

Viterbi Decoding of Complex Channels using Neural Networks

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December 5, 2019

Outline

Background

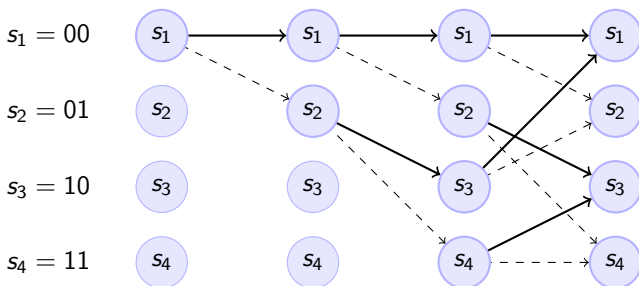
Initial Results

Viterbi Setup

Maximum Likelihood sequence decoding can be formalized as

$$\begin{aligned} & \underset{\mathbf{x}}{\text{maximize}} && Pr(\mathbf{y}|\mathbf{x}) \\ & \underset{\mathbf{x}}{\text{maximize}} && \prod_{i=1}^N Pr(y_i|\mathbf{x}) \end{aligned} \tag{5}$$

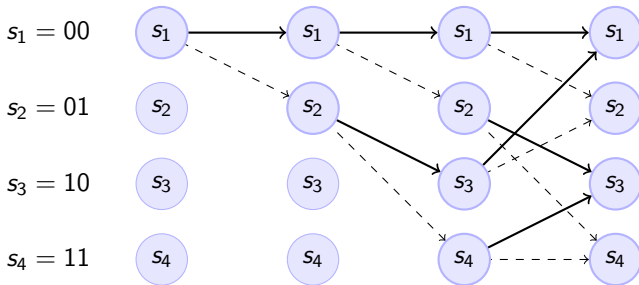
$$\underset{\mathbf{x}}{\text{minimize}} \quad \sum_{i=1}^N -\log(Pr(y_i|\mathbf{x}))$$



Viterbi Setup Continued

Each state change is decided by the metric $Pr(y_i|\mathbf{x})$. In a linear channel with finite impulse response, this metric becomes $Pr(y_i|\mathbf{x}_{i-1}^i)$.

Example with channel impulse response length 2 and constellation size 2



Example with channel impulse response length 2 and constellation size 2.

Incorporating Neural Net into Viterbi Decoding

Problem 1

Viterbi algorithm requires distribution $Pr(y_i|\mathbf{x}_{i-1}^i)$ (or its parameters).

► Solution

Have Neural Network learn $Pr(y_i|\mathbf{x}_{i-1}^i)$

Problem 2

Generating training data $Pr(y_i|\mathbf{x}_{i-1}^i)$ requires knowledge of the channel and its (current) parameters.

► Solution

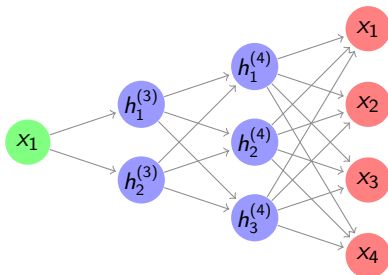
Decompose $Pr(y_i|\mathbf{x}_{i-1}^i)$ into

$$Pr(y_i|\mathbf{x}_{i-1}^i) = \frac{Pr(\mathbf{x}_{i-1}^i|y_i)Pr(y_i)}{Pr(\mathbf{x}_{i-1}^i)} \quad (6)$$

Metrics for $Pr(x_{i-1}^i | y_i)$

Received

States



Metrics for $Pr(y_i)$

Using mixture model from gaussian sources (trained using data used for training Neural Network. In particular the Expectation-Maximization is used. TODO Discuss problems that I'm having with this

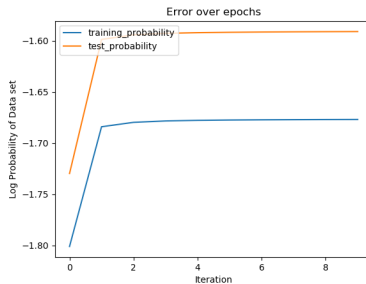
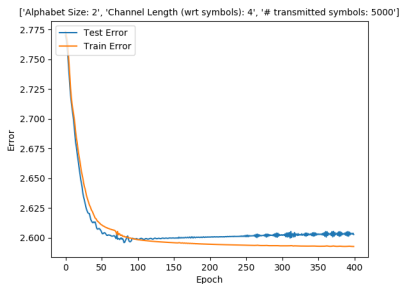
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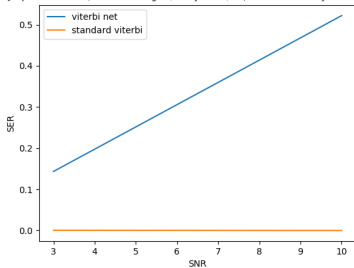
Training Neural Network and Mixture Model



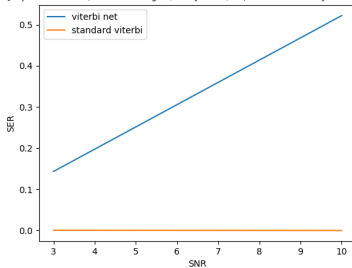
Decoding Performance

Include Channel Info

['Alphabet Size: 2', 'Channel Length (wrt symbols): 2', '# transmitted symbols: 5000']



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Future Work

- ▶ Apply to a sampled molecular communications channel
- ▶ Generate training data for molecular communications channel

Supplement: Data Generation Details