2016 North American School of Information Theory

Shannon's 1100100'th year

Duke University
June 21st - June 23rd, 2016

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Welcome Message

We welcome you to the the 2016 North American School of Information Theory (NASIT) hosted by Duke University. The NASIT is an annual event organized by IEEE Information Theory Society that provides students with the opportunity to learn from distinguished lecturers, to present their own work in poster sessions, and to meet one another

We are grateful to our sponsors: the IEEE Information Theory Society, Duke University, the Center for Science of Information, and the information initiative at Duke.

Sincerely,

The NASIT16 organizing committee: Dror Baron, Matthieu Bloch, Robert Calderbank, Henry Pfister, Galen Reeves

with special thanks to our advisors Andrea Goldsmith and Gerhard Kramer

Tuesday, June 21st

08:30 - 09:00 AM	Continental Breakfast
09:00 - 10:10 AM	Aylin Yener – Information Theoretic Security: Part I
10:10 - 10:40 AM	Break
10:40 - 11:50 AM	Aylin Yener – Information Theoretic Security: Part II
12:00 - 01:50 PM	Lunch and First Poster Session
02:00 - 03:10 PM	Krishna Narayanan – The Peeling Decoder: Theory and Applications
03:10 - 03:40 AM	Break
03:40 - 04:50 PM	Krishna Narayanan – The Peeling Decoder: Theory and Applications
06:30 - 9:30 PM	Evening Activities: Durham Bulls Game or Game Night

Wednesday, June 22nd

08:30 - 09:00 AM	Continental Breakfast
09:00 - 10:10 AM	Natasha Devroye – The Interference Channel: Part I
10:10 - 10:40 AM	Break
10:40 - 11:50 AM	Natasha Devroye – The Interference Channel: Part II
12:00 - 01:50 PM	Lunch and Second Poster Session
02:00 - 03:10 PM	Helmut Bölcskei – The Mathematics of Deep Learning: Part I
03:10 - 03:40 AM	Break
03:40 - 04:50 PM	Helmut Bölcskei – The Mathematics of Deep Learning: Part II
06:00 - 08:00 PM	Dinner Reception – information initiative at Duke (iiD)

Thursday, June 23rd

08:30 - 09:00 AM	Continental Breakfast
09:00 - 10:10 AM	René Vidal – Global Optimality in Matrix and Tensor Factorization, Deep Learning, and Beyond: Part I
10:10 - 10:40 AM	Break
10:40 - 11:50 AM	René Vidal – Global Optimality in Matrix and Tensor Factorization, Deep Learning, and Beyond: Part II
12:00 - 01:00 PM	Lunch and Farewell

Tuesday Morning

Information Theoretic Security

by Aylin Yener
Professor, Pennsylvania State University

Abstract: These lectures will provide the basics of information theoretic secrecy framework starting with the classical wiretap channel model, addressing its multi-terminal extensions and associated tools and insights. These include multi-transmitter models and cooperative jamming, untrusted relay models, multi-antenna models and structured signaling. We will conclude with newly emerging models and tools, state of the art in information theoretic security, open problems and forward look.

Speaker Biography: Aylin Yener is a professor of Electrical Engineering at The Pennsylvania State University, University Park, PA since 2010, where she joined the faculty as an assistant professor in 2002. During the academic year 2008-2009, she was a Visiting Associate Professor with the Department of Electrical Engineering, Stanford University, CA. Her research interests are in information theory, communication theory and network science with recent emphasis on green communications, information security and networked systems. She received the NSF CAREER award in 2003, the best paper award in Communication Theory in the IEEE International Conference on Communications in 2010, the Penn State Engineering Alumni Society (PSEAS) Outstanding Research Award in 2010, the IEEE Marconi Prize paper award in 2014, the PSEAS Premier Research Award in 2014, and the Leonard A. Doggett Award for Outstanding Writing in Electrical Engineering at Penn State in 2014. She is a fellow of the IEEE.

Dr. Yener is an elected member of the board of governors of the IEEE Information Theory Society for the term 2015-2017. Previously, she served on the same board of governors as the treasurer (2012-2014). She served as the student committee chair for the IEEE Information Theory Society 2007-2011, and was the founder (with Gerhard Kramer) of the North American School of Information Theory (NASIT) co-organizing the school in 2008, 2009 and 2010. For the IEEE Communications society, she was a technical (co)-chair for various symposia/tracks at IEEE ICC, PIMRC, VTC, WCNC and Asilomar (2005-2014). She served as an editor for IEEE Transactions on Communications (2009-2012), an editor and an editorial advisory board member for IEEE Transactions on Wireless Communications (2001-2012), a guest editor for IEEE Transactions on Information Forensics and Security (2011) and a guest editor for IEEE Journal on Selected Areas in Communications (2015). Presently, she is an editor for the IEEE Transactions on Mobile Computing, and a senior editor for the IEEE Journal on Selected Areas in Communications.

Tuesday Afternoon

The Peeling Decoder: Theory and Applications

by Krishna Narayanan
Professor, Texas A&M University

Abstract: The peeling decoder is a simple greedy decoder that can be used to decode classes of codes defined on graphs, such as low density parity check (LDPC) codes and low density generator matrix codes, on the erasure channel. This deceptively simple decoder suffices to design capacity achieving coding schemes for the erasure channel. In addition, the peeling decoder can also be used to design optimal universal rateless codes as shown by Luby in the design of LT codes. In part I of this two-part tutorial, we will explain the main theoretical ideas behind the analysis of the peeling decoder and the design of optimal fixed rate and rateless codes for the erasure channel. We will also discuss how the peeling decoder can be used to decode generalized LDPC codes and product codes when used with non-erasure channels. We will conclude part I with a discussion of the relationship between channel coding and syndrome source coding for the compression of sparse sources.

The peeling decoder has been applied successfully not only to decoding codes on the erasure channel, but also in a variety of applications outside of main stream coding theory. In Part II of this tutorial, we will discuss applications of the peeling decoder to massive uncoordinated multiple access schemes, sparse Fourier transform computation and if time permits, to compressed sensing and group testing problems. Remarkably, the peeling decoder can be used to design optimal multiple access schemes in some cases and order-optimal algorithms for sparse transform computation and some sparse support recovery problems.

Speaker Biography: Krishna Narayanan received the B.E. degree from Coimbatore Institute of Technology in 1992, M.S. degree from Iowa State University in 1994 and the Ph.D. degree in Electrical Engineering from Georgia Institute of Technology in 1998. Since 1998, he has been with the Department of Electrical and Computer Engineering at Texas A&M University, where he is currently a professor. He has held visiting appointments at the University of Illinois at Urbana Champaign, Institut Eurecom, Indian Institute of Science and the University of California at Berkeley. His research interests span coding theory, information theory, joint source channel coding and signal processing with applications to wireless networks and data storage. Recently, he has focused on understanding the role of structured codes in multi-terminal information theory, universal codes for multi-user communication, spatially-coupled codes, polar codes, product codes and their variants, the design of uncoordinated multiple access schemes and connections between sparse signal recovery and coding theory.

He is passionate about technology-enabled teaching and innovative pedagogical approaches. He was the recipient of the NSF career award in 2001. He also received the 2006 best paper award from the IEEE technical committee for signal processing for data storage for his work on soft decision decoding of Reed Solomon codes. He currently serves as an associate editor for coding techniques for the IEEE Transactions on Information Theory. He served as the area editor (and as an editor) for the coding theory and applications area of the IEEE Transactions on Communications from 2007 until 2011. In 2014, he received the Professional Progress in Engineering award given to one outstanding alumnus of Iowa State University each year under the age of 44. He was elected as Fellow of the IEEE for contributions to coding for wireless communications and data storage. He has won several awards within Texas A&M university including the 2012 college level teaching award.

The Interference Channel

by Natasha Devroye
Associate Professor, University of Illinois at Chicago

Abstract: The interference channel consists of two independent transmitter-receiver pairs sharing the same medium. The receivers see combinations of the two transmitted signals — and wish to decode their desired message in the presence of the other pair's interfering message. This is a remarkably simple looking and practically relevant channel model — particularly well motivated by wireless communications — whose capacity region has remained unknown for over 40 years. In the first part of the talk, we outline the best known inner and outer bounds to the capacity region and highlight channels for which they almost, or exactly, coincide. In the second part of the talk we focus on recent results for the interference channel and some of its variations. The goal is to understand what is known about the interference channel, and to realize that interference can be dealt with in a number of ways.

Speaker Biography: Natasha Devroye is an Associate Professor in the Department of Electrical and Computer Engineering at the University of Illinois at Chicago (UIC). She obtained her Honors B. Eng in Electrical Engineering from McGill University, her M.Sc. and Ph.D in Engineering Sciences from Harvard University, and was a lecturer at Harvard for 1 year before joining UIC in 2009. Dr. Devroye was a recipient of an NSF CAREER award in 2011 and was named UIC's Researcher of the Year in the "Rising Star" category in 2012. She has been an Associate Editor for the IEEE Transactions on Wireless Communications, IEEE Journal of Selected Areas in Communications, and is currently an Associate Editor for the IEEE Transactions on Cognitive Communications and Networking. Her research focuses on multi-user information theory and applications to cognitive and software-defined radio, radar, relay, interference, and two-way communication networks.

Wednesday Afternoon – Padovani Lecturer

The Mathematics of Deep Learning

by Helmut Bölcskei
Professor, ETH Zurich

Part I – Deep convolutional neural networks have led to breakthrough results in numerous machine learning tasks that require feature extraction, yet a comprehensive mathematical theory explaining this success seems distant. The mathematical analysis of deep neural networks for feature extraction was initiated by Mallat, who considered so-called scattering networks based on the wavelet transform and modulus non-linearities. In this short course, we show how Mallat's theory can be developed further by allowing for general semi-discrete shift-invariant frames (including Weyl-Heisenberg, curvelet, shearlet, ridgelet, and wavelet frames) and general Lipschitz-continuous non-linearities (e.g., rectified linear units, shifted logistic sigmoids, hyperbolic tangents, and modulus functions), as well as pooling through subsampling. For the resulting feature extractor, we prove deformation stability for a large class of deformations, establish a new translation invariance result which is of vertical nature in the sense of the network depth determining the amount of invariance, and show energy conservation under certain technical conditions. On a conceptual level our results establish that deformation stability, vertical translation invariance, and to a certain degree also energy conservation are guaranteed by the network structure per se rather than the specific convolution kernels and non-linearities. This offers a mathematical explanation for the tremendous practical success of deep convolutional neural networks.

Part II – The Discrete Case and New Architectures: We develop a theory of deep neural networks for the discrete case and introduce new network architectures. The talk follows the philosophy of the first talk in this series, and analyzes the impact of signal deformations and translations on the features extracted through discrete networks. The theory incorporates general filters, Lipschitz non-linearities, and Lipschitz pooling operators. We introduce and analyze new network architectures which build the feature vector from outputs on individual or all network layers. This leads us to the notions of local and global feature vector properties and encompasses setups where classification or learning is performed directly on the network output without a subsequent classifier such as, e.g., a support vector machine. Besides providing analytical performance results of general validity, we also investigate how certain structural properties of the input signal are reflected in the feature vector. Specifically, we consider discrete cartoon functions, originally introduced for the continuous-time case by Donoho, 2001. These functions constitute a good model for natural images, images of handwritten digits, and images of geometric objects of different shapes, sizes, and colors, as contained in the Baby AI School data set. We close with numerical results on facial landmark detection and handwritten digit classification.

Speaker Biography: Helmut Bölcskei was born in Mödling, Austria on May 29, 1970, and received the Dipl.-Ing. and Dr. techn. degrees in electrical engineering from Vienna University of Technology, Vienna, Austria, in 1994 and 1997, respectively. In 1998 he was with Vienna University of Technology. From 1999 to 2001 he was a postdoctoral researcher in the Information Systems Laboratory, Department of Electrical Engineering, and in the Department of Statistics, Stanford University, Stanford, CA. He was in the founding team of Iospan Wireless Inc., a Silicon Valley-based startup company (acquired by Intel Corporation in 2002) specialized in multiple-input multiple-output (MIMO) wireless systems for high-speed Internet access, and was a co-founder of Celestrius AG, Zurich, Switzerland. From 2001 to 2002 he was an Assistant Professor of Electrical Engineering at the University of Illinois at Urbana-Champaign. He has been with ETH Zurich since 2002, where he is a Professor of Electrical Engineering. He was a visiting researcher at Philips Research Laboratories Eindhoven, The Netherlands, ENST Paris, France, and the Heinrich Hertz Institute Berlin, Germany. His research interests are in information theory, mathematical signal processing, machine learning, and statistics.

He received the 2001 IEEE Signal Processing Society Young Author Best Paper Award, the 2006 IEEE Communications Society Leonard G. Abraham Best Paper Award, the 2010 Vodafone Innovations Award, the ETH "Golden Owl" Teaching Award, is a Fellow of the IEEE, a 2011 EURASIP Fellow, was a Distinguished Lecturer (2013-2014) of the IEEE Information Theory Society, an Erwin Schrödinger Fellow (1999-2001) of the Austrian National Science Foundation (FWF), was included in the 2014 Thomson Reuters List of Highly Cited Researchers in Computer Science, and is the 2016 Padovani Lecturer of the IEEE Information Theory Society. He served as an associate editor of the IEEE Transactions on Information Theory, the IEEE Transactions on Signal Processing, the IEEE Transactions on Wireless Communications, and the EURASIP Journal on Applied Signal Processing. He was editor-in-chief of the IEEE Transactions on Information Theory during the period 2010-2013. He served on the editorial board of the IEEE Signal Processing Magazine and is currently on the editorial boards of "Foundations and Trends in Networking" and "Foundations and Trends in Communications and Information Theory". He was TPC co-chair of the 2008 IEEE International Symposium on Information Theory and serves on the Board of Governors of the IEEE Information Theory Society.

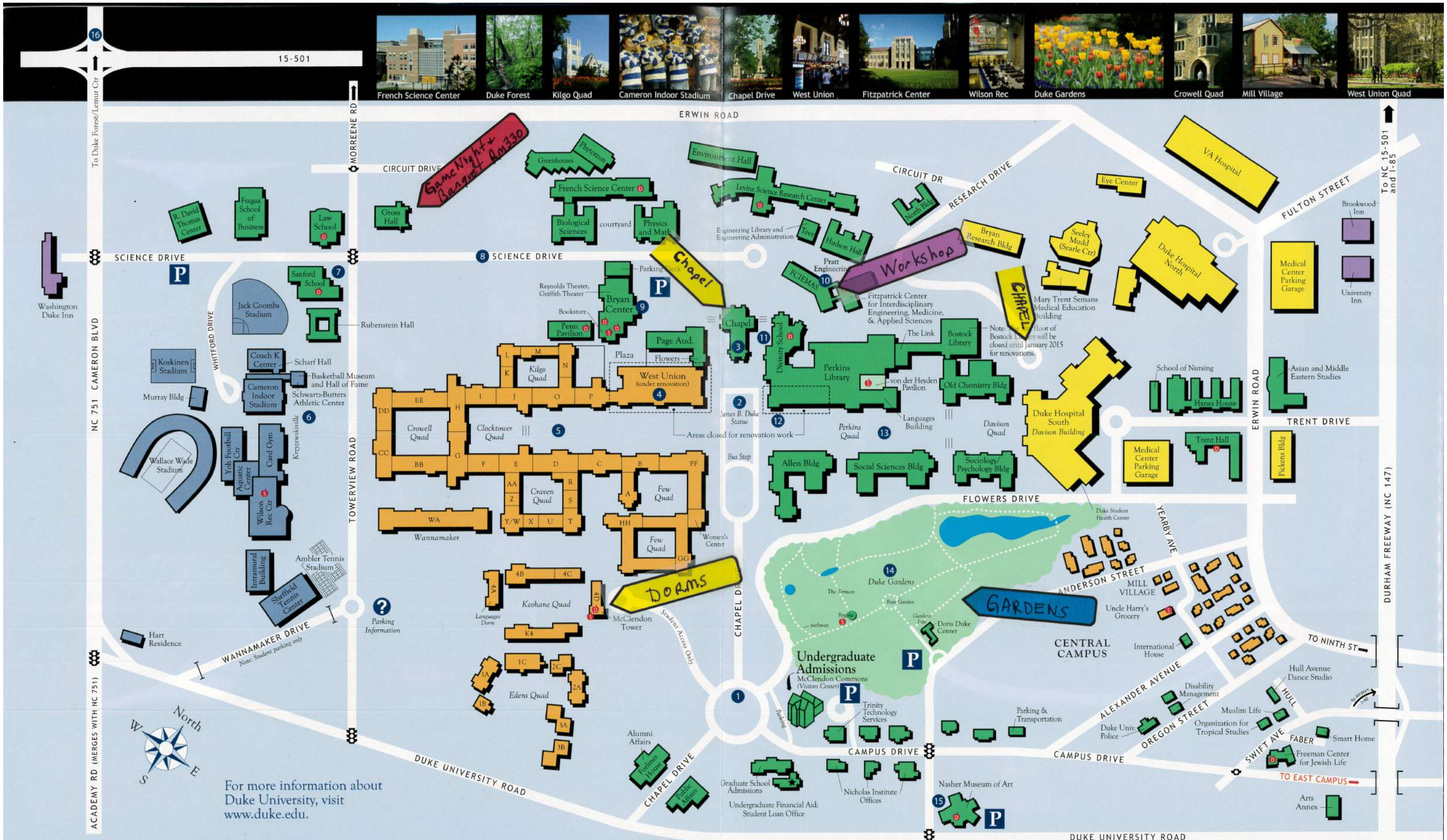
Global Optimality in Matrix and Tensor Factorization, Deep Learning, and Beyond

by René Vidal
Professor, Johns Hopkins University

Abstract: The past few years have seen a dramatic increase in the performance of pattern recognition systems due to the introduction of deep neural networks for representation learning. However, the mathematical reasons for this success remain elusive. A key challenge is that the problem of learning the parameters of a neural network is a non-convex optimization problem, which makes finding the globally optimal parameters extremely difficult. Building on ideas from convex relaxations of matrix factorizations, in this talk I will present a very general framework which allows for the analysis of a wide range of non-convex factorization problems - including matrix factorization, tensor factorization, and deep neural network training formulations. In particular, I will present sufficient conditions under which a local minimum of the non-convex optimization problem is a global minimum and show that if the size of the factorized variables is large enough then from any initialization it is possible to find a global minimizer using a purely local descent algorithm. Our framework also provides a partial theoretical justification for the increasingly common use of Rectified Linear Units (ReLUs) in deep neural networks and offers guidance on deep network architectures and regularization strategies to facilitate efficient optimization. This is joint work with Benjamin Haeffele.

Speaker Biography: Professor Vidal received his B.S. degree in Electrical Engineering (valedictorian) from the Pontificia Universidad Católica de Chile in 1997 and his M.S. and Ph.D. degrees in Electrical Engineering and Computer Sciences from the University of California at Berkeley in 2000 and 2003, respectively. He has been a faculty member in the Center for Imaging Science and Department of Biomedical Engineering of The Johns Hopkins University since 2004. He is co-author of the book "Generalized Principal Component Analysis" (2016), co-editor of the book "Dynamical Vision" (2006), and has co-authored more than 200 articles in machine learning, computer vision, biomedical image analysis, hybrid systems, robotics and signal processing. Dr. Vidal has been Associate Editor of the IEEE Transactions on Pattern Analysis and Machine Intelligence, the SIAM Journal on Imaging Sciences and the Journal of Mathematical Imaging and Vision, Program Chair for ICCV 2015, CVPR 2014, WMVC 2009 and PSIVT 2007, and Area Chair for AAAI 2016, NIPS 2015, MICCAI 2013 and 2014, ICCV 2007, 2011 and 2013, and CVPR 2005 and 2013. He has received many awards for his work including the 2012 J.K. Aggarwal Prize, the 2009

ONR Young Investigator Award, the 2009 Sloan Research Fellowship, the 2005 NFS CAREER Award, and best paper awards at ICCV-3DRR 2013, PSIVT 2013, CDC 2012, MICCAI 2012, CDC 2011 and ECCV 2004. He is a fellow of the IEEE and a member of IAPR, ACM and SIAM.



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