Homework assignment 2.
Convolutional codes and connections with block codes

1 Goals of the homework

Convolutional codes are widely used in practice both separately and as constituent codes of concatenated constructions. Also, from convolutional codes the block codes with the structure suitable for ML and MAP soft decision decoding can be obtained.

The goal of this homework:

- Computing error probability bounds for convolutional codes
- Obtaining block codes from convolutional code.
- Through comparison performances of tailbiting (TB) and zero-tail (ZT) terminated codes.
- Comparison performances of block and convolutional codes.
- Analysis of influence of delay restriction and metric quantization on convolutional code
- Analysis of influence of the number of decoding iterations of WAVA decoder on the performance of TB code decoding

2 Stages of performing the homework

1. Choose the convolutional error-correcting codes with constrain length 4-6 from published papers.
2. Write program for computing union bit and node error probability bounds for chosen code. The weight enumerators can be found in literature.

3. Based on the prototype Matlab programs, implement your own simulation platform (not necessarily in Matlab), for simulating convolutional codes, TB codes, ZT codes.

4. By computer simulations, investigate the dependence of error probability performance as a function of codes and decoders parameters and data presentation precision.

5. Present simulation results in form of plots.

6. Write the report with conclusions based on research results.

3 Details of analysis and simulation scenario

Consider AWGN channel with BPSK modulation.

For simplicity, we study only rate $R = 1/n_0$ codes, $n_0 = 2, 3$.

Energy normalization and data quantization methods are the same as for Homework 1.

4 Research topics

The convolutional, TB and ZT code constructions allow flexible choice of parameters influences both complexity and performance. The following trade-offs could be chosen as research topics:

- For convolutional codes, consider different values of lengths of paths kept in the decoder or decision delay. Depending on SNR value, estimate the minimum decision delay such that further increasing of this parameter does not influence the error rate.

- For a given convolutional code, instead of infinite continuous data transmission, truncated TB or ZT codes can be used. How the termination length influences error probability? How much iterations of WAVA decoder is required for achieving near-ML performance?
• Compare TB and ZT from the coding gain point of view.

• Choose a good convolutional code and apply TB termination. Compare performance of this code with the performance of the best TB codes published in literature. The published TB codes are optimal in sense of achieved minimum distance whereas the best convolutional codes are selected using free distance and spectrum as performance criteria.

• Influence of code rate on error rate performance.

• Influence of LLR precision on error rate performance.

5 Individual assignment

Students select code parameters and 2-3 directions of research. Recommended ranges of code parameters:

• Constraint length $\nu = 4...6$.

• Decoding delay for convolutional code $\tau > 2\nu$.

• Data width for quantized LLRs, $b = 1$ (hard decisions), $2,...,6$.

• Termination length for obtaining TB or ZT codes, $L > 2\nu$.

6 Acceptance procedure

The final evaluation is performed based on

1. Report containing problem statement of the research, experimental results and conclusions.

2. Oral discussion.

3. Testing of programs used for obtaining numerical results.