CORNELL FACULTY OF COMPUTING AND INFORMATION SCIENCE

At the Forefront of a Revolution

...In Computational Biology

Topics in Computational Biology
- DNA databases
- Protein structure and function
- Evolutionary genomics
- Biomechanics
- Computational neuroscience
- Management of natural and agricultural systems

> The vast amounts of data generated by human and other DNA sequencing projects are useless without computational tools that can identify the important patterns and relationships.

Matthew Fondeur/CU

David Stern, Boyce Thompson Institute for Plant Research, works with the Computational Biology Service Unit to uncover potential functions of so-called "junk DNA."

Martin Wiedmann, Food Science, collaborates with the Computational Biology Service Unit to develop software for tracking the sources of food–borne disease outbreaks.

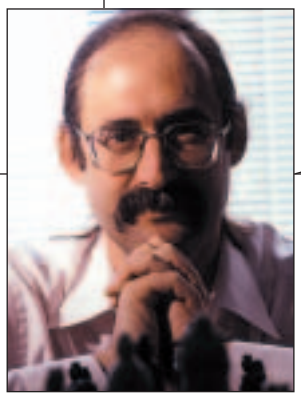
The Computational Biology Service Unit (CBSU) of the Cornell Theory Center created new software, in various collaborations, to
- Uncover potential functions of so-called "junk DNA"
- Track the sources of food-borne disease outbreaks
- Support computational biology researchers at all member institutions of the Tri-Institutional Program in Computational Biology and Medicine.

Computational tools that can theoretically predict the properties of proteins are in extreme demand: the "protein folding problem"—predicting the structure of a protein from the DNA sequence of its gene—was designated as a Grand Challenge Problem by the National Science Foundation. Cornell has been a central player in this research.

Charles Harrington/CU

Harold Scheraga, Chemistry and Chemical Biology, is a pioneer in this work.

these faculty collaborate intensively, particularly in the development of new multiscale hierarchical methods for analyzing and predicting protein structure and dynamics.



Robert Barker/CU

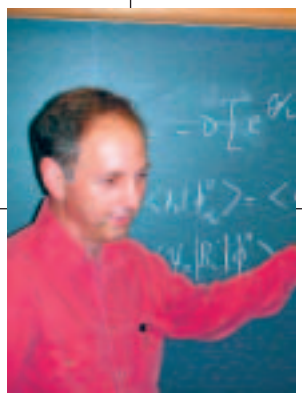
Ron Elber, Computer Science, heads the Computational Biology Service Unit of the Cornell Theory Center

Nicola Kountoupes/CU

Paul Chew, Computer Science

Charles Harrington/CU

Jon Kleinberg, Computer Science



Barry Stark

David Shalloway, Molecular Biology and Genetics

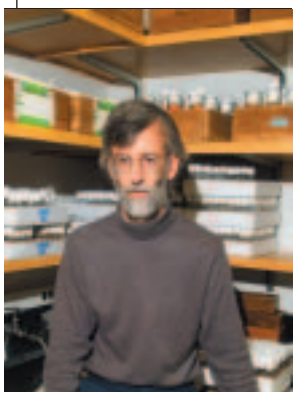
Frank DiMeo/CU

Golan Yona, Computer Science

analyzing single genomes—each typically containing many billions of nucleic acid constituents—and comparing multiple genomes can provide insights with important applications in medicine and agriculture.

these faculty are developing new computational and statistical tools for utilizing genomic information.

Charles Harrington/CU



Andrew Clark, Molecular Biology and Genetics

Matthew Fondeur/CU

Rasmus Nielsen, Biological Statistics and Computational Biology

Nicola Kountoupes/CU

Martin Wells, Biological Statistics and Computational Biology; ILR Social Statistics

at every size scale—proteins, cells, organs, and animals—biological components act together in complex, highly organized networks whose behavior can be mathematically modeled.

Frank DiMeo/CU

Stephen Ellner, Ecology and Evolutionary Biology, studies the rise and fall of insect and other animal populations.

Charles Harrington/CU

Steven Strogatz, Theoretical and Applied Mechanics, studies nonlinear bifurcations and synchronous behavior in biological systems.

Charles Harrington/CU

Kelvin Lee, Chemical Engineering, mathematically models intracellular signaling.

these faculty study computational neuroscience.

Charles Harrington/CU

Christiane Linster, Neurobiology and Behavior

Frank DiMeo/CU

Shimon Edelman, Psychology

David Lynch-Benjamin/CU

Richard Rand, Theoretical and Applied Mechanics, studies cardiac arrhythmias and retinal dynamics.

andrew ruina and jane wang, theoretical and applied mechanics, and francisco valero-cuevas, mechanical and aerospace engineering, study the mechanics of biological motion.

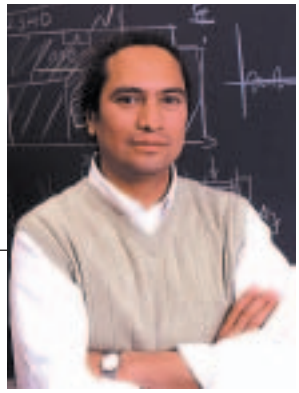
Nicola Kountouriotes/CU

Andrew Ruina

Charles Harrington/CU

Jane Wang

Charles Harrington/CU



Francisco Valero-Cuevas

...In Computational Science and Engineering

how does numerical weather prediction work?

models of physical processes, such as atmospheric circulation, are often formulated as differential equations.

turbulent combustion

Frank DiMeo/CU

Stephen Pope, Mechanical and Aerospace Engineering, studies turbulent combustion

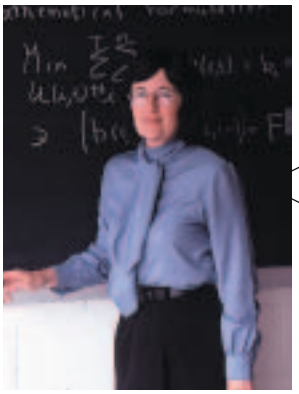
More advanced combustion technologies are required to address the vital issues of energy conservation and environmental protection. Computational modeling of turbulent combustion plays an increasingly crucial role in the design and development of advanced combustion equipment.

turbulent combustion poses a great intellectual and computational challenge.

stephen pope has developed a two-pronged strategy to dramatically reduce the computational cost of implementing combustion chemistry.

optimization and environmental problems

Charles Harrington/CU



Christine Shoemaker, Civil and Environmental Engineering

groundwater remediation can cost hundreds of millions of dollars at a single location, and there are many locations of contamination throughout the u.s.

Shoemaker's groundwater remediation projects deal both with physical means of removing contaminants (pump and treat) and with the use of microbes *in situ* to transform the toxic material in the groundwater to harmless substances. The latter requires modeling the growth and transport of microbes in the ground.

dynamical systems

Jon Reis/PHOTOLINK

John Guckenheimer, Mathematics, studies dynamical systems

Many biological processes are rhythmic—the heartbeat, a steady walking gait, circadian rhythms of sleep, and the menstrual cycle of women are a few in our daily lives. This motivates Guckenheimer's emphasis on determination of periodic solutions and their properties.

Richard Killen/CU

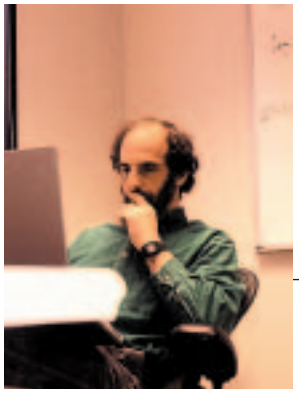
Ronald Harris-Warrick, Neurobiology and Behavior, collaborates with John Guckenheimer, Mathematics, in the research of the stomatogastric ganglion, a small neural network in lobsters that controls rhythmic motions in part of the digestive system.

...In Information Science Research

Research in information science concentrates on the areas where computer science and the social sciences overlap and reinforce each other. As digital technologies have become pervasive in our culture, researchers have found that technical, human, and social questions are interwoven and must be studied together.

The faculty come from disciplines as varied as computer science, communication, science and technology studies, cognitive psychology, operations research, linguistics, economics, sociology, and law.

Nicola Kountoupes/CU



Paul Ginsparg, Computing and Information Science; Physics
e-Print archive (arXiv.org)

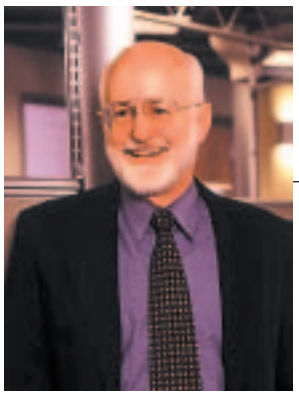
Charles Harrington/CU

Thomas Bruce (l.) and Peter Martin (r.), Law
Legal Information Institute

Cornell-based information systems:

- **e-Print archive** (arXiv.org), physics
- **Legal Information Institute**, legal informatics and automated text processing
- **Nuprl**, mathematical theorems and proofs
- **National Science Digital Library (NSDL)**, a major National Science Foundation program to build a very large digital library for science education

Robert Barker/CU

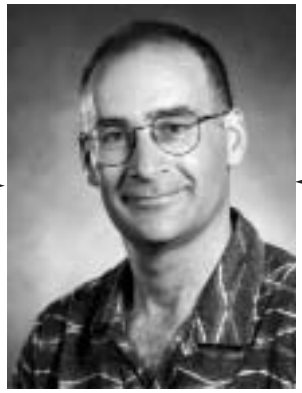


Robert Constable, Computing and Information Science
Nuprl

Frank DiMeo/CU

William Arms, Computer Science
National Science Digital Library (NSDL)

Charles Harrington/CU



Carl Lagoze, digital library scientist
National Science Digital Library (NSDL)

"one theme of information science is how people interact with information."

The Human Computer Interaction Group investigates social, psychological, and design issues surrounding the use of computers at school, work, and home. The group has a human factors laboratory in the Information Science building.

Robert Barker/CU

Geraldine Gay, Communication

Robert Barker/CU

Joseph Walther, Communication

Robert Barker/CU

Phoebe Sengers, Science and Technology Studies

natural language processing and linguistics are further examples of information science research on the boundary between computer science and cognition.

GOAL: TO develop highly effective methods that operate on huge bodies of information, such as the web, at costs that are far lower than conventional, labor-intensive methods. An example is the use of metadata—data about data.

These faculty study how humans interact with information through technology.

Nicola Kountoupes/CU

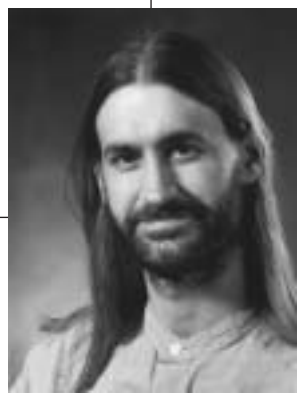
Robert Barker/CU

Joseph Halpern (l.), Computer Science, and David Easley (r.), Economics, study the relationship between individual beliefs, decisions, and social reality.

Frank DiMeo/CU

Shimon Edelman, Psychology, studies cognitive computational neuroscience of vision.

Charles Harrington/CU



Michael Spivey, Psychology, studies how humans extract semantics from information.

one area for research is the role of temporal phenomena in the web—long-range trends, the daily evolution of web content, the minute-by-minute dynamics of news coverage, and the second-by-second dynamics of usage data.

Frank DiMeo/CU

Jayavel Shanmugasundaram, Computer Science, studies metadata models that apply to the semi-structured data found on the Web.

Charles Harrington/CU

Mats Rooth, Linguistics, applies computational linguistics to problems of semantic information in text.

Charles Harrington/CU

Nicola Kountoupes/CU

Lillian Lee (l.) and Claire Cardie (r.), Computer Science, use natural language processing to extract information from documents.

Charles Harrington/CU

Carla Gomes, research associate in Computer Science, heads the Intelligent Information Systems Institute for research in computationally and data-intensive methods for intelligent decision making.

Charles Harrington/CU

Charles Harrington/CU

Richard Caruana (l.) and Thorsten Joachims (r.), Computer Science, use machine learning to probe Web information.

Charles Harrington/CU

Charles Harrington/CU

Daniel Huttenlocher (l.), Johnson Graduate School of Management; Computer Science, Jon Kleinberg (c.) and Bart Selman (r.), Computer Science, are adding a new level of rigor and scope to Web research.

what kind of education should a great university provide to its students in this information age?

the focus of information science at cornell is on systems and their use, rather than on the computing and communication technologies that underlie and sustain them.

Robert Barker/CU

Claire Cardie, Director of Undergraduate Programs in Information Science

goal: to educate a new generation of undergraduate and ph.d. students who are both computer scientists and social scientists, and who thrive on the different approaches to theory, investigation, design, and practice of the established disciplines.