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Seminar Series Supported by Jeffrey and Holly Ullman

Coding Day

26 October, 2009

10:45 Coffee & Tagging

11:05 On the Optimality of Universal Classifiers for finite-length Individual Test Sequences Specifications

Jacob Ziv, Technion Institute

Abstract: An empirical informational divergence (relative entropy) between two individual sequences has been introduced in [1]. It has been demonstrated that if the two sequences are independent realizations of two finite-order, finite alphabet, stationary Markov processes, the proposed empirical divergence measure (ZMM), converges to the relative entropy almost surely. This leads to a realization of an empirical, linear complexity universal classifier which is asymptotically optimal in the sense that the probability of classification error vanishes as the length of the sequence tends to infinity. if the normalized KL-divergence between the two measures is positive [2].

It is demonstrated that for finite-length sequences that are realizations of finite-alphabet, vanishing memory processes with positive transitions, a version of the ZMM [1] is not only asymptotically optimal as the length of the sequences tends to infinity, but is also essentially optimal in the sense that the probability of classification error vanishes if the length of the sequences tends to infinity for a large sub-class of such measures if the length of the sequences is larger than some positive integer N0 . At the same time no universal classifier can yield an efficient discrimination between any two distinct processes in this class, if the length of one of the two sequences N is such that logN < logN0.

It is also demonstrated that there are some classification algorithms which are asymptotically optimal as N tends to infinity, but are not essentially optimal.

A variable-length divergence measure is defined, that tends to the KL-divergence as N tends to infinity.

A new universal classification algorithm is shown to optimal in the sense that the probability of classification error vanishes over the entire class of pairs of finite-alphabet, vanishing memory measures with positive transitions, and a positive variable-length divergence, if logN > logN0, while no efficient classification is possible by any universal classifier if logN < logN0.

11:55 Coffee Break

12:10 Low Density Lattice Codes: From Theory to Practice

Meir Feder, Tel-Aviv University

Abstract: Low density lattice codes (LDLC) are recently proposed lattice codes that can be decoded by linear-time iterative decoding and approach the capacity of the additive white Gaussian noise (AWGN) channel. In LDLC a codeword x is generated directly at the n-dimensional Euclidean space as a linear transformation of a corresponding integer message vector b, i.e., x = Gb, where H=G^{-1} is restricted to be sparse. In LDLC the messages are pdf's of the component of the real codeword x. In order to make LDLC practical for application we proposed parametric representation of the pdf's, making the decoding algorithm very efficient in storage and computations.

Furthermore, for practical application, the infinite lattice should be combined with a shaping algorithm, that maps information bits to lattice points and ensures that the power of the lattice codewords is properly constrained. This work also proposes several efficient and practical shaping algorithms for LDLC. One technique establishes the notion of "systematic lattice codes". As a result, LDLC are not only interesting theoretically, but can practically outperform any other proposed scheme for spectrally efficient communication.

13:00 Lunch

14:00 Bit Interleaving Coded Modulation-Past, Present and Future

Ephraim Zehavi, Bar Ilan University

Abstract: Bit-Interleaved Coded Modulation (BICM) has become an area of significant research effort in the last twenty years as practical coding and modulation techniques for various communication systems, in particular for systems operating over wireless fading channel. This research has lead to the development of novel, practical, and robust transmission techniques through a number of papers on various topics and techniques related to BICM.

In the talk we concentrate on addressing fundamental concepts, motivation and analytical framework arising in BICM. We then proceed to examine the adaptation BICM technique in various communication systems a long with the development turbo code and LDPC and MIMO. Finally, we summarize our conclusions and discuss some possible research directions using BICM approach.

14:50 Coffee Break

15:00 Coding theory and PAPR control in OFDM

Simon Litsyn, Tel-Aviv University

Abstract: Advantages of multi-carrier OFDM systems over single-carrier ones explain their broad acceptance for various telecommunication standards. Architecture of OFDM systems allows a relatively simple implementation. Nonetheless, still a major barrier for implementing OFDM in low-cost wireless applications is its non-constant signal envelope making the transmission sensitive to nonlinear devices in the communication path.

A reasonable measure of the quality of signals is the ratio between the peak power values to their average power (PAPR). Thus the goal of the peak-power control is to diminish the influence of transmit signals with high PAPR on the performance of the transmission system. We will discuss relations between methods of analysis and design of signals with low PAPR and problems from coding theory.

15:50 Multiplication Free Holographic Coding

Shlomi Dolev, Ben-Gurion University

Abstract: Holographic coding has the very appealing property of allowing the gain of partial information on the data, from any part of the coded information. We present holographic coding schemes based on the Walsh orthogonal codes. The schemes only use additions for coding and decoding. We propose randomizing the data so that the coefficient of the Walsh code will be approximately uniform in order to ensure, with high probability, a monotonic gain of information. The data is xored with randomly chosen data from random data that has been stored during a preprocessing stage. We suggest schemes to cope with erasures in the scope of Walsh codes. We suggest parity based schemes to support the erasure correcting of the Walsh coefficient which can tolerate a bounded number of erasures using no multiplications. We then suggest a scheme based on Preparata use of discrete Fourier coefficients extending the data with zeros. Lastly, we present schemes that can withstand almost any number of erasures.

Joint work with Sergey Frenkel.

16:40 End of Coding Day