Detecting and Correcting Errors

But what are Hamming codes? The origin of error correction - 3Blue1Brown
Hamming codes part 2: The one-line implementation - 3Blue1Brown

Error Detection

- Use a **parity bit** - a redundant bit used to check whether no bits are changed
    - detects even and odd single-bit errors
    - does *not* correct errors
    - even parity is 0 and odd parity is 1
- **Hamming distance** is the number of different symbols in a string
    - parity bits can only detect errors when the Hamming distance is 1
    - The scheme Hamming (7,4) is used to visualize the errors in the data or the parity bits

Encoding

Fixed Length Encoding

- used for a finite set of variables like DNA or so

Variable Length Encoding

- one value can have multiple interpretations as shown below, when
    - a = 0
    - b = 1
    - c = 00
    - d = 11
- therefore:
  1) aaabbb = 000111 = 0-0-0-1-1-1
  2) acbd = 000111 = 0-00-1-11
  3) cabd = 000111 = 00-0-1-11
  4) acdb = 000111 = 0-00-11-1
  5) cadb = 000111 = 00-0-11-1
  6) aaabd = 000111 = 0-0-0-1-11
  7) aaadb = 000111 = 0-0-0-11-1
  8) acbbb = 000111 = 0-00-1-1-1
  9) cabbb = 000111 = 00-0-1-1-1

Huffman's Algorithm

- solves the multiple interpretations downside that comes with variable length encoding

- a minimum frequency algorithm that assigns prefix codes

  j - 17 | o - 8 | h - 12 | a - 23 | n - 34

  o - 8 | h - 12 | j - 17 | a -23 | n - 34
  oh - 20 | j - 17 | a - 23 | n - 34
  joh - 37 | a - 23 | n - 34
  joh - 37 | an - 57
  johan - 94

Logic Gates

CircuitVerse

- NOT - one input, output returns flipped
- AND - two inputs, if both are true, return true, otherwise false
- OR - two inputs, if any is true, then output true
- NAND - opposite of AND gate, returns false if both inputs are true, otherwise return false
- NOR - opposite of OR, returns true if both inputs are false, otherwise return false
- XOR - two inputs, returns true if both inputs don't match

Truth table with 4 inputs (and 16 outputs)

0 = 0000
1 = 0001
2 = 0010
3 = 0011
4 = 0100
5 = 0101
6 = 0110
7 = 0111
8 = 1000
9 = 1001
10 = 1010
11 = 1011
12 = 1100
13 = 1101
14 = 1110
15 = 1111