Quantized Belief Propagation Decoders with Low Error Floor for LDPC codes

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Error floor phenomenon of LDPC codes and their associated iterative belief propagation (BP) decoders is commonly attributed to some error-prone substructures within the Tanner graph used to represent the code such as trapping sets, near codewords, or absorbing sets. Many researches have been done to lower the error floor by designing new LDPC codes with fewer such substructures. In this talk, we first investigate the error floor from decoders' perspective, specially the limitation in the implementation of BP decoders that causes the error floor. Then, based on our analysis of the relationship between the error floor and the implementation of BP decoder, we propose a novel quantization method, called $q+1$-bit quantization, which does not require any modification on update rules or structure of original iterative BP-based decoder. With the same decoding complexity as the original iterative decoder, our new method significantly reduces the error floors of the LDPC codes we tested, and it can be applied to all most every type of iterative BP-based decoders such as SPA decoding and Min-Sum decoding. Fig.1 compares the performance of double precision float point unsaturated SPA decoder with three quantized SPA decoders and Gallager B Algorithm. For the quantized decoder, due to their limited range (especially the uniform quantization), we scaled all initial LLR values for channel to ±1. The 6 and 7 bits uniform quantization with step size is 0.25 give high error floor, while our new 6+1-bit quantization performs very close to the unsaturated float point version.

Fig.1 FER versus transition probability for (640,192) QC-LDPC code on BSC

![Graph showing Frame Error Rate (FER) versus transition probability for (640,192) QC-LDPC code on BSC with different quantization methods.]