Implementation and Performance Analysis of Two Error Detection and Correction Techniques: CRC and Hamming Code

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ABSTRACT

In computer communication and telecommunication applications, error detection and correction techniques must be employed to ensure a reliable data transmission from the source to the destination. Two of the most prevailing techniques, Cyclic Redundancy Check (CRC) detection and Hamming code correction, are implemented and analyzed. The CRC method picks up prominence because it joins three focal points: extraordinary blunder identification capacities, minimal overhead, and simplicity of usage. Moreover, both the CRC and Hamming code are binary linear codes. However, one significant difference is that Hamming code only works on data of some fixed size (depending on the Hamming code used), whereas CRC is a convolution code that works on data of any size. In this paper, the authors will show how CRC helps in removing errors by passing three distorted signals and using CRC to receive the signal error free in the MATLAB environment.

KEYWORD
Correction, CRC, Error Detection, Hamming Code

1. INTRODUCTION

In computer communication and telecommunication applications, error detection and correction techniques must be employed to ensure a reliable data transmission from the source to the destination. The communication channels sometimes suffer from channel noise, introduced during the information transmission processes. Error detection schemes are used to detect these kinds of errors and can fix the problems to recover the data to the original format (Wikipedia).

The fundamental idea for realizing error detection is to include some repetition of a message which beneficiaries can use to check consistency of the conveyed message and to recover information resolved to be incorrect. Error detection strategies can be either efficient or non-precise. In a deliberate plan, the transmitter sends the first information and appends a settled number of check bits from the information bits by some deterministic calculation. On the off chance that an exclusive mistake location is required, a collector can apply a similar calculation to the retrieved information bits and contrast its yield with check bits. If the qualities don’t coordinate, a blunder has happened at some points amid the transmission. In a framework that uses a non-methodical code, the first message

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is changed into an encoded message that has, in any event, the same number of bits as the unique message components, incorporating the applicable criteria that follow.

Much research has been conducted in the field of error detection and correction. However, a comparative study and simulation on the existing error correction techniques hasn’t been extensively carried out. Most of the previous works primarily employed VHDL and XILINX ISE as simulation and test-bench verification tools which are either too complex or inaccurate. In this paper, the authors will present the implementation and simulation of the major error correction methods using MATLAB and Modelsim. MATLAB environment has many advantages over other programming languages because of its many built-in algorithms which allow for: interactive work with the data, aid in keeping track of variables or files and simplifying the debugging process. This paper compares different techniques of error detection and correction. It also shows how the use of exclusive OR in constructing Cyclic Redundancy Check (CRC) appears to be computationally more efficient than the complex method by which Hamming codes are built (Song & Maïté, 2013). The organization of this paper is as follows. Section 2 discusses existing error detection and correction techniques. Section 3 and 4 present hardware implementations and MATLAB verification of the CRC technique. Section 5 presents the simulation results and justification. Finally, Section 6 concludes the paper.

2. RELATED WORKS

Several existing error detection and correction schemes are discussed as follows.

2.1. Parity Bit Codes

Parity bit codes are very simple schemes that can be used to detect single or odd numbers (i.e., three, five, etc.) of errors in the output. An even number of flipped bits will make the parity bit appear correct.

2.2. Hamming Codes

Hamming codes are a set of error-correction codes that detect and correct bit errors that happen while moving or storing computer data. The most widely recognized types of error detection codes utilized as a part of RAM depend on the codes contrived by R. W. Hamming. In the Hamming code, k equality bits are added to an n-bit information word, framing another expression of n^k bits. The bit positions are numbered in arrangement from 1 to n^k. Those positions numbered with powers of two are saved for the equality bits. The rest of the bits are the information bits. The code can be utilized with expressions of any length (Ma, Yu, Zhang, & Cheng, 2015).

The basic Hamming code can detect and correct an error on just a single bit. When multiple bit errors are detected, they are erroneously corrected as single bit errors. By adding another parity bit to the coded word, the Hamming code can be used to correct a single error and detect double errors.

2.3. Cyclic Redundancy Check

The CRC is a single burst-error-detecting cyclic code and a non-secure hash function that is designed to detect accidental changes to digital data in computer networks. The CRC is used as the divisor in a polynomial long division over a finite field. It takes the input data as the dividend and the remainder as the result. The CRC technique is preferred among the three methods due to its low overhead in comparison to Hamming code. Moreover, Hamming code is for the fixed Hamming distance, which creates a problem of implementing code for large blocks. CRC is an error detection technique regularly utilized as a part of computerized systems and capacity devices to distinguish coincidental changes to crude information. Pieces of information entering these frameworks get a short check esteem connected, in view of the rest of a polynomial division of their substance. On recovery, the computation is rehashed and, in the occasion the check values don’t coordinate, restorative moves can be made against information corruption. The check (data confirmation) esteem is an excess,
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Shift in Speech Quality and Acceptability Level between 2008-2012