Texas A&M University Institute for Advanced Studies Symposium

Information and Computation: Tools for Better Living

Hawking Auditorium, Mitchell Institute
Texas A&M University
February 24, 2017

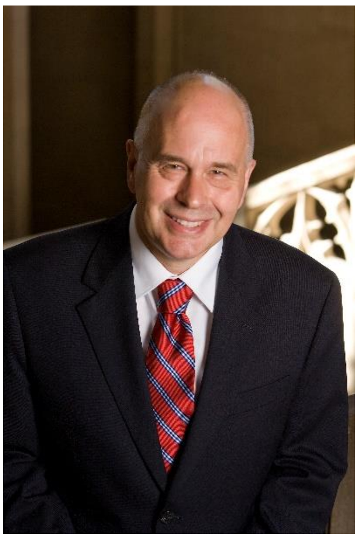
Chair: Costas N. Georghiades, Senior Associate Vice President for Research, Professor and Holder of the Delbert A. Whitaker Chair, Texas A&M University

8:30 AM – 8:40 AM	Welcome and introductions
8:40 AM – 9:20 AM	***Remembering Shannon*** Robert Calderbank, Director of the Information Initiative at Duke University, Professor of Electrical Engineering, Computer Science and Mathematics, Duke University
9:20 PM – 10:00 AM	***Surfing with Wavelets*** Ingrid Daubechies, James B. Duke Professor of Mathematics and Electrical and Computer Engineering, Duke University
10:00 AM – 10:30 AM	Break
10:30 AM – 11:10 AM	***Quantitative Imaging Phenotypes and Deep Learning in Precision Medicine*** Maryellen Giger, A. N. Pritzker Professor of Radiology/Medical Physics, The University of Chicago
11:10 AM – 11:50 PM	***From Engineering Failure to Material Design*** Alan Needleman, Distinguished Research Professor, Department of Materials Science and Engineering, Texas A&M University

Remembering Shannon

Robert Calderbank

Member of National Academy of Engineering
Charles S. Sydnor Professor of Computer Science
Duke University



Robert Calderbank is Director of the Information Initiative at Duke University, where he is Professor of Mathematics and Electrical Engineering. Prior to joining Duke as Dean of Natural Sciences in 2010, he directed the Program in Applied and Computational Mathematics at Princeton University. Prior to joining Princeton in 2004 he was Vice President for Research at AT&T, in charge of what may have been the first industrial research lab where the primary focus was Big Data. Professor Calderbank is well known for contributions to voiceband modem technology, to quantum information theory and for co-invention of space-time codes for wireless communication.

His research papers have been extensively cited and his inventions are found in billions of consumer devices. Professor Calderbank was elected to the National Academy of Engineering in 2005 and has received a number of awards, including the 2013 IEEE Hamming Medal for his contributions to information transmission, and the 2015 Claude E. Shannon Award.

ABSTRACT

The foundation of our Information Age is the transformation of speech, audio, images and video into digital content, and the man who started the digital revolution was Claude Shannon. He arrived at the revolutionary idea of digital representation by sampling the information source at an appropriate rate, and converting the samples to a bit stream. He then characterized the source by a single number, the entropy, which quantifies the information content of the source, and he created coding theory, by introducing redundancy into the digital representation to protect against corruption.

Shannon started from the grand challenges of his day, he developed models that captured what made them so difficult, translated these challenges into mathematical terms and then developed fundamental limits. This talk will review some of what Shannon did, and it will speculate about what he might have done if he were among us today.

Surfing with Wavelets

Ingrid Daubechies

Member of National Academy of Science
Member of National Academy of Engineering
James B. Duke Professor of Mathematics and
Electrical and Computer Engineering
Duke University

Prof. Daubechies earned her Ph.D. in theoretical physics from Vrije Universiteit Brussel. She is best known for her breakthroughs in wavelet research and her contributions to digital signal processing. Some of the wavelet bases she constructed have become a household name in signal analysis; they, and other computational techniques she developed, have been incorporated into the JPEG2000 standard for image compression. Apart from her work on wavelets, she has contributed to other seminal advances in time-frequency analysis.

In addition to her commitment to educating and mentoring the next generation of mathematicians, Daubechies continues to break new ground in mathematics research and expand its impact outside of her discipline, focusing on the analysis of signals and inverse problems in a wide range of settings, with applications ranging from fMRI and geophysics to paleontology and the study of fine art paintings.

ABSTRACT

This talk gives an overview of wavelets: what they are, how they work, why they are useful for image analysis and image compression. Then it will go on to discuss how they have been used recently for the study of paintings by e.g. Van Gogh, Goossen van der Weyden, Gauguin and Giotto.

Quantitative Imaging Phenotypes and Deep Learning in Precision Medicine

Maryellen L. Giger

Member of National Academy of Engineering

A. N. Pritzker Professor of Radiology/Medical Physics

The University of Chicago

Maryellen L. Giger is the A.N. Pritzker Professor and Vice-Chair of Radiology for Basic Science Research at The University of Chicago. She has conducted research on computer-aided diagnosis and quantitative image analysis in the areas of breast cancer, lung cancer, prostate cancer and bone disease. She is a past president of the American Association of Physicists in Medicine, inaugural Editor-in-Chief of the SPIE Journal of Medical Imaging and the current President-Elect of SPIE. She is a member of the National Academy of Engineering, a Fellow of AAPM, AIMBE, SPIE, and IEEE, a recipient of the AAPM William D. Coolidge Gold Medal, and a recipient of the EMBS Academic Career Achievement Award. Her research in computational image-based analyses of breast cancer for risk assessment, diagnosis, prognosis, response to therapy, and biological discovery has yielded various translated components, and she is now using these image-based phenotypes in imaging genomics association studies.

ABSTRACT

Adapting the Precision Medicine Initiative into imaging research includes studies in both discovery and translation to enable conversion of radiological interpretation from the "average patient" to the the individual patient. The goal is to detect disease and give the right person the right treatment at the right time. Discovery is a multi-disciplinary data mining effort involving radiologists, medical physicists, oncologists, computer scientists, engineers, and computational geneticists. Similar to how the genomics community approached the Cancer Genome project, the radiological community continues to conduct collection, annotation, analysis, and evaluation of images of large populations. Advances in computer power and machine learning are allowing for computer-extracted features to yield imaging phenotypes or "radiomics", i.e., the high throughput conversion of image sets into a multi-dimensional feature space. With quantitative imaging, a patient's tumor can be characterized quantitatively via "virtual digital biopsies".

From Engineering Failure to Material Design

Alan Needleman

Member of National Academy of Engineering
University Distinguished Professor
TEES Distinguished Research Professor
Texas A&M Univesity

Alan Needleman completed his Ph.D. at Harvard University in 1970. He then spent five years in Applied Mathematics at MIT before moving to Brown University where he became Florence Pirce Grant University Professor in 1996. In 2009 he moved to the University of North Texas (UNT) and in 2015 he joined the Materials Science and Engineering Department at Texas A&M as TEES Distinguished Research Professor. His contributions include the development of a ductile fracture computational methodology and creation of a framework that enables using discrete dislocation plasticity to solve general boundary value problems.

Professor Needleman is a member of the National Academy of Engineering and the American Academy of Arts and Sciences. He has been awarded the Prager Medal by the Society of Engineering Science, the Drucker and Timoshenko Medals by the American Society of Mechanical Engineers and has been recognized by ISI as a Highly Cited Author in both the fields of Engineering and Materials Science. He holds honorary doctorates from the Technical University of Denmark and Ecole Normale Superior de Cachan (France), and is an Honorary Professor of Dalian University of Technology (China).

ABSTRACT

Structures and components subject to mechanical forces can fail by fracturing or by undergoing a mechanical buckling instability. Much engineering research has been focused on developing the knowledge and computational tools to design against such failures, which has led to safer structures and components. Another more recent trend is to use the knowledge and computational tools developed for analyzing buckling instabilities and fracture to design novel devices as well as to design novel materials that have improved fracture resistance. I will give examples of these types of engineering failures and of the new approaches to computational based device and material design that are emerging from the knowledge gained.