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Active Distances and Cascaded Convolutional Codes

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Abstract — A family of active distances for convolutional codes is introduced. Lower bounds are derived for the ensemble of periodically time-varying convolutional codes.

I. INTRODUCTION

The "extended distances" were introduced by Thommesen and Justesen [1] for unit memory (UM) convolutional codes. We present (non-trivial) extensions to encoder memories m > 1 and call them active distances since they stay "active" in the sense that we consider only those codewords which do not pass two consecutive zero states [2].

II. ACTIVE DISTANCES

Consider the ensemble of binary, rate R = b/c, periodically time-varying convolutional codes encoded by a polynomial generator matrix of memory m and period T,

\[ G = \begin{pmatrix} G_0(t) & \cdots & G_m(t + m) \\ G_0(t + 1) & \cdots & G_m(t + m + 1) \\ \vdots & \ddots & \vdots \end{pmatrix} \]

in which each digit in each of the matrices Gi(t + i) for 0 ≤ i ≤ m and 0 ≤ t ≤ T − 1, is chosen independently and equally likely to be 0 and 1.

Let \( U_{l-m+1}^{t+m} \) be the set of information sequences \( u_l \ldots u_{t+m} \) such that the first m and the last m subblocks are zero and they do not contain m + 1 consecutive zero subblocks.

Let \( U_{l-m}^{t} \) be the set of information sequences \( u_l \ldots u_{t} \) such that the first m subblocks are zero and they do not contain m + 1 consecutive zero subblocks.

Let \( U_{l-m+1}^{t} \) be the set of information sequences \( u_l \ldots u_{t+1} \) such that at least one subblock is nonzero and they do not contain m + 1 consecutive zero subblocks.

Next we introduce the truncated time-varying generator matrix

\[ G_{[t,t+j]} = \begin{pmatrix} G_m(t) & \cdots & G_m(t + j) \\ G_0(t) & \cdots & G_m(t + j) \\ \vdots & \ddots & \vdots \end{pmatrix} \]

III. CASCADED CODES

Consider a scheme with two convolutional codes in cascade.

Theorem 1 There exist cascaded convolutional codes in the ensemble of periodically time-varying cascaded convolutional codes whose active distance satisfies

\[ \delta_i \geq \frac{a_i}{mc} \geq (l + 1) h^{-1} (1 - \frac{l}{l + 1} R) - O\left(\frac{\log_2 m}{m}\right) \]

for \( l \geq l_0 = O\left(\frac{1}{h^2}\right) \),

\[ \delta_i \geq \frac{a_i}{mc} \geq l h^{-1} (1 - \frac{l}{l + 1} R) - O\left(\frac{\log_2 m}{m}\right) \]

for \( l \geq l_0 = O\left(\frac{\log_2 m}{m}\right) \), and

\[ \delta_i \geq \frac{a_i}{mc} \geq l h^{-1} (1 - \frac{l}{l + 1} R) - O\left(\frac{\log_2 m}{m}\right) \]

for \( l \geq l_0 \leq 1 + R + O\left(\frac{\log_2 m}{m}\right) \).

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