

Lee Center & the IST Initiative

Vision for Caltech

by Jehoshua (Shuki) Bruck and Richard Murray

The Information Science and Technology (IST) initiative began in 2001–02 as part of the strategic planning activities within the Division of Engineering and Applied Science. A faculty committee, led by Shuki Bruck, was formed to establish a vision for Caltech’s activities in this important area. The Lee Center provided a strong community building mechanism that connected between faculty in Electrical Engineering, Computer Science, Physics and Economics and served as a fertile ground for the hatching, evolution and definition of the IST initiative. From the earliest discussions, the Lee Center served as a model for how to organize the research activities within IST. In particular, the Lee Center’s emphasis on providing flexible resources to faculty that allowed them pursue new research directions prior to receiving external grants was seen as an exceptional feature that should be emulated within IST.

Based on the recommendations of the IST faculty committee, the IST initiative was formally launched in 2003–04. It combined two existing centers, the Lee Center and the NSF Center for Neuromorphic Systems Engineering (CNSE), with four new centers: the Center for the Physics of Computation (CPI), the Center for Biological Circuit Design (CBCD), the Social and Information Science Laboratory (SISL) and the Center for the Mathematics of Information (CMI). These centers allowed research in a number of new areas, including networking principles in social organizations; storage; processing and retrieval of information in biological structures; technologies based on non-silicon computational material including approaches to quantum computing and the study of mathematical principles that underlie all of these activities.

Professor Shuki Bruck served as the initial Director of IST, and a steering committee of 8 members put into place the organizational structure to move this enterprise forward. Over the last 7 years, several faculty searches were carried out to identify new faculty hires related to IST, including a broad search and several more focused searches in biological circuits, computer science, eco-

nomics and electronics.

Each of the new centers in IST has catalyzed a set of activities that have moved Caltech forward in new research directions:

CENTER FOR THE PHYSICS OF INFORMATION

Information is something that can be encoded in the state of a physical system, and a computation is a task that can be performed with a physically realizable device. Thus the quest for better ways to acquire, store, transmit, and process information leads us to seek more powerful methods for understanding and controlling the physical world. Limitations inherent in the physical form of information (such as the size of atoms and the quantum effects that unavoidably arise in very small systems) pose great challenges that must be overcome if information technology is to continue to advance at the rate to which we have grown accustomed. The CPI is dedicated to the proposition that physical science and information science are interdependent and inseparable. Its research aims to foster physical insights that can pave the way for revolu-

PHYSICS

BIOLOGICAL CIRCUITS

tionary new information technologies and to stimulate new ideas about information that can illuminate fundamental issues in physics and chemistry.

CENTER FOR BIOLOGICAL CIRCUIT DESIGN

The Center for Biological Circuit Design is developing new ways to design, build and analyze biological circuits. These circuits control information flow in biological systems, and as such are a core area of IST. The study of circuits cuts across vast areas of biology, from biochemistry, biophysics and genetics, to cell and developmental biology, to neurobiology and ecology. Understanding how to design and build circuits is crucial for the next generation of bioengineering. The study of biological circuits also opens up new areas for theory in computation. Research in the CBCD combines the experimental biologist's desire to abstract the key principles from the richness and diversity of biological circuits, the physicist's sense of measurement and of simple underlying mechanisms, and the engineer's aesthetic of "to build is to understand." The CBCD is an interdisciplinary group of biologists and engineers from a broad range of engineering and biology disciplines.

SOCIAL AND INFORMATION SYSTEMS LABORATORY

The Social and Information Sciences Laboratory (SISL) studies how markets and other social systems aggregate large amounts of information that is widely distributed. Researchers in SISL are also working to design new and improved markets, network protocols, sensor systems, and political processes. Some of the specific topics being investigated by SISL researchers include the design of combinatorial auctions used for privatization; the design of large-scale interactive distributed systems such as electricity markets; the study of price formation and the possibilities for use of market-based systems for information aggregation in a variety of settings; the optimal structuring of elections, committees, and juries; the formation and evolution of networked systems with independent actors; and many of the computational aspects of system design (e.g., what do users need to compute and what does the system need to compute?).

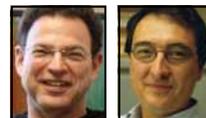
One of the novel aspects of SISL research concerns understanding how humans interact with technology and what that implies about the design of the technology. Since such systems involve both human behavior and technology, SISL brings together researchers from the social sciences, engineering, and applied and computational mathematics.

CENTER FOR THE MATHEMATICS OF INFORMATION

The ability to measure and model physical quantities—energy, temperature, and the like—has inspired the development of modern mathematics. Scientific and engineering questions have provided a source of vitality to, among other fields, algebra, geometry and analysis. Pure mathematical research in those fields coexists today with mathematic's function as a language and tool for the physical sciences. A concern with logical and statistical quantities—information—is central to present-day science and engineering. Indeed, disciplines such as algorithms, complexity, communications and control motivate questions in adjoining fields such as probability, combinatorics, algebra and harmonic analysis. A common framework supporting the study of information and computation across disciplines is as yet a distant goal. The Caltech CMI is a home in which unfettered development of the mathematical foundations of information and computation can be influenced by, and influence in turn, progress in engineering and science. These centers have substantial overlap with each other and with the Lee Center, allowing exchange of ideas across different scientific and engineering applications. ■ ■ ■

SOCIAL AND INFORMATION SYSTEMS

MATHEMATICS



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