Big Data meets big theory at annual symposium

As our abilities to acquire, store, and analyze mountains of data have grown in recent years, so too have questions about Big Data’s true abilities and limits. Proponents tout Big Data as a means to improve the quality of almost any process we can measure. But data alone, without accompanying theory, may not lead to the best questions and hence may not be generating the best answers.

SFI’s annual Business Network and Board of Trustees Symposium will explore both the promise and the limits of Big Data, as well as the value of theory in the Big Data context.

“The fundamental hope of Big Data proponents is that it can provide a tool to help them substantially answer their questions,” says Symposium organizer, neuroscientist, and SFI Business Network Director Chris Wood. “But perhaps the biggest misconception is that we can answer all our scientific, business, government, or political questions if we only have the right data.”

Often the true usefulness of Big Data is uncertain, Wood points out. Social scientists are now using data from social networks such as Twitter and Facebook to make inferences about social interactions in general. Whether or not the conclusions from online network data generalize to other forms of interaction is an important empirical question, he says, but that question cannot be answered from the online data alone.

Sometimes Big Data can be the right resource. Symposium speaker Dan Wagner’s analytics during the 2012 Obama campaign used a variety of commercial and political data to identify those voters likely to favor Obama’s messages, then helped find ways to reach them electronically or face-to-face. The strategy contrasts markedly with more traditional “voting bloc” techniques.

Problems with the digital economy – particularly people’s willingness to give away data about themselves that ad companies will pay dearly for – are the subject of a recent New York Times op-ed by the Symposium’s keynote speaker, author Jaron Lanier. Other Symposium participants include Alexander Szalay, a cosmologist at Johns Hopkins who was among the first to build a very large-scale scientific database; SFI External Professor Cosma Shalizi, a professor of statistics at Carnegie Mellon who offers cautionary tales about incorrect inferences and bulky models; and author James Bamford, a leading scholar on the U.S. National Security Agency, which is perhaps the biggest “Big Data” organization of them all.

In any case, it is essential to question and test assumptions about Big Data and its applications, Wood says. A familiar example is the use of search histories to target online ads. Are all search terms equally valuable to advertisers? Such questions are part of the “arms race” between companies providing online services and seeking to deliver the best “eyes” to their advertisers. The invitation-only Symposium runs October 31-November 2 in Santa Fe.

Workshop: How far can Big Data about cities really take us?

Big Data’s potential to provide a quantitative basis for addressing familiar urban problems has prompted several universities and corporations to launch programs dedicated to urban informatics and policy.

But the use of extensive data in urban management is not new, which poses questions about what specific qualitative leaps are achievable in the near future, and what data those advances require.

For a few days in September, urban researchers, city planners, and representatives from international organizations and major corporations are meeting at SFI to explore how Big Data can help them better understand, plan, and manage cities.

Some Big Data enthusiasts believe “if we can measure everything we can solve everything, without knowing or caring about underlying constraints,” says meeting co-organizer and SFI Distinguished Professor Geoffrey West. The workshop will explore under which specific conditions this may be true.

In that view’s favor, some pressing urban problems – such as effective public transportation or even crime reduction – might be tackled using relatively simple approaches enabled by more and better data. But “we still don’t know how such solutions play out.”

SFI co-founder Gordon Moore’s law about the doubling of computing power every few years is of little significance compared to the astronomically greater improvement in computing power achieved through smarter algorithms, Cris says.

An SFI workshop in early August for physicists and computer scientists sought to prompt collaboration on new algorithms for solving problems and modeling nature.

A primary source of smarter algorithms is statistical physics. Physicists use their insights into a system’s structure to design algorithms and collect empirical evidence of their validity. Of particular interest are algorithms that “skip over the steps that nature takes,” as Cris puts it, bypassing what’s called the “critical slowing down.”

Building a theory for ‘sustainability’

It’s a word being attached to products, businesses, fisheries, farms, and more – but what does “sustainable” really mean? And if you can find a definition that everyone agrees on, how do you know whether you are attaining it?

“The problem is that the term has been used in many ways,” says SFI Professor Luis Bettencourt. “To some it means quick fixes to crop yield or water quality problems, with little consideration of the ecosystems services that support those fixes or the shifts they require in other human demand or consumption. To others it’s useful, but general, aspiration.”
Nonlinearities
From the editor

At the Science of the Whole Institute, a popular place to hang out is the office of Stephanie Forrest, where you can often find her with her team, working on a project. Stephanie is a physicist who has been working at SFI for over 20 years, and she has a passion for exploring the complex systems that underlie our world.

In an August 5 article in the Santa Fe New Mexican, SFI’s Maureen Paiza-DuBayrnik explores ways educators can engage U.S. students in computer science. The column is part of a series of SFI-written “Science for a Complex World” articles.

Several publications noted on August 1 that the White House announced that President Barack Obama intends to nominate Frances Cordova to lead the National Science Foundation. Cordova is an SFI visiting professor.

Ecological and the “Santa Fe stock market model” are getting another look in the wake of recent financial crises and market downturns that classically trained economists failed to foresee, according to a column in the Wall Street Journal on July 10.

In its next Business Network topical meeting, The Natural History of the Corporation, and the relationship between corporate and financial services company Towers Watson.

While parallels can be drawn between the human and corporate life cycles, there are also important differences. For example, corporate life cycles are not inherently inevitable, and corporations can experience rebirth through new technology and continual re-invention.

During the workshop, that challenge made for an intense two-way flow of ideas between the physicists with their intuition and the computer scientists who would like to prove theorems about these smarter algorithms.

“We’re trying to strengthen the bridges between physicists and computer scientists and between physicists and computer scientists and engineers,” he says. As I’m writing this I received word of a special tea for Laura Fortunato and Kyle Yin to take place this week. I feel pulled to invite the individuals who have left for exciting new jobs, to come back and share stories of the renewal that makes the institute such an ideal place. But I feel pulled to invite the individuals who have left for exciting new jobs, to come back and share stories of the renewal that makes the institute such an ideal place.

Are corporate and human life cycles similar?

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Business enterprises, particularly large corporations, are closely woven into the fabric of modern society. Individual corporations go through life cycles of birth, growth, maturity, and death akin to the life cycles of people.

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Sustainability
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“One important meaning is to provide improved well-being to humans without long-termרכים by clouds, mountains, or other bodies of water. The Great Plains region of the United States is particularly appealing in big cities,” says co-organizer Jose Lobo, a senior scientist in the School of Sustainability at Arizona State University. “But often people prefer to open a window or shut the blinds, which undermines such solutions.”

Cities offer a rich interplay of human and social behavior in highly managed and instrumented spaces, Bettencourt notes. The nature of cities is at once to promote efficiencies and socioeconomic development. How this can be achieved through scientific insights, engineering solutions, and creative new policies is the central question for urban research. The meeting creates the opportunity for an exceptionally varied set of leading urban thinkers to talk openly about the future of cities in the age of Big Data, he says.

The invitation-only workshop, How Far Can Big Data Take Us Towards Understanding Cities?, runs September 19-21 in Santa Fe.

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Physicist Sid Redner to join SFI in 2014

External Professor Sidney Redner will join the Institute’s resident faculty next summer, SFI Chair of Faculty Jennifer Dunne announced on August 13. Redner now chairs the Department of Physics at Boston University.

Redner says he’s looking forward to the working style and academic freedom SFI affords, noting, “scientists here say they are happy to have come by. He first tasted life as an SFI during visits in 2004 and 2005, when he was an Visiting Scientist at Los Alamos National Laboratory working on opinion formation.

He hopes to continue work on quantitative social science, but “I couldn’t even predict what I’d be doing six months from now if I really like to reinvent myself at SFI,” he says.

Redner earned an A.B. in physics from UC Berkeley in 1972 before moving to MIT with plans for a career in high-energy experimental physics. Following a few years studying high-energy theory and mathematics, Redner began working on statistical physics, focusing on phase transitions and renormalization theory, with advisor H. Eugene Stanley.

After earning his Ph.D. in 1977, Redner spent a year at the University of Toronto before joining BU’s physics department in 1978. Over the past three and a half decades, he has worked on a variety of topics related to statistical physics, including polymer physics and the theory of random walks, in addition to more recent work on complex networks and on social dynamics such as voting and opinion formation. He has been chair of BU’s physics department since 2011 and joined SFI as an external professor in 1997. He is the author of more than 200 academic papers and books chapters as well as two books on statistical physics.

“Redner is an outstanding addition to the resident faculty,” says Dunne. “His rigorous and creative approaches to a wide range of research topics complement ongoing work at SFI, and he will add new dimensions to the intellectual and institutional life here.”

Ben Althouse brings a computational backdrop to the study of infectious disease epidemiology. Because infections do not spread uniformly through populations, Althouse’s research simulates the consequences of the disease transmission process that give rise to a pathogen’s heterogeneous transmission patterns. He hopes his work might help explain similar phenomena in other fields, and he looks forward to exploring these applications from within SFI’s interdisciplinary community. He holds degrees in biochemistry, mathematics, and bio-statistics and has recently completed his Ph.D. in epidemiology at Johns Hopkins University.

Ruben Andrist is exploring the future landscape of quantum computing. As a researcher and a programmer, he investigates the stability of various quantum codes by determining how well they could retain information in the presence of external noise. Andrist’s current research draws from the distinct fields of quantum information theory and statistical mechanics, and he expects to develop a wealth of new applications in collaboration with SFI researchers from other disciplines. He holds a Ph.D. in computational physics, statistical mechanics, and quantum information science, from the Swiss Federal Institute of Technology in Zurich (ETH Zurich).

Eric Libby is exploring a critical and not-yet-understood phase in evolution—the transition from single-celled to multicellular life. As a quantitative biologist, he models the environments and evolutionary pressures that lead single-celled organisms to emerge as multi-celled individuals. He works in close partnership with experimental evolution researchers, and he looks forward to exploring topics such as self-organization. He is completing a postdoctoral fellowship at the New Zealand Institute for Advanced Study. His Ph.D. is in mathematical biology from McGill University.

Sam Scarpino tracks infectious disease epidemics. The epidemiology of pathogens is directly affected by the complex, dynamic landscape of human and animal populations. Sam believes epidemic models must integrate quantitative techniques from fields such as economics, genetics, ecology, and statistics. The interdisciplinary nature of his work makes SFI an ideal place to advance his research, he says. Sam recently earned his Ph.D. from the University of Texas at Austin, where he worked with public health officials to improve influenza surveillance.

Departing Fellows

Seven Postdoctoral Fellows and Omidyar Fellows have recently left the Institute for positions in academia. SFI Omidyar Fellow Rogerio Braakman has joined the Department of Civil and Environmental Engineering and the Department of Earth, Atmospheric, and Planetary Sciences at the Massachusetts Institute of Technology as a postdoctoral fellow. SFI Omidyar Fellow Laura Fortunato has joined the Institute of Cognitive and Evolutionary Anthropology in the School of Anthropology and Museum Etnography at the University of Oxford as a university lecturer. She also has joined the Evolutionary Anthropology Department at Magdalen College at the University of Oxford as a tutorial fellow.

SFI Omidyar Fellow Anne Kandler has joined the School of Mathematical Sciences at City University London as an assistant professor. SFI Omidyar Fellow James O’Dwyer has joined the Department of Plant Biology at the School of Integrative Biology at the University of Illinois as an assistant professor.

SFI Omidyar Fellow Scott Ortman has joined the Department of Anthropology at the University of Colorado-Boulder as an assistant professor.

SFI Omidyar Fellow Charles Perreault has joined the Department of Anthropology at the University of Missouri-Columbia as an assistant professor.

SFI Postdoctoral Fellow Hyunjoo Youn has joined the Institute for New Economic Thinking, Oxford Martin School, University of Oxford, as a senior research fellow.

The application period for the 2014 SFI Omidyar Fellowship is open. Interested postdoctoral researchers should apply before October 25, 2013. For eligibility requirements and to apply, visit www.santafe.edu/ofellowship. Please email questions to ofellowship@santafe.edu.
Learning Lab coalesces K-12 ed programs

As a relatively recent branch of science, the study of complex systems is nearly nonexist- tent in K-12 science curricula. Yet complexity today touches nearly every other scientific discipline and has informed many recent innovations, says Irene Lee, a longtime edu- cation researcher in SFI’s Education and Out- reach group.

In August, Lee was named director of SFI’s new Learning Lab, created this summer to support an important component of the Institute’s mission: inspiring the next genera- tion of scientists. The Learning Lab will help translate SFI’s research for the general public, with an emphasis on students in kindergarten through 12th grade.

“The problems our world is facing—hunger, climate change, conflict—are going to be best addressed and solved by people who understand complexity,” Lee says. “The ability to consider all the interrelated factors that contribute to these problems will be a critical skill needed in designing solutions.”

Until now, SFI has addressed the community’s need for complexity science education with programs targeted for specific audiences. The Learning Lab will create a more global and strategic approach to sharing SFI research outcomes, conducting research on best prac- tices in teaching complexity science, evaluat- ing current education efforts, and creating new models for complex systems education.

Significantly and symbolically, its staff now resides under one roof, having recently moved to SFI’s Gatehouse near the entrance to the Cowan Campus.

The ability to effectively disseminate out- comes is an important component of all SFI research. The Learning Lab will maintain close relationships with local schools and uni- versities that provide students access to this science, and work closely with researchers to make sure their research is accurately pre- sented and the pedagogy is age-appropriate.

The Learning Lab encompasses all of SFI’s current and future educational programs for local students in kindergarten through 12th grade, including Project GUTS (Growing Up Thinking Scientifically), GUTSY Girls, and the New Mexico Computer Science for All pro- gram, as well as professional development programs for teachers.

The goal, says Lee, is to share the excite- ment and relevance of complexity science with a new generation of young scientists and, ultimately, support efforts to encour- age students to pursue careers in STEM (science, technology, engineering, and math) disciplines.

Now seeking applications/nominations for SFI’s Cowan Chair

The Institute is seeking nominations for and applications from individuals conducting research in the social and behavioral sciences for the SFI Cowan Chair in Human Social Dynamics. This is a full-time resident faculty posi- tion at the equivalent of the assistant or associate professor level. Applica- tions are due by November 1, 2013. More at www.santafe.edu/cowan.

Science symphony merges math & music

Sound is vibration. Rhythms have ratios. Octaves are fractions of one another. For cen- turies, musicians have explored the mathematical relationships among scales and harmonies to pluck our emotions. Composers kull us with patterns and then surprise us with asymme- tries. Even the planets play unheard songs in revolutions and orbits.

On Saturday evening, November 2, SFI and The Santa Fe Symphony present a unique symphony of science. The event features an expansive multimedia presentation and re- marks by SFI Professor Cris Moore, a math- ematician and computer scientist, interspersed with musical selections by The Symphony.

“Mathematics can help us understand why we love the music we love and how to create new music that no one has ever heard be- fore,” says Moore.

November 4 special concert brings math and music to area students

On Monday, November 4, several hundred northern New Mexico 7th-9th grade students will attend a version of the “Majesty of Music and Mathematics” event designed just for them. SIVP for Education and Outreach Ginger Richardson says the field trip/concert at The Lensic will form the basis of an ongo- ing educational website with learning tools for teachers and students, to be available at SFI’s Complexity Explorer (www.complexityexplorer.org).

Greg Helman, The Symphony’s Founder and General Director, says: “Throughout history there has been much conjecture on the com- monality of music and mathematics, and this project is an effort to explore through the language of mathematics the nature of rhythm, symmetry, and harmony.”

The program takes the audience on a jour- ney, from the rhythms of molecules and planets to the harmonies of dolphins and the dissonances of the “devil’s interval,” from the music of Strauss to the theme song of The Simpsons, from the earliest bone flutes 40,000 years ago to the soundtracks of modern cinema.

The Symphony’s performances span the musi- cal spectrum, from demonstrations on the harp and flute to movements from Strauss, Brahms, Prokofiev, Handel, Holst, Wagner, Bach, Adams, and more.

The November 2 concert, “Voyages of Discovery IV: The Majesty of Music and Mathematics,” takes place at 7:30 p.m. at the Lensic Performing Arts Center. Tickets range from $22 to $76 and are available through the Symphony box office at (505) 988-1414 or (800) 480-1319, and through The Lensic Box Office at (505) 988-1234. Tickets are also available online. Visit www.santafesymphony. org or www.lensic.org.

“The Majesty of Music and Mathematics” is the fourth in a series of “Voyages of Dis- covery” events co-organized by SFI and The Symphony.

This year’s Voyages is generously underwrit- ten by the Andrew and Sydney Davis Foundation.

It’s time for transdisciplinary electric power grid science

As climate change increases weather distur- bances, as increasing demand tests power supplies, as smart grid and renewable energy technologies make the grid more complex and distributed, and as planners improve re- sponses to inevitable power failures, a trans- disciplinary understanding of power grid reli- ability and complexity informed by modeling becomes more critical, according to a July 23 opinion piece in PNAS co-authored by SFI Professor Cris Moore, SFI External Professor Raissa D’Souza, and collaborators.

“Validated models enable the next grand challenge: improve and transform power grids to meet 21st century pressures. Reali- able electricity must reach more people demanding more energy in more places... These challenges span engineering, physics, complex networks, computational science, economics, and social sciences,” plus ecol- ogy, they conclude.

Hierarchy in networks could have emerged at random

From river systems to electrical grids, most networks exhibit some degree of hierarchy, but researchers have been slow to under- stand why. In a July 6 paper in PNAS, SFI Ex- ternal Professor Ricard Sole and colleagues at Pompeu Fabra University argue that much of the hierarchy in the world could have emerged at random.

The team began by constructing three mea- sures of hierarchy: how clear the “chain of command” is, how prevalent circular chains are, and how high up the network those circles are. Using those measures, they iden- tified four distinct types of hierarchy, corre- sponding to software and electronic circuits; language, metabolic, and neural networks; gene regulation networks; and food webs.

Simulations showed all but gene regula- tion networks and food webs shared similar structures with random networks, suggest- ing hierarchical networks can form without anything guiding them there.

How network theory is informing cognitive science

Networks have long played a key role in cognitive science, from studies of artificial neural networks to modeling of semantic memory. Today, the inclusion of network theory in the cognitive sciences and the ex- pansion of complex-systems science promise to significantly change how the organiza- tion and dynamics of cognitive and behav- ioral processes are understood, according to a recent paper co-authored by SFI External Professor Morten Christiansen. The paper was published May 30 in Trends in Cogni- tive Science.