Research Institute for Future Media Computing
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Coursework project: Gilbert-Elliot Model

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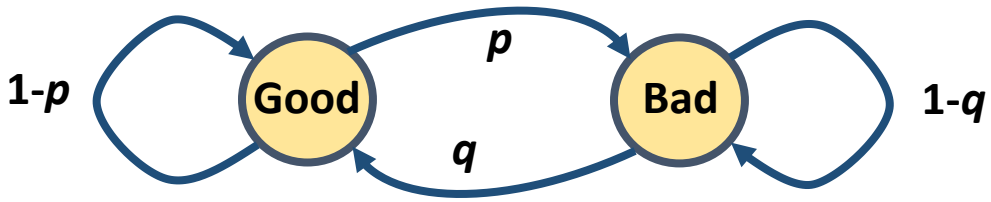

Figure 1. General illustration of Gilbert-Elliot model.

Introduction

In this project, there are two tasks: 1) finding the most likely parameters for Gilbert-Elliot model producing the given bit error sequence, and 2) simulating bit errors by using Gilbert-Elliot model. You can do the work individually or in pairs (if done in pairs, indicate the individual contributions in the project report). The work can be done with any programming language of your choice; however, I do not recommend very exotic alternatives. E.g. Matlab or Python would be suitable for this project. As a documentation for the work, you should write a project report. You should also submit your source code either as an appendix of the project report or as a separate file.

You can implement all the source code for scratch, or you can use source code available for the public in the Internet for individual functions. If you use source code from the Internet, please indicate the source in your report (using source code without proper reference will be considered as plagiarism).

The project will constitute 80% of the total mark, and the homework assignments will constitute the remaining 20%.

Task 1: Find parameters for Gilbert-Elliot model

Transmission error in a radio channel appears when a transmitted symbol is received incorrectly. Digital information is usually processed and transmitted as bits; therefore, we can say that there is a bit error, if transmitted bit 0 is received as 1, or if transmitted bit 1 is received as 0. It has been observed that when digital information is transmitted over a radio channel, transmission errors

usually appear in bursts, rather than isolated from each other. Therefore, bit errors are often simulated by using Gilbert-Elliot model [1], a hidden Markov model with two states: Good state, and Bad state. A general illustration of Gilbert-Elliot model is shown in Figure 1. In Good state, bit error probability P_{good} is low, e.g. $P_{good} = 0$ is often used. In Bad state, bit error probability P_{bad} is high, e.g. $P_{bad} = 0.5$ is often used. We can define that the observed state is 0 if there is no bit error, and the observed state is 1, if there is a bit error. Transition between Good state and Bad state can be expressed by parameters p and q, using the transition matrix A, given (1):

$$A = \begin{bmatrix} 1-p & p \\ q & 1-q \end{bmatrix} \quad (1)$$

In the first part of the project, your task is to find the most likely parameters $\lambda = \{p, q, P_{good}, P_{bad}\}$ for Gilbert-Elliot model producing the bit error sequence included in text file "biterrors.txt". You can e.g. implement Baum-Welch algorithm, or find any other method of your choice to analyze the bit error sequence.

Task 2: Channel simulation using Gilbert-Elliot model

In the second part of the project, your task is to implement a radio channel simulator, using a Gilbert-Elliot model to simulate bit errors. You can generate a sequence of bits randomly, apply simulated errors to the bitstream, and then compare the transmitted and received bitstreams to compute bit error rate *BER*, defined as a ratio of erroneously received bits n_{err}, and the total number of bits N (2):

$$BER = \frac{n_{err}}{N} \quad (2)$$

Using the channel simulator, conduct a small-scale research study, analyzing the impact of Gilbert-Elliot model parameters for transmission performance. You can decide the test scenario yourself, but please write a short motivation for your study in the project report. For example, you can run the simulation with different Gilbert-Elliot model parameters and compare the experimentally achieved bit error rate results against analytically derived results for the respective parameters. For a more challenging scenario, you can implement forward error correcting code (FEC) of your choice and study the impact of error correction on the residual bit error rate. You can use the scenario illustrated in Figure 2 as an inspiration for your study.

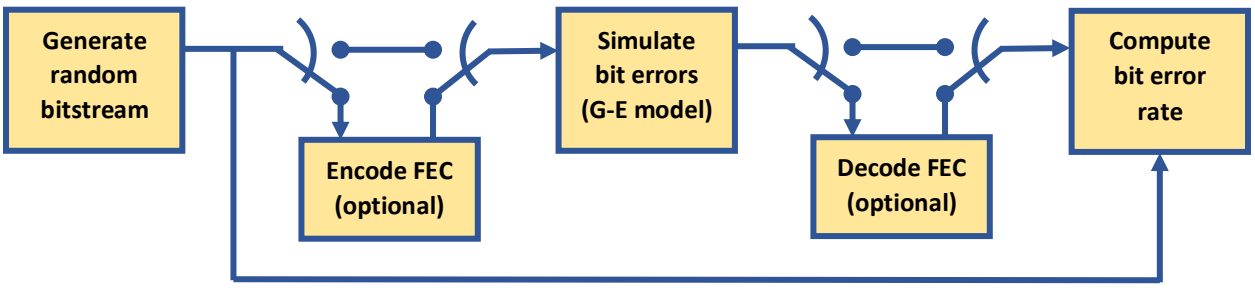

Figure 2. Example bit error simulation scenario.

Project report and evaluation

Write a project report including the following sections: (i) Introduction to set up the background, the research problem, and motivation for the chosen research scenario (max. two pages); (ii) Methods, to record what you have done, what kind of platform and programming language you used, and how you implemented the system (max. two pages if written by one student, three pages if written by two students); (iii) Experimental results for the found Gilbert-Elliot parameters, as well as the results of your simulation study, including discussion on the results (max. three pages if written by one student, four pages if written by two students, excluding graphs and figures); (iv) References.

The project will be evaluated according to the relevance, justification and difficulty level of the chosen simulation study scenario (20%), technical correctness and clarity of the source code (40%), as well as the clarity, structure, coverage and correctness of the project report (40%).

The deadline for submission will be in late June, the exact date will be announced in BlackBoard / WeChat. Please send your project report (template is available) and source code to jari@szu.edu.cn. Remember to include the source code.

References

[1] E. O. Elliot, "Estimates of Error Rates for Codes on Burst-Noise Channels." *Bell System Technical Journal*, 42: 5, pp 1977-1997, September 1963.

Online: https://archive.org/details/bstj42-5-1977/mode/2up