RNN Convolutional Code Decoder

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December 21, 2022

Overview

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Convolutional Codes

Convolutional codes are a powerful method of encoding messages, by using short memory and convolution operators to sequentially create coded bits.

Definition

A **linear shift register (LSR)** is a shift register whose input bit is a linear function of its previous state.

The most commonly used linear function of single bits XOR.

A convolutional encoder utilizes linear shift registers to encode k input bits into n output bits, thus yielding a code of **rate** $R = \frac{k}{n}$. Each output bit depends on the previous L input bits, where L is called the **constraint length**.

Convolutional Encoding

This encoder depicted in the figure below corresponds to the following **generator polynomials**:

$$
\begin{aligned}
g^{(1)} &= 1 + x^2 \qquad & g^{(2)} &= 1 + x + x^2 \\
g^{(1)} &= [1, 0, 1] \qquad & g^{(2)} &= [1, 1, 1]
\end{aligned}
\tag{1}
$$

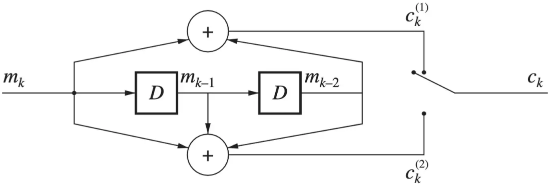


Figure: Convolutional encoder with rate $R = \frac{1}{2}$ and constraint length $K = 2$

Finite State Machine

Other representations of this encoder are a **finite state machine** and a **trellis**.

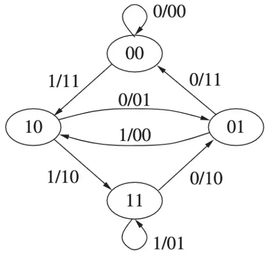


Figure: FSM representation

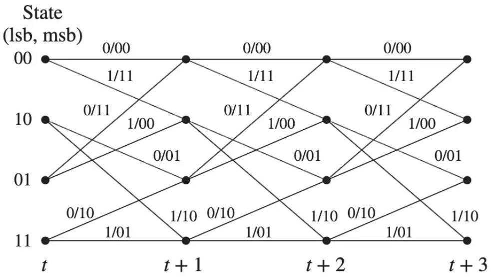


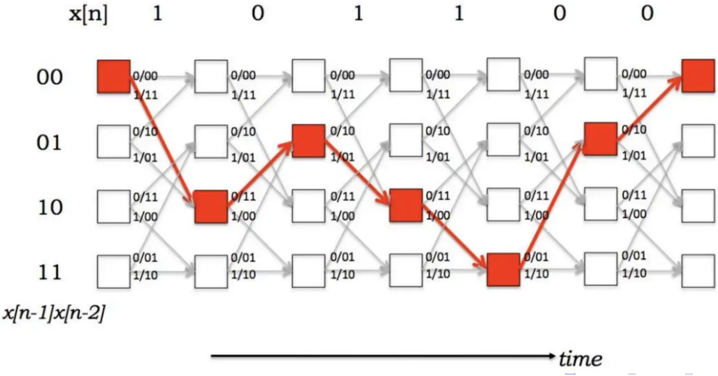
Figure: Trellis representation

The single digit on each edge indicates the input bit and the two digits indicates the output according to the generator polynomials.

Goal

Determine the **most likely** sequence of states that could have produced the given sequence of received bits

Using the trellis representation of the encoding process, the Viterbi decoder determines the **most likely path** along this trellis.



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Goal of the Project

In 1996, Wang and Wicker determined that artificial neural networks with hand-picked coefficients can reproduce the optimal Viterbi decoder.

Our Goal

1. Emulate a convolutional code decoder using neural networks in an attempt to **learn** this decoder in a data-driven manner.
2. Compare its reliability against that of the Viterbi algorithm.

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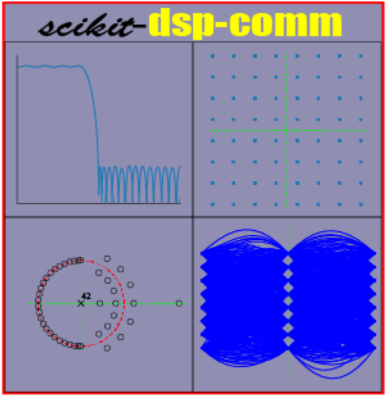
The scikit-dsp-comm package "is a collection of functions and classes to support signal processing and communications theory teaching and research."

Due to some discrepancies between our model and the Viterbi decoder from the package, a patch was created to ensure both outputs were comparable.



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RNN (?)

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Questions?