CSE Welcomes New Assistant Professors

Spyros Blanas, who recently graduated with a PhD from the University of Wisconsin, will be joining Ohio State in January 2014. His primary interests include big data. His doctoral dissertation explored how to improve the performance of data processing if main memory becomes the primary storage medium for data. Part of his dissertation work is being commercialized in Microsoft’s flagship data management product, SQL Server 2014. At Ohio State, Spyros aims to make data management more efficient by exploring how software can better interact with hardware. The goal of his research is to make data-rich applications use less energy and become more responsive.

Facundo Memoli received his PhD in electrical engineering from the University of Minnesota in 2005. He then spent a few years as a postdoctoral researcher in the math department at Stanford University. From 2011 to 2013, he was a regular faculty with the School of Computer Science in the University of Adelaide, Australia. He is interested in computing and characterizing geometrical and topological properties of objects, where objects could be shapes in an image, graphs, three-dimensional shapes, finite metric spaces, documents on the web, proteins, chemical compounds, high-dimensional data-sets (or point clouds), and signals. He applies ideas from geometry and topology to solve these problems in data and shape analysis.

Chunyi Peng received her PhD in computer science from UCLA in 2013. Prior to joining UCLA, she worked as a researcher at Microsoft Research Asia. Her broad research interests are in networking and systems, with a focus on mobile systems, wireless networking, and cloud computing. In particular, she has studied the infrastructural limitations and solutions of current 3G/4G cellular infrastructure, as well as WiFi networks when supporting mobile devices and apps. She envisions that the Internet is entering the era of "mobile applications and services." Her long-term plan is to work on network and systems support for mobile applications, including system architecture design, algorithm and protocol design and analysis, prototype implementation, and performance evaluation.

Alan Ritter is a PhD graduate from the Department of Computer Science and Engineering at the University of Washington. He will spend a year as a postdoctoral researcher at Carnegie Mellon University before joining Ohio State in Fall 2014. His interests include natural language processing in short informal messages (e.g. Twitter), modeling lexical semantics with latent variables, modeling conversations in social media, and paraphrasing between different styles of language. At Ohio State, Alan will work towards the construction of scalable natural language understanding systems, focusing specifically on informal text, time-sensitive information contained in text, and the ever increasing availability of structured data and unstructured text. He is also interested in developing text processing techniques to enable new bio-medical data analysis applications.

Anastasios Sidiropoulos received his PhD in computer science at Massachusetts Institute of Technology. After that, he was a post-doctoral fellow at the University of Toronto, a research assistant professor at the Toyota Technological Institute at Chicago, and a post-doctoral fellow at the University of Illinois at Urbana-Champaign. His work is focused on theoretical aspects of computer science, with an emphasis on the interplay among algorithms, geometry, and topology. More specifically, Anastasios is interested in understanding how ideas from these diverse mathematical areas can help us devise better methods for manipulating and understanding large, complex data.
Message from the Department Chair

Dear CSE Alumni, Parents, Friends, and Colleagues,

We have just started the 2013 academic year and undergraduate CSE major enrollment has grown by 10% to 721 students, while pre-major enrollment has increased 31% to 811 from last year. Total graduate student enrollment has also grown by 17% this year, up to 358 students.

Another critical addition to the department this year is five new assistant professors who focus on five different areas: databases, geometrical computing, wireless networking, natural language processing, and computer science theory.

The CSE department will continue to grow by adding more new faculty members next year. The university has made a goal of increasing the faculty size by ten percent over the next five years. With that goal, the first focused hiring will be on the Discovery Theme investment of big data analytics. The CSE department is working with other departments in different colleges to form a multidisciplinary team to respond to the call, which enables us to expand our talents in this critical area. I will keep you informed about our progress on our efforts to gain additional resources for the data analytics initiative.

This issue continues to introduce stories and updates about our alumni and how their lives have changed after graduating. We are very proud of their achievements and contributions in their fields and to society. Besides featuring selected faculty’s research, we present three cases of CSE faculty research impact, including the Computer Vision Library (OpenCV), Hystor—a basic research project that influences the Apple’s Fusion Drive product, and the MVAPICH open source library that has been widely used in the high performance computing community.

I also want to give a special thank you and welcome to Neelam Soundarajan, who this year begins his first term as the new CSE Associate Chair. The department appreciates his tireless efforts in his new role.

I look forward to hearing more from you in the coming year.

Xiaodong Zhang
Chair and Robert M. Critchfield Professor
Computer Science and Engineering

The Department: By the Numbers

Faculty

<table>
<thead>
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Alumni

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Research Expenditures

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<tr>
<td>2009</td>
<td>$5.6 million</td>
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OpenCV has a Lasting Impact on Education, Research, and Industry

The Computer Vision Library, commonly known as OpenCV, is an open-source software library of programming functions mainly aimed at real-time computer vision and machine learning software. Although originally developed by Intel, the library is now supported by a non-profit foundation called OpenCV.org under the open source BSD license. After its continued development over the past 15 years, this software is playing key roles in education, research, and industrial applications.

CSE’s own Professor James Davis is one of the early contributors to this massive library. His PhD research on Motion History Images at MIT (graduated 2000), along with a later joint project with Gary Bradski from Intel’s Microcomputer Research Labs, was one of the earlier inclusions in the OpenCV library resulting in the OpenCV functions: updateMotionHistory, calcMotionGradient, calcGlobalOrientation, and segmentMotion.

UpdateMotionHistory updates the Motion History Image using a moving silhouette or motion field, and the calcMotionGradient creates a gradient orientation of the Motion History Image. The calcGlobalOrientation calculates a global motion orientation for a selected region while the segmentMotion splits a Motion History Image into parts corresponding to separate independent motions. These functions allow the computer to model and recognize a person’s movements and actions in video, which can then be coupled with a human-computer interactive system. Such examples that have been created include an interactive music synthesis program and an interactive, narrative play-space for children called The KidsRoom.

OpenCV was constructed to provide a shared infrastructure for computer vision applications and to increase the use of machine perception in commercial products. The entire open-source library currently has more than 2,500 optimized algorithms that are used by companies like Google, Yahoo, Microsoft, Intel, IBM, Sony, Honda, and Toyota. OpenCV is used for a variety of purposes including stitching streetview images together, detecting intrusions in surveillance video in Israel, and monitoring mining equipment in China. In addition, it is also used to help robots navigate and pick up objects, to detect swimming pool drowning accidents, to run interactive art, and to perform rapid face detection. OpenCV has a user community of nearly fifty thousand people and the number of downloads exceeds 5 million. The library is used extensively in companies, research groups and by federal agencies.

OpenCV has become a popular component in computer vision and graphics teaching in colleges, graduate schools, and advanced technical learning for engineers.

Video Game for Constraint Induced Movement Therapy

Constraint-Induced Movement therapy, or CI therapy, is a movement rehabilitation technique used after a stroke, multiple sclerosis, or traumatic brain injury in which the treatments are designed to help the brain “rewire” itself. Although CI therapy is the most effective therapy for sufferers of strokes or brain injuries for redeveloping hand and arm abilities, the difficulties of obtaining this intensive treatment make it relatively inaccessible. Associate Professor Roger Crawfis is working with the Neurorecovery and Brain Imaging Lab at The Ohio State University Wexner Medical Center to develop a video game version of CI therapy that can be used in the patient’s home. This helps to eliminate the problems patients report with the therapy—financial burden, shortage of trained therapists, and transportation difficulties.

Current CI therapy techniques usually include exercises like moving beans from one jar to another or stretching rubber bands; these exercises are intended to work the affected muscle groups. In order to make a video game, Crawfis and his team set about thinking of how particular movements, like flexion and extension, are tied to certain activities. The video game incorporates traditional CI therapy movements in different game mechanics: rowing, turning, picking up bottles, swatting bats, fishing, and ducking the head, and more. One factor that influenced the design of the game was the need for gestures to be easily refined by the therapist through data collected from the patient. Each patient is affected differently after a stroke, meaning that different muscle groups have different ranges of motion. Thus, the game has to accommodate for that aspect, as well as the change in muscle strength and ability as the patient progresses through the program.

Although it is unknown how CI therapy helps the brain rewire itself, previous research shows that CI therapy produces increases in brain volume in certain areas of the human brain. Developers hope that by better understanding how CI therapy can change the brain, the effectiveness of rehabilitation can be improved.

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January 6, 1988. It was the day I set foot on Ohio State’s campus for the first time. I have to admit I knew very little about this university and just as little about Columbus, Ohio. Back then Larry Page and Sergey Brin were just 14 years old and Google was far off the horizon. A native of Germany, all I knew about Columbus, Ohio back then when I received an admissions letter to Ohio State’s Biomedical Engineering (BME) Center was a picture I found in a book on the USA my father had on his bookshelf. This picture showed a big cannon on a snow-covered lawn in front of what I know now was the State Capitol. I did my electrical engineering undergraduate studies in a German technology-oriented college with 2,000 students. And so, back on that clear winter day, I was completely awed by the campus’ vast expanse and the massive buildings that housed so many different academic departments.

I ended up joining a research lab in the BME department that dealt with medical imaging processing. One day I saw a fellow student and labmate spin the Utah teapot—a famous computer graphics test dataset—on her screen. I was attracted to that image like a frog that sees a fly for the first time. So I took a graphics course, and another, and yet another, and many more computer science courses. I also took many other courses at Ohio State, so many that a friend once asked me if I accidentally took a course twice. But I brushed that joke aside quickly, and rushed to my ballroom dancing class.

After some time, I had taken enough computer science courses to face the CS PhD qualifying exam, which I successfully passed and which entitled me to switch departments. Research-wise, I was in the fortunate position to have not one but two excellent PhD advisors in two different departments: Dr. Fredrick Cornhill in BME and Dr. Roni Yagel in CS. So during the day I researched iterative algorithms for a medical imaging technique called Computed Tomography (CT) reconstruction, and at night I explored a medical visualization technique called volume rendering, which is essentially ‘inverse’ CT reconstruction. Knowing both ends of the stick turned out to be incredibly useful in making contributions in both fields. While my dissertation was about iterative CT, I published just as many research papers in volume visualization. This turned out to be very helpful to secure a job later on.

I graduated 1998—did I mention I took many classes—and did a postdoc with Dr. Roger Crawfis, also at the Ohio State CSE department. I then resisted the lure of the .com age and became an assistant professor at the computer science department of the State University of New York (SUNY) at Stony Brook, now called Stony Brook University. Living in Manhattan certainly brought some change to my life, including a wonderful wife named Akiko. In my research I stayed true to my dual domain research approach. I still am very active in medical imaging and just as active in visualization. Since 3D volume rendering became a solved research problem over time, I needed to add more dimensions to my visualization research. So very early on at Stony Brook I was fortunate enough to meet two rather adventurous aerosol scientists at Brookhaven National Lab where I am an adjunct scientist. The two had just built a rather sophisticated laser spectrometer that generated massive high-dimensional data. And they wanted me to help analyze them—did I say they were adventurous? This research collaboration, which is still very active, led me into the burgeoning field of visual analytics and all that comes with it: high dimensional data and information visualization, human computer interaction, cognitive science, and machine learning. All of this proved very helpful also for my medical imaging research. In that area, I became a leading figure in high performance computing where I pioneered the use of powerful graphics processors (GPU)—which back then were only used for real time computer games—for real-time 3D CT reconstruction. This high computational performance in turn became crucially important in the complex algorithms needed to enable CT imaging at low radiation doses. Low-dose CT has now become my major research direction in the medical imaging domain, where aside from GPU-acceleration, my expertise in machine learning and visualization comes in very handy to make new research contributions.

Thus far I have authored over 160 peer-reviewed journal and conference papers, which have been cited more than 5,000 times according to Google Scholar. I won the US National Science Foundation CAREER award in 2001 and the SUNY Chancellor Award for Excellence in Scholarship and Creative Activity in 2011. I am also the present chair of the IEEE Technical Committee on Visualization and Computer Graphics, and I am currently the chairman of the computer science department of SUNY Korea, the first American university on Korean soil, living in the new Korean city of Songdo near Seoul. But apart from all of these very interesting activities, what I enjoy the most is watching our almost 2-year old daughter Nico grow up. Observing and taking part in this amazing process has become the most wondrous and fulfilling project of all.

For more information, or to contact Klaus Mueller check out his website at http://www.cs.sunysb.edu/~mueller.
Originally I came to Ohio to study computer graphics; while Ohio State had a great tradition in this field, I found the work of a then new Assistant Professor (Roni Yagel) very inspiring and ended up working on rendering algorithms for volume graphics. This work led me to new, high quality reconstruction algorithms, which are still at the heart of my research today. In fact, this work continued with my students Alireza Entezari (now an Assistant Professor at the University of Florida) and Usman Alim (currently an Assistant Professor at the University of Calgary) at Simon Fraser University and led to the application of box-splines to find proper reconstruction schemes for body-centered and face-centered cubic lattices.

Also while at Ohio State, I had the good fortune of spending a considerable amount of time at the Advanced Computing Center for the Arts and Design (ACCAD). Though it was a great research environment, I especially enjoyed the diversity of students and the exposure to different research cultures and goals. This also triggered in me a desire to move beyond the theoretical foundations of graphics toward creating tools that real folks can use.

I graduated from Ohio State with a PhD and then began an academic career at Simon Fraser University. This led me to explore aspects of Human-Computer Interaction, such as human-centered design and user studies with one of my first students at Simon Fraser University, Melanie Tory (today an Associate Professor of Computing Science at the University of Victoria). Ultimately Melanie and I incorporated the ideas from these different fields into our work. Bridging this gap between human-centered design and mathematical modeling has been the main focus of my work.

I just recently took a position as a Professor at the Faculty of Computing Science at the University of Vienna, Austria. Here I am using this foundation to build a group that specializes in Visualization and Data Analysis.

Some of the early fruits of this work are a number of tools that are being used by real users today. I am particularly proud of a tool we called Vismon (vismon.org): a tool for fisheries science—employed by the Department of Fisheries and Oceans in Alaska for the analysis and prediction of fish stocks. It was a wonderful collaboration between researchers at the Resource and Environmental Management Department of Simon Fraser University and a number of computer scientists, led by my former student Maryam Booshehrian. Such tools are central for the creation and understanding of simulation models in computational science and engineering. However, our success was only possible by understanding how the user works and what questions they need answers to and, at the same time, finding efficient and reliable data structures and algorithms to be able to deal with large amounts of data.

Yet, I am most proud of my students and their success; our work has been recognized with best paper awards from IEEE Conference on Visualization (1997), Symposium on Geometry Processing (2008), and EuroVis (2010), as well as two second best paper awards from EuroVis (2009, 2012).

I am very honored to have been the recipient of a National Science and Engineering Research Council of Canada’s (NSERC) Discovery Accelerator Supplement (DAS) award, which I received in 2010. However, it was a Fulbright scholarship that gave me the opportunity to come to Ohio State in 1992 in the first place. Ohio State and in particular the computer science and engineering department was not just an intellectual treasure trove, I really enjoyed the diversity and friendliness of the student body as well as the support I received not only from my supervisors (Roni Yagel, and later Roger Crawfis) but also from the Buckeye community. One of my proud escapades into campus life was the foundation of a student group called “Active Radio” for the creation of a student radio station, which ultimately led to the founding of KBUX.

I still have many friends in Columbus and am fond to visit. But what was unique and special to me was the camaraderie and passion of my peers—Klaus Mueller (now a Professor at Stony Brook), Raghu Machiraju, Ed Swan (now a Professor at Mississippi State), as well as David Reed (now a Professor at Capital University), and Naeem Shareef.

After 13 wonderful years at SFU, I just recently went back to the old world and started a position at the University of Vienna. But I carry the Buckeye spirit with me and greet strangers with Ohio State shirts with “Go Bucks” from time to time.
Alumni Notes

Mosaliganti Awarded NIH K Grant

Kishore Mosaliganti, PhD ’08, has been awarded the prestigious NIH K award for his work In Toto Analysis of Tissue Mechanics During Vertebrate Ear Development. The project explores the origin and role of cellular and tissue forces in embryonic development.

Mechanical forces play a role in driving individual and collective cell behaviors leading to tissue shape, topology, and material property changes. When organized in space and time, these large-scale tissue changes facilitate the construction of specialized tissues and organs as complex as, for example, the eyes, ears, or kidneys. In particular, he is using cell-resolution confocal imaging with zebrafish embryos expressing fluorescent proteins to study how the ear develops. Mosaliganti is using his computer science background in quantitative microscopy for cell segmentation, tracking and lineage reconstruction, finite-element modeling of tissue growth, and genetic analysis of molecular networks in order to develop an integrated, systems-based approach to understanding ear development.

Understanding ear development is essential to developing clinical therapies for hearing loss and deafness. His current research project involves understanding the origin and role of small cellular forces that drive cell mechanics during development and disease.

The GoFigure2 software integrates algorithms that Kishore developed during his PhD and postdoc for automatically segmenting out the membranes (green) and nuclei (red) in Panels A and B (figure above). The identified cellular components are tracked through time using vision algorithms to create tracks in Panel C. Tracks are further linked through cell divisions to create comprehensive lineage histories of each cell in the animal in Panel D. The data is archived in a MySQL database that can be effectively queried. The availability of such data allows users to build multiscale models of different organs incorporating geometry, genetics, and mechanics.

Christopher Bohn, PhD ’04, is moving to the University of Nebraska-Lincoln (UNL), where he will take command of the Air Force ROTC detachment and be appointed Professor of Aerospace Studies. He will also be helping UNL set up its new cyber security curriculum.

Margaret Steele, former CSE Advising Coordinator, is serving on the NACADA Board as one of nine representatives and serves as a mentor for new professionals.

Chad Sowald, BS ’09, is currently working for The Boeing Company as a software engineer in Washington state.

Kyle Leonhard, BS ’11, was recently hired by Amazon as a software development engineer and moved to Seattle, Washington.

Eric Shaffer, BS ’00 is practicing law in computer patents, software copyrights, and internet law.

Brandon Walters, BS ’07, is employed by Eaton as a lead security analyst. He joined Eaton’s Leadership Development Program and is currently a member of their information security team performing incident response, digital forensics, and litigation response.

Brandon DeHart, BS ’06, has taken a position as a Software Systems Engineer for GE Transportation in Atlanta, Georgia. His job will focus on understanding his customers’ current and future needs and ensuring that the delivered products meet those needs.

Allen Parrish, PhD ’90, Computer Science Professor and Director of the Center for Advanced Public Safety at The University of Alabama, was recognized as a Fellow of CSAB, a society for accreditation of degree programs in computer science, information systems, software engineering, and information technology.

Craig Thornton, BS ’00, was recently promoted to Quality Assurance Automation Manager at McKesson/Paragon in Georgia. His team is currently building automated test cases to ensure the stability of the Paragon applications.
Domenic Matesic, BS ‘09, is currently working as a software developer for H Capital, a small financing company in Teaneck, New Jersey.

John Hanna, BS CIS ‘86, is currently employed with the US Air Force as a lead engineer.

Jennifer Hall, BS ‘85, is a software engineer with Michiana Hematology-Oncology, PC working with customizing the Electronic Medical Records (EMR) system. All three of her sons were students at Ohio State, and were members of the Ohio State Marching Band.

Manish Engineer, CSE BS ‘00, currently works as the project director for the Museum of Modern Art in New York City. He oversees technology projects for the external affairs group consisting of customizing and implementing CRM systems to manage communications, memberships, major donors, special events, visitors, and retail operations.

Randy Clepper, BS ‘89, MS ‘91, is a Principal Software Engineer at STAR Dynamics, Inc. in Hilliard, Ohio. He is the lead software engineer and architect for a family of multi-object tracking radar systems. In his spare time he performs Irish traditional music on bouzouki and guitar.

Vaidyanathan Receives Intel Achievement Award

Karthikeyan Vaidyanathan, PhD ’08, is a Research Scientist in Parallel Computing Labs, Intel, Bangalore. He received an Intel Achievement Award for his contributions in Top500 and Green500 and for delivering Intel's first manycore product (Intel Xeon Phi) to market and exceeding all expectations at SuperComputing 2012 in Salt Lake City, Utah. The Intel Achievement Award is Intel's highest recognition bestowed on its employees. In celebration Intel hosted a weekend-long celebration in San Francisco as a reward for the honored employees and their guests.

Karthik’s research interests are in the areas of high performance computing, high-speed interconnects and storage, and performance optimizations on large-scale systems. He is currently leading the effort in scaling HPC applications on large-scale systems.

Harishankar Named Distinguished Alumnus

Ray Harishankar, MS ‘90, IBM Fellow and vice president of technology and innovation within IBM’s Global Business Services, was awarded The Ohio State University College of Engineering Distinguished Alumnus Award. Having been with IBM since 1999, Ray has closely collaborated with IBM Research and Software divisions to make significant contributions in the area of asset strategies, cloud computing, service oriented architecture, actionable business architecture, reference architectures, enterprise technology architectures, and creation of scalable architecture solutions. Ray is also actively engaged with clients across multiple industries and has developed a recent focus on Smarter Cities.

Since 2003, Ray has received three Outstanding Technical Achievement Awards within IBM and was named an IBM Fellow in May 2006. Ray has played important roles in both external industrial advisory committees of the Ohio State College of Engineering and the Department of Computer Science and Engineering, and has been instrumental in Ohio State—IBM collaboration on big data R&D projects. Ray was named 2009 Asian American Engineer of the Year by the Chinese Institute of Engineers USA.

The faculty of the College of Engineering established the Distinguished Alumnus Award to recognize distinguished achievement on the part of alumni in the field of engineering or architecture by reason of significant inventions, important research or design, administrative leadership, or genius in production.

Sriram Krishnamoorthy, PhD ’08, was recently awarded $2.5 million over five years as part of the 2013 Department of Energy Early Career Research Program award. Sriram is a research scientist with Pacific Northwest National Laboratory. He will continue his work on Concrete Ingredients for Flexible Programming Abstractions on Exascale Systems. His research will fundamentally transform exascale programming models and runtime systems for scientific applications via the design and characterization of algorithms that automate concurrency, data movement, and resilience management. Exascale computing will provide a thousand-fold increase in computing capability that can be applied toward solving crucial energy and environmental problems.

Sriram will centralize his focus into how parallel computing solves problems, making sure that the different pieces of the full calculation are working efficiently. After building the understanding of when and where certain approaches work best in different programs and platforms, he will test how they will perform on future, extreme-scale computer systems.

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Sriram Krishnamoorthy Awarded DOE Early Career Award

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Focus On Research

Kannan Srinivasan

Increasing Efficiency and Reliability in Today’s Wireless Networks

Today’s wireless users require wireless services in order to learn, work, and play. So much so, in fact, that President Obama made a goal to have high-speed wireless services available to at least 98% of the population that also allows for a nationwide wireless public safety network so that first responders can share data and work across jurisdictions. However, creating a wireless infrastructure that could support this kind of load is a tall order. Even though the President has directed federal agencies to make more airwaves available for this purpose, the increased load on the current structure requires significant improvements in order to maintain efficient transmission of data. Currently the auctioning of airwave space to companies that are developing the next generation of wireless services has also increased the funding to support advances in security, reliability, and other features.

However, the spectrum that is available for public use is presently very limited in size. This open-access spectrum is available for free for Wi-Fi users, unlike cell phone companies who have to pay to use different parts of the spectrum. Because many people are trying to use this spectrum, the infrastructure is easily overloaded and this results in the slow connections that many of us are familiar with. This current situation limits the capability of a lot of applications like Skype, which can suffer from poor connection quality leading to one person being unable to hear the other. This is problematic because the service itself is dependent on the ability for users to be able to communicate verbally and visually with one another. Additionally, today’s users are using the spectrum in unprecedented ways. Earlier users simply downloaded information; they would just go to a website like YouTube and request the information required to watch a video, which, despite being a potentially large amount of information, is quite different from uploading large amounts of information. This new “upload” culture that is developing via Facebook and YouTube videos has changed the user from an information consumer to an information producer with a different set of demands. Because of this overwhelming demand for high-quality performance on this very small spectrum, most wireless research is focused on this area. The demand for the type of traffic people are creating and the types of applications they are interested in is constantly changing; so, the wireless networks have to be very adaptive to deal with these different types of demands.

Part of the effort to develop and maintain this kind of wireless infrastructure is through research like the work of Professor Kannan Srinivasan at The Ohio State University, which directs its attention to making this open-access spectrum more efficient and reliable for the everyday user. Driven by the new download and upload culture, Kannan’s research focuses on new radio designs, scheduling and the way we use networks.

The traditional school of thought regarding wireless communication is that if a wireless node is going to be using the spectrum, the node it is “speaking” to, as well as the nodes surrounding them, cannot speak at the same time that it is receiving. This idea is what drove Kannan’s doctoral research that ultimately developed full-duplex technologies and is the fundamental basis for his current research at Ohio State.

Generally, when we are speaking, we cannot simultaneously listen to what our conversation partner has to say. Wireless nodes are also like this because although they can talk and listen, they cannot do both at the same time on the same frequency. In order to solve this, there are different cancellation techniques and different layers of cancellation that can be applied to the send and receive transmissions for a particular node. In a simplified sense these cancellation techniques work by filtering out the “sound” of the send transmission, because the node already knows what it is saying. Nodes that can listen and speak at the same time are operating under full-duplex.

When you have this full-duplex capability in a large network, how does it change interactions and how can users best utilize this capability to increase efficiency? Kannan’s research into Rapid Coordination of Transmission (RCTC) works to utilize this full-duplex capability by effectively coordinating transmissions that are happening at the same time, or in parallel. The more nodes that you have operating in parallel the better, however, these parallel transmissions have to be organized so that they don’t bring down or interfere with other transmissions. Meaning, two

Kannan’s research group. Back (left to right): Vivek Yenamandra, Bo Chen, Wenjie Zhou, Zhenzhi Qian, and Fei Wu. Front (left to right): Yue Qiao, Gopi Krishna Tummala, Kannan Srinivasan, and Sanny Kumar.
people can talk simultaneously as long as their individual receivers (the people listening to them) are not going to be overwhelmed by the sound of both voices. The receivers must be able to isolate their particular sender’s message without interference from the other sender. Now that you have parallel transmissions, how can you make sure that they don’t bring down these other transmissions? In order to answer this question you must first understand more about the network, you need to know who that node is talking to so you can decipher who you can talk to.

Figure 1, below, shows a network of many nodes; Alice, Bob, Carol, Dave and Erwin. They all have packets to send. They are all full duplex nodes: they can send and receive packets simultaneously. Alice starts transmitting to Bob. Bob has the choice to send a packet back to Alice or to Carol at the same time as he is receiving Alice’s packet. Bob chooses to send a packet to Carol. Since Alice is full-duplex, she can hear Bob’s transmission to Carol. Therefore, she knows that Bob is NOT sending anything back. Thus, she can immediately indicate to nodes around her that they can transmit. Note that if Bob had sent something back to Alice, then she could not let the nodes around her transmit as otherwise Bob’s packet at Alice will not succeed due to interference (or collision). Dave hears Alice’s notification and transmits to Erwin. All of the three transmissions happen in parallel in RCTC. RCTC uses very short signaling mechanisms to make sure that these transmissions overlap in time as much as possible; the better their overlap the higher the number of parallel transmissions. In traditional networks, the three transmissions would likely happen at different times. In RCTC, however, all of them happen about the same time. Thus, RCTC improves spectrum usage significantly.

“The demand for the type of traffic people are creating and the types of applications they are interested in is constantly changing, so the wireless networks have to be very adaptive.”

-Kannan Srinivasan

Another aspect of Kannan’s research is based on his work with Symphony. This research is based on access point networks with each access point surrounded by many users seeking to send and receive information. The main goal of Symphony is to pack as many transmissions as possible over time by using only half-duplex wireless radios. Half-duplex radios can only send or receive but not do both simultaneously. In RCTC, every node had full-duplex capability. So, one could have this as a segway from RCTC, leading to Symphony.

The solution is to move away from the traditional transmitter-centric approach to a receiver-centric (or receiver-initiated) approach. When multiple transmitters respond simultaneously, the original receiver orchestrates how the transmissions collide in the subsequent attempts so as to minimize the number of attempts to decode all of the transmissions. Since the access points are connected using wired connections, they can exchange information to coordinate this orchestration and be more efficient. Symphony shows a 5.6 times improvement in data rate compared to traditional WiFi.

Kannan is currently looking at designing a wireless network protocol architecture that has full flexibility in how it wishes to use the available radio resources at every node. Traditionally, every node can only use all of its radio resources to either transmit or receive. Kannan’s group is designing a radio that is capable of using only a subset of the radio resources to transmit and the remaining to receive. It allows a node to change the amount of radio resources it wishes to use for transmission and reception dynamically. This radio design project is funded by his NSF CAREER award. The next step is for his group to build a fully flexible network protocols that can fully utilize this new powerful flexibility provided by a wireless node. His group has predicted many magnitudes of increase in datarate with this new technology. The Ohio State University is currently patenting this technology and is discussing commercialization possibilities with industry.

Kannan is also looking at developing wireless network simulators that will allow a wide range of wireless researchers to innovate. Currently, the latest radio designs are not supported in the state-of-the-art simulators. Kannan is planning to include the support for the latest radio technologies so that innovations on protocols that use these technologies can be possible.

Figure 1. RCTC: Alice, Bob, Carol, Dave, and Erwin are all full-duplex nodes. Alice is sending packets to Bob. Since Bob is a full duplex node, he can simultaneously send packets to Carol. Alice can hear Bob and realizes that Bob is sending to Carol. Alice indicates to others around her to talk to anyone. Dave then sends a packet to Erwin. All of these transmissions happen parallel.

Yue Qiao, Kannan Srinivasan, and Zhenzhi Qian working on a software-defined radio technology using National Instruments’ PXIe platform.
Computer Science Research at Ohio State Makes Impact in Apple’s Hybrid Storage Product

On October 23, 2012, Apple Inc. announced its new storage product called Fusion Drive that combines a small solid state drive (SSD) and a large hard drive. This integrated storage is managed by Apple’s operating system OS X Mountain Lion in a single logical space. This product can significantly accelerate data accesses in a cost-effective way for widely used Apple products, including iMac and Mac Minis.

The product’s untold story is its close relationship with a research project conducted at The Ohio State University by former CSE PhD student Feng Chen and his advisor Xiaodong Zhang, in collaboration with Intel Labs research scientist David Koufaty. The three researchers published and presented a paper entitled Hystor: Making the Best Use of Solid State Drives in High Performance Storage Systems in the 25th ACM International Conference on Supercomputing (ICS 2011) in May 2011. This work presents a hybrid storage system framework called Hystor with a small SSD and a large hard drive. The high performance and cost-effectiveness of the Hystor framework comes from three basic system components. First, instead of using the SSD as a hard drive cache, Hystor logically merges the SSD and the hard disk as a single block device managed by the operating system. Second, Hystor is driven by a set of algorithms that decide in which device (SSD or hard drive) the data should be stored and accessed. Finally, to provide sustained data processing performance, Hystor adaptively and timely migrates and retains data in the the most suitable devices for users by storing smaller, more frequently accessed data in the SSD drive and larger, less used data in the hard drive.

The Hystor paper received the Best Paper Award in ICS 2011. Following the paper’s publication, The Apple Fusion Drive group had detailed discussions with the authors of the paper. A senior software engineer of Apple made the following comment on the Hystor paper:

“Hystor is a well-designed system, and its paper discussed several key systems trade-offs in details. The Apple software engineers had carefully and systematically evaluated Hystor. This work had a significant influence in the design of Apple’s Fusion Drive. Some design elements and algorithms in Hystor have been directly used in Apple’s Fusion Drive.”

After receiving the above comment from Apple, Xiaodong Zhang, CSE Chair and Robert M. Chritchfield Professor in Engineering expressed his excitement about the far-reaching effects of the Hystor research.

“I am glad to see another basic research project of ours make a strong impact in advancing the general-purpose computing systems. In this case, millions of consumers can benefit from the fast data accesses of Apple’s Fusion Drive without purchasing an expensive full SSD drive,” Zhang said.

Chen completed his PhD in CSE at Ohio State in 2010, where he received a Graduate Research Award. He joined Intel Labs as a research scientist after his graduation and currently is an assistant professor of computer science at Louisiana State University.

CSE Hosts First Meeting of the MVAPICH Users Group

CSE hosted the first meeting of the MVAPICH Users Group (MUG), on August 26-27 at the Ohio Supercomputing Center (OSC), for a broad array of users, system administrators, researchers, engineers, and students who share an interest in the MVAPICH2 and MVAPICH2-X libraries.

Professor DK Panda’s Network-Based Computing Research Group developed and enhances the popular HPC system software package. The two-day event included talks from experts in the field, presentations from the MVAPICH2 team on tuning and optimization strategies for various components, trouble-shooting guidelines, contributed presentations, an open-microphone session, and an interactive/hands-on session with the MVAPICH2 developers.

Message Passing Interface (MPI), the lingua franca of scientific parallel computing, is a standard for the communications library that a parallel application uses to share data among tasks and is available on a variety of parallel computer platforms. On the hardware side, InfiniBand is a widely used processor interconnect favored for its open standards and high performance.

MVAPICH2 is a popular implementation of the MPI-3 standard prevalent on InfiniBand-based systems. This communication library is powering several of the world’s fastest supercomputers, including the 462,462 core Stampede system at the Texas Advanced Computing Center at The University of Texas at Austin; the 125,980 core Pleiades array at the NASA Advanced Supercomputing facility at Ames Research Center near Mountain View, California; and 73,728 core Tsubame 2.0 cluster at the Global Scientific Information and Computing Center at the at Tokyo Institute of Technology.

The MVAPICH Users Group event was sponsored by Mellanox Technologies, Advanced Clustering Technologies, OSC and The Ohio State University. More details on this event are available at http://mug.mvapich.cse.ohio-state.edu.

The MUG 2013 Participants in front of the OSC.
Faculty Updates

Feng Qin received an NSF grant to support a project entitled Towards Automated Model Synthesis of Library and System Functions for Program-Environment Co-Analysis. Feng was also promoted to Associate Professor with tenure.

Tamal Dey received a three-year NSF grant for research in Topological Data analysis for Big and High Dimensional Data.

Yusu Wang received a three-year NSF grant for research in Geometric Data Processing and Analysis via Light-weight Structures.

Michael Mandel was awarded a Google Research Award for his project Learning to Recognize Sounds for Separation. He was also given an Outstanding Research Mentor award by the Denman Undergraduate Research Forum.

DK Panda will collaborate with the Texas Advanced Computing Center on the NSF funded Stampede-Enabling, Enhancing, and Extending Petascale Computing for Science and Engineering. In addition, he received an NSF EAGER award entitled HPC Visualization with SR-IOV.


Han-Wei Shen will collaborate with Jen-Ping Chen from the Ohio State Mechanical and Aerospace Engineering Department on a new NSF award entitled BIGDATA: Data Summarization, Analysis, and Triage for Very Large Scale Flow Fields.

Raghu Machiraju with Nationwide Childrens Research Institute, received an NSF award for Predicting Changes in Protein Activity from Changes in Sequence by Identifying the Underlying Biophysical Conditional Random Field.

Nasko Rountev received an NSF award entitled LeakDroid: Exposing Leaks and Jank in Android Applications.

Leon Wang will work with Starkey Hearing Technologies on a new project entitled A Supervised Learning Approach to Combat Reverberation Effects in Speech Understanding.


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Chris Stewart was awarded a three-year grant from the NSF to research Efficient, Low-Latency Networked Storage.


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Huai Named Apache Software Committer

Yin Huai has been selected to become a software committer for the data warehouse software Hive project, sponsored by the Apache Software Foundation. This is a significant recognition to Yin's technical capability and his contributions to Hive. Yin has contributed multiple software patches to Hive. The major effort he has recently made is to merge YSmart to Hive, significantly improving the productivity of data processing. YSmart is a SQL-to-MapReduce translator with powerful optimizations. Yin is a co-author of the YSmart paper that received the Best Paper Award in the 2011 International Conference on Distributed Computing Systems. Being a committer, Yin will have a key responsibility for the future direction, innovation, and quality of Apache Hive.

Apache Hive is a production open source software for big data analytics, which has been widely used in major organizations, including Facebook, LinkedIn, Microsoft, Netflix, and Taobao. Yin Huai is a PhD student under the supervision of Professor Xiaodong Zhang, working on data management in distributed systems.

Featured Undergraduate: Ashley Biales Wise

Sometimes when selecting a university, the activities outside of the classroom are just as important as those offered inside. This is especially true for senior Ashley Biales Wise, who notes that the draw of Ohio State for her was the size of the school and its ability to attract a large number of employers seeking students for co-ops and internships. These internships, and additional outside activities offered at Ohio State are shaping her career interests.

In addition to internship opportunities, Ohio State also offers research positions for undergraduates, an opportunity Ashley has taken full advantage of with her work with Professor Chris Stewart.

“I assisted [Chris Stewart] in work for analyzing soccer data in real time for the ACM International Conference on Distributed Event-Based Systems Grand Challenge, and looked at ways to put as much of the solution into a parallel architecture,” Ashley said.

Ashley also utilizes the large campus community to get involved in clubs and organizations that can bolster her skill set and expose her to new opportunities and people.

For instance, Ashley’s involvement with the Phi Sigma Rho Sorority as their website manager has provided valuable practice for skills she developed in her CSE 3901 project class. The course focuses on web design and the discussions span from front end to databases. The course was the first time Ashley was exposed to web design and it has become one of her favorite aspects of computer science.

For Ashley, and many others, Ohio State is a great place to develop connections that will forge relationships and opportunities down the line. In fact, Ashley was recently awarded the CSE Undergraduate Scholarship which is funded by alumni donations.

“Being a Buckeye means being a part of a larger community, an extended family across the nation and the world. I know I will always have Columbus as a second home, and the connections I made here will last a lifetime.”

LeDonne Awarded DoD Scholarship

Jeremy LeDonne, a CSE, math, and electrical engineering triple major, was awarded the Information Assurance Scholarship from the DoD. This scholarship is for individuals with specializations in information assurance, which focuses on defending critical systems and infrastructures from cyber threats and attacks. The scholarship will allow Jeremy to pursue his interests in computer security and artificial intelligence. As a designated National Center of Academic Excellence in Information Assurance Education, Ohio State CSE students are eligible to apply for this scholarship.

Fuhry Awarded NSF EAPSI Fellowship

Dave Fuhry, a CSE PhD student, was awarded an NSF EAPSI Fellowship award to do research in Singapore this past summer. He worked with Professor Ee-Peng Lim who heads the Living Analytics Research Center (LARC) at Singapore Management University in Singapore. The title of their work is Interactive Visualization of User Communities and Interests in Social Networks, and it is based on finding groups of people in social networks with commonalities such as what they write and/or what places they visit, and visualizing those groups and the relationships between them. Their work will allow an exploring user to specify whether they are fully, partially, or not at all interested in each group and restructure the group configuration to match the specified “soft” interest thresholds. The restructured grouping is presented to the user in an intuitive dynamic visualization interface which can be again refined based on user preference. This work bridges both Dave’s work in Ohio State’s CSE Data Mining Lab—directed by his advisor Srinivasan Parthasarathy—on rapid visual and interactive data mining, and LARC’s strength in analysis of social network groups through topic modeling.
On April 30, 2013 the students in Dr. Roger Crawfis’ capstone course, Game Design and Development Project, presented their final projects. At the beginning of the semester, students were self-divided into groups based on game ideas, interest, or underlying technology and programming languages and groups designed their games throughout the semester. Each group comes up with a game concept that is refined within the first few weeks and then assigns roles to emphasize each individual’s particular skill set. Each individual on the team contributes to a particular technical aspect of the game development, including networking, sound, controllers, AI, and graphics. Several alumni have continued on from this course into careers at middleware vendors like Havok or EA Sports creators AAA studios. Crawfis encourages the growth of crucial skills that aid in the development of such careers.

“To encourage life-long learning, the students form cross-group technical area teams. These teams are responsible for researching current trends, tools, and research in a particular area related to video games and presenting their findings to the entire class,” Crawfis said.

Of the three projects completed for the spring 2013 course, a group called DriPSaP, consisting of CSE senior capstone students Andrew Buelow, Mario Carneiro, Kyle Donovan, Mark Gutentag, and Stephen Hara, designed the “best game,” as voted by their fellow classmates, called Realm of Kaodith. For DriPSaP, these individuals created a highly complex, turn-based strategy game where players strive to defeat their opponent by destroying the enemy’s fortress.

One of the most complex aspects of the game is the terrain generation; the six types of terrain include standard, high seas, great plains, wetlands, forest, and mountains. Each type of terrain provides a unique set of limitations and advantages for attacking and defending forces and each playing experience uses a unique map. Players can also generate different maps by modifying terrain presets and terrain height. The maps are generated via Perlin noise quantized onto a hexagonal grid. Each hexagon is then evaluated and assigned a pseudo-random gradient function which creates natural looking lakes, plains, forests and mountains. In order to smooth the barriers between each hex, a three-dimensional spline interpolation is used. The player’s knowledge of the terrain in the surrounding areas can be advantageous in battle. A “fog of war” limits initial visibility. Ultimately the player who can destroy the enemy fortress before the enemy destroys theirs will win.

**Gaming Capstone Project Awarded Best Game by Peers**

**Best Paper Awards**

Shengbo Chen, Tarun Bansal, Yin Sun, Prasun Sinha, and Ness Shroff were awarded best paper at WiOPT 2013. The paper, *Life-Add: Lifetime Adjustable Design for WiFi Networks with Heterogeneous Energy Supplies*, discusses a solution to decreased battery performance on handheld devices caused by WiFi usage. The paper proposes “Life-Add”—a Lifetime Adjustable design for WiFi networks. Using this technology, a device turns off its radio to save energy when the channel is sensed to be busy, and sleeps for a random time period before sensing the channel again.

Sai Prathyusha Peddi, CSE MS student, received the Best Poster Award at the ACM/IEEE International Conference on Cyber-Physical Systems. Her poster, *Real-Time Adaptive Signaling for Isolated Intersections* focuses on how to bound the amount of lost time, distance, and/or fuel that could be saved if traffic-signal control algorithms used full knowledge of the positions, velocities, and accelerations of vehicles in the vicinity of the intersection. This information about the vehicles would be available if already feasible vehicle-to-infrastructure communications were fully implemented.

Yinxuan Shi, with Roger Crawfis received the Best Paper Award for Design and Serious Games at the Conference on the Foundations of Digital Games 2013. The paper, *Optimal Cover Placement Against Static Enemy Positions* developed a framework and solution for placing objects within a scene that the player could use to seek refuge. The concept of optimal paths through the scene allowed for optimizing towards a desired “fun” profile (e.g. easy then surprise hard, several moments of intensity, etc.).

Wenjie Zeng, Anish Arora, and Kannan Srinivasan were awarded the Best Paper Runner Up-Spots Track for their paper *Low-Power Counting via Collaborative Wireless Communications*, at the 12th ACM/IEEE Conference on Information Processing in Sensor Networks. The core idea is to exploit simultaneous communications in 802.15.4 radios to parallelize a node’s calculation of the number (or set) of its neighbors where some condition of interest holds. The paper presents two methods for the calculation, thereby enabling low power estimation of metrics which are frequently used in wireless sensor networks.

Wenjie Zeng
Sai Prathyusha Peddi
Yinxuan Shi
Shengbo Chen

**Student News**
CSE 17th Annual Awards Banquet

Scholarships

Central Ohio Chapter of Association of Computing Machinery (ACM)  
Maxwell Roseman

Crowe Horwath, LLP & Marathon Oil Co.  
Cory Dahlstrand

Harris Corporation  
Jeremy Villa

Ernest William Leggett, Jr. Scholarship  
The Leggett Family Award  
Ian Freshwater  
Zachary Knickerbocker  
Michael McNamara  
Grace Wannemacher

Matt J. Desch & Ann M. Murphy Award  
Elizabeth Burl  
Jeremy LeDonne

The O’Connell Family Award  
Brandon Mills

Raytheon Corporation  
Alan Thornburg  
Zachary Wein

B. Chandrasekaran & Sandra Mamrak Scholarship  
Olga Benson  
Jeffrey Tornwall

Mike Liu Scholarship  
Brett Dickson  
Adam Wheeler  
Jimmy Yi

CSE Undergraduate Scholarships  
Arathi Mani  
Ashley Biales-Wise  
Tyler Leonhardt  
Claude Mbemba  
Brandon Rogers  
Jacob Shields

The Computer Science and Engineering Department held their 17th Annual Awards Banquet on April 19th, 2013 at the Ohio State University Faculty Club. This is a departmental event to honor the academic achievements of CSE students and the successes of our faculty and staff.

The department wishes to thank those alumni and industry donors who helped make this event possible; either by contributing to the undergraduate scholarship awards or by sponsoring a table. We thank Bruce Flinchaugh, TI, Anne and Matthew Desch, Central Ohio Chapter of Association of Computing Machinery, Harris Corporation, Raytheon, Crowe Horwath, LLP, and Marathon Petroleum Company.

A group of awardees and their guests at the banquet.

Department Awards

Outstanding Teaching Award  
Paolo Bucci  
Bruce Weide

B. Chandrasekaran & Sandra Mamrak Graduate Fellowship  
Krishna Kandalla

Mike Liu Graduate Fellowship Award  
Hari Subramoni  
Jin Teng

Eleanor Quinlan Memorial Award  
Diego Zaccai

Outstanding Service Award  
Kitty Reeves  
Carrie Stein

Founders Recognition  
Roy Reeves
Many Thanks to Our Alumni
and Friends!

We appreciate the following alumni, faculty, staff and friends who directed their Ohio State gifts to the Computer Science and Engineering Department. Listed below are our benefactors over the past six months. These donations are making a difference. Private support can help us to attract outstanding students and promising young faculty. We have used gift dollars to improve research and teaching labs as well.

**Individuals**
- Catherine Agacinski
- Gojko Babic
- Sandip Bapat
- Karl Bloss
- Sarah Bohman
- Jane Leggett Burris
- Feng Chen
- David Chua
- Thomas Christian
- Catrena Collins
- Linda Daniels
- Sean Dunn
- Micha Elsner
- James Giuliani
- Steven Goldberg
- Richard Halverstadt
- Wayne Heym
- Daren Hrelic
- Peter Hsu
- Dale Kruse
- Rahul Kumar
- Ten-Hwang Lai

**Corporations**
- AT&T Foundation
- Bank of America Foundation
- Central Ohio Chapter of Association of Computing Machinery
- Crowe Horwath LLP
- Google Inc.
- IBM International Foundation
- Honda Resarch Institute
- Marathon Petroleum Company
- McKesson Foundation Inc.
- Microsoft
- National Center for Women and Information Technology
- NEC Laboratories America, Inc.
- NVIDIA Corporation
- Raytheon Company
- Tech Corps Ohio
- Toyota Info Technology Center
- Yahoo!
- Wolfe Enterprises Inc.

You may direct your CSE gift or donation to specific uses or specific research online at www.cse.ohio-state.edu/giving or by mail with the attached envelope. For more information about various means of giving, contact: Xiaodong Zhang, Professor and Chair at (614) 292-2770 or zhang@cse.ohio-state.edu.

**Welcoming the New Associate Director of Development: Ashley Waltermeyer**

Greetings alumni, faculty, staff, parents, and friends of the Computer Science and Engineering Department, my name is Ashley Waltermeyer and I began in April as the new Associate Director of Development for the College of Engineering, with a specific focus on the computer science and engineering department. I am a 2011 graduate of The Ohio State University who always hoped I would have the opportunity to return to my alma mater. Prior to coming to Ohio State, I worked as the Phonathon, Student, and Young Alumni Coordinator at Ohio Wesleyan University. Everyone has been incredibly welcoming and I already feel like I’m at home.

I understand the alumni are a vital part of our success. A strong connection with our alumni helps the department recruit the best students from all over the world, contribute to new developments in computing, and connect with leaders in the industry. My primary focus will be to strengthen and maintain those relationships and continue to cultivate scholarships for our students. I have already had the opportunity to meet many amazing alumni in Washington D.C., California, and here in the Columbus area, and I look forward to meeting many more of you in the near future!

Feel free to contact me at (614) 688-1816 or by emailing me at waltermeyer.3@osu.edu. I want to connect each of you to the department in a way that is meaningful to you.
Congratulations to CSE Spring & Summer Term Graduates!

The Department wishes you the best of luck in your future endeavors.

Bachelor’s CIS
Donald Bacharowski
Matthew Bear
Andrew Buelow
Timothy Carpenter
Bradley Chambers
Aaron D’Amico
Simeon Georgiev
Mark Gutentag
Alexandar Heck
Jay Hines
Trevor Holt
Cameron Jett
Frans Kurntawan
Benjamin Morris
Edward Powell
Christopher Price
Philip Ross
Steven Ruiz
Ian Shortridge
Drake Sigler
Todd Simmons
Joel Sowers
David Spetz
Charles Stockton
Daniel Tedder
Raja Tummala
Zeya Wang
Max Weinberg
Jianan Zheng
Adam Zimmerman

Bachelor’s CSE
Jesse Akers
Sofya Akhmametyeva
David Albert
Kyle Albert
Mihir Amin
Christopher Ashton
Scott Beaber
Vishal Bhatnagar
Tiffany Bogantz
Sergiy Borysov
Nathan Braid
Ryan Brown
David Buri
Kevin Cantwell
Lap Hou Chan
Haochi Chen
Joseph Chirico
Jahi Crouch
Ryan Cutler
Kevin David
William Dazeey
Jeffrey Depassio
Michael Detwiler
Sada Diiallo
Nathaniel Dikeman
Connor Dockay
Colin Drake
Maxwell Elliott
Vince Fonte
Joel Friedly
Calvin Goodman
Michael Griscom
Zachary Hall
Gregory Hermack
David Hewitt
Jonathon Hickman
James Hickman
David Huyhn
Zhixuan Jia
Ali Jiraki
Mike Johnson
Neil Johnson
Jason Kao
Basheer Kayali
William Kentris
David Klimek
Lisa Krauss
Kevin Landers
Clayton Mallory
Jonathan Martin
Mark Mathis
Jacob McConnell
William McGowan
Timothy McLean
Mathew Meade
Yi Mei
Samuel Meier
Arthur Mo
Bashiri Mohamed
Alexander Notwell
Evelyn Okorji
Shibayanu Pan
Deven Pandya
Jacob Peddicord
Dmitry Pilipenko
Timothy Raphael
Nicholas Rotonda
Michelle Rush
Christopher Sedar
Matthew Seffernick
Aaron Shortridge
Cari Shotwell
Stephen Smith
Eble Albert Smith
James Sosan
Daniel Steck
Adam Stutz
Troy Stutts
Michael Sustarsic
Tian Tan
Tiffany Terdan
Daniel Thiery
Michael Timko
Chad Travis
Daniel Tucholski
Chau Vo
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