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Performance of Concatenated Kernel Code in Cognitive Radio Networks

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Abstract

Error correction coding is extensively used to achieve reliability in digital communication especially in Physical Layer. In this paper, construction of concatenated kernel code defined over algebraic structure group is discussed. Minimal trellis representation is given for constructed concatenated kernel codeword. Constructed code is tested in cognitive radio network environment subjected to continuous interference due to the behavior of primary users. Proposed code is tested through simulations and its performance is analyzed in terms of Bit Error Rate (BER) in mitigating the effect of continuous interference. Maximum likelihood graph Viterbi decoding technique is used to decode the concatenated kernel code.

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1. Introduction

Reliability in information transmission is achieved through adding redundancy during transmission. Error correction coding deals with such well defined techniques of adding redundancy to information so that errors in transmission, if any, can be corrected with the help of added redundancy. Study and research of such techniques is broadly called as Channel coding. The process of adding redundancy to information by a specified technique is called encoding and thus formed encoded message is called codeword. Similarly, certain techniques are used to reconstruct the actual message from the codeword and the process is called Decoding. Redundancy bits added to information are also termed as parity bits.

Mathematically, a message m of length k from a message space defined over alphabet Σ is encoded into a codeword of length n such that $k < n$. Encoding E can be equivalently given as an injective map from message space Σ^k to the

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codeword space Σ^n[19]. Message space M includes all messages of length k to be encoded. Similarly, codeword space $\mathbb{C}$ includes all the codewords of length n to be transmitted over channel. Encoding E is given as a map as follows:

$$E : \Sigma^k \rightarrow \Sigma^n \tag{1}$$

where, Σ^k denotes message m of length k and Σ^n denotes codeword $\mathbb{C}$ of length n.

Similarly, decoding function D is given as a map as follows:

$$D : \Sigma^n \rightarrow \Sigma^k \tag{2}$$

Encoded message or codeword from codeword space Σ^n is transmitted over channel that can introduce errors η and $\eta \in \Sigma^n$.

In presence of channel noise $\eta \in \Sigma^n$, decoding function D is given as a mapping as follows:

$$D : \Sigma^{(n+\eta)} \rightarrow \Sigma^k \tag{3}$$

Majority of error correcting codes used in present day digital communication are defined over algebraic structure vector space with underlying field [14]. Error correcting codes defined over algebraic structure group has received less attention by researchers [2].

1.1. Concatenated Codes

Concatenated codes were extensively used in space missions lead by NASA in the late 60s and early 70s to achieve better reliability over traditional error correcting codes [4]. Forney introduced concatenated codes with inner code and outer code [7]. Concatenated codes doesnt belong to any specific family of codes [19] and careful selection of inner and outer code results in significant improvement in performance. Concatenated codes achieved goals of both communicating with rate (R) less than the channel capacity (C), i.e., $R < C$ (Shannon Model) [17] and correcting errors that occur during transmission over noisy channel (Hamming model) [8].

1.2. Trellis of a code

Graphs were used to represent codewords and trellis graphs are extensively used to represent codewords of a code $\mathbb{C}$. A trellis T representing a code $\mathbb{C}$ is given as $\mathbb{C}(T)$ [20].

Kschischang and Sorokine defined [11], Trellis for a block code C of length n is an edge labeled directed graph with a distinguished "root" vertex having in-degree zero and a distinguished "goal" vertex having out-degree zero, and with the following properties:

1. all vertices can be reached from the root;
2. the goal can be reached from all vertices;
3. the number of edges traversed in passing from the root to the goal along any path is n; and
4. the set of n-tuples obtained by 'reading off' the edge labels encountered in traversing all paths from the root to the goal is $\mathbb{C}$.

Many popular graph decoding algorithms such as Viterbi graph decoder [21] and Bahl, Cocke, Jelinek and Raviv (also called as BCJR algorithm) [1] are employed to decode the codewords represented as trellis.