



THE EXPONENTIAL POWER OF COMPUTER SCIENCE

Doubling down on its commitment to computer science (CS), Northwestern aims to energize research, education, and economic opportunity.

Northwestern^{CS}

We live in a world where nearly everyone everywhere has a computer in hand or tucked in a purse or pocket all the time. We talk to our computers, ask them for directions, and let them connect us to people next door or on the other side of the world. On a greater level, computers can drive our cars, help diagnose our diseases, and enable us to explore distant planets.

And this is just the beginning.



"THE SYNERGY BETWEEN COMPUTER SCIENCE AND CS+X IS EXCITING. WE HAVE THE OPPORTUNITY NOT ONLY TO REVOLUTIONIZE COMPUTER SCIENCE AT NORTHWESTERN, BUT ALSO TO REVOLUTIONIZE NORTHWESTERN WITH COMPUTER SCIENCE. WE'RE GOING TO INVENT NEW KINDS OF COMPUTER SCIENCE THROUGH CONNECTIONS WITH OTHER DISCIPLINES." LARRY BIRNBAUM PROFESSOR OF COMPUTER SCIENCE

As much as computers have already edged their way into so many of our daily activities, they are now poised to saturate our world and our lives in previously unimagined ways. Computers and computational thinking have already changed and amplified how researchers—in virtually every discipline—think about and use the constantly growing stockpiles of valuable, untapped data. Within the field of computer science itself, emerging specialties such as artificial intelligence, machine learning, robotics, and data analytics have the potential to transform nearly every field of endeavor.

"The power of computer science lies in augmenting our thinking and in its ability to accelerate research exponentially in other areas," says Julio M. Ottino, dean of Northwestern's McCormick School of Engineering. "Even areas as diverse as art, economics, medicine, and political science can benefit from integrating computational thinking into their research and education. The possibilities are endless."

Not surprisingly, Northwestern has experienced an unprecedented spike in student demand for CS courses and identified enormous opportunities for advanced CS research across multiple disciplines. To address these needs and opportunities, the University will add 20 full-time computer science faculty members, half in core computer science areas and the other half as CS+X appointments, which signifies a collaboration between computer science and another discipline. This investment will enable researchers to explore new pathways while empowering students with the essential knowledge of CS they need to do great things in the world.

"We have always recognized that computers are a tool to serve us and make our lives easier," says Kristian J. Hammond, professor of computer science. "But there are still massive areas where we have yet to discover just how much our lives can be enriched by computation."

UNPRECEDENTED DEMAND

In the past five years, student demand for computer science at Northwestern has soared, the number of computer science majors has tripled, and computer science courses have increased enormously in popularity among non-CS majors.

For new college graduates, basic computer science skills have become a prerequisite for many of the best jobs in the career marketplace, but Larry Birnbaum, professor of computer science, thinks that the exploding demand is about more than students wanting to improve their chances of landing a great job.

"Students see computer science as an area where they can really make a tremendous difference in the world and maybe do it quickly," Birnbaum says. "That's because the time and distance from the original conception of an idea to its ubiquitous acceptance and almost universal presence in the world is so much faster in computer science than in any other field."

Birnbaum believes that Northwestern's expanded commitment will enable faculty not just to introduce more students to computer science, but also to introduce computer science majors to new themes within the field. A student might be interested initially in programming, for example, but through new classes, uncover interests in artificial intelligence, data science, and complex systems.

"We're planning cross-cutting themes that will pull in a lot of people from diverse areas within computer science," Birnbaum says.

"To pinpoint those themes, we're looking to the future of computer science and what areas will make that future happen faster."

BROADEST IMPACT

CS+X—computer science plus another discipline—marks the spot where many of the futuristic themes that Birnbaum references lie and where their impact can be greatest. The fundamental concept is not new at Northwestern: collaboration has a long history at the University. Several of the University's computer science professors hold joint appointments in fields as diverse as music, journalism, and education; and many of the newly funded faculty positions will focus on where different disciplines intersect.

In the CS+X faculty search, Hammond will look for researchers whose work can simultaneously affect several disparate fields. Computer science plus decision making, for example, could affect public policy, economics, sociology, and more. "We are looking for themes of impact—places where computer science can genuinely change not just one, but many fields," Hammond says. "We will identify the areas where we can foresee having the most outrageous impact and become leaders in those areas."

Birnbaum and Hammond should know: they are early CS+X pioneers. The duo founded Narrative Science, a company that uses artificial intelligence to extract the most important information from a data source and turn it into a narrative expressed in natural language. The underlying program resulted from a collaboration among the two professors, their students, and students from the Medill School of Journalism, Media, Integrated Marketing Communications. *The New York Times*, *Wired*, and *Business Insider* have featured coverage of Narrative Science, and it received a 2011 Chicago Innovation Award.

"I was drawn to CS+X because of the notion of impact," Hammond notes. "When you're an engineer, you want to build things for people to use. It's not about what the computer can do. It's about how we can use computers to help us do things better, faster, and easier."

Birnbaum says, "The synergy between computer science and CS+X is exciting. We have the opportunity not only to revolutionize computer science at Northwestern, but also to revolutionize Northwestern with computer science. We're going to invent new kinds of computer science through connections with other disciplines."

Other Northwestern Engineering professors also have brought their CS+X research advances to market successfully. 4C, a data science company that helps agencies, brands, and television networks plan, measure, and execute advertising campaigns more effectively was founded by Alok Choudhary, the Henry and Isabel Dever Professor of Electrical Engineering and Computer Science. 4C's algorithm tracks trillions of data points that reflect the behaviors of more than one billion consumers worldwide, including within social networks. It counts among its customers 400 of the Fortune 1000 companies.

GROWING CHICAGO TECH HUB

The symbiosis among Stanford, the University of California-Berkeley, and Silicon Valley is undeniable. The universities helped build the tech industry; the tech industry helped grow the universities.

California doesn't hold a monopoly on symbiosis. With companies like Narrative Science and 4C entering the marketplace, Chicago's technology and entrepreneurship scene is thriving. Birnbaum and Hammond believe that Northwestern is now positioned to contribute to and accelerate growth in this already booming ecosystem.

"It's not an accident that Microsoft and Amazon are in Seattle and that the University of Washington has a great computer science department," Birnbaum says. "These entities feed on each other and grow."

Northwestern is already known for its entrepreneurial students. With its Chicago presence and plans to expand its world-class faculty, Northwestern will strengthen research, train more students, and contribute to intellectual, academic, and economic growth in the Midwest.

"We can now create a generation of computer scientists focused on becoming agents of positive change," Hammond says. "They won't just look at the machine for its own sake. They'll look at it for the sake of the community as well."

AMANDA MORRIS

THE X-FACTOR

By connecting computer science with other disciplines, Northwestern researchers have the opportunity to revolutionize computer science and to create entirely new fields of study. This is CS+X: computer science plus another discipline.

Here just a few examples of Northwestern Engineers who constantly challenge the boundaries of this new frontier.

CS+MUSIC

An accomplished jazz musician, **Bryan Pardo** uses computer science to develop easy-to-understand tools for audio production. His tools include SocialEQ, an equalizer that lets the user achieve a desired effect by listening to the sound and rating alternatives.

CS+ROBOTICS

Working with the Rehabilitation Institute of Chicago, **Brenna Argall** combines computer science with robotics to develop devices for individuals with physical disabilities. Her work includes an autonomous wheelchair that uses technology similar to that in driverless cars.

CS+EDUCATION

Michael Horn designs computer games that help school children learn difficult subject matter in engaging ways. Recently showcased at Chicago's Field Museum of Natural History, Horn's Build-a-Tree game helps players understand diagrams called phylogenetic trees that show the evolutionary history of organisms.

CS+ART

Oliver Cossairt uses computer imaging to uncover the hidden layers in works of art. A member of the Northwestern University/Art Institute of Chicago Center for Scientific Studies in the Arts, he helped reveal how Paul Gauguin created his Nativity print, which was found to be a layering of images created on paper by drawings, transfer of images, and two different inks.

CS+LITERATURE

Douglas Downey worked with Northwestern English and classics professor Martin Mueller to restore the millions of incomplete words in transcriptions of early English texts. Downey used machine-learning techniques to evaluate the contexts of the incomplete words and fill in the missing characters.