**ISIT 2013 Summary**

**<Compressed sensing 1>**

**Title : Achieving Bayes MMSE Performance in the Sparse Signal + Gaussian White Noise Model when the Noise Level is Unknown**

**Authors : David Donoho, Galen Reeves**

In approximate message passing algorithms, each iteration faces a sub-problem of recovering an unknown sparse signal in Gaussian white noise, . N(0,) and iid . The noise level in each sub-problem changes from iteration to iteration in a way that depends on the underlying signal (which we don’t know). For such algorithms to be used in practice (in CS settings), it seems we need an estimator that achieves the MMSE when the noise level is unknown. In this paper, the authors solve the problem of estimating without having knowledge of either or  by using convex optimization and the tools from Stein Unbiased Risk Estimates and Huber Splines.

**Title : Almost Lossless Analog Signal Separation**

**Authors : David Stotz, Erwin Riegler, and Helmut Bolsckei**

The authors consider the following signal separation problem that reconstructs the vectors  and  from the noiseless observation

 

where  and  are measurement matrices with  and  for the compression rate  The main contribution of this paper is as follows: For every deterministic full rank matrix  reconstructing the vectors  and  from the noiseless observation  is possible with high probability for almost all matrices  provided that  is sufficiently large and the compression rate  is larger than the Minkowski dimension compression rate of the vector 

**Title : From compression to compressed sensing**

**Authors: Shirin Jalali, Arian Maleki**

Summary: They studied whether compression algorithms such as JPEG2000, can be employed for recovering signals from their underdetermined set of linear measurements. They established a connection between the rate-distortion performance of compression algorithms and the number of linear measurement required for successful recovery in CS. They also proposed compressible signal pursuit (CSP) algorithm based on exhaustive search over the set of compressible signals, which under a certain condition on the rate-distortion function, recovers signals from fewer measurements than their dimension.

**Title : The Minimax Noise Sensitivity in Compressed Sensing**

**Authors : Galen Reeves, David Donoho**

Consider the compressed sensing problem of estimating an unknown *k*-sparse vector from a set of *m* noisy linear equations. A few of the recent works focus on the noise sensitivity of particular algorithm. The scaling constant c of the reconstruction error is called noise sensitivity. . In this paper, the authors study the minimax noise sensitivity. This fundamental quantity characterizes the difficulty of recovery when nothing is known about the sparse vector other than the fact that it has at most *k* nonzero entries. They express noise sensitiy in terms of MSE of an arbitrary estimator and assuming random sensing matrices (i.i.d. Gaussian), the authors obtain non-asymptotic bounds which show that the minimax noise sensitivity is finite if and infinite if .

The authors also study the large system behavior. There is a phase transition separating successful and unsuccessful recovery: the minimax noise sensitivity is bounded for any and is unbounded for any , where is the under-sampling fraction and  denotes the sparsity fraction. One consequence of our results is that the Bayes optimal phase transitions of Wu and Verdu can be obtained uniformly over the class of all sparse vectors.

**<Joint Source-channel coding>**

**Title : Network Compression: Worst-Case Analysis**

**Authors : Himanshu Asnani, Ilan Shomorony, Salman Avestimehr , Tsachy Weissman**

Stochastic modeling of the data source and the communication medium are essential in data compression and data communication problems. The authors consider the problem of communicating a distributed correlated memoryless source over a memoryless network, from source nodes to destination nodes, under quadratic distortion constraints. They show two results:

(a) For an arbitrary memoryless network, among all distributed memoryless sources with a particular correlation, Gaussian sources are the worst compressible, and

(b) For any arbitrarily distributed memoryless source to be communicated over a memoryless additive noise network, among all noise processes with a fixed correlation, Gaussian noise admits the smallest achievable distortion.

In each case, they describe a systematic way of converting coding schemes designed under Gaussian assumptions into coding schemes that can handle non-Gaussian assumptions. The idea behind the construction of such schemes is by using DFT-based linear transformations.

**<Compressed sensing 2>**

**Title : Time Invariant Error Bounds for Modified-CS based Sparse Signal Sequence Recovery**

**Authors : Jinchun Zhan and Namrata Vaswani**

The authors show performance guarantees for the two-reconstruction algorithms modified-CS and modified-CS-ADD-LS-Del. The authors consider both algorithms as solutions to the problem of sparse reconstruction with partial and possibly erroneous knowledge of the support set. In other words, for a time sequence of sparse signals, the support estimate from the previous time is considered as known support set. Thus, both algorithms try to find a signal that is sparsest outside of the known support among all signals. By analyzing both algorithms, the authors prove that the number of misses and extras from current support estimate are bounded by a time-invariance value.

**Title : Distortion based achievability conditions for joint estimation of sparse signals and measurement parameters from undersampled acquisitions.**

**Authors : Mehmet Akcakaya, Vahid Tarokh**

* For the system model of , the joint estimation of the sparse signal x and the parameter is considered.
* An information theoretic decoder is considered and the achievability conditions for a specified l2 distortion.
* The main challenge in the proofs comes from the fact that  for a given  and a sparse **x** is not necessarily sparse.

**Title : Lower Bounds for Quantized Matrix Completion**

**Authors : Mary Wootters and Yaniv Plan, Mark A. Davenport, and Ewout van den Berg**

The matrix completion problem is to reconstruct a matrix from an incomplete sampling of its entries. Instead of observing a subset of the real-valued entries of a matrix, the authors consider the 1-bit observation model. Namely, for given a matrix  a subset of indices  and a differentiable function  the authors observe

 

The matrix completion considered by the authors is to reconstruct  from  In this paper, the authors show that under certain assumptions it is possible to reconstruct  by optimization a simple convex problem. It is done by showing both upper and lower bounds on  where  is a reconstructed matrix from 

**Title : SRL1: Structured Reweighted L1 Minimization for Compressive Sampling of Videos**

**Authors : Sheng Wang, Behzad Shahrasbi, Nazanin Rahnavard**

The authors study compressive sampling of difference frames in videos by proposing a reconstruction algorithm exploiting the structural characteristic, i.e., clustered sparsity in difference frame. Now, let  be the reference frame in the *j*th group of pictures in a video. The difference frame between the *i*th non-reference frame in the *j*th group of pictures and its reference frame is denoted as for  Then, the difference frame is hard thresholded as follows:

 

where  is a threshold value. Then, the hard thresholded difference frame is sampled using compressive sensing, i.e.,  Now, we begin by defining some definitions for explaining the main idea of their reconstruction algorithm.

**Definition 1**: A cluster is the set of contiguous non-zero pixels

**Definition 2**: Two pixels are connected in the sense of dilation by Structural Element (SE) if the clusters dilated by SE from these pixels are contiguous or intersected

**Definition 3**: A non-zero pixel is said to be isolated in the sense of dilation by SE if the cluster dilated from this pixel is not contiguous or intersected with other cluster.

Let  be the reconstructed difference frame. Then, their algorithm has below two heuristics properties:

1. If a pixel  is zero but is connected to other non-zero pixels, then the pixel is actually non-zero rather than zero with high probability.
2. If a pixel  is non-zero and is isolated, then the pixel is actually zero rather than non-zero with high probability.

Their reconstruction algorithm exploits the two heuristic properties to promote the clustered sparsity in difference frame. Consequently, the first heuristic property is used in the local exploration stage that is to find unreconstructed signal pixels and the second heuristic property is used in the global purification stage that is to eliminate non-zero errors. Last, the author shows that their reconstruction algorithm is the best among SPGL, IRWL1, CLuSS, Block-CoSaMP for their simulations.

**<Compressed Sensing 3>**

**Title : Computing a -sparse n-length Discrete Fourier Transform using at most  samples and  complexity.(Sameer Pawar, Kannan Ramchandran)**

**Authors : Sameer Pawar, Kannan Ramchandran**

* Given an -length input signal , it is well known that its DFT,  can be computed in  complexity using a Fast Fourier Transform.
* If the spectrum  is exactly , we can reliably compute the DFT  using  operation.
* In order to decode, this paper uses Aliasing and Shift in time.
* Randomized Recovery for Boolean Compressed Sensing
* Authors: Mitra Fatemi, Martin Vetterli
* Summary: They studied Boolean compressed sensing or group testing which involves Boolean operations and Bernoulli noise. For example,  and . The goal of group testing is to efficiently recover a small number of defective items in a large set from a few collective binary tests while reducing the total number of tests (measurements). Recently, relaxed linear programming (LP) is used to solve the group testing problem. The relaxed LP algorithm bypasses the binary constraints and solves a linear problem. Then, the outcome undergoes rounding to recover a binary vector and the final result is often less sparse than the original vector. In this paper, rounding procedure is replaced with a random assignment of 1's to the most likely defective entries; each value is randomly mapped to 0 or 1, with a probability determined by the solution of the linear program.

**Title : Reconstruction Guarantee Analysis of Binary Measurement Matrices Based on Girth**

**Authors : Xinji Liu, Shutao Xia**

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**Title : Constructions of Quasi-Cyclic Measurement Matrices Based on Array Codes**

**Authors : Xinji Liu, Shutao Xia**

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**<Compressed Sensing 4>**

**Title : Phase Diagram and Approximate Message Passing for Blind Calibration and Dictionary Learning**

**Authors : Florent Krzakala, Marc Mezard**

* The paper considers dictionary learning and blind calibration for signals and matrices created from a random ensemble.
* 

Figure 1 Factor graph used for the belief propagation inference.

* The paper leads to the AMP algorithm from the Bayesian approach combined with belief propagation (BP) reconstruction algorithm.

**Title : Fixed Points of Generalized Approximate Message Passing with Arbitrary Matrices**

**Authors : Sundeep Rangan, Philip Schniter**

* Although AMP methods admit precise analyses in the context of large random transform matrices , their behavior for general matrices is less well-understood.
* To help overcome these limitations, this paper draws connections between AMP and certain variants of standard optimization methods.
* These connections enable a precise characterization of the fixed-points of both max-sum and sum-product GAMP.
* However, The convergence of AMP methods for general  is still not fully understood.

→ Under general choices of , AMP may diverge.

**Title : Sample complexity of Bayesian Optimal Dictionary Learning**

**Authors : Ayaka Sakata and Yoshiyiki Kabashima**

* A learning problem of identifying a dictionary matrix  from a sample set of  dimensional vectors .
* The minimum sample size(Sample complexity) necessary for perfectly identifying  of the optimal learning scheme.
* Sample complexity  holds as long as ( : density of non-zero entries) is satisfied in the limit of .
* The posterior distribution given  is condensed only at the correct dictionary  when the compression rate  is greater than a certain critical value.
* This paper suggests that BP(belief propagation) allow to learn  with a low computational complexity.

**Title : Compressive Classification**

**Authors : Hugo Reboredo, Francesco Renna, Robert Calderbank, and Miguel R. D. Rodrigues**

The authors exploit CS as feature extraction or supervised dimensionality reduction. They present fundamental limits on compressive classification by considering on measures of operational relevance: the probability of misclassification. They assume that a source signal is described by a Gaussian Mixture Model (GMM). Their main contribution is a characterization of the probability of misclassification as a function of the geometry of the individual classes, their interplay and the number of measurements. They show that the key quantities that determine the asymptotic behavior of the misclassification probability are similar to standard quantities used to characterize the behavior of the error probability in multiple-antenna communications: diversity and coding gain. The diversity order and the measurement gain – in view of its links to the geometry of the measurement system and the geometry of the source – offer a means to pose optimization problem that offer an opportunity to construct dictionaries with good discriminative power

**<Polarization Theory>**

**Title : Polarization of Quasi-Static Fading Channels**

**Authors : J. Boutros, and E. Biglieri**

**Introduction**: in the paper the authors investigates polar code design for block-fading (BF) channels. They use the fading-plane approach to study the outage behavior of polar coding at a fixed transmission rate. They show that polarization does occur at infinity for three types of channel multiplexers; diagonal, horizontal and uniform.

**Short Summary:** The paper starts with description of the main BF channel features and explains how three types of multiplexers work on BF channels. A binary element Xi is transmitted over channel $W\left(PM\_{d}(i)\right)$ with fading coefficient $αM\_{d}(i)$, the polarization kernel in diagonal multiplexing combines two fading binary input memoryless symmetric (BMS) channels into  and  without mutual information loss. Similarly both horizontal and uniform multiplexer are built from the mapping $M\_{h}:ℵ\rightarrow N$. Authors state that for any point  in the fading plane  polarization occurs on a BF channel with diagonal, horizontal or uniform multiplexing as length of polar code becomes very large ~ infinity i.e. the channel outage probability for rate-1/2 can be achieved with a zero SNR gap.

**Titles : Polarization improves E0**

**Authors : M. Alsan and E. Telatar**

**Introduction**: in the paper the authors proved that Gallager’s reliability function E0 for binary input channels can be improved by combining and splitting the channel via Arıkan’s polarization transformation. However it leads to observation that the improvement in E0 translates to an improvement in complexity–error-probability trade-off.

**Short Summary:** The authors in the paper investigate that if polar transform improves E0? They provide two theorems. The theorem1 starts with description that for any binary input channel, $W:F\_{2}\rightarrow Y$ and some , the $E\_{0}\left(ρ,W^{-}\right)+E\_{0}\left(ρ,W^{+}\right)\geq 2E\_{0}\left(ρ,W\right)$ where $W^{-}$ and $W^{+}$ are two new binary input channels synthesized from polar transform. And theorem 2 is extension of theorem 1 for two binary input channels. Thus channel *W* gives $W^{-}$ and $W^{+}$ and by application of second theorem one can get $W^{--}$ ,$W^{-+}$,$ W^{+-}$ and $W^{++}$ channels. Thus ‘n’ repeated application of polar transform yields a set of $2^{n}$ channels. After analysis the channels authors said that the proposed theorems are equivalent to statement that stochastic process $\left\{E\_{0}\left(ρ,W\_{n}\right):n\geq 0\right\}$ is submartingale.

**Titles : On the Correlation Between Polarized BECs**

**Authors : Mani Bastaniparizi, Emre Telatar**

🡪 They provides the tight union bound on the block error probability of polar codes for BECs.

🡪 (How?) By considering correlation coefficients and pairwise correlations between their erasure events.

🡪 They said that the proposed bound is indeed a very good estimation for the block error probability of Polar Codes over BEC.

**<Sparse Signal Recovery>**

**Titles : Oblique pursuits for compressed sensing with random anisotropic measurements.**

**Authors : Kiryung Lee, Yoram Bresler , Marius Junge**

* The measurement model for the anisotropic case is considered.
* A generalized RIP called the restricted biorthogonality property (RBOP) is proposed.
* Oblique pursuit, corresponding modified versions of existing greedy pursuit algorithm, is proposed.

Isotropy property: 

**Titles : Sparse signal recovery via multipath matching pursuit**

**Authors : Suhyuk Kwon, Jian Wang, Byonghyo Shim**

* Multipaths is investigated rather than a single path for a greedy type of search
* In the final moment, the most promising path is chosen.
* They propose “breadth-first search” and “depth-first search” for greedy algorithm.
* They provide analysis for the performance of MMP with RIP

**Titles : Recursive sparse recovery in large but structured noise – part 2**

**Authors : Chenlu Qiu, Namrata Vaswani**

* They study the problem of recursively recovering a time sequence of sparse vectors, St, from measurement Mt:=St+Lt that are corrupted by structured noise Lt.
* Structured noise: Lt should lie in a low dimensional subspace that is either fixed or changes slowly enough, and eigenvalues of its covariance matrix are clustered.
* Support set: the only thing required is that there be some support change every so often.

**<Polar Codes>**

**Titles : Fixed-Threshold Polar Codes**

**Authors : Jing Guo, Albert Guillen I Fabregas, and Jossy Sayir**

🡪Propose a different construction of polar codes. Instead of choosing the best K virtual channels, they choose all channels whose mutual information is above a certain threshold which might depend on the code length

(Originally, Polar codes of rate R =K/N are linear codes whose generator matrix is such that its rows induce the K virtual channels with highest mutual information among all N possible channels.)

🡪This new construction is shown to preserve the capacity-achieving property of original construction of channel polarization as long as the threshold function is bounded appropriately.

🡪This construction induces accurate closed-form upper and lower bounds to the minimum distance of the resulting codes when the design channel is BEC.

🡪 Their results sharpen existing bounds in the literature on the minimum distance of polar codes [2].

**Titles : On the Construction and Decoding of Concatenated Polar Codes**

**Authors : Hessam Mahdavifar , Mostafa El-Khamy, Jungwon Lee, Inyup Kang**

🡪 They proposed a scheme (including encoding and decoding) such that binary polar codes and interleaved Reed-solomon codes are concatenated as inner codes and outer codes, respectively.

🡪The performance of the scheme is better than original polar codes while preserving the low decoding complexity. (Complexity: )

**Titles : A Two Phase Successive Cancellation Decoder Architecture for Polar Codes**

**Authors : Alptekin Pamuk, Erdal Arıkan**

🡪 This is a paper about hardware implementing polar codes.

🡪They propose a two-phase successive cancellation decoder architecture for polar codes that exploits the array-code property of polar codes by breaking the decoding a length-N polar code into a series of length- decoding cycles.

🡪A length  bit polar code is implemented in an FPGA and the synthesis results are compared with a previously reported FPGA implementation. As a result, the proposed architecture has lower complexity, lower memory utilization with higer throughput, and a clock frequency that is less sensitive to code length.

**<Sparsity>**

**Titles : Sparse Phase Retrieval: convex algorithms and limitations**

**Authors : Kishore Jaganathan, Samet Oymak, Babak Hassibi**

* For phase retrieval problem with high sparsity, an iterative decoding algorithm which uses reweighted l1-minimization.
* It uses the fact that the largest eigenvalue of the weighting matrix **V** turns out to be considerably stronger than the other eigenvalues, and the eigenvector corresponding to it happens to contain a lot of information about the support of the signal for higher sparsity.

**Titles : Volume Ratio, Sparsity, and Minimaxity under Unitarily Invariant Norms**

**Authors : Zongming Ma, Yihong Wu**

This paper presents a non-asymptotic study of the minimax estimation of high-dimensional mean and covariance matrices. Mean problem: , , iid matrix with entries N(0,1). The central problem dealt in this paper is the estimation of high-dimensional matrices. This problem arises in functional genomics, network analysis and machine learning. The difficulty of a high-dimensional estimation problem can be captured by the minimax rate (a function of model parameters). The parameters of interests belong to (or approximable by) a space of much lower dimension than the size of the matrix, for ex., banded, sparse, and low-rank. These are called structured problems. Unstructured problems are non-trivial and dealt in this paper. For determining minimax rates of mean and covariance matrices under all unitarily invariant norms, the authors develop a unified volume ratio approach based on the convex geometry of finite-dimensional Banach spaces. The authors also establish the rate for estimating mean matrices with group sparsity, where the sparsity constraint introduces an additional term in the rate.

**Titles : Minimax Universal Sampling for Compound Multiband Channels**

**Authors : Yuxin Chen, Andrea Goldsmith, Yonina C. Eldar**

The maximum rate of information that can be conveyed through an analog channel largely depends on the sampling technique and rate employed at the receiver end. In wideband communication (compound multi-band channel with unknown sub band occupancy) systems, hardware and cost limitations often remove the possibility of sampling at or above the Nyquist rate. Thus, the understanding of sub-Nyquist sampling and its effects upon capacity are crucial in these situations.

In practice, the receiver sampling mechanism is typically static and hence designed based on a family of possible channel realizations. The actual channel realization will vary over this class of channels, and the sampler thus operates independently of instantaneous channel information. This has no effect in the information rate if the sampling rate is equal to or above the Nyquist rate of the channel family. However, in the sub-Nyquist sampling rate regime, the sampler design significantly impacts the information rate achievable over different channel realizations. The capacity-maximizing sub-Nyquist sampling mechanism for a given linear time-invariant channel depends on specific channel realizations. Also, the capacity-optimizing sampler for a given channel structure might result in very low data rates for other channel realizations.

In this paper, the authors explore universal design called random sub-Nyquist sampling. They show that the sampling is robust against the uncertainty and variation of instantaneous channel realizations, based on sampled capacity loss as a metric. In particular, they investigate the fundamental limit of sampled capacity loss, and design a sub-Nyquist sampling system for which the capacity loss can be uniformly controlled and optimized over all possible channel realizations.

**Titles : Tractability of Interpretability via Selection of Group-Sparse Models**

Authors : Nirav Bhan, Luca Baldassarre, Volkan Cevher

Recent extensions of compressive sensing move beyond the simple sparsity model to consider more sophisticated structured sparsity models. Exploiting these structures helps to reduce the number of required measurements for perfect recovery in the noiseless case from *O(K log N/K)* down to *O(K)*, where *N* is the ambient dimension and *K* is the sparsity level. The core intuition behind these achievements is that of customizing the geometry of the optimization problem to that of the class of signals we are interested in recovering.

Most of the structured sparsity models are based on groups of variables that should either be selected or discarded together. These structures naturally arise in applications such as neuroimaging, gene expression data. While in signal processing we are mostly concerned with recovering a signal by exploiting the sparsity, often in machine learning applications it is more important to discover the set of groups that constitute the signal support. In fact, in many applications the groups have specific meanings and it is relevant to understand which groups are active and which are inactive (cancer research)

 In this paper, the authors present a graph based representation of groups and characterize the group structures. With sparsity constrains in these graph models the authors devised dynamic and binary linear programs that can be solved in polynomial time.

**<Multi-User Polar Codes>**

**Titles : A New Polar Coding Scheme for Strong Security on Wiretap Channels**

**Authors : Eren S¸ as¸o˘glu, Alexander Vardy**

🡪They proposed a multi-block polar coding scheme that resolves the difficulty in providing reliability under the strong security.

**Titles : Successive Cancellation Decoding of Polar Codes for the Two-User Binary-Input MAC**

**Authors : S. Onay**

**Introduction**: in the paper the authors a successive cancellation de-coder of polar codes for the two-user binary-input multi-access channel that achieves the full admissible rate region. The polar codes generate a set of extremal channels from repeated uses of a single-user channel. In literature it is mentioned that a specific class of expansions of “monotone” chain rules exists that achieves every point on the dominant face of the Slepian-Wolf (SW) achievable rate region with arbitrarily small precision. By taking aforementioned result as baseline, author investigates a successive can-cellation (SC) decoder of the class of polar codes for two-user binary-input multi-access channels that are generated by monotone chain rules.

**Short Summary:** The author in the paper assumes that be independent samples from a source $\left(Z, X, Y\right)\~p\_{XY}\left(x,y\right)W\left(z|x,y\right)$ then the MAC problem considered here is related to a special case of the generalized SW problem stated above where $p\_{XY}\left(x,y\right)=p\_{X}\left(x\right)p\_{Y}\left(y\right)=1/4$ i.e. X and Y are independent and uniformly distributed on {0,1}. Then the channel rates $\left(R\_{x},R\_{y}\right)$ relate to source rates $\left(R\_{x}^{s},R\_{y}^{s}\right)$ as $R\_{x}=1-R\_{x}^{s}$ , $R\_{y}=1-R\_{y}^{s}$. Thus arbitrary points on the dominant face of *R(W)* can be achieved with such chain rule expansions. Thus polar coding for single-user MAC as: For a given path $b^{2N}$with edge variables (s1, . . . , s2N ), the coordinate channels: $W\_{N}^{\left(b\_{k},i,j\right)}:X\rightarrow Z^{N}×X^{k-1}, 0\leq i\leq N,1\leq k=i+j\leq 2N$ as:



The capacity terms of these channels polarize to 0 or 1 as N goes to infinity. Hence, four different types of extremal channels emerge. These channels can be interpreted as the effective channel seen by the successive cancellation decoder (provided that sk−1 was decoded correctly).

The decoder at each step of decoding the decoder decodes a single bit of either user 1 or 2 in increasing order of indices. The decoder decisions are:  if bk=0 or  if bk=1. Although these channels are two-user, yet the decision is not made on values of ui and vj at a single step. Instead decoder runs for 2N steps and then to make decision the decoder calculates one of the a posteriori probabilities (APP)  or . Then, it decides on the value of the information bit as given in (10) or (11).

**Authors : Lossless Polar Compression of q-ary Sources**

**Titles : S. Cayci and O. Arikan**

**Summary:** In literature a lossless polar coding scheme is employed such that uses a decoder at the encoder and corrects all decoding errors at the expense of additional overhead prior to transmission is introduced for binary memoryless sources. The authors generalize aforementioned scheme to q-ary memoryless sources over prime-size alphabets. The average codeword length is then reduced by a polar compression scheme based on successive cancellation list decoding. The proposed compression scheme is then extended to arbitrary finite source alphabets by using layered approach. The proposed coding scheme compress the given sequence into information set . Then a compressed word is formed. The simulation result prove that polar compression achieves rates close to the entropy bound with proposed low complexity encoding and decoding algorithms.

**<Non-binary Polar codes>**

**Titles : Polar Lattices: Where Arikan Meets Forney**

**Authors : Yanfei Yan, Cong Ling, Xiaofu Wu**

🡪 They propose the explicit construction of a new class of lattices based on polar codes, which are provably good for the additive white Gaussian noise (AWGN) channel.

🡪 They follow the multilevel construction of Forney et al., where the code on each level is a capacity achieving polar code for that level.

🡪The proposed polar lattices are efficiently decodable by using multistage decoding.

🡪Compared with existing schemes, polar lattices are distinguished by their provable AWGN-goodness and low complexity, namely, they asymptotically achieve the sphere bound with multistage decoding.

**Titles : Polarization theorems for Arbitrary DMCs**

**Authors : Rajai Nasser and Emre Telatar**

🡪A polarization phenomenon in a special sense is shown for an arbitrary discrete memoryless channel (DMC) by imposing a quasi-group structure on the input alphabet

🡪 The same technique is used to derive a pol.arization theorem for an arbitrary multiple access channel (MAC) by using an appropriate Abelian group structure.

🡪 These results can be used to construct capacity-achieving polar codes for arbitrary DMCs with a block error probability of o() and an encoding/decoding complexity of O(N logN), where N is the block length

🡪 In this paper, it was shown that being a quasi-group is a sufficient property for an operation to ensure polarization when it is used in the construction of polar codes.

🡪The determination of a more general property that is both necessary and sufficient remains an open problem.

**Titles : Multilevel Polar-Coded Modulation**

**Authors : Mathis Seidl, Andreas Schenk, Clemens Stierstorfer, and Johannes B. Huber**

🡪 They combined polar coding and multilevel coding by representing both as sequential binary partitions. Based on this representation, they have derived rules for optimization of multilevel polar codes.

**Titles : Controlled polarization for q-ary alphabets**

**Authors : Woomyoung Park, Alexander Barg**

- Design polar codes for q-ary input, q =, that polarize to an arbitrary given subset of extremal configurations out of the original triangular array of r+1 such configurations.

- they constructed polarization kernels that yield q-ary codes, q = , that polarize to any given subset of the set of r + 1 extremal configurations, resulting in symbols that carry precisely the desired number of perfect bits over the channel

- they also talk about that transmission can benefit from relying on symbols that carry different amounts of information over the channel.

- Finaly, they conclude this paper with relation about video coding (MPEG). From this papers work, they said that we can avoid additional overhead in the encoder and decoder.

- [3] W. Park and A. Barg, “Polar codes for q-ary channels, q = 2r,” IEEE Trans. Inform. Theory, vol. 59, no. 2, pp. 955-969, 2013 -> this paper advance the approach of [3].

**<LP Decoding>**

**Titles : Linear Programming Decoding of spatially coupled Codes.**

**Authors : Louay Bazzi, Badih Ghazi, and Rudiger Urbanke**

🡪For a given family of spatially coupled codes, we prove that the LP threshold on the BSC of the tail-biting graph cover ensemble is the same as the LP threshold on the BSC of the derived spatially coupled ensemble.

🡪This result is in contrast with the fact that the BP threshold of the derived spatially coupled ensemble is believed to be larger than the BP threshold of the tail-biting graph cover ensemble [1], [2].

**Titles : Towards Combinatorial LP Turbo Decoding**

**Authors : M. Helmling and S. Ruzika**

**Summary:** Authors presented an algorithm that solves turbo code (TC) linear programming (LP) decoding problem in a finite number of steps by Euclidean distance minimization. The minimization process relies on repeated shortest path computations in trellis graph representing the turbo codes. They showed that maximum likelihood (ML) LP decoding is equivalent to solving LP-relaxed shortest path problem in trellis graph. They formulate the ML decoding as an integer linear program by introducing a binary flow variable. Generally LP decoding of linear block codes is NP-complete. In literature it has been tried to solve through Lagrangian relaxation technique. However in this method the convergence is often slow in practice and solution is also not exact, leaving it an approximate method. Therefore authors adopt geometric interpretation of the image of the path polytope in the “constraints space” in their proposed nearest point algorithm. This results in the exact LP solution in finitely many steps.

**<Construction of LDPC Codes>**

**Titles : New results on Construction A Lattices based on Very Sparse Parity-Check Matrices**

**Authors : Nicola di Pietro, Gilles Z´emor , Joseph Jean Boutros**

- they talk about the problem of transmission of information over the AWGN channel using lattices. (“how good the intrinsic quality of the LDA family is under full lattice decoding”)

- they find some particular ensemble of LDA lattices(thm1 on papers), evaluate its quality and show that a random member in it can be reliably decoded for any value of the channel noise variance up to Poltyrev limit

- there exists a Poltyrev-capacity-achieving family of LDA lattices associated to very sparse p-ary parity-check matrices and the number of non-zero entries per matrix-row or per column is a (typically small) constant.

- finally, they talk that their values of  and parameters are in accordance with the optimal parameters found experimentally under iterative decoding.

**Titles : Correcting Combinations of Errors and Erasure with Euclidean Geometry LDPC Codes**

**Authors: Qiuju Diao, Ying Yu Tai, Shu Lin, Khaled Abdel-Ghaffar**

Summary: Euclidean geometry LDPC codes in conjunction with their shortened codes obtained by puncturing their parity-check matrices are effective in correcting combinations of errors and erasures with a two-phase decoding scheme. At first phase, the erasures are removed from the received vector resulting in a shortened received vector. This shortened received vector is then decoded based on its corresponding parity-check matrix to correct the errors using an iterative message-passing algorithm. At second phase, the removed erasures are reinserted back in their original positions. Then, the erasures are corrected using a simple algebraic method based on the parity-check matrix of the original code. The parity-check matrix of a shortened code is a submatrix of original parity-check matrix obtained by deleting a set of chosen columns and the rows that have 1-entries in the locations corresponding to the deleted columns. For this approach, it is necessary that the parity-check matrix of the original code has a large number of redundant rows in order to contain the parity-check matrices of the shortened codes as submatrices. This is exactly the case the parity-check matrices of EG-LDPC codes.

**<Spatial Coupling 1>**

**Titles : Universal Multiple Access via Spatially Coupling Data Transmission**

**Authors : Dmitri Truhachev**

🡪The main feature discussed in the paper is the data stream coupling accomplished by linear superposition of the independent data streams transmitted with time offsets by a single or multiple transmitters.

🡪Consider a two-user multiple access channel(MAC), then prove that the entire capacity region of the two-user Gaussian MAC can be achieved by spatially coupling data transmission(a universal multiple access technique.)

🡪Universal multiple access technique achieves the entire capacity region of AWGN multiple access channel for equal power and equal rate data streams, which is the most difficult for multiple user detection.

**<MDS Codes and the Singleton Bound>**

**Titles : Balanced Sparsest Generator Matrices for MDS Codes**

**Authors : Hoang Dau, Wentu Song, Zheng Dong, Chau Yuen**

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**Titles : A Lattice Singleton Bound**

**Authors : Srikanth B. Pai, B. Sundar Rajan**

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| The contributions of this paper are as follows: 1. They derive a Singleton bound in the framework of lattices.
2. They obtain a new Singleton bound for non-constant dimension subspace codes.

(For details, we need to carefully read this paper) |

**<Spatial Coupling 2>**

**Titles : Spatially-Coupled Multi-Edge Type LDPC Codes with Bounded Degrees that Achieve Capacity on the BEC under BP Decoding**

**Authors : Naruomi Obata, Yung-Yih Jian, Kenta Kasai, Henry D. Pfister**

Previously, Kasai and Sakaniwa showed empirically that, for the BEC, this limitation can be overcome by using spatially-coupled MacKay-Neal (MN) and Hsu-Anastasopoulos (HA) ensembles. We prove that some SC-MN and SC-HA codes achieve capacity on the BEC under BP decoding. In particular, we prove this analytically for (k,2,2)-MN and (2,k,2)-HA ensembles when k is at least 3. The proof is based on the simple approach to threshold saturation, introduced by Yedla et al., which relies on potential functions.

**Titles : Spatially-Coupled Precoded Rateless Codes**

**Authors : Kosuke Sakata, Kenta Kasai, Kohichi Sakaniwa**

Aref and Urbanke investigated the potential advantage of universal achieving-capacity property of proposed spatially-coupled (SC) low-density generator matrix (LDGM) codes. However, the decoding error probability of SCLDGM codes is bounded away from 0. In this paper, we investigate SC-LDGM codes concatenated with SC low-density parity-check codes. The proposed codes can be regarded as SC Hsu-Anastasopoulos rateless codes. We derive a lower bound of the asymptotic overhead from stability analysis for successful decoding by density evolution. We observe that with a sufficiently large number of information bits, the asymptotic overhead and the decoding error rate approach 0 with bounded maximum degree

**Titles : And Now to Something Completely Different: Spatial Coupling as a Proof Technique**

**Authors : Andrei Giurgiu, Nicolas Macris, R¨udiger L. Urbanke**

The aim of this paper is to show that spatial coupling can be viewed not only as a means to build better graphical models, but also as a tool to better understand uncoupled models. The starting point is the observation that some asymptotic properties of graphical models are easier to prove in the case of spatial coupling. In such cases, one can then use the so-called interpolation method to transfer results known for the spatially coupled case to the uncoupled one.

**Titles : Multi-Dimensional Spatially-Coupled Codes**

**Authors : Ryunosuke Ohashi, Kenta Kasai, Keigo Takeuchi**

Spatially-coupled (SC) codes are constructed by coupling many regular low-density parity-check codes in a chain. The decoding chain of SC codes aborts when facing burst erasures. This problem cannot be overcome by increasing the chain length. In this paper, we introduce multi-dimensional (MD) SC codes to circumvent it. Numerical results show that two-dimensional SC codes are more robust against the burst erasures than one dimensional SC codes. Furthermore, we consider designing multidimensional SC codes with smaller rateloss.

**Titles : The Space of Solutions of Coupled XORSAT Formulae**

**Authors : S. Hamed Hassani, Nicolas Macris, R¨udiger L. Urbanke**

The XOR-satisfiability (XORSAT) problem deals with a system of *n* Boolean variables and *m* clauses. Each clause is a linear Boolean equation (XOR) of a subset of the variables. A *K*-clause is a clause involving *K* distinct variables.

We consider a coupled *K*-XORSAT ensemble, consisting of a chain of random XORSAT models that are spatially coupled across a finite window along the chain direction. We observe that the threshold saturation phenomenon takes place for this ensemble and we characterize various properties of the space of solutions of such coupled formulae.

**<Quasi-Cyclic LDPC codes>**

**Titles : Necessary Conditions for Quasi-Cyclic LDPC Codes to Have a Given Girth**

**Authors : Kyung-Joong Kim, Jin-Ho Chung, Kyeongcheol Yang**

Short cycles in the Tanner graph of a low-density parity-check (LDPC) code may cause a severe performance degradation. In this paper, we investigate the cycle properties of quasi-cyclic LDPC (QC-LDPC) codes. We first analyze a necessary and sufficient condition for a cycle of a given length to exist, by using the sequence representation of a parity-check matrix for a QC-LDPC code. We then derive bounds which are necessary conditions for a QC-LDPC code to have a given girth in terms of its parameters.

**<Nonbinary LDPC Codes>**

**Titles : Analysis and Enumeration of Absorbing Sets for Non-Binary Graph-Based Codes**

**Authors : Behzad Amiri, Joerg Kliewer , Lara Dolecek Approaching**

- This work provides a generalization of absorbing sets for linear channel codes over non-binary alphabets.

- They do that 1) define and analyze NB-ASs for codes over GF(q), q > 2, 2) Analysis and Enumeration otf their definition 3) propose an algorithm based on our classification of ASs.

- they show that as q gets larger, it is harder to satisfy edge labeling conditions of absorbing sets -> as a result the number of absorbing sets decreases for larger field sizes.

- Further, they also proposed an algorithm to decrease the number of absorbing sets in the Tanner graph by changing carefully chosen edge weights.

- At here, the fact “that non-binary edge weights enables us to reduce the number of ASs by just changing the weights of edges in the Tanner graph without changing its structure” it is the key idea of this paper.

- NB – AS 정의 -> NB-AS 특징 분석 -> NB-AS 피하기 위한 알고리즘 -> 성능개선

**Titles : Approaching Multiple-Access Channel Capacity by Nonbinary Coding-Spreading**

**Authros : Yuta Tsujii, Gauanghui Song, Jun Cheng, and Yoichiro Watanabe**

🡪Nonbinary coding-spreading scheme is proposed for a synchronous binary-input multiple-access channel(MAC) with Gaussian noise, equal-power, and equal-rate users.

🡪This scheme is better than the binary coding and binary spreading scheme.

(The iterative multi-user decoding threshold of nonbinary coding-spreading scheme is less than 0.5dB away from the MAC capacity at many sum rates. At least, the binary cases are more than 1.4 dB away)

🡪In this scheme, each user employ the same nonbinary LDPC code serially concatenated with a nonbinary low rate mapping, referred to as nonbinary spreading.

🡪Solve a nonbinary coding-spreading trade-off problem, where the optimal nonbinary LDPC code rate and the nonbinary spreading length is obtained by their EXIT chart analysis

**Titles : Message Passing Algorithm with MAP Decoding on Zigzag Cycles for Non-binary LDPC Codes**

**Authors : Takayuki Nozaki, Kenta Kasai, Kohichi Sakaniwa**

- In this paper, we propose a decoding algorithm which lowers decoding erasure rates in the error floor regions for non-binary LDPC codes transmitted over the BECs.

- zigzag cycles (simple cycle of small weight erasures)cause decoding erasures in the Error Floor Region

- decoding algorithm is a combination with belief propagation (BP) decoding and maximum a posteriori (MAP) decoding on zigzag cycles. (BP -> zigzag cycles detection -> MAP on zigzag)

- MAP decoding on the zigzag cycles is realized by means of message passing algorithm.

- the result shows that the decoding erasure rates in the error floor regions by the proposed decoding algorithm are lower than those by the BP decoder.

- error floor 영역은 low weight 가 문제 -> zigzag

- DB -> zigzag 찾기 -> MAP : error floor 영역에서 erasure rate 낮추기.

**Titles : Weight Distribution for Non-binary Cluster LDPC Code Ensemble**

**Authors : Takayuki Nozaki, Masaki Maehara, Kenta Kasai, Kohichi Sakaniwa**

- they derive the average weight distributions for the irregular non-binary cluster (LDPC) code ensembles.

- they give the exponential growth rate of the average weight distribution in the limit of large code length.

- they show that there exist (2; dc)-regular nonbinary cluster LDPC code ensembles whose normalized typical minimum distances are strictly positive.

- 저자는 weight distribution을 분석하는 것이 linear 코드의 decoding performance를 분석하는데 중요하다고 시작하면서, NB-cluster-LDPC code 에 대한 수학적인 특징 분석을 하고 있습니다.

- average symbol / bit - weight distribution , growth rate, small weight codeword 일때의 growth rate 분석 등

- For the non-binary cluster LDPC codes, each edge in the Tanner graphs is labeled by a cluster which is a full-rank p\*r binary matrix, where p>= r.