Improved Space-Time Trellis Codes
Using Expanded Signal Set in Slow Rayleigh Fading Channels

Young Seok Jung  
School of Electrical Engineering  
Seoul National University  
Shillim-Dong, Gwanak-Gu, Seoul 151-742, Korea  
e-mail: jys3@snu.ac.kr

Jae Hong Lee  
School of Electrical Engineering  
Seoul National University  
Shillim-Dong, Gwanak-Gu, Seoul 151-742, Korea

Space-time trellis codes (STTC), that provide transmit diversity and coding gain, has been known to give good performance in fading channels [1]-[5]. So far, most work on STTC has focused on full rate STTC. However, given the transmission rate of the STTC, its performance can be improved by using expanded signal set. In this paper we obtain the optimal STTC on expanded signal set in terms of measure of coding gain, which has been proposed in [5], through computer search.

Previous studies of STTC designs have focussed on minimizing the maximum pairwise error probability (PWE). However, some results in [3] shows that minimization of the maximum PWE does not necessarily minimize the frame error rate (FER). [4] and [5] proposed performance measures considering some PWEs, respectively. Each of them is called the expurgate union bound of order \(N\), \(S_{NR}(N)\), and measure of coding gain order \(L\), \(g_{f,nR}^L\). Although both are based on the fact that union of the simple error events is equal to the union of all error events, they have the different theoretical basis. While Akkas et al. exploited the first error event analysis assuming the infinite frame length, we derived the measure of coding gain for STTC with finite frame length.

We consider \(2^r\) state STTC with full rank and transmission rate \(k\) bps/Hz used in system with \(n_T\) transmit antennas and \(n_R\) receive antennas. As our purpose is to find the optimal STTC, it is the reasonable assumption that considered STTC have the full rank. Assume that a codeword \(c = (c_1, c_2, \ldots, c_l)\) is transmitted where \(c_i = (c_1^i, c_2^i, \ldots, c_{T}^i)\) is a space-time symbol at time \(t\) and \(l\) is frame length. Let \(c \rightarrow e\) is the event that the path metric of another codeword \(e\) is less than the path metric of codeword \(c\), i.e., the set of received sequences when ML decoder prefers \(e\) to \(c\). Then PWE is bounded by [1]

\[
P(c \rightarrow e) \leq d(c, e)^{-nR} \cdot \left( \frac{E_b}{4N_0} \right)^{-nT-nR} \quad (1)
\]

where \(d(c, e)\) is the determinant of the distance matrix \(A(c, e)\) which is defined as \((c-e) \cdot (c-e)^H\).

Let \(C\) be the codeword set and let \(D_c\) be the set of codewords that diverge from the codeword \(c\) only once and merge into the codeword \(c\) in the trellis diagram. The codeword pair \((c, e)\) is called simple if \(e \in D_c\) [4]. Then each of FER and BER is bounded by [5]

\[
P_f(e) \leq \sum_{c \in C} \sum_{e \in D_c} P(c \rightarrow e) \cdot P(e) \quad (2)
\]

\footnote{This work was supported in part by the Brain Korea 21 Project and the National Research Laboratory Program.}

REFERENCES


