ECE 435/535a Digital Communications I
Semester Project

February 14, 2022

Viterbi Sequence Detection

Project description

You are given the state transition diagram of a finite state machine (FSM) in Fig. 1. The input sequence is from an independent and identically distributed data sequence $\bar{x} = x_1, x_2, \ldots$, where $x_k \in \{-1, 1\}$. The FSM outputs data sequence $\bar{y} = y_1, y_2, \ldots$. where x_k and y_k denotes the output and input symbol at time k respectively. The state transitions are labeled as input/output (x_k, y_k).

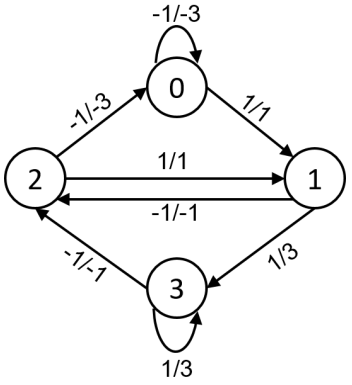

Figure 1: State Transition diagram of the FSM. The state transitions are labeled as input/output (x_k, y_k)

The output sequence $\bar{y}$ passes through an additive white Gaussian noise (AWGN) channel with mean $\mu = 0$ and variance σ^2. The received sequence at the channel output is $\bar{r}$. In this project you will write a software for a Viterbi detector which produces the input sequence $\bar{x}$ given the noisy sequence $\bar{r}$. You will also perform a probability of error analysis using Monte Carlo simulation.

Tips

1. Draw the complete Trellis diagram used for Viterbi algorithm for this received sequence. Make sure that you label the computed branch metrics.
2. Calculate the accumulated metrics at each stage of the trellis.
3. Find the most likely path and the corresponding input sequence using the Viterbi algorithm.

4. Derive the power of the sequence $\bar{y}$.
5. Do by hand the detection for the following finite sequence $\bar{r} = \{-3, -4, 1, -2, -4, -3\}$. Assume that the starting state is 0.
6. (For Graduate Students only) What is meant by maximum-likelihood detection. Explain mathematically how the Viterbi algorithm achieves maximum likelihood sequence detection for the case of AWGN channel.

Project submission details

You are required to submit a single zip file containing:

1. Your commented functions in Matlab, C or C++ performing the algorithm and simulations. Your code may not store input output and state sequences. It should work in a sequential way: one symbol in – one bit out. If your software does not meet this specification, you cannot get more than 50% for this assignment.
2. The plots of BER vs. BER showing the performance of the Viterbi detector for the FSM given. $SNR = \log_{10}(E_b/N_0)$, where E_b is energy per bit, $N_0/2$ is noise power. The simulations of the BER need to show a BER from 10^{-1} to 10^{-6} (at least).
3. A short LaTex report (2-3 pages) in IEEE Transactions format detailing the problem statement, a brief description of the solution, and a discussion on results of the study. Please cite references as needed.

Submit by e-mail this single zip file. If your name is Bane Vasić, the attached file should have the following name: bane_vasic.zip. Deadline for this report is April 20, 3pm.