On EXIT-Charts for Space-Time Block Codes

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Abstract — **In this work, we consider the application of the well-known space-time block code (STBC), the Alamouti-scheme, as inner code within a "turbo" coding scheme for the multiple-input-multiple-output (MIMO) Rayleigh fading channel. We analyze therefore the applicability of the Alamouti-scheme for iterative space-time detection and decoding applied at the receiver. To this end, we use extrinsic information transfer characteristics (EXIT-charts) in order to predict the performance of the Alamouti-scheme. Furthermore, we analyze the impact of different mapping strategies on the information transfer of the soft-input-soft-output (SISO) space-time detector and show analytically that it is possible to improve the performance by employing other mapping schemes than Gray mapping.**

I. Characterizing different mappings by mutual information and EXIT-charts

In the following, we analyze the impact of different 8PSK mappings (analogous to [1]) on the transfer characteristics of the detector for an AWGN channel. The extension to a Rayleigh fading channel is straightforward. With the chain rule of mutual information it can be shown that the mutual information $I(s; r) = I(\mathbf{c}; r) = I(c_1, \ldots, c_m; r)$ between transmitted constellation symbol $s = f(\mathbf{c})$ and received AWGN channel output r (assuming that all constellation symbols are equiprobable) can be decomposed into $I(\mathbf{c}; r) = \sum_{L=0}^{m-1} I_L$, where I_L is the average mutual information [1], when L bits are already known to the receiver. Hence, for 8PSK ($m=3$) we have

$$I_0 = \frac{1}{m\binom{m-1}{0}} \sum_{i=1}^{m} I(c_i; r); \; I_1 = \frac{1}{m\binom{m-1}{1}} \sum_{i=1}^{m} \sum_{\substack{j=1, \\ j \neq i}}^{m} I(c_i; r|c_j);$$

$$I_2 = \frac{1}{m\binom{m-1}{2}} \sum_{i=1}^{m} \sum_{\substack{j=1, \\ j \neq i}}^{m} \sum_{\substack{k=j+1, \\ k \neq i}}^{m} I(c_i; r|c_j, c_k). \tag{1}$$

Note that conditioning (i.e. increasing *a priori* knowledge) increases the mutual information, i.e. $I_L \geq I_{L-1}$. In comparing (1) for different mappings, we observe that for Gray mapping the difference between I_2 and I_0 is not as large as in the case of the other mappings. This means that increasing *a priori* knowledge has only small impact on the information transfer of the detector for Gray mapping. Interestingly, this is not true for the other mappings, which we choose from all possible 8PSK mappings. Here, we observe an improved information transfer by increasing the *a priori* knowledge. Note that, I_0 is larger with Gray mapping in comparison to the other mappings. Therefore, we expect a better performance
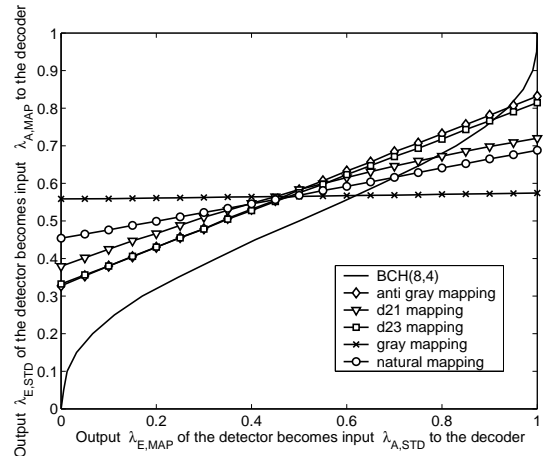
Figure 1: EXIT-chart of inner space-time-detector for $E_b/N_0 = 5dB$. Additionally, the transfer characteristic for a rate $R_{out} = 1/2$ outer code is depicted.

with Gray mapping in the case, where no *a priori* knowledge is available at the receiver.

Next, we analyze the behaviour of the different mapping strategies with the help of EXIT-charts [2]. We consider a system with $n_T = 2$ transmit and $n_R = 1$ receive antennas. Fig. 1 shows the transfer characteristics of the space-time detector as the inner decoder for different mapping strategies. Different mappings result in transfer characteristics of different slopes. Note that the detector transfer characteristics are almost straight lines and increasing the SNR shifts the curve up. Additionally, note that for high SNR values, the slope of the detector transfer characteristics is also affected (not depicted here). From the figure, we see also that the natural mapping provides good extrinsic output at the beginning but provides diminishing output for higher *a priori* input λ_A. For the anti gray mapping it is the other way around. The detector which uses gray mapping provides almost the same extrinsic output for all *a priori* input. Therefore, we expect that the performance of the detector with gray and natural mapping is good in the low SNR regime and for a few iterations in comparison to the other mappings. But in the high SNR regime and for more iterations, we expect that it is the other way around.

References

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