The Convo Game

Team COMMets

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Introduction

Why do need error-correcting code ?

- To compensate for the errors received in the receiver due to a noisy channel, we need error - correcting codes.

What does error correcting do ?

- An error correcting code is designed to add or concatenate some redundant bits known as parity bits to the message bits. This coded message is then transmitted over a communication link (after modulation).
- Error correcting codes are broadly classified into 2 types, Block code and Convolution code.

How does Convolutional Coding work ?

- For every additional bit in the input sequence which has to be encoded, the parity code is a function of some of the previous bits in the bitstream. Each permutation of the previous bits used generates a different code as the window moves forward. A single generator decides to use only a single permutation or rule of selecting the previous bits.
- The set of code sequences produced by a k-input, n-output encoder (n-generators) and which uses a maximum of m-previous input bits is called (n,k,m) convolution code.

What is Interleaving ?

- Interleaving is a process by which the ordering sequence of the encoded bits is changed, so that the burst of errors gets distributed across various codewords present in the data rather than being bound to a single codeword.
- By distributing the burst of errors, Interleaving allows decoding by assuming them as random errors.

Objectives

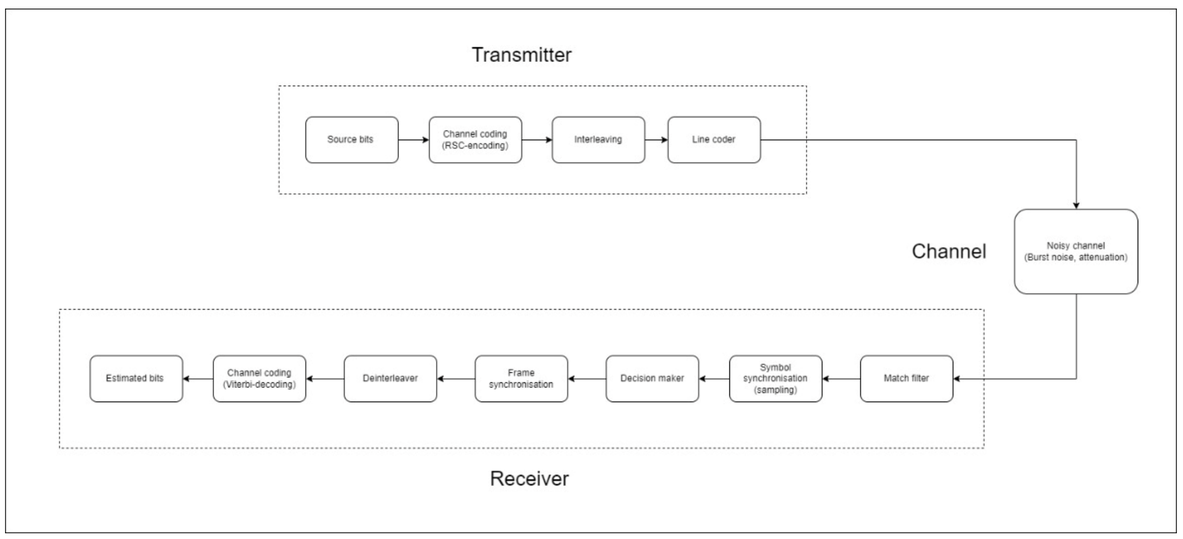
To understand and implement the following in MATLAB

- Rate ½ (5,7) Recursive Systematic Convolutional (RSC) encoder
- Interleaver- Convolutional
- Convolutional Decoder using Viterbi Algorithm
- End to end simulation of Digital Communication system using the above blocks.

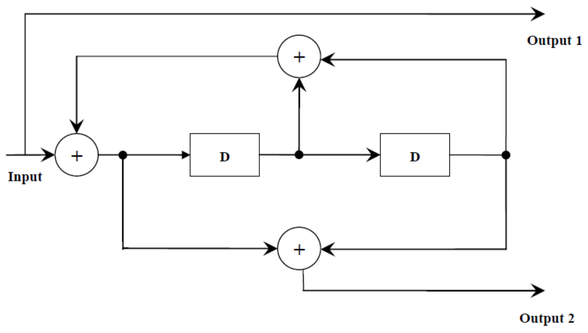
Porting of the Labsheet 5 from MATLAB to Python

Block Diagrams

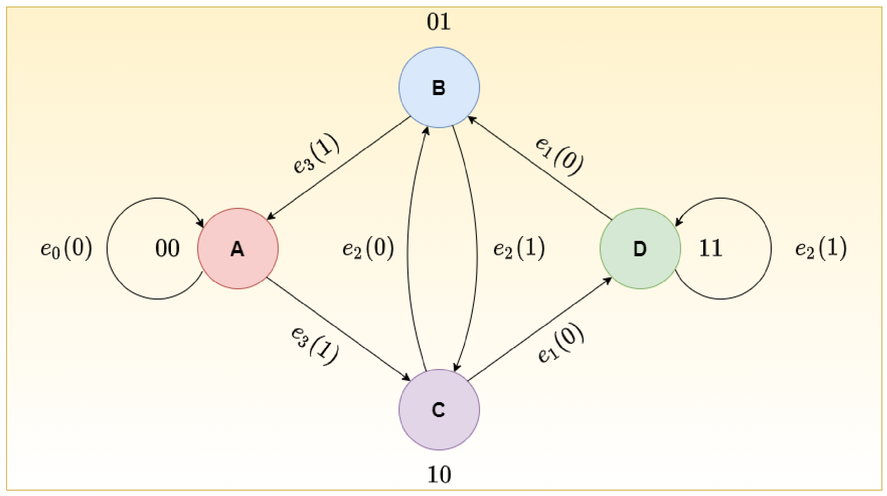
Block diagram of the Digital Communication System to be implemented



Block Diagram of RSC encoder with r = 1/2 and K = 3



State Diagram for Convolution Decoder



Viterbi Algorithm

$$e \rightarrow \text{Hamming distance}$$

$$e_m = \sum_{i=0}^{n} \mathbb{I}(r_i \neq b_i)$$

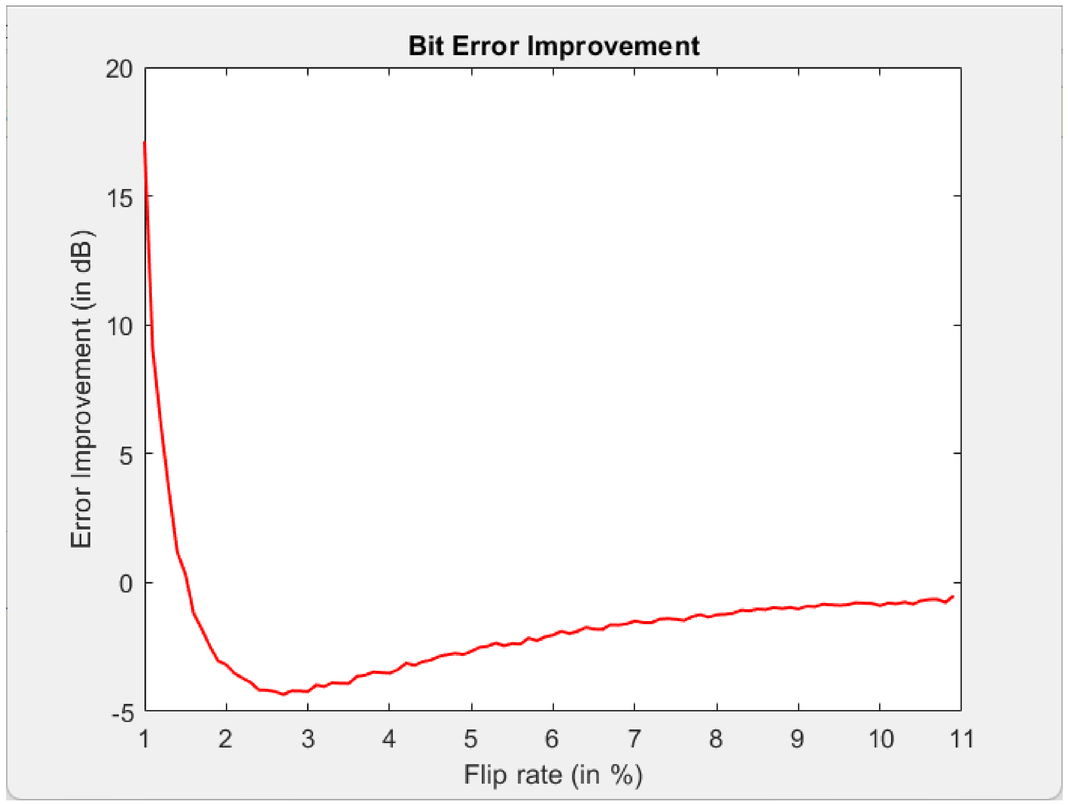
$$m = \text{integer}\,(b_n\, b_{n-1}\, \cdots\, b_2\, b_1\, b_0)$$

$$r = r_n\, r_{n-1}\, \cdots\, r_2\, r_1\, r_0$$

(Received sequence)

Hamming distance is used here as a measure to find optimal sequence using MAP

Results



References

- NPTEL course titled “An Introduction to Coding theory” by Dr. Adrish Banerjee, IIT Kanpur
- Wikipedia page on Error correction codes
- Online article on Convolutional encoder
- C. Berrou, A. Glavieux and P. Thitimajshima, "Near Shannon limit error-correcting coding and decoding: Turbo-codes. 1," Proceedings of ICC '93 - IEEE International Conference on Communications, 1993, pp. 1064-1070 vol.2, doi: 10.1109/ICC.1993.397441.
- Wikipedia page on Noisy-channel coding theorem
- Online article on Interleaving