Report from ISTC - 2010

Hesam and Raj

I. Iterative Information Processing

- [Tanner] As an invited speaker, Tanner gave an intuitive talk on various problems in areas other than coding theory which can be solved using message passing and iterative information processing. A particular example was to solve the Laplace wave equation for a drum surface using message passing. The idea is to break the surface into smaller building blocks. Then, each block acts as a node and sends messages regarding its overall forces to its neighbors. This approach was shown be less computationally demanding in simulating mechanical structures. Another Interesting topic he mentioned was fault tolerant decoding (in the context of full-parallel pipeline implementations of iterative decoders): we always talk about handling errors in the channel, but how do we handle errors during the decoding process itself? For instance, what happens if a variable or check node fails? How can we design fault tolerant codes?

- [Sahai] Anant Sahai introduces an interesting idea about "low power" error correcting codes, in the context of "green radio" systems. In a communication system, power is consumed both by the transmitter, and by the decoder in the receiver. Often, one neglects the power consumption at the receiver. This talk presented a framework where one minimizes the total sum power in both the Tx and the Rx. If the power consumed to decode a code is very large, one might choose to use less powerful/uncoded systems, to conserve total power. One goal is to design error correcting codes with least power consumption. He derived some general bounds for any type of codes on graph regarding power consumption (assuming that power consumption is proportional to the size of the decoding neighbourhood) and mentioned a new perspective to interpret the gap to capacity: if we allow a small gap to capacity, we can achieve error correction with much less power consumed by the decoder.

- [Montanari] Andrea Montanari mentioned applications of message passing in estimation. In particular, suppose we have a message, x, which is measured according to a matrix A. As usual, the measurement, y, is noisy. In other words y = Ax + w, where w is the noise. The problem is now to estimate x having A and y. He proposed an algorithm based on message passing and showed that it can achieve better performance compared to some other approaches. He also said that this is similar to density evolution in some sense, but for dense graphs.

- [Arikan], and [Blahut]: Both these invited talks had a similar flavor, which is to present the way in which the cut-off rate has influenced recent developments in coding theory. A history of the cutoff rate and sequential decoding was presented, and it was shown how the polar coding framework is inspired by the works of Pinsker and Massey (which tried to improve the computational cutoff rate).

- [Thangaraj]: Andrew Thangaraj presented some results on using LDPC codes over the wiretap channel, to implement physical layer security. Both strong and weak secrecy frameworks were considered. Also, the assumption is that the main sender-receiver channel is noiseless, and that the channel to the eavesdropper is either a BSC or a BEC. While polar codes are known to be capacity achieving over such channels (shown by others), this paper showed that LDPC codes are good only under certain conditions.

II. Rateless Codes

- [Chong et al]: This group of authors from the Institute for Infocomm research consider LT codes where the degree distribution is allowed to vary over the duration of transmission. A theoretical framework is presented in terms of posets to analyze the performance of such schemes under ML decoding, and show improvements over using static degree distributions.

III. LDPC Codes

- [Urbanke] Rudiger Urbanke gave a talk on different problems he and his students has been working on regarding LDPC and LDGM codes. He mentioned coupled LDPC and LDGM codes which are built by lifting a simple variable-check node structure L times, making the whole structure symmetric by introducing some ”fixed” variable nodes in the boundaries of the lifted graph and then make M copies of this new graph. Using EXIT charts, he showed that the BP threshold for these coupled codes are the same as their MAP threshold which is equal to the MAP threshold of the base code.

- [Kudekar et al.] Kudekar (one of Rudiger's former students) talked about the coupling technique which was mentioned by Rudiger the other day. He showed some simulation results confirming that the same phenomenon, i.e. having equal MAP and BP threshold for the coupled ensemble, also happens in AWGN (as well as BSC and BEC as shown before). However, one the problem with this technique is that the code rate is slightly less than the nominal rate. He mentioned some techniques to remedy the situation and achieve higher rates but still we are bounded away from the nominal rate.

- [Sayir] Jossy Sayir introduced some ideas about how to implement message passing on chips where the messages can not be real, as they are in the theoretical framework. He proposed a method to design decoders that instead of real messages, can use, say, 4-bit quantized versions of the messages and see how the performance compares to other approaches. Although what he had got in terms of probability of error vs. SNR was not better than current approaches, but he mentioned a few ways to overcome these limitations in future.

IV. Neural Information Processing

- [Berrou] Finally, Berrou introduced a new technique for designing better content addressable memories (in usual memories, like RAM, you give the address to the device and the content of that address is retrieved. However, in a content addressable memory, you give an input pattern and receive the memorized pattern as the output. This is similar to the way brain memorizes and retrieves different patterns). The new approach is inspired from the functionality of pattern matching neural network. An interesting issue in such networks is the performance and the mechanism of recalling process in presence of noise, i.e. when some of the input bits are erased (think of it as recalling a misspelled word!). He showed that compared to other current methods, the new scheme can achieve much better performance in terms of the number of patterns memorized and correctly recalled when noise is present. This was particularly interesting as we are also working on somewhat a similar problem, i.e. applying coding theoretical arguments to investigate the mechanism of recalling procedure in neuronal networks.