient geometric algorithms to reduce the cost and time spent through Rapid Physical Prototyping (RPP) with 3-D printers. RPP is a manufacturing technology that allows physical prototypes of 3-D solid objects to be printed from their digital representations with a desktop sized printer. RPP dramatically reduces production costs and the time it takes to bring a product to market. It is used in the automotive, aerospace, and medical industries, among others. In RPP, the digital model is sliced into thousands of parallel layers and the layers are printed in succession, each atop the previous one. Different commercial RPP processes differ in how the layers are printed. While the printing is straightforward, what is not is determining the optimal geometric parameters for the process. Janardan and colleagues have developed a suite of geometric optimization algorithms and software to address this and other issues, and have significantly improved the process. Some of this work has been done in collaboration with Minnesota based Stratasys, Inc., one of the largest RPP companies in the world. Janardan's ongoing work in this area includes developing efficient approximation algorithms for optimization problems and exploring the application of these methods in the medical field to surgical planning and to scaffold construction in tissue engineering.

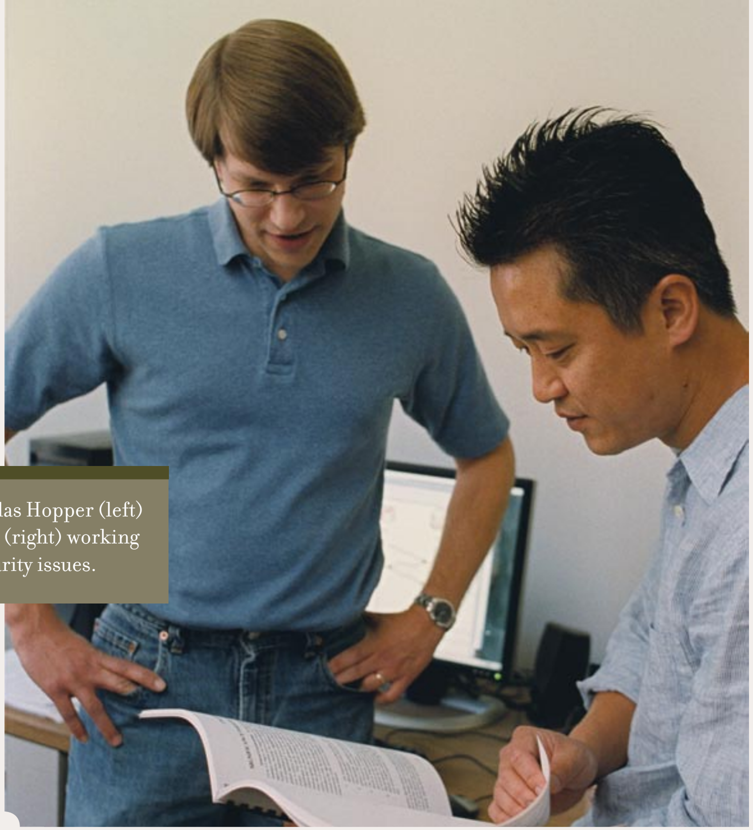


PHOTO BY RICHARD G. ANDERSON

Professors Nicholas Hopper (left) and Yongdae Kim (right) working on computer security issues.

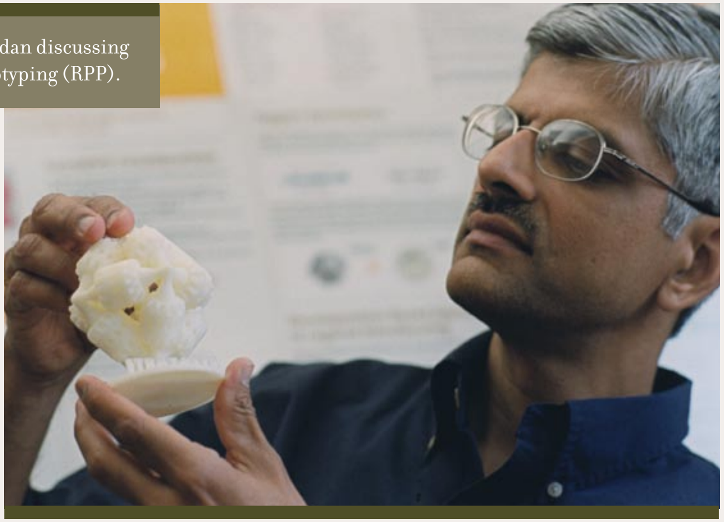
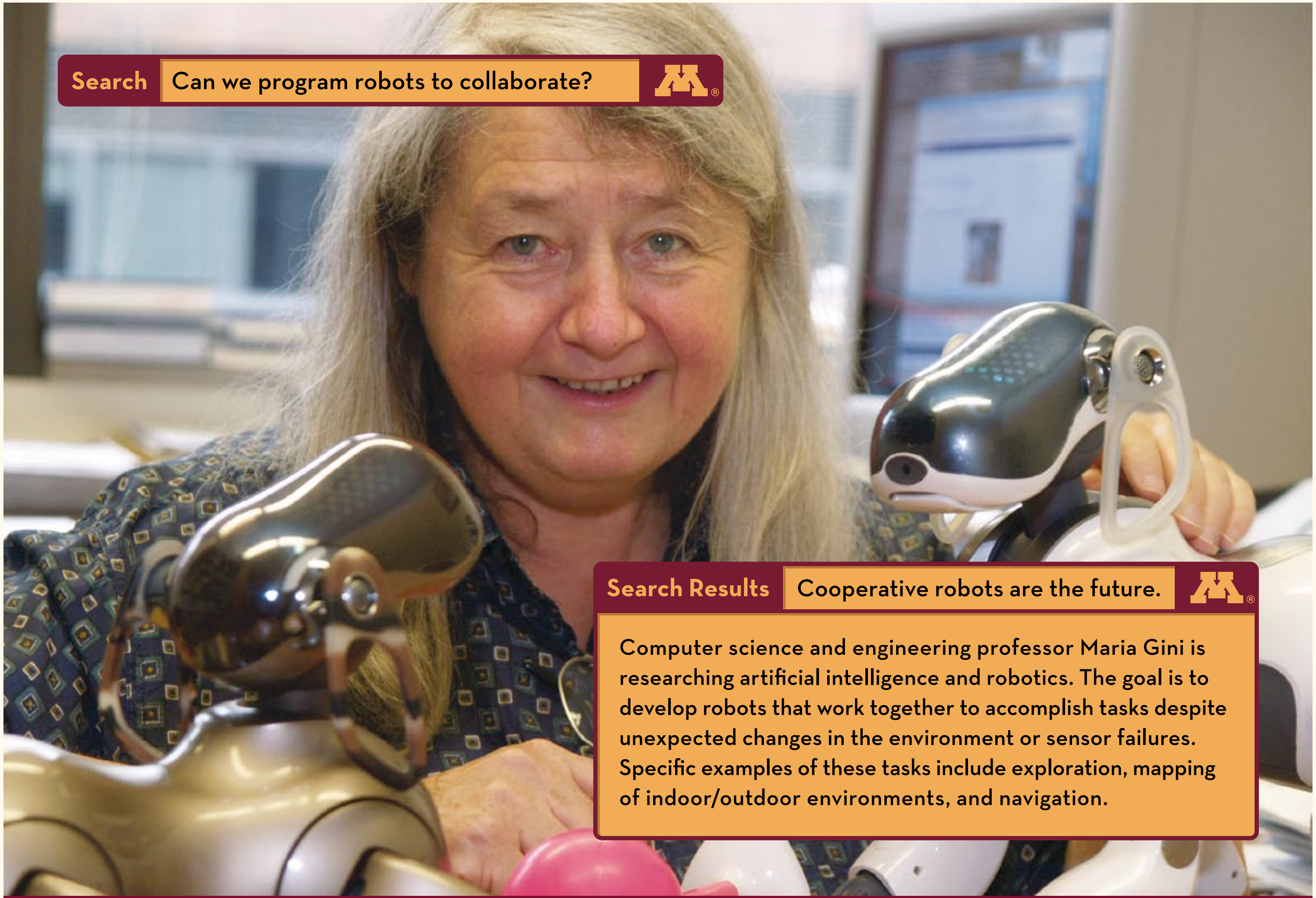


PHOTO BY RICHARD G. ANDERSON

Professor Ravi Janardan discussing Rapid Physical Prototyping (RPP).

Securing Private Data

The convenience of the Internet is undeniable, but so is the risk of leaking private informa tion when using it. Motivated by the dangers of online communication, Professor Nicholas Hopper uses computational theory to better understand and formally define network secu rity through information hiding. This is in contrast to the traditional approach, which is an "arms race" between the creators who design new protocols and the researchers who attempt friendly hacks to find the weak spots. Hopper's goal is to prove there are no weak spots for hackers to find. He proved the security of steganography, which is the practice of hiding a secret message within a public, inconspicuous one. Hopper is also advancing digital watermarking and anonymity protocols. Watermarking gives the producer the ability to restrict content use, whereas anonymity conceals the identity of those communicating. Hopper has shown that users must accept a small amount of information leaking for useful anonymity of systems. This work can help guarantee privacy to users browsing sites about sensitive medical conditions or allow our government to browse terrorist Web sites without their knowledge.



Search | Can we program robots to collaborate?

Search Results | Cooperative robots are the future.

Computer science and engineering professor Maria Gini is researching artificial intelligence and robotics. The goal is to develop robots that work together to accomplish tasks despite unexpected changes in the environment or sensor failures. Specific examples of these tasks include exploration, mapping of indoor/outdoor environments, and navigation.

PHOTO BY BRAD STAUFFER

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